

# **TECHNICAL SUPPORT DOCUMENT FOR §194.23 - MODELS AND COMPUTER CODES VOLUME 2 of 3 APPENDICES**

**U.S. ENVIRONMENTAL PROTECTION AGENCY  
Office of Radiation and Indoor Air  
Center for the Waste Isolation Pilot Plant  
401 M. Street, S.W.  
Washington, DC 20460**

**MAY, 1998**

Technical support for this document was provided by S. Cohen and Associates, Inc. and/or its subcontractors under EPA Contract Number 68D70073.

## **APPENDIX A      COMPUTER CODE EVALUATIONS**

### **APPENDIX A1 FMT COMPUTER CODE EVALUATION**

The Fracture Matrix Transport (FMT) code solves chemical equilibrium problems using the Pitzer activity coefficient formalism. The Pitzer approach is the most accurate method for calculating activity coefficients for ionic species under conditions of high ionic strength as found in the WIPP brines. The FMT model computes activities and concentrations of constituents in brine solutions based on thermodynamic data and Pitzer parameters from Harvie, Møller, and Weare and Felmy & Weare (Docket: A-93-02, II-G-1, Ref. #286 and Ref. #245) for the following major components; hydrogen, oxygen, sodium, potassium, magnesium, calcium, chlorine, sulfur, carbon, boron, bromine, chlorate, phosphorus. This database has been augmented to include data for Am(III), Th(IV), and Np(V) which are relevant to use of FMT at WIPP. Positions in the database exist for U(VI) species, but no data actually exist in the database for these species and

consequently the FMT code is not used to model uranium chemistry.

For implementation in the PA, the FMT code is used to calculate the concentrations of Am(III), Th(IV), and Np(V) from the solubilities of specified actinide solids under conditions of chemical equilibrium. The code is not actually used for transport calculations as might be implied from its name. The effects on chemical conditions caused by equilibrium with specific solid phases part of the database are also included in the FMT calculation scheme. This capability is important for determining the effects of specific reactions, such as between magnesium hydroxide and magnesium carbonates, that are expected to be important for controlling pH and CO<sub>2</sub>(g) fugacity in the repository—i.e., parameters that strongly affect the solubilities of actinide solids. The FMT model is not used for calculating redox equilibria. Instead, actinides are specified to exist completely in a single oxidation state, i.e., Am(III), Th(IV), and Np(V). Using oxidation state analogies, the results for these actinides are extrapolated to Pu(III), Np(IV), U(IV), and Pu(IV).

## EPA REVIEW

### a) Any compliance application shall include:

#### a.1) A description of the conceptual models and scenario construction used to support any compliance application.

A fundamental precept of the representation of the repository environment in the performance assessment is that the actinide source term can be described by chemical equilibrium processes. The FMT code is a model of chemical equilibrium as applied to actinide chemistry that incorporates the Pitzer approach for calculating activity coefficients relevant to the high ionic strength conditions present in the Salado and Castile brines. This conceptualization is summarized in Appendix SOTERM (Docket: A-93-02, II-G-1, Volume XVII) and more detail regarding chemical equilibrium processes are provided in Docket: A-93-02, II-G-1, Ref. #302, Ref. #477, Ref. #479; Docket: A-93-02, II-G-3, Volume 6, User's Manual; Novak, et. al. 1995; and Bynum 1996.

In summary, the chemical equilibrium concept as applied to the repository environment involves the following assumptions:

- the system of brine and wastes is well-mixed (Appendix SOTERM)
- the brine composition entering the repository is constant with time

(Appendix SOTERM)

- the brines are in chemical equilibrium with the common minerals found in the Salado and Castile formations (e.g., halite and anhydrite) (Appendix SOTERM and Ref. #479)
- the brine pH (or pCH) and fugacity of CO<sub>2</sub>(g) will be buffered to specific values by the equilibrium between brucite [Mg(OH)<sub>2</sub>] and magnesite [MgCO<sub>3</sub>] as a result of brine interactions with the MgO backfill material (Appendix SOTERM and Ref. #479)
- the concentrations of actinides released to the brines can be represented by the experimentally determined solubilities of the actinide-bearing solids expected to form under the prevailing solution conditions (Appendix SOTERM, Ref. #477, Ref. #479 and Novak, et. al., 1995)
- the effects of redox reactions can be adequately represented by assuming dominant valence states for the actinides expected to be stable under the reducing conditions of the repository, where reducing conditions are generated from the consumption of oxygen by decaying organic material and ferrous metals (Appendix SOTERM)
- oxidation state analogies can be used to represent the concentrations of actinides for which solid-phase solubility data are not available or inadequate, i.e., Am(III) is used to represent Pu(III), where Th(IV) is used to represent Np(IV), Pu(IV) and U(IV), etc. (Appendix SOTERM and Novak, et. al., 1995)
- solubility and aqueous speciation data are inadequate to model U(VI), hence a model solubility of  $8.8 \times 10^{-6}$  M (in Castile brine) is used to provide a conservative representation of expected U(VI) concentrations based on a variety of empirical measurements (Appendix SOTERM and Ref. #302)
- the uncertainty in predicted solubilities of actinide solids can be represented by the deviances between solubilities determined in individual experimental studies and concentrations predicted by models used to fit experimental data to aqueous speciation schemes (Appendix SOTERM, and Bynum 1996)
- the Pitzer approach provides the best representation of activity coefficient for the high ionic strength solutions found in the Salado and Castile brines (Appendix SOTERM, User's Manual, Ref. #477, Ref. #479, and Novak, et.

al., 1995)

a.2) A description of plausible alternative conceptual model(s) seriously considered but not used to support such application, and an explanation of the reason(s) why such model(s) was not deemed necessary to accurately portray performance of the disposal system.

A discussion of alternative approaches for calculating actinide concentrations is provided in Appendix SOTERM (pages 21-22) but the discussion is brief and lacking in details. Additional information is found in supplementary references, including ref. #477, Ref. #479, and Novak, et. al. 1995.

A number of geochemical models of equilibrium chemistry exist that may have been considered for calculating actinide concentrations from available solubility data rather than FMT, although these possibilities are not discussed in Appendix SOTERM. For the most part, these other geochemical models are applicable to low ionic strength solutions and cannot be considered applicable to the Salado and Castile brines. The implementation of alternative activity coefficient models, such as Harned's Rule and Specific Ion Interaction Theory are discussed in Appendix SOTERM, pages 22-23. However, the Pitzer approach as implemented in FMT using the databases of Harvie, Møller, and Weare and Felmy & Weare (Docket: A-93-02, II-G-1, Ref. #286 and Ref. #245) has been found to be more accurate than the other methods and directly applicable to the brine solutions of the Salado and Castile formations. Additionally, a well-tested database of Pitzer ion interaction parameters was already in existence from the work described in these same references that could be implemented directly in FMT.

Other geochemical models, including EQ3/6 and PHRQPITZ, exist that also contain algorithms based on the Pitzer approach and the cited databases for calculating activity coefficients under high ionic strength conditions applicable to the WIPP repository. These other models are not discussed in any detail in the references, although they were used for comparison of their calculation results to those from FMT in the Requirements Document & Verification and Validation Plan and the Validation Document for FMT (Docket: A-93-02, II-G-3, Volume 6). These alternative models have been in wider use in the scientific community than the FMT model, and EQ3/6 was developed primarily by the DOE for the high level nuclear waste program.

In another investigation, an expert panel was convened to define probable actinide concentrations that might be expected in the repository environment. Because of

uncertainties in chemical conditions, such as pH and CO<sub>2</sub>(g) fugacity, this panel produced estimates of actinide concentrations ranging over many orders of magnitude based primarily on aqueous speciation and solubility data (Trauth, et. al. 1992 [Docket: A-93-02, II-G-1, Ref. #636] cited in Appendix SOTERM and Hobart, et. al. 1996 [Docket: A-93-02, II-G-1, Ref #304]). This range is probably too large to be meaningful. Since the time of the expert panel report, the use of an MgO backfill has been incorporated into the operation plan for WIPP. Reactions between the MgO and brines are expected to greatly narrow the range of chemical condition and consequently narrow the range of uncertainties in actinide concentrations calculated from solubility data.

Additionally, the possibility of measuring actinide concentrations directly in experiments designed to mimic waste/brine conditions expected in the repository is discussed in Appendix SOTERM, page 22, as an alternative approach. However, this approach is subject to numerous experimental difficulties, is extremely time consuming, and provides scant information on the potential long-term evolution of the brine/waste system. For these reasons, direct experimental studies were not considered to be practical as the primary source of predictive data for long-term actinide concentrations in the repository (*ibid.*).

### **a.3) Documentation that:**

a.3.i) conceptual models and scenarios reasonably represent possible future states of the disposal system.

By definition, the thermodynamic approach used to calculate actinide concentrations under conditions of chemical equilibrium provides a depiction of the chemical state to which the disposal system should evolve over time (see FMT User's Manual and Appendix SOTERM for descriptions of the thermodynamic approach).

a.3.ii) mathematical models incorporate equations and boundary conditions which reasonably represent the mathematical formulation of the conceptual model.

To determine conditions of chemical equilibrium for a solid/solution system, the FMT model uses the criteria of minimization of free energy given the constraints of the chemical composition of the fluid in question and principles of mass and charge balance and mass action defined for individual chemical reactions (see FMT User's Manual). This method is entirely consistent with the definition of chemical equilibrium as being the state of lowest free energy. The equations of mass action and mass balance are defined in the thermodynamic database of the FMT model in

terms of specific reactions for aqueous speciation and solid phase solubility (see FMT User's Manual).

The FMT model was designed for application to high ionic strength solutions and contains algorithms that incorporate the Pitzer approach to calculating activity coefficients for dissolved species based on the databases developed in Docket: A-93-02, II-G-1, Ref. #245 and Ref. #286. These databases were developed for representing chemical equilibrium in the high ionic strength solutions found in evaporative lakes and are directly applicable to representing chemical reactions in the high ionic strength brines of the Salado and Castile formations.

a.3.iii) numerical models provide numerical schemes which enable the mathematical models to obtain stable solutions.

The FMT model uses the Villars-Cruise-Smith method to solve the system of linear mass balance and nonlinear equilibrium reactions that represent aqueous speciation and solid-phase solubility reactions for aqueous systems (FMT User's Manual). This method should produce stable and real solutions to problems that are well defined and do not contain phase-rule violations. The verification and validation studies described below indicate that the numerical schemes produce precise solutions when compared to criteria of mass balance and replication of equilibrium constants.

a.3.iv) computer models accurately implement the numerical models; i.e., computer models are free of coding errors and produce stable solutions.

A series of 9 verification and validation model runs or tests are described in the Requirement Document & Verification and Validation Plan (RD/VVP) and the Validation Document (VD) for FMT (Docket: A-93-02, II-G-3, Volume 6). These verification tests adequately cover the calculation limits of the FMT code used in the CCA PA. They are designed to test the ability of the FMT model to implement its numerical algorithms correctly and produce stable solutions.

The results from the first run verify that the FMT model correctly maintains mass balances for chemical components and accurately reproduces equilibrium constants (see VD, pages 198-208).

The second test indicates that the FMT model can reproduce the general effect of carbonate concentration on  $\text{NaNpO}_2\text{CO}_3(\text{s})$  solubility, although the model calculation concentrations were generally lower than those measured in

experiments (see VD, pages 218-220).

The third test shows that FMT can reproduce the measured solubilities of various solids commonly found in evaporite deposits, such as the Salado and Castile formations, when compared to experimental measurements. These results indicate that the Pitzer ion interaction parameters of references 286 and 245 were entered correctly and provide accurate depictions of activity coefficients in high ionic strength solutions (see VD, pages 273, 276).

In the fourth test, results from FMT were compared with those obtained from EQ3/6 and PHRQPITZ, which are also models of chemical equilibrium with implementations of the databases of references 286 and 245. The FMT results are in very good agreement with those from the other models except for boron from the EQ3/6 model (see VD, pages 280-282). However, EQ3/6 did not contain a full boron model and boron is not considered to have any impact on actinide concentrations, hence the small discrepancies are not considered important.

The fifth test involved using FMT to titrate sulfate solutions with HCl to determine the effect on the solubility of  $\text{AmPO}_4$  for comparison to experimental data and previous FMT calculations. The results show a very good match to the experimental data and replication of the FMT calculations used to represent  $\text{AmPO}_4$  solubility in a previous FMT application.

In the sixth test, the criteria of mass balance was tested for an Am(III)-containing SPC (Salado) brine titrated with NaOH. Mass balances for oxygen and hydrogen were examined and found to match starting masses indicating that FMT's numerical solution scheme correctly satisfied the constraint of mass conservation in its calculation of equilibrium solution composition. Calculations of equilibrium constants for various speciation reactions also closely matched the values contained in the FMT database.

For the seventh test, results from FMT calculations were compared to Am(III) concentrations from solubility experiments with  $\text{NaAm}(\text{CO}_3)_2 \cdot 6\text{H}_2\text{O}$  conducted over a range of carbonate concentrations. The comparison shows that FMT closely reproduces the solubility data, indicating that it provides an accurate representation of experimental results.

The eighth test case was directed at examining FMT calculations of the effects of elevated  $\text{CO}_2(\text{g})$  fugacity on speciation of the SPC brine. The problem was run for a  $\text{CO}_2(\text{g})$  fugacity of 60 atm and results were examined for mass balance violations.

The results showed that carbon and other elements were conserved.

In the ninth and final test, a number of test cases were run with input values that either represented physically impossible situations and incorrect chemical specifications. In all cases, the FMT code reported an error and stopped execution or produced a solution composition that reflected the errors in the input.

The verification and validation plan for the FMT code as described in the RD/VVP and the VD provides a clear indication that the FMT code provides correct and stable solutions for a variety of chemical equilibrium problems. The tests were appropriate, including checks of elemental mass balance, calculation of equilibrium constants, and comparisons of results with other geochemical codes. Additionally, FMT calculations of actinide-solid solubilities were in good agreement with experimental data. This test is important because FMT is used to calculate actinide concentrations from solubility data for input to the performance assessment.

The only test that was lacking in detail in the verification and validation study was directed at FMT's representation of CO<sub>2</sub>(g) equilibria. However, additional execution of the FMT code, that has been conducted as part of other subsequent studies, indicate that FMT does provide accurate calculations of aqueous speciation and solubility in CO<sub>2</sub>(g)-containing system (see below Section d). As a result, this issue is not considered to be a significant omission in the testing of the FMT code.

a.3.v) [conceptual models have undergone peer review according to § 194.27.](#)

The dissolved actinide source term, colloidal actinide source term, and chemical conditions conceptual models were reviewed by the Conceptual Models Peer Review Panel Documents. The Panel concluded that all these models were adequate for use in performance assessment (see Section 3 of the TSD(1) for details.)

b) [Computer codes used to support any compliance application shall be documented in a manner that complies with the requirements of ASME NQA-2a-1990 addenda, part 2.7, to ASME NQA-2-1989 edition. \(Incorporation by reference as specified in § 194.5.\)](#)

The FMT code is documented as specified in NQA-2a-1990 in the User's Manual, the Requirements Document & Verification and Validation Plan, the Validation Document, and the Implementation Document (Docket: A-93-02, II-G-1, Volume 5).

Although these reports describe the operation and testing of the FMT code, they do



not document the generation of the thermodynamic database used by FMT or the modifications to that database planned for the future. This issue is important because calculations of the solubilities of actinide solids with FMT are directly dependent on its thermodynamic database. This database has undergone continuous revision since the publication of the User's Manual and the CCA, and this has undoubtedly resulted in improvements, but the changes have made it difficult to reproduce past results exactly. For example, the database used for the verification studies is indicated to be `fmt_hmw_np_am.chemdat` in the Script file on page 29 of the RD/VVP, implying that it does not contain data for Th(IV). However, Table SOTERM-2 of Appendix SOTERM—which provides the calculated actinide concentrations from FMT for the CCA—concentrations are given for +IV actinides, i.e., Th(IV). Because Th(IV) is the model for the +IV actinides, a database distinct from that used in the RD/VVP and the VD containing data for Th(IV) species must have been used. Documentation of the history of changes in the FMT thermodynamic database and implementation for the CCA process is absent in the materials associated with the CCA. However, a complete copy of the data base was provided by Novak 1997.

c) Documentation of all models and computer codes are included as part of any compliance application performance assessment calculation shall be provided. Such documentation shall include, but not limited to:

c.1) Description of the theoretical backgrounds of each model and the method of analysis or assessment.

Theoretical aspects of the model construction are described in Section 4 of the User's Manual. Additional information is also provided in association with the results of the verification and validation model runs in the VD.

c.2) General descriptions of the models; discussions of the limits of the applicability of each model; detailed instructions for executing the computer codes, including hardware and software requirements, input and output formats with explanations of each input and output variable and parameter (e.g., parameter name and units); listings of input and output files from a sample computer run; and reports on code verification, benchmarking, validation, and quality assurance procedures.

A general description of the FMT code is provided in the User's Manual, including detailed instructions for executing the code. Lists of variable names are also provided in the User's Manual. Hardware and software requirements, input and

output formats with explanations of variables are also provided in the User's Manual with additional information in the RD/VVP and the VD. A series of listings of example input and output files are given in the User's Manual, and additional files are provided in the RD/VVP and the VD. Reports on code verification and validation are provided in RD/VVP and the VD, respectively.

The verification and validation study involved 9 test cases that cover the functional requirements of the FMT code. These tests were discussed above.

The UM, RD/VVP, VD and ID have all been subjected to internal peer review as indicated by quality assurance sign-off sheets attached to the references.

The FMT code was also tested for non-ANSI FORTRAN coding and uncalled modules by DECset SCA during testing. The results indicated no instances where the FMT code deviated from ANSI standard FORTRAN. Examination of the calling tree for modules indicated that none were isolated from the remainder of the code but were all implemented as needed. In the verification test cases, three modules were not exercised, including ACTBDT, EHCALC, and VSCHG, that are designed to calculate activity coefficients with the B-dot equation, oxidation potential, and surface charge, respectively. Because these implementations are not relevant to the actinide source term modeling for the WIPP PA, their lack of use in the test cases is not considered significant with regard to the CCA.

### **c.3) Detailed descriptions of the structure of computer codes and complete listings of the source codes.**

The generalized structure of the file system and information flow for the FMT code is summarized in flow diagrams in the User's Manual (see Figures 1 and 2, page 23). A complete code listing for FMT is provided in the ID. However, the title of the ID refers to Version 2.1, whereas the code listing contained therein is for Version 2.0.

### **c.4) Detailed descriptions of data collection procedures, sources of data, data reduction and analysis, and code input parameter development.**

The FMT code depends on a database of thermodynamic constants characteristic of specific reactions. Chemical potentials and Pitzer ion interaction parameters for the major elements included in the FMT database are based on the work of Harvie, Møller, & Weare 1984 and Felmy & Weare 1986 (Docket: A-93-02, II-G-1, Ref. #286 and Ref. #245) and their procedures for determining these constants are well documented. Constants for the actinides relevant to specific reactions described in

Appendix SOTERM are taken from a variety of sources published in the scientific peer-reviewed literature. As described in Appendix SOTERM, constants for the actinides were generated from fits to solubility data using the NONLIN program (Docket: A-93-02, II-G-1, Ref. #477, and WIPP PA 1996, cited in Appendix SOTERM). The NONLIN program contains the same database of Pitzer ion interaction parameters and chemical potentials as used by FMT so that internal consistency is maintained in the generation of new constants for inclusion in the FMT database. Details on the use of the NONLIN code are not provided in Appendix SOTERM of the CCA, but the reader is referred to the references above.

Although Appendix SOTERM identifies specific sources of thermodynamic data for the FMT code, it does not provide an indication of the specific database used for the performance assessment calculations presented in the CCA. Supplementary references cited in Appendix SOTERM also do not indicate which thermodynamic database was used for model calculations of actinide concentrations for the performance assessment as presented in Table SOTERM-2 of Appendix SOTERM. The database has undergone continuous revision since the CCA, which has probably resulted in improvements in its values and completeness, but has apparently obscured the identity of the database version specifically used for the CCA. This issue is raised because the results of chemical equilibrium problems are primarily dependent on the thermodynamic data used to represent pertinent reactions. As noted earlier, a complete copy of the data base is included in Novak 1997 and this updated version was included in the EPA mandated PAVT (Docket: A-93-02, II-G-26).

The other primary inputs to the FMT code are the chemical compositions of the Salado and Castile brines and the identity of solubility controlling phases expected to be present in the repository environment. Brine compositions are provided in Table SOTERM-1 of Appendix SOTERM. Specific solubility controlling phases are not clearly identified in Appendix SOTERM, but are provided in supplementary information in Docket: A-93-02, II-G-1, Ref. #479.

#### **c.5) Any necessary licenses.**

The code runs on OpenVMS AXP, versions 1.5 and 6.1 on DEC Alpha and Power Macintosh platforms. A FORTRAN 77 compiler is needed to recompile the codes, but no licenses are required for the FMT computer code.

#### **c.6) An explanation of the manner in which models and computer codes incorporate the effects of parameter correlation.**

The effects of parameter correlation are not explicitly discussed in the UM, RD/VVP, VD and ID. However, it is generally understood that equilibrium reactions result in nonlinear correlations between concentrations and master variables, such as pH or CO<sub>2</sub>(g) fugacity, because of various hydrolysis and complexation reactions. These effects are explicitly accounted for in the reaction stoichiometries in the FMT thermodynamic database and related constants.

d) The Administrator or the Administrator's authorized representative may verify results of computer simulations used to support any compliance application by performing independent simulations. Data files, source codes, executable versions of computer software for each model, other material or information needed to permit the Administrator or the Administrator's authorized representative to perform independent simulations, and access to necessary hardware to perform such simulations, shall be provided within 30 calendar days of a request by the Administrator or the Administrator's authorized representative.

A study was undertaken by EPA to reproduce the concentrations of actinides presented in Table SOTERM-2 of the User's Manual and is discussed below.

The FMT model was used by the Department of Energy (DOE) to calculate concentrations of actinides based on solubility equilibria under expected repository conditions. The results form the basis for the actinide source term and are presented in Appendix SOTERM of the Compliance Certification Application. As part of the EPA review of the actinide source term a series of computer modeling runs was conducted with the FMT code to verify the results reported by DOE. During the course of conducting these modeling runs, incorrect results were obtained for Th(IV) and Np(V) under certain conditions. As a result, the FMT thermodynamic database was revised by Sandia National Laboratory (SNL) to correct values of ion interaction parameters to be more representative of experimental data. These revisions have resulted in calculated actinide concentrations that differ from those reported in the CCA PA as summarized below.

In an initial set of EPA computer modeling runs with the FMT model (version 2.0) conducted in January, 1997, results were obtained that, for the most part, approximated those reported by DOE in the CCA (Table A1-1). Differences of about 50% were found for Am(III) that could not be completely explained. They were presumably attributable to differences in the thermodynamic data for Am(III) species between the FMT database version used for verification compared to the

version used for the CCA. At the time of conducting these initial verification runs, there was some confusion at SNL about exactly which thermodynamic database had been used for the CCA calculations. These initial FMT verification runs relevant to the CCA were conducted for chemical conditions controlled by the equilibrium between brucite [ $\text{Mg}(\text{OH})_2$ ] and magnesite [ $\text{MgCO}_3$ ].

Later substantiated by experimental results (Docket: A-93-02, II-A-39), it was determined that chemical conditions in the repository would be more appropriately represented by the equilibrium between brucite and hydromagnesite [ $\text{Mg}_5(\text{CO}_3)_4(\text{OH})_2 \cdot 4\text{H}_2\text{O}$ ] or, less likely, brucite and nesquehonite [ $\text{MgCO}_3 \cdot 3\text{H}_2\text{O}$ ]. Because these reactions result in different sets of pH and  $\text{CO}_2(\text{g})$  partial pressure, factors that can strongly affect actinide solid solubilities, a series of FMT runs were conducted under conditions of brucite/hydromagnesite and brucite/nesquehonite equilibrium for comparison to the standard case of brucite/magnesite equilibrium used in the CCA.

These runs calculated Th(IV) and Np(V) concentrations so high that they were clearly in error (Table A1-2). The erroneously high concentrations were traced to unrepresentative values for ion interaction parameters for  $\text{Th}(\text{CO}_3)_5^{-6}$  and Np(V)-carbonate species by Craig Novak of SNL, who also noticed the high concentrations at about the same time (Novak 1997). Novak subsequently modified the ion interaction parameters for Th(VI) and Np(V) species with chloride, sodium, and potassium based on values from recent experimental results (Docket: A-93-02, II-G-1, Ref. #249, Ref. #481 and Novak et al. 1996) to correct the FMT database. He documented the changes in the FMT database and produced calculations of actinide solubilities under conditions of equilibria between brucite/magnesite, brucite/hydromagnesite, and brucite/nesquehonite in Novak 1997. The calculated actinide concentrations are also summarized in Docket: A-93-02, II-A-39.

Because the version of the FMT database that was originally used for the CCA was in error, calculated actinide solubilities based on it were no longer considered valid for verification purposes. Instead, solubility calculations described in Novak 1997 were obtained with the corrected database and were considered to be the most appropriate targets for verification. Additionally, version 2.2 of the FMT code was used in these calculations because of its availability at the time and improved output of parameters such as  $\text{CO}_2(\text{g})$  partial pressure (Novak 1997).

The results of the FMT verification runs closely match those provided by Novak

(1997) for conditions of equilibrium with different brucite/magnesium carbonate solids (Tables A1-3 and A1-4). Results are provided for two different hydromagnesite stoichiometries because it was not clear which would be prevalent under the repository conditions, although the calculated actinide concentrations for both forms are not widely different.

Experimental studies conducted at SNL have shown that nesquehonite forms initially upon reaction between brucite, air, and brine (Docket: A-93-02, II-A-39). The nesquehonite rapidly converts to hydromagnesite in a matter of days to weeks. Although SNL scientists, argue that the hydromagnesite should eventually convert to magnesite based on analogies with some natural experimental systems at elevated temperatures (*ibid.*), this reaction has not been observed to proceed completely under the low temperature conditions of their experiments. Consequently, to be consistent with the thermodynamic approach used to conceptualize the repository chemical conditions and actinide source term, the equilibria between brucite and hydromagnesite must be considered as the most probable reaction controlling the pH and CO<sub>2</sub>(g) partial pressure in the presence of the brines and MgO backfill.

A comparison of the actinide concentrations calculated under these conditions (Tables 3 and 4) shows that they are generally lower than those originally calculated for brucite/magnesite equilibria presented in the CCA (see Table A1-1). The lower concentrations are a direct result of the modifications to the FMT database made to correct the errors observed in modeling runs described above and in Novak 1997. However, these lower concentrations should be more accurate because of the improvements to the FMT thermodynamic database made since the submittal of the CCA.

**Table A1-1. Comparison of FMT results provided by Docket: A-93-02, II-G-1, Ref. #480 for the CCA to those obtained in the verification runs for the SPC brine (Salado) and ERDA6 brine (Castile). (Concentration - molal)**

| Element  | Salado Brine       |          | Castile Brine      |          |
|----------|--------------------|----------|--------------------|----------|
|          | Novak <sup>d</sup> | Verif.   | Novak <sup>d</sup> | Verif.   |
| Hydrogen | 1.11E+02           | 1.11E+02 | 1.11E+02           | 1.11E+02 |
| Oxygen   | 5.59E+01           | 5.59E+01 | 5.65E+01           | 5.65E+01 |
| Sodium   | 4.69E+00           | 4.69E+00 | 6.20E+00           | 6.20E+00 |

|            | Salado Brine   |                 | Castile Brine  |                 |
|------------|--|-----------------|--|-----------------|
| Element    | Novak <sup>d</sup>   | Verif.          | Novak <sup>d</sup>   | Verif.          |
| Potassium  | 1.05E+00   | 1.05E+00        | 1.09E-01   | 1.07E-01        |
| Magnesium  | 5.09E-01   | 5.09E-01        | 4.43E-02   | 4.33E-02        |
| Calcium    | 3.31E-02   | 3.31E-02        | 1.33E-02   | 1.35E-02        |
| Chlorine   | 6.67E+00   | 6.67E+00        | 5.97E+00   | 5.97E+00        |
| Sulfur     | 6.02E-02   | 6.02E-02        | 1.91E-01   | 1.87E-01        |
| Carbon     | 4.08E-05   | 4.10E-05        | 3.15E-05   | 3.18E-05        |
| Boron      | 2.72E-02   | 2.73E-02        | 7.08E-02   | 6.92E-02        |
| Bromine    | 1.36E-02   | 1.36E-02        | 1.24E-02   | 1.21E-02        |
| Th(IV)     | <b>4.98E-09</b>  | <b>5.01E-06</b> | <b>6.78E-09</b>  | <b>6.91E-09</b> |
| Am(III)    | <b>4.39E-07</b>  | <b>6.67E-07</b> | <b>4.12E-07</b>  | <b>7.37E-08</b> |
| Np(V)      | <b>2.64E-06</b>  | <b>2.63E-06</b> | <b>2.53E-06</b>  | <b>2.56E-06</b> |
| pH         | 8.69   | 8.69            | 9.24   | 9.24            |
| pmH        | 9.37   | 9.37            | 9.89   | 9.90            |
| Charge     | -8.17E-16  | 1.25E-17        | -1.97E-15  | 2.07E-15        |
| Equilibria | halite<br>anhydrite<br>AmOHCO <sub>3</sub> (s)<br>ThO <sub>2</sub> (am)<br>KNpO <sub>2</sub> CO <sub>3</sub> ·2H <sub>2</sub> O(s)<br>brucite<br>magnesite |                 | halite<br>anhydrite<br>AmOHCO <sub>3</sub> (s)<br>ThO <sub>2</sub> (am)<br>KNpO <sub>2</sub> CO <sub>3</sub> ·2H <sub>2</sub> O(s)<br>brucite<br>magnesite |                 |

Table A1-2. Brine compositions and actinide concentrations calculated with the CCA version of FMT for different magnesium carbonate equilibria for the SPC brine (Salado) and ERDA6 brine (Castile) showing high Th(IV) and Np(V) concentrations. (Concentration - molal)

|  | Salado Brine               |                          | Castile Brine              |                          |
|--|----------------------------|--------------------------|----------------------------|--------------------------|
|  | Brucite/<br>Hvdromaonesite | Brucite/<br>Nesauehonite | Brucite/<br>Hvdromaonesite | Brucite/<br>Nesauehonite |
|  |                            |                          |                            |                          |

|                                 | Salado Brine  |   | Castile Brine   |   |
|---------------------------------|---|---|---|---|
| Element                         | Brucite/<br>Hydromagnesite<br>[Mg <sub>5</sub> (CO <sub>3</sub> ) <sub>4</sub> (OH) <sub>2</sub> ·4H <sub>2</sub> O]  | Brucite/<br>Nesquehonite<br>[MgCO <sub>3</sub> ·3H <sub>2</sub> O]  | Brucite/<br>Hydromagnesite<br>[Mg <sub>5</sub> (CO <sub>3</sub> ) <sub>4</sub> (OH) <sub>2</sub> ·4H <sub>2</sub> O]  | Brucite/<br>Nesquehonite<br>[MgCO <sub>3</sub> ·3H <sub>2</sub> O]  |
| Hydrogen                        | 1.11E+02  | 1.11E+02  | 1.11E+02  | 1.11E+02  |
| Oxygen                          | 5.78E+01  | 5.98E+01  | 5.67E+01  | 5.90E+01  |
| Sodium                          | 3.81E+00  | 2.01E+00  | 5.64E+00  | 4.15E+00  |
| Potassium                       | 9.67E-01  | 8.78E-01  | 1.06E-01  | 9.67E-02  |
| Magnesium                       | 1.35E+00  | 2.66E+00  | 3.64E-01  | 1.57E+00  |
| Calcium                         | 4.02E-02  | 1.41E-02  | 1.07E-02  | 3.53E-02  |
| Chlorine                        | 6.60E+00  | 6.29E+00  | 5.97E+00  | 6.00E+00  |
| Sulfur                          | 1.22E-01  | 4.10E-01  | 2.23E-01  | 2.29E-01  |
| Carbon                          | 5.59E-01  | 8.01E-01  | 5.39E-03  | 7.64E-01  |
| Boron                           | 2.52E-02  | 2.25E-02  | 6.88E-02  | 6.28E-02  |
| Bromine                         | 1.25E-02  | 1.12E-02  | 1.20E-02  | 1.10E-02  |
| <b>Th(IV)</b>                   | <b>1.12E-01</b>   | <b>9.98E-02</b>   | <b>1.02E-03</b>   | <b>1.53E-01</b>   |
| <b>Am(III)</b>                  | <b>1.64E-07</b>   | <b>2.19E-08</b>   | <b>4.94E-08</b>   | <b>5.61E-08</b>   |
| <b>Np(V)</b>                    | <b>1.08E-06</b>   | <b>9.99E-02</b>   | <b>1.87E-06</b>   | <b>1.93E-05</b>   |
| pH                              | 8.52  | 8.40  | 8.79  | 8.56  |
| pmH                             | 9.18  | 9.02  | 9.42  | 9.15  |
| log [CO <sub>2</sub> ]<br>(bar) | -5.63   | -4.68   | -5.65   | -5.51   |
| Charge                          | 7.92E-15  | 5.74E-15  | 2.06E-15  | 4.63E-15  |
| Equilibria                      | halite<br>anhydrite<br>AmOHCO <sub>3</sub> (s)<br>ThO <sub>2</sub> (am)<br>KNpO <sub>2</sub> CO <sub>3</sub> ·2H <sub>2</sub> O(s)<br>brucite<br>magnesite<br>calcite<br>Mg-oxvchloride | halite<br>anhydrite<br>AmOHCO <sub>3</sub> (s)<br>ThO <sub>2</sub> (am)<br>KNpO <sub>2</sub> CO <sub>3</sub> ·2H <sub>2</sub> O(s)<br>brucite<br>magnesite<br>calcite | halite<br>anhydrite<br>AmOHCO <sub>3</sub> (s)<br>ThO <sub>2</sub> (am)<br>KNpO <sub>2</sub> CO <sub>3</sub> ·2H <sub>2</sub> O(s)<br>brucite<br>magnesite<br>calcite<br>glauberite | halite<br>anhydrite<br>AmOHCO <sub>3</sub> (s)<br>ThO <sub>2</sub> (am)<br>KNpO <sub>2</sub> CO <sub>3</sub> ·2H <sub>2</sub> O(s)<br>brucite<br>magnesite<br>calcite<br>glauberite |



Table A1-3. Brine compositions and actinide concentrations calculated with version 2.2 of FMT with corrected database for different magnesium carbonate equilibria for the SPC brine (Salado formation). (Concentration - molal)

| Element                 | Brucite/<br>Hydromagnesite<br>[Mg <sub>5</sub> (CO <sub>3</sub> ) <sub>4</sub> (OH) <sub>2</sub> ·4H <sub>2</sub> O] |                 | Brucite/<br>Hydromagnesite<br>[Mg <sub>4</sub> (CO <sub>3</sub> ) <sub>3</sub> (OH) <sub>2</sub> ·3H <sub>2</sub> O] |                 | Brucite/<br>Nesquehonite<br>[MgCO <sub>3</sub> ·3H <sub>2</sub> O] |                 | Brucite/<br>Magnesite<br>[MgCO <sub>3</sub> ] |           |
|-------------------------|--|-----------------|--|-----------------|--|-----------------|---|-----------|
|                         | Novak  | Verif.          | Novak  | Verif.          | Novak  | Verif.          | Novak   |           |
| Hydrogen                | 1.11E+02   | 1.11E+02        | 1.11E+02   | 1.11E+02        | 1.11E+02   | 1.11E+02        | not reported                                  | 1.        |
| Oxygen                  | 5.59E+01   | 5.59E+01        | 5.59E+01   | 5.59E+01        | 5.59E+01   | 5.59E+01        | not reported                                  | 5.        |
| Sodium                  | 4.68E+00   | 4.69E+00        | 4.68E+00   | 4.69E+00        | 4.66E+00   | 4.69E+00        | not reported                                  | 4.        |
| Potassium               | 1.07E+00   | 1.05E+00        | 1.07E+00   | 1.05E+00        | 1.11E+00   | 1.05E+00        | not reported                                  | 1.        |
| Magnesium               | 5.09E-01   | 5.09E-01        | 5.09E-01   | 5.09E-01        | 5.30E-01   | 5.30E-01        | not reported                                  | 5.        |
| Calcium                 | 3.29E-02   | 3.31E-02        | 3.29E-02   | 3.31E-02        | 3.34E-02   | 3.39E-02        | not reported                                  | 3.        |
| Chlorine                | 6.68E+00   | 6.67E+00        | 6.68E+00   | 6.67E+00        | 6.69E+00   | 6.66E+00        | not reported                                  | 6.        |
| Sulfur                  | 6.06E-02   | 6.02E-03        | 6.06E-02   | 6.02E-02        | 6.22E-02   | 6.10E-02        | not reported                                  | 6.        |
| Carbon                  | 4.13E-04   | 4.13E-04        | 5.38E-04   | 5.38E-04        | 2.26E-02   | 2.27E-02        | not reported                                  | 1.        |
| Boron                   | 2.77E-02   | 2.73E-02        | 2.77E-02   | 2.73E-02        | 2.88E-02   | 2.72E-02        | not reported                                  | 2.        |
| Bromine                 | 1.39E-02   | 1.36E-02        | 1.39E-02   | 1.36E-02        | 1.44E-02   | 1.36E-02        | not reported                                  | 1.        |
| Th(IV)                  | <b>1.37E-08</b>  | <b>1.37E-08</b> | <b>1.75E-08</b>  | <b>1.75E-08</b> | <b>7.22E-04</b>  | <b>7.49E-04</b> | not reported                                  | <b>1.</b> |
| Am(III)                 | <b>1.08E-07</b>  | <b>1.06E-07</b> | <b>8.31E-08</b>  | <b>8.21E-08</b> | <b>3.64E-07</b>  | <b>3.53E-07</b> | not reported                                  | <b>7.</b> |
| Np(V)                   | <b>1.38E-07</b>  | <b>1.40E-07</b> | <b>1.23E-07</b>  | <b>1.25E-07</b> | <b>1.36E-07</b>  | <b>1.45E-07</b> | not reported                                  | <b>1.</b> |
| pH                      | 8.69   | 8.69            | 8.69   | 8.69            | 8.69   | 8.69            | not reported                                  |           |
| pmH                     | 9.37   | 9.37            | 9.37   | 9.37            | 9.37   | 9.36            | not reported                                  |           |
| log CO <sub>2</sub> (g) | -5.50  | -5.50           | -5.39  | -5.39           | -3.84  | -3.84           | not reported                                  |           |
| Charge                  | 5.87E-15   | 5.82E-15        | 8.97E-15   | 3.07E-15        | 1.30E-14   | 3.72E-15        | not reported                                  | 4.        |

|            | Brucite/<br>Hydromagnesite<br>[Mg <sub>5</sub> (CO <sub>3</sub> ) <sub>4</sub> (OH) <sub>2</sub> ·4H <sub>2</sub> O]                                   |        | Brucite/<br>Hydromagnesite<br>[Mg <sub>4</sub> (CO <sub>3</sub> ) <sub>3</sub> (OH) <sub>2</sub> ·3H <sub>2</sub> O]                                   |        | Brucite/<br>Nesquehonite<br>[MgCO <sub>3</sub> ·3H <sub>2</sub> O]   |        | Brucite/<br>Magnesite<br>[MgCO <sub>3</sub> ]  |  |
|------------|--|--------|--|--------|--|--------|--|--|
| Element    | Novak  | Verif. | Novak  | Verif. | Novak  | Verif. | Novak  |  |
| Equilibria | Anhydrite<br>MgOxychloride<br>Brucite<br>Hydromagnesite<br>Halite<br>ThO <sub>2</sub> (am)<br>AmOHCO <sub>3</sub><br>KNpO <sub>2</sub> CO <sub>3</sub> |        | Anhydrite<br>MgOxychloride<br>Brucite<br>Hydromagnesite<br>Halite<br>ThO <sub>2</sub> (am)<br>AmOHCO <sub>3</sub><br>KNpO <sub>2</sub> CO <sub>3</sub> |        | Anhydrite<br>MgOxychloride<br>Brucite<br>Nesquehonite<br>Halite<br>ThO <sub>2</sub> (am)<br>AmOHCO <sub>3</sub><br>KNpO <sub>2</sub> CO <sub>3</sub> |        | Anhydrite<br>Brucite<br>Magnesite<br>Halite<br>ThO <sub>2</sub> (am)<br>Am(OH) <sub>3</sub> (s)<br>KNpO <sub>2</sub> CO <sub>3</sub> |  |

**Table A1-4. Brine compositions and actinide concentrations calculated with version 2.2 of FMT with corrected database for different magnesium carbonate equilibria for the ERDA6 brine (Castile formation). (Concentration - molal)**

|           | Brucite/<br>Hydromagnesite<br>[Mg <sub>5</sub> (CO <sub>3</sub> ) <sub>4</sub> (OH) <sub>2</sub> ·4H <sub>2</sub> O] |                 | Brucite/<br>Hydromagnesite<br>[Mg <sub>4</sub> (CO <sub>3</sub> ) <sub>3</sub> (OH) <sub>2</sub> ·3H <sub>2</sub> O] |                 | Brucite/<br>Nesquehonite<br>[MgCO <sub>3</sub> ·3H <sub>2</sub> O] |                 | Brucite/<br>Magnesite<br>[MgCO <sub>3</sub> ] |          |
|-----------|--|-----------------|--|-----------------|--|-----------------|---|----------|
| Element   | Novak  | Verif.          | Novak  | Verif.          | Novak  | Verif.          | Novak   |          |
| Hydrogen  | 1.11E+02   | 1.11E+02        | 1.11E+02   | 1.11E+02        | 1.11E+02   | 1.11E+02        | not reported                                  | 1.       |
| Oxygen    | 5.66E+01   | 5.65E+01        | 5.66E+01   | 5.65E+01        | 5.67E+01   | 5.66E+01        | not reported                                  | 5.       |
| Sodium    | 6.20E+00   | 6.20E+00        | 6.20E+00   | 6.20E+00        | 6.18E+00   | 6.18E+00        | not reported                                  | 6.       |
| Potassium | 1.11E-01   | 1.07E-01        | 1.11E-01   | 1.07E-01        | 1.16E-01   | 1.06E-01        | not reported                                  | 1        |
| Magnesium | 4.57E-02   | 4.40E-02        | 4.59E-02   | 4.42E-02        | 7.74E-02   | 7.35E-02        | not reported                                  | 4        |
| Calcium   | 1.34E-02   | 1.36E-02        | 1.34E-02   | 1.36E-02        | 1.61E-02   | 1.64E-02        | not reported                                  | 1        |
| Chlorine  | 5.97E+00   | 5.97E+00        | 5.97E+00   | 5.97E+00        | 5.96E+00   | 5.96E+00        | not reported                                  | 5.       |
| Sulfur    | 1.91E-01   | 1.87E-01        | 1.91E-01   | 1.87E-01        | 1.93E-01   | 1.90E-01        | not reported                                  | 1        |
| Carbon    | 7.77E-04   | 7.91E-04        | 1.01E-03   | 1.03E-03        | 3.54E-02   | 3.67E-02        | not reported                                  | 3        |
| Boron     | 7.21E-02   | 6.92E-02        | 7.21E-02   | 6.92E-02        | 7.48E-02   | 6.91E-02        | not reported                                  | 7        |
| Bromine   | 1.26E-02   | 1.21E-02        | 1.26E-02   | 1.21E-02        | 1.31E-02   | 1.21E-02        | not reported                                  | 1        |
| Th(IV)    | <b>4.63E-08</b>  | <b>4.70E-08</b> | <b>5.98E-08</b>  | <b>6.07E-08</b> | <b>1.19E-03</b>  | <b>1.30E-03</b> | not reported                                  | <b>3</b> |

|                         | Brucite/<br>Hydromagnesite<br>[Mg <sub>5</sub> (CO <sub>3</sub> ) <sub>4</sub> (OH) <sub>2</sub> ·4H <sub>2</sub> O]                                |          | Brucite/<br>Hydromagnesite<br>[Mg <sub>4</sub> (CO <sub>3</sub> ) <sub>3</sub> (OH) <sub>2</sub> ·3H <sub>2</sub> O]                                |          | Brucite/<br>Nesquehonite<br>[MgCO <sub>3</sub> ·3H <sub>2</sub> O]  |          | Brucite/<br>Magnesite<br>[MgCO <sub>3</sub> ]  |   |
|-------------------------|---|----------|---|----------|---|----------|--|---|
| Element                 | Novak   | Verif.   | Novak   | Verif.   | Novak   | Verif.   | Novak  |   |
| pH                      | 9.24  | 9.24     | 9.23  | 9.24     | 9.17  | 9.18     | not reported   |   |
| pmH                     | 9.89  | 9.90     | 9.89  | 9.89     | 9.82  | 9.83     | not reported   |   |
| log CO <sub>2</sub> (g) | -5.50   | -5.50    | -5.39   | -5.39    | -3.87   | -3.87    | not reported   |   |
| Charge                  | 1.54E-14  | 1.55E-15 | 7.56E-15  | 4.09E-16 | 1.62E-15  | 1.95E-15 | not reported   | 5 |
| Equilibria              | Anhydrite<br>Brucite<br>Hydromagnesite<br>Halite<br>Glauberite<br>ThO <sub>2</sub> (am)<br>KNpO <sub>2</sub> CO <sub>3</sub><br>AmOHCO <sub>3</sub> |          | Anhydrite<br>Brucite<br>Hydromagnesite<br>Halite<br>Glauberite<br>ThO <sub>2</sub> (am)<br>KNpO <sub>2</sub> CO <sub>3</sub><br>AmOHCO <sub>3</sub> |          | Anhydrite<br>Brucite<br>Nesquehonite<br>Halite<br>Glauberite<br>ThO <sub>2</sub> (am)<br>Na <sub>3</sub> NpO <sub>2</sub> (CO <sub>3</sub> ) <sub>2</sub><br>NaAm(CO <sub>3</sub> ) <sub>2</sub> ·6H <sub>2</sub> O |          | Anhydrite<br>Brucite<br>Magnesite<br>Halite<br>Glauberite<br>ThO <sub>2</sub> (am)<br>Am(OH) <sub>3</sub> (s)<br>KNpO <sub>2</sub> CO <sub>3</sub> |   |

## REFERENCES

- Bynum, R. V. 1996. *Analysis to Estimate the Uncertainty for Predicted Actinide Solubilities*. WBS 1.1.10.1.1, Rev. 0, effective date 9/3/96 (WPO41374).
- Novak, C. F. 1997. *Calculation of Actinide Solubilities in WIPP SPC and ERDA6 Brines under MgO Backfill Scenarios Containing Either Nesquehonite or Hydromagnesite as the Mg-CO<sub>3</sub> Solubility-Limiting Phase*. Memo to R. Vann Bynum, dated April 21, 1997, Sandia National Laboratory, Albuquerque, New Mexico.
- Novak, C. F., I. Al Mahamid, K. A. Becraft, S. A. Carpenter, N. Hakem, and T. Prussin 1996b. *Measurement and Thermodynamic Modeling of Np(V) Solubility in Dilute through Concentrated K<sub>2</sub>CO<sub>3</sub> Media*. SAND96-1604J, Sandia National Laboratory, Albuquerque, New Mexico.
- Novak, C. F., N. J. Dhooge, H. W. Papenguth, and R. F. Weiner 1995. *Systems Prioritization Method - Iteration 2 Baseline Position Paper: Actinide Source Term*. Sandia National Laboratory, Albuquerque, New Mexico, dated March 31, 1995.

## APPENDIX A2

# PANEL COMPUTER CODE EVALUATION

This evaluation examines PANEL Version 3.60. PANEL's role in the CCA performance assessment (PA) is to estimate the mobilized radioactive contaminant load in the brine phase of the brine/gas mixture that seeps or flows through the repository's decommissioned waste panels. This code is used in S6 scenarios in which 2 boreholes penetrate the same waste panel—with the second borehole also penetrating a pressurized Castile brine pocket. When applicable—i.e., if a borehole intrudes into a pressurized repository—PANEL is able to calculate the contaminant load contained in the volume of brine that would be released directly to the surface.

### EPA REVIEW

a) **Any compliance application shall include:**

a.1) **A description of the conceptual models and scenario construction used to support any compliance application.**

Descriptions of the model and related methods are provided in the WIPP CCA (Docket: A-93-02, II-G-1, Volume XI, Appendix PANEL), the PANEL User's Manual (UM) (Docket: A-93-02, II-G-3, Volume II), and the Task 2 Analysis Package (Docket: A-93-02, II-G-09).

a.2) **A description of plausible alternative conceptual model(s) seriously considered but not used to support such application, and an explanation of the reason(s) why such model(s) was not deemed to accurately portray performance of the disposal system.**

As employed in the CCA, PANEL performs two basic functions: the code calculates radioactive decay and calculates the amount of radioactive material dissolved in brine and transported from a waste panel—given a volume of brine within the waste panel, the solubilities of the radionuclides present, and the brine outflow. For the first of these functions, radioactive decay, there is no question of alternative models, since radioactive decay is governed by well documented physical process. The parameters, including brine volume, radionuclide solubilities, and brine outflow that govern the second function, are calculated in other codes and then entered into PANEL. The chief assumptions made within PANEL are: a) all of a given radionuclide contained within a waste panel is

instantaneously available for mixing with the brine present at a given time-step, and b) the maximum possible amount of a radionuclide instantly goes into solution. Also note for calculation purposes, PANEL lumps together the effects of dissolution and colloidal suspension. No other approach is discussed, but the implementation of the code maximizes the amount of material mobilized and is conservative.

### a.3) Documentation that:

a.3.i) conceptual models and scenarios reasonably represent possible future states of the disposal system.

PANEL supports a framework based on conceptual models and scenarios that are described in Volume I of the CCA (Docket: A-93-02, II-G-1, Chapter 6), in the PANEL UM (Docket: A-93-02, II-G-3, Volume II), and in the Task 2 Analysis Package (Docket: A-93-02, II-G-09). The models and scenarios appear to reasonably represent possible future states of the disposal system.

a.3.ii) mathematical models incorporate equations and boundary conditions which reasonably represent the mathematical formulation of the conceptual models.

The equations in PANEL are described by the UM (*ibid.*) and they reasonably represent the conceptual models used.

a.3.iii) numerical models provide numerical schemes which enable the mathematical models to obtain stable solutions.

The mathematics used in PANEL produce straightforward analytical solutions to the relevant equations. No numerical methods are used.

a.3.iv) computer models accurately implement the numerical models; i.e., computer codes are free of coding errors and produce stable solutions.

The performance of the PANEL code is described in the UM (*ibid.*) and documented in the PANEL Validation Document (VD) (Docket: A-93-02, II-G-3, Volume II). The computer code used in PANEL appears to accurately implement the numerical models.

a.3.v) conceptual models have undergone peer review according to § 194.27.

The peer review of the conceptual models that PANEL supports is described in the Volume I of the CCA and Appendix PEER, PEER 1 (Docket: A-93-02, II-G-1).

b) Computer codes used to support any compliance application shall be documented in a manner that complies with the requirements of ASME NQA-2a-1990 addenda, part 2.7, to ASME NQA-2-1989 edition.  
(Incorporation by reference as specified in § 194.5)

The four QA documents reviewed for PANEL Version 3.60 are (Docket: A-93-02, II-G-3, Volume II):

User's Manual (UM) (2)

Implementation Document (ID) (5)

Requirements Document/ Validation & Verification Plan (RD/VVP) (6)

Validation Document (VD) (9)

These documents are discussed in order below.

### *User's Manual*

PANEL performs two basic functions by calculating: the radioactive decay of the significant radionuclides contained in the WIPP inventory and the amount of each nuclide mobilized in brine including that removed by transport from a waste panel. In relation to these calculations, the UM adequately explains the technical basis for the code, provides a description of the equations used for the processes modeled by the code, and explains how the equations were selected or developed.

The UM provides sufficient information to run the code, assuming the user is familiar with VMS and Digital Command Language. The UM provides a chart of the run sequence for PANEL to illustrate the codes that must be run prior to PANEL to provide the necessary input. Examples of input and output files are provided in the UM.

During the Sandia QA review of PANEL, it was noted that the PANEL test case for radioactive decay only tested one radionuclide and not the entire list used in CCA runs. The conclusion made at the time of the test is that the single radionuclide case is adequate to evaluate the code's algorithm and further testing was not considered necessary. This is based on the provision that radioactive half-lives and decay chains are hard-wired into PANEL for the remaining radionuclides and that this can be verified by the documentation in the UM. The Task 2 Analysis Package, dated December 19, 1996 (Docket: A-93-02, II-G-9, pp. 56-57), compares the PANEL data to the PA Data Base values obtained from the independent ORIGEN computer code (4) and finds no significant differences. Based on this, the PANEL data are acceptable—also see the additional remarks

provided in the Requirements Document/Validation & Verification Plan (RD/VVP) discussion below.

### ***Implementation Document***

The ID provides a complete listing of the source code.

### ***Requirements Document/Validation & Verification Plan***

Three functional requirements are listed in the RD/VVP. The RD/VVP notes that PANEL must be able to compute the following at all future times up to 10,000 years:

R.1 The mass of each radioisotope present in the repository by accounting for radioactive decay.

R.2 The amount of each radioisotope that transforms into a mobile phase.

R.3 The amount of each mobilized radioisotope that is transported by the brine flow and removed from the waste area.

These functions appropriately represent the usage of PANEL in the CCA PA. The VVP presents an approach to test these functions. The radioactive decay function is tested separately from the other two functions. This is appropriate since decay and mobilization occur independent of each other. The independent testing also simplifies the verification of results. Requirement R.1, the calculation of radioactive decay, is tested by setting up an input file specifying a given quantity of a single radioisotope, assuming no mobilization nor transport occurs, and then evaluating the results. The transport test uses input for two radioisotopes with extremely long half-lives—so radioactive decay is negligible—and assumes a given intrusion time and brine inflow. The correct performance of the calculations in this test verifies requirements R.2 and R.3.

The acceptance criteria specified in the PANEL Version 3.60 RD/VVP rely on comparing the present results with those from the preceding version, PANEL Version 3.50ZO. This was accomplished through a comparison with independent test results for the preceding version. This is acceptable if the documentation for PANEL Version 3.50ZO is available for review and is determined to be adequate for this evaluation (see discussion under Validation Document below).

The RD/VVP notes that while the test case for radioactive decay serves to validate PANEL's decay model, it does not provide verification of all the decay chains

available in PANEL. The RD/VVP states that the exercise of documenting and verifying PANEL's decay chains and isotope half-lives "will be performed as part of the *WIPP PA User's Manual for PANEL Version 3.60*" (2). As noted in the preceding discussion of the UM, this material is not present in the manual, but the issue is addressed in the Task 2 Analysis Package. While this documentation should be corrected, the lack of decay chain information does not materially affect the validity of the PANEL code.

### ***Validation Document (VD)***

The VD presents the results of running the test cases for radioactive decay and for transport, and compares the results to the acceptance criteria specified in the RD/VVP. The results of the test cases fulfill the requirements of the acceptance criteria from the PANEL Version 3.60 RD/VVP. Noting the caveat concerning availability and acceptability as stated above, the UM (1), RD/VVP (2), and VD (3) for PANEL Version 3.50ZO were also reviewed. These documents demonstrate that PANEL Version 3.50ZO was tested and gave results that met acceptance criteria based on comparison to independent calculations. EPA also successfully ran the test cases for PANEL Version 3.60 which are adequate for demonstrating PANEL's performance.

c) Documentation of all models and computer codes are included as part of any compliance application performance assessment calculation shall be provided. Such documentation shall include, but not be limited to:

c.1) Description of the theoretical backgrounds of each model and the method of analysis or assessment.

Description of the theoretical backgrounds and methods of analysis used in PANEL are provided in Volume I of the CCA, the UM, and in the Task 2 Analysis Package.

c.2) General descriptions of the models; discussions of the limits of applicability of each model; detailed instructions for executing the computer codes, including hardware and software requirements, input and output formats with explanations of each input and output variable and parameter (e.g., parameter name and units); listings of input and output files from a sample computer run; and reports on code verification, benchmarking, validation, and quality assurance procedures.

General descriptions of the models used in PANEL are provided in Volume I of the



CCA (pp. 6-174 - 6-179), the UM (pp. 8-17), and in the Task 2 Analysis Package (pp. 18-23). The UM provides detailed instructions for executing the code, along with sample input and output files. The VD provides verification and validation information.

**c.3) Detailed descriptions of the structure of computer codes and complete listings of the source codes.**

The structure of the PANEL code is described in the UM. A listing of the source code is contained in the Implementation Document (ID).

**c.4) Detailed descriptions of data collection procedures, sources of data, data reduction and analysis, and code input parameter development.**

Input parameters are discussed in the UM. Brine volume and brine outflow are calculated by another code such as BRAGFLO or BRAGFLO\_DBR and are then placed in an input file for PANEL. One of the most critical inputs to PANEL are the solubilities which are calculated by the ALGEBRA code. A detailed description of the development of the solubilities used in PANEL is contained in the Task 2 Analysis Package.

**c.5) Any necessary licenses.**

No licenses are necessary for PANEL.

**c.6) An explanation of the manner in which models and computer codes incorporate the effects of parameter correlation.**

Three of the principal parameters used in PANEL (radionuclide half-lives, radionuclide inventory, and solubilities) are not interrelated. Two principal parameters (brine volume and brine outflow) are the result of calculations performed by a predecessor code (e.g., BRAGFLO or BRAGFLO\_DBR) and are not correlated as used in PANEL.

**d) The Administrator or the Administrator's authorized representative may verify results of computer simulations used to support any compliance application by performing independent simulations. Data files, source codes, executable versions of computer software for each model, other material or information needed to permit the Administrator or the Administrator's authorized representative to perform independent simulations, and access to necessary hardware to perform such simulations, shall be provided within 30 calendar days of a request by the**

## Administrator or the Administrator's authorized representative.

EPA was given access to the Sandia computer system and to files described as necessary to run PANEL. Information on operation of the Sandia computer system and specific information on running PANEL was provided. However, during the initial attempts to verify the results of the two VD tests for PANEL, the Agency discovered that corrupted versions of the necessary input files were contained in CCA-CMS. Sandia personnel subsequently found that uncorrupted versions of the files exist on back-up tapes dated prior to June 12, 1996. The EPA then accessed the uncorrupted files on February 24, 1997, and successfully ran the PANEL test cases.

## REFERENCES

Oak Ridge National Laboratory, RSIC Computer Code Collection, "ORIGEN 2.1; Isotope Generation and Depletion Code, Matrix Exponential Method," December 1991 included in the CCA.

WIPP PA User's Manual for PANEL, Version 3.50ZO, WPO #37361, September 29, 1995.

WIPP PA Requirements Document & Validation and Verification Plan for PANEL, Version 3.50ZO, WPO# 24326, September 28, 1995.

WIPP PA Validation Document for PANEL, Version 3.50ZO, WPO# 24328, September 28, 1995.

See Appendix B(3) for a listing of docketed references.

## APPENDIX A3 SANTOS COMPUTER CODE EVALUATION

The computer code SANTOS enters the Compliance Certification Application (CCA) via "Creep Closure" as described in 6.4.3.1 Creep Closure, pages 6-97 to 6-99 (Docket: A-93-02, II-G-1, Volume I, Chapter 6). Supplementary information is contained in Appendix PORSURF and attachments to Appendix PORSURF which contain additional references (Docket: A-93-02, II-G-1, Volume XVI). SANTOS provides for two-dimensional stress analysis of repository rooms experiencing finite creep strains.

Creep closure histories from SANTOS calculations provide room pressure - room porosity histories for input to the fluid-flow computer code BRAGFLO. The

actual mechanics of room closure are not considered important except as interbed fracture may occur.

## EPA REVIEW

a) *Any compliance application shall include:*

a.1) **A description of conceptual models and scenario construction used to support any compliance application.**

The conceptual model for creep closure is described in the CCA, Section 6.4.3.1 Creep Closure, pages 6-97 to 6-99, and in the supporting references in Appendices PORSURF.1 and PORSURF Attachment 1.

The model focuses on salt creep that results in time-dependent reduction of disposal room volume. Creep is attributed to differences in principal stresses in the salt induced by room excavation. The pre-excavation stress state is hydrostatic, characterized by equality of principal stresses. After excavation, the salt flows like a viscous fluid until the stress state becomes hydrostatic once again. Volumetric strain of the salt is considered elastic similar to fluids that lack volumetric viscosity.

Total room volume is composed of two parts: a solid part equal to the volume of solid waste placed in a room and a void part equal to the room volume less the solid volume. Fluid pressure in the room void space and resistance of solid waste to compression impede room volume reduction. Room solid volume is considered constant, although decomposition of the solid waste by chemical and biological processes occurs in time. These processes generate gas pressure in addition to the pressure increase caused by compression of air trapped within a sealed room. Pressure generation caused by waste decomposition is governed by the ideal gas law and waste decomposition rate which varies in time.

Room pressure may be generated in excess of the weight of the overlying strata and cause room volume reduction to cease and, indeed, to begin a relative expansion. This eventuality is cause for concern since it creates the possibility that fracture of less ductile anhydrite beds near repository rooms will occur enhancing potential fast-flow paths to and from waste rooms.

The importance of salt creep and related room void volume and gas pressure variation is in connection with fluid flow. Void volume relates to gas and brine storage, while gas pressure directly influences fluid flow rate. Both are input conditions to fluid flow calculations. The details of the closure process are

therefore not considered important, only the consequences in terms of fluid pressure and room void volume. In this regard, room closure rate is slow enough to not affect the active life of the repository (about 25 years), but is much faster than waste decomposition. Closure is essentially complete within about one hundred years, while gas pressure build-up is maintained over hundreds of years.

**a.2) A description of plausible alternative conceptual model(s) seriously considered but not used to support such application, and an explanation of the reason(s) why such model(s) was not deemed to accurately portray performance of the disposal system.**

There appear to be no alternative models to the *porosity surface* approach with the exception of a reference by Freeze 1996 (Docket: A-93-02, II-G-1, Ref. #258) to a coupled model of fluid flow and porous solid deformation that is dismissed as impractical. In this regard, care needs to be exercised in the understanding of the label *coupled model*. The usual understanding of coupled models in mechanics implies simultaneous occurrence of several distinct phenomena, for example, fluid flow in porous media and deformation of the solid skeleton. However, coupling in the CCA refers to linkage between computer codes, for example, between SANTOS and BRAGFLO. Alternative conceptual models noted by Freeze and coauthors thus refer to the linkage, that is, *coupling* between computer codes and not to conventional coupled models in continuum mechanics. Similarly, alternatives to the conceptual model associated with salt creep are alternatives to the porosity surface linkage scheme as discussed by Freeze, et al. (Docket: A-93-02, II-G-1, Ref. #260 and Ref. #261).

An interesting calculation in Freeze, et al. (*ibid.*, Ref. #260) is described in an appendix (memorandum to B.M. Butcher from C.M. Stone). The calculation is in the spirit of a genuinely coupled continuum model in which fluid flow and solid deformation calculations are interleaved. One model solution is obtained for a given time step and then the other is obtained using the results from the first part and so on. This *coupled structural/porous flow* calculation leads to fluid pressures in the Salado of 20 MPa at substantial distances from repository rooms. In view of overburden stresses of 14.5 MPa, such a fluid pressure—through the concept of effective stress as explained in Chapter 6 of the CCA (equation 1, page 6-98,  $\sigma_T = \sigma_e + p$  where  $\sigma_T$  is the weight of the overburden,  $p$  is the pressure of the pore fluid and  $\sigma_e$  is the stress supported by the porous matrix)—gives rise to a tensile stress in the Salado of 5.5 MPa (800 psi) which is likely to be well above salt tensile strength. The equation applies to each of the three principal stresses at a point. As

a consequence, the overburden will be lifted as the salt disintegrates under hydrostatic tension. The damage would be expected to greatly enhance permeability. However, the purpose of the calculation is to assess the role of solid deformation on brine flow to repository rooms—i.e., to see whether the salt *squeeze* would increase the volume of room flow from the Salado. The consequences of salt failure in tension were not explored.

### a.3) Documentation that:

#### a.3.i) conceptual models and scenarios reasonably represent possible future states of the disposal system.

Scenarios in terms of features, events, and processes (FEP's) are described in the CCA, Chapter 6, Section 6.2, page 6-35 (Docket: A-93-02, II-G-1, Volume I).

Discussion of the adequacy of the porosity surface approach is referenced to a document by Freeze (Docket: A-93-02, II-G-1, Ref. #258). Coupling between room closure and fluid flow is stated to be through room pressure and that this type of coupling is valid for PA computations. The work by Freeze, et al. (Docket: A-93-02, II-G-1, Ref. #260 and Ref. #261) is cited as supporting evidence. The main concern in this work is whether the constant volume room model used in the fluid flow codes is consistent with the variable volume room model used in the solid *creep* codes. The conclusion is that a consistent linkage is possible provided the room pressure histories are similar and room void volume is properly taken into account in the flow codes.

Repository subsidence in any form is considered to be of no consequence as are roof falls, pillar spalls and even floor separation and fracture. Such events are considered normal features of salt mine operation and will be handled accordingly.

The relatively new M-D model developed by Sandia National Laboratories from micromechanics mechanisms—with the goal of improved predictability of creep closure—turns out to be most dependent on an "unidentified" mechanism. A 12.5 adjustment factor for implementation is required by the earlier R-D model to account for transitory creep leading to the steady-state. The M-D model multiplies the steady-state creep rate by a function, instead of a constant, to account for transient creep in arriving at the actual creep rate of the halite.

#### a.3.ii) mathematical models incorporate equations and boundary conditions which reasonably represent the mathematical formulation of the conceptual models,

A description of spatial boundary conditions is found in PORSURF Attachment 1,

page 1 (Docket: A-93-02, II-G-1, Volume XVI). In this description, a typical two-dimensional strip of a half-room and half-pillar is considered in a tunnel-like vertical cross-section. Displacements normal to the sides of the strip are prevented. Forces representing the overburden load are applied to the strip top and bottom. The exposed surfaces of the room and waste package must support applied tractions corresponding to room gas pressure. A typical repository room is about 10 m wide, 4 m high, and 91 m long. Rooms are spaced on about 40 m centers. A two-dimensional cross-section ("strip") is therefore a reasonable representation of a typical repository room and pillar, and the boundary conditions used are proper for analyses done.

Where repository rooms are connected to access tunnels and shafts, the geometry is three-dimensional. Analysis of the closure mechanics would require a three-dimensional creep code. However, such regions of the WIPP are not used for waste containment and are important only to operation of the mine. Of course, these regions will also creep to closure in time. However, the functional life of room seals may be an open question, so connection between rooms and access tunnels is probable, given the long life of the repository. The effect of connection would be to increase void volume and therefore to reduce gas pressure. Both appear to be beneficial to waste containment. The enormous cost of a lengthy series of three-dimensional analyses of such scenarios appears to be unjustified by any potential quantitative insight to be gained.

[a.3.iii\) numerical models provide numerical schemes which enable the mathematical models to obtain stable solutions,](#)

The SANTOS Verification and Qualification Document, (Docket: A-93-02, II-G-3, Volume II, pages 1-1 to 21-11) contains a number of test problems that demonstrate solutions obtained. These test systematically exercise various aspects of SANTOS including the large displacement, large strain capability needed for creep closure analysis. Problem 20 is of particular interest because of the benchmark comparisons of SANTOS with the SANCHO, SPECTRUM and ANSALT codes. The comparison problem (Problem 20) is the isothermal strip model of a half-room and half-pillar geometry that contains various strata (salt, anhydrite and clay seams) represented by slide lines. SANTOS meets the benchmark criteria. This same problem (Problem 20) was rerun by EPA during a recent technical qualification study at Sandia National Laboratories with identical results.

[a.3.iv\) computer models accurately implement the numerical models, i.e.,](#)

computer codes are free of coding errors and produce stable solutions,

The SANTOS Verification and Qualification Document (*ibid.*) contains a number of tests problems demonstrating that the computer model implements the numerical model. Theoretically, there can be no guarantee that a computer code is free of coding errors or conflicts. However, numerous example problems and a long history of successful code application indicate that SANTOS is reliable. This inference means that the code functions as intended. Given physically realistic input data, the output data from a well-converged program run can be viewed with confidence. In this regard, Problem 20 solved by SANTOS shows similar results to the same problem solved by other computer codes, specifically, SANCHO, SPECTRUM and ANSALT.

a.3.v) conceptual models have undergone peer review according to §194.27,

The conceptual model of creep closure has undergone peer review as summarized in Appendix PEER, PEER 1 (Docket: A-93-02, II-G-1, Volume XII). The report concludes that the models (conceptual, mathematical, numerical) are adequate and implemented accurately with respect to the porosity surface approach. The report also concludes that long-term validity could not be assessed in the absence of long-term observations. Long-term refers to thousands of years. Observations extend over a period of about ten years. There were no dissenting opinions amongst the peer review panelists.

b) Computer codes used to support any compliance application shall be documented in a manner that complies with the requirements of ASME NQA-2a-1990 addenda, part 2.7, to ASME NQA-2-1989 edition.

See CARD 22 for additional discussion (Docket: A-93-02, III-B-2).

Technical evaluation of SANTOS quality assurance is based on WPO #35673 - Quality Assurance Document for SANTOS (Version 2.0.0) and WPO #35675 - SANTOS - Verification and Qualification Document (Docket: A-93-02, II-G-3, Volume II).

c) Documentation of all models and computer codes are included as part of any compliance application performance assessment calculation shall be provided.

The documents Quality Assurance Document for SANTOS (Version 2.0.0), SANTOS User's Manual and SANTOS - Verification and Qualification Document address this requirement in detail (*ibid.*). Comments on some of these key

documents are provided below.

#### 1) Design document (for new computer codes)

SANTOS is not a new computer code nor was it specifically developed for WIPP application, so no design document is required. In this regard, earlier analyses for the WIPP Project were done using SANCHO. SANTOS replaced SANCHO after careful benchmark analyses and comparisons. These results are described by Stone in a memorandum report that is contained in the document by Freeze, et al., 1995 (Docket: A-93-02, II-G-1, Ref. #260). Results for gas generation rates of  $f=0.0$  and  $f=1.0$  were obtained. Room porosity, vertical closure and horizontal closure histories are in excellent agreement over the simulated time (plotted to 2000 years) with and without contact surfaces. In fact, the SANTOS contact surface model is smoother than SANCHO as seen in Fig. 13, page C-123. SANTOS also models the gap between room roof and waste package top in a superior manner. Thus, SANTOS, which is faster and therefore more economical to run than SANCHO, was qualified for repository analyses through a series of benchmark analyses and comparisons in a process similar to that used for qualifying other creep codes, such as SPECTRUM, for possible WIPP use.

#### 2) RD/VVP (Requirements Document/Verification and Validation Plan)

Requirements are outlined in Sections 2.0 and 3.0 of the Quality Assurance Document for SANTOS (Version 2.0.0). The 21 functional requirements described in Section 2.0 are those necessary for PA code usage. These include handling the two-dimensional, large displacement, finite strain, time-dependent response of salt and the inelastic response of other geologic media such as anhydrite. Modeling of contact surfaces is also a requirement as is the consolidation of porous materials. The latter differs from a conventional soil mechanics (porous geologic medium) consolidation process which requires a genuinely coupled material model. Compaction is a more apt description of this material model requirement that is intended for waste behavior.

The description of test cases, input files and acceptance criteria exercise all code portions required in the list of Section 2.0 (RD). However, specific acceptance criteria indicated in the VVP (page 9) as being in Sections 1 through 21 of the Verification and Qualification Document are not present. Acceptance criteria in this context are replaced by comparisons with known solutions or to solutions obtained independently by other computer codes. This approach is a conventional way of validating computer codes, that is, by a series of comparisons with known



analytical and numerical results that test various combinations of code options. There are no performance or attribute requirements for SANTOS relative to WIPP.

### 3) ID (Implementation Document)

Source code for SANTOS is not in the public domain; a source code listing is not provided for copyright security with an exception mentioned in Section 4.0 of the Quality Assurance Document for SANTOS (Version 2.0.0) on page 10.

EPA was provided with access to SANTOS for hands-on testing. In particular, the PA Version was compiled and run to repeat analysis of three test problems. The test problems were: Problem 20 of the V&QD document and two porosity surface calculations, one at a zero gas generation rate ( $f=0.0$ ) and one at the standard rate of gas generation ( $f=1.0$ ). All three were successfully executed. These problems required mesh generation and call back of input data files as well as compilation and execution of the SANTOS source code (Version 2.0.0). Thus, the proper version of SANTOS is available, can be compiled, and executes properly.

### 4) UM (User's Manual)

Functional requirements for SANTOS User's Manual are outlined in Section 5.0 of the Quality Assurance Document for SANTOS (Version 2.0.0). The SANTOS User's Manual is contained in PORSURF Attachment 7 (Docket: A-93-02, II-G-1, Volume XVI). The description of SANTOS is brief but efficient. A number of different material models are available, although only three are germane to the WIPP site. There is no discussion of alternatives to the choices presented. A trained user, one familiar with finite element analysis and related mechanics is required to run the code. Familiarity with the SNL computing system is also needed. Creation of an input data file is possible from the User's Manual description with the exception of the mesh data. The User's Manual does not address the question of mesh data format and how mesh data are read by SANTOS. In fact, the data are generated by FASTQ, a two-dimensional mesh generating program developed by SNL. Numerous other utility programs for reading, plotting, and similar functions are also accessed in the course of establishing an input data file and post-processing output. These programs and SANTOS itself are used for WIPP calculations but were not specifically developed for WIPP PA studies. Although the User's Manual is helpful in understanding the physical foundations of SANTOS, as a practical matter, SANTOS must be run at SNL with the guidance of an experienced user. While transport of an executable code copy, user training and off-site use is possible in principle, the process would be

time-consuming and costly.

#### 5) VD (Validation Document)

Test information is referenced to the SANTOS - Verification and Qualification Document. Repeatability is ensured by the information and files supplied in the Validation Document and the DAT tapes. Appendix A of that document presents additional DAT information. Recent hands-on testing of three SANTOS problems produced output similar to the corresponding output in the VD. A Unix file comparison command revealed a single change in SANTOS. This change was in a constant used for numerical control, to prevent a zero divide. Specifically, the constant SRATIO was changed to  $5.E-05 * G$  from  $1.0E-05 * G$  where G is a shear modulus. This change did not affect results from any of the test problems. For example, Problem 20 was rerun at SNL from mesh generation through code execution and post-processing of selected output data. Examination of residual output information being generated during problem execution agreed precisely with the output sample data in the VD. Agreement with residuals in the solution of a nonlinear problem such as Problem 20 is a most severe test of repeatability that was successfully met in the course of this technical evaluation and qualification task. Similar results were obtained in the course of two porosity surface calculations which require three to four times more CPU time than Problem 20.

Such documentation shall include, but shall not be limited to:

#### **c.1) Description of the theoretical backgrounds of each model and the method of analysis or assessment,**

The SANTOS User's Manual meets this requirement which is an elaboration of the mathematical model background.

SANTOS is a two-dimensional, quasi-static, finite element computer program that allows for large deformation and finite strain. Creep of salt around a typical repository room will, in time, lead to large displacements and finite strains, so the capability for handling the kinematics of such is essential. The kinematics of large displacement, finite strain are integral to the mathematical model the underlies SANTOS (Section 2.1, SANTOS User's Manual). Closely linked to the kinematics of finite strain is the need for suitable measures of stress and strain rates, a question pursued with great interest in continuum mechanics and since resolved. This question is addressed compactly in Section 2.2 of the User's Manual. The requirements of stress equilibrium in the interior of a solid and at an interface, and

appropriate boundary conditions are presented in Section 2.3 of the User's Manual.

In addition to kinematics and equilibrium requirements, material laws are needed to form a complete mathematical model. SANTOS material laws or models, also known as constitutive equations, are described in Section 4.0 of the SANTOS User's Manual. The code is described as containing 12 material models ranging from a purely elastic model to time-dependent viscoplastic behavior. Eleven are implemented in SANTOS; apparently the twelfth may be provided by the user or else the interface "slide-line" is considered a material model. Only three are related to WIPP performance assessment; these generic models are the elastic-plastic, creep (deviatoric creep) and porous media consolidation (volumetric plasticity) which relate to anhydrite beds, salt formations and waste in rooms, respectively. The first and last are time-independent plasticity models, while the second is rate-dependent. All allow for separate deviatoric and volumetric strain treatment. In this regard, the sum of the stress transmitted in the solid skeleton and the fluid stress transmitted in the connected void space of porous materials is the stress required for equilibrium. The solid stress, which is the difference between total and fluid stress, is also known as the effective stress. It is the effective stress that is used in all constitutive models. However, this distinction is not intrinsic to any of the SANTOS constitutive models. SANTOS is used as a "dry" code for WIPP PA analyses. A dry code is in contrast to a "wet" code that allows for fluid flow as well as solid deformation.

The role of fluid stress, gas and brine pressure in rooms and adjacent strata, is handled on an improvised basis for PA purposes. In adjacent strata, total and effective stresses are considered to be the same; pore pressure is ignored. In rooms, void space and space occupied by solid waste are lumped into a ratio equated to *room porosity* rather than distributed through the waste as is physically the case. The solid fraction is held constant, although it is decomposition of the solid waste that generates gas. Also note, brine flow further complicates the room mass balance. The purpose of the code is to assist in calculating room void volume and thus to estimate room gas pressure in accordance with the ideal gas law that relates pressure to volume occupied at constant room temperature and given mass of gas. The mass of gas—i.e., the number of moles present depends on the rate of gas generation from waste decomposition. Room gas pressure and void space is important to BRAGFLO calculations. Indeed, this is the main role that SANTOS plays in the PA, providing room pressure and room void volume to BRAGFLO.

**c.2) General descriptions of the models, discussions of the limits of the**

applicability of each model, detailed instructions for executing the computer codes, including hardware and software requirements, input and output formats and explanations of each input and output variable and parameter (e.g., parameter name and units); listings of input and output files from a sample computer run; and reports on code verification, bench marking, validation, and quality assurance procedures.

SANTOS is limited to two-dimensional problems. The problem formulated for SANTOS is a vertical section through a typical room- or tunnel-like opening of rectangular cross-section in series of identical rooms separated by identical pillars and is therefore two-dimensional. The representation is reasonable in consideration of the small cross-sectional dimensions (room width and height) relative to room length. The two-dimensional limitation is therefore quite acceptable for such room and pillar analyses. Analysis of shaft deformation is also acceptable for the same reasons: the geometry of the excavation is sensibly two-dimensional in horizontal cross-section.

The creep model treats salt as a nonlinear viscoelastic fluid that flows until a hydrostatic state of stress is reached. Volumetric behavior is purely elastic. On a geological time scale and in consideration of salt domes and similar structures, the viscous fluid model seems reasonable. Whether the same model is applicable over an engineering time scale of only several hundreds of years is not clear. Total WIPP room closure is predicted in 100 years or so, depending on the various stratigraphic simplifications made. For example, inclusion of an anhydrite layer, in comparison with all salt stratigraphy, shows a 50% greater room volume (Docket: A-93-02, II-G-1, Volume XVI, Appendix PORSURF, Attachment 1, Fig.2, page 4) after 100 years.

The anhydrite material model uses Drucker-Prager yield, associated deviatoric plastic strain and elastic volumetric strain, somewhat similar to the strain decomposition of the salt creep model. In the latter, emphasis was placed on the use of a Tresca criterion which has corners on the yield surface. This emphasis was developed in consideration of measurements at the WIPP site. Whether an analogous situation occurs for anhydrite is open to question. An alternative would be to use a Mohr-Coulomb criterion that has edges rather than the smooth Drucker-Prager criterion. Drucker-Prager yield is convenient and physically appropriate to many rock types.

There is no report on SANTOS validation in the sense defined in the Introduction to the SANTOS - Verification and Qualification Document that requires

predictions from the code and the data measured in the field to be in agreement. There are papers in various symposia that describe such work. A very open technical dialogue has been maintained by publication of papers related to WIPP studies, but none are included in the CCA documents reviewed.

The creep closure conceptual model assumes that the rooms will creep to closure. Mechanical effects are local in extent, so model details and any limitations are ultimately not important to site undisturbed performance assessment. This view is endorsed by the Conceptual Model Peer Review Panel which noted certain limitations but agreed that the model is adequate.

Engineering analyses are always based on simplifying assumptions because not every detail is of great importance. Much of the engineering art is detecting when a model is overly simplified and a more complex model is needed. Even with the limitations noted, SANTOS computer run times may range to tens of hours on main frame computers. The reason lies in the many iterations needed for accommodating finite creep strains. Any benefit from an increase in complexity of existing models would have to be weighed against possible increases in run times. Current DOE opinion is that a coupled model that includes the simultaneous effects of pore pressure and solid strain is impractical.

Instructions for executing a SANTOS run including hardware and software requirements, input and output formats and a description of variables and parameters are contained in the User's Manual (Docket: A-93-02, II-G-1, Volume XVI, Appendix PORSURF, Attachment 7). SANTOS is written in Fortran-77.

Installation of an executable copy of SANTOS is a complicated process that requires a Unix platform and familiarity with software of the SNL ACCESS system. A Cray-J916 is the SNL hardware host.

Key words used in SANTOS input are described in Appendix A to PORSURF Attachment 7 (*ibid.*), which includes a description of control variables, boundary specifications, and material parameters required for 11 of the specified material models. Input is conveniently in free form. Output is described in Appendix C. Appendix E has several sample problems, although output is not given. However, there are many other sample problems in the SANTOS -Verification and Qualification Document that contain output.

Code validation is described in the SANTOS - Verification and Qualification Document in the form of 21 example problems complete with input data and sample output. The various examples exercise different features of SANTOS. In

this regard, the material model of porous media consolidation mentioned in the Requirements Document (RD) contained in the Quality Assurance Document for SANTOS (Version 2.0.0) is an ambiguous material model name. At first glance, one might assume this is the model for waste consolidation. However, it is actually the generic elastic-plastic model and is labeled SOILS N FOAMS in an input list. The only example problem that used this material model, according to the RD (page 8), is Problem 21 in the SANTOS - Verification and Qualification Document which involves a heated room that contains no waste. In fact, there are no sample problems that illustrate waste compaction, i.e., consolidation by room creep closure. However, such a problem exists in porosity surface calculations. The porosity surface calculation is described in Appendix PORSURF (Docket: A-93-02, II-G-1, Volume XVI).

**c.3) Detailed descriptions of the structure of computer codes and complete listings of the source codes,**

Protection of the commercial value of SANTOS precludes distribution of the source code listing without an appropriate agreement, but an exception was made for QA purposes as mentioned in the VVP (page 9) and noted above (ID). Details concerning the code structure are not readily available.

**c.4) Detailed descriptions of data collection procedures, sources of data, data reduction and analysis, and code input parameter development,**

Properties input for porosity surface calculations are listed in PORSURF Attachment 1 (*ibid.*) where the statement is made that the property values are the best estimates based on WIPP project documents, contractor reports, scoping analyses and analyses insights.

In this regard, there are some properties that may be derived from measured or other given properties. An example is the set of elastic properties in Table 1, page 6, of PORSURF Attachment 1 (*ibid.*) where Young's modulus, shear modulus and Poisson's ratio are tabulated. Only two of these properties are independent; the third may be computed from the first two, as is well-known in isotropic elasticity theory.

**c.5) Any necessary licenses,**

SANTOS is the property of SNL and is not in the public domain, so no license is required by DOE (SNL).

**c.6) An explanation of the manner in which models and computer codes**

incorporate the effects of parameter correlation.

The input parameters are independent material properties which may have a loose physical correlation. For example, a high Young's modulus may be expected to associate with a high compressive strength. However, no defined parameter correlations are included.

d) The Administrator or the Administrator's authorized representative may verify results of computer simulations used to support any compliance application by performing independent simulations. Data files, source codes, executable versions of computer software for each model, other material or information needed to permit the Administrator or the Administrator's authorized representative to perform independent simulations, and access to necessary hardware to perform such simulations, shall be provided within 30 calendar days of a request by the Administrator or the Administrator's authorized representative.

Three test problems were analyzed at SNL for the purpose of technical verification. These hands-on analyses were done with the assistance of SNL personnel who are familiar and have access to the SNL CRAY computer system. The three problems were: 1) Problem 20 - Isothermal WIPP Parallel Calculation, 2) porosity surface analysis at a zero gas generation rate,  $f=0.0$  and 3) porosity surface analysis at the standard gas generation rate,  $f=1.0$ .

Problem 20 is described in detail in the SANTOS Verification and Qualification Document, pages 20-1 through 20-8, and in Appendix T-Input/Output Data for Problem 20 - Isothermal WIPP Parallel Calculation, pages T-1 through T-32. Output data are listed on pages T-19 through T-32. Output data obtained during the verification run and contained in Attachment

A3-1 (Problem 20) of this report are identical to the CCA data with the exception of small differences in central processing unit (CPU) time. These small differences are due to machine processing features involved with system queuing, etc. and have no effect on the results of the analysis.

Plots of vertical closure (relative displacement between roof and floor centerlines) and horizontal displacement versus time are presented in the V&QD, Figs. 20.5 and 20.6, respectively. These plots also show the results obtained by ANSALT and SANCHO. The SANTOS vertical room closure after 10 years is 0.279 m; horizontal displacement of the rib (room side) center is 0.195 m. Plots of the same data obtained from the verification analysis and shown in Attachment A3-1 of the

Appendix A3 (Problem 20) show the same results. Annotation of the plots in the Appendix A3 also indicates that utility programs ALGEBRA and BLOT were used to construct the plots from SANTOS output. These results confirm repeatability of SANTOS with respect to the V&QD Problem 20.

The second verification problem is an analysis of room closure with waste but without backfill and involves a simulated time span of 10,000 years. After the room is sealed, gas pressure is generated through waste decomposition that affects the room closure rate. Gas pressure generation is characterized by a parameter  $f$ . Values of this parameter range from 0.0 to 2.0. A value of 0.0 corresponds to no pressure generation; a value of 1.0 is considered the base case. This second verification problem involves  $f=0.0$ , that is, no gas pressure build-up in the rooms. Detailed output data for this problem are not presented in the CCA. However, the important information in the form of histories of room porosity and gas pressure are available in the Appendix PORSURF, Figs. 3 and 4, pages 11 and 13, respectively (Docket: A-93-02, II-G-1, Volume XVI). In the case of no gas pressure generation, the plot coincides with the x-axis and no curve is to be seen. The 10,000 year room porosity history in Fig. 3 starts at nearly 0.85, which is difficult to see on the plot because of the steep fall off with time at the beginning. After 10,000 yrs, the porosity decreases to about 0.205. The plot of the same porosity history shown in Attachment 2 of this report (Porosity Surface,  $f=0.0$ ) indicates a somewhat higher porosity at 10,000 yrs, approximately 0.235. The difference may be caused by graphical errors developed in the publishing process. In this regard, there is a small typographical error in Figure PORSURF-3. (Fig. 3); the label of  $f=1.8$  should be  $f=0.8$ . A gas generation rate of 1.8 was not used, but an 0.8 rate was, as explained in the text.

Verification data for the case of a gas generation rate of 1.0 are given in Attachment 3 (Porosity Surface,  $f=1.0$ ) of this report. Starting porosities appear to be the same, as before. Again, the porosities at 10,000 yrs are slightly different. Fig. 3 in Appendix PORSURF indicates a porosity of about 0.71 while the verification run result is about 0.73. The reason for this small difference is unknown and may be simply plotting accuracy. Gas pressure at 10,000 yrs in Appendix PORSURF (Fig. 4) is about 17.0 MPa and in the verification run, about 17.5 MPa. This difference is consistent with the observed porosity difference.

## REFERENCES

See Appendix B(4) for a listing of docketed references.



## ATTACHMENT A3-1 - Problem 20

This attachment contains a sampling of output data obtained from a rerun of Problem 20 - Isothermal WIPP Parallel Calculation that is described in APPENDIX T of the SANTOS - Verification and Qualification Document. Comparisons show the outputs are in agreement with the exception of small differences in CPU time. These differences serve the useful purpose of demonstrating the fact that a rerun was actually done. This appendix also contains plots of horizontal and vertical room closure which are in agreement with previous results (Figs. 20.5 and 20.6, pg 20-7, SANTOS - Verification and Qualification Document).

The remainder of this attachment is not available electronically

## ATTACHMENT A3-2 - Plot of Porosity History

Not available electronically

## ATTACHMENT A3-3 - Verification Data for Gas Generation Rate of 1.0

Not available electronically

## APPENDIX A4 CUTTINGS\_S COMPUTER CODE EVALUATION

The CUTTINGS\_S computer code estimates short term releases of radioactivity to the land surface in the event that an inadvertent drilling intrusion penetrates waste in the WIPP repository. CUTTINGS\_S considers three release mechanisms: *cuttings*, the volume of waste directly intercepted by the drill bit; *cavings*, additional waste removed from the borehole wall by erosion of the drilling fluid as it exits the drill bit and flows through the annulus between the drill collar and the borehole wall; and *spallings*, waste expelled from the borehole if the pressure in the repository exceeds about 8 MPa. Cuttings and cavings releases are adjusted based on the volume-based probability that specific waste streams are intercepted by the drill bit.

## EPA REVIEW

a) Any compliance application shall include:

a.1) A description of the conceptual models and scenario construction used to support any compliance application

The conceptual model is described in the User's Manual (UM) (Docket: A-93-02, II-G-1, Volume V, Appendix CUTTINGS). The manual provides a description of the conceptual and mathematical models used in the CCA to predict direct removal of waste from oil and gas well drilling operations. The *cuttings* model is derived from a simple exercise in geometry as the removed waste is represented by a *cookie-cutter* section based on an ideal area calculated using the drill bit diameter.

The *cavings* model is derived from fluid flow equations developed to optimize the rheological properties of drilling mud. These fluid flow equations were developed as a practical guide to adjust fluid properties to maintain the gauge of the bore, minimize drilling time, and enhance safety.

Two *spallings* models are presented in the UM. Model 1 predicts waste will erode from the surfaces of an increasing void space around the drill hole from excess pressure in the waste. Model 2 uses a refined model based on bench scale experiments involving fine grained silicas to predict waste erosion from fracture surfaces which is created when the drill bit first punctures a pressurized waste repository.

**a.2) A description of plausible alternative conceptual model(s) seriously considered but not used to support such application, and an explanation of the reason(s) why such model(s) was not deemed to accurately portray performance of the disposal system.**

The Conceptual Models Peer Review Panel (CMPRP) concluded that "There are no meaningful alternatives for the cuttings and cavings model, except perhaps to consider using a finite fixed assumed input value, which would be more arbitrary." (Docket: A-93-02, II-G-1, Volume XII, Appendix PEER, PEER 1, Section 3.13.2.3).

Appendix MASS, Section MASS.16.1.1 (*ibid.*, Volume X) provides limited discussions of the progression of the spallings model to incorporate experimental information in refining the conceptual model for this aspect of the CUTTINGS\_S code. Because the spallings conceptual model is judged to be inadequate by the CMPRP, DOE developed an alternative mechanistically based model which demonstrated that the spallings model used in the CCA produces conservative results (Docket: A-93-02, II-G-23).

**a.3) Documentation that:**

**a.3.i) conceptual models and scenarios reasonably represent possible future states**

of the disposal system.

The conceptual models are based on standard drilling practices for the region surrounding the WIPP site. Section 194.33(c)(1) states “Future drilling practices and technology will be remain consistent with practices in the Delaware basin at the time a compliance application is prepared.” Based on this, the CCA meets this requirement.

Section 5.0 of the User’s Manual explicitly states the CUTTINGS\_S code is based on present-day drilling methods and technologies that apply at a WIPP-like site, but cautions against application of the code for parameter ranges that are atypical of the WIPP and its immediate environs.

a.3.ii) mathematical models incorporate equations and boundary conditions which reasonably represent the mathematical formulation of the conceptual models.

The CUTTINGS\_S UM presents the mathematical models used to implement the conceptual models. The UM provides a discussions of boundary conditions related to permeability and pressures which govern selection of appropriate models, e.g. spallings occurs only when the repository pressure exceeds 8 MPa.

Equation 18 of the UM presents the equation used to calculate a critical borehole radius. In an eroding borehole, an increase in the well bore diameter results in a decreasing Reynolds number. For an initially turbulent flow, a check is made at the final eroded radius to determine if the flow at that radius is still within the turbulent regime. If it is not, equation 18 is used to calculate a borehole radius corresponding to the Reynolds number of 2100—which is the cross over point in the model between turbulent and laminar flow regimes. The laminar flow solution is then started at this critical radius and continued to final eroded radius.

Equation 14, the pressure loss in an annulus, uses a general equation found on page 27 in Broc 1982. A more specific equation for calculating pressure loss in an annulus subject to turbulent flow also appears on that same page in Broc. Broc also presents an empirical relation between the friction factor,  $f$ , and the Reynolds number,  $N_{Re}$ :

$$f = 0.05 / N_{Re}^{0.2}$$

DOE chose to use a derivation for the friction factor,  $f$ , from Whittaker 1985 to relate the friction factor to the Reynolds number and relative roughness. Hand calculations suggest no significant differences between the two factors. In fact, the

solution used by DOE is more rigorous since it accounts for the influence of surface roughness in calculating the friction factor.

a.3.iii) numerical models provide numerical schemes which enable the mathematical models to obtain stable solutions.

The code uses a numerical technique to solve for the derivative of shear stress with respect to radius for small assumed changes in radius. Based on it review the EPA determined the numerical methods used is adequate for use in the CCA PA and produces stable solutions as used in the CCA PA.

a.3.iv) computer models accurately implement the numerical models; i.e., computer codes are free of coding errors and produce stable solutions.

EPA conducted a sensitivity analysis on the CUTTINGS\_S code using ranges of variables cited in the UM. 100 Latin Hypercube Sampling (LHS) samples were generated and run through CUTTINGS\_S to generate a response surface map. Three of these runs (Cases 45, 57, and 78) failed to reach convergence because of particular parameter combinations.

To investigate this potential non-convergence problem, the DRILL subroutine—including all subroutines and functions called by DRILL—were extracted from CUTTINGS and compiled for the PC with Lahey FORTRAN 90. A driver routine was written to *feed* the parameters for the 100 cases to DRILL. When the 100 cases were run on the PC, only 93 cases ran to completion. In addition to the three cases above, Cases 34, 61, 71, and 88 did not converge.

The non-convergence problem was traced to the following line of code near the end of the INTERFACE subroutine:

```
IF(ABS(TREY-2100.).GT.1.0)GOTO 912
```

When there is turbulent flow, the INTERFACE subroutine is called by DRILL to calculate a multiplier of the linear velocity. All 100 cases were made to run to completion by changing the above line of code to:

```
IF(ABS(TREY-2100.).GT.1.0 .and. abs(treyold-2100.).gt.1.0  
+.and. abs(treyold-trey).gt.1.0)GOTO 912
```

As shown in Table A4-1, even with this change there is good agreement between the DEC and the PC results (*i.e.*, the ratio of the DEC results (area\_c) to the PC results (xnewarea) ranged from 0.983 to 1.015 with an average ratio for all cases of

1.000).

**Table A4-1. Summary of Sampled Parameters and Comparison of DEC and PC Results. Note that cases 34, 45, 57, 61, 71, 78, and 88 are summarized at the end of the table.**

| Case | DIAMMOD | DOMEGA | TAUFAIL | DENSITY | ABSRROUGH | VISCO | YLDSTRSS | area_c  | xnew |
|------|---------|--------|---------|---------|-----------|-------|----------|---------|------|
| 1    | 0.29    | 9.46   | 0.188   | 1169    | 0.014     | 0.01  | 15.98    | 0.39539 | 0.3  |
| 2    | 0.32    | 4.4    | 0.647   | 1160    | 0.02      | 0.012 | 10.01    | 0.20083 | 0.19 |
| 3    | 0.3     | 20.39  | 0.097   | 1226    | 0.03      | 0.017 | 11.04    | 0.55239 | 0.54 |
| 4    | 0.32    | 8      | 3.401   | 1220    | 0.022     | 0.01  | 9.158    | 0.15281 | 0.15 |
| 5    | 0.32    | 6.19   | 0.536   | 1305    | 0.013     | 0.017 | 3.904    | 0.21472 | 0.21 |
| 6    | 0.43    | 5.2    | 0.059   | 1261    | 0.023     | 0.024 | 12.74    | 0.61777 | 0.62 |
| 7    | 0.42    | 16.11  | 1.182   | 1295    | 0.02      | 0.011 | 5.919    | 0.32374 | 0.32 |
| 8    | 0.3     | 22.68  | 0.261   | 1257    | 0.021     | 0.011 | 16.29    | 0.51483 | 0.51 |
| 9    | 0.36    | 18.33  | 0.103   | 1302    | 0.035     | 0.023 | 16.36    | 0.60772 | 0.60 |
| 10   | 0.39    | 7.7    | 0.19    | 1149    | 0.019     | 0.015 | 7.498    | 0.39598 | 0.39 |
| 11   | 0.34    | 14.79  | 0.076   | 1336    | 0.019     | 0.01  | 3.446    | 0.94104 | 0.9  |
| 12   | 0.28    | 17.11  | 2.368   | 1181    | 0.026     | 0.025 | 6.142    | 0.10583 | 0.10 |
| 13   | 0.44    | 12.84  | 7.926   | 1246    | 0.033     | 0.013 | 3.234    | 0.14945 | 0.15 |
| 14   | 0.34    | 4.2    | 0.053   | 1158    | 0.03      | 0.01  | 10.84    | 0.6708  | 0.66 |
| 15   | 0.29    | 20.64  | 0.215   | 1161    | 0.031     | 0.01  | 9.381    | 0.66082 | 0.6  |
| 16   | 0.41    | 11.58  | 4.214   | 1242    | 0.014     | 0.01  | 6.642    | 0.18361 | 0.18 |
| 17   | 0.33    | 17.71  | 0.567   | 1210    | 0.011     | 0.01  | 5.081    | 0.37478 | 0.37 |
| 18   | 0.37    | 22.95  | 1.855   | 1141    | 0.013     | 0.012 | 8.281    | 0.2345  | 0.23 |
| 19   | 0.35    | 6.27   | 1.666   | 1217    | 0.021     | 0.01  | 18.84    | 0.20808 | 0.20 |
| 20   | 0.42    | 8.35   | 3.477   | 1220    | 0.027     | 0.018 | 16.54    | 0.14556 | 0.14 |
| 21   | 0.41    | 8.59   | 1.135   | 1238    | 0.036     | 0.022 | 17.82    | 0.20072 | 0.20 |
| 22   | 0.28    | 10.38  | 5.826   | 1364    | 0.029     | 0.025 | 17.04    | 0.09056 | 0.08 |
| 23   | 0.28    | 22.35  | 8.998   | 1211    | 0.033     | 0.02  | 5.447    | 0.09258 | 0.09 |

| Case | DIAMMOD | DOMEGA | TAUFAIL | DENSITY | ABSROUGH | VISCO | YLDSTRSS | area_c  | xnewi |
|------|---------|--------|---------|---------|----------|-------|----------|---------|-------|
| 24   | 0.31    | 17.34  | 0.103   | 1193    | 0.027    | 0.021 | 12.61    | 0.54272 | 0.54  |
| 25   | 0.34    | 15.56  | 0.868   | 1176    | 0.039    | 0.01  | 8.175    | 0.36011 | 0.36  |
| 26   | 0.4     | 6.49   | 0.123   | 1203    | 0.012    | 0.023 | 19.08    | 0.41526 | 0.41  |
| 27   | 0.42    | 20.33  | 0.201   | 1224    | 0.039    | 0.01  | 17.37    | 0.81209 | 0.81  |
| 28   | 0.34    | 13.88  | 8.3     | 1299    | 0.019    | 0.01  | 8.52     | 0.15298 | 0.15  |
| 29   | 0.35    | 18.88  | 0.162   | 1318    | 0.026    | 0.012 | 2.947    | 0.70063 | 0.70  |
| 30   | 0.38    | 10.54  | 0.16    | 1346    | 0.038    | 0.01  | 15.24    | 0.73733 | 0.73  |
| 31   | 0.43    | 13.34  | 7.661   | 1335    | 0.039    | 0.018 | 9.545    | 0.14719 | 0.14  |
| 32   | 0.41    | 16.01  | 0.105   | 1204    | 0.017    | 0.022 | 14.21    | 0.58607 | 0.    |
| 33   | 0.37    | 4.75   | 0.112   | 1272    | 0.025    | 0.01  | 3.247    | 0.54316 | 0.54  |
| 35   | 0.39    | 19.51  | 4.441   | 1267    | 0.015    | 0.01  | 11.57    | 0.20991 | 0.21  |
| 36   | 0.36    | 22.23  | 2.102   | 1326    | 0.038    | 0.015 | 7.08     | 0.2469  | 0.24  |
| 37   | 0.29    | 11.34  | 0.118   | 1231    | 0.016    | 0.017 | 18.64    | 0.40081 | 0.40  |
| 38   | 0.28    | 14.63  | 4.589   | 1199    | 0.028    | 0.01  | 10.28    | 0.13995 | 0.14  |
| 39   | 0.36    | 7.18   | 0.742   | 1183    | 0.033    | 0.029 | 10.8     | 0.17244 | 0.17  |
| 40   | 0.36    | 8.96   | 0.077   | 1339    | 0.028    | 0.014 | 10.63    | 0.6827  | 0.67  |
| 41   | 0.33    | 21.94  | 0.09    | 1260    | 0.034    | 0.02  | 18.5     | 0.70268 | 0.70  |
| 42   | 0.33    | 19.8   | 0.306   | 1315    | 0.024    | 0.01  | 13.11    | 0.57978 | 0.58  |
| 43   | 0.44    | 9.82   | 1.404   | 1311    | 0.036    | 0.028 | 8.681    | 0.19261 | 0.19  |
| 44   | 0.35    | 18.07  | 0.329   | 1200    | 0.015    | 0.026 | 4.538    | 0.27421 | 0.27  |
| 46   | 0.28    | 15.75  | 1.628   | 1247    | 0.023    | 0.03  | 4.186    | 0.10829 | 0.10  |
| 47   | 0.29    | 5.37   | 2.758   | 1151    | 0.037    | 0.029 | 4.71     | 0.09235 | 0.09  |
| 48   | 0.31    | 5.99   | 0.069   | 1357    | 0.015    | 0.01  | 16.92    | 0.72682 | 0.72  |
| 49   | 0.4     | 21.09  | 0.247   | 1234    | 0.018    | 0.014 | 12.03    | 0.58254 | 0.58  |
| 50   | 0.39    | 12.93  | 1.78    | 1236    | 0.028    | 0.027 | 5.624    | 0.15513 | 0.15  |
| 51   | 0.36    | 10.74  | 0.447   | 1189    | 0.022    | 0.014 | 11.47    | 0.30698 | 0.30  |
| 52   | 0.43    | 12.32  | 0.429   | 1215    | 0.032    | 0.01  | 2.407    | 0.53936 | 0.54  |

| Case | DIAMMOD | DOMEGA | TAUFAIL | DENSITY | ABSROUGH | VISCO | YLDSTRSS | area_c  | xnewa |
|------|---------|--------|---------|---------|----------|-------|----------|---------|-------|
| 53   | 0.37    | 7.43   | 2.396   | 1377    | 0.027    | 0.013 | 14.74    | 0.17917 | 0.17  |
| 54   | 0.29    | 13.13  | 4.008   | 1244    | 0.034    | 0.01  | 4.819    | 0.18165 | 0.17  |
| 55   | 0.43    | 20.02  | 0.602   | 1196    | 0.03     | 0.015 | 2.823    | 0.40285 | 0.40  |
| 56   | 0.35    | 15.11  | 0.065   | 1323    | 0.025    | 0.01  | 10.31    | 1.0696  | 1.    |
| 58   | 0.38    | 18.69  | 0.229   | 1341    | 0.017    | 0.023 | 16.68    | 0.42937 | 0.43  |
| 59   | 0.29    | 17.86  | 0.94    | 1144    | 0.037    | 0.027 | 11.96    | 0.13777 | 0.13  |
| 60   | 0.32    | 15.03  | 4.853   | 1290    | 0.01     | 0.013 | 6.93     | 0.13187 | 0.13  |
| 62   | 0.44    | 16.97  | 0.41    | 1299    | 0.014    | 0.021 | 7.256    | 0.39054 | 0.38  |
| 63   | 0.44    | 14.48  | 0.377   | 1206    | 0.021    | 0.01  | 8.815    | 0.5508  | 0.54  |
| 64   | 0.3     | 12.64  | 0.135   | 1281    | 0.02     | 0.017 | 9.079    | 0.42243 | 0.42  |
| 65   | 0.37    | 9.49   | 0.612   | 1250    | 0.038    | 0.01  | 8.069    | 0.38957 | 0.38  |
| 66   | 0.41    | 10.92  | 3.757   | 1342    | 0.029    | 0.016 | 12.29    | 0.16788 | 0.16  |
| 67   | 0.33    | 21.6   | 1.943   | 1354    | 0.017    | 0.019 | 6.049    | 0.18933 | 0.18  |
| 68   | 0.27    | 8.85   | 0.173   | 1329    | 0.04     | 0.012 | 11.71    | 0.38944 | 0.38  |
| 69   | 0.37    | 12.08  | 1.048   | 1288    | 0.036    | 0.011 | 11.24    | 0.29638 | 0.29  |
| 70   | 0.32    | 19.12  | 3.053   | 1293    | 0.025    | 0.01  | 15.54    | 0.22368 | 0.    |
| 72   | 0.3     | 18.63  | 7.013   | 1370    | 0.013    | 0.01  | 15.12    | 0.14237 | 0.14  |
| 73   | 0.31    | 11.72  | 0.086   | 1353    | 0.022    | 0.019 | 14.58    | 0.51215 | 0.51  |
| 74   | 0.35    | 6.77   | 0.888   | 1332    | 0.011    | 0.011 | 14.42    | 0.22336 | 0.2   |
| 75   | 0.42    | 19.32  | 0.753   | 1361    | 0.032    | 0.01  | 19       | 0.52762 | 0.52  |
| 76   | 0.4     | 21.44  | 0.057   | 1348    | 0.031    | 0.016 | 6.389    | 1.1641  | 1.1   |
| 77   | 0.3     | 20.8   | 5.156   | 1252    | 0.035    | 0.01  | 13.25    | 0.20801 | 0.20  |
| 79   | 0.43    | 17.44  | 0.082   | 1318    | 0.024    | 0.019 | 14.94    | 0.87606 | 0.86  |
| 80   | 0.38    | 9.94   | 0.987   | 1274    | 0.029    | 0.012 | 2.711    | 0.26928 | 0.26  |
| 81   | 0.38    | 14.04  | 0.051   | 1144    | 0.037    | 0.01  | 12.89    | 1.2923  | 1.2   |
| 82   | 0.42    | 13.56  | 6.194   | 1165    | 0.023    | 0.016 | 17.89    | 0.13828 | 0.13  |
| 83   | 0.44    | 15.34  | 8.955   | 1360    | 0.031    | 0.01  | 5.364    | 0.1747  | 0.17  |

| Case | DIAMMOD | DOMEGA | TAUFAIL | DENSITY | ABSROUGH | VISCO | YLDSTRSS | area_c   | xnewa |
|------|---------|--------|---------|---------|----------|-------|----------|----------|-------|
| 84   | 0.4     | 19.83  | 0.15    | 1148    | 0.016    | 0.01  | 14.04    | 0.7562   | 0.75  |
| 85   | 0.31    | 4.97   | 6.292   | 1228    | 0.015    | 0.01  | 7.418    | 0.10866  | 0.10  |
| 86   | 0.27    | 8.32   | 3.187   | 1307    | 0.038    | 0.01  | 7.609    | 0.14894  | 0.14  |
| 87   | 0.42    | 5.59   | 0.464   | 1155    | 0.012    | 0.014 | 3.922    | 0.27128  | 0.26  |
| 89   | 0.38    | 18.24  | 0.363   | 1366    | 0.018    | 0.01  | 9.822    | 0.627    | 0.63  |
| 90   | 0.4     | 16.41  | 0.819   | 1264    | 0.018    | 0.024 | 17.64    | 0.23765  | 0.23  |
| 91   | 0.39    | 22.54  | 0.129   | 1175    | 0.024    | 0.014 | 18.15    | 0.75573  | 0.74  |
| 92   | 0.31    | 14.24  | 5.326   | 1165    | 0.032    | 0.01  | 17.28    | 0.17639  | 0.17  |
| 93   | 0.27    | 11.43  | 2.929   | 1172    | 0.023    | 0.021 | 13.9     | 0.10097  | 0.10  |
| 94   | 0.28    | 4.95   | 0.062   | 1373    | 0.016    | 0.028 | 6.492    | 0.53635  | 0.53  |
| 95   | 0.39    | 6.87   | 2.591   | 1178    | 0.025    | 0.02  | 15.5     | 0.13758  | 0.13  |
| 96   | 0.34    | 12.14  | 0.275   | 1351    | 0.029    | 0.01  | 3.69     | 0.59407  | 0.59  |
| 97   | 0.27    | 21.14  | 0.14    | 1278    | 0.019    | 0.012 | 4.357    | 0.55086  | 0.55  |
| 98   | 0.43    | 5.88   | 0.493   | 1268    | 0.035    | 0.018 | 13.35    | 0.29353  | 0.29  |
| 99   | 0.3     | 11.04  | 0.678   | 1372    | 0.031    | 0.026 | 15.76    | 0.18297  | 0.18  |
| 100  | 0.33    | 9.26   | 6.844   | 1254    | 0.011    | 0.01  | 16.05    | 0.12824  | 0.12  |
| 34   | 0.35    | 7.9    | 0.288   | 1190    | 0.034    | 0.01  | 13.6     | 0.48462  | 0.48  |
| 61   | 0.41    | 16.74  | 1.242   | 1311    | 0.016    | 0.01  | 7.941    | 0.36033  | 0.36  |
| 71   | 0.34    | 10.17  | 1.558   | 1321    | 0.04     | 0.01  | 9.682    | 0.29697  | 0.29  |
| 88   | 0.41    | 21.83  | 0.233   | 1283    | 0.011    | 0.01  | 12.4     | 0.70952  | 0.70  |
| 45   | 0.384   | 13.67  | 2.26    | 1186    | 0.035    | 0.01  | 18.2     | DNCR     | 0.2   |
| 57   | 0.36    | 7.309  | 0.346   | 1276    | 0.026    | 0.01  | 13.8     | DNCR     | 0.44  |
| 78   | 0.32    | 16.5   | 1.31    | 1287    | 0.011    | 0.01  | 5.18     | DNCR     | 0.29  |
| Min  | 0.27    | 4.2    | 0.051   | 1141    | 0.01     | 0.01  | 2.407    | 0.09056  | 0.08  |
| Max  | 0.44    | 22.95  | 8.998   | 1377    | 0.04     | 0.03  | 19.08    | 1.2923   | 1.2   |
| Avg  | 0.3556  | 13.604 | 1.7719  | 1258.4  | 0.025    | 0.014 | 10.804   | 0.388494 | 0.387 |



No convergence problems appeared with this code when running the DOE verification tests or in operating the code during a variety of other tests in the course of the EPA review. Since convergence problems were not experienced during normal use of the code, no changes to the source code are required.

**a.3.v) conceptual models have undergone peer review according to § 194.27.**

The Conceptual Model Peer Review Panel (CMPRP) approved the conceptual models for cuttings/cavings but initially rejected the spillings model. The spillings sub-model was subsequently reviewed by the CMPRP on three additional occasions. While the CMPRP was not satisfied with the spillings model, based on significant additional data provided by DOE

(Docket: A-93-02, II-G-23), they concluded that the model provided conservative results and that actual spillings releases would likely be less than calculated with the spillings sub-model.

**b) Computer codes used to support any compliance application shall be documented in a manner that complies with the requirements of ASME NQA-2a-1990 addenda, part 2.7, to ASME NQA-2-1989 edition.**

**(Incorporation by reference as specified in § 194.5)**

The Requirements Document/Validation & Verification Plan (RD/VVP) (Docket: A-93-02, II- G-3, Volume 4) presents four functional requirements and 12 external interface requirements for the CUTTINGS\_S code. These requirements are adequate for the usage of CUTTINGS\_S in the CCA PA calculations. The RD/VVP also describes model functionality that is not tested and provides adequate documentation as to why this functionality is not tested.

The User's Manual provides sufficient information to exercise the CUTTINGS\_S. The technical basis for the code is well written and understandable. The math can be easily followed for most of the document. Equations were cross checked against source documents and no inconsistencies were found.

Each of the input files is presented and described in the User's Manual (UM). In addition, the Validation Document (VD) (Docket: A-93-02, II-G-3, Volume 4) presents source listings of input and outputs files for each test case and documents that the tests met the acceptance criteria.

**c) Documentation of all models and computer codes are included as part of any compliance application performance assessment calculation**

shall be provided. Such documentation shall include, but not be limited to:

c.1) Description of the theoretical backgrounds of each model and the method of analysis or assessment,

The UM provides an adequate description of the theoretical background of the CUTTINGS\_S computer code.

c.2) General descriptions of the models; discussions of the limits of applicability of each model; detailed instructions for executing the computer codes, including hardware and software requirements, input and output formats with explanations of each input and output variable and parameter (e.g., parameter name and units); listings of input and output files from a sample computer run; and reports on code verification, benchmarking, validation, and quality assurance procedures.

Discussion of the limits of applicability of the models is contained in Section 5.0 of the UM and appears to be complete. Detailed instructions for executing the computer code are also contained in the User's Manual. The information is complete and accurate. Listings of input and output files from a sample computer run are contained in Sections 7 and 9 of the UM, respectively. The analysis plans, RD/VVP, and VD provide the required documentation on code verification, benchmarking, validation, and quality assurance procedures.

c.3) Detailed descriptions of the structure of computer codes and complete listings of the source codes;

A complete listing of the source code is contained in the Implementation Document. The description of the structure of the code is adequate.

c.4) Detailed descriptions of data collection procedures, sources of data, data reduction and analysis, and code input parameter development.

Details of the data collection procedures, sources of data, data reduction and analysis and code input parameter development are discussed in the Technical Support Document for Section 194.23: Parameter Report (Docket: A-93-02, III-B-12).

c.5) Any necessary licenses;

No licenses were required for CUTTINGS\_S. The code was produced specifically for the CCA.

c.6) An explanation of the manner in which models and computer codes incorporate the effects of parameter correlation.

No correlated parameters were included as input to the CUTTINGS\_S code.

d) The Administrator or the Administrator's authorized representative may verify results of computer simulations used to support any compliance application by performing independent simulations. Data files, source codes, executable versions of computer software for each model, other material or information needed to permit the Administrator or the Administrator's authorized representative to perform independent simulations, and access to necessary hardware to perform such simulations, shall be provided within 30 calendar days of a request by the Administrator or the Administrator's authorized representative.

DOE identified appropriate contacts and provided the documentation required by EPA for its review of this code.

## **ATTACHMENT A4-A DOCUMENTATION OF CUTTINGS\_S TEST RUNS**

EPA conducted tests of the CUTTINGS\_S code to accomplish the following:

1. Verify ability to run the model.
2. Verify ability to reproduce Validation & Verification (VV) runs.
3. Exercise models to evaluate parameter sensitivity that was not documented in the CCA.

EPA conducted these tests on the Sandia WIPP cluster in the EPA section on the Sandia VAX environment. Input files and executables were obtained by fetching these files from the CCA-CMS CUSP library. The tests are described below.

### ***Test 1 - Verification of VV Runs***

The RD/VVD for CUTTINGS\_S presents the approach used to verify the code by running the same data through the CCA production model and the simplified validation codes. The results from the verification tests were compared and evaluated to determine if the acceptance criteria were met. EPA was able to re-run the test. The output file generated by the EPA test run was compared against the output of the DOE test runs stored in the CUSP CCA-CMS library. The VMS DIFFERENCE command was used to compare the output files and other than dates no differences were noted. This demonstrates that the DOE VV exercise was

reproducible.

***Test 2 - Generation of Response Surface Map***

Parameter distributions are presented in the UM for eight separate variables in the cuttings/cavings model (pages 48-49). In the CCA, the only variable defined by a probability distribution is erosion shear resistance (TAUFAIL). A new run was configured to exercise the CUTTINGS\_S code substituting probability distributions for seven of eight parameter distributions listed in the CUTTINGS\_S UM. These distributions are listed in Table A4.2

**Table A4.2. Input Distributions for Cuttings/Cavings Variables Used in EPA Sensitivity Analysis**

| Variable |                                       | Distribution Type | Upper | Lower |
|----------|---------------------------------------|-------------------|-------|-------|
| TAUFAIL  | Erosion Shear Resistance (Pa)         | Loguniform        | 0.05  | 10    |
| DOMEGA   | Drill String Angular Velocity (rad/s) | Uniform           | 4.2   | 23    |
| DNSFLUID | Drilling mud density (kg/m3)          | Uniform           | 1139. | 1378. |
| VISCO    | Bingham plastic viscosity (Pa s)      | Loguniform        | 0.005 | 0.03  |
| YLDSTRSS | Bingham yield stress (Pa)             | Uniform           | 2.4   | 19.2  |
| ABSROUGH | Absolute roughness (m)                | Uniform           | 0.01  | 0.04  |
| DIAMMOD  | Drill bit diameter (m)                | Uniform           | 0.267 | 0.444 |

The VMS script EVAL\_CUSP\_RUN.COM was executed to run GENMESH, MATSET, PRELHS, and LHS to create 100 CDB input files for CUTTINGS\_S. Input file scripts were created for each sample and a VMS script was written to submit all 100 LHS samples through CUTTINGS\_S in batch mode on the Sandia WIPP cluster. Three of these runs were terminated after running for 12 hours each. Typical CPU times for the other 97 runs were 3 minutes.

Once the remaining 97 batch runs were completed, the input and output data were extracted from the binary output files using a script which automated the extraction process using the GROPE command. Ninety-seven text files were created from this extraction process and summarized into a final text file,

CUSP\_MVM\_GROPE\_ALL.SEA. This data file was downloaded from the WIPP cluster and the raw data was extracted and converted into a database file. Using a PC based statistical package, SIMSTAT, descriptive summaries of the data were produced and are presented in Table A4.3. A rank regression analysis was performed on the response surface map to evaluate sensitivity of the input variables. The rank regression analysis results are presented below:

$$\text{AREA\_C} = 81.3550 + (.2002 * \text{DIAMMOD}) + (.2175 * \text{DOMEGA}) + (-.8990 * \text{TAUFAIL}) + (.08065 * \text{DENSITY}) + (.03710 * \text{ABSROUGH}) + (-.3057 * \text{VISCO}) + (.008979 * \text{YLDSTRSS})$$

where AREA\_C is the area of the eroded borehole. Table A4.3 provides additional information on the regression analysis coefficients (B) including the standard error and confidence limits (CL).

**Table A4.3. Limits on Regression Analysis Variables**

| Variable  | B       | Std Error B | Upper 95% CL | Lower 95% CL |
|-----------|---------|-------------|--------------|--------------|
| Intercept | 81.8346 |             |              |              |
| TAUFAIL   | -.8990  | .01408      | -.9269       | -.8710       |
| VISCO     | -.3057  | .01394      | -.3334       | -.2780       |
| DOMEGA    | .2175   | .01390      | .1899        | .2451        |
| DIAMMOD   | .2002   | .01393      | .1725        | .2278        |
| DENSITY   | .08065  | .01390      | .0535        | .1082        |
| ABSROUGH  | .03710  | .01392      | .009467      | .06474       |
| YLDSTRSS  | .008979 | .01398      | -.01878      | .03674       |

These results as defined in Table A4.3 demonstrate that erosion shear resistance, TAUFAIL, is the dominant influence on cavings area. Bingham plastic viscosity, drill string angular rotation, and drill bit diameter also had significant (>20 %) influence on cavings area. This is illustrated in the scatter plot below (Figure A4.1) where the relationship between TAUFAIL and cavings area is not the same monatomic function as presented in Figure 11 of the Analysis Package for Cuttings and Spalling Calculations (Docket: A-93-02, II-G-06). The minimum cavings area

quoted in the Analysis Package of approximately 0.1 m<sup>2</sup> is in close agreement with the minimum of 0.09 m<sup>2</sup> calculated here. Both values are only slightly greater than the drill bit area of 0.076 m<sup>2</sup>. However, the maximum area reported in the Analysis Package is approximately 0.73 m<sup>2</sup> while the maximum area determined in this sensitivity analysis is 1.3 m<sup>2</sup>.

Data summarizing the LHS runs are included in Table A4.4. Note that for this analysis a log uniform distribution was assumed for TAUFAIL while a uniform distribution is assumed in the CCA. Thus, the median value for this parameter in the CCA is 5 Pa while in this study the median is 0.61 Pa.

During the Agency’s parameter review (A-93-02, III-B-12, III-B-13 and III-B-14(5)) TAUFAIL, VISCO, DOMEGA, DIAMMOD, DENSITY, ABSROUGH, and YLDSTRSS were evaluated because of the results of this review. The EPA found that, except for TAUFAIL, the values used in the CCA PA calculations were reasonable, appropriate and adequate.

**Figure A4.1. Variability in Eroded Borehole Area as Function of Waste Erosion Shear Resistance**

**Table A4.4. Summary of Results of Uncertainty Analysis**

| Percentile | Cavings Area | Waste Strength | Drilling Mud Density | Drill Collar Absolute Roughness | Drilling Mud Viscosity | Drilling Mud Yield Stress | Drill Bit Diameter | Drill String Angular Velocity |
|------------|--------------|----------------|----------------------|---------------------------------|------------------------|---------------------------|--------------------|-------------------------------|
| Min        | .09          | .05            | 1141.                | .01                             | .01                    | 2.41                      | .27                | 4.2                           |
| 10         | .14          | .08            | 1161.                | .01                             | .01                    | 3.92                      | .28                | 5.9                           |
| 20         | .15          | .13            | 1187.                | .02                             | .01                    | 5.8                       | .30                | 7.9                           |
| 30         | .19          | .21            | 1210.                | .02                             | .01                    | 7.45                      | .32                | 9.8                           |
| 40         | .23          | .37            | 1234.                | .02                             | .01                    | 9.09                      | .34                | 11.6                          |
| 50         | .31          | .61            | 1257.                | .02                             | .01                    | 10.8                      | .35                | 13.2                          |
| 60         | .40          | 1.04           | 1283.                | .03                             | .02                    | 12.38                     | .37                | 15.2                          |
| 70         | .54          | 1.91           | 1309.                | .03                             | .02                    | 14.14                     | .39                | 17.6                          |
| 80         | .60          | 3.43           | 1333.                | .03                             | .02                    | 15.85                     | .41                | 19.4                          |
| 90         | .73          | 5.9            | 1354.                | .04                             | .03                    | 17.42                     | .43                | 21.2                          |
| Max        | 1.29         | 9.0            | 1377.                | .04                             | .03                    | 19.08                     | .44                | 22.9                          |
| AVG        | .39          | 1.79           | 1259.                | .03                             | .01                    | 10.75                     | .36                | 13.6                          |

---

## REFERENCES

Broc, R., ed. 1982. *Drilling Mud and Cement Slurry Rheology Manual*, Houston, TX: Gulf Publishing Company

Whittaker, A., ed. 1985. *Theory and Application of Drilling Fluid Hydraulics*, International Human Resources Development Corporation, Boston, MA.

See Appendix B for listing of docketed references.

## APPENDIX A5 CCDFGF COMPUTER CODE EVALUATION

Appendix B to 40 CFR Part 191 contains the following guidance for performance assessment models used to evaluate waste disposal systems:

The Agency assumes that, whenever practicable, the implementing agency will assemble all of the results of the performance assessments to determine compliance with 191.13 into a *complementary cumulative distribution function* that indicates the probability of exceeding various levels of cumulative release.

Additional guidance is provided in Appendix A to 40 Part CFR 191 where the primary measure of the consequence, or seriousness, of a release resulting from an intrusion is defined as the *cumulative normalized release* that occurs over the 10,000 years following closure of the repository. Specific procedures for calculating the cumulative normalized release are defined in Appendix A, Table 1 of the rule. Applicable release limits for the WIPP are to be calculated based on the total curies of transuranic activity placed in the disposal system at the time of closure.

The release limits are defined in terms of probabilities at §191.13.

Disposal systems for spent nuclear fuel or high-level or transuranic radioactive wastes shall be designed to provide a reasonable expectation, based upon performance assessments, that cumulative releases of radionuclides to the accessible environment for 10,000 years after disposal from all significant processes and events that may affect the disposal system shall:

(1) Have a likelihood of less than one chance in 10 of exceeding the quantities calculated according to Table 1 (Appendix A); and

(2) Have a likelihood of less than one chance in 1,000 of exceeding ten times the quantities calculated according to Table 1 (Appendix A).

Note that the release limits (1) and (2) are defined in terms of probabilities. Each estimated Complementary Cumulative Distribution Function (CCDF) provides a probability distribution of the possible values for R, the summed normalized release defined in Appendix A of the rule for use of Table 1 quantities. The CCDF is a function of the cumulative normalized release (R). The estimated CCDF must comply with the following requirements.

- (1)  $CCDF(R=1) < 0.1$  (less than one chance in 10 that  $R > 1$ ), and
- (2)  $CCDF(R=10) < 0.001$  (less than one chance in 1,000 that  $R > 10$ ).

These requirements mean that the WIPP is *not* in compliance if there is a greater than 10 percent probability of occurrence of a normalized release, accumulated over 10,000 years, that is greater than 1. In addition, the site is not in compliance if there is a greater than 0.1 percent probability that the normalized release exceeds a value of 10.

The PA program CCDFGF is designed to calculate one CCDF for each Latin Hypercube Sample (LHS) vector of model parameters. The resulting mean CCDFs are compared, individually and collectively, to the established release limits.

Much of the information on which the EPA review of this code was based is contained in the QA Package for the CCDFGF computer code (Docket: A-93-02, II-G-03, Volumes 2 and 3). These volumes contain the following relevant documents:

UM - User's Manual for CCDFGF (Version 1.00)

DD - Design Document for CCDFGF and GRIDFLO

RD - Requirements Document for CCDFGF (Version 1.00)

ID - Implementation Document for CCDFGF (Version 1.00)

VVP - Verification and Validation Plan for CCDFGF (Version 1.00)

VD - Validation Document, Version 1.00

The Design Document is also included as Appendix CCDFGF (Docket: A-93-02, II-G-1, Volume V).



In the ensuing discussion these documents will be referred to by their generic title (i.e., User's Manual) or their generic abbreviation (i.e., UM). The detailed titles and docket references will not be repeated.

## EPA REVIEW

### a) Any compliance application shall include:

#### a.1) A description of the conceptual models and scenario construction used to support any compliance application.

Compliance calculations in the CCA CCDFGF program differ from calculations performed in the 1991 through 1994 PA documents. Substantive changes were made in the approach to simulation, the method for modeling multiple intrusions, and the treatment of brine encounters. Chapter 6 of the CCA (Docket: A-93-02, II-G-1, Volume I) provides a simplified discussion of the new approach designed to be accessible to readers not familiar with the WIPP PA methodology (pp. 6-11 to 6-35). Mathematical details of the new approach are described in the Design Document for CCDFGF, included as CCA Appendix CCDFGF (Docket: A-93-02, II-G-1, Volume V).

The application of CCDFs in determining compliance is addressed in the *Technical Support Document for 194.34* (Docket: A-93-02, III-B-23). A review of CCDFs and the requirements of 40 CFR 191 and 40 CFR 194 is summarized below.

### ***Complementary Cumulative Distribution Functions***

The FORTRAN code in the program CCDFGF is designed to calculate one Complementary Cumulative Distribution Function (CCDF) for each Latin Hypercube Sample (LHS) vector. The procedures for selecting LHS parameter values are discussed in Appendix A6 of this TSD. In the CCA, 57 parameters were selected for inclusion in the LHS procedures. In the EPA-mandated verification test, 60 parameters were assigned to the LHS (Docket: A-93-02, II-G-26). Calculations for cuttings, spallings, and direct brine releases are performed for a variety of conditions and selected times using other codes of the PA model. The calculations are performed for each of 100 LHS vectors. The entire procedure is run three times, with different random values selected for the parameters in each replicate. The 300 data sets are assembled into a single intermediate data file by the CCDFGF program when it is run in the preprocessor mode.

The normal mode of the CCDFGF program uses the release values tabulated by the preprocessor mode of the program to simulate future human intrusion scenarios.

The simulation for a single LHS vector in the CCA generated  $N = 10,000$  simulated futures, each future consisting of a sequence of intrusion events occurring at random times over the next 10,000 years. Interpolation is used to estimate appropriate release values for each simulated intrusion.

The frequency distribution of the simulated cumulative releases over 10,000 years generates a single estimate of the CCDF. This procedure is repeated for each of the 100 LHS vectors. There are three replicates of the entire procedure. In each replicate, the 100 CCDFs are combined in the CCDFSUM program to generate summary CCDF curves, such as the sample mean, median, 10<sup>th</sup>, and 90<sup>th</sup> percentile CCDFs at each value of the release for the replicate. These calculations provide three point estimates for each type of summary CCDF curve at each value of the normalized release  $R$ , one point estimate from each replicate.

Table 1 of Appendix A of 40 CFR Part 191 provides numerical criteria for calculating the total normalized release of transuranic isotopes. The release limits (1) and (2) are defined in terms of probabilities. The estimated CCDFs provide a probability distribution of the possible values for  $R$ , the summed normalized release defined in Appendix A for use of Table 1 quantities. The estimated CCDF must comply with the following requirements.

- (1)  $CCDF(R=1) < 0.1$  (less than one chance in 10 that  $R > 1$ ), and
- (2)  $CCDF(R=10) < 0.001$  (less than one chance in 1,000 that  $R > 10$ ).

These requirements mean that the WIPP is *not* in compliance if there is a greater than 10 percent probability of occurrence of a normalized release, accumulated over 10,000 years, that is greater than 1. In addition, DOE is not in compliance if there is a greater than 0.1 percent probability that the normalized release exceeds 10.

The above requirements are interpreted often in terms of an *exclusion region* on a graph of cumulative probability versus normalized release, as shown in Figures 6-3 and 6-4 of the CCA (Docket: A-93-02, II-G-1, Volume I, Chapter 6). In these figures, the irregular step-shaped region in the upper right corner is the region prohibited by the requirements of §191.13(a)(1) and (2). A CCDF is in compliance if the entire curve lies below and to the left of the exclusion region.

The normalized release limits in Table 1 of Appendix A to 40 CFR Part 191 are defined in terms of the amount of waste in place in the repository at the time of closure. The WIPP waste inventory estimates have been revised and updated

annually by DOE. Estimates of activity provided by the waste generators and storage sites are based on estimated activity, as stored. DOE adjusted these figures to provide estimates of all radionuclide activities decayed to the end of 1995 (see Appendix BIR of the CCA [Docket: A-93-02, II-G-1, Volumes III and IV] and CARD 24 [Docket: A-93-02, III-B-2]). To account for newly generated waste volumes, DOE assumes that the activity levels of newly generated waste will be proportional to the activity of older waste streams, on a volume basis (i.e., the curies per cubic meter will be the same).

The WIPP disposal inventory shown in Table 4-6 of the CCA (Docket: A-93-02, II-G-1, Chapter 4) is used as the basis for determining waste unit factors consistent with instructions in Table 1 of Appendix A of 40 CFR Part 191. Table 4-6 shows that 98.9 percent of the total CH-TRU curies is contributed by Pu-238, Pu-239, Pu-240, Pu-241, and Am-241. In contrast, approximately 96.5 percent of the total curies associated with RH-TRU waste is contributed by Cs-137, Sr-90, Ba-137, Pu-241, and Y-90. Almost all of the activity in the CH-TRU waste stream is from TRU nuclides, while most of the activity in the RH-TRU stream is due to fission products.

The WIPP disposal inventory data are used by the program EPAUNI (for EPA units) as the basis for determining waste unit factors. The EPAUNI program first performs calculations for determining the decay resulting in the activity levels for the year 2033, then determines the number of EPA units per unit volume, along with the associated weighting (volume factors) for each TRU waste stream. Waste unit estimates are then stored in the files EPAUNITS.OUT and EPAUNIT2.OUT for use by CCDFGF in the preprocessor mode.

The CCDFGF program combines the waste units with the estimated releases from the other PA models to calculate the cuttings, spillings and blowout releases in EPA units of measure. In Section 4.1.3.3 of the CCA, DOE states that the allowable normalized release under 40 CFR 191 is related to the number of waste units of TRU nuclides disposed of at the WIPP facility, as per the data in Table 4-6 (*ibid.*).

### ***Methodology for Calculating the Mean CCDF***

The DOE's simulations conducted with the CCDFGF code generated 100 CCDFs in each replicate. Each of the 100 CCDFs for each replicate reports the results of 10,000 futures simulated by the program. Hence, there could be as many as 10,000 steps on each CCDF curve, one step for the value of the cumulative normalized

release obtained in each of the 10,000 futures. To avoid unnecessary detail in storing the CCDFs, DOE used a binning procedure similar to that often used to create a bar chart. The range of estimated release values was divided by the DOE into 161 bins for this purpose. The CCDFGF program counts the number of futures with simulated cumulative normalized release values falling within each bin. The bin count can be zero for some bins, although most are not zero.

After the estimated release values for all 10,000 futures are binned, the CCDFGF program created a cumulative curve by calculating the number of futures with estimated releases greater than the release value associated with the upper end of each bin. The final CCDF is constructed by dividing these accumulated bin counts by the number 10,000. The specific release values estimated in any single future simulation are not retained by the model.

The 100 CCDF curves in each replicate are reduced by the DOE to a smaller number of summary CCDF curves in the program CCDFSUM. This program uses a point-wise procedure for calculating the summary curves from the original CCDFs. For example, the mean CCDF curve is generated by calculating an average of the 100 CCDF values at a selected value of the release R. The procedure is then repeated for a large number of values of R. Theoretically, this procedure could lead to as many as  $100 \times 10,000 = 1,000,000$  steps on the mean CCDF curve. However, because only 161 bins were used in creating the 100 original CCDF curves, and because the bins are selected in a similar fashion for each curve, the actual number of steps on the point-wise estimated mean CCDF curve is much smaller than 1,000,000.

Similar point-wise procedures are used by the DOE to construct the 10<sup>th</sup> and 90<sup>th</sup> percentile curves. At each selected value of the release R, there are 100 CCDF values to consider. The tenth one from the top (or bottom) is used as an estimate of the 90<sup>th</sup> (or 10<sup>th</sup>) percentile summary CCDF curve at that value of R. Note that the point-wise definition may select one CCDF as the 90<sup>th</sup> percentile value at one value of R, while at the next, slightly higher value of R, a different CCDF curve may mark the 90<sup>th</sup> percentile. The mean CCDF curve for each replicate is of particular interest because the containment requirements presented in §194.34(f) are phrased in terms of the mean CCDF.

Graphs of the summary curves for the mean CCDF from each of the three replicates and the overall mean CCDF are presented by DOE in Figure 6-38 of Chapter 6 of the CCA (Docket: A-93-02, II-G-1, Volume I). The mean CCDF

curves for each replicate and the overall mean CCDF are shown by the DOE, to be in compliance by several orders of magnitude in this figure.

The overall mean and its 95 percent UCL (and 95 percent lower confidence limit) also are shown in Chapter 6 of the CCA in Figure 6-39 (*ibid.*). The 95 percent UCL for the mean is in compliance with the regulatory requirements of this section by several orders of magnitude.

Additional WIPP implementation instructions promulgated in 40 CFR Part 194 require that there be a 95 percent level of confidence that the mean CCDF is in compliance with the 40 CFR Part 191 requirements defined for a single CCDF. The DOE uses confidence intervals derived from the Student t distribution to satisfy the requirement that there be a 95 percent level of statistical confidence that the mean CCDF is in compliance. The three mean CCDF values from the three replicates are the data used for this calculation.

Let  $X_R$  denote an estimate of the mean CCDF at any value of the cumulative normalized release  $R$ , and let  $SE_N(X_R)$  denote the standard error of the estimated mean due to sampling variation when the sample size is  $N = 3$ . The regulations at §191.13 require for compliance that the probability of exceeding a cumulative normalized release of 1 is to be less than  $10^{-1}$ , and the probability of exceeding a release of 10 is to be less than  $10^{-3}$ . Let  $L_1$  denote the upper limit of probability specified in the requirement, i.e.,  $L_1 = 0.1$  and  $L_2 = 0.001$ . A 95 percent Upper Confidence Limit (UCL) is defined by DOE as:

$$UCL_R(N) = X_R + k_{.95}(N) \cdot SE_N(X_R)$$

The constant  $k_{.95}(N)$  is selected using the t distribution with two degrees of freedom. The 95 percent confidence level is obtained when the UCL is below limit  $L_1$ .  $X_R$  is the average of the three mean CCDF values, SE is the standard deviation of the three values, divided by the square of  $N - 1$ .

Section §194.34(f) requires that the 95 percent upper confidence limit for the mean be in compliance. Use of the CCDFGF/CCDFSUM models with  $N = 10,000$  futures yields CCDFs with 100 percent of the curves lying below the limit of resolution at  $R = 10$ , and approximately 98 percent of the CCDFs below the limit of resolution at  $R = 1$ . As a result, the estimated mean CCDF is also below the limit of resolution of the model at  $R=1$  and  $R=10$ .

Additional information on the construction and use of CCDFs to determine compliance is contained in Chapter 6 and Appendix CCDFGF of the CCA

(Docket: A-93-02, II-G-1, Volumes I and V). Chapter 6 of the CCA presents general descriptions of the risk assessment calculations performed by DOE. The chapter includes references to details provided in Appendix CCDFGF. More information on CCDF construction is provided in the *Analysis Package for the CCDF Construction* (Docket: A-93-02, II-G-10) and the *Preliminary Summary of Uncertainty and Sensitivity Analysis Results Obtained in Support of the 1996 Compliance Certification Application for the Waste Isolation Pilot Plant* (Docket: A-93-02, II-G-07). Discussion of the LHS procedures is included in Appendix A6 of this TSD.

**a.2) A description of plausible alternative conceptual model(s) seriously considered but not used to support such application, and an explanation of the reason(s) why such model(s) was not deemed to accurately portray performance of the disposal system.**

Alternative mathematical formulations that account for both stochastic and parameter uncertainty are discussed formally in Helton (1996). The analysis details several possible simulation/integration schemes for obtaining the unconditional mean CCDF. Monte Carlo integration over the stochastic variables is performed by the CCDFGF program for each LHS parameter vector. The conditional CCDFs generated by the model for each vector of parameter values are all equally likely. Hence, it is appropriate to combine them using equal weights into a single unconditional CCDF.

**a.3) Documentation that:**

**a.3.i) Conceptual models and scenarios reasonably represent possible future states of the disposal system**

The CCDFGF code simulates the occurrence of inadvertent drilling intrusions during the 10,000 years following closure of the repository. These events are assumed to occur randomly, at a rate calculated to reflect exploration drilling rates for hydrocarbons in the Delaware Basin in recent years.

The conceptual model for CCDF construction in the 1996 CCA replaces previous PA methods for modeling the Poisson process. The broad concept of a Poisson model is retained, but is implemented in a different way. The current CCA uses a simulation approach rather than the importance sampling applied in previous PAs. Multiple intrusions are simulated to occur as a random sequence of E1 or E2 events, step-by-step through 10,000 years. This approach to simulating the Poisson process is a refinement to the approximations based on importance

sampling. In previous PAs, the Poisson distribution was used to approximate the probabilities appropriate for selected multiple intrusion scenarios. In the current model, the exponential distribution is used as a model for the inter-arrival times between intrusion events.

The conceptual models in CCDFGF include sub-models in three areas:

- simulation of the Poisson process
- treatment of brine reservoirs
- the method for estimating the mean CCDF

Each of these conceptual sub-models have changed from the approaches used in previous PAs.

### ***Poisson Model Implementation***

The CCDFGF simulation is based on the Poisson process model, a probability model often used to simulate the random occurrence of discrete events within a specified time interval. The Poisson model requires only one parameter, the rate of occurrence  $\lambda$ . In the CCA run, DOE's use of a 600-year period for Passive Institutional Controls (PIC), following 100 years of active institutional controls (AIC), complicates the simulation model used in the CCA. During this period, which represents approximately 6 percent of the total regulatory time period, the intrusion rate is assumed by DOE to be 1/100th of the rate in the remaining 9,300 years. Because  $\lambda$  now changes over time, the model is called a *time-varying* Poisson process. Hence, the model consists of three different constant parameter Poisson processes, one with a rate of  $\lambda$  equals zero for the first 100 years, the second with a constant rate  $\lambda/100$  from 100 to 700 years, and a third with constant rate  $\lambda$  from 700 to 10,000 years. Because the drilling rate for the 600 year PIC period set at only 1 percent of the drilling rate for the last 9,300 years, intrusions are rarely encountered until the end of the PIC period. In the EPA-mandated verification test, no credit for the PIC period was assumed (Docket: A-93-02, II-G-26).

The use of a simulation approach creates opportunities for the introduction of additional details into the modeling process that is not available in the previous formulations based on importance sampling. These additional details are implemented using a set of simulation rules that govern the simulation of multiple intrusions and brine encounters. These rules are extensions of the Multiple Intrusion and Castile and Brine Reservoirs Conceptual Models. There are different rules for each of the three release modes analyzed—cuttings, spallings, and direct

brine releases. They were implemented in a fashion to limit the estimated release due to multiple intrusions. A determination of the reasonableness of the CCDFGF simulation can be made by examination of these rules in detail.

### ***Simulation Procedures***

The ten disposal panels are considered independently in the CCA for the purpose of drilling intrusion events.

1. Starting at the time of closure ( $t=0$ ), a random number is drawn from the exponential distribution to determine the waiting time to the next intrusion. A constant drilling intrusion rate is assumed. After the PIC period, a rate of  $46.8/\text{km}^2/10,000$  years is used. During the PIC period, a rate 100 times smaller is used. (In the EPA-mandated PAVT, no credit for the PIC period is assumed.)

2. At the selected intrusion time, a second random variable is drawn to choose a location (1 of 144 discrete locations in the disposal region), and a third to determine if the intrusion is in one of the following:

- a=0 unexcavated area
- a=1 excavated RH area
- a=2 excavated CH area

3. If a=2 in the previous step, then three random numbers are drawn to select three waste streams for calculating cuttings release activity levels, drawn from the BIR probability distribution of volume across 569 waste streams. This assumes independence of the three vertically stacked drums with respect to waste streams.

4. A random number is selected to decide if the intrusion penetrates a brine reservoir. Approximately 8% of drilling intrusions hit brine, excavated or not. The calculations proceed next as follows.

a) If not excavated, the brine reservoir hit counter is incremented and determine if pressure depletion has occurred by this intrusion. The number of hits required to deplete depends on the size of the reservoir.

b) If excavated, then

1. If waste type is remotely handled (RH), do cuttings and cavings calculations only.

2. If waste type is contact handled (CH), do cuttings, cavings, spillings



and direct brine releases, as discussed below.

3. Increment brine reservoir hit count and determine if pressure depletion has occurred by this time.

5. If excavated intrusion, draw a random number to choose one of three plugging patterns:

p=1 continuous concrete plug (prob=0.02)

p=2 two plugs, one above repository, one below brine pocket (prob=0.68)

p=3 three plugs, two as above, plus one between brine and repository (prob=0.30)

Note that if plugging pattern 1 or 3 is selected, initially there is almost no bore hole flow between the brine reservoir and the repository. Plugging pattern 1 also prevents bore hole flow above the repository in the initial period. The permeability of the bore hole plugs is assumed to degrade over time, after the initial period of 200 years.

### ***Release Calculations for Intrusions***

The following procedures were developed for estimating releases using the CCDFGF code. Intrusions into the excavated area are simulated to occur at specific times  $T_1, T_2, \dots, T_{n\text{BHexc}}$  during the 10,000 years after closure, where  $n\text{BHexc}$  refers to the number of bore holes hitting the excavated disposal area. Each excavated area intrusion has the potential to generate four types of releases from the repository:

1. cuttings and cavings
2. spallings
3. direct brine releases
4. subsurface groundwater releases

Every excavated intrusion will generate releases due to cuttings and cavings, but the other three types only occur under specified repository conditions. The first three types of releases are surface releases expected to occur immediately (within one month) after the intrusion. Groundwater releases may continue from the time of the intrusion to the end of the 10,000- year regulatory period.

Each of the four types of releases requires a separate modeling approach in the CCA. Cuttings, cavings and spallings are estimated using the CUTTINGS\_S code.

Direct brine releases are modeled within the BRAGFLO\_DBR/PANEL codes. Groundwater releases, primarily through the Culebra, are modeled using the NUTS/PANEL/SECO codes. Each of these three major groups of code rely on outputs of the BRAGFLO code.

BRAGFLO provides pore pressures, brine saturations, and porosities to the CUTTINGS\_S code for calculating the direct release of solids brought to the surface during and immediately after drilling. BRAGFLO\_DBR receives repository properties from BRAGFLO and initial conditions from the CUTTINGS\_S code. If there is sufficient pressure and brine in the repository at the time of the intrusion, this code provides estimates of the amount of radioactivity carried to the surface by brine flows immediately after the intrusion. The groundwater release codes receive complete information on subsurface brine and gas flows from the BRAGFLO code. Unlike the short time frame models used for estimating surface releases, the groundwater models require BRAGFLO outputs over the entire 10,000 year period.

The surface release models operate over a short time period and these codes are faster than BRAGFLO. However, even these codes require too much time to be able to run the codes for every excavated intrusion in each of the 10,000 futures simulated for each LHS vector of parameters. Because of this limitation, several levels of interpolation are necessary to estimate surface releases for each excavated intrusion.

The interpolation scheme proceeds as follows, for each LHS vector.

1. Using the parameter values in the vector  $x_{S,U}$ , the BRAGFLO model is run six times. Permeabilities assigned to each element in the bore hole are modified over the 10,000 years in six different ways, to reflect borehole conditions for six intrusion scenarios:

- S1 - Undisturbed repository conditions
- S2 - E1 at 350 years
- S3 - E1 at 1000 years
- S4 - E2 at 350 years
- S5 - E2 at 1000 years
- S6 - E2 at 800 years and E1 at 2000 years

2. Using repository conditions calculated by BRAGFLO for these six basic scenarios, the first level of interpolation is generated by running the short-term

BRAGFLO\_DBR and CUTTINGS\_S codes at a variety of selected intrusion times.

3. Initial excavated intrusions are modeled with the BRAGFLO\_DBR and CUTTINGS\_S computer codes using the S1 (undisturbed) BRAGFLO set of repository conditions as initial conditions. The computational grid used in BRAGFLO\_DBR is different than the one used in BRAGFLO, with a horizontal rather than vertical orientation.
4. For multiple intrusions, only the case of two intrusions times is modeled explicitly in the BRAGFLO computer code. The second intrusion is modeled using the BRAGFLO repository conditions contained in the S2, S3, S4 and S5 scenarios. Similar passes of grid values are made as for the initial intrusions. The actual calculations are performed for a selected grid of first-intrusion and second-intrusion times shown as filled circles in Figure 4.1 in the *Design Document for CCDFGF* (Docket: A-93-02, II-G-1, Volume V, Appendix CCDFGF). At each of the 23 closed circles in the figure, the CUTTINGS\_S and BRAGFLO\_DBR codes were used to generate release matrices R-SP( $t_1, t_2$ ) and R-BL( $t_1, t_2$ ) where  $t_2 > t_1$  and  $t_1 = 350$  or 1000 years, for multiple intrusions. Similar 1-dimensional matrices also were generated for initial intrusions.
5. Interpolation and extrapolations performed by the preprocessor mode of the CCDFGF code were used to complete the calculations for the open circles in Figure 4.1. The 23 closed circle data sets provided the initial information from the BRAGFLO\_DBR and CUTTINGS\_S codes for these calculations. This step filled the remaining entries in the R-SP and R-BL matrices for initial intrusion times other than 350 or 1000 years.
6. At the final stage of the interpolation process, the normal mode of the CCDFGF program uses the tabulated release estimates (stored in the intermediate file RELTABRx) to estimate releases for each intrusion in the simulation of the 10,000 futures. In the CCDFGF code, the times between successive intrusions is modeled using the exponential distribution. The first draw from this distribution selects the time of the first intrusion, say  $t$ . Releases are retrieved from the RELTABRx matrix for grid times immediately before and after the intrusion time. Releases for time  $t$  are calculated using linear interpolated between the tabulated grid values. For two intrusions, say at times  $t$  and  $T$ , bilinear interpolation is required. The four tabulated values nearest the point ( $t, T$ ) in Figure 4.1 (ibid.) are used for this calculation.
7. For multiple intrusions involving more than two intrusions, the releases

estimated for the second intrusion are used.

Several additional features of the simulation procedure are noteworthy:

- Intrusions that penetrate RH waste result in no spillings releases and no direct brine release. Cuttings release for RH is determined using a single RH waste stream.
- The consequence of any intrusion is calculated using linear interpolation of the appropriate input file that contains estimated scenario release values.
- A brine pocket is assigned a maximum number of hits after which it is assumed that the brine pocket will be depressurized and no subsequent hits will result in direct brine releases.
- If a brine pocket is hit for the first time and the bore hole is sealed with a plugging pattern 1, it will be as though the brine pocket was never hit, and the next hit will be treated as if it were the first.
- Hence, when the first excavated intrusion uses plugging pattern 1, subsequent excavated intrusions are treated as initial excavated intrusions for the calculation of spillings and direct brine releases until either plugging patterns 2 or 3 is used for an excavated intrusion.

### ***Assumptions for Groundwater Releases***

Although previous PAs addressed groundwater releases through the Culebra as the main component of release to the accessible environment, the current CCA analysis for groundwater releases from the repository into the Culebra indicates that releases do not reach the accessible environment due to physical and chemical retardation effects in the Culebra. Because there are no releases to the accessible environment to model, an alternative approach was developed for the CCA which models releases *into* the Culebra as a result of E1 and E2 type intrusions.

Releases *into* the Culebra that remain within the WIPP land withdrawal area are not a directly regulated quantity and calculations done for this pathway are more for the purpose of understanding the modeling process than for compliance demonstration. These calculations were not presented in the CCA delivered to EPA. Some results of this modeling of movement within the Culebra are discussed in the report entitled *Preliminary Summary of Uncertainty and Sensitivity Analysis Results Obtained in Support of the 1996 Compliance Certification Application for the Waste Isolation Pilot Plant (A-93-02, II-G-7)* provided circulated after the

CCA was delivered to EPA.

Additional modeling assumptions are required to estimate the cumulative groundwater release into the Culebra of element  $k$  of decay chain  $j$  due to an intrusion of type E1, E2 or E1E2 at time  $t$  into waste panel  $p$ . The assumptions are detailed in the four unnumbered equations appearing at the end of Table 4.8 in Section 4.5 of the CCDFGF Design Document (A-93-02, II-G-1, Volume V). The equations describe the CCDFGF procedure for using interpolated results from a relatively small number of BRAGFLO/PANEL/NUTS model calculations to assign appropriate cumulative releases to the simulated E1, E2 and E1E2 event sequences encountered in the simulation.

The interpolated BRAGFLO/PANEL/NUTS release information is contained in the terms  $rE1(I, j, k, l)$ ,  $rE2(I, j, k, l)$  and  $rE12(I, j, k, l)$  which are defined as the cumulative groundwater release from the repository into the Culebra of element  $k$  of decay chain  $j$  from time  $I$  to time  $l$  due to an E1, E2 or E1E2 type intrusion, respectively. Colloidal movements are tracked by species within the model. The fraction of radionuclide  $k$  of decay chain  $j$  that is attached to colloidal species  $s$  is contained in the terms  $fCE1(s, j, k)$  and  $fCE2(s, j, k)$  for the E1 and E2 scenarios, respectively. Of the four equations in Table 4.8, the first two treat releases for the dissolved radionuclides that are not attached to any colloidal species, while the final two equations treat releases of radionuclides attached to colloidal species. In each set of equations, the first equation defines releases on a panel-by-panel basis, while the second equation sums the results over all panels. Hence the first equation in each set is the most detailed equation for examining the assumptions concerning multiple releases.

The first equation in each set contains four different expressions, for four different time periods. The first time period covers the period up to the first excavated intrusion ( $t < p_1$ ). In this time period, the repository is in the undisturbed condition and releases to the Culebra are set equal to zero.

The second time period covers the time from the first intrusion in an excavated area of panel  $p$  to the second excavated intrusion in the same panel. If the first excavated intrusion is an E1 event, the groundwater release into the Culebra from this panel in the second time period is assigned using the BRAGFLO/PANEL/NUTS E1 release results. If the next excavated intrusion is an E2 event, then the first E1E2 event arises, which is covered by the fourth expression.

If the first excavated intrusion is an E2 event, the groundwater release into the Culebra in the second time period is assigned using the BRAGFLO/PANEL/NUTS E2 release results. This level of consequence is maintained until an E1 event occurs. Then the first E1E2 event arises, which is covered by the fourth expression.

In the fourth expression of the first equation of each set the consequences of multiple E1E2 intrusions are calculated for all time periods after the occurrence of the first E1E2 event. From the time of the first E1E2 event, multiple E1E2 groundwater releases are assumed to remain that of a single E1E2 event, until the next E1 event. That is, any additional E2 events will not cause greater releases because, it is argued, the single bore hole into the brine pocket is the limiting factor. Subsequent E1E2 events are defined to occur when the subsequent E1 events occur—after the first E1E2 event—regardless of the number of E2 events that occur in the intervening period. As additional E1 events are encountered, the release profiles from additional E1E2 events are added to the release profiles of the earlier E1E2 events.

### ***Brine Pocket Conceptual Model***

The probability of a drilling intrusion encountering pressurized brine is treated as a constant parameter in the CCA. This parameter determines the relative proportion of drilling intrusions into the repository that are expected also to strike pressurized brine in the Castile formation beneath the WIPP. The parameter is used in the CCDFGF code to determine the probability of an intrusion hitting pressurized brine. The percentage underlain with brine reduces both the frequency and consequences of the E1E2 scenario. Intrusions that strike brine result in higher releases to the accessible environment due to direct brine release, increased likelihood of releases due to spallings, and an increase in the chances of groundwater releases into the Culebra formation above the repository.

The CCA documentation for this parameter shows that a constant probability value of 0.080 was used in the CCA for this parameter. Supporting documentation for this value is presented in the MASS Attachment 18-6 (Docket: A-93-02, II-G-1, Volume X, Appendix MASS) where a probability of 0.082 is recommended based on semi-variograms and ordinary Kriging analysis of drill hole data.

The geostatistical analysis correlates occurrence of brine reservoirs with disturbed areas of the Castile, using driller-reported brine encounters in a broad area of the Castile surrounding the WIPP site. The estimated spatial correlation distance for

the brine-encounter data is smaller than the distance from the disposal site to WIPP-12. Hence, in the absence of other data within a few correlation distances of the WIPP site, the analysis assigns a probability value at the WIPP site that is near the wide-area average for undisturbed regions of the basin. This value is 8 percent.

The geostatistical approach ignores the local depth-to-first-conductor data obtained in the TDEM study (Docket: A-93-02, II-G-1, Ref. #229) reported in the 1992 WIPP PA. Given the large uncertainty surrounding the existence of brine in the vicinity of the disposal site, there appears to be little justification for the use of a single fixed percentage for this parameter. However, the Conceptual Models Peer Review Panel considered the impact of a change in the percentage of brine encounters on the overall CCA results to be small (Docket: A-93-02, II-G-12, p.2).

Other assumptions effect brine pockets in the model. A new feature of the conceptual model introduced for the CCA is the assumption that the Castile brine reservoir will experience pressure depletion due to bore holes drilled through both the excavated and unexcavated areas inside the berm. The index for selecting a brine pocket is an LHS parameter used in the CCDFGF code (Docket: A-93-02, II-G-1, Volume XI, Appendix PAR, p. PAR-113). This parameter determines the size of brine pocket that may be encountered in the Castile formation beneath the WIPP. The size of the brine pocket and the initial pressure in the brine pocket are used in the BRAGFLO code to determine the potential for brine flow into the repository after penetration by drilling intrusions.

The documentation for this parameter (*ibid.*) describes a discrete probability distribution with 32 equally likely integer values ranging from 1 to 32. These values are mapped to one of five possible brine pocket volume values: 32,000, 64,000, 96,000, 128,000 or 160,000 cubic meters. The assigned distribution is skewed toward the low end of the size range. A total of 19 of the 32 possible integer values for this variable are assigned to the smallest size brine pocket, 32,000 cubic meters. Ten integers each are assigned to the 64,000 and 96,000 cubic meters size classes. Five integers are assigned to the 128,000 cubic meter size class, and one integer to the largest 160,000 cubic meters size category. The result is that less than 20 percent of brine pocket encounters involve the two largest size classes: 128,000 or 160,000 cubic meters, with over 80 percent of encounters being of size 96,000 cubic meters or less. (See Technical Support Document for Section 194.23: Parameter Justification Report, Docket: A-93-02, III-B-14 for additional discussion.)

a.3.ii) [mathematical models incorporate equations and boundary conditions which](#)

reasonably represent the mathematical formulation of the conceptual models.

DOE uses a simulation approach to generate estimates of the CCDF curve for WIPP performance assessment. The conceptual model for the simulations is based on the Poisson space-time process, a probability model used to simulate the random occurrence of discrete events at a given rate within a specified time interval, geographical area, or both. The Poisson space-time model for intrusions into the WIPP disposal area requires only one parameter,  $\lambda$ , the average rate of intrusions per km<sup>2</sup> per 10,000 years.

The CCDFGF code is designed to calculate one CCDF for each LHS vector of sampled parameters. The program estimates probabilities for the scenario consequences obtained from the other models to generate a CCDF for each LHS vector of parameters. The CCDFGF code reads the files created by the other PA models for each scenario and performs stochastic simulations necessary to generate 10,000 futures.

The cumulative normalized release for each future is retained, and used to construct a CCDF of release values. The value of CCDF(R) is calculated for any R by counting the number of futures that result in cumulative normalized release greater than R, then dividing the count by the total of 10,000 futures. Using this estimator, the smallest probability value that can be simulated by the model is  $1/10000 = 10^{-4}$ , which may be considered as the lower limit of resolution of the model when used to estimate probabilities based on the Poisson space-time model. This approach is consistent with the EPA requirements in §194.32(d) that performance assessments need not consider processes and events with an occurrence probability less than  $10^{-4}$ .

The specific equations used to estimate releases within each future are designed to reflect the Poisson space-time conceptual and mathematical models. The program first uses random sampling from the exponential distribution to simulate the inter-arrival times between intrusion events in the temporal part of the Poisson process. Additional random variables are introduced to simulate whether the intrusion hits an excavated area or not, the type of bore hole plugging pattern used, whether brine is hit or not, which panel is hit, which waste containers, etc. With the exception of plugging pattern and waste container, these variables are assumed to be distributed randomly over the disposal area proportional to the areas involved, as expected for the spatial portion of the Poisson process.

Plugging patterns are implemented with a non-uniform distribution, in accordance



with historical experience. Waste containers are simulated from a list of 567 waste streams in proportion to their expected frequency in filling the repository, based on DOE's waste inventory data (Docket: A-93-02, II-G-1, Volumes III-IV). These two variables are not part of the Poisson space-time conceptual model, but reflect the historical record and future expectations.

There are no boundary conditions used in these calculations, which depend on Monte Carlo simulation methods rather than direct numerical algorithms which would lead to analytic solutions of the relevant physical equations.

a.3.iii) numerical models provide numerical schemes which enable the mathematical models to obtain stable solutions.

The Monte Carlo simulation approach is used in the CCDFGF code to implement numerical evaluation of the mathematical models. The Monte Carlo method simulates the occurrence and location of intrusions into the repository over 10,000 years. The numerical quantity estimated in the simulation is the proportion of simulated futures with a cumulative normalized release greater than  $R$ —this is a calculation used to estimate the CCDF at  $R$ .

The stability of the simulation method for estimating the CCDF is determined by the number of futures used in the simulation. In the current CCA, 10,000 futures are simulated. The sample size limits the numerical accuracy for the estimation of probabilities to within approximately  $\pm 10^{-4}$  at all levels of probability reported by the code. The probabilities of interest in evaluating compliance are  $10^{-1}$  at  $R = 1$  and  $10^{-3}$  at  $R = 10$ , where  $R$  is the cumulative normalized release. Hence, the approximate percentage error contributed by the use of 10,000 futures ranges from 1 percent to 10 percent, respectively.

The CCDFGF computer code also requires numerical algorithms for random number generation and for interpolation. The random number generator algorithm and code was selected by Press 1992 as the "best" uniform random number generator, in this standard source of off-the-shelf FORTRAN code. The interpolation routines use both linear and bilinear interpolation. Interpolation results in a small amount of additional error in the estimated release values. The magnitude of this error is small with respect to the larger sources of uncertainty in the release estimates, including model specification, homogeneity and parameter uncertainty.

a.3.iv) computer models accurately implement the numerical models; i.e.,

computer codes are free of coding errors and produce stable solutions.

The *Implementation Document* for the CCDFGF program contains approximately 15,000 lines of FORTRAN, encompassing approximately 140 subroutines and user-defined functions. The test plan presented in the VVP provides functional requirements related to the correct coding implementation of the CCDFGF numerical model. For dynamic analyses, the Validation Document (VD) describes four tests to validate the CCDFGF code. The first test is a test of the preprocessor mode, while tests 2, 3, and 4 are for the normal mode of operation of the CCDFGF code. A complete replication of the tests was conducted by EPA within the EPA-CMS framework to verify proper code implementation for the CCA.

In addition, the CCDFGF program prints a diagnostic to report results of internal tests that are designed to ensure the probabilities of events generated by the model match closely with calculated probabilities from the assigned probability distributions. These distributions closely match the theoretical distributions.

The program CCDFGF estimates releases of radionuclides by multiplication of an activity level times the estimated volume of material releases. For fixed activity, the resulting release should be linearly proportional to the volume released. Alternatively, for fixed volumes, the estimated releases should be linearly proportional to the activity of the material. This property of the CCDFGF code is referred to as bilinearity, which was the subject of an additional test conducted by EPA. Examination of the outputs for this comparison showed that this part of the bilinearity test was successfully completed and produced adequate results for use in the CCA PA.

EPA's analysis concluded that the DOE has presented performance assessment results in CCDFs which show the probability of exceeding regulatory levels of cumulative releases. Numerical models for the calculation of the WIPP CCDFs are defined in Appendix CCDFGF, also known as the *Design Document for CCDFGF*. The CCDFGF Fortran code for implementing the numerical model is presented in the *Implementation Document*. The correctness of the implementation is demonstrated using tests proposed in the *Verification and Validation Plan*. The results of the validation tests obtained by DOE are presented in the *Validation Document*. EPA review of the validation tests for the CCDFGF code is discussed in Section b.1(6). Additional tests performed on the code by EPA are discussed in Section b.2(7) of this Appendix.

a.3.v) conceptual models have undergone peer review according to § 194.27.

As discussed in Chapter 9 of the CCA (Docket: A-93-02, II-G-1, Volume I), the conceptual models contained in CCDFGF modules have undergone Peer Review. The Conceptual Models Peer Review Panel reviewed the exclusion of large brine reservoirs, and the depletion of reservoir pressure due to repeated intrusions. The Panel agreed with these approaches.

The Peer Review Panel assessed the use of a single-event model such as BRAGFLO to evaluate releases for multiple intrusions in the E1E2 scenario and found this to be an adequate approach.

The Peer Review Panel stated two specific objections to the approach presented by Powers, *et. al.* (Docket: A-93-02, II-G-1, Volume X, Appendix MASS, MASS Attachment 18-6), for estimating the probability of encountering brine. These were:

- (1) the lack of data in the immediate vicinity of the WIPP
- (2) the implicit assumption that geologic conditions at the WIPP would be similar to those in areas where brine encounters and drilling are more abundant

The Panel also noted that the time-domain electromagnetic geophysical study completed by the DOE prior to the current geostatistical study represents the only site specific data over the waste panel area, and very significant low resistivity anomalies were noted under some of the waste panel area that are consistent with the depths of the lower to middle Castile. The Peer Review Panel questioned the geostatistical approach (independent of geophysical data) for modeling the probability of intercepting a brine reservoir when more specific indicators and site specific data are available. However, the Panel also noted that it expected these shortcomings would have only a small impact on the overall results of the assessment.

b) Computer codes used to support any compliance application shall be documented in a manner that complies with the requirements of ASME NQA-2a-1990 addenda, part 2.7, to ASME NQA-2-1989 edition. (Incorporation by reference as specified in §194.5)

The CCDFGF program may be run in two modes. In the first mode, called the preprocessor mode, the program collects required outputs for 100 LHS vectors from the other PA programs and writes these results to an intermediate file RELTABRx, where x denotes the replicate number. The file contains an array of

consequence estimates, written here as  $R_{s,c,e,t,h}$ , and the associated times  $t$  for each consequence value. The  $R$  matrix contains consequence and time values for each:

- LHS observation,  $s = 1, \dots, 100$
- category of release,  $c = \{\text{CUSP, BF4, NUTS, SECO}\}$
- type of intrusion scenario,  $e = \{\text{E0, E1, E2}\}$
- time of intrusion,  $t = t_1, \dots, t_n$
- upper or lower panel,  $h = \text{U/L}$

When run in the normal mode, the CCDFGF program reads this intermediate file, and performs stochastic simulations necessary to generate  $N = 10,000$  futures for each LHS input vector. Within each future, the program samples to determine the time to the next intrusion, whether the intrusion hits an excavated area or not, the type of plugging pattern used, whether brine is hit or not, which panel is hit, which waste containers, etc. While simulating each future, the program keeps track of multiple intrusions into the waste panels and into the brine pocket to implement specific rules for the treatment of multiple intrusions.

In simple terms, the normal mode of the program attaches probabilities to the consequence estimates contained in RELTABRx to generate a CCDF for each LHS vector. The result is a set of 100 CCDFs for each of the three replicates. The data set for the CCDF curves, consisting of a set of graph points,  $\{R, F_{s,c}(R)\}$  contains separate estimates for each category of release  $c$ , as well as CCDFs which are combined over all categories of release ( $c=0$ ). The values  $F_{s,c}(R)$  are generated by counting how many of the 10,000 futures result in cumulative release over greater than  $R$ , then dividing that count by 10,000. Using this estimator, the smallest probability value that can be simulated by the model is  $1/10000 = 0.0001 = 10^{-4}$ .

- *Technical evaluation of adequacy of CCA PA QA documents*

QA documents specific to the CCDFGF code are discussed in this section (See Docket: A-93-02, II-G-3, Volumes 2 and 3).

- *Requirements Document/Verification and Validation Plan*

Functional requirements are listed in the *Requirements Document*. The test plan presented in the VVP fully develop for the functional requirements. This provides additional functional requirements related to the correct implementation of the CCDFGF code. Additional tests are presented to ensure that the preprocessor

mode of the program correctly interpolates and extrapolates the release tables received from other PA models. Seven tests are presented for the simulation rules discussed in Section a.3.i of this Appendix. Additional internal consistency checks are part of the CCDFGF code to ensure that the probabilities of events generated by the model match closely with calculated probabilities from the assigned probability distributions.

The acceptance criteria listed in the VVP rely on visual inspection of printed outputs and comparison to printed inputs. Verification using hand calculations is also proposed.

- *Implementation Document*

The *Implementation Document* for the CCDFGF program contains approximately 15,000 lines of FORTRAN, encompassing approximately 140 subroutines and user-defined functions. This code was used to compile the executable, CCDFGF\_PA96.EXE, used for the CCA.

- *User's Manual*

The User's Manual provides instructions for running the codes and describes capabilities and limitation. Hardware and software requirements are cited.

- *Validation Document*

The Validation Document first reports the results of static analyses on the CCDFGF code, including a FLINT analysis and coverage analysis. The static analyses were done using the DEC-supplied source code analyzers. The FLINT analysis reported several variables that were set but later were not referenced. These were determined to be features of the code which are not used in the CCA PA. The FLINT analysis also reported lines in excess of 72 characters. These were determined to be caused by extra blanks at the end of records which have no effect in the code.

The coverage analysis reported that seven subroutines were not functional in the code: E1E2R, E1ORE2, EPAREL, NOBH, PRTTST, RELCUT, and RELMDS. These were not used in the CCA analysis. Additional analyses of the CCDFGF PA96 code revealed that there are five other subroutines which are referenced and called, but have been "short-circuited" by placing a Return statement as the first executable statement in the subroutine. See section d.2(8) of this Appendix for a list of these subroutines.

For dynamic analyses, the VD describes four tests to validate the CCDFGF code. The first test is a test of the preprocessor mode, while tests 2, 3, and 4 are for the normal mode of the CCDFGF code. A complete replication of Tests 1, 2, 3 and 4 was conducted by EPA to verify these tests. The latter three tests run the CCDFGF executable in the normal mode, using command script files (\*.COM) to define the working directory, source for executables, and necessary input files. Output files are written on the same directory with the inputs. The script was modified as needed to run the three tests.

The original script for Test 3 was prepared by Mike Williamson of DEC, who also set up a Configuration Management System, the EPA-CMS, to record file operations for QA purposes as the tests are reproduced. The EPA-CMS contains pointers to the original CCA-CMS. It will also contain new files created by EPA, and records all file operations. The commands *CSE CMS show element*, and *CFE CMS fetch element*, are available to find and fetch elements (files) from the EPA-CMS libraries. To locate the files needed for the CCDFGF code, the command *LIBCCGF* was used to direct the current pointer to the CCGF library, prior to using the *CSE* and *CFE* commands.

Only one input file differs among the latter three tests. This file is named to facilitate use of a unique CMS search identifier, such as "CSE \*MISC\*.INP" to locate the file in the CMS. The necessary MISC input file for each test was located in the EPA-CMS using the *CSE* command and fetched to the current working directory using the *CFE* command. The remaining input files to each of the three tests are identical. These files were retrieved from the EPA-CMS on Wednesday, January 15, 1997, by Mike Williamson, to the [.MIKE\_FILES] subdirectory on the [ROOT.ABWOLBA] directory.

Chronologically, The tests were reconstructed in this order: Test 3, Test 4, Test 2, then Test 1.

### ***Reconstruction of Test 3***

The following steps were completed to review Test 3:

Created working directory [.T3] and moved to that directory.

Copied all input files from the MIKE\_FILES subdirectory. Also copied .COM script from that directory. Used *CFE* to fetch \*MISC\*.INP files from the CMS to the T3 directory. Modified the .COM script to access the current working directory. At this point the .COM script referred to the executable named

“PA96\_2,” as indicated in the script received from Mike Williamson.

Compared the output file CCGF\_CCDFGF\_T3.OUT with the corresponding file fetched from the CCA-CMS using the VAX DIF command. The files did not match. The code's author, Jay Johnson of Gram, Inc., informed us that the PA96\_2 executable is the latest version 1.01, which has been modified since the CCA was prepared. After modifying the .COM script to access the older executable named “PA96,” the script was run again. This time the output files matched exactly with the output files obtained from the CCA-CMS, because PA96 is the version 1.00 executable used in the tests EPA received from SANDIA.

### ***Reconstruction of Test 4***

Created working directory [.T4]. Used CFE to fetch the \*MISC\*.INP file for Test 4. Modified .COM script from Test 3 to run Test 4. Copied all necessary input files, other than the MISC file, to the working directory from the [.T3] directory. Ran both the Version 1.00 and Version 1.01 tests. Used DIF to compare the 2 sets of output files to the corresponding files in the EPA-CMS. All four output files matched exactly.

### ***Test 3 and 4 Summary***

Test 4 is somewhat different than Test 2 and 3. The Tests 2 and 3 provide printouts of selected observations and futures from the PA run performed for the CCA. Test 4, however, uses modified parameter values for the maximum number of intrusions which can produce spillings or blowouts, to test these features of the code. These features could not be tested using the actual CCA parameters because the assigned maximum values are never reached in the CCA simulation.

### ***Reconstruction of Test 2***

Created directory [.T2]. Copied script from Test 4 and input files (other than \*MISC\*.INP) from the Test 3 directory. Used CFE to fetch the \*MISC\*.INP file for Test 2 from the CCA-CMS.

Modified the .COM script to address the current working directory and to access the PA96 (Version 1.00) executable for the test.

Ran the script to generate the output files for Test 2. Could not find an output file CCGF\_T2.OUT in the CCA-CMS for comparison. Found larger output file, CCGF\_CCDFGF\_T2.OUT, which contains detailed futures listings to complete the visual comparison part of Test 2.

Matched the CCGF\_CCDFGF\_T2.OUT file from the test run to the corresponding file in the CCA-CMS using DIF. No differences were found.

In addition to the test files, input files and executables for Version 1.00, the EPA-CMS has corresponding files for the newer Version 1.01 of the PA, usually referred to with the symbol \_2, e.g., PA96\_2. While conducting the tests of Version 1.00, the tests were also successfully run on Version 1.01. To the extent which these tests were completed, the new version test output files all matched with those generated by Sandia during the recently completed test runs on the new Version 1.01 executable.

The data file RELTABR1 used in Tests 2, 3, and 4 is produced by the preprocessor mode of CCGF. This file contains all release values from the other modules of the PA. Tests 2, 3, and 4—which test the normal mode of the CCGF code—read this file as a primary input file. However, the file was also created by the CCGF executable, when run in the preprocessor mode.

### ***Reconstruction of Test 1***

Test 1 involves running EPAUNI, LHS, in both the preprocessor and normal modes of the CCDFGF program, and the final summary program CCDFSUM. Considering the strong performance of the normal mode of the program in Tests 2, 3 and 4 discussed above, the most crucial aspect is that Test 1 addresses the correct operation of the preprocessor mode of the CCDFGF program. Running the preprocessor mode requires over 150 input files, many of are not easily located in the CMS. Test 1 also differs from Tests 2, 3 and 4 in that the results for all three replicates are required to test the program CCDFSUM. All programs up to and including CCDFGF\_1 must be run for all three replicates before running the CCDFSUM program. Due to the complexity of Test 1, with the large number of input files and long job submission times, the test was not reconstructed in a single run. A detailed execution script (EVAL\_CCGF\_OCT96.INP) was prepared to define all job steps and the required CMS input files. This re-entrant script, prepared by Mike Williamson and Kathy Aragon of Digital Equipment Corporation, under contract with SNL, permitted running selected subsections of the job stream in different phases. A listing of the entire script is provided at the end of this appendix.

Using the evaluation script, the reconstruction of Test 1 was conducted in three phases:

- 1) Preprocessor mode of CCDFGF - 3 runs, 1 for each replicate



- 2) Normal mode of CCDFGF - 3 runs, 1 for each replicate
- 3) CCDFSUM - 1 run, uses all 3 replicates

The input files required for running Test 1 are listed at the end of this appendix. These files were used as proxies for the real data in the development of the program. Although the input files are still required to run the program, much of the proxy data contained in these input files is ignored, being over-written later in the CCDFGF program by values obtained from the most recent CCA-CMS run. The input files are:

- CCGF\_MISC\_POSTCCA\_VERBOSE\_1.INP
- CCGF\_NODE3\_CCA.INP
- CCGF\_INV5\_CCA.INP
- CCGF\_REGION\_CCA.INP

*Phase 1*

After the necessary input files were assembled on a local working directory, the three phases of the Test 1 verification were conducted using scripts that accessed files from the EPA-CMS files associated with the OCT\_96 class. The entire script is included in the files listed at the end of this appendix, under the name EVAL\_CCGF\_OCT96.INP. A portion of the beginning of the script used for phase 1 is listed here:

\* The codes/steps that are accessible from this script are:

```
* EPAUNI_RH
* EPAUNI_CH
* PRECCDFGF
* PRELHS
* LHS
* CCDFGF_1
* CCDFSUM_PLT_1
* CCDFSUM_ADOBE_1
*
```

```
* WARNING - run up through CCDFGF_2 for R1, R2, and R3 before
* running the CCDFSUM steps. CCDFSUM expects output files from
* all 3 replicates and will fail without them.
*
```

```
*-----
* GLOBAL SYMBOLS AND LOGICALS
SYMBOL          UNIQUE_ID          OCT96
SYMBOL          USER_TYPE          EPA
SYMBOL          INPUT_CLASS      oct96
SYMBOL          REPLICATE_NUM          1
SYMBOL          FIRST_CODE          EPAUNI_RH
SYMBOL          LAST_CODE          PRECCDFGF
LOGICAL          WORKING_DIR          sys$login
*
```

Using the FIRST\_CODE, LAST\_CODE and REPLICATE\_NUM features, the

script was executed in phase 1 from the program EPAUNI\_RH to the program PRECCDFGF for each replicate by changing the value assigned to REPLICATE\_NUM from 1 to 2 to 3. During this phase the script reads a large number of files containing consequence estimates for cuttings, spillings and direct brine releases for each scenario. The results are written to the intermediate file RELTABRx for each replicate  $x = 1, 2, 3$ .

After completing the phase 1 runs for each of the three replicates from the PRELHS program to the CCDFGF\_1 program, the output file RELTABRx was checked against the corresponding RELTABRx files included in the CCA-CMS using the Difference program. Outputs of the difference program runs are included at the end of the appendix. No difference were noted in the comparisons.

### *Phase 2*

After examining the phase 1 output files for each replicate, the second phase of the EVAL\_ script, from the program PRELHS down to and including the program CCDFGF\_1, was executed by modifying the FIRST\_CODE and LAST\_CODE features:

```
SYMBOL    FIRST_CODE    PRELHS
SYMBOL    LAST_CODE     CCDFGF_1.
```

In this phase, the script was executed from the program PRELHS to the program CCDFGF\_1 for each replicate by changing the value assigned to REPLICATE\_NUM. This phase of the reconstruction of Test 1 creates output files with CCDFs that describe results the simulations performed by the normal mode of the CCDFGF code for each replicate. In the CMS, the phase 2 output file for replicate 1 is named CCGF\_POSTCCA\_R1\_VERBOSE\_1.OUT. The reconstructed output file for replicate 1 in phase 2 has the name CCGF\_R1\_1\_OCT96.OUT. Similar files were prepared for replicates 2 and 3. After completing the phase 2 runs, the output files were compared to the corresponding output files included in the CCA-CMS. No difference were encountered when the Difference program was used to compare the two files. Output files showing the results printed by the Difference program are listed at the end of this appendix.

### *Phase 3*

Phase 3 includes the final section of the script, which runs the program CCDFSUM. As noted in the warning in the portion of the evaluation script listed

above, this phase is run after all three replicates have successfully completed using the preprocessor and normal modes of the CCDFGF program in phases 1 and 2. The CCDFSUM program creates the summary mean CCDF curves for each replicate, estimates of the overall mean and its confidence interval, and graphs of all CCDFs in Postscript and Adobe formats.

The FIRST\_CODE and LAST\_CODE lines of the EVAL script are modified for this phase as follows:

```
SYMBOL    FIRST_CODE    CCDFSUM_PLT_1
SYMBOL    LAST_CODE     CCDFSUM_ADOBE_1.
```

After completing the phase 3 run, the output file CCGF\_CCDFSUM\_1A\_OCT96.OUT was compared to the corresponding output file CCGF\_CCDFSUM\_POSTCCA\_VERBOSE\_1A.PLT included in the CCA-CMS. No differences were found when the difference program (DIF) was run on the two files. The output of the difference program is listed at the end of this appendix.

A bilinearity test was also conducted by EPA of the CCDFGF code. The program CCDFGF estimates releases of radionuclides by multiplication of an activity level times the estimated volume of material releases. For fixed activity, the resulting release should be linearly proportional to the volume released. Alternatively, for fixed volumes, the estimated releases should be linearly proportional to the activity of the material. This property of the CCDFGF code is referred to as bilinearity, which is the subject of an additional test conducted by EPA.

The bilinearity test was designed to determine if the CCDFs generated by the CCDFGF program respond linearly to its two inputs, volume and activity. The base run for the model in normal mode uses a selected LHS vector to generate an intermediate release matrix R for that vector. This matrix generates a set of CCDF graph points F. The test was conducted by increasing ten-fold all release volumes contained in the RELTABR1.DAT data file that is generated by the preprocessor mode of the CCDFGF program. The version of this file used as the Replicate 1 input for Test 2 was selected as the basis for this test.

The release volumes in each sub-matrix of the intermediate release tables were multiplied by a factor of 10. The program for doing this multiplication was constructed by deleting all unnecessary code from the current CCDFGF FORTRAN code, other than the subroutines required to read and write the intermediate release file. The program, named RELT.FOR, is listed at the end of

this appendix. The CCA-CMS contains the output file CCGF\_T2\_PA96.OUT from the CCDFGF normal mode when the data file RELTABR1.DAT is used as the input file for Test 2. The adjusted RELTABR1.NEW matrix created by the program RELT.FOR was then used as input to a second run of the normal mode of the CCDFGF program, generating a second version of the CCDFGF output file with the same name, but stored on a different directory.

A second FORTRAN program, named CCG.FOR, was used to read the output file associated with the adjusted RELTABR1.NEW input file, and divide all estimated release values by the same factor of 10 used to adjust the RELTABR1.NEW file. The CCG.FOR program is listed at the end of this appendix. The output file from CCG.FOR was named CCGF\_T2\_PA96.NEW. The two versions of the output file from CCDFGF were then compared using the Difference program. No differences were found. Output of the difference program is listed at the end of this appendix (see Attachment 1).

A similar program was used to multiply all radioactivity concentrations received from EPAUNI by a factor of 10, generating a second test output. It was expected in each case that the new sets of CCDF curves would be higher by a factor of 10 at all values of the cumulative normalized release. Examination of the outputs for this comparison showed that this part of the bilinearity test was successfully completed also.

EPA's analysis concluded that the DOE adequately tested the functional requirements of the CCDFGF computer code and that the additional test done by the Agency shows that the computer code is adequate for use in the CCA PA.

c) Documentation of all models and computer codes are included as part of any compliance application performance assessment calculation shall be provided. Such documentation shall include, but not be limited to:

c.1) Descriptions of the theoretical backgrounds of each model and the method of analysis or assessment,

The theoretical background of the CCDFGF code is discussed in Chapter 6 of the CCA (*op. cit.*) and in Appendix CCDFGF (*op. cit.*). Complete mathematical details of the approach are presented in Helton 1996.

c.2) General descriptions of the models; discussions of the limits of applicability of each model; detailed instructions for executing the computer codes, including hardware and software requirements, input and output

formats with explanations of each input and output variable and parameter (e.g., parameter name and units); listings of input and output files from a sample computer run; and reports on code verification, benchmarking, validation, and quality assurance procedures.

- *Limits of applicability*

The User's Manual (p.8) notes that the software can only be used if input file from the CCA PA calculations are first condensed for use by CCDF using the SUMMARIZE software.

- *Detailed instructions for executing code*

*The User's Manual* is inadequate for running the code. Instructions for running the code contained in the VVD test discussions are more informative.

- *Hardware requirements*

Hardware requirements are specifically addressed in the *User's Manual*.

- *Software requirements*

Section 6 of the User's Manual summarizes software requirements.

- *Input and output formats*

Input and output formats are discussed in the *User's Manual* (pp. 10-12). Sample pages are printed in the Appendices to the User's Manual.

- *Explanation of each input and output variable and parameter*

Mathematical definitions of each input and output variables are provided in Appendix CCDFGF, (pp. 14 - 52). Additional information is included in Chapter 6 and Appendix MASS.

- *Listing of input and output files*

Listings of the input and output files are included in the *User's Manual* and in the *Validation Document*.

- *Explanation of each parameter with name and units*

The mathematical definitions of each variable and the appropriate units are presented in Appendix CCDFGF, pp. 14 - 52.

- *Report on code verification*

See *Report on Code Validation* below.

- *Report on benchmarking of code*

No report on benchmarking of the new CCDFGF code was located. There is no prior standard to support a benchmarking.

- *Report on code validation*

The VD reports the results of four tests performed to validate the CCDFGF code. The acceptance criteria rely on visual inspection of printed outputs and comparison to printed inputs. Verification was also done using hand calculations. Results of the tests of the preprocessor and normal modes indicate all requirements listed in the VVP were satisfied.

- *Report on quality assurance procedures*

Reviewer forms for the *Requirements Document*, the *Verification and Validation Plan*, the *User's Manual*, *Implementation Document* and *Validation Document*, with cover sheets was received.

### c.3) Detailed descriptions of the structure of computer codes and complete listings of the source codes.

- *Detailed description of the structure of the computer code*

The *Validation Document* provides a listing of the call tree for the code on pp. 33 - 35.

- *Detailed listing of the computer code*

The *Implementation Document* for the CCGF program contains a listing of approximately 15,000 lines of FORTRAN, encompassing approximately 140 subroutines and user-defined functions. Build scripts are also included.

### c.4) Detailed descriptions of data collection procedures, sources of data, data reduction and analysis, and code input parameter development.

- *Description of data collection procedures*

The random numbers generated in the CCDFGF program to simulate future drilling scenarios require parameters for each type of variable. The model includes

the following variables.

1. Drilling rate parameter to be used in the exponential distribution for the waiting time to next intrusion. A constant drilling intrusion rate is assumed. The CCA uses a period 600 years in which passive institutional controls are assumed to be effective. After the PIC period, a rate of 46.8/km<sup>2</sup>/10,000 years is used. During PIC period, a rate 100 times smaller is used. No intrusions are assumed to occur during the initial 100 years when active institutional controls are assumed to be effective.
  2. A discrete random variable to choose a location as one of 144 discrete locations in the disposal region. This distribution assigned is discrete uniform.
  3. A variable for non-excavated, excavated CH, or excavated RH intrusions.
  4. Three random numbers drawn to select three waste drums for calculating cuttings release activity levels. The probability distribution for this variable comes from the BIR distribution of volumes across 569 selected waste streams. The waste stream data are discussed in Appendix BIR (Docket: A-93-02, II-G-1, Volumes III-IV).
  5. A random number to decide if the intrusion has penetrated a brine reservoir. Approximately 8 percent of drilling intrusions hit brine, excavated or not.
  6. A random number to choose a plugging pattern:
    - p=1 continuous concrete plug (prob=0.02)
    - p=2 two plugs, one above repository, one below brine pocket (prob=0.68)
    - p=3 three plugs, two as above, plus one between brine and repository (prob=0.30)
- *Identification of sources of data*

The model includes the following variables and the corresponding data sources.

1. Exponential distribution rate parameter. A fixed drilling rate is used based on the use of Delaware basin drilling data, as required by §194.33(b)(3). The use of a factor of 100 for the PIC period is entirely subjective. This assumption was not used in the EPA-mandated PAVT (Docket: A-93-02, II-G-26).

2. Location in the disposal region. This distribution is assigned as discrete uniform to make all locations equally probable.
  3. Variable for non-excavated, excavated CH, or excavated RH intrusions. This distribution is determined from the geometry of the site.
  4. Waste stream distribution. The BIR data underlying this distribution are discussed in CARD 24 (Docket: A-93-02, II-B-3).
  5. Percentage of disposal area underlain by pressurized Castile brine. Supporting documentation for this fixed parameter is discussed below in the description of data reduction and analysis.
  6. Index for selecting a brine pocket. This LHS parameter is discussed below under input parameter development.
  7. Random number for plugging pattern. The probabilities are assigned based on a field survey as discussed in Appendix DEL of the CCA (Docket: A-93-02, II-G-1, Volume V).
- *Description of data reduction and analysis*

The probability of a drilling intrusion encountering pressurized brine is treated as a constant parameter in the CCA. This parameter determines the relative proportion of drilling intrusions into the repository that are expected to also strike pressurized brine in the Castile Formation beneath the WIPP. The parameter is used in the CCDFGF code to determine the probability of an intrusion hitting pressurized brine. The percentage underlain with brine reduces both the frequency and consequences of the E1E2 scenario. Intrusions that strike brine result in higher releases to the accessible environment due to direct brine release, increased likelihood of releases due to spillings, and an increase in the chances of groundwater releases into the Culebra member of the Rustler Formation above the repository.

The CCA documentation for this parameter shows that a constant probability value of 0.080 was used. Supporting documentation for this value is presented in the MASS Attachment 18-6 (Docket: A-93-02, II-G-1, Volume X, Appendix MASS) where a probability of 0.082 is recommended based on semi-variograms and ordinary Kriging analysis of drill hole data.

The geostatistical analysis correlates occurrences of brine reservoirs with disturbed areas of the Castile, using driller-reported brine encounters in a broad area of the



Castile surrounding the WIPP site. The estimated spatial correlation distance for the brine encounter data is smaller than the distance from the disposal site to WIPP-12.

The geostatistical approach ignores the local depth-to-first-conductor data obtained in the TDEM study reported in the 1992 WIPP PA. Given the large uncertainty surrounding the existence of brine in the vicinity of the disposal site, there appears to be little justification for the use of a single fixed percentage for this parameter. However, the Conceptual Models Peer Review Panel considered the impact of a change in the percentage of brine encounters on the overall CCA results to be small.

Other assumptions effect brine pockets in the model. A new feature of the conceptual model introduced for the CCA PA is the assumption that the Castile brine reservoir will experience pressure depletion due to bore holes drilled through both the excavated and unexcavated areas inside the berm. Bore holes which penetrate RH waste areas, the disturbed rock zone, and drift and panel areas also are distinguished in the model.

- *Description of input parameter development*

The index for selecting a brine pocket (ID#3194) is an LHS parameter used in the CCDFGF code. This parameter determines the size of brine pocket that may be encountered in the Castile formation beneath the WIPP. The size of the brine pocket and the initial pressure in the brine pocket are used in the BRAGFLO code to determine the potential for brine flows into the repository after penetration by drilling intrusions.

The documentation for this parameter (Docket: A-93-02, II-G-1, Volume XI, Appendix PAR, p. PAR-113) describes a discrete probability distribution with 32 equally likely integer values ranging from 1 to 32. These values are mapped to one of five possible brine pocket volume values: 32,000, 64,000, 96,000, 128,000 or 160,000 cubic meters. The assigned distribution is highly skewed toward the low end of the size range. A total of 19 of the 32 possible integer value for this variable are assigned to the smallest size brine pocket, 32,000 cubic meters. Ten integers each are assigned to the 64,000 and 96,000 cubic meters size classes. Five integers are assigned to the 128,000 cubic meter size class, and only one integer to the largest 160,000 cubic meters size category. The result is that in less than 20 percent of brine pocket encounters with the two largest size classes: 128,000 or 160,000 cubic meters, with over 80 percent of encounters being of size 96,000

cubic meters or less.

**c.5) Any necessary licenses**

This consideration is not applicable to the CCDFGF program. No licenses are required.

**c.6) An explanation of the manner in which models and computer codes incorporate the effects of parameter correlation.**

Parameter correlations for the PA as a whole are introduced in the LHS code, which is also reviewed in Appendix A-6 of this TSD. No correlations are used for parameters unique to the CCDFGF code. The CCDFGF parameters are:

1. Exponential distribution rate parameter.
2. Location in the disposal region.
3. Non-excavated, excavated CH, or excavated RH intrusion.
4. Waste stream encountered.
5. Percentage underlain by pressurized Castile brine.
6. Random selection of plugging pattern.

The CCDFGF parameters are assumed to be mutually independent, and to be independent of the LHS parameters. An assumption of pair-wise independence appears reasonable when considering most pairs in the list above.

Note that the CCDFGF code is structured to allow for correlations between locations in the repository and the probability of encountering brine, because different probabilities may be assigned for each location. However, the input file used in the CCA run has the same probability value for this parameter at all locations.

**d) The Administrator or the Administrator's authorized representative may verify results of computer simulations used to support any compliance application by performing independent simulations. Data files, source codes, executable versions of computer software for each model, other material or information needed to permit the Administrator or the Administrator's authorized representative to perform independent simulations, and access to necessary hardware to perform such simulations, shall be provided within 30 calendar days of a request by the**

## Administrator or the Administrator's authorized representative.

Independent simulation of the tests presented in the VVD was relatively straight-forward, if careful distinction is made between PA96 and PA96\_2 input and output files and executables.

- *Ability to access appropriate version of input data files*

Input data files for several generations of the code are available in the CCA-CMS. The appropriate file names are often distinguished by a "\_2" in the name. In some cases, this distinction was not clear.

- *Ability to access appropriate version of source codes*

The CCDFGF\_PA96 and CCDFGF\_PA96\_2 source codes are available in the CCA-CMS. The PA96 source code was downloaded to a PC, and an attempt was made to compile the code using Microsoft Fortran Power Station compiler for Windows 95. The Microsoft compiler reported a variety of incompatibilities with the DEC VAX Fortran code. These included unrecognized I/O keywords, such as READONLY, and one keyword name conflict, the use of the Fortran keyword INT to represent an integer variable name.

After correcting these incompatibilities, only one type of error was reported - the use of a double precision function RAN1 using a single precision name in the calling subroutine. This error occurred in the subroutines RWMB, RWDL, RWSURF, RWCULT, and RWCULF.

After consultation with the code's author, it was determined that all five subroutines where the error occurred were not used in the CCDFGF CCA calculations. The subroutines are not reported as dead code in the coverage analysis, because the code was short-circuited by inserting a Return statement as the first executable statement in each subroutine. These subroutines are designed for future use to model Marker Beds, Dewey Lake, and Culebra releases. The newer version of the PA96\_2 code does not contain this error.

- *Ability to access appropriate version of executable*

The CCDFGF\_PA96 and CCDFGF\_PA96\_2 executables are available in the CCA-CMS. Test 3 and 4 listed in the VVD were run with both versions of the executable.

- *Sufficient information to permit the verification by performing independent*

## *simulation*

Independent simulations were performed in the replication of the Validation Tests 1, 2, 3 and 4 in the VVD. These tests are discussed in Section b.1.v(9). Analyses also have been performed to implement additional tests discussed in Section b.2(10).

- *Ability to access necessary hardware to perform independent simulations*

Access to the Sandia VAX hardware was available through internet Telnet connections, after obtaining proper authorization.

## REFERENCES

Helton, J. C. 1996. *Probability, Conditional Probability, and Complementary Cumulative Distribution Functions in Performance Assessment for Radioactive Waste Disposal*. SAND95-2571, Sandia National Laboratories, Albuquerque, NM, March 1996.

Press, W. H., *et. al.*, 1992. *Numerical Recipes in FORTRAN, the Art of Scientific Computing, 2nd Ed.*, Cambridge University Press, New York, NY, 1992.

See Appendix B for a detailed listing of docket references.

## ATTACHMENT 1 - EVAL\_ Script Used for Replicate 3 in the Reconstruction of Test 1, Phase 2

### REPLICATE 3

```
(Scripts for other phases and replicates of Test 1 were derived from the sa
* File Name:          EVAL_CCGF_OCT96.INP
* Purpose:   Special-case for 10/4/96 snapshot of the CCA for CCGF.
*
* Author:    Mike Williamson, Digital Systems Integration
* Date      Jan 21, 1997
*
*           Modified March 6, 1997.  Kathy Aragon, Digital Systems Integration
*           Modified March 14, 1997. Kathy Aragon, Digital Systems Integration
*
* Description:  Contains default values for variables (file names, symbols,
*              logicals, parameters) required to start a specific instance
*              run for a CCDFGF code sequence.
*
* Note:        The * character in column 1 indicates the line is a comment.
*              Do not change any value that is in cap's.  Items in capitals
```

\* should not be changed by the user. Numerics and items in  
\* lower case may be changed by trained users.

\* The codes/steps that are accessible from this script are:

\* EPAUNI\_RH  
\* EPAUNI\_CH  
\* PRECCDFGF  
\* PRELHS  
\* LHS  
\* CCDFGF\_1  
\* CCDFSUM\_PLT\_1  
\* CCDFSUM\_ADOBE\_1

\* WARNING - run up through CCDFGF\_2 for R1, R2, and R3 before  
\* running the CCDFSUM steps. CCDFSUM expects output files from  
\* all 3 replicates and will fail without them.

\*-----  
\* GLOBAL SYMBOLS AND LOGICALS

|         |               |            |
|---------|---------------|------------|
| SYMBOL  | UNIQUE_ID     | OCT96      |
| SYMBOL  | USER_TYPE     | EPA        |
| SYMBOL  | INPUT_CLASS   | oct96      |
| SYMBOL  | REPLICATE_NUM | 3          |
| SYMBOL  | FIRST_CODE    | PRELHS     |
| SYMBOL  | LAST_CODE     | CCDFGF_1   |
| LOGICAL | WORKING_DIR   | sys\$login |

\*Do not change the following value for TOTAL\_VECTORS 100

|        |               |     |
|--------|---------------|-----|
| SYMBOL | TOTAL_VECTORS | 100 |
|--------|---------------|-----|

\*END

\*EPAUNI\_RH

|        |                        |     |        |      |                 |
|--------|------------------------|-----|--------|------|-----------------|
| INPUT  | eput_wipp_sca.rh       | EPU | CCA    | NONE | EPU_RH_FILE_INP |
| OUTPUT | eput_ccgf_cca_crh@.dat | EPU | CREATE | NONE | EPU_RH_FILE_DAT |

\*END

\*EPAUNI\_CH

|        |                        |     |        |      |                 |
|--------|------------------------|-----|--------|------|-----------------|
| INPUT  | eput_waste_st.ch       | EPU | CCA    | NONE | EPU_CH_FILE_INP |
| OUTPUT | eput_ccgf_cca_cch@.dat | EPU | CREATE | NONE | EPU_CH_FILE_DAT |

\*END

\*

\*

\*PRECCDFGF

INPUT CCGF\_CCA\_CH\_TRU.DAT CCGF CCA NONE CH\_TRU\$INP  
INPUT CCGF\_MISC\_PRE\_CCA.INP CCGF CCA NONE CCGF\_MISC\$INP  
INPUT CCDFGF.SDB SDB CCA NONE CCGF\_SDB\$INP

\*

INPUT CCGF\_CCA\_HT\_FRAC.DAT CCGF CCA NONE HT\_FRAC\$INP  
INPUT SUM\_CUSP\_CCDFGF\_R#\_S1\_L\_T5000.TBL SUM CCA NONE SUM\_CUSP\_CCGF\_CCA\$INP

\*

INPUT SUM\_PANEL\_CCA\_CON\_R#\_S1.TBL SUM CCA NONE SUM\_CCDFGF\_CCA\_CAVGE0D\$INP  
INPUT SUM\_PANEL\_CCA\_CON\_R#\_S2.TBL SUM CCA NONE SUM\_CCDFGF\_CCA\_CAVGE1D\$INP  
INPUT SUM\_BF4\_CCGF\_CCA\_R#\_S1\_L\_T100.TBL SUM CCA NONE BF4\_S1\_L\_T100\$INP  
INPUT SUM\_BF4\_CCGF\_CCA\_R#\_S1\_L\_T350.TBL SUM CCA NONE BF4\_S1\_L\_T350\$INP  
INPUT SUM\_BF4\_CCGF\_CCA\_R#\_S1\_L\_T1000.TBL SUM CCA NONE BF4\_S1\_L\_T1000\$INP  
INPUT SUM\_BF4\_CCGF\_CCA\_R#\_S1\_L\_T3000.TBL SUM CCA NONE BF4\_S1\_L\_T3000\$INP  
INPUT SUM\_BF4\_CCGF\_CCA\_R#\_S1\_L\_T5000.TBL SUM CCA NONE BF4\_S1\_L\_T5000\$INP  
INPUT SUM\_BF4\_CCGF\_CCA\_R#\_S1\_L\_T10000.TBL SUM CCA NONE BF4\_S1\_L\_T10000\$INP

\*

INPUT SUM\_BF4\_CCGF\_CCA\_R#\_S1\_U\_T100.TBL SUM CCA NONE BF4\_S1\_U\_T100\$INP  
INPUT SUM\_BF4\_CCGF\_CCA\_R#\_S1\_U\_T350.TBL SUM CCA NONE BF4\_S1\_U\_T350\$INP  
INPUT SUM\_BF4\_CCGF\_CCA\_R#\_S1\_U\_T1000.TBL SUM CCA NONE BF4\_S1\_U\_T1000\$INP  
INPUT SUM\_BF4\_CCGF\_CCA\_R#\_S1\_U\_T3000.TBL SUM CCA NONE BF4\_S1\_U\_T3000\$INP  
INPUT SUM\_BF4\_CCGF\_CCA\_R#\_S1\_U\_T5000.TBL SUM CCA NONE BF4\_S1\_U\_T5000\$INP  
INPUT SUM\_BF4\_CCGF\_CCA\_R#\_S1\_U\_T10000.TBL SUM CCA NONE BF4\_S1\_U\_T10000\$INP

\*

INPUT SUM\_BF4\_CCGF\_CCA\_R#\_S2\_L\_T550.TBL SUM CCA NONE BF4\_S2\_L\_T550\$INP  
INPUT SUM\_BF4\_CCGF\_CCA\_R#\_S2\_L\_T750.TBL SUM CCA NONE BF4\_S2\_L\_T750\$INP  
INPUT SUM\_BF4\_CCGF\_CCA\_R#\_S2\_L\_T2000.TBL SUM CCA NONE BF4\_S2\_L\_T2000\$INP  
INPUT SUM\_BF4\_CCGF\_CCA\_R#\_S2\_L\_T4000.TBL SUM CCA NONE BF4\_S2\_L\_T4000\$INP  
INPUT SUM\_BF4\_CCGF\_CCA\_R#\_S2\_L\_T10000.TBL SUM CCA NONE BF4\_S2\_L\_T10000\$INP

\*

INPUT SUM\_BF4\_CCGF\_CCA\_R#\_S2\_U\_T550.TBL SUM CCA NONE BF4\_S2\_U\_T550\$INP  
INPUT SUM\_BF4\_CCGF\_CCA\_R#\_S2\_U\_T750.TBL SUM CCA NONE BF4\_S2\_U\_T750\$INP  
INPUT SUM\_BF4\_CCGF\_CCA\_R#\_S2\_U\_T2000.TBL SUM CCA NONE BF4\_S2\_U\_T2000\$INP  
INPUT SUM\_BF4\_CCGF\_CCA\_R#\_S2\_U\_T4000.TBL SUM CCA NONE BF4\_S2\_U\_T4000\$INP  
INPUT SUM\_BF4\_CCGF\_CCA\_R#\_S2\_U\_T10000.TBL SUM CCA NONE BF4\_S2\_U\_T10000\$INP

\*

INPUT SUM\_BF4\_CCGF\_CCA\_R#\_S3\_L\_T1200.TBL SUM CCA NONE BF4\_S3\_L\_T1200\$INP  
INPUT SUM\_BF4\_CCGF\_CCA\_R#\_S3\_L\_T1400.TBL SUM CCA NONE BF4\_S3\_L\_T1400\$INP  
INPUT SUM\_BF4\_CCGF\_CCA\_R#\_S3\_L\_T3000.TBL SUM CCA NONE BF4\_S3\_L\_T3000\$INP  
INPUT SUM\_BF4\_CCGF\_CCA\_R#\_S3\_L\_T5000.TBL SUM CCA NONE BF4\_S3\_L\_T5000\$INP  
INPUT SUM\_BF4\_CCGF\_CCA\_R#\_S3\_L\_T10000.TBL SUM CCA NONE BF4\_S3\_L\_T10000\$INP

\*

|       |                                     |     |          |                       |
|-------|-------------------------------------|-----|----------|-----------------------|
| INPUT | SUM_BF4_CCGF_CCA_R#_S3_U_T1200.TBL  | SUM | CCA NONE | BF4_S3_U_T1200\$INP   |
| INPUT | SUM_BF4_CCGF_CCA_R#_S3_U_T1400.TBL  | SUM | CCA NONE | BF4_S3_U_T1400\$INP   |
| INPUT | SUM_BF4_CCGF_CCA_R#_S3_U_T3000.TBL  | SUM | CCA NONE | BF4_S3_U_T3000\$INP   |
| INPUT | SUM_BF4_CCGF_CCA_R#_S3_U_T5000.TBL  | SUM | CCA NONE | BF4_S3_U_T5000\$INP   |
| INPUT | SUM_BF4_CCGF_CCA_R#_S3_U_T10000.TBL | SUM | CCA NONE | BF4_S3_U_T10000\$INP  |
| *     |                                     |     |          |                       |
| INPUT | SUM_BF4_CCGF_CCA_R#_S4_L_T550.TBL   | SUM | CCA NONE | BF4_S4_L_T550\$INP    |
| INPUT | SUM_BF4_CCGF_CCA_R#_S4_L_T750.TBL   | SUM | CCA NONE | BF4_S4_L_T750\$INP    |
| INPUT | SUM_BF4_CCGF_CCA_R#_S4_L_T2000.TBL  | SUM | CCA NONE | BF4_S4_L_T2000\$INP   |
| INPUT | SUM_BF4_CCGF_CCA_R#_S4_L_T4000.TBL  | SUM | CCA NONE | BF4_S4_L_T4000\$INP   |
| INPUT | SUM_BF4_CCGF_CCA_R#_S4_L_T10000.TBL | SUM | CCA NONE | BF4_S4_L_T10000\$INP  |
| *     |                                     |     |          |                       |
| INPUT | SUM_BF4_CCGF_CCA_R#_S4_U_T550.TBL   | SUM | CCA NONE | BF4_S4_U_T550\$INP    |
| INPUT | SUM_BF4_CCGF_CCA_R#_S4_U_T750.TBL   | SUM | CCA NONE | BF4_S4_U_T750\$INP    |
| INPUT | SUM_BF4_CCGF_CCA_R#_S4_U_T2000.TBL  | SUM | CCA NONE | BF4_S4_U_T2000\$INP   |
| INPUT | SUM_BF4_CCGF_CCA_R#_S4_U_T4000.TBL  | SUM | CCA NONE | BF4_S4_U_T4000\$INP   |
| INPUT | SUM_BF4_CCGF_CCA_R#_S4_U_T10000.TBL | SUM | CCA NONE | BF4_S4_U_T10000\$INP  |
| *     |                                     |     |          |                       |
| INPUT | SUM_BF4_CCGF_CCA_R#_S5_L_T1200.TBL  | SUM | CCA NONE | BF4_S5_L_T1200\$INP   |
| INPUT | SUM_BF4_CCGF_CCA_R#_S5_L_T1400.TBL  | SUM | CCA NONE | BF4_S5_L_T1400\$INP   |
| INPUT | SUM_BF4_CCGF_CCA_R#_S5_L_T3000.TBL  | SUM | CCA NONE | BF4_S5_L_T3000\$INP   |
| INPUT | SUM_BF4_CCGF_CCA_R#_S5_L_T5000.TBL  | SUM | CCA NONE | BF4_S5_L_T5000\$INP   |
| INPUT | SUM_BF4_CCGF_CCA_R#_S5_L_T10000.TBL | SUM | CCA NONE | BF4_S5_L_T10000\$INP  |
| *     |                                     |     |          |                       |
| INPUT | SUM_BF4_CCGF_CCA_R#_S5_U_T1200.TBL  | SUM | CCA NONE | BF4_S5_U_T1200\$INP   |
| INPUT | SUM_BF4_CCGF_CCA_R#_S5_U_T1400.TBL  | SUM | CCA NONE | BF4_S5_U_T1400\$INP   |
| INPUT | SUM_BF4_CCGF_CCA_R#_S5_U_T3000.TBL  | SUM | CCA NONE | BF4_S5_U_T3000\$INP   |
| INPUT | SUM_BF4_CCGF_CCA_R#_S5_U_T5000.TBL  | SUM | CCA NONE | BF4_S5_U_T5000\$INP   |
| INPUT | SUM_BF4_CCGF_CCA_R#_S5_U_T10000.TBL | SUM | CCA NONE | BF4_S5_U_T10000\$INP  |
| *     |                                     |     |          |                       |
| INPUT | SUM_CUSP_CCDFGF_R#_S1_L_T100.TBL    | SUM | CCA NONE | CUSP_S1_L_T100\$INP   |
| INPUT | SUM_CUSP_CCDFGF_R#_S1_L_T350.TBL    | SUM | CCA NONE | CUSP_S1_L_T350\$INP   |
| INPUT | SUM_CUSP_CCDFGF_R#_S1_L_T1000.TBL   | SUM | CCA NONE | CUSP_S1_L_T1000\$INP  |
| INPUT | SUM_CUSP_CCDFGF_R#_S1_L_T3000.TBL   | SUM | CCA NONE | CUSP_S1_L_T3000\$INP  |
| INPUT | SUM_CUSP_CCDFGF_R#_S1_L_T5000.TBL   | SUM | CCA NONE | CUSP_S1_L_T5000\$INP  |
| INPUT | SUM_CUSP_CCDFGF_R#_S1_L_T10000.TBL  | SUM | CCA NONE | CUSP_S1_L_T10000\$INP |
| *     |                                     |     |          |                       |
| INPUT | SUM_CUSP_CCDFGF_R#_S1_U_T100.TBL    | SUM | CCA NONE | CUSP_S1_U_T100\$INP   |
| INPUT | SUM_CUSP_CCDFGF_R#_S1_U_T350.TBL    | SUM | CCA NONE | CUSP_S1_U_T350\$INP   |
| INPUT | SUM_CUSP_CCDFGF_R#_S1_U_T1000.TBL   | SUM | CCA NONE | CUSP_S1_U_T1000\$INP  |
| INPUT | SUM_CUSP_CCDFGF_R#_S1_U_T3000.TBL   | SUM | CCA NONE | CUSP_S1_U_T3000\$INP  |
| INPUT | SUM_CUSP_CCDFGF_R#_S1_U_T5000.TBL   | SUM | CCA NONE | CUSP_S1_U_T5000\$INP  |

|       |                                    |     |                                |
|-------|------------------------------------|-----|--------------------------------|
| INPUT | SUM_CUSP_CCDFGF_R#_S1_U_T10000.TBL | SUM | CCA NONE CUSP_S1_U_T10000\$INP |
| *     |                                    |     |                                |
| INPUT | SUM_CUSP_CCDFGF_R#_S2_L_T550.TBL   | SUM | CCA NONE CUSP_S2_L_T550\$INP   |
| INPUT | SUM_CUSP_CCDFGF_R#_S2_L_T750.TBL   | SUM | CCA NONE CUSP_S2_L_T750\$INP   |
| INPUT | SUM_CUSP_CCDFGF_R#_S2_L_T2000.TBL  | SUM | CCA NONE CUSP_S2_L_T2000\$INP  |
| INPUT | SUM_CUSP_CCDFGF_R#_S2_L_T4000.TBL  | SUM | CCA NONE CUSP_S2_L_T4000\$INP  |
| INPUT | SUM_CUSP_CCDFGF_R#_S2_L_T10000.TBL | SUM | CCA NONE CUSP_S2_L_T10000\$INP |
| *     |                                    |     |                                |
| INPUT | SUM_CUSP_CCDFGF_R#_S2_U_T550.TBL   | SUM | CCA NONE CUSP_S2_U_T550\$INP   |
| INPUT | SUM_CUSP_CCDFGF_R#_S2_U_T750.TBL   | SUM | CCA NONE CUSP_S2_U_T750\$INP   |
| INPUT | SUM_CUSP_CCDFGF_R#_S2_U_T2000.TBL  | SUM | CCA NONE CUSP_S2_U_T2000\$INP  |
| INPUT | SUM_CUSP_CCDFGF_R#_S2_U_T4000.TBL  | SUM | CCA NONE CUSP_S2_U_T4000\$INP  |
| INPUT | SUM_CUSP_CCDFGF_R#_S2_U_T10000.TBL | SUM | CCA NONE CUSP_S2_U_T10000\$INP |
| *     |                                    |     |                                |
| INPUT | SUM_CUSP_CCDFGF_R#_S3_L_T1200.TBL  | SUM | CCA NONE CUSP_S3_L_T1200\$INP  |
| INPUT | SUM_CUSP_CCDFGF_R#_S3_L_T1400.TBL  | SUM | CCA NONE CUSP_S3_L_T1400\$INP  |
| INPUT | SUM_CUSP_CCDFGF_R#_S3_L_T3000.TBL  | SUM | CCA NONE CUSP_S3_L_T3000\$INP  |
| INPUT | SUM_CUSP_CCDFGF_R#_S3_L_T5000.TBL  | SUM | CCA NONE CUSP_S3_L_T5000\$INP  |
| INPUT | SUM_CUSP_CCDFGF_R#_S3_L_T10000.TBL | SUM | CCA NONE CUSP_S3_L_T10000\$INP |
| *     |                                    |     |                                |
| INPUT | SUM_CUSP_CCDFGF_R#_S3_U_T1200.TBL  | SUM | CCA NONE CUSP_S3_U_T1200\$INP  |
| INPUT | SUM_CUSP_CCDFGF_R#_S3_U_T1400.TBL  | SUM | CCA NONE CUSP_S3_U_T1400\$INP  |
| INPUT | SUM_CUSP_CCDFGF_R#_S3_U_T3000.TBL  | SUM | CCA NONE CUSP_S3_U_T3000\$INP  |
| INPUT | SUM_CUSP_CCDFGF_R#_S3_U_T5000.TBL  | SUM | CCA NONE CUSP_S3_U_T5000\$INP  |
| INPUT | SUM_CUSP_CCDFGF_R#_S3_U_T10000.TBL | SUM | CCA NONE CUSP_S3_U_T10000\$INP |
| *     |                                    |     |                                |
| INPUT | SUM_CUSP_CCDFGF_R#_S4_L_T550.TBL   | SUM | CCA NONE CUSP_S4_L_T550\$INP   |
| INPUT | SUM_CUSP_CCDFGF_R#_S4_L_T750.TBL   | SUM | CCA NONE CUSP_S4_L_T750\$INP   |
| INPUT | SUM_CUSP_CCDFGF_R#_S4_L_T2000.TBL  | SUM | CCA NONE CUSP_S4_L_T2000\$INP  |
| INPUT | SUM_CUSP_CCDFGF_R#_S4_L_T4000.TBL  | SUM | CCA NONE CUSP_S4_L_T4000\$INP  |
| INPUT | SUM_CUSP_CCDFGF_R#_S4_L_T10000.TBL | SUM | CCA NONE CUSP_S4_L_T10000\$INP |
| *     |                                    |     |                                |
| INPUT | SUM_CUSP_CCDFGF_R#_S4_U_T550.TBL   | SUM | CCA NONE CUSP_S4_U_T550\$INP   |
| INPUT | SUM_CUSP_CCDFGF_R#_S4_U_T750.TBL   | SUM | CCA NONE CUSP_S4_U_T750\$INP   |
| INPUT | SUM_CUSP_CCDFGF_R#_S4_U_T2000.TBL  | SUM | CCA NONE CUSP_S4_U_T2000\$INP  |
| INPUT | SUM_CUSP_CCDFGF_R#_S4_U_T4000.TBL  | SUM | CCA NONE CUSP_S4_U_T4000\$INP  |
| INPUT | SUM_CUSP_CCDFGF_R#_S4_U_T10000.TBL | SUM | CCA NONE CUSP_S4_U_T10000\$INP |
| *     |                                    |     |                                |
| INPUT | SUM_CUSP_CCDFGF_R#_S5_L_T1200.TBL  | SUM | CCA NONE CUSP_S5_L_T1200\$INP  |
| INPUT | SUM_CUSP_CCDFGF_R#_S5_L_T1400.TBL  | SUM | CCA NONE CUSP_S5_L_T1400\$INP  |
| INPUT | SUM_CUSP_CCDFGF_R#_S5_L_T3000.TBL  | SUM | CCA NONE CUSP_S5_L_T3000\$INP  |
| INPUT | SUM_CUSP_CCDFGF_R#_S5_L_T5000.TBL  | SUM | CCA NONE CUSP_S5_L_T5000\$INP  |



```

INPUT SUM_CUSP_CCDFGF_R#_S5_L_T10000.TBL  SUM  CCA NONE CUSP_S5_L_T10000$INP
*
INPUT SUM_CUSP_CCDFGF_R#_S5_U_T1200.TBL  SUM  CCA NONE CUSP_S5_U_T1200$INP
INPUT SUM_CUSP_CCDFGF_R#_S5_U_T1400.TBL  SUM  CCA NONE CUSP_S5_U_T1400$INP
INPUT SUM_CUSP_CCDFGF_R#_S5_U_T3000.TBL  SUM  CCA NONE CUSP_S5_U_T3000$INP
INPUT SUM_CUSP_CCDFGF_R#_S5_U_T5000.TBL  SUM  CCA NONE CUSP_S5_U_T5000$INP
INPUT SUM_CUSP_CCDFGF_R#_S5_U_T10000.TBL SUM  CCA NONE CUSP_S5_U_T10000$INP
*
INPUT SUM_ST_CCGF_CCA_R#_S1.TBL          SUM  CCA NONE ALG_ST_CCGF_CCA_S1$INP
INPUT SUM_ST_CCGF_CCA_R#_S2.TBL          SUM  CCA NONE ALG_ST_CCGF_CCA_S2$INP
*
INPUT SUM_NUT_CCGF_CCA_R#_S1.TBL          SUM  CCA NONE SUM_NUTS_S1$INP
INPUT SUM_NUT_CCGF_CCA_R#_S2_T100.TBL     SUM  CCA NONE SUM_NUTS_S2_100$INP
INPUT SUM_NUT_CCGF_CCA_R#_S2_T350.TBL     SUM  CCA NONE SUM_NUTS_S2_350$INP
INPUT SUM_NUT_CCGF_CCA_R#_S3_T1000.TBL    SUM  CCA NONE SUM_NUTS_S3_1000$INP
INPUT SUM_NUT_CCGF_CCA_R#_S3_T3000.TBL    SUM  CCA NONE SUM_NUTS_S3_3000$INP
INPUT SUM_NUT_CCGF_CCA_R#_S3_T5000.TBL    SUM  CCA NONE SUM_NUTS_S3_5000$INP
INPUT SUM_NUT_CCGF_CCA_R#_S3_T7000.TBL    SUM  CCA NONE SUM_NUTS_S3_7000$INP
INPUT SUM_NUT_CCGF_CCA_R#_S3_T9000.TBL    SUM  CCA NONE SUM_NUTS_S3_9000$INP
*
INPUT SUM_NUT_CCGF_CCA_R#_S4_T100.TBL     SUM  CCA NONE SUM_NUTS_S4_100$INP
INPUT SUM_NUT_CCGF_CCA_R#_S4_T350.TBL     SUM  CCA NONE SUM_NUTS_S4_350$INP
INPUT SUM_NUT_CCGF_CCA_R#_S5_T1000.TBL    SUM  CCA NONE SUM_NUTS_S5_1000$INP
INPUT SUM_NUT_CCGF_CCA_R#_S5_T3000.TBL    SUM  CCA NONE SUM_NUTS_S5_3000$INP
INPUT SUM_NUT_CCGF_CCA_R#_S5_T5000.TBL    SUM  CCA NONE SUM_NUTS_S5_5000$INP
INPUT SUM_NUT_CCGF_CCA_R#_S5_T7000.TBL    SUM  CCA NONE SUM_NUTS_S5_7000$INP
INPUT SUM_NUT_CCGF_CCA_R#_S5_T9000.TBL    SUM  CCA NONE SUM_NUTS_S5_9000$INP
*
INPUT SUM_PANEL_CCDFGF_R#_S6_100.TBL      SUM  CCA NONE SUM_PNL_S6_100$INP
INPUT SUM_PANEL_CCDFGF_R#_S6_350.TBL      SUM  CCA NONE SUM_PNL_S6_350$INP
INPUT SUM_PANEL_CCDFGF_R#_S6_1000.TBL     SUM  CCA NONE SUM_PNL_S6_1000$INP
INPUT SUM_PANEL_CCDFGF_R#_S6_2000.TBL     SUM  CCA NONE SUM_PNL_S6_2000$INP
INPUT SUM_PANEL_CCDFGF_R#_S6_4000.TBL     SUM  CCA NONE SUM_PNL_S6_4000$INP
INPUT SUM_PANEL_CCDFGF_R#_S6_6000.TBL     SUM  CCA NONE SUM_PNL_S6_6000$INP
INPUT SUM_PANEL_CCDFGF_R#_S6_9000.TBL     SUM  CCA NONE SUM_PNL_S6_9000$INP
*
INPUT SUM_ST2D3_CCGF_CCA_R#_PM.TBL        SUM  CCA NONE ST2D3_CCA_PM$INP
INPUT SUM_ST2D3_CCGF_CCA_R#_FM.TBL        SUM  CCA NONE ST2D3_CCA_FM$INP
*
OUTPUT CCGF_CCDFGF_CCA_r#@.out            EPA_CCGF CREATE NONE CCGF_PRT$OUT
OUTPUT CCGF_CCA_r#@.OUT                   EPA_CCGF CREATE NONE CCGF$OUT
OUTPUT CCGF_CUTTING_CCA_R#@.TRN          CCGF      CREATE NONE CCGF_CUTTING$OUT

```

```

OUTPUT CCGF_BLOWOUT_CCA_R#@.TRN      EPA_CCGF CREATE NONE CCGF_BLOWOUT$OUT
OUTPUT CCGF_SPALLING_CCA_R#@.TRN     EPA_CCGF CREATE NONE CCGF_SPALLING$OUT
OUTPUT CCGF_NUT_CCA_R#@.TRN          EPA_CCGF CREATE NONE CCGF_NUTS$OUT
OUTPUT CCGF_SECOTP_CCA_R#@.TRN       EPA_CCGF CREATE NONE CCGF_SECOTP$OUT
OUTPUT CCGF_RELTAB_CCA_R#@.DAT       EPA_CCGF CREATE EPA_CCGF CCGF_RELTAB$OUT
*
*END
*
*PRELHS
SYMBOL          LHSDB          WIPP::WIPP_DB
SYMBOL          LHSCALC         CCA9
INPUT  lhs1_ccgf_r#.inp          LHS  CCA      NONE  LHS1_FILE_INP
OUTPUT lhs1_ccgf_trn_r#@.out     LHS  CREATE  NONE  LHS1_FILE_TRN
OUTPUT lhs1_ccgf_r#@.out         LHS  CREATE  NONE  LHS1_FILE_OUT
*END
*
*LHS
OUTPUT lhs2_ccgf_trn_r#@.out     LHS  CREATE  NONE  LHS2_FILE_TRN
OUTPUT lhs2_ccgf_dbg_r#@.out     LHS  CREATE  NONE  LHS2_FILE_DBG
*END
*
*
*CCDFGF_1
INPUT  ccgf_misc_postcca_verbose_1.inp  CCGF  CCA  NONE  CCGF_1_MISC_FILE_INP
INPUT  ccgf_node3_cca.inp              CCGF  CCA  NONE  CCGF_1_NODE3_FILE_INP
INPUT  ccgf_inv5_cca.inp               CCGF  CCA  NONE  CCGF_1_INV5_FILE_INP
INPUT  ccgf_region_cca.inp            CCGF  CCA  NONE  CCGF_1_REGION_FILE_INP
INPUT  CCDFGF.SDB                     SDB   CCA  NONE  CCGF_1_SDB_FILE_INP
INPUT  ccgf_reltab_cca_R#@.dat         EPA_CCGF EPA  NONE  CCGF_1_RELTAB_FILE_INP
OUTPUT ccgf_ccdfgf_r#_1@.out          CCGF  CREATE EPA_CCGF CCGF_1_FILE_PRT
OUTPUT ccgf_r#_1@.out                 CCGF  CREATE EPA_CCGF CCGF_1_FILE_OUT
*END
*
*
*CCDFSUM_PLT_1
INPUT  ccgf_r1_1@.out  EPA_CCGF EPA NONE CCDFSUM_FILE_INP1
INPUT  ccgf_r2_1@.out  EPA_CCGF EPA NONE CCDFSUM_FILE_INP2
INPUT  ccgf_r3_1@.out  EPA_CCGF EPA NONE CCDFSUM_FILE_INP3
INPUT  ccgf_ccdfsum_cca.inp          CCGF      CCA NONE CCDFSUM_PLT_1_FILE_INP
OUTPUT ccgf_ccdfsum_1a@.out CCGF  CREATE EPA_CCGF CCDFSUM_PLT_1_FILE_OUT
*END
*

```

```

*CCDFSUM_ADOBE_1
  INPUT  ccgf ccdsum cca.inp          CCGF CCA    NONE    CCDFSUM ADOBE 1
  OUTPUT ccgf_ccdsum_1@.pi    CCGF CREATE EPA_CCGF CCDFSUM_ADOBE_1_FILE_TMP
  OUTPUT ccgf_ccdsum_1@.pi_* CCGF CREATE EPA_CCGF CCDFSUM_ADOBE_1_FILE_OUT
*END
*
*-----
*Substitutions are preformed in file names (INPUT and OUTPUT records only)
*as follows:
*  # - replicate number ( 1,2,3 )
*  + - substitute with local node name (used for node name based
*      disk names like disk$beatle_ccal.
*  @ - id field to be added at run time, depending on the value of unique_id.
*      When the symbol "unique_id" is provided (in the first group of symbols,
*      that will be used for the id field. This allows users to run
*      partial jobs, using unique id's, and later run additional steps.
*      The old time stamp will be put into the new steps to keep names
*      consistent.
*
* Record types and layouts - all fields are delimited with spaces or tabs.
*
* SYMBOL param_name param_value
*   param_name      - symbol name to be created
*   param_value     - symbol value to be assigned
*
* LOGICAL
*   logical_name    - logical name to be created
*   logical_value   - logical value to be assigned.
*
* INPUT
* OUTPUT
*   file_name       - File name
*   code_prefix     - The code prefix assigned by the CMS librarian.
*   file_loc        - CCA, EPA,WORKING_DIR.
*   file_disp       - NONE, EPA_XXX. If the file is to be
*                   stored in CMS after the run.
*   file_id         - Symbol used in the program, do not change.
*   dependencies    - list of downstream codes that use the file
*                   (if any), this is only used for documentation.
*-----

```

## OUTPUTS FROM THE DIFFERENCE PROGRAM COMPARING THE CMS AND RECONSTRUCTED VERSIONS OF THE TEST 1 OUTPUT

## FILES

### TEST 1, PHASE 1, REPLICATE 1

Number of difference sections found: 0

Number of difference records found: 0

```
DIFFERENCES /IGNORE=()/MERGED=1/OUTPUT=$2$DKB400:[ROOT.HJCHMEL.DOUBLE_R]RELT1 DIF
    $2$DKB400:[ROOT.HJCHMEL.DOUBLE_R]RELTABR1.DAT;1-
    $2$DKB400:[ROOT.HJCHMEL.DOUBLE_R]RELTABR1.NEW;1
```

### TEST 1, PHASE 1, REPLICATE 2

Number of difference sections found: 0

Number of difference records found: 0

```
DIFFERENCES /IGNORE=()/MERGED=1/OUTPUT=$2$DKB400:[ROOT.HJCHMEL.DOUBLE_R]RELT2 DIF
    $2$DKB400:[ROOT.HJCHMEL.DOUBLE_R]RELTABR2.DAT;1-
    $2$DKB400:[ROOT.HJCHMEL.DOUBLE_R]RELTABR2.NEW;1
```

### TEST 1, PHASE 1, REPLICATE 3

Number of difference sections found: 0

Number of difference records found: 0

```
DIFFERENCES /IGNORE=()/MERGED=1/OUTPUT=$2$DKB400:[ROOT.HJCHMEL.DOUBLE_R]RELT3 DIF
    $2$DKB400:[ROOT.HJCHMEL.DOUBLE_R]RELTABR3.DAT;1-
    $2$DKB400:[ROOT.HJCHMEL.DOUBLE_R]RELTABR3.NEW;1
```

## OUTPUTS FROM THE DIFFERENCE PROGRAM COMPARING THE CMS AND RECONSTRUCTED VERSIONS OF THE TEST 1 OUTPUT FILES

### TEST 1, PHASE 2, REPLICATE 1

Number of difference sections found: 0

Number of difference records found: 0

```
DIFFERENCES /IGNORE=()/MERGED=1/OUTPUT=$2$DKB400:[ROOT.HJCHMEL.TESTCMS.CCDFGF_1]C
    $2$DKB400:[ROOT.HJCHMEL.TESTCMS.CCDFGF_1]CCGF_POSTCCA_R1_VERBOSE_1.OUT;1-
    $2$DKB400:[ROOT.HJCHMEL.TESTCMS.CCDFGF_1]CCGF_R1_1_OCT96.OUT;1
```

### TEST 1, PHASE 2, REPLICATE 2

Number of difference sections found: 0

Number of difference records found: 0

```
DIFFERENCES /IGNORE=()/MERGED=1/OUTPUT=$2$DKB400:[ROOT.HJCHMEL.TESTCMS.CCDFGF_1]C
    $2$DKB400:[ROOT.HJCHMEL.TESTCMS.CCDFGF_1]CCGF_POSTCCA_R2_VERBOSE_1.OUT;1-
    $2$DKB400:[ROOT.HJCHMEL.TESTCMS.CCDFGF_1]CCGF_R2_1_OCT96.OUT;1
```

### TEST 1, PHASE 2, REPLICATE 3

Number of difference sections found: 0

Number of difference records found: 0

```
DIFFERENCES /IGNORE=()/MERGED=1/OUTPUT=$2$DKB400:[ROOT.HJCHMEL.TESTCMS.CCDFGF 1]C
$2$DKB400:[ROOT.HJCHMEL.TESTCMS.CCDFGF_1]CCGF_POSTCCA_R3_VERBOSE_1.OUT;1-
$2$DKB400:[ROOT.HJCHMEL.TESTCMS.CCDFGF_1]CCGF_R3_1_OCT96.OUT;1
```

## TEST 1, PHASE 3

Number of difference sections found: 0

Number of difference records found: 0

```
DIFFERENCES /IGNORE=()/MERGED=1/OUTPUT=$2$DKB400:[ROOT.HJCHMEL.TESTCMS.CCDFSUM PL
$2$DKB400:[ROOT.HJCHMEL.TESTCMS.CCDFSUM_PLT]CCGF_CCDFSUM_1A_OCT96.OUT;2-
$2$DKB400:[ROOT.HJCHMEL.TESTCMS.CCDFSUM PLT]CCGF CCDFSUM POSTCCA VERBOSE 1A.P
```

## OUTPUT FROM THE DIFFERENCE PROGRAM COMPARING THE CMS AND RECONSTRUCTED VERSIONS OF THE TEST 2 OUTPUT FILE

### TEST 2

Number of difference sections found: 0

Number of difference records found: 0

```
DIFFERENCES /IGNORE=()/MERGED=1/OUTPUT=$2$DKB400:[ROOT.HJCHMEL.DOUBLE R]CCGF DIFF
$2$DKB400:[ROOT.HJCHMEL.DOUBLE_R]CCGF_T2_PA96.OUT;1-
$2$DKB400:[ROOT.HJCHMEL.DOUBLE_R]CCGF_T2_PA96.NEW;1
```

## INPUT FILES FOR THE RECONSTRUCTION OF TEST 1

### CCGF\_MISC\_POSTCCA\_VERBOSE\_1.INP

```
TEST CASE FOR WIPP DRILLING INTRUSION SCENARIO
(SECOND TITLE RECORD)
3 10000 NUMBER OF OBS, NUMBER OF FUTURES PER OBS
0 0 2 1 OPTIONS (0=NORMAL,1=PREPROC)(0=TABLES,1=GRIDFLO)(1=VAR,2=CONST)(1
1 3 NUMBER OF OBS FOR DETAILED PRINT, OBS INDICES
40 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
29 30 31 32 33 34 35 36 37 38 39 40 NUMBER OF FUTURES FOR DETAILED PRINT, FUTURE
100. 0.0 INITIAL AND SUBSEQUENT ADMIN CONTROL TIMES (YR)
100. 10000. 1.0E6 1.0E6 TS LIMIT (YR), END TIME (YR), RESET TS (YR), PRT FRQ
4.07E6 TOTAL ACTIVITY IN REPOSITORY (CI)
0.6285 TOTAL AREA OF DISPOSAL REGION (KM2)
1.632E7 TOTAL MASS OF SOLIDS IN REPOSITORY (KG)
823. 140. ELEVATIONS (M) FOR CULEBRA AND CASTILLE
87. 1078. PRESSURE HEADS (M) FOR CULEBRA AND CASTILLE
46.8 10000. 600. 0.01 NUMBER OF INTRUSIONS, TIME PERIOD (YR), TRANSITION TIME
1.00E-4 600. 0.01 MINING INTRUSION RATE (1/YR), TRANSITION TIME (YR), INITIA
0.31115 0.31115 0.31115 BOREHOLE DIAMETER RANGE AND MODE ABOVE REPOSITORY (M)
0.31115 0.31115 0.31115 BOREHOLE DIAMETER RANGE AND MODE BELOW REPOSITORY (M)
1.0E-9 1.0E-9 1.0E-9 BOREHOLE PERMEABILITY RANGE AND MODE ABOVE REPOSITORY
1.0E-9 1.0E-9 1.0E-9 BOREHOLE PERMEABILITY RANGE AND MODE BELOW REPOSITORY
```

```

1230.          BRINE DENSITY (KG/M3)
1.8E-3        BRINE VISCOSITY (KG/M/S)
1            NUMBER OF REGIONS
0.0 1.115E5 1.576E4  REGION 1 PENETRATION PROB EACH WASTE TYPE (NONE,CH,RH)
3 1          NUMBER OF WASTE STREAMS TO AVG FOR CH WASTES AND RH WASTES
1          NUMBER OF BRINE POCKETS
31 1000      LHS VAR DEplete INDEX (0=LHS NOT USED), NUMBER OF INTRUSIONS
0.02 0.68 0.30 PLUGGING PATTERN PROBABILITIES (MUST BE 3 VALUES)
0.50        CUTOFF FRACTION FOR BUFFER SOLUBILITY LIMIT EFFECT
0          1000 SPALLINGS REFERENCE (1=AFTER E1) AND NUMBER OF INTRUSIONS
0          1000 BLOWOUT REFERENCE (1=AFTER E1) AND NUMBER OF INTRUSIONS
9.80665     ACCELERATION DUE TO GRAVIY (M/S2)
3.14159     PI
-1701       RANDOM NUMBER GENERATOR SEED (MUST BE NEGATIVE)
1.0E-6      RELATIVE ROUNDOFF TOLERANCE
1.0E-10     RELATIVE PRESSURE TOLERANCE

```

## INPUT FILES FOR THE RECONSTRUCTION OF TEST 2

### CCGF\_MISC\_T2.INP

```

TEST CASE FOR WIPP DRILLING INTRUSION SCENARIO
(SECOND TITLE RECORD)
3 10000      NUMBER OF OBS, NUMBER OF FUTURES PER OBS
0 0 2 1      OPTIONS (0=NORMAL,1=PREPROC)(0=TABLES,1=GRIDFLO)(1=VAR,2=CONST)(1
1 3          NUMBER OF OBS FOR DETAILED PRINT, OBS INDICES
40 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
29 30 31 32 33 34 35 36 37 38 39 40  NUMBER OF FUTURES FOR DETAILED PRINT, FUTURE
100. 0.0     INITIAL AND SUBSEQUENT ADMIN CONTROL TIMES (YR)
100. 10000. 1.0E6 1.0E6  TS LIMIT (YR), END TIME (YR), RESET TS (YR), PRT FRQ
4.07E6      TOTAL ACTIVITY IN REPOSITORY (CI)
0.6285     TOTAL AREA OF DISPOSAL REGION (KM2)
1.632E7    TOTAL MASS OF SOLIDS IN REPOSITORY (KG)
823.      140.  ELEVATIONS (M) FOR CULEBRA AND CASTILLE
87.      1078.  PRESSURE HEADS (M) FOR CULEBRA AND CASTILLE
46.8 10000. 600. 0.01 NUMBER OF INTRUSIONS, TIME PERIOD (YR), TRANSITION TIME
1.00E-4 600. 0.01 MINING INTRUSION RATE (1/YR), TRANSITION TIME (YR), INITIA
0.31115 0.31115 0.31115 BOREHOLE DIAMETER RANGE AND MODE ABOVE REPOSITORY (M)
0.31115 0.31115 0.31115 BOREHOLE DIAMETER RANGE AND MODE BELOW REPOSITORY (M)
1.0E-9 1.0E-9 1.0E-9 BOREHOLE PERMEABILITY RANGE AND MODE ABOVE REPOSITORY
1.0E-9 1.0E-9 1.0E-9 BOREHOLE PERMEABILITY RANGE AND MODE BELOW REPOSITORY
1230.          BRINE DENSITY (KG/M3)
1.8E-3        BRINE VISCOSITY (KG/M/S)
1            NUMBER OF REGIONS

```

0.0 1.115E5 1.576E4 REGION 1 PENETRATION PROB EACH WASTE TYPE (NONE,CH,RH)  
3 1 NUMBER OF WASTE STREAMS TO AVG FOR CH WASTES AND RH WASTES  
1 NUMBER OF BRINE POCKETS  
31 1000 LHS VAR DEplete INDEX (0=LHS NOT USED), NUMBER OF INTRUSIONS  
0.02 0.68 0.30 PLUGGING PATTERN PROBABILITIES (MUST BE 3 VALUES)  
0.50 CUTOFF FRACTION FOR BUFFER SOLUBILITY LIMIT EFFECT  
0 1000 SPALLINGS REFERENCE (1=AFTER E1) AND NUMBER OF INTRUSIONS  
0 1000 BLOWOUT REFERENCE (1=AFTER E1) AND NUMBER OF INTRUSIONS  
9.80665 ACCELERATION DUE TO GRAVIY (M/S2)  
3.14159 PI  
-1701 RANDOM NUMBER GENERATOR SEED (MUST BE NEGATIVE)  
1.0E-6 RELATIVE ROUND OFF TOLERANCE  
1.0E-10 RELATIVE PRESSURE TOLERANCE  
INPUT FILES FOR THE RECONSTRUCTION OF TEST 3  
CCGF\_MISC\_T3.INP  
TEST CASE FOR WIPP DRILLING INTRUSION SCENARIO  
(SECOND TITLE RECORD)  
3 10000 NUMBER OF OBS, NUMBER OF FUTURES PER OBS  
0 0 2 1 OPTIONS (0=NORMAL,1=PREPROC)(0=TABLES,1=GRIDFLO)(1=VAR,2=CONST)(1  
1 3 NUMBER OF OBS FOR DETAILED PRINT, OBS INDICES  
40 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28  
29 30 31 32 33 34 35 36 37 38 39 40 NUMBER OF FUTURES FOR DETAILED PRINT, FUTURE  
100. 0.0 INITIAL AND SUBSEQUENT ADMIN CONTROL TIMES (YR)  
100. 10000. 1.0E6 1.0E6 TS LIMIT (YR), END TIME (YR), RESET TS (YR), PRT FRQ  
4.07E6 TOTAL ACTIVITY IN REPOSITORY (CI)  
0.6285 TOTAL AREA OF DISPOSAL REGION (KM2)  
1.632E7 TOTAL MASS OF SOLIDS IN REPOSITORY (KG)  
823. 140. ELEVATIONS (M) FOR CULEBRA AND CASTILLE  
87. 1078. PRESSURE HEADS (M) FOR CULEBRA AND CASTILLE  
46.8 10000. 600. 0.01 NUMBER OF INTRUSIONS, TIME PERIOD (YR), TRANSITION TIME  
1.00E-4 600. 0.01 MINING INTRUSION RATE (1/YR), TRANSITION TIME (YR), INITIA  
0.31115 0.31115 0.31115 BOREHOLE DIAMETER RANGE AND MODE ABOVE REPOSITORY (M)  
0.31115 0.31115 0.31115 BOREHOLE DIAMETER RANGE AND MODE BELOW REPOSITORY (M)  
1.0E-9 1.0E-9 1.0E-9 BOREHOLE PERMEABILITY RANGE AND MODE ABOVE REPOSITORY  
1.0E-9 1.0E-9 1.0E-9 BOREHOLE PERMEABILITY RANGE AND MODE BELOW REPOSITORY  
1230. BRINE DENSITY (KG/M3)  
1.8E-3 BRINE VISCOSITY (KG/M/S)  
1 NUMBER OF REGIONS  
0.0 1.115E5 1.576E4 REGION 1 PENETRATION PROB EACH WASTE TYPE (NONE,CH,RH)  
3 1 NUMBER OF WASTE STREAMS TO AVG FOR CH WASTES AND RH WASTES  
1 NUMBER OF BRINE POCKETS  
31 1000 LHS VAR DEplete INDEX (0=LHS NOT USED), NUMBER OF INTRUSIONS

0.02 0.68 0.30 PLUGGING PATTERN PROBABILITIES (MUST BE 3 VALUES)  
 0.50 CUTOFF FRACTION FOR BUFFER SOLUBILITY LIMIT EFFECT  
 0 1000 SPALLINGS REFERENCE (1=AFTER E1) AND NUMBER OF INTRUSIONS  
 0 1000 BLOWOUT REFERENCE (1=AFTER E1) AND NUMBER OF INTRUSIONS  
 9.80665 ACCELERATION DUE TO GRAVITY (M/S<sup>2</sup>)  
 3.14159 PI  
 -1701 RANDOM NUMBER GENERATOR SEED (MUST BE NEGATIVE)  
 1.0E-6 RELATIVE ROUNDOFF TOLERANCE  
 1.0E-10 RELATIVE PRESSURE TOLERANCE

## INPUT FILES FOR THE RECONSTRUCTION OF TEST 4

### CCGF\_MISC\_T4.INP

TEST CASE FOR WIPP DRILLING INTRUSION SCENARIO  
 (SECOND TITLE RECORD)

1 20 NUMBER OF OBS, NUMBER OF FUTURES PER OBS  
 0 0 2 1 OPTIONS (0=NORMAL,1=PREPROC)(0=TABLES,1=GRIDFLO)(1=VAR,2=CONST)(1  
 1 1 NUMBER OF OBS FOR DETAILED PRINT, OBS INDICES  
 20 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 NUMBER OF FUTURES FOR D  
 100. 0.0 INITIAL AND SUBSEQUENT ADMIN CONTROL TIMES (YR)  
 100. 10000. 1.0E6 1.0E6 TS LIMIT (YR), END TIME (YR), RESET TS (YR), PRT FRQ  
 4.07E6 TOTAL ACTIVITY IN REPOSITORY (CI)  
 0.6285 TOTAL AREA OF DISPOSAL REGION (KM<sup>2</sup>)  
 1.632E7 TOTAL MASS OF SOLIDS IN REPOSITORY (KG)  
 823. 140. ELEVATIONS (M) FOR CULEBRA AND CASTILLE  
 87. 1078. PRESSURE HEADS (M) FOR CULEBRA AND CASTILLE  
 46.8 10000. 600. 0.01 NUMBER OF INTRUSIONS, TIME PERIOD (YR), TRANSITION TIME  
 1.00E-4 600. 0.01 MINING INTRUSION RATE (1/YR), TRANSITION TIME (YR), INITIA  
 0.31115 0.31115 0.31115 BOREHOLE DIAMETER RANGE AND MODE ABOVE REPOSITORY (M)  
 0.31115 0.31115 0.31115 BOREHOLE DIAMETER RANGE AND MODE BELOW REPOSITORY (M)  
 1.0E-9 1.0E-9 1.0E-9 BOREHOLE PERMEABILITY RANGE AND MODE ABOVE REPOSITORY  
 1.0E-9 1.0E-9 1.0E-9 BOREHOLE PERMEABILITY RANGE AND MODE BELOW REPOSITORY  
 1230. BRINE DENSITY (KG/M<sup>3</sup>)  
 1.8E-3 BRINE VISCOSITY (KG/M/S)  
 1 NUMBER OF REGIONS  
 0.0 1.115E5 1.576E4 REGION 1 PENETRATION PROB EACH WASTE TYPE (NONE,CH,RH)  
 3 1 NUMBER OF WASTE STREAMS TO AVG FOR CH WASTES AND RH WASTES  
 1 NUMBER OF BRINE POCKETS  
 31 1000 LHS VAR DEplete INDEX (0=LHS NOT USED), NUMBER OF INTRUSIONS  
 0.02 0.68 0.30 PLUGGING PATTERN PROBABILITIES (MUST BE 3 VALUES)  
 0.50 CUTOFF FRACTION FOR BUFFER SOLUBILITY LIMIT EFFECT  
 0 2 SPALLINGS REFERENCE (1=AFTER E1) AND NUMBER OF INTRUSIONS  
 0 3 BLOWOUT REFERENCE (1=AFTER E1) AND NUMBER OF INTRUSIONS



9.80665 ACCELERATION DUE TO GRAVITY (M/S2)  
 3.14159 PI  
 -1701 RANDOM NUMBER GENERATOR SEED (MUST BE NEGATIVE)  
 1.0E-6 RELATIVE ROUNDOFF TOLERANCE  
 1.0E-10 RELATIVE PRESSURE TOLERANCE

## AUXILIARY INPUT FILES FOR THE RECONSTRUCTION OF TESTS 1, 2, 3, AND 4

### CCGF\_INV5\_CCA.INP

DRILLING INTRUSION INVENTORY

(SPECIES,DESCEND,ACT(CI)orMASS(KG),THALF(Y),MW,EPALIM,MBK(KG/M3)orKD(KG/KG)RANGE,

| MG    | NONE  | 4.86E7 | 0.0    | 40.3 | 0.0  | 0.243    | 0.243    | 1.0 |
|-------|-------|--------|--------|------|------|----------|----------|-----|
| AM241 | NP237 | 7.15E5 | 4.32E2 | 241  | 100. | 0.239E-5 | 0.239E-1 | 1.0 |
| NP237 | U233  | 2.08E1 | 2.14E6 | 237  | 100. | 0.239E-6 | 0.239E-4 | 1.0 |
| U233  | TH229 | 1.53E3 | 1.59E5 | 233  | 100. | 0.239E-4 | 0.239E-2 | 1.0 |
| TH229 | NONE  | 0.0    | 7.43E3 | 229  | 100. | 0.239E-5 | 0.239E-4 | 1.0 |

Note: The values in this file are not used in the current version of the CCDFGF p

## AUXILIARY INPUT FILES FOR THE RECONSTRUCTION OF TESTS 1, 2, 3, AND 4

### CCGF\_NODE3\_CCA.INP

| NODE DEFINITIONS FOR WIPP REPOSITORY (M) (7/17/95) |        |       |       |      |      |         |       |     |      | (X1,X2,Y1,Y2,H,W,K,PF,WF |
|--|--------|-------|-------|------|------|---------|-------|-----|------|--------------------------|
| 495.0  | 1204.0 | 5.0   | 5.0   | 3.96 | 10.0 | 6.70E-7 | 0.400 | 1.0 | 384. | TOTAL HORIZO             |
| 495.0  | 1204.0 | 106.5 | 106.5 | 3.96 | 10.0 | 6.70E-7 | 0.400 | 1.0 | 384. |                          |
| 495.0  | 1204.0 | 177.5 | 177.5 | 3.96 | 10.0 | 6.70E-7 | 0.400 | 1.0 | 384. |                          |
| 495.0  | 1204.0 | 279.0 | 279.0 | 3.96 | 10.0 | 6.70E-7 | 0.400 | 1.0 | 384. |                          |
| 495.0  | 1204.0 | 319.0 | 319.0 | 3.96 | 10.0 | 6.70E-7 | 0.400 | 1.0 | 384. |                          |
| 495.0  | 1204.0 | 420.5 | 420.5 | 3.96 | 10.0 | 6.70E-7 | 0.400 | 1.0 | 384. |                          |
| 495.0  | 1204.0 | 491.5 | 491.5 | 3.96 | 10.0 | 6.70E-7 | 0.400 | 1.0 | 384. |                          |
| 495.0  | 1204.0 | 593.0 | 593.0 | 3.96 | 10.0 | 6.70E-7 | 0.400 | 1.0 | 384. |                          |
| 495.0  | 495.0  | 5.0   | 593.0 | 3.96 | 10.0 | 6.70E-7 | 0.400 | 1.0 | 384. | TOTAL VERTIC             |
| 535.5  | 535.5  | 5.0   | 593.0 | 3.96 | 10.0 | 6.70E-7 | 0.400 | 1.0 | 384. |                          |
| 576.0  | 576.0  | 5.0   | 593.0 | 3.96 | 10.0 | 6.70E-7 | 0.400 | 1.0 | 384. |                          |
| 616.5  | 616.5  | 5.0   | 593.0 | 3.96 | 10.0 | 6.70E-7 | 0.400 | 1.0 | 384. |                          |
| 657.0  | 657.0  | 5.0   | 593.0 | 3.96 | 10.0 | 6.70E-7 | 0.400 | 1.0 | 384. |                          |
| 697.5  | 697.5  | 5.0   | 593.0 | 3.96 | 10.0 | 6.70E-7 | 0.400 | 1.0 | 384. |                          |
| 738.0  | 738.0  | 5.0   | 593.0 | 3.96 | 10.0 | 6.70E-7 | 0.400 | 1.0 | 384. |                          |
| 778.0  | 778.0  | 5.0   | 593.0 | 3.96 | 10.0 | 6.70E-7 | 0.400 | 1.0 | 384. |                          |
| 824.5  | 824.5  | 5.0   | 593.0 | 3.96 | 10.0 | 6.70E-7 | 0.400 | 1.0 | 384. |                          |
| 877.0  | 877.0  | 5.0   | 593.0 | 3.96 | 10.0 | 6.70E-7 | 0.400 | 1.0 | 384. |                          |
| 921.0  | 921.0  | 5.0   | 593.0 | 3.96 | 10.0 | 6.70E-7 | 0.400 | 1.0 | 384. |                          |

|        |        |       |       |      |      |          |       |     |      |              |
|--------|--------|-------|-------|------|------|----------|-------|-----|------|--------------|
| 961.0  | 961.0  | 5.0   | 593.0 | 3.96 | 10.0 | 6.70E-7  | 0.400 | 1.0 | 384. |              |
| 1001.5 | 1001.5 | 5.0   | 593.0 | 3.96 | 10.0 | 6.70E-7  | 0.400 | 1.0 | 384. |              |
| 1042.0 | 1042.0 | 5.0   | 593.0 | 3.96 | 10.0 | 6.70E-7  | 0.400 | 1.0 | 384. |              |
| 1082.5 | 1082.5 | 5.0   | 593.0 | 3.96 | 10.0 | 6.70E-7  | 0.400 | 1.0 | 384. |              |
| 1123.0 | 1123.0 | 5.0   | 593.0 | 3.96 | 10.0 | 6.70E-7  | 0.400 | 1.0 | 384. |              |
| 1163.5 | 1163.5 | 5.0   | 593.0 | 3.96 | 10.0 | 6.70E-7  | 0.400 | 1.0 | 384. |              |
| 1204.0 | 1204.0 | 5.0   | 593.0 | 3.96 | 10.0 | 6.70E-7  | 0.400 | 1.0 | 384. |              |
| 778.0  | 921.0  | 5.0   | 5.0   | 3.96 | 6.4  | 6.70E-7  | 0.400 | 1.0 | 384. | REDEFINE PAN |
| 778.0  | 921.0  | 106.5 | 106.5 | 3.96 | 4.3  | 6.70E-7  | 0.400 | 1.0 | 384. |              |
| 778.0  | 921.0  | 177.5 | 177.5 | 3.96 | 6.4  | 6.70E-7  | 0.400 | 1.0 | 384. |              |
| 778.0  | 921.0  | 279.0 | 279.0 | 3.96 | 4.3  | 6.70E-7  | 0.400 | 1.0 | 384. |              |
| 778.0  | 921.0  | 319.0 | 319.0 | 3.96 | 6.4  | 6.70E-7  | 0.400 | 1.0 | 384. |              |
| 778.0  | 921.0  | 420.5 | 420.5 | 3.96 | 4.3  | 6.70E-7  | 0.400 | 1.0 | 384. |              |
| 778.0  | 921.0  | 491.5 | 491.5 | 3.96 | 6.4  | 6.70E-7  | 0.400 | 1.0 | 384. |              |
| 778.0  | 921.0  | 593.0 | 593.0 | 3.96 | 6.1  | 6.70E-7  | 0.400 | 1.0 | 384. |              |
| 738.0  | 778.0  | 5.0   | 5.0   | 3.96 | 6.4  | 6.70E-09 | 1.0   | 0.0 | 384. | REDEFINE SHA |
| 738.0  | 778.0  | 106.5 | 106.5 | 3.96 | 4.3  | 6.70E-09 | 1.0   | 0.0 | 384. |              |
| 738.0  | 778.0  | 177.5 | 177.5 | 3.96 | 6.4  | 6.70E-09 | 1.0   | 0.0 | 384. |              |
| 738.0  | 778.0  | 279.0 | 279.0 | 3.96 | 4.3  | 6.70E-09 | 1.0   | 0.0 | 384. |              |
| 738.0  | 778.0  | 319.0 | 319.0 | 3.96 | 6.4  | 6.70E-09 | 1.0   | 0.0 | 384. |              |
| 738.0  | 778.0  | 420.5 | 420.5 | 3.96 | 4.3  | 6.70E-09 | 1.0   | 0.0 | 384. |              |
| 738.0  | 778.0  | 491.5 | 491.5 | 3.96 | 6.4  | 6.70E-09 | 1.0   | 0.0 | 384. |              |
| 738.0  | 778.0  | 593.0 | 593.0 | 3.96 | 6.1  | 6.70E-09 | 1.0   | 0.0 | 384. |              |
| 921.0  | 961.0  | 5.0   | 5.0   | 3.96 | 6.4  | 6.70E-09 | 1.0   | 0.0 | 384. |              |
| 921.0  | 961.0  | 106.5 | 106.5 | 3.96 | 4.3  | 6.70E-09 | 1.0   | 0.0 | 384. |              |
| 921.0  | 961.0  | 177.5 | 177.5 | 3.96 | 6.4  | 6.70E-09 | 1.0   | 0.0 | 384. |              |
| 921.0  | 961.0  | 279.0 | 279.0 | 3.96 | 4.3  | 6.70E-09 | 1.0   | 0.0 | 384. |              |
| 921.0  | 961.0  | 319.0 | 319.0 | 3.96 | 6.4  | 6.70E-09 | 1.0   | 0.0 | 384. |              |
| 921.0  | 961.0  | 420.5 | 420.5 | 3.96 | 4.3  | 6.70E-09 | 1.0   | 0.0 | 384. |              |
| 921.0  | 961.0  | 491.5 | 491.5 | 3.96 | 6.4  | 6.70E-09 | 1.0   | 0.0 | 384. |              |
| 921.0  | 961.0  | 593.0 | 593.0 | 3.96 | 6.1  | 6.70E-09 | 1.0   | 0.0 | 384. |              |
| 778.0  | 778.0  | 279.0 | 319.0 | 3.96 | 4.3  | 6.70E-09 | 1.0   | 0.0 | 384. |              |
| 824.5  | 824.5  | 279.0 | 319.0 | 3.96 | 4.3  | 6.70E-09 | 1.0   | 0.0 | 384. |              |
| 877.0  | 877.0  | 279.0 | 319.0 | 3.96 | 7.6  | 6.70E-09 | 1.0   | 0.0 | 384. |              |
| 921.0  | 921.0  | 279.0 | 319.0 | 3.96 | 4.3  | 6.70E-09 | 1.0   | 0.0 | 384. |              |
| 490.0  | 770.0  | 110.0 | 170.0 | 0.00 | 0.0  | 0.0      | 0.0   | 0.0 | 384. | REDEFINE REG |
| 490.0  | 770.0  | 290.0 | 310.0 | 0.00 | 0.0  | 0.0      | 0.0   | 0.0 | 384. |              |
| 490.0  | 770.0  | 430.0 | 480.0 | 0.00 | 0.0  | 0.0      | 0.0   | 0.0 | 384. |              |
| 930.0  | 1210.0 | 110.0 | 170.0 | 0.00 | 0.0  | 0.0      | 0.0   | 0.0 | 384. |              |
| 930.0  | 1210.0 | 290.0 | 310.0 | 0.00 | 0.0  | 0.0      | 0.0   | 0.0 | 384. |              |
| 930.0  | 1210.0 | 430.0 | 480.0 | 0.00 | 0.0  | 0.0      | 0.0   | 0.0 | 384. |              |

## AUXILIARY INPUT FILES FOR THE RECONSTRUCTION OF TESTS 1, 2,

### 3, AND 4

## CCGF\_REGION\_CCA.INP

| REGION, PANEL, BRINE POCKET, AREA FRACTION, EXCAVATED AREA FRACTION, BRN PCKT PRO |        |        |       |        |        |            |            |       |
|---|--------|--------|-------|--------|--------|------------|------------|-------|
| X-NODE  | Y-NODE | REGION | PANEL | LOW/UP | BRNPCK | FRCTOTAREA | FRCEXCAREA | P(BP) |
| 1   | 1      | 1      | 5     | 1      | 1      | 0.006944   | 0.2091     | 0.08  |
| 2   | 1      | 1      | 5     | 1      | 1      | 0.006944   | 0.2091     | 0.08  |
| 3   | 1      | 1      | 5     | 1      | 1      | 0.006944   | 0.2091     | 0.08  |
| 4   | 1      | 1      | 5     | 1      | 1      | 0.006944   | 0.2091     | 0.08  |
| 5   | 1      | 1      | 5     | 1      | 1      | 0.006944   | 0.2091     | 0.08  |
| 6   | 1      | 1      | 5     | 1      | 1      | 0.006944   | 0.2091     | 0.08  |
| 7   | 1      | 1      | 5     | 1      | 1      | 0.006944   | 0.2091     | 0.08  |
| 8   | 1      | 1      | 10    | 1      | 1      | 0.006944   | 0.2091     | 0.08  |
| 9   | 1      | 1      | 10    | 1      | 1      | 0.006944   | 0.2091     | 0.08  |
| 10  | 1      | 1      | 10    | 1      | 1      | 0.006944   | 0.2091     | 0.08  |
| 11  | 1      | 1      | 10    | 1      | 1      | 0.006944   | 0.2091     | 0.08  |
| 12  | 1      | 1      | 4     | 1      | 1      | 0.006944   | 0.2091     | 0.08  |
| 13  | 1      | 1      | 4     | 1      | 1      | 0.006944   | 0.2091     | 0.08  |
| 14  | 1      | 1      | 4     | 1      | 1      | 0.006944   | 0.2091     | 0.08  |
| 15  | 1      | 1      | 4     | 1      | 1      | 0.006944   | 0.2091     | 0.08  |
| 16  | 1      | 1      | 4     | 1      | 1      | 0.006944   | 0.2091     | 0.08  |
| 17  | 1      | 1      | 4     | 1      | 1      | 0.006944   | 0.2091     | 0.08  |
| 18  | 1      | 1      | 4     | 1      | 1      | 0.006944   | 0.2091     | 0.08  |
| 1   | 2      | 1      | 5     | 1      | 1      | 0.006944   | 0.2091     | 0.08  |
| 2   | 2      | 1      | 5     | 1      | 1      | 0.006944   | 0.2091     | 0.08  |
| 3   | 2      | 1      | 5     | 1      | 1      | 0.006944   | 0.2091     | 0.08  |
| 4   | 2      | 1      | 5     | 1      | 1      | 0.006944   | 0.2091     | 0.08  |
| 5   | 2      | 1      | 5     | 1      | 1      | 0.006944   | 0.2091     | 0.08  |
| 6   | 2      | 1      | 5     | 1      | 1      | 0.006944   | 0.2091     | 0.08  |
| 7   | 2      | 1      | 5     | 1      | 1      | 0.006944   | 0.2091     | 0.08  |
| 8   | 2      | 1      | 10    | 1      | 1      | 0.006944   | 0.2091     | 0.08  |
| 9   | 2      | 1      | 10    | 1      | 1      | 0.006944   | 0.2091     | 0.08  |
| 10  | 2      | 1      | 10    | 1      | 1      | 0.006944   | 0.2091     | 0.08  |
| 11  | 2      | 1      | 10    | 1      | 1      | 0.006944   | 0.2091     | 0.08  |
| 12  | 2      | 1      | 4     | 1      | 1      | 0.006944   | 0.2091     | 0.08  |
| 13  | 2      | 1      | 4     | 1      | 1      | 0.006944   | 0.2091     | 0.08  |
| 14  | 2      | 1      | 4     | 1      | 1      | 0.006944   | 0.2091     | 0.08  |
| 15  | 2      | 1      | 4     | 1      | 1      | 0.006944   | 0.2091     | 0.08  |
| 16  | 2      | 1      | 4     | 1      | 1      | 0.006944   | 0.2091     | 0.08  |
| 17  | 2      | 1      | 4     | 1      | 1      | 0.006944   | 0.2091     | 0.08  |
| 18  | 2      | 1      | 4     | 1      | 1      | 0.006944   | 0.2091     | 0.08  |
| 1   | 3      | 1      | 6     | 2      | 1      | 0.006944   | 0.2091     | 0.08  |

|    |   |   |    |   |   |          |        |      |
|----|---|---|----|---|---|----------|--------|------|
| 2  | 3 | 1 | 6  | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 3  | 3 | 1 | 6  | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 4  | 3 | 1 | 6  | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 5  | 3 | 1 | 6  | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 6  | 3 | 1 | 6  | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 7  | 3 | 1 | 6  | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 8  | 3 | 1 | 10 | 1 | 1 | 0.006944 | 0.2091 | 0.08 |
| 9  | 3 | 1 | 10 | 1 | 1 | 0.006944 | 0.2091 | 0.08 |
| 10 | 3 | 1 | 10 | 1 | 1 | 0.006944 | 0.2091 | 0.08 |
| 11 | 3 | 1 | 10 | 1 | 1 | 0.006944 | 0.2091 | 0.08 |
| 12 | 3 | 1 | 3  | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 13 | 3 | 1 | 3  | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 14 | 3 | 1 | 3  | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 15 | 3 | 1 | 3  | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 16 | 3 | 1 | 3  | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 17 | 3 | 1 | 3  | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 18 | 3 | 1 | 3  | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 1  | 4 | 1 | 6  | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 2  | 4 | 1 | 6  | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 3  | 4 | 1 | 6  | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 4  | 4 | 1 | 6  | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 5  | 4 | 1 | 6  | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 6  | 4 | 1 | 6  | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 7  | 4 | 1 | 6  | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 8  | 4 | 1 | 10 | 1 | 1 | 0.006944 | 0.2091 | 0.08 |
| 9  | 4 | 1 | 10 | 1 | 1 | 0.006944 | 0.2091 | 0.08 |
| 10 | 4 | 1 | 10 | 1 | 1 | 0.006944 | 0.2091 | 0.08 |
| 11 | 4 | 1 | 10 | 1 | 1 | 0.006944 | 0.2091 | 0.08 |
| 12 | 4 | 1 | 3  | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 13 | 4 | 1 | 3  | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 14 | 4 | 1 | 3  | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 15 | 4 | 1 | 3  | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 16 | 4 | 1 | 3  | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 17 | 4 | 1 | 3  | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 18 | 4 | 1 | 3  | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 1  | 5 | 1 | 7  | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 2  | 5 | 1 | 7  | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 3  | 5 | 1 | 7  | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 4  | 5 | 1 | 7  | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 5  | 5 | 1 | 7  | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 6  | 5 | 1 | 7  | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 7  | 5 | 1 | 7  | 2 | 1 | 0.006944 | 0.2091 | 0.08 |

|    |   |   |   |   |   |          |        |      |
|----|---|---|---|---|---|----------|--------|------|
| 8  | 5 | 1 | 9 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 9  | 5 | 1 | 9 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 10 | 5 | 1 | 9 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 11 | 5 | 1 | 9 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 12 | 5 | 1 | 2 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 13 | 5 | 1 | 2 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 14 | 5 | 1 | 2 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 15 | 5 | 1 | 2 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 16 | 5 | 1 | 2 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 17 | 5 | 1 | 2 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 18 | 5 | 1 | 2 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 1  | 6 | 1 | 7 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 2  | 6 | 1 | 7 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 3  | 6 | 1 | 7 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 4  | 6 | 1 | 7 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 5  | 6 | 1 | 7 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 6  | 6 | 1 | 7 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 7  | 6 | 1 | 7 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 8  | 6 | 1 | 9 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 9  | 6 | 1 | 9 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 10 | 6 | 1 | 9 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 11 | 6 | 1 | 9 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 12 | 6 | 1 | 2 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 13 | 6 | 1 | 2 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 14 | 6 | 1 | 2 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 15 | 6 | 1 | 2 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 16 | 6 | 1 | 2 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 17 | 6 | 1 | 2 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 18 | 6 | 1 | 2 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 1  | 7 | 1 | 8 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 2  | 7 | 1 | 8 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 3  | 7 | 1 | 8 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 4  | 7 | 1 | 8 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 5  | 7 | 1 | 8 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 6  | 7 | 1 | 8 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 7  | 7 | 1 | 8 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 8  | 7 | 1 | 9 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 9  | 7 | 1 | 9 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 10 | 7 | 1 | 9 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 11 | 7 | 1 | 9 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 12 | 7 | 1 | 1 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 13 | 7 | 1 | 1 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |

|    |   |   |   |   |   |          |        |      |
|----|---|---|---|---|---|----------|--------|------|
| 14 | 7 | 1 | 1 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 15 | 7 | 1 | 1 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 16 | 7 | 1 | 1 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 17 | 7 | 1 | 1 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 18 | 7 | 1 | 1 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 1  | 8 | 1 | 8 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 2  | 8 | 1 | 8 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 3  | 8 | 1 | 8 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 4  | 8 | 1 | 8 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 5  | 8 | 1 | 8 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 6  | 8 | 1 | 8 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 7  | 8 | 1 | 8 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 8  | 8 | 1 | 9 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 9  | 8 | 1 | 9 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 10 | 8 | 1 | 9 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 11 | 8 | 1 | 9 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 12 | 8 | 1 | 1 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 13 | 8 | 1 | 1 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 14 | 8 | 1 | 1 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 15 | 8 | 1 | 1 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 16 | 8 | 1 | 1 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 17 | 8 | 1 | 1 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |
| 18 | 8 | 1 | 1 | 2 | 1 | 0.006944 | 0.2091 | 0.08 |

Note: The brine pocket probability values in this file are not used in the curren

## FORTRAN PROGRAMS USED FOR BILINEARITY TEST

### RELT.FOR

C\*\*\*\*\*INPUT FILES:

C\*\*\*\*\* 2 = RELEASE SUMMARY TABLE (RELTABR1.DAT)

C\*\*\*\*\*OUTPUT FILES:

C\*\*\*\*\* 11 = RUN SUMMARY (CCGF\_OUT)

C\*\*\*\*\* 12 = DOUBLED RELEASE TABLE (RELTABR1.NEW)

C\*\*\*\*\* 14 = NEW TABLES (CCGF\_PRT)

IMPLICIT DOUBLE PRECISION (A-H, O-Z)

PARAMETER (MXY=20, MAXREC=100, MAXBH=100, MAXRES=50, MAXBIN=161,

1 MAXSPC=10, MAXSC=30, MAXOBS=100, MAXTH=10000,

2 MAXTIM=20, MAXBP=5, MAXACT=1000, MAXTC=200,

3 MAXVAR=100, MAXREG=5, NEQM=MXY\*MXY, IBWM=3\*MXY+1,

4 NUSED=3, NOTUSE=5, NTWO=2)

COMMON /INPUT1/ ISEED, IMBKCD, IOBS, ISPVAR, ITH, LHSVBP, NOBS,

1 NPF, NTH, NSPC, NREG, NBP, NPP

```

CHARACTER*80 FILBOR, FILINV, FILLHS, FILNOD, FILPAR, FILREG,
1          FILREL
COMMON /FILES/ FILBOR, FILINV, FILLHS, FILNOD, FILPAR, FILREG,
1          FILREL
CHARACTER*130 TITLEB, TITLEI, TITLEN, TITLEP, TITLER, TITLET
COMMON /TITLES/ TITLEB, TITLEI, TITLEN, TITLEP, TITLER, TITLET
LOGICAL GRDFLO, MINERD, PRTOBS, PRTHH
COMMON /INPUT0/ GRDFLO, MINERD, PRTOBS(MAXOBS), PRTHH(MAXTH)
COMMON /INPUT2/ SMT, VBT, TOTACT, ACTI, ACTS, TSMAX, TSLIM,
1          TEND, TENDBH, STPRST, DD1, DD2, DDTIME, PPP(3),
2          DM1, DM2, DMTIME, TOL, RTOL, RPTOL, BUFFRC,
3          GRAV, PI, ECULEB, ECASTI, PCULEB, PCASTI,
4          DIAMNA, DIAMXA, DIAMNB, DIAMXB, DMODA, DMODB,
5          PRMMNA, PRMMXA, PRMMNB, PRMMXB, PMODA, PMODB,
6          BRNDEN, BRNVIS
COMMON /CUT1/ NTCH, NTRH, NCH, NRH, NACH, NARH
COMMON /CUT2/ DBDIAM, ACH, ARH, FVCH, FVRH, HCH, HRH,
1          PCUT(MAXACT), TCH(MAXTIM), TRH(MAXTIM),
2          RCUT(MAXTIM,MAXACT), PWT(3,MAXREG)
COMMON /SPAL1/ NTSC, NTSLE0, NTSUE0,
1          NTSSE11, NTSDE11, NTSSE21, NTSDE21,
1          NTSSE12(MAXTIM), NTSDE12(MAXTIM),
2          NTSSE22(MAXTIM), NTSDE22(MAXTIM)
COMMON /SPAL2/ TSC(MAXTIM), CSA(MAXTIM),
1          TSLE0(MAXTIM), TSUE0(MAXTIM),
2          RSLE0(MAXTIM), RSUE0(MAXTIM),
3          TSSE1(MAXTIM,MAXTIM), RSSE1(MAXTIM,MAXTIM),
4          TSDE1(MAXTIM,MAXTIM), RSDE1(MAXTIM,MAXTIM),
5          TSSE2(MAXTIM,MAXTIM), RSSE2(MAXTIM,MAXTIM),
6          TSDE2(MAXTIM,MAXTIM), RSDE2(MAXTIM,MAXTIM)
COMMON /BLOW1/ NTBC, NTBLE0, NTBUE0,
1          NTBSE11, NTBDE11, NTBSE21, NTBDE21,
2          NTBSE12(MAXTIM), NTBDE12(MAXTIM),
3          NTBSE22(MAXTIM), NTBDE22(MAXTIM)
COMMON /BLOW2/ TBC(MAXTIM), CBE0(MAXTIM),
1          CBE1(MAXTIM), CBE2(MAXTIM),
2          TBLE0(MAXTIM), TBUE0(MAXTIM),
3          RBLE0(MAXTIM), RBUE0(MAXTIM),
4          TBSE1(MAXTIM,MAXTIM), RBSE1(MAXTIM,MAXTIM),
5          TBDE1(MAXTIM,MAXTIM), RBDE1(MAXTIM,MAXTIM),
6          TBSE2(MAXTIM,MAXTIM), RBSE2(MAXTIM,MAXTIM),
7          TBDE2(MAXTIM,MAXTIM), RBDE2(MAXTIM,MAXTIM)

```

```

CHARACTER LABSET(MAXREC,NUSED,NTWO)*48
CHARACTER LNOUSE(NOTUSE)*38, LINE3(NUSED)*30
CHARACTER SLABEL(MAXREC,NUSED,NTWO)*55
CHARACTER BLABEL(MAXREC,NUSED,NTWO)*55
COMMON /LABEL1/ BLABEL, LABSET, LINE3, LNOUSE
COMMON /LABEL2/ SLABEL

C
C*****OPEN RELEASE SUMMARY TABLE FILE
      OPEN( 2,FILE='RELTABR1.DAT', RECL=100, STATUS='UNKNOWN')
C      OPEN( 2,FILE='RELTABR1.OUT', RECL=100, STATUS='UNKNOWN')
C*****OPEN RELEASE SUMMARY TABLE FILE
      OPEN(12,FILE='RELTABR1.NEW', RECL=100, STATUS='UNKNOWN')

C
C*****OPEN PRINT FILE
      OPEN (11, FILE='CCGF_PRT', RECL=200, STATUS='UNKNOWN')
C*****OPEN FILE FOR STORING NEW TABLES
      OPEN (14, FILE='CCGF_OUT', RECL=1000, STATUS='UNKNOWN')
      NOBS=100
      ACTI=1.E32
      TEND=1.E-32
C*****OPEN AND READ INPUT DATA FILES
      CALL INPUT
C*****LOOP OVER OBSERVATIONS
      DO 5000 IOBS=1,NOBS
C*****READ RELEASE TABLES
      CALL READR
C *****PRINT NUMBERS READ
      NINE=9
      LAST=570
      IF(IOBS.EQ.NOBS .OR. IOBS.EQ.1) THEN
        WRITE(14,*) 'SPALLINGS, IOBS=',IOBS
        WRITE(14,914) (TSLE0(IT),IT=1,NINE)
        WRITE(14,914) (RSLE0(IT),IT=1,NINE)
        WRITE(14,914) (TSUE0(IT),IT=1,NINE)
        WRITE(14,914) (RSUE0(IT),IT=1,NINE)
        DO 205 IT2=1,NINE
          WRITE(14,914) (RSSE1(IT2,IT1),IT1=1,NINE)
          WRITE(14,914) (RSDE2(IT2,IT1),IT1=1,NINE)
205      CONTINUE
        WRITE(14,*) 'BLOWOUT, IOBS=',IOBS
        WRITE(14,914) (RBLE0(IT),IT=1,NINE)
        WRITE(14,914) (RBUE0(IT),IT=1,NINE)

```



```

        DO 210 IT2=1,NINE
            WRITE(14,914) (RBSE1(IT2,IT1),IT1=1,NINE)
            WRITE(14,914) (RBDE2(IT2,IT1),IT1=1,NINE)
210    CONTINUE
        WRITE(14,*) 'CUTTINGS, IOBS=',IOBS
        WRITE(14,913) 'STREAM CDF ',(TCH(IT),IT=1,NINE)
913    FORMAT(A12,9F7.0)
        DO 200 ISTREAM=1,LAST
            WRITE(14,912) ISTREAM,PCUT(ISTREAM),
2                (RCUT(IT,ISTREAM),IT=1,NINE)
912    FORMAT(I4,F8.6,9F7.3)
200    CONTINUE
914    FORMAT(9E9.1)
        ENDIF
        CALL DOUBLE
5000 CONTINUE
C
        STOP
        END
C
C.....^.....
        SUBROUTINE RDREL (ERR)
C*****READ SUMMARY RELEASE TABLES FILE HEADERS
        IMPLICIT DOUBLE PRECISION (A-H, O-Z)
        PARAMETER (MXY=20, MAXREC=100, MAXBH=100, MAXRES=50, MAXBIN=161,
1            MAXSPC=10, MAXSC=30, MAXOBS=100, MAXTH=10000,
2            MAXTIM=20, MAXBP=5, MAXACT=1000, MAXTC=200,
3            MAXVAR=100, MAXREG=5, NEQM=MXY*MXY, IBWM=3*MXY+1,
4            NUSED=3, NOTUSE=5, NTWO=2)
        COMMON /INPUT1/ ISEED, IMBCKD, IOBS, ISPVAR, ITH, LHSVBP, NOBS,
1            NPF, NTH, NSPC, NREG, NBP, NPP
        CHARACTER*130 TITLEB, TITLEI, TITLEN, TITLEP, TITLER, TITLET
        COMMON /TITLES/ TITLEB, TITLEI, TITLEN, TITLEP, TITLER, TITLET
        CHARACTER*80 FILBOR, FILINV, FILLHS, FILNOD, FILPAR, FILREG,
1            FILREL
        COMMON /FILES/ FILBOR, FILINV, FILLHS, FILNOD, FILPAR, FILREG,
1            FILREL
        LOGICAL ERR
        CHARACTER LABSET(MAXREC,NUSED,NTWO)*48
        CHARACTER LNOUSE(NOTUSE)*38, LINE3(NUSED)*30
        CHARACTER SLABEL(MAXREC,NUSED,NTWO)*55
        CHARACTER BLABEL(MAXREC,NUSED,NTWO)*55

```

```

COMMON /LABEL1/ BLABEL, LABSET, LINE3, LNOUSE
COMMON /LABEL2/ SLABEL

C
C
C*****READ RELEASE SUMMARY TABLE TITLE
      READ(2,1001,ERR=9200,END=9300) TITLET
      LINE3(1)=TITLET
C*****LABEL SECOND TITLE RECORD FOR RELEASE SUMMARY TABLE
      READ(2,911,ERR=9200,END=9300) LINE3(2)
911  FORMAT(A30)
C*****READ NUMBER OF OBSERVATIONS ON RELEASE SUMMARY TABLE
      READ(2,912,ERR=9200,END=9300) NOBST,LINE3(3)
912  FORMAT(I10,A30)
C*****CHECK NUMBER OF OBSERVATIONS ON RELEASE SUMMARY TABLE FOR AT LEAST
C*****AS MANY OBSERVATIONS SPECIFIED ON RUN CONTROL PARAMETERS FILE
      IF (NOBS .GT. NOBST) THEN
C*****NOT ENOUGH OBSERVATIONS ON RELEASE SUMMARY TABLE FILE
      WRITE(11,*) '>>>>FEWER OBSERVATIONS ON RELEASE SUMMARY ',
1      'TABLE FILE (' , NOBST, ' )'
      WRITE(11,*) '>>>>THAN ON RUN CONTROL PARAMETERS FILE (' ,
1      NOBS, ' )'
      ERR=.TRUE.
      ENDIF
      RETURN
C*****ERROR OPENING RELEASE SUMMARY TABLES FILE
C 9100 CONTINUE
C      WRITE(11,*) '>>>>ERROR OPENING RELEASE SUMMARY TABLES FILE'
C      ERR=.TRUE.
C      RETURN
C*****I/O ERROR READING HEADER RECORDS FROM RELEASE SUMMARY TABLES FILE
9200 CONTINUE
      WRITE(11,*) '>>>>I/O ERROR READING HEADER RECORDS FROM ',
1      'RELEASE SUMMARY TABLES FILE'
      ERR=.TRUE.
      RETURN
C*****PREMATURE EOF ENCOUNTERED READING HEADER RECORDS FROM RELEASE SUMMARY
C*****TABLES FILE
9300 CONTINUE
      WRITE(11,*) '>>>>PREMATURE EOF ENCOUNTERED READING ',
1      'RELEASE SUMMARY TABLES FILE'
      ERR=.TRUE.
      RETURN

```

```

C*****FORMAT STATEMENTS
1001 FORMAT(A)
      END
C
C.....^.....
      SUBROUTINE INPUT
C*****READ NODE DEFINITION AND REDEFINITION DESCRIPTIONS
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
      PARAMETER (MXY=20, MAXREC=100, MAXBH=100, MAXRES=50, MAXBIN=161,
1          MAXSPC=10, MAXSC=30, MAXOBS=100, MAXTH=10000,
2          MAXTIM=20, MAXBP=5, MAXACT=1000, MAXTC=200,
3          MAXVAR=100, MAXREG=5, NEQM=MXY*MXY, IBWM=3*MXY+1)
      COMMON /INPUT1/ ISEED, IMBKCD, IOBS, ISPVAR, ITH, LHSVBP, NOBS,
1          NPF, NTH, NSPC, NREG, NBP, NPP
      CHARACTER*130 TITLEB, TITLEI, TITLEN, TITLEP, TITLER, TITLET
      COMMON /TITLES/ TITLEB, TITLEI, TITLEN, TITLEP, TITLER, TITLET
      CHARACTER*80 FILBOR, FILINV, FILLHS, FILNOD, FILPAR, FILREG,
1          FILREL
      COMMON /FILES/ FILBOR, FILINV, FILLHS, FILNOD, FILPAR, FILREG,
1          FILREL
      LOGICAL ERR
C*****INITIALIZE ERROR FLAG
      ERR=.FALSE.
C*****READ RELEASE SUMMARY TABLES FILE HEADERS
      CALL RDREL (ERR)
      IF (ERR) THEN
          WRITE(6,*) '>>>>ERROR(1) ENCOUNTERED, EXECUTION TERMINATED'
          STOP
      ENDIF
      END
C
C.....^.....
      SUBROUTINE RDCUT
C*****READ CUTTINGS RELEASE TABLES
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
      PARAMETER (MXY=20, MAXREC=100, MAXBH=100, MAXRES=50, MAXBIN=161,
1          MAXSPC=10, MAXSC=30, MAXOBS=100, MAXTH=10000,
2          MAXTIM=20, MAXBP=5, MAXACT=1000, MAXTC=200,
3          MAXVAR=100, MAXREG=5, NEQM=MXY*MXY, IBWM=3*MXY+1,
4          NUSED=3, NOTUSE=5, NTWO=2)
      LOGICAL GRDFLO, MINERD, PRTOBS, PRTH
      COMMON /INPUT0/ GRDFLO, MINERD, PRTOBS(MAXOBS), PRTH(MAXTH)

```

```

COMMON /INPUT1/ ISEED, IMCKD, IOBS, ISPVAR, ITH, LHSVBP, NOBS,
1          NPF, NTH, NSPC, NREG, NBP, NPP
COMMON /INPUT2/ SMT, VBT, TOTACT, ACTI, ACTS, TSMAX, TSLIM,
1          TEND, TENDBH, STPRST, DD1, DD2, DDTIME, PPP(3),
2          DM1, DM2, DMTIME, TOL, RTOL, RPTOL, BUFFRC,
3          GRAV, PI, ECULEB, ECASTI, PCULEB, PCASTI,
4          DIAMNA, DIAMXA, DIAMNB, DIAMXB, DMODA, DMODB,
5          PRMMNA, PRMMXA, PRMMNB, PRMMXB, PMODA, PMODB,
6          BRNDEN, BRNVIS
COMMON /CUT1/ NTCH, NTRH, NCH, NRH, NACH, NARH
COMMON /CUT2/ DBDIAM, ACH, ARH, FVCH, FVRH, HCH, HRH,
1          PCUT(MAXACT), TCH(MAXTIM), TRH(MAXTIM),
2          RCUT(MAXTIM,MAXACT), PWT(3,MAXREG)
CHARACTER LABSET(MAXREC,NUSED,NTWO)*48
CHARACTER LNOUSE(NOTUSE)*38, LINE3(NUSED)*30
CHARACTER SLABEL(MAXREC,NUSED,NTWO)*55
CHARACTER BLABEL(MAXREC,NUSED,NTWO)*55
COMMON /LABEL1/ BLABEL, LABSET, LINE3, LNOUSE
COMMON /LABEL2/ SLABEL

C
C
C*****READ FLAGS ON CUTTINGS RELEASES TITLE RECORD
      READ(2,911,ERR=9200,END=9300) IOBST, IFLG, LABSET(IOBS,1,1)
911  FORMAT(2I10,A48)
C*****VALIDATE OBSERVATION INDEX
C      WRITE(*,*) IOBST,IFLG,IOBS
      IF (IOBST .NE. IOBS) THEN
C*****INVALID OBSERVATION INDEX VALUE
          WRITE(11,*) '>>>>INVALID OBSERVATION INDEX VALUE FOR ',
1          'CUTTINGS RELEASE TABLES'
          WRITE(6,*) '>>>>ERROR(2) ENCOUNTERED, EXECUTION TERMINATED'
          STOP
      ENDIF
C*****READ NUMBER OF TIMES, NUMBER OF WASTE TYPES, WASTE AREA,
C*****WASTE HEIGHT, VOLUME FRACTION, AND DRILL BIT DIAMETER FOR CH WASTE
      READ(2,*,ERR=9200,END=9300) NTCH, NCH, ACH, HCH, FVCH, DBDIAM
C*****READ NUMBER OF TIMES, NUMBER OF WASTE TYPES, WASTE AREA,
C*****WASTE HEIGHT, AND VOLUME FRACTION FOR RH WASTE
      READ(2,*,ERR=9200,END=9300) NTRH, NRH, ARH, HRH, FVRH
C      WRITE(*,*) NCH,NRH,NTCH,NTRH
C*****VALIDATE TIME DIMENSION
      IF ((NTCH .GT. MAXTIM) .OR. (NTRH .GT. MAXTIM)) THEN

```

```

        WRITE(11,*) '>>>>INCREASE PARAMETER MAXTIM TO AT LEAST ',
1          MAX(NTCH,NTRH)
        WRITE(6,*) '>>>>ERROR(3) ENCOUNTERED, EXECUTION TERMINATED'
        STOP
    ENDIF
C*****VALIDATE TOTAL NUMBER OF CH AND RH WASTE TYPES
    IF (NCH+NRH .GT. MAXACT) THEN
        WRITE(11,*) '>>>>INCREASE PARAMETER MAXACT TO AT LEAST ',
1          NCH+NRH
        WRITE(6,*) '>>>>ERROR(4) ENCOUNTERED, EXECUTION TERMINATED'
        STOP
    ENDIF
C*****CHECK FLAG FOR READING RELEASE TABLES
    IF (IFLG .EQ. 0) RETURN
C*****READ PROBABILITIES ASSOCIATED WITH EACH ACTIVITY LEVEL FOR
C*****CH AND RH WASTES
        READ(2,*,ERR=9200,END=9300) (PCUT(ICH),ICH=1,NCH),
1          (PCUT(NCH+IRH),IRH=1,NRH)
C*****WRITE TIMES FOR ACTIVITY LEVELS FOR CH WASTE
        READ(2,*,ERR=9200,END=9300) (TCH(IT),IT=1,NTCH)
C*****READ TIMES FOR ACTIVITY LEVELS FOR RH WASTE
        READ(2,*,ERR=9200,END=9300) (TRH(IT),IT=1,NTRH)
C*****READ RELEASES FOR ALL TIMES FOR CH AND RH WASTE
        READ(2,*,ERR=9200,END=9300) ((RCUT(IT,ICH),IT=1,NTCH),ICH=1,NCH),
1          ((RCUT(IT,NCH+IRH),IT=1,NTRH),IRH=1,NRH)
C*****CHECK FOR MORE THAN ONE TYPE OF CH WASTE
    IF (NCH .GT. 1) THEN
C*****LOOP OVER TYPE OF CH WASTE
        DO 1000 ICH=2,NCH
C*****CONVERT PROBABILITIES FOR EACH ACTIVITY LEVEL TO CUMULATIVE PROB
            PCUT(ICH)=PCUT(ICH-1) + PCUT(ICH)
1000    CONTINUE
        ENDIF
C*****CHECK FOR MORE THAN ONE TYPE OF RH WASTE
    IF (NRH .GT. 1) THEN
C*****LOOP OVER TYPE OF RH WASTE
        DO 2000 IRH=NCH+2,NCH+NRH
C*****CONVERT PROBABILITIES FOR EACH ACTIVITY LEVEL TO CUMULATIVE PROB
            PCUT(IRH)=PCUT(IRH-1) + PCUT(IRH)
2000    CONTINUE
        ENDIF
C*****VALIDATE TIME RANGE FOR CUTTINGS CH RELEASES

```

```

IF ((TCH(1) .GT. ACTI) .OR. (TCH(NTCH) .LT. TEND)) THEN
  WRITE(11,*) '>>>>CUTTINGS CH RELEASE TABLE DOES NOT SPAN ',
1          'POTENTIAL INTRUSION'
  WRITE(11,*) '>>>>TIMES (', ACTI, ' TO ', TEND, ' YR)'
  WRITE(6,*) '>>>>ERROR(5) ENCOUNTERED, EXECUTION TERMINATED'
  STOP
ENDIF

C*****VALIDATE TIME RANGE FOR CUTTINGS RH RELEASES
IF ((TRH(1) .GT. ACTI) .OR. (TRH(NTRH) .LT. TEND)) THEN
  WRITE(11,*) '>>>>CUTTINGS RH RELEASE TABLE DOES NOT SPAN ',
1          'POTENTIAL INTRUSION'
  WRITE(11,*) '>>>>TIMES (', ACTI, ' TO ', TEND, ' YR)'
  WRITE(6,*) '>>>>ERROR(6) ENCOUNTERED, EXECUTION TERMINATED'
  STOP
ENDIF
RETURN

9200 CONTINUE

C*****I/O ERROR WHILE READING CUTTINGS RELEASE TABLES
WRITE(11,*) '>>>>I/O ERROR WHILE READING CUTTINGS RELEASE TABLES'
WRITE(6,*) '>>>>ERROR(7) ENCOUNTERED, EXECUTION TERMINATED'
STOP

9300 CONTINUE

C*****PREMATURE EOF ENCOUNTERED READING CUTTINGS RELEASE TABLES
WRITE(11,*) '>>>>PREMATURE EOF ENCOUNTERED READING ',
1          'CUTTINGS RELEASE TABLES'
WRITE(6,*) '>>>>ERROR(8) ENCOUNTERED, EXECUTION TERMINATED'
STOP
END

C
C.....^.....
SUBROUTINE RDSPL

C*****READ SPALLINGS RELEASE TABLES
IMPLICIT DOUBLE PRECISION (A-H, O-Z)
PARAMETER (MXY=20, MAXREC=100, MAXBH=100, MAXRES=50, MAXBIN=161,
1          MAXSPC=10, MAXSC=30, MAXOBS=100, MAXTH=10000,
2          MAXTIM=20, MAXBP=5, MAXACT=1000, MAXTC=200,
3          MAXVAR=100, MAXREG=5, NEQM=MXY*MXY, IBWM=3*MXY+1,
4          NUSED=3, NOTUSE=5, NTWO=2)
LOGICAL GRDFLO, MINERD, PRTOBS, PRTH
COMMON /INPUT0/ GRDFLO, MINERD, PRTOBS(MAXOBS), PRTH(MAXTH)
COMMON /INPUT1/ ISEED, IMCKD, IOBS, ISPVAR, ITH, LHSVBP, NOBS,
1          NPF, NTH, NSPC, NREG, NBP, NPP

```

```

COMMON /INPUT2/ SMT, VBT, TOTACT, ACTI, ACTS, TSMAX, TSLIM,
1          TEND, TENDBH, STPRST, DD1, DD2, DDTIME, PPP(3),
2          DM1, DM2, DMTIME, TOL, RTOL, RPTOL, BUFFRC,
3          GRAV, PI, ECULEB, ECASTI, PCULEB, PCASTI,
4          DIAMNA, DIAMXA, DIAMNB, DIAMXB, DMODA, DMODB,
5          PRMMNA, PRMMXA, PRMMNB, PRMMXB, PMODA, PMODB,
6          BRNDEN, BRNVIS
COMMON /SPAL1/ NTSC, NTSLE0, NTSUE0,
1          NTSSE11, NTSDE11, NTSSE21, NTSDE21,
1          NTSSE12(MAXTIM), NTSDE12(MAXTIM),
2          NTSSE22(MAXTIM), NTSDE22(MAXTIM)
COMMON /SPAL2/ TSC(MAXTIM), CSA(MAXTIM),
1          TSLE0(MAXTIM), TSUE0(MAXTIM),
2          RSLE0(MAXTIM), RSUE0(MAXTIM),
3          TSSE1(MAXTIM,MAXTIM), RSSE1(MAXTIM,MAXTIM),
4          TSDE1(MAXTIM,MAXTIM), RSDE1(MAXTIM,MAXTIM),
5          TSSE2(MAXTIM,MAXTIM), RSSE2(MAXTIM,MAXTIM),
6          TSDE2(MAXTIM,MAXTIM), RSDE2(MAXTIM,MAXTIM)
CHARACTER LABSET(MAXREC,NUSED,NTWO)*48
CHARACTER LNOUSE(NOTUSE)*38, LINE3(NUSED)*30
CHARACTER SLABEL(MAXREC,NUSED,NTWO)*55
CHARACTER BLABEL(MAXREC,NUSED,NTWO)*55
COMMON /LABEL1/ BLABEL, LABSET, LINE3, LNOUSE
COMMON /LABEL2/ SLABEL

C
C
C*****READ FLAGS ON SPALLINGS RELEASES TITLE RECORD
      READ(2,911,ERR=9200,END=9300) IOBST, IFLG, LABSET(IOBS,2,1)
911  FORMAT(2I10,A48)
C      WRITE(*,*) IOBST,IFLG,IOBS
C*****VALIDATE OBSERVATION INDEX
      IF (IOBST .NE. IOBS) THEN
C*****INVALID OBSERVATION INDEX VALUE
          WRITE(11,*) '>>>>INVALID OBSERVATION INDEX VALUE FOR ',
1          'SPALLINGS RELEASE TABLES'
          WRITE(6,*) '>>>>ERROR(9) ENCOUNTERED, EXECUTION TERMINATED'
          STOP
      ENDIF
C*****CHECK FLAG FOR READING RELEASE TABLES
      IF (IFLG .EQ. 0) RETURN
C*****LABEL SPALLINGS HEADER RECORD FOR CONCENTRATIONS
      READ(2,912,ERR=9200,END=9300) LABSET(IOBS,2,2)

```

```

912  FORMAT(A48)
C*****READ CONCENTRATION VALUES FOR SPALLINGS RELEASES
      READ(2,*,ERR=9200,END=9300) NTSC, (TSC(IT),IT=1,NTSC),
1                                     (CSA(IT),IT=1,NTSC)
C*****LABEL SPALLINGS HEADER RECORD FOR UNDISTURBED CONDITIONS (LOWER PANELS)
      READ(2,913,ERR=9200,END=9300) SLABEL(IOBS,1,1)
913  FORMAT(A55)
C*****READ SPALLINGS RELEASES FOR UNDISTURBED CONDITIONS (LOWER PANELS)
      READ(2,*,ERR=9200,END=9300) NTSLE0, (TSLE0(IT),IT=1,NTSLE0),
1                                     (RSLE0(IT),IT=1,NTSLE0)
C*****LABEL SPALLINGS HEADER RECORD FOR UNDISTURBED CONDITIONS (UPPER PANELS)
      READ(2,913,ERR=9200,END=9300) SLABEL(IOBS,1,2)
C*****READ SPALLINGS RELEASES FOR UNDISTURBED CONDITIONS (UPPER PANELS)
      READ(2,*,ERR=9200,END=9300) NTSUE0, (TSUE0(IT),IT=1,NTSUE0),
1                                     (RSUE0(IT),IT=1,NTSUE0)
C*****LABEL SPALLINGS HEADER RECORD FOR E1 INTRUSIONS (SAME PANEL)
      READ(2,913,ERR=9200,END=9300) SLABEL(IOBS,2,1)
C*****READ SPALLINGS RELEASES FOR E1 INTRUSIONS (SAME PANEL)
      READ(2,*,ERR=9200,END=9300) NTSSE11, (NTSSE12(IT1),
1          (TSSE1(IT2,IT1),IT2=1,NTSSE12(IT1)),
2          (RSSE1(IT2,IT1),IT2=1,NTSSE12(IT1)), IT1=1,NTSSE11)
C*****LABEL SPALLINGS HEADER RECORD FOR E1 INTRUSIONS (DIFFERENT PANEL)
      READ(2,913,ERR=9200,END=9300) SLABEL(IOBS,2,2)
C*****READ SPALLINGS RELEASES FOR E1 INTRUSIONS (DIFFERENT PANEL)
      READ(2,*,ERR=9200,END=9300) NTSDE11, (NTSDE12(IT1),
1          (TSDE1(IT2,IT1),IT2=1,NTSDE12(IT1)),
2          (RSDE1(IT2,IT1),IT2=1,NTSDE12(IT1)), IT1=1,NTSDE11)
C*****LABEL SPALLINGS HEADER RECORD FOR E2 INTRUSIONS (SAME PANEL)
      READ(2,913,ERR=9200,END=9300) SLABEL(IOBS,3,1)
C*****READ SPALLINGS RELEASES FOR E2 INTRUSIONS (SAME PANEL)
      READ(2,*,ERR=9200,END=9300) NTSSE21, (NTSSE22(IT1),
1          (TSSE2(IT2,IT1),IT2=1,NTSSE22(IT1)),
2          (RSSE2(IT2,IT1),IT2=1,NTSSE22(IT1)), IT1=1,NTSSE21)
C*****LABEL SPALLINGS HEADER RECORD FOR E2 INTRUSIONS (DIFFERENT PANEL)
      READ(2,913,ERR=9200,END=9300) SLABEL(IOBS,3,2)
C*****READ SPALLINGS RELEASES FOR E2 INTRUSIONS (DIFFERENT PANEL)
      READ(2,*,ERR=9200,END=9300) NTSDE21, (NTSDE22(IT1),
1          (TSDE2(IT2,IT1),IT2=1,NTSDE22(IT1)),
2          (RSDE2(IT2,IT1),IT2=1,NTSDE22(IT1)), IT1=1,NTSDE21)
C*****VALIDATE TIME RANGE FOR SPALLINGS RELEASES
      IF ((TSC(1) .GT. ACTI) .OR.
1      (TSLE0(1) .GT. ACTI) .OR. (TSUE0(1) .GT. ACTI) .OR.

```



```

2   (TSSE1(1,1) .GT. ACTI) .OR. (TSDE1(1,1) .GT. ACTI) .OR.
3   (TSSE2(1,1) .GT. ACTI) .OR. (TSDE2(1,1) .GT. ACTI)) THEN
WRITE(11,*) '>>>>SPALLINGS RELEASE TABLE DOES NOT SPAN ',
1       'POTENTIAL INTRUSION TIMES'
WRITE(11,*) '>>>>(', ACTI, ' TO ', TEND, ' YR)'
WRITE(6,*) '>>>>ERROR(A) ENCOUNTERED, EXECUTION TERMINATED'
STOP

ENDIF

C*****DETERMINE MAXIMUM COUNTER FOR SPALLINGS RELEASE TABLES
NTSMAX=MAX (NTSC, NTSLE0, NTSUE0, NTSSE11, NTSDE11, NTSSE21,
1         NTSDE21)
C*****VALIDATE TIME RANGE FOR SPALLINGS RELEASES
IF ((TSC(NTSC) .LT. TEND) .OR. (TSLE0(NTSLE0) .LT. TEND) .OR.
1   (TSUE0(NTSUE0) .LT. TEND)) THEN
WRITE(11,*) '>>>>SPALLINGS RELEASE TABLE DOES NOT SPAN ',
1       'POTENTIAL INTRUSION TIMES'
WRITE(11,*) '>>>>(', ACTI, ' TO ', TEND, ' YR)'
WRITE(6,*) '>>>>ERROR(B) ENCOUNTERED, EXECUTION TERMINATED'
STOP

ENDIF

DO 2100 IT1=1,NTSSE11
NTSMAX=MAX (NTSMAX, NTSSE12(IT1))
C*****VALIDATE TIME RANGE FOR SPALLINGS RELEASES
IF (TSSE1(NTSSE12(IT1),IT1) .LT. TEND) THEN
WRITE(11,*) '>>>>SPALLINGS RELEASE TABLE DOES NOT SPAN ',
1       'POTENTIAL INTRUSION TIMES'
WRITE(11,*) '>>>>(', ACTI, ' TO ', TEND, ' YR)'
WRITE(6,*) '>>>>ERROR(C) ENCOUNTERED, EXECUTION TERMINATED'
STOP

ENDIF

2100 CONTINUE
DO 2150 IT1=1,NTSDE11
NTSMAX=MAX (NTSMAX, NTSDE12(IT1))
C*****VALIDATE TIME RANGE FOR SPALLINGS RELEASES
IF (TSDE1(NTSDE12(IT1),IT1) .LT. TEND) THEN
WRITE(11,*) '>>>>SPALLINGS RELEASE TABLE DOES NOT SPAN ',
1       'POTENTIAL INTRUSION TIMES'
WRITE(11,*) '>>>>(', ACTI, ' TO ', TEND, ' YR)'
WRITE(6,*) '>>>>ERROR(D) ENCOUNTERED, EXECUTION TERMINATED'
STOP

ENDIF

2150 CONTINUE

```

```

DO 2200 IT1=1,NTSSE21
    NTSMAX=MAX (NTSMAX, NTSSE22(IT1))
C*****VALIDATE TIME RANGE FOR SPALLINGS RELEASES
    IF (TSSE2(NTSSE22(IT1),IT1) .LT. TEND) THEN
        WRITE(11,*) '>>>>SPALLINGS RELEASE TABLE DOES NOT SPAN ',
1          'POTENTIAL INTRUSION TIMES'
        WRITE(11,*) '>>>>(', ACTI, ' TO ', TEND, ' YR)'
        WRITE(6,*) '>>>>ERROR(E) ENCOUNTERED, EXECUTION TERMINATED'
        STOP
    ENDIF
2200 CONTINUE
DO 2250 IT1=1,NTSDE21
    NTSMAX=MAX (NTSMAX, NTSDE22(IT1))
C*****VALIDATE TIME RANGE FOR SPALLINGS RELEASES
    IF (TSDE2(NTSDE22(IT1),IT1) .LT. TEND) THEN
        WRITE(11,*) '>>>>SPALLINGS RELEASE TABLE DOES NOT SPAN ',
1          'POTENTIAL INTRUSION TIMES'
        WRITE(11,*) '>>>>(', ACTI, ' TO ', TEND, ' YR)'
        WRITE(6,*) '>>>>ERROR(F) ENCOUNTERED, EXECUTION TERMINATED'
        STOP
    ENDIF
2250 CONTINUE
C*****VALIDATE MAXIMUM COUNTER FOR SPALLINGS RELEASE TABLES
    IF (NTSMAX .GT. MAXTIM) THEN
        WRITE(11,*) '>>>>INCREASE VALUE OF PARAMETER MAXTIM TO AT ',
1          'LEAST ', NTSMAX
        WRITE(6,*) '>>>>ERROR(G) ENCOUNTERED, EXECUTION TERMINATED'
        STOP
    ENDIF
C*****VALIDATE 1ST INTRUSION TIMES (INCREASING ORDER), UNDISTURBED CONDITIONS
DO 2300 IT=2,NTSLE0
    IF (TSLE0(IT) .LE. TSLE0(IT-1)) THEN
        WRITE(11,*) '>>>>SPALLINGS RELEASE TIMES FOR UNDISTURBED ',
1          'CONDITIONS NOT IN INCREASING ORDER'
        WRITE(6,*) '>>>>ERROR(H) ENCOUNTERED, EXECUTION TERMINATED'
        STOP
    ENDIF
2300 CONTINUE
DO 2350 IT=2,NTSUE0
    IF (TSUE0(IT) .LE. TSUE0(IT-1)) THEN
        WRITE(11,*) '>>>>SPALLINGS RELEASE TIMES FOR UNDISTURBED ',
1          'CONDITIONS NOT IN INCREASING ORDER'

```

```

        WRITE(6,*) '>>>>ERROR(I) ENCOUNTERED, EXECUTION TERMINATED'
        STOP
    ENDIF
2350 CONTINUE
C*****VALIDATE 1ST INTRUSION TIMES (INCREASING ORDER), E1 INTRUSIONS
    DO 2400 IT1=2,NTSSE11
        IF (TSSE1(1,IT1) .LE. TSSE1(1,IT1-1)) THEN
            WRITE(11,*) '>>>>SPALLINGS RELEASE TIMES FOR E1 ',
1                'INTRUSIONS NOT IN INCREASING ORDER'
            WRITE(6,*) '>>>>ERROR(J) ENCOUNTERED, EXECUTION TERMINATED'
            STOP
        ENDIF
2400 CONTINUE
    DO 2450 IT1=2,NTSDE11
        IF (TSDE1(1,IT1) .LE. TSDE1(1,IT1-1)) THEN
            WRITE(11,*) '>>>>SPALLINGS RELEASE TIMES FOR E1 ',
1                'INTRUSIONS NOT IN INCREASING ORDER'
            WRITE(6,*) '>>>>ERROR(K) ENCOUNTERED, EXECUTION TERMINATED'
            STOP
        ENDIF
2450 CONTINUE
C*****VALIDATE 2ND INTRUSION TIMES (INCREASING ORDER), E1 INTRUSIONS
    DO 2600 IT1=1,NTSSE11
        DO 2500 IT2=2,NTSSE12(IT1)
            IF (TSSE1(IT2,IT1) .LE. TSSE1(IT2-1,IT1)) THEN
                WRITE(11,*) '>>>>SPALLINGS RELEASE TIMES FOR E1 ',
1                    'INTRUSIONS NOT IN INCREASING ORDER'
                WRITE(6,*) '>>>>ERROR(L) ENCOUNTERED, EXECUTION ',
1                    'TERMINATED'
                STOP
            ENDIF
2500 CONTINUE
2600 CONTINUE
    DO 2650 IT1=1,NTSDE11
        DO 2550 IT2=2,NTSDE12(IT1)
            IF (TSDE1(IT2,IT1) .LE. TSDE1(IT2-1,IT1)) THEN
                WRITE(11,*) '>>>>SPALLINGS RELEASE TIMES FOR E1 ',
1                    'INTRUSIONS NOT IN INCREASING ORDER'
                WRITE(6,*) '>>>>ERROR(M) ENCOUNTERED, EXECUTION ',
1                    'TERMINATED'
                STOP
            ENDIF

```

```

2550 CONTINUE
2650 CONTINUE
C*****VALIDATE 1ST INTRUSION TIMES (INCREASING ORDER), E2 INTRUSIONS
DO 2700 IT1=2,NTSSE21
  IF (TSSE2(1,IT1) .LE. TSSE2(1,IT1-1)) THEN
    WRITE(11,*) '>>>>SPALLINGS RELEASE TIMES FOR E2 ',
1      'INTRUSIONS NOT IN INCREASING ORDER'
    WRITE(6,*) '>>>>ERROR(N) ENCOUNTERED, EXECUTION TERMINATED'
    STOP
  ENDIF
2700 CONTINUE
DO 2750 IT1=2,NTSDE21
  IF (TSDE2(1,IT1) .LE. TSDE2(1,IT1-1)) THEN
    WRITE(11,*) '>>>>SPALLINGS RELEASE TIMES FOR E2 ',
1      'INTRUSIONS NOT IN INCREASING ORDER'
    WRITE(6,*) '>>>>ERROR(L) ENCOUNTERED, EXECUTION TERMINATED'
    STOP
  ENDIF
2750 CONTINUE
C*****VALIDATE 2ND INTRUSION TIMES (INCREASING ORDER), E2 INTRUSIONS
DO 2900 IT1=1,NTSSE21
  DO 2800 IT2=2,NTSSE22(IT1)
    IF (TSSE2(IT2,IT1) .LE. TSSE2(IT2-1,IT1)) THEN
      WRITE(11,*) '>>>>SPALLINGS RELEASE TIMES FOR E2 ',
1      'INTRUSIONS NOT IN INCREASING ORDER'
      WRITE(6,*) '>>>>ERROR(M) ENCOUNTERED, EXECUTION ',
1      'TERMINATED'
      STOP
    ENDIF
2800 CONTINUE
2900 CONTINUE
DO 2950 IT1=1,NTSDE21
  DO 2850 IT2=2,NTSDE22(IT1)
    IF (TSDE2(IT2,IT1) .LE. TSDE2(IT2-1,IT1)) THEN
      WRITE(11,*) '>>>>SPALLINGS RELEASE TIMES FOR E2 ',
1      'INTRUSIONS NOT IN INCREASING ORDER'
      WRITE(6,*) '>>>>ERROR(N) ENCOUNTERED, EXECUTION ',
1      'TERMINATED'
      STOP
    ENDIF
2850 CONTINUE
2950 CONTINUE

```

```

RETURN
C*****I/O ERROR WHILE READING SPALLINGS RELEASE TABLES
9200 CONTINUE
WRITE(11,*) '>>>>I/O ERROR WHILE READING SPALLINGS RELEASE ',
1          'TABLES'
WRITE(6,*) '>>>>ERROR(O) ENCOUNTERED, EXECUTION TERMINATED'
STOP
C*****PREMATURE EOF ENCOUNTERED READING SPALLINGS RELEASE TABLES
9300 CONTINUE
WRITE(11,*) '>>>>PREMATURE EOF ENCOUNTERED READING ',
1          'SPALLINGS RELEASE TABLES'
WRITE(6,*) '>>>>ERROR(P) ENCOUNTERED, EXECUTION TERMINATED'
STOP
END
C
C.....^.....
SUBROUTINE RDBLW
C*****READ BLOWOUT RELEASE TABLES
IMPLICIT DOUBLE PRECISION (A-H, O-Z)
PARAMETER (MXY=20, MAXREC=100, MAXBH=100, MAXRES=50, MAXBIN=161,
1          MAXSPC=10, MAXSC=30, MAXOBS=100, MAXTH=10000,
2          MAXTIM=20, MAXBP=5, MAXACT=1000, MAXTC=200,
3          MAXVAR=100, MAXREG=5, NEQM=MXY*MXY, IBWM=3*MXY+1,
4          NUSED=3, NOTUSE=5, NTWO=2)
LOGICAL GRDFLO, MINERD, PRTOBS, PRTH
COMMON /INPUT0/ GRDFLO, MINERD, PRTOBS(MAXOBS), PRTH(MAXTH)
COMMON /INPUT1/ ISEED, IMBKD, IOBS, ISPVAR, ITH, LHSVBP, NOBS,
1          NPF, NTH, NSPC, NREG, NBP, NPP
COMMON /INPUT2/ SMT, VBT, TOTACT, ACTI, ACTS, TSMAX, TSLIM,
1          TEND, TENDBH, STPRST, DD1, DD2, DDTIME, PPP(3),
2          DM1, DM2, DMTIME, TOL, RTOL, RPTOL, BUFFRC,
3          GRAV, PI, ECULEB, ECASTI, PCULEB, PCASTI,
4          DIAMNA, DIAMXA, DIAMNB, DIAMXB, DMODA, DMODB,
5          PRMNA, PRMNA, PRMNB, PRMNB, PMODA, PMODB,
6          BRNDEN, BRNVIS
COMMON /BLOW1/ NTBC, NTBLE0, NTBUE0,
1          NTBSE11, NTBDE11, NTBSE21, NTBDE21,
2          NTBSE12(MAXTIM), NTBDE12(MAXTIM),
3          NTBSE22(MAXTIM), NTBDE22(MAXTIM)
COMMON /BLOW2/ TBC(MAXTIM), CBE0(MAXTIM),
1          CBE1(MAXTIM), CBE2(MAXTIM),
2          TBLE0(MAXTIM), TBUE0(MAXTIM),

```

```

3          RBLE0(MAXTIM), RBUE0(MAXTIM),
4          TBSE1(MAXTIM,MAXTIM), RBSE1(MAXTIM,MAXTIM),
5          TBDE1(MAXTIM,MAXTIM), RBDE1(MAXTIM,MAXTIM),
6          TBSE2(MAXTIM,MAXTIM), RBSE2(MAXTIM,MAXTIM),
7          TBDE2(MAXTIM,MAXTIM), RBDE2(MAXTIM,MAXTIM)
CHARACTER LABSET(MAXREC,NUSED,NTWO)*48
CHARACTER LNOUSE(NOTUSE)*38, LINE3(NUSED)*30
CHARACTER SLABEL(MAXREC,NUSED,NTWO)*55
CHARACTER BLABEL(MAXREC,NUSED,NTWO)*55
COMMON /LABEL1/ BLABEL, LABSET, LINE3, LNOUSE
COMMON /LABEL2/ SLABEL

C
C
C*****READ FLAGS ON BLOWOUT RELEASES TITLE RECORD
      READ(2,911,ERR=9200,END=9300) IOBST, IFLG, LABSET(IOBS,3,1)
911  FORMAT(2I10,A48)
C      WRITE(*,*) IOBST,IFLG,IOBS
C*****VALIDATE OBSERVATION INDEX
      IF (IOBST .NE. IOBS) THEN
C*****INVALID OBSERVATION INDEX VALUE
          WRITE(11,*) '>>>>INVALID OBSERVATION INDEX VALUE FOR ',
1          'BLOWOUT RELEASE TABLES'
          WRITE(6,*) '>>>>ERROR(Q) ENCOUNTERED, EXECUTION TERMINATED'
          STOP
      ENDIF
C*****CHECK FLAG FOR READING RELEASE TABLES
      IF (IFLG .EQ. 0) RETURN
C*****LABEL BLOWOUT HEADER RECORD FOR CONCENTRATIONS
      READ(2,912,ERR=9200,END=9300) LABSET(IOBS,3,2)
912  FORMAT(A48)
C*****READ CONCENTRATION VALUES FOR BLOWOUT RELEASES
      READ(2,*,ERR=9200,END=9300) NTBC, (TBC(IT),IT=1,NTBC),
1          (CBE0(IT),IT=1,NTBC),
2          (CBE1(IT),IT=1,NTBC),
3          (CBE2(IT),IT=1,NTBC)
C*****LABEL BLOWOUT HEADER RECORD FOR UNDISTURBED CONDITIONS (LOWER PANELS)
      READ(2,913,ERR=9200,END=9300) BLABEL(IOBS,1,1)
913  FORMAT(A55)
C*****READ BLOWOUT RELEASES FOR UNDISTURBED CONDITIONS (LOWER PANELS)
      READ(2,*,ERR=9200,END=9300) NTBLE0, (TBLE0(IT),IT=1,NTBLE0),
1          (RBLE0(IT),IT=1,NTBLE0)
C*****LABEL BLOWOUT HEADER RECORD FOR UNDISTURBED CONDITIONS (UPPER PANELS)

```

```

      READ(2,913,ERR=9200,END=9300) BLABEL(IOBS,1,2)
C*****READ BLOWOUT RELEASES FOR UNDISTURBED CONDITIONS (UPPER PANELS)
      READ(2,*,ERR=9200,END=9300) NTBUE0, (TBUE0(IT),IT=1,NTBUE0),
1          (RBUE0(IT),IT=1,NTBUE0)
C*****LABEL BLOWOUT HEADER RECORD FOR E1 INTRUSIONS (SAME PANEL)
      READ(2,913,ERR=9200,END=9300) BLABEL(IOBS,2,1)
C*****READ BLOWOUT RELEASES FOR E1 INTRUSIONS (SAME PANEL)
      READ(2,*,ERR=9200,END=9300) NTBSE11, (NTBSE12(IT1),
1          (TBSE1(IT2,IT1),IT2=1,NTBSE12(IT1))),
2          (RBSE1(IT2,IT1),IT2=1,NTBSE12(IT1)), IT1=1,NTBSE11)
C*****LABEL BLOWOUT HEADER RECORD FOR E1 INTRUSIONS (DIFFERENT PANEL)
      READ(2,913,ERR=9200,END=9300) BLABEL(IOBS,2,2)
C*****READ BLOWOUT RELEASES FOR E1 INTRUSIONS (DIFFERENT PANEL)
      READ(2,*,ERR=9200,END=9300) NTBDE11, (NTBDE12(IT1),
1          (TBDE1(IT2,IT1),IT2=1,NTBDE12(IT1))),
2          (RBDE1(IT2,IT1),IT2=1,NTBDE12(IT1)), IT1=1,NTBDE11)
C*****LABEL BLOWOUT HEADER RECORD FOR E2 INTRUSIONS (SAME PANEL)
      READ(2,913,ERR=9200,END=9300) BLABEL(IOBS,3,1)
C*****READ BLOWOUT RELEASES FOR E2 INTRUSIONS (SAME PANEL)
      READ(2,*,ERR=9200,END=9300) NTBSE21, (NTBSE22(IT1),
1          (TBSE2(IT2,IT1),IT2=1,NTBSE22(IT1))),
2          (RBSE2(IT2,IT1),IT2=1,NTBSE22(IT1)), IT1=1,NTBSE21)
C*****LABEL BLOWOUT HEADER RECORD FOR E2 INTRUSIONS (DIFFERENT PANEL)
      READ(2,913,ERR=9200,END=9300) BLABEL(IOBS,3,2)
C*****READ BLOWOUT RELEASES FOR E2 INTRUSIONS (DIFFERENT PANEL)
      READ(2,*,ERR=9200,END=9300) NTBDE21, (NTBDE22(IT1),
1          (TBDE2(IT2,IT1),IT2=1,NTBDE22(IT1))),
2          (RBDE2(IT2,IT1),IT2=1,NTBDE22(IT1)), IT1=1,NTBDE21)
C*****VALIDATE TIME RANGE FOR BLOWOUT RELEASES
      IF ((TBC(1) .GT. ACTI) .OR.
1      (TBLE0(1) .GT. ACTI) .OR. (TBUE0(1) .GT. ACTI) .OR.
2      (TBSE1(1,1) .GT. ACTI) .OR. (TBDE1(1,1) .GT. ACTI) .OR.
3      (TBSE2(1,1) .GT. ACTI) .OR. (TBDE2(1,1) .GT. ACTI)) THEN
      WRITE(11,*) '>>>>BLOWOUT RELEASE TABLE DOES NOT SPAN ',
1          'POTENTIAL INTRUSION TIMES'
      WRITE(11,*) '>>>>(', ACTI, ' TO ', TEND, ' YR)'
      WRITE(6,*) '>>>>ERROR(R) ENCOUNTERED, EXECUTION TERMINATED'
      STOP
      ENDIF
C*****DETERMINE MAXIMUM COUNTER FOR BLOWOUT RELEASE TABLES
      NTBMAX=MAX (NTBC, NTBLE0, NTBUE0, NTBSE11, NTBDE11, NTBSE21,
1          NTBDE21)

```

```

C*****VALIDATE TIME RANGE FOR BLOWOUT RELEASES
      IF ((TBC(NTBC) .LT. TEND) .OR. (TBLE0(NTBLE0) .LT. TEND) .OR.
1      (TBUE0(NTBUE0) .LT. TEND)) THEN
      WRITE(11,*) '>>>>BLOWOUT RELEASE TABLE DOES NOT SPAN ',
1      'POTENTIAL INTRUSION TIMES'
      WRITE(11,*) '>>>>(', ACTI, ' TO ', TEND, ' YR)'
      WRITE(6,*) '>>>>ERROR(S) ENCOUNTERED, EXECUTION TERMINATED'
      STOP
      ENDIF
      DO 2100 IT1=1,NTBSE11
      NTBMAX=MAX (NTBMAX, NTBSE12(IT1))
C*****VALIDATE TIME RANGE FOR BLOWOUT RELEASES
      IF (TBSE1(NTBSE12(IT1),IT1) .LT. TEND) THEN
      WRITE(11,*) '>>>>BLOWOUT RELEASE TABLE DOES NOT SPAN ',
1      'POTENTIAL INTRUSION TIMES'
      WRITE(11,*) '>>>>(', ACTI, ' TO ', TEND, ' YR)'
      WRITE(6,*) '>>>>ERROR(T) ENCOUNTERED, EXECUTION TERMINATED'
      STOP
      ENDIF
2100 CONTINUE
      DO 2150 IT1=1,NTBDE11
      NTBMAX=MAX (NTBMAX, NTBDE12(IT1))
C*****VALIDATE TIME RANGE FOR BLOWOUT RELEASES
      IF (TBDE1(NTBDE12(IT1),IT1) .LT. TEND) THEN
      WRITE(11,*) '>>>>BLOWOUT RELEASE TABLE DOES NOT SPAN ',
1      'POTENTIAL INTRUSION TIMES'
      WRITE(11,*) '>>>>(', ACTI, ' TO ', TEND, ' YR)'
      WRITE(6,*) '>>>>ERROR(U) ENCOUNTERED, EXECUTION TERMINATED'
      STOP
      ENDIF
2150 CONTINUE
      DO 2200 IT1=1,NTBSE21
      NTBMAX=MAX (NTBMAX, NTBSE22(IT1))
C*****VALIDATE TIME RANGE FOR BLOWOUT RELEASES
      IF (TBSE2(NTBSE22(IT1),IT1) .LT. TEND) THEN
      WRITE(11,*) '>>>>BLOWOUT RELEASE TABLE DOES NOT SPAN ',
1      'POTENTIAL INTRUSION TIMES'
      WRITE(11,*) '>>>>(', ACTI, ' TO ', TEND, ' YR)'
      WRITE(6,*) '>>>>ERROR(V) ENCOUNTERED, EXECUTION TERMINATED'
      STOP
      ENDIF
2200 CONTINUE

```



```

DO 2250 IT1=1,NTBDE21
  NTBMAX=MAX (NTBMAX, NTBDE22(IT1))
C*****VALIDATE TIME RANGE FOR BLOWOUT RELEASES
  IF (TBDE2(NTBDE22(IT1),IT1) .LT. TEND) THEN
    WRITE(11,*) '>>>>BLOWOUT RELEASE TABLE DOES NOT SPAN ',
1      'POTENTIAL INTRUSION TIMES'
    WRITE(11,*) '>>>>(', ACTI, ' TO ', TEND, ' YR)'
    WRITE(6,*) '>>>>ERROR(W) ENCOUNTERED, EXECUTION TERMINATED'
    STOP
  ENDIF
2250 CONTINUE
C*****VALIDATE MAXIMUM COUNTER FOR BLOWOUT RELEASE TABLES
  IF (NTBMAX .GT. MAXTIM) THEN
    WRITE(11,*) '>>>>INCREASE VALUE OF PARAMETER MAXTIM TO AT ',
1      'LEAST ', NTBMAX
    WRITE(6,*) '>>>>ERROR(X) ENCOUNTERED, EXECUTION TERMINATED'
    STOP
  ENDIF
C*****VALIDATE 1ST INTRUSION TIMES (INCREASING ORDER), UNDISTURBED CONDITIONS
DO 2300 IT=2,NTBLE0
  IF (TBLE0(IT) .LE. TBLE0(IT-1)) THEN
    WRITE(11,*) '>>>>BLOWOUT RELEASE TIMES FOR UNDISTURBED ',
1      'CONDITIONS NOT IN INCREASING ORDER'
    WRITE(6,*) '>>>>ERROR(Y) ENCOUNTERED, EXECUTION TERMINATED'
    STOP
  ENDIF
2300 CONTINUE
DO 2350 IT=2,NTBUE0
  IF (TBUE0(IT) .LE. TBUE0(IT-1)) THEN
    WRITE(11,*) '>>>>BLOWOUT RELEASE TIMES FOR UNDISTURBED ',
1      'CONDITIONS NOT IN INCREASING ORDER'
    WRITE(6,*) '>>>>ERROR(Z) ENCOUNTERED, EXECUTION TERMINATED'
    STOP
  ENDIF
2350 CONTINUE
C*****VALIDATE 1ST INTRUSION TIMES (INCREASING ORDER), E1 INTRUSIONS
DO 2400 IT1=2,NTBSE11
  IF (TBSE1(1,IT1) .LE. TBSE1(1,IT1-1)) THEN
    WRITE(11,*) '>>>>BLOWOUT RELEASE TIMES FOR E1 INTRUSIONS ',
1      'NOT IN INCREASING ORDER'
    WRITE(6,*) '>>>>ERROR(a) ENCOUNTERED, EXECUTION TERMINATED'
    STOP

```

```

        ENDIF
2400 CONTINUE
        DO 2450 IT1=2,NTBDE11
            IF (TBDE1(1,IT1) .LE. TBDE1(1,IT1-1)) THEN
                WRITE(11,*) '>>>>BLOWOUT RELEASE TIMES FOR E1 INTRUSIONS ',
1                'NOT IN INCREASING ORDER'
                WRITE(6,*) '>>>>ERROR(b) ENCOUNTERED, EXECUTION TERMINATED'
                STOP
            ENDIF
2450 CONTINUE
C*****VALIDATE 2ND INTRUSION TIMES (INCREASING ORDER), E1 INTRUSIONS
        DO 2600 IT1=1,NTBSE11
            DO 2500 IT2=2,NTBSE12(IT1)
                IF (TBSE1(IT2,IT1) .LE. TBSE1(IT2-1,IT1)) THEN
                    WRITE(11,*) '>>>>BLOWOUT RELEASE TIMES FOR E1 ',
1                    'INTRUSIONS NOT IN INCREASING ORDER'
                    WRITE(6,*) '>>>>ERROR(d) ENCOUNTERED, EXECUTION ',
1                    'TERMINATED'
                    STOP
                ENDIF
2500 CONTINUE 2600 CONTINUE
            DO 2650 IT1=1,NTBDE11
                DO 2550 IT2=2,NTBDE12(IT1)
                    IF (TBDE1(IT2,IT1) .LE. TBDE1(IT2-1,IT1)) THEN
                        WRITE(11,*) '>>>>BLOWOUT RELEASE TIMES FOR E1 ',
1                        'INTRUSIONS NOT IN INCREASING ORDER'
                        WRITE(6,*) '>>>>ERROR(e) ENCOUNTERED, EXECUTION ',
1                        'TERMINATED'
                        STOP
                    ENDIF
2550 CONTINUE
2650 CONTINUE
C*****VALIDATE 1ST INTRUSION TIMES (INCREASING ORDER), E2 INTRUSIONS
        DO 2700 IT1=2,NTBSE21
            IF (TBSE2(1,IT1) .LE. TBSE2(1,IT1-1)) THEN
                WRITE(11,*) '>>>>BLOWOUT RELEASE TIMES FOR E2 ',
1                'INTRUSIONS NOT IN INCREASING ORDER'
                WRITE(6,*) '>>>>ERROR(f) ENCOUNTERED, EXECUTION TERMINATED'
                STOP
            ENDIF
2700 CONTINUE
        DO 2750 IT1=2,NTBDE21

```

```

        IF (TBDE2(1,IT1) .LE. TBDE2(1,IT1-1)) THEN
            WRITE(11,*) '>>>>BLOWOUT RELEASE TIMES FOR E2 INTRUSIONS ',
1            'NOT IN INCREASING ORDER'
            WRITE(6,*) '>>>>ERROR(g) ENCOUNTERED, EXECUTION TERMINATED'
            STOP
        ENDIF
2750 CONTINUE
C*****VALIDATE 2ND INTRUSION TIMES (INCREASING ORDER), E2 INTRUSIONS
        DO 2900 IT1=1,NTBSE21
            DO 2800 IT2=2,NTBSE22(IT1)
                IF (TBSE2(IT2,IT1) .LE. TBSE2(IT2-1,IT1)) THEN
                    WRITE(11,*) '>>>>BLOWOUT RELEASE TIMES FOR E2 ',
1                    'INTRUSIONS NOT IN INCREASING ORDER'
                    WRITE(6,*) '>>>>ERROR(h) ENCOUNTERED, EXECUTION ',
1                    'TERMINATED'
                    STOP
                ENDIF
2800 CONTINUE
2900 CONTINUE
        DO 2950 IT1=1,NTBDE21
            DO 2850 IT2=2,NTBDE22(IT1)
                IF (TBDE2(IT2,IT1) .LE. TBDE2(IT2-1,IT1)) THEN
                    WRITE(11,*) '>>>>BLOWOUT RELEASE TIMES FOR E2 ',
1                    'INTRUSIONS NOT IN INCREASING ORDER'
                    WRITE(6,*) '>>>>ERROR(i) ENCOUNTERED, EXECUTION ',
1                    'TERMINATED'
                    STOP
                ENDIF
2850 CONTINUE
2950 CONTINUE
            RETURN
C*****I/O ERROR READING BLOWOUT RELEASE TABLES
9200 CONTINUE
        WRITE(11,*) '>>>>I/O ERROR READING BLOWOUT RELEASE TABLES'
        WRITE(6,*) '>>>>ERROR(j) ENCOUNTERED, EXECUTION TERMINATED'
        STOP
C*****PREMATURE EOF ENCOUNTERED READING BLOWOUT RELEASE TABLES
9300 CONTINUE
        WRITE(11,*) '>>>>PREMATURE EOF ENCOUNTERED READING ',
1        'BLOWOUT RELEASE TABLES'
        WRITE(6,*) '>>>>ERROR(k) ENCOUNTERED, EXECUTION TERMINATED'
        STOP

```

```

      END
C
C.....^.....
      SUBROUTINE READR
C*****READ RELEASE TABLES FOR CURRENT OBSERVATION
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
      PARAMETER (MXY=20, MAXREC=100, MAXBH=100, MAXRES=50, MAXBIN=161,
1          MAXSPC=10, MAXSC=30, MAXOBS=100, MAXTH=10000,
2          MAXTIM=20, MAXBP=5, MAXACT=1000, MAXTC=200,
3          MAXVAR=100, MAXREG=5, NEQM=MXY*MXY, IBWM=3*MXY+1,
4          NUSED=3, NOTUSE=5, NTWO=2)
      CHARACTER LABSET(MAXREC,NUSED,NTWO)*48
      CHARACTER LNOUSE(NOTUSE)*38, LINE3(NUSED)*30
      CHARACTER SLABEL(MAXREC,NUSED,NTWO)*55
      CHARACTER BLABEL(MAXREC,NUSED,NTWO)*55
      COMMON /LABEL1/ BLABEL, LABSET, LINE3, LNOUSE
      COMMON /LABEL2/ SLABEL
C
C
C*****READ CUTTINGS RELEASE TABLES
      CALL RDCUT C*****READ SPALLINGS RELEASE TABLES
      CALL RDSPL
C*****READ BLOWOUT RELEASE TABLES
      CALL RDBLW
C*****READ MARKER BED RELEASE TABLES
C      CALL RDMB
      READ(2,900) LNOUSE(1)
      900 FORMAT(20X,A38)
C*****READ DEWEY LAKES RELEASE TABLES
C      CALL RDDDL
      READ(2,900) LNOUSE(2)
C*****READ SURFACE RELEASE TABLES
C      CALL RDSURF
      READ(2,900) LNOUSE(3)
C*****READ FLOW TO CULEBRA RELEASE TABLES
C      CALL RDCULT
      READ(2,900) LNOUSE(4)
C*****READ CULEBRA TRANSPORT RELEASE TABLES
C      CALL RDCULF
      READ(2,900) LNOUSE(5)
      RETURN
      END

```

C

C.....^.....

SUBROUTINE DOUBLE

C\*\*\*\*\*PRINT DOUBLED RELEASE TABLES

IMPLICIT DOUBLE PRECISION (A-H, O-Z)

INTEGER INDIC(3)

PARAMETER (MXY=20, MAXREC=100, MAXBH=100, MAXRES=50, MAXBIN=161,

1 MAXSPC=10, MAXSC=30, MAXOBS=100, MAXTH=10000,

2 MAXTIM=20, MAXBP=5, MAXACT=1000, MAXTC=200,

3 MAXVAR=100, MAXREG=5, NEQM=MXY\*MXY, IBWM=3\*MXY+1,

4 NUSED=3, NOTUSE=5, NTWO=2)

LOGICAL GRDFLO, MINERD, PRTOBS, PRTH

COMMON /INPUT0/ GRDFLO, MINERD, PRTOBS(MAXOBS), PRTH(MAXTH)

COMMON /INPUT1/ ISEED, IMBKCD, IOBS, ISPVAR, ITH, LHSVBP, NOBS,

1 NPF, NTH, NSPC, NREG, NBP, NPP

COMMON /INPUT2/ SMT, VBT, TOTACT, ACTI, ACTS, TSMAX, TSLIM,

1 TEND, TENDBH, STPRST, DD1, DD2, DDTIME, PPP(3),

2 DM1, DM2, DMTIME, TOL, RTOL, RPTOL, BUFFRC,

3 GRAV, PI, ECULEB, ECASTI, PCULEB, PCASTI,

4 DIAMNA, DIAMXA, DIAMNB, DIAMXB, DMODA, DMODB,

5 PRMMNA, PRMMXA, PRMMNB, PRMMXB, PMODA, PMODB,

6 BRNDEN, BRNVIS

COMMON /BLOW1/ NTBC, NTBLE0, NTBUE0,

1 NTBSE11, NTBDE11, NTBSE21, NTBDE21,

2 NTBSE12(MAXTIM), NTBDE12(MAXTIM),

3 NTBSE22(MAXTIM), NTBDE22(MAXTIM)

COMMON /BLOW2/ TBC(MAXTIM), CBE0(MAXTIM),

1 CBE1(MAXTIM), CBE2(MAXTIM),

2 TBLE0(MAXTIM), TBUE0(MAXTIM),

3 RBLE0(MAXTIM), RBUE0(MAXTIM),

4 TBSE1(MAXTIM,MAXTIM), RBSE1(MAXTIM,MAXTIM),

5 TBDE1(MAXTIM,MAXTIM), RBDE1(MAXTIM,MAXTIM),

6 TBSE2(MAXTIM,MAXTIM), RBSE2(MAXTIM,MAXTIM),

7 TBDE2(MAXTIM,MAXTIM), RBDE2(MAXTIM,MAXTIM)

COMMON /SPAL1/ NTSC, NTSLE0, NTSUE0,

1 NTSSE11, NTSDE11, NTSSE21, NTSDE21,

1 NTSSE12(MAXTIM), NTSDE12(MAXTIM),

2 NTSSE22(MAXTIM), NTSDE22(MAXTIM)

COMMON /SPAL2/ TSC(MAXTIM), CSA(MAXTIM),

1 TSLE0(MAXTIM), TSUE0(MAXTIM),

2 RSLE0(MAXTIM), RSUE0(MAXTIM),

3 TSSE1(MAXTIM,MAXTIM), RSSE1(MAXTIM,MAXTIM),

```

4          TSDE1(MAXTIM,MAXTIM), RSDE1(MAXTIM,MAXTIM),
5          TSSE2(MAXTIM,MAXTIM), RSSE2(MAXTIM,MAXTIM),
6          TSDE2(MAXTIM,MAXTIM), RSDE2(MAXTIM,MAXTIM)
COMMON /CUT1/ NTCH, NTRH, NCH, NRH, NACH, NARH
COMMON /CUT2/ DBDIAM, ACH, ARH, FVCH, FVRH, HCH, HRH,
1          PCUT(MAXACT), TCH(MAXTIM), TRH(MAXTIM),
2          RCUT(MAXTIM,MAXACT), PWT(3,MAXREG)
CHARACTER LABSET(MAXREC,NUSED,NTWO)*48
CHARACTER LNOUSE(NOTUSE)*38, LINE3(NUSED)*30
CHARACTER SLABEL(MAXREC,NUSED,NTWO)*55
CHARACTER BLABEL(MAXREC,NUSED,NTWO)*55
COMMON /LABEL1/ BLABEL, LABSET, LINE3, LNOUSE
COMMON /LABEL2/ SLABEL
C
C
IFLG=1
IONE=1
INDIC(1)=1
INDIC(2)=1      INDIC(3)=1
IF(IOBS.GT.1) IFLG=0
IF(IFLG.EQ.1) THEN
  FACTOR=-1.0
  WRITE(*,*) 'ENTER SCALING FACTOR (>0)'
  READ(*,*) FACTOR
  IF(FACTOR.LE.0.) STOP 'STOP: REQUIRE POSITIVE FACTOR'
  FACTCU=FACTOR*INDIC(1)
  FACTSP=FACTOR*INDIC(2)
  FACTBL=FACTOR*INDIC(3)
  LEND=LABEND(LINE3(1),30)
  WRITE(12,900) (LINE3(1)(L:L),L=1,LEND)
  LEND=LABEND(LINE3(2),30)
  WRITE(12,900) (LINE3(2)(L:L),L=1,LEND)
900  FORMAT(55A1)
  LEND=LABEND(LINE3(3),30)
  WRITE(12,921) NOBS,(LINE3(3)(L:L),L=1,LEND)
921  FORMAT(I10,55A1)
ENDIF
LEND=LABEND(LABSET(IOBS,1,1),48)
C*****WRITE FLAGS ON CUTTINGS RELEASES TITLE RECORD
  WRITE(12,901) IOBS, IFLG, (LABSET(IOBS,1,1)(L:L),L=1,LEND)
901  FORMAT(2I10,55A1)
C*****WRITE NUMBER OF TIMES, NUMBER OF WASTE TYPES, WASTE AREA,

```

```

C*****WASTE HEIGHT, VOLUME FRACTION, AND DRILL BIT DIAMETER FOR CH WASTE
      WRITE(12,922) NTCH, NCH, ACH, HCH, FVCH, DBDIAM
922  FORMAT(2I10,1P,14E10.3)
C*****WRITE NUMBER OF TIMES, NUMBER OF WASTE TYPES, WASTE AREA,
C*****WASTE HEIGHT, AND VOLUME FRACTION FOR RH WASTE
      WRITE(12,922) NTRH, NRH, ARH, HRH, FVRH
C*****WRITE PROBABILITIES ASSOCIATED WITH EACH ACTIVITY LEVEL FOR
C*****CH AND RH WASTES
      IF(IFLG.LT.1) GOTO 199
      WRITE(12,903) PCUT(1), (PCUT(ICH)-PCUT(ICH-1), ICH=2, NCH),
1          (PCUT(NCH+IRH), IRH=1, NRH)
903  FORMAT(1P,8E10.3)
C*****WRITE TIMES FOR ACTIVITY LEVELS FOR CH WASTE
      WRITE(12,903) (TCH(IT), IT=1, NTCH)
C*****WRITE TIMES FOR ACTIVITY LEVELS FOR RH WASTE
      WRITE(12,903) (TRH(IT), IT=1, NTRH)
C*****WRITE RELEASES FOR ALL TIMES FOR CH AND RH WASTE
      WRITE(12,903) ((FACTCU*RCUT(IT, ICH), IT=1, NTCH), ICH=1, NCH),
1          ((FACTCU*RCUT(IT, NCH+IRH), IT=1, NTRH), IRH=1, NRH)
C
C
199  LEND=LABEND(LABSET(IOBS, 2, 1), 48)
      WRITE(12,901) IOBS, IONE, (LABSET(IOBS, 2, 1)(L:L), L=1, LEND)
C*****LABEL SPALLINGS HEADER RECORD FOR CONCENTRATIONS
      LEND=LABEND(LABSET(IOBS, 2, 2), 48)
      WRITE(12,948) (LABSET(IOBS, 2, 2)(L:L), L=1, LEND)
948  FORMAT(55A1)
C*****WRITE CONCENTRATION VALUES FOR SPALLINGS RELEASES
      WRITE(12,904) NTSC, (TSC(IT), IT=1, NTSC),
1          (CSA(IT), IT=1, NTSC)
904  FORMAT(I10,1P,2(/8E10.3/E10.3))
C*****LABEL SPALLINGS HEADER RECORD FOR UNDISTURBED CONDITIONS (LOWER PANELS)
      LEND=LABEND(SLABEL(IOBS, 1, 1), 55)
      WRITE(12,902) (SLABEL(IOBS, 1, 1)(L:L), L=1, LEND)
902  FORMAT(55A1)
C*****WRITE SPALLINGS RELEASES FOR UNDISTURBED CONDITIONS (LOWER PANELS)
      WRITE(12,905) NTSLE0, (TSLE0(IT), IT=1, NTSLE0),
1          (FACTSP*RSLE0(IT), IT=1, NTSLE0)
905  FORMAT(I10/1P,6E10.3/6E10.3)
C*****LABEL SPALLINGS HEADER RECORD FOR UNDISTURBED CONDITIONS (UPPER PANELS)
      LEND=LABEND(SLABEL(IOBS, 1, 2), 55)
      WRITE(12,902) (SLABEL(IOBS, 1, 2)(L:L), L=1, LEND)

```

```

C*****WRITE SPALLINGS RELEASES FOR UNDISTURBED CONDITIONS (UPPER PANELS)
      WRITE(12,905) NTSUE0, (TSUE0(IT),IT=1,NTSUE0),
1          (FACTSP*RSUE0(IT),IT=1,NTSUE0)
C*****LABEL SPALLINGS HEADER RECORD FOR E1 INTRUSIONS (SAME PANEL)
      LEND=LABEND(SLABEL(IOBS,2,1),55)
      WRITE(12,902) (SLABEL(IOBS,2,1)(L:L),L=1,LEND)
C*****WRITE SPALLINGS RELEASES FOR E1 INTRUSIONS (SAME PANEL)
      WRITE(12,906) NTSSE11, (NTSSE12(IT1),
1          (TSSE1(IT2,IT1),IT2=1,NTSSE12(IT1))),
2  (FACTSP*RSSE1(IT2,IT1),IT2=1,NTSSE12(IT1)), IT1=1,NTSSE11)
906  FORMAT(I10/,I10/,1P,2(8E10.3/),
1      I10/,2(6E10.3/),I10/,2(6E10.3/),I10/,2(6E10.3/),
2      I10/,2(6E10.3/),I10/,2(5E10.3/),I10/,E10.3/E10.3)
C*****LABEL SPALLINGS HEADER RECORD FOR E1 INTRUSIONS (DIFFERENT PANEL)
      LEND=LABEND(SLABEL(IOBS,2,2),55)
      WRITE(12,902) (SLABEL(IOBS,2,2)(L:L),L=1,LEND)
C*****WRITE SPALLINGS RELEASES FOR E1 INTRUSIONS (DIFFERENT PANEL)
      WRITE(12,906) NTSDE11, (NTSDE12(IT1),
1          (TSDE1(IT2,IT1),IT2=1,NTSDE12(IT1))),
2  (FACTSP*RSDE1(IT2,IT1),IT2=1,NTSDE12(IT1)), IT1=1,NTSDE11)
C*****LABEL SPALLINGS HEADER RECORD FOR E2 INTRUSIONS (SAME PANEL)
      LEND=LABEND(SLABEL(IOBS,3,1),55)
      WRITE(12,902) (SLABEL(IOBS,3,1)(L:L),L=1,LEND)
C*****WRITE SPALLINGS RELEASES FOR E2 INTRUSIONS (SAME PANEL)
      WRITE(12,906) NTSSE21, (NTSSE22(IT1),
1          (TSSE2(IT2,IT1),IT2=1,NTSSE22(IT1))),
2  (FACTSP*RSSE2(IT2,IT1),IT2=1,NTSSE22(IT1)), IT1=1,NTSSE21)
C*****LABEL SPALLINGS HEADER RECORD FOR E2 INTRUSIONS (DIFFERENT PANEL)
      LEND=LABEND(SLABEL(IOBS,3,2),55)
      WRITE(12,902) (SLABEL(IOBS,3,2)(L:L),L=1,LEND)
C*****WRITE SPALLINGS RELEASES FOR E2 INTRUSIONS (DIFFERENT PANEL)
      WRITE(12,906) NTSDE21, (NTSDE22(IT1),
1          (TSDE2(IT2,IT1),IT2=1,NTSDE22(IT1))),
2  (FACTSP*RSDE2(IT2,IT1),IT2=1,NTSDE22(IT1)), IT1=1,NTSDE21)
C
C
C*****WRITE FLAGS ON BLOWOUT RELEASES TITLE RECORD
      LEND=LABEND(LABSET(IOBS,3,1),48)
      WRITE(12,901) IOBS, IONE, (LABSET(IOBS,3,1)(L:L),L=1,LEND)
C*****LABEL BLOWOUT HEADER RECORD FOR CONCENTRATIONS
      LEND=LABEND(LABSET(IOBS,3,2),48)
      WRITE(12,948) (LABSET(IOBS,3,2)(L:L),L=1,LEND)

```



```

C*****WRITE CONCENTRATION VALUES FOR BLOWOUT RELEASES
      WRITE(12,907) NTBC, (TBC(IT),IT=1,NTBC),
1          (CBE0(IT),IT=1,NTBC),
2          (CBE1(IT),IT=1,NTBC),
3          (CBE2(IT),IT=1,NTBC)
907  FORMAT(I10,1P,4(/8E10.3/E10.3))
C*****LABEL BLOWOUT HEADER RECORD FOR UNDISTURBED CONDITIONS (LOWER PANELS)
      LEND=LABEND(BLABEL(IOBS,1,1),55)
      WRITE(12,902) (BLABEL(IOBS,1,1)(L:L),L=1,LEND)
C*****WRITE BLOWOUT RELEASES FOR UNDISTURBED CONDITIONS (LOWER PANELS)
      WRITE(12,905) NTBLE0, (TBLE0(IT),IT=1,NTBLE0),
1          (FACTBL*RBLE0(IT),IT=1,NTBLE0)
C*****LABEL BLOWOUT HEADER RECORD FOR UNDISTURBED CONDITIONS (UPPER PANELS)
      LEND=LABEND(BLABEL(IOBS,1,2),55)
      WRITE(12,902) (BLABEL(IOBS,1,2)(L:L),L=1,LEND)
C*****WRITE BLOWOUT RELEASES FOR UNDISTURBED CONDITIONS (UPPER PANELS)
      WRITE(12,905) NTBUE0, (TBUE0(IT),IT=1,NTBUE0),
1          (FACTBL*RBUE0(IT),IT=1,NTBUE0)
C*****LABEL BLOWOUT HEADER RECORD FOR E1 INTRUSIONS (SAME PANEL)
      LEND=LABEND(BLABEL(IOBS,2,1),55)
      WRITE(12,902) (BLABEL(IOBS,2,1)(L:L),L=1,LEND)
C*****WRITE BLOWOUT RELEASES FOR E1 INTRUSIONS (SAME PANEL)
      WRITE(12,906) NTBSE11, (NTBSE12(IT1),
1          (TBSE1(IT2,IT1),IT2=1,NTBSE12(IT1))),
2  (FACTBL*RBSE1(IT2,IT1),IT2=1,NTBSE12(IT1)), IT1=1,NTBSE11)
C*****LABEL BLOWOUT HEADER RECORD FOR E1 INTRUSIONS (DIFFERENT PANEL)
      LEND=LABEND(BLABEL(IOBS,2,2),55)
      WRITE(12,902) (BLABEL(IOBS,2,2)(L:L),L=1,LEND)
C*****WRITE BLOWOUT RELEASES FOR E1 INTRUSIONS (DIFFERENT PANEL)
      WRITE(12,906) NTBDE11, (NTBDE12(IT1),
1          (TBDE1(IT2,IT1),IT2=1,NTBDE12(IT1))),
2  (FACTBL*RBDE1(IT2,IT1),IT2=1,NTBDE12(IT1)), IT1=1,NTBDE11)
C*****LABEL BLOWOUT HEADER RECORD FOR E2 INTRUSIONS (SAME PANEL)
      LEND=LABEND(BLABEL(IOBS,3,1),55)
      WRITE(12,902) (BLABEL(IOBS,3,1)(L:L),L=1,LEND)
C*****WRITE BLOWOUT RELEASES FOR E2 INTRUSIONS (SAME PANEL)
      WRITE(12,906) NTBSE21, (NTBSE22(IT1),
1          (TBSE2(IT2,IT1),IT2=1,NTBSE22(IT1))),
2  (FACTBL*RBSE2(IT2,IT1),IT2=1,NTBSE22(IT1)), IT1=1,NTBSE21)
C*****LABEL BLOWOUT HEADER RECORD FOR E2 INTRUSIONS (DIFFERENT PANEL)
      LEND=LABEND(BLABEL(IOBS,3,2),55)
      WRITE(12,902) (BLABEL(IOBS,3,2)(L:L),L=1,LEND)

```

```

C*****WRITE BLOWOUT RELEASES FOR E2 INTRUSIONS (DIFFERENT PANEL)
      WRITE(12,906) NTBDE21, (NTBDE22(IT1),
1         (TBDE2(IT2,IT1),IT2=1,NTBDE22(IT1)),
2  (FACTBL*RBDE2(IT2,IT1),IT2=1,NTBDE22(IT1)), IT1=1,NTBDE21)
      DO 100 KK=1,5
          LEND=LABEND(LNOUSE(KK),38)
100     WRITE(12,908) IOBS, 0, (LNOUSE(KK)(L:L),L=1,LEND)
908     FORMAT(2I10,55A1)
      RETURN
      END

C
C.....^.....
      INTEGER FUNCTION LABEND(STR,JEND)
      CHARACTER STR*(*)
      LABEND=0
C     WRITE(*,*) JEND
      DO 1000 J=1,JEND
          JB=JEND+1-J
          IF(STR(JB:JB).NE.' ') THEN
              LABEND=JB
              RETURN
          ENDIF
1000    CONTINUE
      RETURN
      END

```

## FORTRAN PROGRAMS USED FOR BILINEARITY TEST

### CCG.FOR

```

C*****READ CCDF.OUT FILE AND DIVIDE RELEASES BY INPUT FACTOR (.NEW)
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
      PARAMETER (MAXBIN=161,MAXRES=50)
      CHARACTER RLAB(0:MAXRES)*30, TITLEP*130
      DIMENSION CUMPRB(MAXBIN), VAL(MAXBIN), RMEAN(0:MAXRES),
1  PNZERO(0:MAXRES),PEAK(0:MAXRES),PPEAK(0:MAXRES),RSCMIN(0:MAXRES)
C
      OPEN(14,FILE='CCGF_T2_PA96.OUT',STATUS='UNKNOWN')
      OPEN(20,FILE='CCGF_T2_PA96.NEW',STATUS='UNKNOWN',RECL=1000)
C     OPEN(14,FILE='CCGF_T2.OUT')
C     OPEN(20,FILE='CCGF_T2.NEW')
C
C*****SET RESULT LABELS, WILL BE REPLACED ON READ
      RLAB(0)='Buffer'

```

```

      RLAB(1)='Cuttings'
      RLAB(2)='Spallings'
      RLAB(3)='Blowout'
      RLAB(4)='Cuttings Volume'
      RLAB(5)='Spallings Volume'
      RLAB(6)='Blowout Volume'
      RLAB(7)='Marker Beds'
      RLAB(8)='Dewey Lakes'
      RLAB(9)='Surface'
      RLAB(10)='Cutting+Spalling+Blowout'
      RLAB(11)='Total To Culebra-D'
      RLAB(12)='Total From Culebra-D'
      RLAB(13)='Total To Culebra-C'
      RLAB(14)='Total From Culebra-C'
      RLAB(15)='Total To Culebra'
      RLAB(16)='Total From Culebra'
      RLAB(17)='Total'
C*****READ HEADER RECORDS TO CCDF OUTPUT FILE
C*****READ TITLE FROM MISC INPUT FILE
      READ(14,2001) TITLEP
      WRITE(20,2001) TITLEP
C*****READ NUMBER OF OBSERVATIONS, NUMBER OF FUTURES PER OBS,
C*****TOTAL NUMBER OF RESULTS, NUMBER OF BASE RESULTS, NUMBER OF SPECIES,
C*****NUMBER OF BINS PER CCDF
      READ(14,2002) NOBS, NTH, NRES, NRESO, NRESB, NSPC, MAXDUM
      WRITE(20,2002) NOBS, NTH, NRES, NRESO, NRESB, NSPC, MAXDUM
C*****READ RESULT LABELS
      DO 2000 IRES=0,NRES
          READ(14,2001) RLAB(IRES)
          WRITE(20,2001) RLAB(IRES)
      2000 CONTINUE
C*****FORMAT STATEMENTS
      2001 FORMAT(A)
      2002 FORMAT(10I8)
          FACTOR=-1.0
          WRITE(*,*) 'ENTER SCALING FACTOR (>0)'
          READ(*,*) FACTOR
          IF(FACTOR.LE.0.) STOP 'STOP: REQUIRE POSITIVE FACTOR'
          DO LOOP=1,2
C*****ACCUMULATE RESULT DISTRIBUTIONS
          DO 4000 IRES=0,NRES
C*****READ RESULT DISTRIBUTION SUMMARY AND CCDF INFO TO FILE

```

```

        READ(14,1001) IOBS, IDUMMY, RMEAN(IRES), PNZERO(IRES),
1          PEAK(IRES), PPEAK(IRES), RSCMIN(IRES)
        WRITE(20,201) IOBS, IDUMMY, RMEAN(IRES), PNZERO(IRES),
1          PEAK(IRES), PPEAK(IRES), RSCMIN(IRES)
        READ(14,1002) (VAL(IBIN), IBIN=1, MAXBIN)
        WRITE(20,202) (VAL(IBIN)/FACTOR, IBIN=1, MAXBIN)
        READ(14,1002) (CUMPRB(IBIN), IBIN=1, MAXBIN)
        WRITE(20,202) (CUMPRB(IBIN), IBIN=1, MAXBIN)
4000    CONTINUE
        ENDDO
        STOP
C*****FORMAT STATEMENTS
1001  FORMAT(2I5,100E10.3)
1002  FORMAT(100E10.3)
201   FORMAT(2I5,1P100E10.3)
202   FORMAT(1P100E10.3)
        END

```

## OUTPUT FROM THE DIFFERENCE PROGRAM COMPARING THE CMS AND LINEARITY TEST OUTPUT FILES

Number of difference sections found: 0

Number of difference records found: 0

```

DIFFERENCES /IGNORE=()/MERGED=1/OUTPUT=$2$DKB400:[ROOT.HJCHMEL.DOUBLE_R]CCGF DIFF
$2$DKB400:[ROOT.HJCHMEL.DOUBLE_R]CCGF_T2_PA96.OUT;1-
$2$DKB400:[ROOT.HJCHMEL.DOUBLE_R]CCGF_T2_PA96.NEW;1

```

## APPENDIX A6 LHS COMPUTER CODE EVALUATION

The PA model is designed to generate estimates of the cumulative normalized release from the repository over a 10,000 year period after closure. Estimates of the releases include subjective uncertainties in the estimates of model parameters, and stochastic uncertainty in the modeling of future processes and events that may affect the repository. Latin Hypercube Sampling (LHS) of uncertain model input parameters addresses the subjective uncertainty surrounding the correct value to use for the PA model parameters. Stochastic uncertainty is addressed within the CCDFGF code as discussed in Appendix A5 for this TSD.

LHS is adopted *in lieu* of a pure Monte Carlo sampling approach to generate efficient estimates of the mean CCDF. LHS ensures selection of random samples from across the entire range covered by the parameter distributions. In a pure Monte Carlo approach, each value for each input parameter is sampled

independently from the appropriate distribution. The LHS method first divides the range of the parameter distribution into strata, defined as intervals of equal probability. An interval is selected, then a random sample is drawn from the selected interval of the distribution.

The effect of this constrained randomization is to ensure a more uniform spread of sampled values over the entire range of the parameter distribution than might be obtained by simple Monte Carlo sampling. If Monte Carlo were used with small sample sizes, it is unlikely that values would be selected from all regions of the parameter distribution. For small sample sizes, the LHS procedure provides a more efficient sampling technique for estimating the mean CCDF.

Much of the information on which the EPA review was based is contained in the QA Packages for 13 PA Codes (Docket: A-93-02, II-G-03, Volume 8). Volume 8 contains the following documents:

UM - Users Manual for LHS Version 2.41, Version 1.00

RD&VVP - Requirements Document & Verification and Validation Plan - Version 1.00 for LHS (Version 2.40)

VD - Validation Document, Version 1.00 for LHS (Version 2.40)

ID - Implementation Document - Version 1.00 for LHS (Version 2.41)

In the ensuing discussion these documents will be referred to by their generic title (i.e., User's Manual) or their generic title abbreviation (i.e., UM). The detailed titles and docket references will not be repeated.

## EPA REVIEW

a) **Any compliance application shall include:**

**a.1) A description of the conceptual models and scenario construction used to support any compliance application.**

The objective of the LHS approach is to provide a measure of the sampling uncertainty associated with the normalized releases estimated by the model. Measures of the sampling variability of the estimated values are required in order to reflect uncertainty in the comparison of the estimated summary CCDF curve to the requirements of 40 CFR 194 and 40 CFR 191.13(a). The requirements of §194.34(f) are summarized as follows.

Any compliance application shall provide information which demonstrates that there is at least a 95 percent level of statistical confidence that the mean of the population of CCDFs meets the containment requirement of §191.13 ...

The level of statistical confidence is determined by the variability in the estimated mean CCDF due to subjective parameter uncertainty.

Important input parameters in the PA are assigned a univariate probability distribution to reflect the uncertainty in the value of the parameter. This provides a unique marginal probability distribution for each LHS parameter. The univariate parameter distributions are described in Appendix PAR (Docket: A-93-02, II-G-1, Volume XI), in Chapter 6 of the CCA (Docket: A-93-02, II-G-1, Volume I), and in User's Manual for LHS. Additional information is provided in Iman and Shortencarier 1984 (Docket: A-93-02, II-G-1, Ref. #327).

The LHS program is also capable of inducing pairwise correlations between the sampled parameter values where correlations are desired. This feature is used sparingly in the CCA. See Section c.6 below for additional information on parameter correlations.

**a.2) A description of plausible alternative conceptual model(s) seriously considered but not used to support such application, and an explanation of the reason(s) why such model(s) was not deemed to accurately portray performance of the disposal system.**

The LHS sampling procedure operates at two levels. At the first level, 100 equiprobable intervals are created for each input parameter included in the LHS procedure. A random sample is selected from each interval. At the second level of the LHS procedure employed by DOE, the sample values from the first level are arranged into a matrix with values for each of the 57 parameters that will be used in each of the 100 runs. This second level of LHS, called *restricted pairing*, is designed to control unwanted correlations between selected pairs of parameters that may arise by chance if a truly random arrangement were used for this matrix. The rearrangement is done for all parameters, not only the parameters which are assigned to have non-zero correlations.

The LHS program treats each parameter independently, but permits user-specified correlations to be imposed between specified pairs of parameters after the LHS sample is selected. This option is not necessary for traditional LHS analysis and is applied sparingly in the current CCA calculations. The CCA LHS methodology is a constrained LHS method in which unwanted pair-wise correlations are

suppressed (i.e., purposely set to 0). Plausible alternative conceptual models include the use of simple Monte Carlo sampling methods and the use of LHS methods without the restricted pairings option to control correlations.

Efforts to eliminate *spurious* correlations—those that would naturally occur in both unrestricted LHS and pure Monte Carlo methods—serves to decrease the variability of the estimated mean. The precision of the LHS estimate of the mean using restricted pairings may be over-estimated, as compared with pure Monte Carlo Sampling or unrestricted LHS. However, the magnitude of this undesirable effect decreases with increasing sample size. LHS sampling differs from Monte Carlo sampling because it involves sampling without replacement, whereas Monte Carlo sampling involves sampling with replacement. For large sample sizes the difference between sampling with or without replacement is small. Using sample sizes as large as 100 should reduce the effect to acceptable levels.

### a.3) Documentation that:

#### a.3.i) Conceptual models and scenarios reasonably represent possible future states of the disposal system

Unlike other PA models, the LHS program does not model physical phenomena nor does it solve equations that model physical processes. Its principal role in the PA is to generate samples from probability distributions that reasonably represent value of the input parameters required to run the PA model. The list of 57 uncertain parameters selected for inclusion in the LHS procedure is included in Appendix PAR (*ibid.*). The list does not include several important random variables which are unique to the CCDFGF program. The variables generated in the CCDFGF code reflect stochastic uncertainty rather than subjective uncertainty.

Evaluation of the appropriateness of each parameter distribution is covered in the Technical Support Document for Section 194.23: Parameter Justification Report (Docket: A-93-02, III-B-14). This Appendix concentrates on the correct use of the probability distributions assigned elsewhere in the model (*e.g.*, Appendix PAR).

#### a.3.ii) mathematical models incorporate equations and boundary conditions which reasonably represent the mathematical formulation of the conceptual models.

The mathematical formulation for stochastic and parameter uncertainty is discussed formally in Helton (1996). The mathematical analysis presented in that paper details several possible simulation/integration schemes for obtaining the unconditional mean CCDF for PA.

A pure Monte Carlo simulation approach is used for the stochastic variables. A conditional CCDF is generated by the CCDFGF simulation model for each LHS vector of parameter values. The LHS procedure is designed so that the conditional CCDFs are all equally likely. Hence, it is appropriate to combine the conditional CCDFs into a single unconditional CCDF using equal weights for the CCDF associated with each LHS vector.

Although the general mathematical approach to sampling of parameters is described briefly in Chapter 6 of the CCA (*op. cit.*), the User's Manual for LHS (*op. cit.*), and Appendix PAR (*op. cit.*), no detailed discussion of the Latin Hypercube Sampling (LHS) procedure is included in the CCA. The User's Manual contains a brief discussion of the advantages of this approach. Previous PAs addressed this issue in the main document. A summary of the mathematics is presented in the remainder of this section.

A typical forecasting model for a scalar quantity  $z$  given a vector of input parameters is

$$z = g(\mathbf{x}) + e,$$

where the arguments of the deterministic forecasting function  $g$  are contained in parameter vector  $\mathbf{x}$ , and the random variable  $e$  represents forecasting error. If the parameter vector  $\mathbf{x}$  is known and the error term has expectation zero, then the scalar value  $g(\mathbf{x})$  is the appropriate forecast for  $z$ .

Let the notation  $E(A|B)$  denote conditional expectation of random variable  $A$ , given a specific selected value of the random variable  $B$ .

If the parameter vector  $\mathbf{x}$  has been assigned a probability distribution, the conditional expectation is used to forecast  $z$ . Given any fixed vector value for  $\mathbf{x}$ , this forecast is

$$E(z|\mathbf{x}) = g(\mathbf{x}).$$

In the CCA, a multivariate probability distribution function  $f(\mathbf{x})$  has been developed to describe the uncertainties in the parameter vector  $\mathbf{x}$ . This multivariate distribution for  $\mathbf{x}$  is specified by applying the 57 univariate marginal distributions and three selected pair-wise correlations, as developed in Appendix PAR.

In general, the unconditional expectation (forecast) of  $z$  is obtained by averaging the conditional expectation over all possible values of  $\mathbf{x}$ . The unconditional expectation of  $z$  is a weighted average of various  $g(\mathbf{x})$  values, with  $f(\mathbf{x})$  providing



the appropriate weights:

$$E(z) = E[ E(z|\mathbf{x}) ] = \int \mathbf{x} g(\mathbf{x}) f(\mathbf{x}) d\mathbf{x}$$

The required integral is extremely difficult to evaluate mathematically, however. The LHS method is one Monte Carlo approach to approximating a value for this integral.

a.3.iii) numerical models provide numerical schemes which enable the mathematical models to obtain stable solutions.

As noted in the User's Manual for LHS, the minimum number of sample vectors required to assure representative sampling is roughly 4/3 times the number of parameters sampled. Based on this argument, DOE uses a set of three independent replicates, each of size 100, to demonstrate that the PA model reaches stable solutions. Each replicate uses a different LHS sample of parameter values. Only small differences were noted among the three replicates, indicating that it is not necessary to use higher sample sizes.

a.3.iv) computer models accurately implement the numerical models; i.e., computer codes are free of coding errors and produce stable solutions.

Numerical models for the implementation of the LHS methods are defined in Iman and Shortencarier 1984 (*op cit.*). A summary of the numerical approach is included in the User's Manual. The LHS Fortran code for implementing the numerical model is listed in the Implementation Document. The correctness of the implementation is tested by the tests proposed in the Requirements Documents & Verification and Validation Plan. The results of these tests obtained by DOE are presented in the Validation Document. An EPA review of the validation tests for the LHS code is discussed in Section b.1.v(11) of this appendix.

a.3.v) Conceptual models have undergone peer review according to §194.27

The conceptual model for LHS program is not addressed in Chapter 6 of the CCA. Brief descriptions are found in the User's Manual and Iman and Shortencarier 1984 (*op. cit.*). No Peer Review of the LHS procedures was conducted, as this program does not model future events and process in the repository.

b) Computer codes used to support any compliance application shall be documented in a manner that complies with the requirements of ASME NQA-2a-1990 addenda, part 2.7, to ASME NQA-2-1989 edition.

## (Incorporation by reference as specified in § 194.5)

A technical evaluation of the adequacy of the CCA PA QA documents is summarized below.

- *Requirements Document/Verification and Validation Plan*

Functional requirements are listed in the Requirements Document & Verification and Validation Plan (RD/VVP) for LHS. The requirements are that the program correctly implements the LHS procedure, correctly generates the probability distributions assigned to the parameters, properly uses the information contained in the input data sets, and generates a sample with the proper user-specified rank correlations, if this option is selected.

The test plan presented in the VVP provides additional information on these functional requirements related to the correct implementation of the LHS code. Additional static tests are presented, including a coverage analysis. Ten functional tests are presented. The first four tests concern the correct operation of the program in the areas described above. All 10 tests were run on previous versions of the LHS code. Output files from the current version are compared with corresponding files produced by earlier versions of the code.

- *Implementation Document*

The Implementation Document for the LHS program contains over 10,000 lines of FORTRAN code, encompassing approximately 70 subroutines and user-defined functions. This code was used to compile the executable, LHS\_PA96.EXE, used for the CCA.

- *User's Manual*

The User's Manual contains a brief discussion of the techniques and advantages of the LHS approach. The manual describes the input and output files, and gives examples of the calculations for a simplified LHS problem.

- *Validation Document*

The Validation Document reports the results of static analyses on the LHS code. The static analysis was completed using the DEC-supplied source code analyzers. The coverage analysis reported that there are 30 LHS modules not called in the coverage test cases. These routines are all used with LHS options not used for the WIPP PA analysis.

The VD also reports the results of the ten tests performed for the LHS code. The tests were run using command script files (.COM) to define the working directory, source for executables, and necessary input files for each test. Output files are written to [.OUT] output and [.DBG] debug subdirectories. The original scripts for the LHS tests were prepared for the CCA-CMS. As part of the review of the VD, all ten tests were rerun and results compared to those reported in the CCA. Attachment 1 of the appendix provides file listings for the tests reconstructed by EPA. The first four tests concern the correct operation of the program in the areas described above. The final six tests determine whether the program recognizes erroneous data in the input files, and provides appropriate error messages. No output files are generated by these tests other than the file containing the error message.

The command LIBCCGF was used to direct the current CCA-CMS pointer to the CCGF library, prior to using the CSE and CFE commands to locate and fetch the required .COM script and .INP input files for the tests. The CSE command was used to locate the .COM files used for running the original LHS tests for the CCA. These files were then fetched using the CFE command. The directory names referenced in the .COM script for each test were modified as needed to run the various tests using the PA96 executable in the CCA-CMS. Note, the required .INP files had been modified to include CCA-CMS documentation lines at the end of each file. This necessitated removing these lines from the end of each file to obtain proper execution of the LHS program.

The tests were conducted in numerical order. The first 4 tests use valid input files and are expected to run to completion with no error messages. It was also expected that the output files for each test would match those in the CMS. The final six tests use input files with erroneous input data—i.e., to test the error handling capability of the code. It was expected that error messages would be encountered when running these tests. The scripts and input files used for each test are shown in the listing at the end of this appendix. Output files and the results of the DIFFERENCE program—comparing the old and new files—are also listed there.

The following steps were completed to review the LHS tests:

Created working directory [-.LHS.TEST] and moved the files to that directory.

Created .DBG and .OUT subdirectories to hold output files for the ten tests.

Reconstruction of Test 1:

Used CFE to fetch the .INP file for Test 1. Removed last few records. Modified

the .COM script to run Test 1. Ran the LHS Version 2.40 executable. No error messages were noted on execution. Changed to the .OUT directory. Fetched the Test 1 .OUT file from the CCA-CMS. Used the DIF command to compare the two output file. No differences were found.

#### Reconstruction of Test 2:

Used CFE to fetch the .INP file for Test 2. Removed last few records. Modified the .COM script to run Test 2. Ran the LHS Version 2.40 executable. No error messages were noted on execution. Changed to the .OUT directory. Fetched the Test 2 .OUT file from the CCA-CMS. Used the DIF command to compare the two output files. No differences were found.

#### Reconstruction of Test 3:

Used CFE to fetch the .INP file for Test 3. Removed last few records. Modified the .COM script to run Test 3. Ran the LHS Version 2.40 executable. No error messages were noted on execution. Changed to the .OUT directory. Fetched the Test 3 .OUT file from the CCA-CMS. Used the DIF command to compare the two output files. Major differences were found between the two files. Determined that the .OUT file for Test 3 in the CCA-CMS was an older version of the Test 3 output file, created on 8/23/95. Apparently, an output file from an earlier run of the test was inadvertently selected for incorporation into the CCA-CMS when it was built. Even though the output file failed the difference test, further inspection indicated that the test had run properly.

#### Reconstruction of Test 4:

Used CFE to fetch the .INP file for Test 4. Removed last few records. Modified the .COM script to run Test 4. Ran the LHS Version 2.40 executable. No error messages were noted on execution. Changed to the .OUT directory. Fetched the Test 4 .OUT file from the CCA-CMS. Used the DIF command to compare the two output files. No differences were found.

#### Reconstruction of Test 5:

Used CFE to fetch the .INP file for Test 5. Removed last few records. Modified the .COM script to run Test 5. Ran the LHS Version 2.40 executable. As expected, error messages were noted on execution. Moved to the output directory, checked output file which contained the appropriate error message.

#### Reconstruction of Test 6:

Used CFE to fetch the .INP file for Test 6. Removed last few records. Modified the .COM script to run Test 6. Ran the LHS Version 2.40 executable. As expected, error messages were noted on execution. Moved to the output directory, checked output file which contained the appropriate error message.

#### Reconstruction of Test 7:

Used CFE to fetch the .INP file for Test 7. Removed last few records. Modified the .COM script to run Test 7. Ran the LHS Version 2.40 executable. As expected, error messages were noted on execution. Moved to the output directory, checked output file which contained the appropriate error message.

#### Reconstruction of Test 8:

Used CFE to fetch the .INP file for Test 8. Removed last few records. Modified the .COM script to run Test 8. Ran the LHS Version 2.40 executable. As expected, error messages were noted on execution. Moved to the output directory, checked output file which contained the appropriate error message.

#### Reconstruction of Test 9:

Used CFE to fetch the .INP file for Test 9. Removed last few records. Modified the .COM script to run Test 9. Ran the LHS Version 2.40 executable. As expected, error messages were noted on execution. Moved to the output directory, checked output file which contained the appropriate error message.

#### Reconstruction of Test 10:

Used CFE to fetch the .INP file for Test 10. Removed last few records. Modified the .COM script to run Test 10. Ran the LHS Version 2.40 executable. As expected, error messages were noted on execution. Moved to the output directory, checked output file. It contained the appropriate error message.

c) Documentation of all models and computer codes are included as part of any compliance application performance assessment calculation shall be provided. Such documentation shall include, but not be limited to:

c.1) Descriptions of the theoretical backgrounds of each model and the method of analysis or assessment,

The theoretical background for the LHS code is found in the User's Manual and in

Iman and Shortencarier 1984 (*op. cit.*).

c.2) General descriptions of the models; discussions of the limits of applicability of each model; detailed instructions for executing the computer codes, including hardware and software requirements, input and output formats with explanations of each input and output variable and parameter (e.g., parameter name and units); listings of input and output files from a sample computer run; and reports on code verification, benchmarking, validation, and quality assurance procedures.

Capabilities and limitations are discussed on page 12 of the User's Manual. Detailed instructions for executing the code are found in the User's Manual (pp. 12 - 50), and in the VVD where execution instructions are included as part of the testing. A brief discussion of Hardware Requirements is included in the VD. The Implementation Document for LHS provides a code listing and build script. Software requirements for implementing the coverage analysis are also included in the VVD. Input and output formats are discussed in the User's Manual for LHS (pp. 7-50). Sample pages are printed in the Appendices to the User's Manual.

The input parameters to the LHS program consist of the coefficients which specify probability distributions for each of the 57 PA model parameters included in the LHS procedure. Physical parameters used in the model have been assigned probability distributions based either on available data or the subjective opinion of experts. Many types of probability distributions are used to describe the uncertainty in the WIPP PA model input parameters.

The families of probability distributions selected for the PA model input parameters include the uniform, loguniform, triangular, Student's t, cumulative, logcumulative and delta distributions. All but the delta distribution are defined for variables that can take a continuous range of values. The delta distribution is used for parameters which can take only a discrete set of values. The uniform, loguniform, and triangular distributions are appropriate for parameters that are assumed to lie in an interval between two known endpoints. In the LHS code, the Student's t distributions is defined to extend only to the 1st and 99th percentiles, rather than to continue indefinitely past these extremes.

Some distributions do not belong to a known family of distributions. The cumulative or *constructed* distribution is created directly from the observed data by forming the observed cumulative distribution function. The logcumulative distribution uses the same method applied to the logarithms of the parameter

values. Appendix PAR (*op. cit.*) also introduces the normal and lognormal distributions, however it appears no parameters were assigned distributions of these types.

The LHS program is capable of inducing pair-wise correlations between the sampled parameter values where correlations are desired. This feature is used sparingly in the CCA. Current LHS procedures treat almost all pairs of input variables as uncorrelated. This is a generally accepted statistical practice. Correlations were assigned to three pairs of parameters. These pairs are examined in Section c.6 of this appendix.

Mathematical definitions of each input and output variable are provided in Iman and Shortencarier 1984 (*op. cit.*). Additional information is included in the User's Manual for LHS. Explanations of the source for each parameter distribution are described in Appendix PAR references. Additional information is available on the Data Entry Forms (Form 464).

The Validation Document reports the results of ten tests performed to validate the LHS code. Results of the tests indicate all requirements listed in the VVP were satisfied.

### **c.3) Detailed descriptions of the structure of computer codes and complete listings of the source codes.**

Iman and Shortencarier 1984 (*op. cit.*) contains a description of the LHS code. The Implementation Document for the LHS program contains a listing of FORTRAN code, encompassing approximately 70 subroutines and user-defined functions. This code was used to compile the executable, LHS\_PA96.EXE, used for the CCA.

### **c.4) Detailed descriptions of data collection procedures, sources of data, data reduction and analysis, and code input parameter development.**

This consideration is not applicable to the LHS code. No parameters are used by the LHS code other than the required sample size and the coefficients of the probability distributions for the WIPP model parameters.

Parameters and their distributions are discussed in the Technical Support Document for Section 194.23: Parameter Report (Docket: A-93-02, III-B-12) and the Technical Support Document for Section 194.23: Parameter Justification Report (Docket: A-93-02, III-B-14).

A description of input parameter development is not applicable to the LHS code.

No data are used by the code other than the sample size and the parameters of the probability distributions for the WIPP model parameters.

**c.5) Any necessary licenses**

This consideration is not applicable to the LHS code. No licenses are required.

**c.6) An explanation of the manner in which models and computer codes incorporate the effects of parameter correlation.**

DOE samples 57 uncertain parameters in LHS. Current LHS procedures treat most input variables as uncorrelated. This is a generally accepted statistical practice. The general methods for addressing correlation are included in Iman and Shortencarier 1984 (*op. cit.*).

Several variables are identified in Appendix PAR (p. PAR-12) with strong correlations. In BRAGFLO, rock compressibility and intrinsic permeability in MB139 are assigned a -0.99 correlation. The same highly negative correlation is used for the same parameters in the Salado halite.

The other significant example of parameter correlation actually used in the current CCA involves the Castile brine reservoir region, where the rock compressibility and intrinsic permeability are assigned a correlation of -0.75.

**d) The Administrator or the Administrator's authorized representative may verify results of computer simulations used to support any compliance application by performing independent simulations. Data files, source codes, executable versions of computer software for each model, other material or information needed to permit the Administrator or the Administrator's authorized representative to perform independent simulations, and access to necessary hardware to perform such simulations, shall be provided within 30 calendar days of a request by the Administrator or the Administrator's authorized representative.**

Independent simulation of the tests presented in the VVD was relatively straight-forward. The replication of these tests are discussed in Section b.1.v(12) above.

Input data files for the LHS code, the LHS\_PA96 source code, and the LHS\_PA96 executable are available in the CCA-CMS. Tests 1 through 10 listed in the VVD were run with this version of the executable, as discussed in Section b.1.v(13).

Access to the Sandia VAX hardware is available through internet Telnet



connections, after obtaining proper authorization.

## REFERENCES

Helton, J.C. 1996. *Probability, Conditional Probability, and Complementary Cumulative Distribution Functions for Radioactive Waste Disposal*. SAND95-2571. Sandia National Laboratories, Albuquerque NM. March 1996.

See Appendix B for listing of docketed references.

## ATTACHMENT 1 - FILE LISTINGS FOR LHS TESTS RECONSTRUCTED BY EPA

### .COM FILE FOR RUNNING LHS TESTS

```
$! -----
$! MODULE:   LHS2_RUN_PCA.COM
$! PURPOSE: RUN TEST CASES FOR LHS USING THE PA96 PRODUCTION VERSION OF
$!           LHS VERSION 2.40
$! PARAMETERS:  NONE
$! AUTHOR:   H. J. CHMELYNSKI
$! DATE:    02/03/97
$! -----
$! Setup for testing
$ SET NOON
$ TESTDIR:= "EPA:[ROOT.HJCHMEL.LHS2.TEST]"
$ OUTDIR  := "EPA:[ROOT.HJCHMEL.LHS2.TEST.OUT]"
$ DBGDIR  := "EPA:[ROOT.HJCHMEL.LHS2.TEST.DBG]"
$ EXE_SRC := $WP$PRODROOT:[LHS.EXE]LHS_PA96.EXE
$! -----
$! Set number of last test case and initialize counter
$ NCASE = 10
$ STARTCASE = 0
$ P1 = STARTCASE
$! -----
$! Execute all test cases
$ EXETEST:
$ P1 = P1 + 1
$! Define file names
$ DEFINE LHS2_UIF$INPUT   'TESTDIR'LHS2_T'P1'.INP
$ DEFINE LHS2_OUT$OUTPUT 'OUTDIR'LHS2_T'P1'.OUT
$ DEFINE LHS2_DBG$OUTPUT 'DBGDIR'LHS2_T'P1'_DBG.OUT
$ DEFINE LHS2_NO2$SCRTCH FOR002.DAT
$ DEFINE LHS2_NO3$SCRTCH FOR003.DAT
```

```

$ DEFINE LHS2_NO4$SCRTCH FOR004.DAT
$ DEFINE LHS2_NO7$SCRTCH FOR007.DAT
$ DEFINE LHS2_NO8$SCRTCH FOR008.DAT
$ DEFINE LHS2_NO9$SCRTCH FOR009.DAT
$! -----
$! Execute test case P1
$ EXE_SRC
$! Go to start of execute loop for next case if not all done
$ IF P1 .LT. NCASE THEN GOTO EXETEST
$! -----
$! Inform user where files are
$ write sys$output " Test cases Completed"
$ write sys$output " Output files are in directory [LHS2.TEST.OUT]"
$ write sys$output " Debug files are in directory [LHS2.TEST.DBG]"
$! -----
$ EXIT
$! CMS REPLACEMENT HISTORY, Element LHS2_TEST.COM
$! *7      12-FEB-1996 10:04:33 LNSMITH "TEST CASE SUITE MODIFIED."
$! *6      6-FEB-1996 14:32:42 LNSMITH "REVISION TO .COM FILE NECESSARY."
$! *5     19-OCT-1995 08:29:24 LNSMITH "REMOVED EXTRANEIOUS COMMENT LINES."
$! *4     28-SEP-1995 12:14:07 LNSMITH "REMOVED BLANK LINES IN FILE."
$! *3      5-SEP-1995 15:33:31 LNSMITH "ADDED ADDITIONAL TEST CASE."
$! *2     28-AUG-1995 14:33:12 LNSMITH "MODIFIED EXECUTABLE FILE NAME."
$! *1     28-AUG-1995 11:15:41 LNSMITH "INITIAL LOAD."
$! CMS REPLACEMENT HISTORY, Element LHS2_TEST.COM
OUTPUT OF DIFFERENCE COMMANDS FROM LHS TESTS
OUTPUT OF DIFFERENCE COMMAND FOR TEST 1
Number of difference sections found: 0
Number of difference records found: 0
DIFFERENCES /IGNORE=()/MERGED=1/OUTPUT=$2$DKB400:[ROOT.HJCHMEL.LHS2.TEST.OUT]LHS2
    $2$DKB400:[ROOT.HJCHMEL.LHS2.TEST.OUT]LHS2_T1.OUT;2-
    $2$DKB400:[ROOT.HJCHMEL.LHS2.TEST.OUT]LHS2_T1.OUT;1
OUTPUT OF DIFFERENCE COMMAND FOR TEST 2
Number of difference sections found: 0
Number of difference records found: 0
DIFFERENCES /IGNORE=()/MERGED=1/OUTPUT=$2$DKB400:[ROOT.HJCHMEL.LHS2.TEST.OUT]LHS2
    $2$DKB400:[ROOT.HJCHMEL.LHS2.TEST.OUT]LHS2_T2.OUT;2-
    $2$DKB400:[ROOT.HJCHMEL.LHS2.TEST.OUT]LHS2_T2.OUT;1
OUTPUT OF DIFFERENCE COMMAND FOR TEST 3
< FILE TOO LARGE TO PRINT. MANY DIFFERENCE FOUND. SEE TEXT. >
OUTPUT OF DIFFERENCE COMMAND FOR TEST 4
Number of difference sections found: 0

```

Number of difference records found: 0

DIFFERENCES /IGNORE=()/MERGED=1/OUTPUT=\$2\$DKB400:[ROOT.HJCHMEL.LHS2.TEST.OUT]LHS2  
\$2\$DKB400:[ROOT.HJCHMEL.LHS2.TEST.OUT]LHS2\_T4.OUT;1-  
\$2\$DKB400:[ROOT.HJCHMEL.LHS2.TEST.OUT]LHS2\_T4.OUT;2

## INPUT FILE FOR LHS TEST 1

TITLE CMS Test Input File for the LHS Code Test 1

|                   |              |            |          |
|-------------------|--------------|------------|----------|
| NOBS              | 75           |            |          |
| RANDOM SEED       | 933090934    |            |          |
| NORMAL            |              | NORMMAT1   | NORMPRP1 |
| 0.00000E+00       | 2.00000E-01  |            |          |
| NORMAL            |              | NORMMAT2   | NORMPRP2 |
| 5.77000E+02       | 1.04200E+03  |            |          |
| NORMAL            |              | NORMMAT3   | NORMPRP3 |
| -3.67370E-02      | 8.32640E-02  |            |          |
| LOGNORMAL         |              | LOGNMAT1   | LOGNPRP1 |
| 1.00000E-02       | 2.13000E+00  |            |          |
| LOGNORMAL         |              | LOGNMAT2   | LOGNPRP2 |
| 1.00000E-03       | 3.50000E+02  |            |          |
| LOGNORMAL         |              | LOGNMAT3   | LOGNPRP3 |
| 1.00000E-04       | 5.25000E+04  |            |          |
| UNIFORM           |              | UNIFMAT1   | UNIFPRP1 |
| -5.00000E-01      | 5.00000E-01  |            |          |
| UNIFORM           |              | UNIFMAT2   | UNIFPRP2 |
| 0.00000E+00       | 1.00000E+00  |            |          |
| UNIFORM           |              | UNIFMAT3   | UNIFPRP3 |
| 1.25000E+01       | 5.00000E+02  |            |          |
| LOGUNIFORM        |              | LOGUMAT1   | LOGUPRP1 |
| 1.00000E-17       | 1.00000E-11  |            |          |
| LOGUNIFORM        |              | LOGUMAT2   | LOGUPRP2 |
| 1.00000E-06       | 1.00000E+03  |            |          |
| LOGUNIFORM        |              | LOGUMAT3   | LOGUPRP3 |
| 5.60000E+13       | 5.60000E+15  |            |          |
| USER DISTRIBUTION | (CUMULATIVE) | CUMMAT1    | CUMPRP1  |
| 4                 | SPECIFIED    | CONTINUOUS |          |
| -8.00000E+00      | 0.10000      |            |          |
| -6.57000E+00      | 0.80000      |            |          |
| -4.77000E+00      | 0.10000      |            |          |
| -2.00000E+00      | 0.00000      |            |          |
| USER DISTRIBUTION | (CUMULATIVE) | CUMMAT2    | CUMPRP2  |
| 4                 | SPECIFIED    | CONTINUOUS |          |
| -1.25000E+01      | 0.15000      |            |          |
| -9.00000E+00      | 0.45000      |            |          |

|                   |              |             |             |             |             |
|-------------------|--------------|-------------|-------------|-------------|-------------|
| -6.51000E+00      | 0.40000      |             |             |             |             |
| -5.00000E+00      | 0.00000      |             |             |             |             |
| USER DISTRIBUTION | (CUMULATIVE) |             | CUMMAT3     | CUMPRP3     |             |
| 4                 | SPECIFIED    |             | CONTINUOUS  |             |             |
| -8.60000E+00      | 0.10000      |             |             |             |             |
| -8.00000E+00      | 0.60000      |             |             |             |             |
| -3.25000E+00      | 0.30000      |             |             |             |             |
| -2.00000E+00      | 0.00000      |             |             |             |             |
| USER DISTRIBUTION | (DATA)       |             | DATAMAT1    | DATAPRP1    |             |
| 21                | EQUAL        |             | CONTINUOUS  |             |             |
| 5.80565E-02       | 9.55000E-02  | 1.03330E-01 | 1.07400E-01 | 1.15000E-01 | 1.20500E-01 |
| 1.22250E-01       | 1.23500E-01  | 1.29000E-01 | 1.38500E-01 | 1.44330E-01 | 1.46500E-01 |
| 1.61600E-01       | 1.61800E-01  | 1.65170E-01 | 1.78000E-01 | 1.78400E-01 | 1.79600E-01 |
| 2.02500E-01       | 2.07750E-01  | 2.52500E-01 |             |             |             |
| USER DISTRIBUTION | (DATA)       |             | DATAMAT2    | DATAPRP2    |             |
| 9                 | EQUAL        |             | CONTINUOUS  |             |             |
| 2.30500E+01       | 2.90600E+01  | 3.45620E+01 | 4.13200E+01 | 5.53900E+01 | 6.34200E+01 |
| 7.94300E+01       | 8.90880E+01  | 1.03800E+02 |             |             |             |
| USER DISTRIBUTION | (DATA)       |             | DATAMAT3    | DATAPRP3    |             |
| 12                | EQUAL        |             | CONTINUOUS  |             |             |
| 1.22250E+00       | 9.30000E+00  | 1.09000E+01 | 1.38500E+01 | 2.74330E+01 | 3.46500E+01 |
| 4.61600E+01       | 5.01800E+01  | 6.15170E+01 | 7.38000E+01 | 8.78400E+01 | 9.49600E+01 |
| USER DISTRIBUTION | (DELTA)      |             | DELTMAT1    | DELTPRP1    |             |
| 14                | SPECIFIED    |             | DISCRETE    |             |             |
| 5.08000E-02       | 0.07143      |             |             |             |             |
| 1.01600E-01       | 0.07143      |             |             |             |             |
| 1.52400E-01       | 0.07143      |             |             |             |             |
| 1.93680E-01       | 0.07143      |             |             |             |             |
| 2.19080E-01       | 0.07143      |             |             |             |             |
| 2.28600E-01       | 0.07143      |             |             |             |             |
| 2.50830E-01       | 0.07143      |             |             |             |             |
| 2.79400E-01       | 0.07143      |             |             |             |             |
| 3.04800E-01       | 0.07143      |             |             |             |             |
| 3.49250E-01       | 0.07143      |             |             |             |             |
| 3.81000E-01       | 0.07143      |             |             |             |             |
| 4.44500E-01       | 0.07143      |             |             |             |             |
| 5.58800E-01       | 0.07143      |             |             |             |             |
| 6.09600E-01       | 0.07141      |             |             |             |             |
| USER DISTRIBUTION | (DELTA)      |             | DELTMAT2    | DELTPRP2    |             |
| 4                 | SPECIFIED    |             | DISCRETE    |             |             |
| 1.00000E+00       | 0.30000      |             |             |             |             |
| 2.00000E+00       | 0.15000      |             |             |             |             |

|                   |           |          |          |
|-------------------|-----------|----------|----------|
| 3.00000E+00       | 0.20000   |          |          |
| 4.00000E+00       | 0.35000   |          |          |
| USER DISTRIBUTION | (DELTA)   | DELTMAT3 | DELTPRP3 |
| 6                 | SPECIFIED | DISCRETE |          |
| -1.00000E+01      | 0.13000   |          |          |
| 2.00000E+00       | 0.13000   |          |          |
| 8.00000E+00       | 0.26000   |          |          |
| 2.30000E+01       | 0.15000   |          |          |
| 3.40000E+01       | 0.15000   |          |          |
| 4.00000E+01       | 0.18000   |          |          |

CORRELATION MATRIX

|   |   |       |
|---|---|-------|
| 7 |   |       |
| 1 | 3 | 0.999 |
| 2 | 5 | 0.950 |
| 4 | 6 | 0.800 |
| 5 | 2 | 0.950 |
| 7 | 8 | 0.650 |
| 7 | 9 | 0.650 |
| 8 | 9 | 0.650 |

OUTPUT CORR HIST DATA

## INPUT FILE FOR LHS TEST 2

TITLE CMS Test Input File for the LHS Code Test 2

|              |             |          |  |
|--------------|-------------|----------|--|
| NOBS         | 200         |          |  |
| RANDOM SEED  | 933090934   |          |  |
| NORMAL       | GLOBAL      | DISPPERC |  |
| 0.00000E+00  | 2.00000E-01 |          |  |
| NORMAL       | WEP203      | QRF_M2CS |  |
| 5.77000E+02  | 1.04200E+03 |          |  |
| NORMAL       | WEP203      | QRF_M2TC |  |
| -3.67370E-02 | 8.32640E-02 |          |  |
| LOGNORMAL    | TESTMAT1    | TESTPRP1 |  |
| .01          | 2.13        |          |  |
| LOGNORMAL    | TESTMAT2    | TESTPRP2 |  |
| .001         | 3.45        |          |  |
| LOGNORMAL    | TESTMAT3    | TESTPRP3 |  |
| .0001        | 5.25        |          |  |
| UNIFORM      | CANISTER    | EFFCAREA |  |
| -5.00000E-01 | 5.00000E-01 |          |  |
| UNIFORM      | CANISTER    | BACFRC   |  |
| 0.00000E+00  | 1.00000E+00 |          |  |
| UNIFORM      | PU          | KDFE     |  |
| 1.25000E+01  | 5.00000E+02 |          |  |

|                   |              |              |             |             |             |
|-------------------|--------------|--------------|-------------|-------------|-------------|
| LOGUNIFORM        |              | GCERAMIC     | CORATEOX    |             |             |
| 1.00000E-17       |              | 1.00000E-11  |             |             |             |
| LOGUNIFORM        |              | CANISTER     | EFFDAREA    |             |             |
| 1.00000E-06       |              | 1.00000E+03  |             |             |             |
| LOGUNIFORM        |              | IN825        | CORATEOX    |             |             |
| 5.60000E+13       |              | 5.60000E+15  |             |             |             |
| USER DISTRIBUTION | (CUMULATIVE) |              | NP          |             | LOGSOLMS    |
| 4                 | SPECIFIED    |              | CONTINUOUS  |             |             |
| -8.00000E+00      | 0.10000      |              |             |             |             |
| -6.57000E+00      | 0.80000      |              |             |             |             |
| -4.77000E+00      | 0.10000      |              |             |             |             |
| -2.00000E+00      | 0.00000      |              |             |             |             |
| USER DISTRIBUTION | (CUMULATIVE) |              | PU          |             | LOGSOLMS    |
| 4                 | SPECIFIED    |              | CONTINUOUS  |             |             |
| -1.25000E+01      | 0.10000      |              |             |             |             |
| -9.00000E+00      | 0.80000      |              |             |             |             |
| -6.51000E+00      | 0.10000      |              |             |             |             |
| -5.00000E+00      | 0.00000      |              |             |             |             |
| USER DISTRIBUTION | (CUMULATIVE) |              | U           |             | LOGSOLMS    |
| 4                 | SPECIFIED    |              | CONTINUOUS  |             |             |
| -8.60000E+00      | 0.10000      |              |             |             |             |
| -8.00000E+00      | 0.80000      |              |             |             |             |
| -3.25000E+00      | 0.10000      |              |             |             |             |
| -2.00000E+00      | 0.00000      |              |             |             |             |
| USER DISTRIBUTION | (DATA)       |              | Culebra     | Porosity    |             |
| 21                | EQUAL        |              | CONTINUOUS  |             |             |
| 5.80565E-02       | 9.55000E-02  | 1.03330E-01  | 1.07400E-01 | 1.15000E-01 | 1.20500E-01 |
| 1.22250E-01       | 1.23500E-01  | 1.29000E-01  | 1.38500E-01 | 1.44330E-01 | 1.46500E-01 |
| 1.61600E-01       | 1.61800E-01  | 1.65170E-01  | 1.78000E-01 | 1.78400E-01 | 1.79600E-01 |
| 2.02500E-01       | 2.07750E-01  | 2.52500E-01  |             |             |             |
| USER DISTRIBUTION | (DATA)       |              | TESTMAT1    | TESTPRM1    |             |
| 9                 | EQUAL        |              | CONTINUOUS  |             |             |
| 2.30500E+01       | 2.90600E+01  | 3.45620E+01  | 4.13200E+01 | 5.53900E+01 | 6.34200E+01 |
| 7.94300E+01       | 8.90880E+01  | 1.03800E+02  |             |             |             |
| USER DISTRIBUTION | (DATA)       |              | TESTMAT2    | TESTPRM2    |             |
| 12                | EQUAL        |              | CONTINUOUS  |             |             |
| -1.22250E+00      | -9.30000E-01 | -1.29000E-01 | 1.38500E-01 | 9.74330E-01 | 1.46500E+00 |
| 3.61600E+00       | 6.01800E+00  | 1.15170E+01  | 1.38000E+01 | 1.78400E+01 | 1.99600E+01 |
| USER DISTRIBUTION | (DELTA)      |              | BOREHOLE    | DIAMMOD     |             |
| 14                | SPECIFIED    |              | DISCRETE    |             |             |
| 5.08000E-02       | 0.07143      |              |             |             |             |
| 1.01600E-01       | 0.07143      |              |             |             |             |

1.52400E-01 0.07143  
 1.93680E-01 0.07143  
 2.19080E-01 0.07143  
 2.28600E-01 0.07143  
 2.50830E-01 0.07143  
 2.79400E-01 0.07143  
 3.04800E-01 0.07143  
 3.49250E-01 0.07143  
 3.81000E-01 0.07143  
 4.44500E-01 0.07143  
 5.58800E-01 0.07143  
 6.09600E-01 0.07144

USER DISTRIBUTION (DELTA) DRZ\_0 RELP\_MOD  
 4 SPECIFIED DISCRETE  
 1.00000E+00 0.30000  
 2.00000E+00 0.15000  
 3.00000E+00 0.20000  
 4.00000E+00 0.35000

USER DISTRIBUTION (DELTA) S\_HALITE GRID\_ID  
 6 SPECIFIED DISCRETE  
 -1.00000E+01 0.13000  
 2.00000E+00 0.13000  
 8.00000E+00 0.26000  
 2.30000E+01 0.15000  
 3.40000E+01 0.15000  
 4.00000E+01 0.18000

OUTPUT CORR HIST DATA

## INPUT FILE FOR LHS TEST 3

TITLE CMS Test Input File for the LHS Code Test 3  
 NOBS 75  
 RANDOM SEED 933090934  
 NORMAL GLOBAL DISPPERC  
 5.00000E-02 2.00000E-01  
 LOGNORMAL COLLOID CONC  
 1.00000E-02 1.00000E+02  
 UNIFORM WAS\_AREA TAUFAIL  
 4.80000E-02 9.60000E+00  
 LOGUNIFORM WAS\_AREA SPPERM  
 1.00000E-17 1.00000E-12  
 USER DISTRIBUTION (CUMULATIVE) BOREHOLE DOMEGA  
 20 SPECIFIED CONTINUOUS  
 4.20000E+00 0.00000

|             |         |
|-------------|---------|
| 4.20000E+00 | 0.15000 |
| 6.30000E+00 | 0.00000 |
| 6.30000E+00 | 0.50000 |
| 8.40000E+00 | 0.00000 |
| 8.40000E+00 | 0.15000 |
| 1.05000E+01 | 0.00000 |
| 1.05000E+01 | 0.10000 |
| 1.26000E+01 | 0.00000 |
| 1.26000E+01 | 0.05000 |
| 1.47000E+01 | 0.00000 |
| 1.47000E+01 | 0.02000 |
| 1.68000E+01 | 0.00000 |
| 1.68000E+01 | 0.01000 |
| 1.88000E+01 | 0.00000 |
| 1.88000E+01 | 0.01000 |
| 2.09000E+01 | 0.00000 |
| 2.09000E+01 | 0.01000 |
| 2.30000E+01 | 0.00000 |
| 2.30000E+01 | 0.00000 |

| USER DISTRIBUTION (DATA) |             | CULEBRA POROSITY |             |             |             |
|--------------------------|-------------|------------------|-------------|-------------|-------------|
| 21                       | EQUAL       | CONTINUOUS       |             |             |             |
| 5.80563E-02              | 9.55000E-02 | 1.03330E-01      | 1.07400E-01 | 1.15000E-01 | 1.20500E-01 |
| 1.22250E-01              | 1.23500E-01 | 1.29000E-01      | 1.38500E-01 | 1.44330E-01 | 1.46500E-01 |
| 1.61600E-01              | 1.61800E-01 | 1.65170E-01      | 1.78000E-01 | 1.78400E-01 | 1.79600E-01 |
| 2.02500E-01              | 2.07750E-01 | 2.52500E-01      |             |             |             |

| USER DISTRIBUTION (DELTA) |           | BOREHOLE DIAMMOD |  |
|---------------------------|-----------|------------------|--|
| 14                        | SPECIFIED | DISCRETE         |  |
| 5.08000E-02               | 0.07143   |                  |  |
| 1.01600E-01               | 0.07143   |                  |  |
| 1.52400E-01               | 0.07143   |                  |  |
| 1.93680E-01               | 0.07143   |                  |  |
| 2.19080E-01               | 0.07143   |                  |  |
| 2.28600E-01               | 0.07143   |                  |  |
| 2.50830E-01               | 0.07143   |                  |  |
| 2.79400E-01               | 0.07143   |                  |  |
| 3.04800E-01               | 0.07143   |                  |  |
| 3.49250E-01               | 0.07143   |                  |  |
| 3.81000E-01               | 0.07143   |                  |  |
| 4.44500E-01               | 0.07143   |                  |  |
| 5.58800E-01               | 0.07143   |                  |  |
| 6.09600E-01               | 0.07144   |                  |  |

|            |          |          |
|------------|----------|----------|
| TRIANGULAR | WAS_AREA | GRATCORI |
|------------|----------|----------|



|             |             |             |             |             |             |
|-------------|-------------|-------------|-------------|-------------|-------------|
| 0.00000E+00 | 3.20000E-09 | 6.40000E-07 |             |             |             |
| STUDENT     | S_MB139     | POROSITY    |             |             |             |
| 16          |             |             |             |             |             |
| 4.00000E-03 | 5.00000E-03 | 5.00000E-03 | 8.00000E-03 | 1.00000E-02 | 1.10000E-02 |
| 1.30000E-02 | 1.30000E-02 | 1.60000E-02 | 1.60000E-02 | 1.60000E-02 | 1.70000E-02 |
| 1.80000E-02 | 1.90000E-02 | 2.10000E-02 | 2.70000E-02 |             |             |
| LOGSTUDENT  | STULMAT1    | STULPRP1    |             |             |             |
| 20          |             |             |             |             |             |
| 9.55000E-07 | 1.03330E-06 | 1.57400E-06 | 2.15000E-06 | 4.20500E-06 | 8.22250E-06 |
| 2.23500E-05 | 4.29000E-05 | 7.38500E-05 | 9.44330E-05 | 1.46500E-04 | 3.61600E-04 |
| 5.61800E-04 | 7.65170E-04 | 9.78000E-04 | 1.78400E-03 | 2.79600E-03 | 5.02500E-03 |
| 7.07750E-03 | 9.52500E-03 |             |             |             |             |

CORRELATION MATRIX

|   |   |        |
|---|---|--------|
| 7 |   |        |
| 1 | 3 | -0.999 |
| 2 | 5 | -0.950 |
| 4 | 6 | -0.800 |
| 5 | 2 | -0.950 |
| 7 | 8 | -0.650 |
| 7 | 9 | -0.650 |
| 8 | 9 | -0.650 |

OUTPUT CORR HIST DATA

## INPUT FILE FOR LHS TEST 4

TITLE CMS Test Input File for the LHS Code Test 4

NOBS 75

RANDOM SEED 933090934

|                   |             |                   |
|-------------------|-------------|-------------------|
| UNIFORM           | UNIFMAT2    | UNIFPRP2          |
| 0.00000E+00       | 1.00000E+00 |                   |
| NORMAL            | NORMMAT3    | NORMPRP3          |
| -3.67370E-02      | 8.32640E-02 |                   |
| LOGNORMAL         | LOGNMAT2    | LOGNPRP2          |
| 1.00000E-03       | 3.50000E+02 |                   |
| UNIFORM           | UNIFMAT1    | UNIFPRP1          |
| -5.00000E-01      | 5.00000E-01 |                   |
| USER DISTRIBUTION | (DELTA)     | DELTMAT3 DELTPRP3 |
| 6                 | SPECIFIED   | DISCRETE          |
| -1.00000E+01      | 0.13000     |                   |
| 2.00000E+00       | 0.13000     |                   |
| 8.00000E+00       | 0.26000     |                   |
| 2.30000E+01       | 0.15000     |                   |
| 3.40000E+01       | 0.15000     |                   |
| 4.00000E+01       | 0.18000     |                   |

|                   |              |             |             |             |                         |
|-------------------|--------------|-------------|-------------|-------------|-------------------------|
| UNIFORM           |              | UNIFMAT3    | UNIFPRP3    |             |                         |
|                   | 1.25000E+01  | 5.00000E+02 |             |             |                         |
| LOGUNIFORM        |              | LOGUMAT1    | LOGUPRP1    |             |                         |
|                   | 1.00000E-17  | 1.00000E-11 |             |             |                         |
| USER DISTRIBUTION | (DATA)       |             | DATAMAT2    | DATAPRP2    |                         |
|                   | 9            | EQUAL       | CONTINUOUS  |             |                         |
|                   | 2.30500E+01  | 2.90600E+01 | 3.45620E+01 | 4.13200E+01 | 5.53900E+01 6.34200E+01 |
|                   | 7.94300E+01  | 8.90880E+01 | 1.03800E+02 |             |                         |
| NORMAL            |              | NORMMAT1    | NORMPRP1    |             |                         |
|                   | 0.00000E+00  | 2.00000E-01 |             |             |                         |
| USER DISTRIBUTION | (DELTA)      |             | DELTMAT1    | DELTPRP1    |                         |
|                   | 14           | SPECIFIED   | DISCRETE    |             |                         |
|                   | 5.08000E-02  | 0.07143     |             |             |                         |
|                   | 1.01600E-01  | 0.07143     |             |             |                         |
|                   | 1.52400E-01  | 0.07143     |             |             |                         |
|                   | 1.93680E-01  | 0.07143     |             |             |                         |
|                   | 2.19080E-01  | 0.07143     |             |             |                         |
|                   | 2.28600E-01  | 0.07143     |             |             |                         |
|                   | 2.50830E-01  | 0.07143     |             |             |                         |
|                   | 2.79400E-01  | 0.07143     |             |             |                         |
|                   | 3.04800E-01  | 0.07143     |             |             |                         |
|                   | 3.49250E-01  | 0.07143     |             |             |                         |
|                   | 3.81000E-01  | 0.07143     |             |             |                         |
|                   | 4.44500E-01  | 0.07143     |             |             |                         |
|                   | 5.58800E-01  | 0.07143     |             |             |                         |
|                   | 6.09600E-01  | 0.07141     |             |             |                         |
| LOGUNIFORM        |              | LOGUMAT3    | LOGUPRP3    |             |                         |
|                   | 5.60000E+13  | 5.60000E+15 |             |             |                         |
| USER DISTRIBUTION | (CUMULATIVE) |             | CUMMAT1     | CUMPRP1     |                         |
|                   | 4            | SPECIFIED   | CONTINUOUS  |             |                         |
|                   | -8.00000E+00 | 0.10000     |             |             |                         |
|                   | -6.57000E+00 | 0.80000     |             |             |                         |
|                   | -4.77000E+00 | 0.10000     |             |             |                         |
|                   | -2.00000E+00 | 0.00000     |             |             |                         |
| NORMAL            |              | NORMMAT2    | NORMPRP2    |             |                         |
|                   | 5.77000E+02  | 1.04200E+03 |             |             |                         |
| USER DISTRIBUTION | (CUMULATIVE) |             | CUMMAT3     | CUMPRP3     |                         |
|                   | 4            | SPECIFIED   | CONTINUOUS  |             |                         |
|                   | -8.60000E+00 | 0.10000     |             |             |                         |
|                   | -8.00000E+00 | 0.60000     |             |             |                         |
|                   | -3.25000E+00 | 0.30000     |             |             |                         |
|                   | -2.00000E+00 | 0.00000     |             |             |                         |

```

LOGNORMAL                LOGNMAT1  LOGNPRP1
    1.00000E-02    2.13000E+00
USER DISTRIBUTION (DATA)                DATAMAT1  DATAPRP1
    21                EQUAL                CONTINUOUS
    5.80565E-02    9.55000E-02    1.03330E-01    1.07400E-01    1.15000E-01    1.20500E-01
    1.22250E-01    1.23500E-01    1.29000E-01    1.38500E-01    1.44330E-01    1.46500E-01
    1.61600E-01    1.61800E-01    1.65170E-01    1.78000E-01    1.78400E-01    1.79600E-01
    2.02500E-01    2.07750E-01    2.52500E-01

```

```

LOGNORMAL                LOGNMAT3  LOGNPRP3
    1.00000E-04    5.25000E+04
USER DISTRIBUTION (DATA)                DATAMAT3  DATAPRP3
    12                EQUAL                CONTINUOUS
    1.22250E+00    9.30000E+00    1.09000E+01    1.38500E+01    2.74330E+01    3.46500E+01
    4.61600E+01    5.01800E+01    6.15170E+01    7.38000E+01    8.78400E+01    9.49600E+01

```

CORRELATION MATRIX

```

7
1  3  0.999
2  5  0.950
4  6  0.800
5  2  0.950
7  8  0.650
7  9  0.650
8  9  0.650

```

```

USER DISTRIBUTION (CUMULATIVE)                CUMMAT2  CUMPRP2
    4                SPECIFIED                CONTINUOUS
    -1.25000E+01    0.15000
    -9.00000E+00    0.45000
    -6.51000E+00    0.40000
    -5.00000E+00    0.00000

```

```

LOGUNIFORM                LOGUMAT2  LOGUPRP2
    1.00000E-06    1.00000E+03
USER DISTRIBUTION (DELTA)                DELTMAT2  DELTPRP2
    4                SPECIFIED                DISCRETE
    1.00000E+00    0.30000
    2.00000E+00    0.15000
    3.00000E+00    0.20000
    4.00000E+00    0.35000

```

OUTPUT CORR HIST DATA

## INPUT FILE FOR LHS TEST 5

```

TITLE CMS Test Input File for the LHS Code  Test 5
NOBS                75THIS IS THE NUMBER OF OBSERVATIONS TO GENERATE
RANDOM SEED        933090934

```

|                   |              |          |            |         |
|-------------------|--------------|----------|------------|---------|
| NORMAL            |              | NORMMAT1 | NORMPRP1   |         |
| 0.00000E+00       | 2.00000E-01  |          |            |         |
| NORMAL            |              | NORMMAT2 | NORMPRP2   |         |
| 5.77000E+02       | 1.04200E+03  |          |            |         |
| NORMAL            |              | NORMMAT3 | NORMPRP3   |         |
| -3.67370E-02      | 8.32640E-02  |          |            |         |
| LOGNORMAL         |              | LOGNMAT1 | LOGNPRP1   |         |
| 1.00000E-02       | 2.13000E+00  |          |            |         |
| LOGNORMAL         |              | LOGNMAT2 | LOGNPRP2   |         |
| 1.00000E-03       | 3.50000E+02  |          |            |         |
| LOGNORMAL         |              | LOGNMAT3 | LOGNPRP3   |         |
| 1.00000E-04       | 5.25000E+04  |          |            |         |
| UNIFORM           |              | UNIFMAT1 | UNIFPRP1   |         |
| -5.00000E-01      | 5.00000E-01  |          |            |         |
| UNIFORM           |              | UNIFMAT2 | UNIFPRP2   |         |
| 0.00000E+00       | 1.00000E+00  |          |            |         |
| UNIFORM           |              | UNIFMAT3 | UNIFPRP3   |         |
| 1.25000E+01       | 5.00000E+02  |          |            |         |
| LOGUNIFORM        |              | LOGUMAT1 | LOGUPRP1   |         |
| 1.00000E-17       | 1.00000E-11  |          |            |         |
| LOGUNIFORM        |              | LOGUMAT2 | LOGUPRP2   |         |
| 1.00000E-06       | 1.00000E+03  |          |            |         |
| LOGUNIFORM        |              | LOGUMAT3 | LOGUPRP3   |         |
| 5.60000E+13       | 5.60000E+15  |          |            |         |
| USER DISTRIBUTION | (CUMULATIVE) |          | CUMMAT1    | CUMPRP1 |
| 4                 | SPECIFIED    |          | CONTINUOUS |         |
| -8.00000E+00      | 0.10000      |          |            |         |
| -6.57000E+00      | 0.80000      |          |            |         |
| -4.77000E+00      | 0.10000      |          |            |         |
| -2.00000E+00      | 0.00000      |          |            |         |
| USER DISTRIBUTION | (CUMULATIVE) |          | CUMMAT2    | CUMPRP2 |
| 4                 | SPECIFIED    |          | CONTINUOUS |         |
| -1.25000E+01      | 0.15000      |          |            |         |
| -9.00000E+00      | 0.45000      |          |            |         |
| -6.51000E+00      | 0.40000      |          |            |         |
| -5.00000E+00      | 0.00000      |          |            |         |
| USER DISTRIBUTION | (CUMULATIVE) |          | CUMMAT3    | CUMPRP3 |
| 4                 | SPECIFIED    |          | CONTINUOUS |         |
| -8.60000E+00      | 0.10000      |          |            |         |
| -8.00000E+00      | 0.60000      |          |            |         |
| -3.25000E+00      | 0.30000      |          |            |         |
| -2.00000E+00      | 0.00000      |          |            |         |

|                           |             |             |             |             |             |  |
|---------------------------|-------------|-------------|-------------|-------------|-------------|--|
| USER DISTRIBUTION (DATA)  |             |             | DATAMAT1    | DATAPRP1    |             |  |
| 21                        | EQUAL       |             | CONTINUOUS  |             |             |  |
| 5.80565E-02               | 9.55000E-02 | 1.03330E-01 | 1.07400E-01 | 1.15000E-01 | 1.20500E-01 |  |
| 1.22250E-01               | 1.23500E-01 | 1.29000E-01 | 1.38500E-01 | 1.44330E-01 | 1.46500E-01 |  |
| 1.61600E-01               | 1.61800E-01 | 1.65170E-01 | 1.78000E-01 | 1.78400E-01 | 1.79600E-01 |  |
| 2.02500E-01               | 2.07750E-01 | 2.52500E-01 |             |             |             |  |
| USER DISTRIBUTION (DATA)  |             |             | DATAMAT2    | DATAPRP2    |             |  |
| 9                         | EQUAL       |             | CONTINUOUS  |             |             |  |
| 2.30500E+01               | 2.90600E+01 | 3.45620E+01 | 4.13200E+01 | 5.53900E+01 | 6.34200E+01 |  |
| 7.94300E+01               | 8.90880E+01 | 1.03800E+02 |             |             |             |  |
| USER DISTRIBUTION (DATA)  |             |             | DATAMAT3    | DATAPRP3    |             |  |
| 12                        | EQUAL       |             | CONTINUOUS  |             |             |  |
| 1.22250E+00               | 9.30000E+00 | 1.09000E+01 | 1.38500E+01 | 2.74330E+01 | 3.46500E+01 |  |
| 4.61600E+01               | 5.01800E+01 | 6.15170E+01 | 7.38000E+01 | 8.78400E+01 | 9.49600E+01 |  |
| USER DISTRIBUTION (DELTA) |             |             | DELTMAT1    | DELTPRP1    |             |  |
| 14                        | SPECIFIED   |             | DISCRETE    |             |             |  |
| 5.08000E-02               | 0.07143     |             |             |             |             |  |
| 1.01600E-01               | 0.07143     |             |             |             |             |  |
| 1.52400E-01               | 0.07143     |             |             |             |             |  |
| 1.93680E-01               | 0.07143     |             |             |             |             |  |
| 2.19080E-01               | 0.07143     |             |             |             |             |  |
| 2.28600E-01               | 0.07143     |             |             |             |             |  |
| 2.50830E-01               | 0.07143     |             |             |             |             |  |
| 2.79400E-01               | 0.07143     |             |             |             |             |  |
| 3.04800E-01               | 0.07143     |             |             |             |             |  |
| 3.49250E-01               | 0.07143     |             |             |             |             |  |
| 3.81000E-01               | 0.07143     |             |             |             |             |  |
| 4.44500E-01               | 0.07143     |             |             |             |             |  |
| 5.58800E-01               | 0.07143     |             |             |             |             |  |
| 6.09600E-01               | 0.07141     |             |             |             |             |  |
| USER DISTRIBUTION (DELTA) |             |             | DELTMAT2    | DELTPRP2    |             |  |
| 4                         | SPECIFIED   |             | DISCRETE    |             |             |  |
| 1.00000E+00               | 0.30000     |             |             |             |             |  |
| 2.00000E+00               | 0.15000     |             |             |             |             |  |
| 3.00000E+00               | 0.20000     |             |             |             |             |  |
| 4.00000E+00               | 0.35000     |             |             |             |             |  |
| USER DISTRIBUTION (DELTA) |             |             | DELTMAT3    | DELTPRP3    |             |  |
| 6                         | SPECIFIED   |             | DISCRETE    |             |             |  |
| -1.00000E+01              | 0.13000     |             |             |             |             |  |
| 2.00000E+00               | 0.13000     |             |             |             |             |  |
| 8.00000E+00               | 0.26000     |             |             |             |             |  |
| 2.30000E+01               | 0.15000     |             |             |             |             |  |

3.40000E+01 0.15000

4.00000E+01 0.18000

CORRELATION MATRIX

7

1 3 -0.999

2 5 -0.950

4 6 -0.800

5 2 -0.950

7 8 -0.650

7 9 -0.650

8 9 -0.650

OUTPUT CORR HIST DATA

## INPUT FILE FOR LHS TEST 6

TITLE CMS Test Input File for the LHS Code Test 6

NOBS -75

RANDOM SEED 933090934

NORMAL NORMMAT1 NORMPRP1

0.00000E+00 2.00000E-01

NORMAL NORMMAT2 NORMPRP2

5.77000E+02 1.04200E+03

NORMAL NORMMAT3 NORMPRP3

-3.67370E-02 8.32640E-02

LOGNORMAL LOGMAT1 LOGNPRP1

1.00000E-02 2.13000E+00

LOGNORMAL LOGMAT2 LOGNPRP2

1.00000E-03 3.50000E+02

LOGNORMAL LOGMAT3 LOGNPRP3

1.00000E-04 5.25000E+04

UNIFORM UNIFMAT1 UNIFPRP1

-5.00000E-01 5.00000E-01

UNIFORM UNIFMAT2 UNIFPRP2

0.00000E+00 1.00000E+00

UNIFORM UNIFMAT3 UNIFPRP3

1.25000E+01 5.00000E+02

LOGUNIFORM LOGUMAT1 LOGUPRP1

1.00000E-17 1.00000E-11

LOGUNIFORM LOGUMAT2 LOGUPRP2

1.00000E-06 1.00000E+03

LOGUNIFORM LOGUMAT3 LOGUPRP3

5.60000E+13 5.60000E+15

USER DISTRIBUTION (CUMULATIVE) CUMMAT1 CUMPRP1

4 SPECIFIED CONTINUOUS

|                   |              |             |             |             |             |
|-------------------|--------------|-------------|-------------|-------------|-------------|
| -8.00000E+00      | 0.10000      |             |             |             |             |
| -6.57000E+00      | 0.80000      |             |             |             |             |
| -4.77000E+00      | 0.10000      |             |             |             |             |
| -2.00000E+00      | 0.00000      |             |             |             |             |
| USER DISTRIBUTION | (CUMULATIVE) | CUMMAT2     | CUMPRP2     |             |             |
| 4                 | SPECIFIED    | CONTINUOUS  |             |             |             |
| -1.25000E+01      | 0.15000      |             |             |             |             |
| -9.00000E+00      | 0.45000      |             |             |             |             |
| -6.51000E+00      | 0.40000      |             |             |             |             |
| -5.00000E+00      | 0.00000      |             |             |             |             |
| USER DISTRIBUTION | (CUMULATIVE) | CUMMAT3     | CUMPRP3     |             |             |
| 4                 | SPECIFIED    | CONTINUOUS  |             |             |             |
| -8.60000E+00      | 0.10000      |             |             |             |             |
| -8.00000E+00      | 0.60000      |             |             |             |             |
| -3.25000E+00      | 0.30000      |             |             |             |             |
| -2.00000E+00      | 0.00000      |             |             |             |             |
| USER DISTRIBUTION | (DATA)       | DATAMAT1    | DATAPRP1    |             |             |
| 21                | EQUAL        | CONTINUOUS  |             |             |             |
| 5.80565E-02       | 9.55000E-02  | 1.03330E-01 | 1.07400E-01 | 1.15000E-01 | 1.20500E-01 |
| 1.22250E-01       | 1.23500E-01  | 1.29000E-01 | 1.38500E-01 | 1.44330E-01 | 1.46500E-01 |
| 1.61600E-01       | 1.61800E-01  | 1.65170E-01 | 1.78000E-01 | 1.78400E-01 | 1.79600E-01 |
| 2.02500E-01       | 2.07750E-01  | 2.52500E-01 |             |             |             |
| USER DISTRIBUTION | (DATA)       | DATAMAT2    | DATAPRP2    |             |             |
| 9                 | EQUAL        | CONTINUOUS  |             |             |             |
| 2.30500E+01       | 2.90600E+01  | 3.45620E+01 | 4.13200E+01 | 5.53900E+01 | 6.34200E+01 |
| 7.94300E+01       | 8.90880E+01  | 1.03800E+02 |             |             |             |
| USER DISTRIBUTION | (DATA)       | DATAMAT3    | DATAPRP3    |             |             |
| 12                | EQUAL        | CONTINUOUS  |             |             |             |
| 1.22250E+00       | 9.30000E+00  | 1.09000E+01 | 1.38500E+01 | 2.74330E+01 | 3.46500E+01 |
| 4.61600E+01       | 5.01800E+01  | 6.15170E+01 | 7.38000E+01 | 8.78400E+01 | 9.49600E+01 |
| USER DISTRIBUTION | (DELTA)      | DELTMAT1    | DELTPRP1    |             |             |
| 14                | SPECIFIED    | DISCRETE    |             |             |             |
| 5.08000E-02       | 0.07143      |             |             |             |             |
| 1.01600E-01       | 0.07143      |             |             |             |             |
| 1.52400E-01       | 0.07143      |             |             |             |             |
| 1.93680E-01       | 0.07143      |             |             |             |             |
| 2.19080E-01       | 0.07143      |             |             |             |             |
| 2.28600E-01       | 0.07143      |             |             |             |             |
| 2.50830E-01       | 0.07143      |             |             |             |             |
| 2.79400E-01       | 0.07143      |             |             |             |             |
| 3.04800E-01       | 0.07143      |             |             |             |             |
| 3.49250E-01       | 0.07143      |             |             |             |             |

3.81000E-01 0.07143  
4.44500E-01 0.07143  
5.58800E-01 0.07143  
6.09600E-01 0.07141

USER DISTRIBUTION (DELTA) DELTMAT2 DELTPRP2  
4 SPECIFIED DISCRETE  
1.00000E+00 0.30000  
2.00000E+00 0.15000  
3.00000E+00 0.20000  
4.00000E+00 0.35000

USER DISTRIBUTION (DELTA) DELTMAT3 DELTPRP3  
6 SPECIFIED DISCRETE  
-1.00000E+01 0.13000  
2.00000E+00 0.13000  
8.00000E+00 0.26000  
2.30000E+01 0.15000  
3.40000E+01 0.15000  
4.00000E+01 0.18000

CORRELATION MATRIX

7  
1 3 0.999  
2 5 0.950  
4 6 0.800  
5 2 0.950  
7 8 0.650  
7 9 0.650  
8 9 0.650

OUTPUT CORR HIST DATA

## INPUT FILE FOR LHS TEST 7

TITLE CMS Test Input File for the LHS Code Test 7

NOBS 75  
RANDOM SEED 933090934  
NORMAL NORMMAT1 NORMPRP1  
0.00000E+00 2.00000E-01  
NORMAL NORMMAT2 NORMPRP2  
5.77000E+02 1.04200E+03  
NORMAL NORMMAT3 NORMPRP3  
-3.67370E-02 8.32640E-02  
LOGNORMAL LOGNMAT1 LOGNPRP1  
1.00000E-02 2.13000E+00  
LOGNORMAL LOGNMAT2 LOGNPRP2  
1.00000E-03 3.50000E+02



|                   |              |             |             |             |             |
|-------------------|--------------|-------------|-------------|-------------|-------------|
| LOGNORMAL         |              | LOGNMAT3    | LOGNPRP3    |             |             |
| 1.00000E-04       | 5.25000E+04  |             |             |             |             |
| UNIFORM           |              | UNIFMAT1    | UNIFPRP1    |             |             |
| -5.00000E-01      | 5.00000E-01  |             |             |             |             |
| UNIFORM           |              | UNIFMAT2    | UNIFPRP2    |             |             |
| 0.00000E+00       | 1.00000E+00  |             |             |             |             |
| UNIFORM           |              | UNIFMAT3    | UNIFPRP3    |             |             |
| 1.25000E+01       | 5.00000E+02  |             |             |             |             |
| LOGUNIFORM        |              | LOGUMAT1    | LOGUPRP1    |             |             |
| 1.00000E-17       | 1.00000E-11  |             |             |             |             |
| LOGUNIFORM        |              | LOGUMAT2    | LOGUPRP2    |             |             |
| 1.00000E-06       | 1.00000E+03  |             |             |             |             |
| LOGUNIFORM        |              | LOGUMAT3    | LOGUPRP3    |             |             |
| 5.60000E+13       | 5.60000E+15  |             |             |             |             |
| USER DISTRIBUTION | (CUMULATIVE) |             | CUMMAT1     | CUMPRP1     |             |
| 4                 | SPECIFIED    |             | CONTINUOUS  |             |             |
| -8.00000E+00      | 0.10000      |             |             |             |             |
| -6.57000E+00      | 0.80000      |             |             |             |             |
| -4.77000E+00      | 0.10000      |             |             |             |             |
| -2.00000E+00      | 0.00000      |             |             |             |             |
| USER DISTRIBUTION | (CUMULATIVE) |             | CUMMAT2     | CUMPRP2     |             |
| 4                 | SPECIFIED    |             | CONTINUOUS  |             |             |
| -1.25000E+01      | 0.15000      |             |             |             |             |
| -9.00000E+00      | 0.45000      |             |             |             |             |
| -6.51000E+00      | 0.40000      |             |             |             |             |
| -5.00000E+00      | 0.00000      |             |             |             |             |
| USER DISTRIBUTION | (CUMULATIVE) |             | CUMMAT3     | CUMPRP3     |             |
| 4                 | SPECIFIED    |             | CONTINUOUS  |             |             |
| -8.60000E+00      | 0.10000      |             |             |             |             |
| -8.00000E+00      | 0.60000      |             |             |             |             |
| -3.25000E+00      | 0.30000      |             |             |             |             |
| -2.00000E+00      | 0.00000      |             |             |             |             |
| USER DISTRIBUTION | (DATA)       |             | DATAMAT1    | DATAPRP1    |             |
| 21                | EQUAL        |             | CONTINUOUS  |             |             |
| 5.80565E-02       | 9.55000E-02  | 1.03330E-01 | 1.07400E-01 | 1.15000E-01 | 1.20500E-01 |
| 1.22250E-01       | 1.23500E-01  | 1.29000E-01 | 1.38500E-01 | 1.44330E-01 | 1.46500E-01 |
| 1.61600E-01       | 1.61800E-01  | 1.65170E-01 | 1.78000E-01 | 1.78400E-01 | 1.79600E-01 |
| 2.02500E-01       | 2.07750E-01  | 2.52500E-01 |             |             |             |
| USER DISTRIBUTION | (DATA)       |             | DATAMAT2    | DATAPRP2    |             |
| 9                 | EQUAL        |             | CONTINUOUS  |             |             |
| 2.30500E+01       | 2.90600E+01  | 3.45620E+01 | 4.13200E+01 | 5.53900E+01 | 6.34200E+01 |
| 7.94300E+01       | 8.90880E+01  | 1.03800E+02 |             |             |             |

|                           |             |             |             |             |             |
|---------------------------|-------------|-------------|-------------|-------------|-------------|
| USER DISTRIBUTION (DATA)  |             | DATAMAT3    | DATAPRP3    |             |             |
| 12                        | EQUAL       | CONTINUOUS  |             |             |             |
| 1.22250E+00               | 9.30000E+00 | 1.09000E+01 | 1.38500E+01 | 2.74330E+01 | 3.46500E+01 |
| 4.61600E+01               | 5.01800E+01 | 6.15170E+01 | 7.38000E+01 | 8.78400E+01 | 9.49600E+01 |
| USER DISTRIBUTION (DELTA) |             | DELTMAT1    | DELTPRP1    |             |             |
| 14                        | SPECIFIED   | DISCRETE    |             |             |             |
| 5.08000E-02               | 0.07143     |             |             |             |             |
| 1.01600E-01               | 0.07143     |             |             |             |             |
| 1.52400E-01               | 0.07143     |             |             |             |             |
| 1.93680E-01               | 0.07143     |             |             |             |             |
| 2.19080E-01               | 0.07143     |             |             |             |             |
| 2.28600E-01               | 0.07143     |             |             |             |             |
| 2.50830E-01               | 0.07143     |             |             |             |             |
| 2.79400E-01               | 0.07143     |             |             |             |             |
| 3.04800E-01               | 0.07143     |             |             |             |             |
| 3.49250E-01               | 0.07143     |             |             |             |             |
| 3.81000E-01               | 0.07143     |             |             |             |             |
| 4.44500E-01               | 0.07143     |             |             |             |             |
| 5.58800E-01               | 0.07143     |             |             |             |             |
| 6.09600E-01               | 0.07141     |             |             |             |             |
| USER DISTRIBUTION (DELTA) |             | DELTMAT2    | DELTPRP2    |             |             |
| 4                         | SPECIFIED   | DISCRETE    |             |             |             |
| 1.00000E+00               | 0.30000     |             |             |             |             |
| 2.00000E+00               | 0.15000     |             |             |             |             |
| 3.00000E+00               | 0.20000     |             |             |             |             |
| 4.00000E+00               | 0.35000     |             |             |             |             |
| USER DISTRIBUTION (DELTA) |             | DELTMAT3    | DELTPRP3    |             |             |
| 6                         | SPECIFIED   | DISCRETE    |             |             |             |
| -1.00000E+01              | 0.13000     |             |             |             |             |
| 2.00000E+00               | 0.13000     |             |             |             |             |
| 8.00000E+00               | 0.26000     |             |             |             |             |
| 2.30000E+01               | 0.15000     |             |             |             |             |
| 3.40000E+01               | 0.15000     |             |             |             |             |
| 4.00000E+01               | 0.18000     |             |             |             |             |
| NORMAL                    |             | NORMMAT1    | NORMPRP1    |             |             |
| 0.00000E+00               | 2.00000E-01 |             |             |             |             |
| NORMAL                    |             | NORMMAT2    | NORMPRP2    |             |             |
| 5.77000E+02               | 1.04200E+03 |             |             |             |             |
| NORMAL                    |             | NORMMAT3    | NORMPRP3    |             |             |
| -3.67370E-02              | 8.32640E-02 |             |             |             |             |
| LOGNORMAL                 |             | LOGNMAT1    | LOGNPRP1    |             |             |
| 1.00000E-02               | 2.13000E+00 |             |             |             |             |

|                   |              |             |             |             |             |
|-------------------|--------------|-------------|-------------|-------------|-------------|
| LOGNORMAL         |              | LOGNMAT2    | LOGNPRP2    |             |             |
| 1.00000E-03       | 3.50000E+02  |             |             |             |             |
| LOGNORMAL         |              | LOGNMAT3    | LOGNPRP3    |             |             |
| 1.00000E-04       | 5.25000E+04  |             |             |             |             |
| UNIFORM           |              | UNIFMAT1    | UNIFPRP1    |             |             |
| -5.00000E-01      | 5.00000E-01  |             |             |             |             |
| UNIFORM           |              | UNIFMAT2    | UNIFPRP2    |             |             |
| 0.00000E+00       | 1.00000E+00  |             |             |             |             |
| UNIFORM           |              | UNIFMAT3    | UNIFPRP3    |             |             |
| 1.25000E+01       | 5.00000E+02  |             |             |             |             |
| LOGUNIFORM        |              | LOGUMAT1    | LOGUPRP1    |             |             |
| 1.00000E-17       | 1.00000E-11  |             |             |             |             |
| LOGUNIFORM        |              | LOGUMAT2    | LOGUPRP2    |             |             |
| 1.00000E-06       | 1.00000E+03  |             |             |             |             |
| LOGUNIFORM        |              | LOGUMAT3    | LOGUPRP3    |             |             |
| 5.60000E+13       | 5.60000E+15  |             |             |             |             |
| USER DISTRIBUTION | (CUMULATIVE) |             | CUMMAT1     | CUMPRP1     |             |
| 4                 | SPECIFIED    |             | CONTINUOUS  |             |             |
| -8.00000E+00      | 0.10000      |             |             |             |             |
| -6.57000E+00      | 0.80000      |             |             |             |             |
| -4.77000E+00      | 0.10000      |             |             |             |             |
| -2.00000E+00      | 0.00000      |             |             |             |             |
| USER DISTRIBUTION | (CUMULATIVE) |             | CUMMAT2     | CUMPRP2     |             |
| 4                 | SPECIFIED    |             | CONTINUOUS  |             |             |
| -1.25000E+01      | 0.15000      |             |             |             |             |
| -9.00000E+00      | 0.45000      |             |             |             |             |
| -6.51000E+00      | 0.40000      |             |             |             |             |
| -5.00000E+00      | 0.00000      |             |             |             |             |
| USER DISTRIBUTION | (CUMULATIVE) |             | CUMMAT3     | CUMPRP3     |             |
| 4                 | SPECIFIED    |             | CONTINUOUS  |             |             |
| -8.60000E+00      | 0.10000      |             |             |             |             |
| -8.00000E+00      | 0.60000      |             |             |             |             |
| -3.25000E+00      | 0.30000      |             |             |             |             |
| -2.00000E+00      | 0.00000      |             |             |             |             |
| USER DISTRIBUTION | (DATA)       |             | DATAMAT1    | DATAPRP1    |             |
| 21                | EQUAL        |             | CONTINUOUS  |             |             |
| 5.80565E-02       | 9.55000E-02  | 1.03330E-01 | 1.07400E-01 | 1.15000E-01 | 1.20500E-01 |
| 1.22250E-01       | 1.23500E-01  | 1.29000E-01 | 1.38500E-01 | 1.44330E-01 | 1.46500E-01 |
| 1.61600E-01       | 1.61800E-01  | 1.65170E-01 | 1.78000E-01 | 1.78400E-01 | 1.79600E-01 |
| 2.02500E-01       | 2.07750E-01  | 2.52500E-01 |             |             |             |
| USER DISTRIBUTION | (DATA)       |             | DATAMAT2    | DATAPRP2    |             |
| 9                 | EQUAL        |             | CONTINUOUS  |             |             |

|                           |             |             |             |             |             |
|---------------------------|-------------|-------------|-------------|-------------|-------------|
| 2.30500E+01               | 2.90600E+01 | 3.45620E+01 | 4.13200E+01 | 5.53900E+01 | 6.34200E+01 |
| 7.94300E+01               | 8.90880E+01 | 1.03800E+02 |             |             |             |
| USER DISTRIBUTION (DATA)  |             | DATAMAT3    | DATAPRP3    |             |             |
| 12                        | EQUAL       | CONTINUOUS  |             |             |             |
| 1.22250E+00               | 9.30000E+00 | 1.09000E+01 | 1.38500E+01 | 2.74330E+01 | 3.46500E+01 |
| 4.61600E+01               | 5.01800E+01 | 6.15170E+01 | 7.38000E+01 | 8.78400E+01 | 9.49600E+01 |
| USER DISTRIBUTION (DELTA) |             | DELTMAT1    | DELTPRP1    |             |             |
| 14                        | SPECIFIED   | DISCRETE    |             |             |             |
| 5.08000E-02               | 0.07143     |             |             |             |             |
| 1.01600E-01               | 0.07143     |             |             |             |             |
| 1.52400E-01               | 0.07143     |             |             |             |             |
| 1.93680E-01               | 0.07143     |             |             |             |             |
| 2.19080E-01               | 0.07143     |             |             |             |             |
| 2.28600E-01               | 0.07143     |             |             |             |             |
| 2.50830E-01               | 0.07143     |             |             |             |             |
| 2.79400E-01               | 0.07143     |             |             |             |             |
| 3.04800E-01               | 0.07143     |             |             |             |             |
| 3.49250E-01               | 0.07143     |             |             |             |             |
| 3.81000E-01               | 0.07143     |             |             |             |             |
| 4.44500E-01               | 0.07143     |             |             |             |             |
| 5.58800E-01               | 0.07143     |             |             |             |             |
| 6.09600E-01               | 0.07141     |             |             |             |             |
| USER DISTRIBUTION (DELTA) |             | DELTMAT2    | DELTPRP2    |             |             |
| 4                         | SPECIFIED   | DISCRETE    |             |             |             |
| 1.00000E+00               | 0.30000     |             |             |             |             |
| 2.00000E+00               | 0.15000     |             |             |             |             |
| 3.00000E+00               | 0.20000     |             |             |             |             |
| 4.00000E+00               | 0.35000     |             |             |             |             |
| USER DISTRIBUTION (DELTA) |             | DELTMAT3    | DELTPRP3    |             |             |
| 6                         | SPECIFIED   | DISCRETE    |             |             |             |
| -1.00000E+01              | 0.13000     |             |             |             |             |
| 2.00000E+00               | 0.13000     |             |             |             |             |
| 8.00000E+00               | 0.26000     |             |             |             |             |
| 2.30000E+01               | 0.15000     |             |             |             |             |
| 3.40000E+01               | 0.15000     |             |             |             |             |
| 4.00000E+01               | 0.18000     |             |             |             |             |
| NORMAL                    |             | NORMMAT1    | NORMPRP1    |             |             |
| 0.00000E+00               | 2.00000E-01 |             |             |             |             |
| NORMAL                    |             | NORMMAT2    | NORMPRP2    |             |             |
| 5.77000E+02               | 1.04200E+03 |             |             |             |             |
| NORMAL                    |             | NORMMAT3    | NORMPRP3    |             |             |
| -3.67370E-02              | 8.32640E-02 |             |             |             |             |

|                   |              |             |             |             |             |
|-------------------|--------------|-------------|-------------|-------------|-------------|
| LOGNORMAL         |              | LOGNMAT1    | LOGNPRP1    |             |             |
| 1.00000E-02       | 2.13000E+00  |             |             |             |             |
| LOGNORMAL         |              | LOGNMAT2    | LOGNPRP2    |             |             |
| 1.00000E-03       | 3.50000E+02  |             |             |             |             |
| LOGNORMAL         |              | LOGNMAT3    | LOGNPRP3    |             |             |
| 1.00000E-04       | 5.25000E+04  |             |             |             |             |
| UNIFORM           |              | UNIFMAT1    | UNIFPRP1    |             |             |
| -5.00000E-01      | 5.00000E-01  |             |             |             |             |
| UNIFORM           |              | UNIFMAT2    | UNIFPRP2    |             |             |
| 0.00000E+00       | 1.00000E+00  |             |             |             |             |
| UNIFORM           |              | UNIFMAT3    | UNIFPRP3    |             |             |
| 1.25000E+01       | 5.00000E+02  |             |             |             |             |
| LOGUNIFORM        |              | LOGUMAT1    | LOGUPRP1    |             |             |
| 1.00000E-17       | 1.00000E-11  |             |             |             |             |
| LOGUNIFORM        |              | LOGUMAT2    | LOGUPRP2    |             |             |
| 1.00000E-06       | 1.00000E+03  |             |             |             |             |
| LOGUNIFORM        |              | LOGUMAT3    | LOGUPRP3    |             |             |
| 5.60000E+13       | 5.60000E+15  |             |             |             |             |
| USER DISTRIBUTION | (CUMULATIVE) |             | CUMMAT1     | CUMPRP1     |             |
| 4                 | SPECIFIED    |             | CONTINUOUS  |             |             |
| -8.00000E+00      | 0.10000      |             |             |             |             |
| -6.57000E+00      | 0.80000      |             |             |             |             |
| -4.77000E+00      | 0.10000      |             |             |             |             |
| -2.00000E+00      | 0.00000      |             |             |             |             |
| USER DISTRIBUTION | (CUMULATIVE) |             | CUMMAT2     | CUMPRP2     |             |
| 4                 | SPECIFIED    |             | CONTINUOUS  |             |             |
| -1.25000E+01      | 0.15000      |             |             |             |             |
| -9.00000E+00      | 0.45000      |             |             |             |             |
| -6.51000E+00      | 0.40000      |             |             |             |             |
| -5.00000E+00      | 0.00000      |             |             |             |             |
| USER DISTRIBUTION | (CUMULATIVE) |             | CUMMAT3     | CUMPRP3     |             |
| 4                 | SPECIFIED    |             | CONTINUOUS  |             |             |
| -8.60000E+00      | 0.10000      |             |             |             |             |
| -8.00000E+00      | 0.60000      |             |             |             |             |
| -3.25000E+00      | 0.30000      |             |             |             |             |
| -2.00000E+00      | 0.00000      |             |             |             |             |
| USER DISTRIBUTION | (DATA)       |             | DATAMAT1    | DATAPRP1    |             |
| 21                | EQUAL        |             | CONTINUOUS  |             |             |
| 5.80565E-02       | 9.55000E-02  | 1.03330E-01 | 1.07400E-01 | 1.15000E-01 | 1.20500E-01 |
| 1.22250E-01       | 1.23500E-01  | 1.29000E-01 | 1.38500E-01 | 1.44330E-01 | 1.46500E-01 |
| 1.61600E-01       | 1.61800E-01  | 1.65170E-01 | 1.78000E-01 | 1.78400E-01 | 1.79600E-01 |
| 2.02500E-01       | 2.07750E-01  | 2.52500E-01 |             |             |             |

|                           |             |             |             |             |             |
|---------------------------|-------------|-------------|-------------|-------------|-------------|
| USER DISTRIBUTION (DATA)  |             | DATAMAT2    | DATAPRP2    |             |             |
| 9                         | EQUAL       | CONTINUOUS  |             |             |             |
| 2.30500E+01               | 2.90600E+01 | 3.45620E+01 | 4.13200E+01 | 5.53900E+01 | 6.34200E+01 |
| 7.94300E+01               | 8.90880E+01 | 1.03800E+02 |             |             |             |
| USER DISTRIBUTION (DATA)  |             | DATAMAT3    | DATAPRP3    |             |             |
| 12                        | EQUAL       | CONTINUOUS  |             |             |             |
| 1.22250E+00               | 9.30000E+00 | 1.09000E+01 | 1.38500E+01 | 2.74330E+01 | 3.46500E+01 |
| 4.61600E+01               | 5.01800E+01 | 6.15170E+01 | 7.38000E+01 | 8.78400E+01 | 9.49600E+01 |
| USER DISTRIBUTION (DELTA) |             | DELTMAT1    | DELTPRP1    |             |             |
| 14                        | SPECIFIED   | DISCRETE    |             |             |             |
| 5.08000E-02               | 0.07143     |             |             |             |             |
| 1.01600E-01               | 0.07143     |             |             |             |             |
| 1.52400E-01               | 0.07143     |             |             |             |             |
| 1.93680E-01               | 0.07143     |             |             |             |             |
| 2.19080E-01               | 0.07143     |             |             |             |             |
| 2.28600E-01               | 0.07143     |             |             |             |             |
| 2.50830E-01               | 0.07143     |             |             |             |             |
| 2.79400E-01               | 0.07143     |             |             |             |             |
| 3.04800E-01               | 0.07143     |             |             |             |             |
| 3.49250E-01               | 0.07143     |             |             |             |             |
| 3.81000E-01               | 0.07143     |             |             |             |             |
| 4.44500E-01               | 0.07143     |             |             |             |             |
| 5.58800E-01               | 0.07143     |             |             |             |             |
| 6.09600E-01               | 0.07141     |             |             |             |             |
| USER DISTRIBUTION (DELTA) |             | DELTMAT2    | DELTPRP2    |             |             |
| 4                         | SPECIFIED   | DISCRETE    |             |             |             |
| 1.00000E+00               | 0.30000     |             |             |             |             |
| 2.00000E+00               | 0.15000     |             |             |             |             |
| 3.00000E+00               | 0.20000     |             |             |             |             |
| 4.00000E+00               | 0.35000     |             |             |             |             |
| USER DISTRIBUTION (DELTA) |             | DELTMAT3    | DELTPRP3    |             |             |
| 6                         | SPECIFIED   | DISCRETE    |             |             |             |
| -1.00000E+01              | 0.13000     |             |             |             |             |
| 2.00000E+00               | 0.13000     |             |             |             |             |
| 8.00000E+00               | 0.26000     |             |             |             |             |
| 2.30000E+01               | 0.15000     |             |             |             |             |
| 3.40000E+01               | 0.15000     |             |             |             |             |
| 4.00000E+01               | 0.18000     |             |             |             |             |
| NORMAL                    |             | NORMMAT1    | NORMPRP1    |             |             |
| 0.00000E+00               | 2.00000E-01 |             |             |             |             |
| NORMAL                    |             | NORMMAT2    | NORMPRP2    |             |             |
| 5.77000E+02               | 1.04200E+03 |             |             |             |             |

|                   |              |             |             |             |             |
|-------------------|--------------|-------------|-------------|-------------|-------------|
| NORMAL            |              | NORMMAT3    | NORMPRP3    |             |             |
| -3.67370E-02      | 8.32640E-02  |             |             |             |             |
| LOGNORMAL         |              | LOGNMAT1    | LOGNPRP1    |             |             |
| 1.00000E-02       | 2.13000E+00  |             |             |             |             |
| LOGNORMAL         |              | LOGNMAT2    | LOGNPRP2    |             |             |
| 1.00000E-03       | 3.50000E+02  |             |             |             |             |
| LOGNORMAL         |              | LOGNMAT3    | LOGNPRP3    |             |             |
| 1.00000E-04       | 5.25000E+04  |             |             |             |             |
| UNIFORM           |              | UNIFMAT1    | UNIFPRP1    |             |             |
| -5.00000E-01      | 5.00000E-01  |             |             |             |             |
| UNIFORM           |              | UNIFMAT2    | UNIFPRP2    |             |             |
| 0.00000E+00       | 1.00000E+00  |             |             |             |             |
| UNIFORM           |              | UNIFMAT3    | UNIFPRP3    |             |             |
| 1.25000E+01       | 5.00000E+02  |             |             |             |             |
| LOGUNIFORM        |              | LOGUMAT1    | LOGUPRP1    |             |             |
| 1.00000E-17       | 1.00000E-11  |             |             |             |             |
| LOGUNIFORM        |              | LOGUMAT2    | LOGUPRP2    |             |             |
| 1.00000E-06       | 1.00000E+03  |             |             |             |             |
| LOGUNIFORM        |              | LOGUMAT3    | LOGUPRP3    |             |             |
| 5.60000E+13       | 5.60000E+15  |             |             |             |             |
| USER DISTRIBUTION | (CUMULATIVE) |             | CUMMAT1     | CUMPRP1     |             |
| 4                 | SPECIFIED    |             | CONTINUOUS  |             |             |
| -8.00000E+00      | 0.10000      |             |             |             |             |
| -6.57000E+00      | 0.80000      |             |             |             |             |
| -4.77000E+00      | 0.10000      |             |             |             |             |
| -2.00000E+00      | 0.00000      |             |             |             |             |
| USER DISTRIBUTION | (CUMULATIVE) |             | CUMMAT2     | CUMPRP2     |             |
| 4                 | SPECIFIED    |             | CONTINUOUS  |             |             |
| -1.25000E+01      | 0.15000      |             |             |             |             |
| -9.00000E+00      | 0.45000      |             |             |             |             |
| -6.51000E+00      | 0.40000      |             |             |             |             |
| -5.00000E+00      | 0.00000      |             |             |             |             |
| USER DISTRIBUTION | (CUMULATIVE) |             | CUMMAT3     | CUMPRP3     |             |
| 4                 | SPECIFIED    |             | CONTINUOUS  |             |             |
| -8.60000E+00      | 0.10000      |             |             |             |             |
| -8.00000E+00      | 0.60000      |             |             |             |             |
| -3.25000E+00      | 0.30000      |             |             |             |             |
| -2.00000E+00      | 0.00000      |             |             |             |             |
| USER DISTRIBUTION | (DATA)       |             | DATAMAT1    | DATAPRP1    |             |
| 21                | EQUAL        |             | CONTINUOUS  |             |             |
| 5.80565E-02       | 9.55000E-02  | 1.03330E-01 | 1.07400E-01 | 1.15000E-01 | 1.20500E-01 |
| 1.22250E-01       | 1.23500E-01  | 1.29000E-01 | 1.38500E-01 | 1.44330E-01 | 1.46500E-01 |

|                   |             |             |             |             |             |
|-------------------|-------------|-------------|-------------|-------------|-------------|
| 1.61600E-01       | 1.61800E-01 | 1.65170E-01 | 1.78000E-01 | 1.78400E-01 | 1.79600E-01 |
| 2.02500E-01       | 2.07750E-01 | 2.52500E-01 |             |             |             |
| USER DISTRIBUTION | (DATA)      |             | DATAMAT2    | DATAPRP2    |             |
| 9                 | EQUAL       |             | CONTINUOUS  |             |             |
| 2.30500E+01       | 2.90600E+01 | 3.45620E+01 | 4.13200E+01 | 5.53900E+01 | 6.34200E+01 |
| 7.94300E+01       | 8.90880E+01 | 1.03800E+02 |             |             |             |
| USER DISTRIBUTION | (DATA)      |             | DATAMAT3    | DATAPRP3    |             |
| 12                | EQUAL       |             | CONTINUOUS  |             |             |
| 1.22250E+00       | 9.30000E+00 | 1.09000E+01 | 1.38500E+01 | 2.74330E+01 | 3.46500E+01 |
| 4.61600E+01       | 5.01800E+01 | 6.15170E+01 | 7.38000E+01 | 8.78400E+01 | 9.49600E+01 |
| USER DISTRIBUTION | (DELTA)     |             | DELTMAT1    | DELTPRP1    |             |
| 14                | SPECIFIED   |             | DISCRETE    |             |             |
| 5.08000E-02       | 0.07143     |             |             |             |             |
| 1.01600E-01       | 0.07143     |             |             |             |             |
| 1.52400E-01       | 0.07143     |             |             |             |             |
| 1.93680E-01       | 0.07143     |             |             |             |             |
| 2.19080E-01       | 0.07143     |             |             |             |             |
| 2.28600E-01       | 0.07143     |             |             |             |             |
| 2.50830E-01       | 0.07143     |             |             |             |             |
| 2.79400E-01       | 0.07143     |             |             |             |             |
| 3.04800E-01       | 0.07143     |             |             |             |             |
| 3.49250E-01       | 0.07143     |             |             |             |             |
| 3.81000E-01       | 0.07143     |             |             |             |             |
| 4.44500E-01       | 0.07143     |             |             |             |             |
| 5.58800E-01       | 0.07143     |             |             |             |             |
| 6.09600E-01       | 0.07141     |             |             |             |             |
| USER DISTRIBUTION | (DELTA)     |             | DELTMAT2    | DELTPRP2    |             |
| 4                 | SPECIFIED   |             | DISCRETE    |             |             |
| 1.00000E+00       | 0.30000     |             |             |             |             |
| 2.00000E+00       | 0.15000     |             |             |             |             |
| 3.00000E+00       | 0.20000     |             |             |             |             |
| 4.00000E+00       | 0.35000     |             |             |             |             |
| USER DISTRIBUTION | (DELTA)     |             | DELTMAT3    | DELTPRP3    |             |
| 6                 | SPECIFIED   |             | DISCRETE    |             |             |
| -1.00000E+01      | 0.13000     |             |             |             |             |
| 2.00000E+00       | 0.13000     |             |             |             |             |
| 8.00000E+00       | 0.26000     |             |             |             |             |
| 2.30000E+01       | 0.15000     |             |             |             |             |
| 3.40000E+01       | 0.15000     |             |             |             |             |
| 4.00000E+01       | 0.18000     |             |             |             |             |
| NORMAL            |             |             | NORMMAT1    | NORMPRP1    |             |
| 0.00000E+00       | 2.00000E-01 |             |             |             |             |



|                   |              |          |            |          |
|-------------------|--------------|----------|------------|----------|
| NORMAL            |              | NORMMAT2 | NORMPRP2   |          |
| 5.77000E+02       | 1.04200E+03  |          |            |          |
| NORMAL            |              | NORMMAT3 | NORMPRP3   |          |
| -3.67370E-02      | 8.32640E-02  |          |            |          |
| LOGNORMAL         |              | LOGNMAT1 | LOGNPRP1   |          |
| 1.00000E-02       | 2.13000E+00  |          |            |          |
| LOGNORMAL         |              | LOGNMAT2 | LOGNPRP2   |          |
| 1.00000E-03       | 3.50000E+02  |          |            |          |
| LOGNORMAL         |              | LOGNMAT3 | LOGNPRP3   |          |
| 1.00000E-04       | 5.25000E+04  |          |            |          |
| UNIFORM           |              | UNIFMAT1 | UNIFPRP1   |          |
| -5.00000E-01      | 5.00000E-01  |          |            |          |
| UNIFORM           |              | UNIFMAT2 | UNIFPRP2   |          |
| 0.00000E+00       | 1.00000E+00  |          |            |          |
| UNIFORM           |              | UNIFMAT3 | UNIFPRP3   |          |
| 1.25000E+01       | 5.00000E+02  |          |            |          |
| LOGUNIFORM        |              | LOGUMAT1 | LOGUPRP1   |          |
| 1.00000E-17       | 1.00000E-11  |          |            |          |
| LOGUNIFORM        |              | LOGUMAT2 | LOGUPRP2   |          |
| 1.00000E-06       | 1.00000E+03  |          |            |          |
| LOGUNIFORM        |              | LOGUMAT3 | LOGUPRP3   |          |
| 5.60000E+13       | 5.60000E+15  |          |            |          |
| USER DISTRIBUTION | (CUMULATIVE) |          | CUMMAT1    | CUMPRP1  |
| 4                 | SPECIFIED    |          | CONTINUOUS |          |
| -8.00000E+00      | 0.10000      |          |            |          |
| -6.57000E+00      | 0.80000      |          |            |          |
| -4.77000E+00      | 0.10000      |          |            |          |
| -2.00000E+00      | 0.00000      |          |            |          |
| USER DISTRIBUTION | (CUMULATIVE) |          | CUMMAT2    | CUMPRP2  |
| 4                 | SPECIFIED    |          | CONTINUOUS |          |
| -1.25000E+01      | 0.15000      |          |            |          |
| -9.00000E+00      | 0.45000      |          |            |          |
| -6.51000E+00      | 0.40000      |          |            |          |
| -5.00000E+00      | 0.00000      |          |            |          |
| USER DISTRIBUTION | (CUMULATIVE) |          | CUMMAT3    | CUMPRP3  |
| 4                 | SPECIFIED    |          | CONTINUOUS |          |
| -8.60000E+00      | 0.10000      |          |            |          |
| -8.00000E+00      | 0.60000      |          |            |          |
| -3.25000E+00      | 0.30000      |          |            |          |
| -2.00000E+00      | 0.00000      |          |            |          |
| USER DISTRIBUTION | (DATA)       |          | DATAMAT1   | DATAPRP1 |
| 21                | EQUAL        |          | CONTINUOUS |          |

|                           |             |                   |             |             |             |
|---------------------------|-------------|-------------------|-------------|-------------|-------------|
| 5.80565E-02               | 9.55000E-02 | 1.03330E-01       | 1.07400E-01 | 1.15000E-01 | 1.20500E-01 |
| 1.22250E-01               | 1.23500E-01 | 1.29000E-01       | 1.38500E-01 | 1.44330E-01 | 1.46500E-01 |
| 1.61600E-01               | 1.61800E-01 | 1.65170E-01       | 1.78000E-01 | 1.78400E-01 | 1.79600E-01 |
| 2.02500E-01               | 2.07750E-01 | 2.52500E-01       |             |             |             |
| USER DISTRIBUTION (DATA)  |             | DATAMAT2 DATAPRP2 |             |             |             |
| 9                         | EQUAL       | CONTINUOUS        |             |             |             |
| 2.30500E+01               | 2.90600E+01 | 3.45620E+01       | 4.13200E+01 | 5.53900E+01 | 6.34200E+01 |
| 7.94300E+01               | 8.90880E+01 | 1.03800E+02       |             |             |             |
| USER DISTRIBUTION (DATA)  |             | DATAMAT3 DATAPRP3 |             |             |             |
| 12                        | EQUAL       | CONTINUOUS        |             |             |             |
| 1.22250E+00               | 9.30000E+00 | 1.09000E+01       | 1.38500E+01 | 2.74330E+01 | 3.46500E+01 |
| 4.61600E+01               | 5.01800E+01 | 6.15170E+01       | 7.38000E+01 | 8.78400E+01 | 9.49600E+01 |
| USER DISTRIBUTION (DELTA) |             | DELTMAT1 DELTPRP1 |             |             |             |
| 14                        | SPECIFIED   | DISCRETE          |             |             |             |
| 5.08000E-02               | 0.07143     |                   |             |             |             |
| 1.01600E-01               | 0.07143     |                   |             |             |             |
| 1.52400E-01               | 0.07143     |                   |             |             |             |
| 1.93680E-01               | 0.07143     |                   |             |             |             |
| 2.19080E-01               | 0.07143     |                   |             |             |             |
| 2.28600E-01               | 0.07143     |                   |             |             |             |
| 2.50830E-01               | 0.07143     |                   |             |             |             |
| 2.79400E-01               | 0.07143     |                   |             |             |             |
| 3.04800E-01               | 0.07143     |                   |             |             |             |
| 3.49250E-01               | 0.07143     |                   |             |             |             |
| 3.81000E-01               | 0.07143     |                   |             |             |             |
| 4.44500E-01               | 0.07143     |                   |             |             |             |
| 5.58800E-01               | 0.07143     |                   |             |             |             |
| 6.09600E-01               | 0.07141     |                   |             |             |             |
| USER DISTRIBUTION (DELTA) |             | DELTMAT2 DELTPRP2 |             |             |             |
| 4                         | SPECIFIED   | DISCRETE          |             |             |             |
| 1.00000E+00               | 0.30000     |                   |             |             |             |
| 2.00000E+00               | 0.15000     |                   |             |             |             |
| 3.00000E+00               | 0.20000     |                   |             |             |             |
| 4.00000E+00               | 0.35000     |                   |             |             |             |
| USER DISTRIBUTION (DELTA) |             | DELTMAT3 DELTPRP3 |             |             |             |
| 6                         | SPECIFIED   | DISCRETE          |             |             |             |
| -1.00000E+01              | 0.13000     |                   |             |             |             |
| 2.00000E+00               | 0.13000     |                   |             |             |             |
| 8.00000E+00               | 0.26000     |                   |             |             |             |
| 2.30000E+01               | 0.15000     |                   |             |             |             |
| 3.40000E+01               | 0.15000     |                   |             |             |             |
| 4.00000E+01               | 0.18000     |                   |             |             |             |

CORRELATION MATRIX

7  
1 3 0.999  
2 5 0.950  
4 6 0.800  
5 2 0.950  
7 8 0.650  
7 9 0.650  
8 9 0.650

OUTPUT CORR HIST DATA

## INPUT FILE FOR LHS TEST 8

TITLE CMS Test Input File for the LHS Code Test 8

NOBS 75  
RANDOM SEED 933090934  
NORMAL NORMMAT1 NORMPRP1  
0.00000E+00 2.00000E-01  
NORMAL NORMMAT2 NORMPRP2  
5.77000E+02 1.04200E+03  
NORMAL NORMMAT3 NORMPRP3  
LOGNORMAL LOGNMAT1 LOGNPRP1  
1.00000E-02 2.13000E+00  
LOGNORMAL LOGNMAT2 LOGNPRP2  
1.00000E-03 3.50000E+02  
LOGNORMAL LOGNMAT3 LOGNPRP3  
1.00000E-04 5.25000E+04  
UNIFORM UNIFMAT1 UNIFPRP1  
-5.00000E-01 5.00000E-01  
UNIFORM UNIFMAT2 UNIFPRP2  
0.00000E+00 1.00000E+00  
UNIFORM UNIFMAT3 UNIFPRP3  
1.25000E+01 5.00000E+02  
LOGUNIFORM LOGUMAT1 LOGUPRP1  
1.00000E-17 1.00000E-11  
LOGUNIFORM LOGUMAT2 LOGUPRP2  
1.00000E-06 1.00000E+03  
LOGUNIFORM LOGUMAT3 LOGUPRP3  
5.60000E+13 5.60000E+15  
USER DISTRIBUTION (CUMULATIVE) CUMMAT1 CUMPRP1  
4 SPECIFIED CONTINUOUS  
-8.00000E+00 0.10000  
-6.57000E+00 0.80000  
-4.77000E+00 0.10000

|                   |              |             |             |             |             |
|-------------------|--------------|-------------|-------------|-------------|-------------|
| -2.00000E+00      | 0.00000      |             |             |             |             |
| USER DISTRIBUTION | (CUMULATIVE) |             | CUMMAT2     | CUMPRP2     |             |
| 4                 | SPECIFIED    |             | CONTINUOUS  |             |             |
| -1.25000E+01      | 0.15000      |             |             |             |             |
| -9.00000E+00      | 0.45000      |             |             |             |             |
| -6.51000E+00      | 0.40000      |             |             |             |             |
| -5.00000E+00      | 0.00000      |             |             |             |             |
| USER DISTRIBUTION | (CUMULATIVE) |             | CUMMAT3     | CUMPRP3     |             |
| 4                 | SPECIFIED    |             | CONTINUOUS  |             |             |
| -8.60000E+00      | 0.10000      |             |             |             |             |
| -8.00000E+00      | 0.60000      |             |             |             |             |
| -3.25000E+00      | 0.30000      |             |             |             |             |
| -2.00000E+00      | 0.00000      |             |             |             |             |
| USER DISTRIBUTION | (DATA)       |             | DATAMAT1    | DATAPRP1    |             |
| 21                | EQUAL        |             | CONTINUOUS  |             |             |
| 5.80565E-02       | 9.55000E-02  | 1.03330E-01 | 1.07400E-01 | 1.15000E-01 | 1.20500E-01 |
| 1.22250E-01       | 1.23500E-01  | 1.29000E-01 | 1.38500E-01 | 1.44330E-01 | 1.46500E-01 |
| 1.61600E-01       | 1.61800E-01  | 1.65170E-01 | 1.78000E-01 | 1.78400E-01 | 1.79600E-01 |
| 2.02500E-01       | 2.07750E-01  | 2.52500E-01 |             |             |             |
| USER DISTRIBUTION | (DATA)       |             | DATAMAT2    | DATAPRP2    |             |
| 9                 | EQUAL        |             | CONTINUOUS  |             |             |
| 2.30500E+01       | 2.90600E+01  | 3.45620E+01 | 4.13200E+01 | 5.53900E+01 | 6.34200E+01 |
| 7.94300E+01       | 8.90880E+01  | 1.03800E+02 |             |             |             |
| USER DISTRIBUTION | (DATA)       |             | DATAMAT3    | DATAPRP3    |             |
| 12                | EQUAL        |             | CONTINUOUS  |             |             |
| 1.22250E+00       | 9.30000E+00  | 1.09000E+01 | 1.38500E+01 | 2.74330E+01 | 3.46500E+01 |
| 4.61600E+01       | 5.01800E+01  | 6.15170E+01 | 7.38000E+01 | 8.78400E+01 | 9.49600E+01 |
| USER DISTRIBUTION | (DELTA)      |             | DELTMAT1    | DELTPRP1    |             |
| 14                | SPECIFIED    |             | DISCRETE    |             |             |
| 5.08000E-02       | 0.07143      |             |             |             |             |
| 1.01600E-01       | 0.07143      |             |             |             |             |
| 1.52400E-01       | 0.07143      |             |             |             |             |
| 1.93680E-01       | 0.07143      |             |             |             |             |
| 2.19080E-01       | 0.07143      |             |             |             |             |
| 2.28600E-01       | 0.07143      |             |             |             |             |
| 2.50830E-01       | 0.07143      |             |             |             |             |
| 2.79400E-01       | 0.07143      |             |             |             |             |
| 3.04800E-01       | 0.07143      |             |             |             |             |
| 3.49250E-01       | 0.07143      |             |             |             |             |
| 3.81000E-01       | 0.07143      |             |             |             |             |
| 4.44500E-01       | 0.07143      |             |             |             |             |
| 5.58800E-01       | 0.07143      |             |             |             |             |

6.09600E-01 0.07141  
 USER DISTRIBUTION (DELTA) DELTMAT2 DELTPRP2  
 4 SPECIFIED DISCRETE  
 1.00000E+00 0.30000  
 2.00000E+00 0.15000  
 3.00000E+00 0.20000  
 4.00000E+00 0.35000

USER DISTRIBUTION (DELTA) DELTMAT3 DELTPRP3  
 6 SPECIFIED DISCRETE  
 -1.00000E+01 0.13000  
 2.00000E+00 0.13000  
 8.00000E+00 0.26000  
 2.30000E+01 0.15000  
 3.40000E+01 0.15000  
 4.00000E+01 0.18000

CORRELATION MATRIX

7  
 1 3 0.999  
 2 5 0.950  
 4 6 0.800  
 5 2 0.950  
 7 8 0.650  
 7 9 0.650  
 8 9 0.650

OUTPUT CORR HIST DATA

## INPUT FILE FOR LHS TEST 9

TITLE CMS Test Input File for the LHS Code Test 9

NOBS 75  
 RANDOM SEED 933090934578  
 NORMAL NORMMAT1 NORMPRP1  
 0.00000E+00 2.00000E-01  
 NORMAL NORMMAT2 NORMPRP2  
 5.77000E+02 1.04200E+03  
 NORMAL NORMMAT3 NORMPRP3  
 -3.67370E-02 8.32640E-02  
 LOGNORMAL LOGNMAT1 LOGNPRP1  
 1.00000E-02 2.13000E+00  
 LOGNORMAL LOGNMAT2 LOGNPRP2  
 1.00000E-03 3.50000E+02  
 LOGNORMAL LOGNMAT3 LOGNPRP3  
 1.00000E-04 5.25000E+04  
 UNIFORM UNIFMAT1 UNIFPRP1

|                   |              |             |             |             |             |
|-------------------|--------------|-------------|-------------|-------------|-------------|
| -5.00000E-01      | 5.00000E-01  |             |             |             |             |
| UNIFORM           | UNIFMAT2     | UNIFPRP2    |             |             |             |
| 0.00000E+00       | 1.00000E+00  |             |             |             |             |
| UNIFORM           | UNIFMAT3     | UNIFPRP3    |             |             |             |
| 1.25000E+01       | 5.00000E+02  |             |             |             |             |
| LOGUNIFORM        | LOGUMAT1     | LOGUPRP1    |             |             |             |
| 1.00000E-17       | 1.00000E-11  |             |             |             |             |
| LOGUNIFORM        | LOGUMAT2     | LOGUPRP2    |             |             |             |
| 1.00000E-06       | 1.00000E+03  |             |             |             |             |
| LOGUNIFORM        | LOGUMAT3     | LOGUPRP3    |             |             |             |
| 5.60000E+13       | 5.60000E+15  |             |             |             |             |
| USER DISTRIBUTION | (CUMULATIVE) | CUMMAT1     | CUMPRP1     |             |             |
| 4                 | SPECIFIED    | CONTINUOUS  |             |             |             |
| -8.00000E+00      | 0.10000      |             |             |             |             |
| -6.57000E+00      | 0.80000      |             |             |             |             |
| -4.77000E+00      | 0.10000      |             |             |             |             |
| -2.00000E+00      | 0.00000      |             |             |             |             |
| USER DISTRIBUTION | (CUMULATIVE) | CUMMAT2     | CUMPRP2     |             |             |
| 4                 | SPECIFIED    | CONTINUOUS  |             |             |             |
| -1.25000E+01      | 0.15000      |             |             |             |             |
| -9.00000E+00      | 0.45000      |             |             |             |             |
| -6.51000E+00      | 0.40000      |             |             |             |             |
| -5.00000E+00      | 0.00000      |             |             |             |             |
| USER DISTRIBUTION | (CUMULATIVE) | CUMMAT3     | CUMPRP3     |             |             |
| 4                 | SPECIFIED    | CONTINUOUS  |             |             |             |
| -8.60000E+00      | 0.10000      |             |             |             |             |
| -8.00000E+00      | 0.60000      |             |             |             |             |
| -3.25000E+00      | 0.30000      |             |             |             |             |
| -2.00000E+00      | 0.00000      |             |             |             |             |
| USER DISTRIBUTION | (DATA)       | DATAMAT1    | DATAPRP1    |             |             |
| 21                | EQUAL        | CONTINUOUS  |             |             |             |
| 5.80565E-02       | 9.55000E-02  | 1.03330E-01 | 1.07400E-01 | 1.15000E-01 | 1.20500E-01 |
| 1.22250E-01       | 1.23500E-01  | 1.29000E-01 | 1.38500E-01 | 1.44330E-01 | 1.46500E-01 |
| 1.61600E-01       | 1.61800E-01  | 1.65170E-01 | 1.78000E-01 | 1.78400E-01 | 1.79600E-01 |
| 2.02500E-01       | 2.07750E-01  | 2.52500E-01 |             |             |             |
| USER DISTRIBUTION | (DATA)       | DATAMAT2    | DATAPRP2    |             |             |
| 9                 | EQUAL        | CONTINUOUS  |             |             |             |
| 2.30500E+01       | 2.90600E+01  | 3.45620E+01 | 4.13200E+01 | 5.53900E+01 | 6.34200E+01 |
| 7.94300E+01       | 8.90880E+01  | 1.03800E+02 |             |             |             |
| USER DISTRIBUTION | (DATA)       | DATAMAT3    | DATAPRP3    |             |             |
| 12                | EQUAL        | CONTINUOUS  |             |             |             |
| 1.22250E+00       | 9.30000E+00  | 1.09000E+01 | 1.38500E+01 | 2.74330E+01 | 3.46500E+01 |

4.61600E+01 5.01800E+01 6.15170E+01 7.38000E+01 8.78400E+01 9.49600E+01

USER DISTRIBUTION (DELTA) DELTMAT1 DELTPRP1

| 14          | SPECIFIED | DISCRETE |
|-------------|-----------|----------|
| 5.08000E-02 | 0.07143   |          |
| 1.01600E-01 | 0.07143   |          |
| 1.52400E-01 | 0.07143   |          |
| 1.93680E-01 | 0.07143   |          |
| 2.19080E-01 | 0.07143   |          |
| 2.28600E-01 | 0.07143   |          |
| 2.50830E-01 | 0.07143   |          |
| 2.79400E-01 | 0.07143   |          |
| 3.04800E-01 | 0.07143   |          |
| 3.49250E-01 | 0.07143   |          |
| 3.81000E-01 | 0.07143   |          |
| 4.44500E-01 | 0.07143   |          |
| 5.58800E-01 | 0.07143   |          |
| 6.09600E-01 | 0.07141   |          |

USER DISTRIBUTION (DELTA) DELTMAT2 DELTPRP2

| 4           | SPECIFIED | DISCRETE |
|-------------|-----------|----------|
| 1.00000E+00 | 0.30000   |          |
| 2.00000E+00 | 0.15000   |          |
| 3.00000E+00 | 0.20000   |          |
| 4.00000E+00 | 0.35000   |          |

USER DISTRIBUTION (DELTA) DELTMAT3 DELTPRP3

| 6            | SPECIFIED | DISCRETE |
|--------------|-----------|----------|
| -1.00000E+01 | 0.13000   |          |
| 2.00000E+00  | 0.13000   |          |
| 8.00000E+00  | 0.26000   |          |
| 2.30000E+01  | 0.15000   |          |
| 3.40000E+01  | 0.15000   |          |
| 4.00000E+01  | 0.18000   |          |

CORRELATION MATRIX

| 7 |   |        |
|---|---|--------|
| 1 | 3 | -0.999 |
| 2 | 5 | -0.950 |
| 4 | 6 | -0.800 |
| 5 | 2 | -0.950 |
| 7 | 8 | -0.650 |
| 7 | 9 | -0.650 |
| 8 | 9 | -0.650 |

OUTPUT CORR HIST DATA

INPUT FILE FOR LHS TEST 10

TITLE CMS Test Input File for the LHS Code Test 10

|                   |              |            |          |
|-------------------|--------------|------------|----------|
| NOBS              | 75           |            |          |
| RANDOM SEED       | 933090934    |            |          |
| NORMAL            |              | NORMMAT1   | NORMPRP1 |
| 0.00000E+00       | 2.00000E-01  |            |          |
| NORMAL            |              | NORMMAT2   | NORMPRP2 |
| 5.77000E+02       | 1.04200E+03  |            |          |
| NORMAL            |              | NORMMAT3   | NORMPRP3 |
| -3.67370E-02      | 8.32640E-02  |            |          |
| LOGNORMAL         |              | LOGNMAT1   | LOGNPRP1 |
| 1.00000E-02       | 2.13000E+00  |            |          |
| LOGNORMAL         |              | LOGNMAT2   | LOGNPRP2 |
| 1.00000E-03       | 3.50000E+02  |            |          |
| LOGNORMAL         |              | LOGNMAT3   | LOGNPRP3 |
| 1.00000E-04       | 5.25000E+04  |            |          |
| UNIFORM           |              | UNIFMAT1   | UNIFPRP1 |
| -5.00000E-01      | 5.00000E-01  |            |          |
| UNIFORM           |              | UNIFMAT2   | UNIFPRP2 |
| 0.00000E+00       | 1.00000E+00  |            |          |
| UNIFORM           |              | UNIFMAT3   | UNIFPRP3 |
| 1.25000E+01       | 5.00000E+02  |            |          |
| LOGUNIFORM        |              | LOGUMAT1   | LOGUPRP1 |
| 1.00000E-17       | 1.00000E-11  |            |          |
| LOGUNIFORM        |              | LOGUMAT2   | LOGUPRP2 |
| 1.00000E-06       | 1.00000E+03  |            |          |
| LOGUNIFORM        |              | LOGUMAT3   | LOGUPRP3 |
| 5.60000E+13       | 5.60000E+15  |            |          |
| USER DISTRIBUTION | (CUMULATIVE) | CUMMAT1    | CUMPRP1  |
| 4                 | SPECIFIED    | CONTINUOUS |          |
| -8.00000E+00      | 0.10000      |            |          |
| -6.57000E+00      | 0.80000      |            |          |
| -4.77000E+00      | 0.10000      |            |          |
| -2.00000E+00      | 0.00000      |            |          |
| USER DISTRIBUTION | (CUMULATIVE) | CUMMAT2    | CUMPRP2  |
| 4                 | SPECIFIED    | CONTINUOUS |          |
| -1.25000E+01      | 0.15000      |            |          |
| -9.00000E+00      | 0.45000      |            |          |
| -6.51000E+00      | 0.40000      |            |          |
| -5.00000E+00      | 0.00000      |            |          |
| USER DISTRIBUTION | (CUMULATIVE) | CUMMAT3    | CUMPRP3  |
| 4                 | SPECIFIED    | CONTINUOUS |          |
| -8.60000E+00      | 0.10000      |            |          |



|                           |             |             |             |             |             |
|---------------------------|-------------|-------------|-------------|-------------|-------------|
| -8.00000E+00              | 0.60000     |             |             |             |             |
| -3.25000E+00              | 0.30000     |             |             |             |             |
| -2.00000E+00              | 0.00000     |             |             |             |             |
| USER DISTRIBUTION (DATA)  |             | DATAMAT1    | DATAPRP1    |             |             |
| 21                        | EQUAL       | CONTINUOUS  |             |             |             |
| 5.80565E-02               | 9.55000E-02 | 1.03330E-01 | 1.07400E-01 | 1.15000E-01 | 1.20500E-01 |
| 1.22250E-01               | 1.23500E-01 | 1.29000E-01 | 1.38500E-01 | 1.44330E-01 | 1.46500E-01 |
| 1.61600E-01               | 1.61800E-01 | 1.65170E-01 | 1.78000E-01 | 1.78400E-01 | 1.79600E-01 |
| 2.02500E-01               | 2.07750E-01 | 2.52500E-01 |             |             |             |
| USER DISTRIBUTION (DATA)  |             | DATAMAT2    | DATAPRP2    |             |             |
| 9                         | EQUAL       | CONTINUOUS  |             |             |             |
| 2.30500E+01               | 2.90600E+01 | 3.45620E+01 | 4.13200E+01 | 5.53900E+01 | 6.34200E+01 |
| 7.94300E+01               | 8.90880E+01 | 1.03800E+02 |             |             |             |
| USER DISTRIBUTION (DATA)  |             | DATAMAT3    | DATAPRP3    |             |             |
| 12                        | EQUAL       | CONTINUOUS  |             |             |             |
| 1.22250E+00               | 9.30000E+00 | 1.09000E+01 | 1.38500E+01 | 2.74330E+01 | 3.46500E+01 |
| 4.61600E+01               | 5.01800E+01 | 6.15170E+01 | 7.38000E+01 | 8.78400E+01 | 9.49600E+01 |
| USER DISTRIBUTION (DELTA) |             | DELTMAT1    | DELTPRP1    |             |             |
| 14                        | SPECIFIED   | DISCRETE    |             |             |             |
| 5.08000E-02               | 0.07143     |             |             |             |             |
| 1.01600E-01               | 0.07143     |             |             |             |             |
| 1.52400E-01               | 0.07143     |             |             |             |             |
| 1.93680E-01               | 0.07143     |             |             |             |             |
| 2.19080E-01               | 0.07143     |             |             |             |             |
| 2.28600E-01               | 0.07143     |             |             |             |             |
| 2.50830E-01               | 0.07143     |             |             |             |             |
| 2.79400E-01               | 0.07143     |             |             |             |             |
| 3.04800E-01               | 0.07143     |             |             |             |             |
| 3.49250E-01               | 0.07143     |             |             |             |             |
| 3.81000E-01               | 0.07143     |             |             |             |             |
| 4.44500E-01               | 0.07143     |             |             |             |             |
| 5.58800E-01               | 0.07143     |             |             |             |             |
| 6.09600E-01               | 0.07141     |             |             |             |             |
| USER DISTRIBUTION (DELTA) |             | DELTMAT2    | DELTPRP2    |             |             |
| 4                         | SPECIFIED   | DISCRETE    |             |             |             |
| 1.00000E+00               | 0.30000     |             |             |             |             |
| 2.00000E+00               | 0.15000     |             |             |             |             |
| 3.00000E+00               | 0.20000     |             |             |             |             |
| 4.00000E+00               | 0.35000     |             |             |             |             |
| USER DISTRIBUTION (DELTA) |             | DELTMAT3    | DELTPRP3    |             |             |
| 6                         | SPECIFIED   | DISCRETE    |             |             |             |
| -1.00000E+01              | 0.13000     |             |             |             |             |

2.00000E+00 0.13000  
 8.00000E+00 0.26000  
 2.30000E+01 0.15000  
 3.40000E+01 0.15000  
 4.00000E+01 0.18000

CORRELATION MATRIX

7  
 1 3 0.999  
 2 5 0.950  
 4 6 0.800  
 5 2 0.950  
 7 8 0.650  
 7 9 0.650  
 8 9 0.650

OUTPUT CORR HITS DATA

## OUTPUT FILE FOR LHS TEST 1

RANDOM SEED = 933090934

NUMBER OF VARIABLES = 21

NUMBER OF OBSERVATIONS = 75

AN INPUT CORRELATION MATRIX HAS BEEN SPECIFIED

THE SAMPLE INPUT VECTORS WILL BE PRINTED ALONG WITH THEIR CORRESPONDING RANKS  
 HISTOGRAMS OF THE ACTUAL SAMPLE WILL BE PLOTTED FOR EACH INPUT VARIABLE

THE CORRELATION MATRICES (RAW DATA AND RANK CORRELATIONS) WILL BE PRINTED

| VARIABLE | DISTRIBUTION               | RANGE                     | LABEL                |
|----------|----------------------------|---------------------------|----------------------|
| 1        | NORMAL                     | 0.0000E+00 TO 0.2000      | NORMMAT1 NORMPRP1    |
| 2        | NORMAL                     | 577.0 TO 1042.            | NORMMAT2 NORMPRP2    |
| 3        | NORMAL                     | -3.6737E-02 TO 8.3264E-02 | NORMMAT3 NORMPRP3    |
| 4        | LOGNORMAL                  | 1.0000E-02 TO 2.130       | LOGNMAT1 LOGNPRP1    |
| 5        | LOGNORMAL                  | 1.0000E-03 TO 350.0       | LOGNMAT2 LOGNPRP2    |
| 6        | LOGNORMAL                  | 1.0000E-04 TO 5.2500E+04  | LOGNMAT3 LOGNPRP3    |
| 7        | UNIFORM                    | -0.5000 TO 0.5000         | UNIFMAT1 UNIFPRP1    |
| 8        | UNIFORM                    | 0.0000E+00 TO 1.000       | UNIFMAT2 UNIFPRP2    |
| 9        | UNIFORM                    | 12.50 TO 500.0            | UNIFMAT3 UNIFPRP3    |
| 10       | LOGUNIFORM                 | 1.0000E-17 TO 1.0000E-11  | LOGUMAT1 LOGUPRP1    |
| 11       | LOGUNIFORM                 | 1.0000E-06 TO 1000.       | LOGUMAT2 LOGUPRP2    |
| 12       | LOGUNIFORM                 | 5.6000E+13 TO 5.6000E+15  | LOGUMAT3 LOGUPRP3    |
| 13       | USER SUPPLIED DISTRIBUTION |                           | (CUMULATIVE) CUMMAT1 |
| 14       | USER SUPPLIED DISTRIBUTION |                           | (CUMULATIVE) CUMMAT2 |
| 15       | USER SUPPLIED DISTRIBUTION |                           | (CUMULATIVE) CUMMAT3 |
| 16       | USER SUPPLIED DISTRIBUTION |                           | (DATA) DATAMAT1 DAT  |
| 17       | USER SUPPLIED DISTRIBUTION |                           | (DATA) DATAMAT2 DAT  |
| 18       | USER SUPPLIED DISTRIBUTION |                           | (DATA) DATAMAT3 DAT  |

|    |                            |         |          |   |
|----|----------------------------|---------|----------|---|
| 19 | USER SUPPLIED DISTRIBUTION | (DELTA) | DELTMAT1 | D |
| 20 | USER SUPPLIED DISTRIBUTION | (DELTA) | DELTMAT2 | D |
| 21 | USER SUPPLIED DISTRIBUTION | (DELTA) | DELTMAT3 | D |

INPUT RANK CORRELATION MATRIX

|   |        |        |        |        |        |        |        |        |        |
|---|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| 1 | 1.0000 |        |        |        |        |        |        |        |        |
| 2 | 0.0000 | 1.0000 |        |        |        |        |        |        |        |
| 3 | 0.9990 | 0.0000 | 1.0000 |        |        |        |        |        |        |
| 4 | 0.0000 | 0.0000 | 0.0000 | 1.0000 |        |        |        |        |        |
| 5 | 0.0000 | 0.9500 | 0.0000 | 0.0000 | 1.0000 |        |        |        |        |
| 6 | 0.0000 | 0.0000 | 0.0000 | 0.8000 | 0.0000 | 1.0000 |        |        |        |
| 7 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 |        |        |
| 8 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.6500 | 1.0000 |        |
| 9 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.6500 | 0.6500 | 1.0000 |
|   | 1      | 2      | 3      | 4      | 5      | 6      | 7      | 8      | 9      |

VARIABLES

LATIN HYPERCUBE SAMPLE INPUT VECTORS

| RUN NO. | X(1)      | X(2)      | X(3)       | X(4)      | X(5)      | X(6)      | X(7)      |
|---------|-----------|-----------|------------|-----------|-----------|-----------|-----------|
| 1       | 1.546E-01 | 7.814E+02 | 5.587E-02  | 1.390E-01 | 1.286E-01 | 3.042E+00 | -9.939E-0 |
| 2       | 1.008E-01 | 7.908E+02 | 2.679E-02  | 2.382E-01 | 4.892E-01 | 3.504E+00 | 3.863E-0  |
| 3       | 1.157E-01 | 9.056E+02 | 3.308E-02  | 1.250E-01 | 1.853E+01 | 8.707E-02 | -3.450E-0 |
| 4       | 8.294E-02 | 7.667E+02 | 1.062E-02  | 6.878E-01 | 4.196E-02 | 3.374E+02 | -1.557E-0 |
| 5       | 8.873E-02 | 7.847E+02 | 1.480E-02  | 1.112E-01 | 2.590E-01 | 1.057E+02 | -4.615E-0 |
| 6       | 1.283E-01 | 7.455E+02 | 4.096E-02  | 1.062E-01 | 5.157E-01 | 3.557E-01 | 2.662E-0  |
| 7       | 1.191E-01 | 7.361E+02 | 3.438E-02  | 2.668E-02 | 8.740E-02 | 4.761E-03 | -5.500E-0 |
| 8       | 1.201E-01 | 7.604E+02 | 3.534E-02  | 1.191E-01 | 3.486E-01 | 1.465E-01 | -2.172E-0 |
| 9       | 1.305E-01 | 9.646E+02 | 4.279E-02  | 1.953E-02 | 1.701E+01 | 5.156E-04 | 6.570E-0  |
| 10      | 1.439E-01 | 8.224E+02 | 4.878E-02  | 3.728E-02 | 4.041E-01 | 1.539E-03 | 3.796E-0  |
| 11      | 1.419E-01 | 6.056E+02 | 4.901E-02  | 8.737E-02 | 4.000E-03 | 4.733E-02 | -4.083E-0 |
| 12      | 7.728E-02 | 8.496E+02 | 6.720E-03  | 2.585E-02 | 5.316E+00 | 1.419E-02 | 3.198E-0  |
| 13      | 1.796E-01 | 7.938E+02 | 6.895E-02  | 7.830E-02 | 4.408E-01 | 1.676E+00 | 4.362E-0  |
| 14      | 7.080E-02 | 8.654E+02 | 7.381E-03  | 1.657E-01 | 7.981E+00 | 2.653E-01 | -3.165E-0 |
| 15      | 9.041E-03 | 7.430E+02 | -3.176E-02 | 1.168E-01 | 1.030E-01 | 5.535E+00 | 3.944E-0  |
| 16      | 1.001E-01 | 8.848E+02 | 2.427E-02  | 6.072E-02 | 1.303E+00 | 1.747E-01 | 2.133E-0  |
| 17      | 1.611E-01 | 8.787E+02 | 6.012E-02  | 5.243E-02 | 7.333E+00 | 2.469E+00 | 1.117E-0  |
| 18      | 9.597E-02 | 7.648E+02 | 2.051E-02  | 1.364E-01 | 1.549E-01 | 2.762E+01 | -1.102E-0 |
| 19      | 1.055E-01 | 5.853E+02 | 2.577E-02  | 1.568E-01 | 1.000E-03 | 6.347E+00 | -1.559E-0 |
| 20      | 1.844E-01 | 9.998E+02 | 7.501E-02  | 8.939E-01 | 3.500E+02 | 4.051E+01 | -3.952E-0 |
| 21      | 5.024E-02 | 6.346E+02 | -7.449E-03 | 3.389E-02 | 1.934E-02 | 5.176E-01 | 3.543E-0  |
| 22      | 9.894E-02 | 7.756E+02 | 2.118E-02  | 4.646E-02 | 6.026E-02 | 2.941E-03 | 2.383E-0  |
| 23      | 1.093E-01 | 8.304E+02 | 2.837E-02  | 1.145E+00 | 5.773E-01 | 1.175E+04 | 3.285E-0  |
| 24      | 1.474E-01 | 8.392E+02 | 5.291E-02  | 2.055E-01 | 1.427E+00 | 1.124E+00 | -2.349E-0 |
| 25      | 1.041E-01 | 8.830E+02 | 2.482E-02  | 6.689E-02 | 2.271E+00 | 6.366E-02 | 1.811E-0  |

|    |            |           |            |           |           |           |           |
|----|------------|-----------|------------|-----------|-----------|-----------|-----------|
| 26 | 1.154E-01  | 7.080E+02 | 3.215E-02  | 1.535E-01 | 2.866E-02 | 2.421E-01 | 4.953E-0  |
| 27 | 8.641E-02  | 8.195E+02 | 1.651E-02  | 9.178E-02 | 7.731E-01 | 8.677E-01 | -2.550E-0 |
| 28 | 2.398E-02  | 8.252E+02 | -2.378E-02 | 2.565E-01 | 1.950E+00 | 1.209E-01 | -3.291E-0 |
| 29 | 1.076E-01  | 8.627E+02 | 2.723E-02  | 2.933E-02 | 1.170E+01 | 3.863E+00 | -3.117E-0 |
| 30 | 9.421E-02  | 8.154E+02 | 1.983E-02  | 3.339E-01 | 1.192E-01 | 1.503E+02 | 1.257E-0  |
| 31 | -2.235E-08 | 7.721E+02 | -3.674E-02 | 1.288E-01 | 2.333E-01 | 7.594E-01 | 4.576E-0  |
| 32 | 4.387E-02  | 7.776E+02 | -9.647E-03 | 9.959E-01 | 8.364E-02 | 4.658E+03 | 1.448E-0  |
| 33 | 8.915E-02  | 9.309E+02 | 1.730E-02  | 1.021E-01 | 3.349E+01 | 7.931E+00 | -7.949E-0 |
| 34 | 6.021E-02  | 9.024E+02 | -6.423E-04 | 8.412E-02 | 5.203E+00 | 1.238E+01 | -3.625E-0 |
| 35 | 3.629E-02  | 8.695E+02 | -1.195E-02 | 2.009E-01 | 2.459E+00 | 2.212E+00 | 8.825E-0  |
| 36 | 3.104E-02  | 6.750E+02 | -1.740E-02 | 1.720E-02 | 1.188E-02 | 1.038E-02 | -1.755E-0 |
| 37 | 4.249E-02  | 8.345E+02 | -1.326E-02 | 9.341E-02 | 8.935E-01 | 8.056E+00 | 2.864E-0  |
| 38 | 2.834E-02  | 8.066E+02 | -1.865E-02 | 4.260E-02 | 3.735E-01 | 6.069E-03 | -4.790E-0 |
| 39 | 2.000E-01  | 7.523E+02 | 8.326E-02  | 5.589E-02 | 1.764E-01 | 1.485E+00 | -4.317E-0 |
| 40 | 1.351E-01  | 6.850E+02 | 4.433E-02  | 1.000E-02 | 4.898E-02 | 3.211E-02 | -4.278E-0 |
| 41 | 6.824E-02  | 9.757E+02 | 1.586E-03  | 4.446E-02 | 4.954E+01 | 2.084E-01 | 1.709E-0  |
| 42 | 1.371E-01  | 7.162E+02 | 4.596E-02  | 1.821E-01 | 2.744E-01 | 2.091E+00 | -1.203E-0 |
| 43 | 1.287E-01  | 8.089E+02 | 3.832E-02  | 3.277E-01 | 2.087E-01 | 1.799E+02 | 5.480E-0  |
| 44 | 5.503E-02  | 7.992E+02 | -1.370E-03 | 2.905E-01 | 6.784E-01 | 3.707E-01 | 1.375E-0  |
| 45 | 6.337E-02  | 7.315E+02 | 1.472E-03  | 2.197E-01 | 6.922E-01 | 1.480E-02 | 2.272E-0  |
| 46 | 1.118E-01  | 8.382E+02 | 3.145E-02  | 3.525E-01 | 1.590E+00 | 1.575E+01 | -4.935E-0 |
| 47 | 7.213E-02  | 7.130E+02 | 5.339E-03  | 7.458E-02 | 2.807E-02 | 1.029E-03 | -2.891E-0 |
| 48 | 1.593E-01  | 8.024E+02 | 5.773E-02  | 6.304E-02 | 1.338E-01 | 1.942E-02 | -2.043E-0 |
| 49 | 1.245E-01  | 6.250E+02 | 3.795E-02  | 4.294E-01 | 2.019E-03 | 1.130E+02 | 8.149E-0  |
| 50 | 5.349E-02  | 7.223E+02 | -4.801E-03 | 1.487E-01 | 3.666E-02 | 4.492E-01 | -4.536E-0 |
| 51 | 1.029E-01  | 7.299E+02 | 2.337E-02  | 1.895E+00 | 7.515E-02 | 5.250E+04 | -2.655E-0 |
| 52 | 7.995E-02  | 6.874E+02 | 1.271E-02  | 6.994E-02 | 2.013E-02 | 1.227E+00 | 1.990E-0  |
| 53 | 9.713E-02  | 1.019E+03 | 2.217E-02  | 7.187E-02 | 1.134E+02 | 9.461E-01 | 2.953E-0  |
| 54 | 1.267E-01  | 8.115E+02 | 4.016E-02  | 1.703E-01 | 1.912E+00 | 5.694E-01 | 4.842E-0  |
| 55 | 9.081E-02  | 9.263E+02 | 1.830E-02  | 3.688E-01 | 1.383E+01 | 2.217E+01 | 3.437E-0  |
| 56 | 6.703E-02  | 6.973E+02 | 4.962E-03  | 1.748E-01 | 5.680E-02 | 1.809E+01 | -1.426E-0 |
| 57 | 1.324E-01  | 9.445E+02 | 4.188E-02  | 7.538E-01 | 3.702E+01 | 7.030E+01 | 1.871E-0  |
| 58 | 5.828E-02  | 9.125E+02 | -2.770E-03 | 6.577E-01 | 3.872E+00 | 1.027E+03 | -4.390E-0 |
| 59 | 1.103E-01  | 7.953E+02 | 2.962E-02  | 4.846E-01 | 9.333E-01 | 1.300E+01 | 4.101E-0  |
| 60 | 7.518E-02  | 8.924E+02 | 9.935E-03  | 9.944E-02 | 6.045E+00 | 3.627E+01 | 4.311E-0  |
| 61 | 7.916E-02  | 8.439E+02 | 1.213E-02  | 5.538E-01 | 1.544E+00 | 2.695E+02 | 1.630E-0  |
| 62 | 9.209E-02  | 8.738E+02 | 1.857E-02  | 3.131E-01 | 1.074E+00 | 7.355E+01 | 4.694E-0  |
| 63 | 1.717E-01  | 8.967E+02 | 6.589E-02  | 4.494E-01 | 3.417E+00 | 6.270E+02 | -4.655E-0 |
| 64 | 1.530E-01  | 6.560E+02 | 5.535E-02  | 2.724E-01 | 8.289E-03 | 5.145E+01 | 2.542E-0  |
| 65 | 4.705E-02  | 9.394E+02 | -6.991E-03 | 2.230E-01 | 4.391E+00 | 5.073E+00 | -3.696E-0 |
| 66 | 1.668E-01  | 8.573E+02 | 6.336E-02  | 2.817E-01 | 3.038E+00 | 4.016E+02 | -2.004E-0 |
| 67 | 1.490E-01  | 7.574E+02 | 5.170E-02  | 1.943E-01 | 1.841E-01 | 5.264E-02 | -1.918E-0 |

|    |           |           |           |           |           |           |           |
|----|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| 68 | 7.340E-02 | 7.512E+02 | 8.893E-03 | 1.744E+00 | 3.068E-01 | 2.492E+03 | 3.002E-0  |
| 69 | 8.526E-02 | 1.042E+03 | 1.557E-02 | 1.433E-02 | 1.577E+02 | 1.000E-04 | 2.383E-0  |
| 70 | 1.126E-01 | 9.194E+02 | 3.065E-02 | 2.465E-01 | 2.385E+01 | 1.660E+03 | -3.909E-0 |
| 71 | 6.463E-02 | 8.554E+02 | 3.472E-03 | 4.937E-01 | 2.830E+00 | 1.022E+01 | -6.939E-0 |
| 72 | 8.353E-02 | 8.461E+02 | 1.356E-02 | 3.997E-01 | 1.152E+00 | 7.326E+02 | -2.740E-0 |
| 73 | 1.397E-01 | 6.636E+02 | 4.693E-02 | 5.024E-02 | 7.021E-03 | 2.935E-02 | 3.504E-0  |
| 74 | 1.174E-01 | 9.570E+02 | 3.400E-02 | 3.850E-02 | 9.696E+00 | 9.654E-02 | -2.252E-0 |
| 75 | 1.228E-01 | 7.042E+02 | 3.702E-02 | 5.807E-01 | 1.307E-02 | 2.923E+01 | -1.302E-0 |

LATIN HYPERCUBE SAMPLE INPUT VECTORS

| RUN NO. | X(11)     | X(12)     | X(13)      | X(14)      | X(15)      | X(16)     | X(17)    |
|---------|-----------|-----------|------------|------------|------------|-----------|----------|
| 1       | 7.931E-06 | 1.740E+14 | -5.323E+00 | -5.598E+00 | -7.694E+00 | 2.029E-01 | 9.254E+0 |
| 2       | 1.162E-05 | 2.606E+14 | -6.077E+00 | -6.342E+00 | -4.229E+00 | 1.390E-01 | 2.639E+0 |
| 3       | 2.020E-01 | 8.655E+14 | -6.272E+00 | -8.964E+00 | -6.927E+00 | 5.809E-02 | 9.880E+0 |
| 4       | 5.276E+01 | 1.147E+14 | -4.858E+00 | -7.018E+00 | -5.523E+00 | 1.184E-01 | 3.721E+0 |
| 5       | 8.870E-04 | 1.618E+14 | -6.544E+00 | -7.284E+00 | -2.801E+00 | 9.187E-02 | 4.016E+0 |
| 6       | 9.155E-01 | 1.266E+15 | -5.448E+00 | -6.650E+00 | -2.386E+00 | 1.546E-01 | 3.788E+0 |
| 7       | 1.167E+00 | 7.919E+13 | -6.325E+00 | -5.726E+00 | -3.235E+00 | 1.617E-01 | 9.387E+0 |
| 8       | 8.915E-02 | 4.253E+15 | -5.680E+00 | -5.539E+00 | -4.360E+00 | 1.265E-01 | 2.935E+0 |
| 9       | 4.286E-05 | 6.288E+13 | -2.816E+00 | -7.866E+00 | -4.954E+00 | 1.790E-01 | 9.540E+0 |
| 10      | 3.566E-06 | 7.147E+14 | -5.855E+00 | -6.146E+00 | -2.228E+00 | 1.042E-01 | 7.958E+0 |
| 11      | 1.046E+02 | 3.135E+15 | -5.930E+00 | -5.096E+00 | -2.658E+00 | 1.527E-01 | 7.727E+0 |
| 12      | 3.711E-02 | 3.900E+14 | -6.433E+00 | -5.502E+00 | -3.435E+00 | 1.616E-01 | 4.345E+0 |
| 13      | 1.824E-06 | 1.205E+14 | -4.924E+00 | -8.077E+00 | -3.955E+00 | 1.087E-01 | 3.136E+0 |
| 14      | 2.884E-06 | 2.402E+15 | -5.174E+00 | -8.495E+00 | -8.596E+00 | 1.453E-01 | 3.038E+0 |
| 15      | 1.509E+02 | 1.618E+15 | -3.614E+00 | -5.048E+00 | -3.864E+00 | 1.063E-01 | 3.188E+0 |
| 16      | 5.276E-04 | 2.576E+14 | -5.040E+00 | -5.416E+00 | -2.138E+00 | 1.165E-01 | 4.919E+0 |
| 17      | 2.215E+01 | 5.745E+14 | -4.782E+00 | -6.160E+00 | -8.515E+00 | 2.499E-01 | 3.491E+0 |
| 18      | 6.188E-06 | 1.313E+14 | -5.554E+00 | -7.962E+00 | -7.874E+00 | 1.630E-01 | 3.437E+0 |
| 19      | 4.446E-01 | 6.348E+13 | -6.465E+00 | -1.044E+01 | -6.234E+00 | 1.451E-01 | 6.324E+0 |
| 20      | 2.177E-05 | 2.886E+14 | -6.375E+00 | -6.057E+00 | -5.655E+00 | 8.774E-02 | 2.338E+0 |
| 21      | 4.528E-06 | 8.433E+13 | -7.205E+00 | -7.603E+00 | -2.730E+00 | 1.894E-01 | 3.293E+0 |
| 22      | 3.669E+00 | 1.790E+15 | -6.146E+00 | -9.911E+00 | -5.386E+00 | 1.716E-01 | 7.481E+0 |
| 23      | 9.180E-03 | 2.847E+15 | -5.608E+00 | -9.540E+00 | -2.300E+00 | 1.211E-01 | 3.920E+0 |
| 24      | 1.214E-04 | 1.436E+15 | -3.356E+00 | -9.305E+00 | -2.536E+00 | 1.461E-01 | 1.014E+0 |
| 25      | 3.844E+01 | 5.852E+14 | -7.014E+00 | -7.034E+00 | -5.905E+00 | 1.787E-01 | 3.890E+0 |
| 26      | 2.949E-04 | 4.683E+14 | -4.904E+00 | -8.935E+00 | -6.054E+00 | 1.231E-01 | 5.800E+0 |
| 27      | 2.034E+02 | 7.099E+13 | -5.007E+00 | -8.805E+00 | -2.852E+00 | 1.288E-01 | 7.179E+0 |
| 28      | 3.459E+02 | 1.505E+14 | -4.962E+00 | -5.303E+00 | -4.791E+00 | 1.435E-01 | 5.999E+0 |
| 29      | 1.260E-02 | 4.891E+14 | -2.437E+00 | -6.685E+00 | -3.170E+00 | 1.149E-01 | 4.242E+0 |
| 30      | 2.382E+00 | 4.751E+15 | -6.111E+00 | -7.784E+00 | -2.962E+00 | 1.784E-01 | 3.644E+0 |
| 31      | 3.535E-01 | 5.139E+14 | -5.262E+00 | -7.622E+00 | -6.037E+00 | 1.230E-01 | 8.278E+0 |
| 32      | 1.789E-01 | 4.172E+14 | -5.898E+00 | -8.326E+00 | -5.506E+00 | 1.781E-01 | 5.685E+0 |

|    |           |           |            |            |            |           |          |
|----|-----------|-----------|------------|------------|------------|-----------|----------|
| 33 | 4.521E+02 | 1.006E+14 | -5.477E+00 | -5.231E+00 | -3.361E+00 | 1.331E-01 | 6.183E+0 |
| 34 | 1.642E-06 | 9.649E+14 | -4.840E+00 | -8.163E+00 | -6.391E+00 | 1.783E-01 | 6.929E+0 |
| 35 | 6.130E-02 | 1.283E+15 | -7.555E+00 | -5.638E+00 | -7.416E+00 | 1.226E-01 | 4.677E+0 |
| 36 | 1.450E-04 | 1.976E+15 | -6.357E+00 | -7.368E+00 | -7.793E+00 | 1.782E-01 | 5.607E+0 |
| 37 | 7.340E+02 | 8.058E+14 | -4.122E+00 | -8.664E+00 | -2.675E+00 | 1.491E-01 | 6.143E+0 |
| 38 | 1.114E-01 | 3.532E+15 | -5.715E+00 | -1.005E+01 | -4.735E+00 | 1.791E-01 | 8.897E+0 |
| 39 | 7.733E+02 | 8.949E+14 | -5.875E+00 | -7.507E+00 | -2.604E+00 | 2.183E-01 | 2.446E+0 |
| 40 | 2.162E+00 | 3.960E+15 | -5.069E+00 | -7.398E+00 | -8.154E+00 | 1.195E-01 | 5.421E+0 |
| 41 | 6.482E-05 | 3.253E+14 | -7.719E+00 | -5.184E+00 | -7.490E+00 | 1.409E-01 | 8.699E+0 |
| 42 | 1.147E+01 | 2.128E+14 | -6.234E+00 | -1.185E+01 | -5.187E+00 | 1.804E-01 | 6.034E+0 |
| 43 | 1.390E-03 | 1.469E+15 | -4.988E+00 | -5.253E+00 | -4.115E+00 | 1.386E-01 | 7.844E+0 |
| 44 | 2.300E-03 | 2.175E+15 | -6.514E+00 | -7.166E+00 | -4.619E+00 | 1.654E-01 | 3.086E+0 |
| 45 | 3.214E-03 | 1.118E+15 | -5.286E+00 | -8.632E+00 | -2.068E+00 | 1.360E-01 | 5.172E+0 |
| 46 | 7.334E+00 | 3.742E+14 | -6.059E+00 | -7.237E+00 | -4.306E+00 | 2.076E-01 | 9.112E+0 |
| 47 | 1.936E-04 | 9.169E+13 | -6.471E+00 | -5.850E+00 | -3.804E+00 | 1.052E-01 | 3.393E+0 |
| 48 | 7.717E-02 | 2.324E+15 | -5.576E+00 | -6.931E+00 | -6.622E+00 | 1.211E-01 | 2.751E+0 |
| 49 | 1.754E-03 | 1.138E+15 | -5.757E+00 | -6.269E+00 | -4.495E+00 | 1.962E-01 | 6.658E+0 |
| 50 | 1.021E-04 | 1.874E+14 | -4.814E+00 | -5.914E+00 | -8.025E+00 | 1.038E-01 | 2.608E+0 |
| 51 | 3.285E-01 | 5.950E+13 | -5.788E+00 | -6.066E+00 | -8.288E+00 | 1.108E-01 | 4.061E+0 |
| 52 | 2.149E-02 | 4.403E+14 | -6.170E+00 | -1.135E+01 | -3.156E+00 | 1.253E-01 | 2.831E+0 |
| 53 | 4.726E+00 | 6.430E+14 | -5.983E+00 | -1.226E+01 | -3.003E+00 | 1.628E-01 | 2.983E+0 |
| 54 | 4.179E-03 | 1.327E+14 | -7.931E+00 | -6.829E+00 | -7.041E+00 | 1.617E-01 | 4.426E+0 |
| 55 | 2.857E+02 | 9.049E+13 | -5.145E+00 | -5.787E+00 | -5.032E+00 | 1.618E-01 | 5.578E+0 |
| 56 | 1.272E-06 | 1.886E+15 | -5.204E+00 | -6.525E+00 | -2.405E+00 | 9.943E-02 | 8.351E+0 |
| 57 | 2.964E-02 | 1.052E+15 | -5.819E+00 | -8.229E+00 | -3.707E+00 | 2.037E-01 | 3.551E+0 |
| 58 | 1.304E-05 | 1.471E+14 | -5.384E+00 | -8.768E+00 | -2.461E+00 | 2.061E-01 | 2.421E+0 |
| 59 | 1.887E-05 | 2.438E+14 | -5.532E+00 | -6.439E+00 | -8.201E+00 | 1.767E-01 | 8.841E+0 |
| 60 | 6.706E+01 | 4.434E+15 | -6.295E+00 | -8.414E+00 | -8.430E+00 | 1.021E-01 | 9.971E+0 |
| 61 | 4.249E-04 | 3.681E+15 | -5.999E+00 | -8.516E+00 | -2.010E+00 | 1.219E-01 | 8.488E+0 |
| 62 | 2.774E-05 | 3.412E+15 | -5.633E+00 | -5.693E+00 | -8.093E+00 | 1.612E-01 | 8.161E+0 |
| 63 | 5.867E+00 | 2.940E+15 | -6.216E+00 | -5.965E+00 | -6.487E+00 | 7.594E-02 | 4.827E+0 |
| 64 | 3.264E+01 | 3.033E+14 | -5.415E+00 | -6.464E+00 | -3.545E+00 | 1.158E-01 | 1.034E+0 |
| 65 | 5.601E-05 | 2.212E+14 | -6.016E+00 | -5.402E+00 | -2.211E+00 | 2.312E-01 | 6.872E+0 |
| 66 | 7.792E-03 | 3.531E+14 | -7.362E+00 | -5.116E+00 | -3.094E+00 | 1.672E-01 | 8.631E+0 |
| 67 | 1.636E+00 | 1.660E+15 | -4.284E+00 | -7.703E+00 | -7.309E+00 | 1.830E-01 | 8.113E+0 |
| 68 | 6.515E-04 | 6.657E+14 | -2.311E+00 | -5.870E+00 | -7.181E+00 | 2.059E-01 | 5.039E+0 |
| 69 | 1.986E+01 | 7.220E+13 | -5.098E+00 | -1.105E+01 | -6.295E+00 | 1.121E-01 | 3.297E+0 |
| 70 | 5.516E-03 | 1.933E+14 | -6.569E+00 | -1.068E+01 | -2.895E+00 | 1.312E-01 | 9.691E+0 |
| 71 | 1.183E+02 | 7.764E+14 | -6.760E+00 | -8.041E+00 | -6.732E+00 | 1.439E-01 | 7.268E+0 |
| 72 | 6.520E-01 | 5.433E+15 | -5.344E+00 | -6.244E+00 | -5.252E+00 | 1.235E-01 | 5.921E+0 |
| 73 | 1.991E-02 | 2.674E+15 | -5.699E+00 | -6.386E+00 | -6.887E+00 | 1.645E-01 | 2.775E+0 |
| 74 | 1.131E-03 | 5.099E+15 | -5.422E+00 | -6.773E+00 | -5.748E+00 | 1.221E-01 | 2.514E+0 |

75 1.210E+01 1.072E+14 -5.228E+00 -1.188E+01 -7.573E+00 9.805E-02 6.484E+0

LATIN HYPERCUBE SAMPLE INPUT VECTORS

| RUN NO. | X(21)      |
|---------|------------|
| 1       | 4.000E+01  |
| 2       | 3.400E+01  |
| 3       | 4.000E+01  |
| 4       | 4.000E+01  |
| 5       | 8.000E+00  |
| 6       | 4.000E+01  |
| 7       | -1.000E+01 |
| 8       | 2.300E+01  |
| 9       | -1.000E+01 |
| 10      | 4.000E+01  |
| 11      | 3.400E+01  |
| 12      | 2.300E+01  |
| 13      | 2.000E+00  |
| 14      | 2.000E+00  |
| 15      | 2.300E+01  |
| 16      | 8.000E+00  |
| 17      | 4.000E+01  |
| 18      | 8.000E+00  |
| 19      | 8.000E+00  |
| 20      | 2.000E+00  |
| 21      | 8.000E+00  |
| 22      | 2.300E+01  |
| 23      | 8.000E+00  |
| 24      | 4.000E+01  |
| 25      | 8.000E+00  |
| 26      | 4.000E+01  |
| 27      | 2.300E+01  |
| 28      | 2.300E+01  |
| 29      | -1.000E+01 |
| 30      | 3.400E+01  |
| 31      | 3.400E+01  |
| 32      | 8.000E+00  |
| 33      | -1.000E+01 |
| 34      | 3.400E+01  |
| 35      | 4.000E+01  |
| 36      | 2.300E+01  |
| 37      | 3.400E+01  |
| 38      | 8.000E+00  |
| 39      | 8.000E+00  |

40 2.300E+01  
 41 2.000E+00  
 42 4.000E+01  
 43 8.000E+00  
 44 2.300E+01  
 45 -1.000E+01  
 46 8.000E+00  
 47 8.000E+00  
 48 2.000E+00  
 49 2.000E+00  
 50 4.000E+01  
 51 8.000E+00  
 52 -1.000E+01  
 53 3.400E+01  
 54 4.000E+01  
 55 8.000E+00  
 56 3.400E+01  
 57 2.000E+00  
 58 4.000E+01  
 59 2.000E+00  
 60 8.000E+00  
 61 -1.000E+01  
 62 8.000E+00  
 63 3.400E+01  
 64 2.300E+01  
 65 4.000E+01  
 66 3.400E+01  
 67 8.000E+00  
 68 8.000E+00  
 69 2.300E+01  
 70 8.000E+00  
 71 2.000E+00  
 72 -1.000E+01  
 73 -1.000E+01  
 74 3.400E+01  
 75 2.000E+00

RANKS OF LATIN HYPERCUBE SAMPLE INPUT VECTORS

| RUN NO. | X(1) | X(2) | X(3) | X(4) | X(5) | X(6) | X(7) |
|---------|------|------|------|------|------|------|------|
| 1       | 68.  | 30.  | 68.  | 37.  | 22.  | 40.  | 31   |
| 2       | 39.  | 32.  | 42.  | 50.  | 36.  | 41.  | 67   |
| 3       | 49.  | 63.  | 49.  | 34.  | 68.  | 17.  | 12   |
| 4       | 26.  | 26.  | 24.  | 69.  | 13.  | 66.  | 37   |



|    |     |     |     |     |     |     |    |
|----|-----|-----|-----|-----|-----|-----|----|
| 5  | 30. | 31. | 28. | 31. | 29. | 61. | 3  |
| 6  | 56. | 20. | 57. | 30. | 37. | 25. | 58 |
| 7  | 51. | 18. | 51. | 6.  | 19. | 6.  | 34 |
| 8  | 52. | 24. | 52. | 33. | 32. | 20. | 22 |
| 9  | 58. | 71. | 59. | 4.  | 67. | 2.  | 43 |
| 10 | 64. | 42. | 63. | 9.  | 34. | 4.  | 66 |
| 11 | 63. | 2.  | 64. | 25. | 3.  | 14. | 7  |
| 12 | 23. | 50. | 20. | 5.  | 60. | 9.  | 62 |
| 13 | 73. | 33. | 73. | 23. | 35. | 36. | 71 |
| 14 | 19. | 54. | 21. | 41. | 63. | 24. | 14 |
| 15 | 2.  | 19. | 2.  | 32. | 20. | 44. | 68 |
| 16 | 38. | 59. | 39. | 17. | 46. | 21. | 54 |
| 17 | 70. | 57. | 70. | 15. | 62. | 39. | 46 |
| 18 | 35. | 25. | 35. | 36. | 24. | 54. | 30 |
| 19 | 42. | 1.  | 41. | 40. | 1.  | 45. | 26 |
| 20 | 74. | 73. | 74. | 71. | 75. | 57. | 8  |
| 21 | 10. | 4.  | 9.  | 8.  | 8.  | 28. | 65 |
| 22 | 37. | 28. | 36. | 13. | 16. | 5.  | 40 |
| 23 | 44. | 44. | 44. | 73. | 38. | 74. | 63 |
| 24 | 65. | 47. | 66. | 47. | 47. | 33. | 20 |
| 25 | 41. | 58. | 40. | 19. | 52. | 16. | 52 |
| 26 | 48. | 12. | 48. | 39. | 11. | 23. | 75 |
| 27 | 29. | 41. | 30. | 26. | 41. | 31. | 19 |
| 28 | 3.  | 43. | 3.  | 52. | 51. | 19. | 13 |
| 29 | 43. | 53. | 43. | 7.  | 65. | 42. | 15 |
| 30 | 34. | 40. | 34. | 58. | 21. | 63. | 47 |
| 31 | 1.  | 27. | 1.  | 35. | 28. | 30. | 72 |
| 32 | 8.  | 29. | 8.  | 72. | 18. | 73. | 49 |
| 33 | 31. | 67. | 31. | 29. | 70. | 46. | 32 |
| 34 | 14. | 62. | 14. | 24. | 59. | 49. | 11 |
| 35 | 6.  | 55. | 7.  | 46. | 53. | 38. | 45 |
| 36 | 5.  | 7.  | 5.  | 3.  | 6.  | 8.  | 25 |
| 37 | 7.  | 45. | 6.  | 27. | 42. | 47. | 59 |
| 38 | 4.  | 37. | 4.  | 11. | 33. | 7.  | 2  |
| 39 | 75. | 22. | 75. | 16. | 25. | 35. | 38 |
| 40 | 60. | 8.  | 60. | 1.  | 14. | 13. | 6  |
| 41 | 18. | 72. | 16. | 12. | 72. | 22. | 51 |
| 42 | 61. | 14. | 61. | 44. | 30. | 37. | 29 |
| 43 | 57. | 38. | 55. | 57. | 27. | 64. | 42 |
| 44 | 12. | 35. | 13. | 55. | 39. | 26. | 48 |
| 45 | 15. | 17. | 15. | 48. | 40. | 10. | 55 |
| 46 | 46. | 46. | 47. | 59. | 49. | 51. | 1  |

|    |     |     |     |     |     |     |    |
|----|-----|-----|-----|-----|-----|-----|----|
| 47 | 20. | 13. | 19. | 22. | 10. | 3.  | 16 |
| 48 | 69. | 36. | 69. | 18. | 23. | 11. | 23 |
| 49 | 54. | 3.  | 54. | 62. | 2.  | 62. | 44 |
| 50 | 11. | 15. | 11. | 38. | 12. | 27. | 4  |
| 51 | 40. | 16. | 38. | 75. | 17. | 75. | 18 |
| 52 | 25. | 9.  | 26. | 20. | 9.  | 34. | 53 |
| 53 | 36. | 74. | 37. | 21. | 73. | 32. | 60 |
| 54 | 55. | 39. | 56. | 42. | 50. | 29. | 74 |
| 55 | 32. | 66. | 32. | 60. | 66. | 53. | 64 |
| 56 | 17. | 10. | 18. | 43. | 15. | 52. | 27 |
| 57 | 59. | 69. | 58. | 70. | 71. | 59. | 39 |
| 58 | 13. | 64. | 12. | 68. | 57. | 70. | 5  |
| 59 | 45. | 34. | 45. | 64. | 43. | 50. | 69 |
| 60 | 22. | 60. | 23. | 28. | 61. | 56. | 70 |
| 61 | 24. | 48. | 25. | 66. | 48. | 65. | 50 |
| 62 | 33. | 56. | 33. | 56. | 44. | 60. | 73 |
| 63 | 72. | 61. | 72. | 63. | 56. | 68. | 35 |
| 64 | 67. | 5.  | 67. | 53. | 5.  | 58. | 57 |
| 65 | 9.  | 68. | 10. | 49. | 58. | 43. | 10 |
| 66 | 71. | 52. | 71. | 54. | 55. | 67. | 36 |
| 67 | 66. | 23. | 65. | 45. | 26. | 15. | 24 |
| 68 | 21. | 21. | 22. | 74. | 31. | 72. | 61 |
| 69 | 28. | 75. | 29. | 2.  | 74. | 1.  | 56 |
| 70 | 47. | 65. | 46. | 51. | 69. | 71. | 9  |
| 71 | 16. | 51. | 17. | 65. | 54. | 48. | 33 |
| 72 | 27. | 49. | 27. | 61. | 45. | 69. | 17 |
| 73 | 62. | 6.  | 62. | 14. | 4.  | 12. | 41 |
| 74 | 50. | 70. | 50. | 10. | 64. | 18. | 21 |
| 75 | 53. | 11. | 53. | 67. | 7.  | 55. | 28 |

RANKS OF LATIN HYPERCUBE SAMPLE INPUT VECTORS

| RUN NO. | X(11) | X(12) | X(13) | X(14) | X(15) | X(16) | X(17) |
|---------|-------|-------|-------|-------|-------|-------|-------|
| 1       | 8.    | 19.   | 50.   | 64.   | 11.   | 68.   | 68    |
| 2       | 9.    | 26.   | 24.   | 49.   | 44.   | 35.   | 6     |
| 3       | 45.   | 45.   | 18.   | 12.   | 18.   | 1.    | 72    |
| 4       | 65.   | 12.   | 65.   | 39.   | 31.   | 18.   | 23    |
| 5       | 25.   | 18.   | 9.    | 35.   | 61.   | 4.    | 27    |
| 6       | 50.   | 51.   | 45.   | 44.   | 69.   | 44.   | 24    |
| 7       | 51.   | 6.    | 16.   | 61.   | 53.   | 47.   | 69    |
| 8       | 42.   | 71.   | 38.   | 65.   | 42.   | 29.   | 10    |
| 9       | 14.   | 2.    | 73.   | 27.   | 37.   | 62.   | 70    |
| 10      | 5.    | 42.   | 32.   | 53.   | 71.   | 9.    | 57    |
| 11      | 67.   | 66.   | 29.   | 74.   | 64.   | 43.   | 55    |

|    |     |     |     |     |     |     |    |
|----|-----|-----|-----|-----|-----|-----|----|
| 12 | 39. | 32. | 13. | 66. | 51. | 46. | 30 |
| 13 | 3.  | 13. | 63. | 24. | 46. | 12. | 14 |
| 14 | 4.  | 62. | 55. | 19. | 1.  | 40. | 12 |
| 15 | 69. | 55. | 71. | 75. | 47. | 11. | 15 |
| 16 | 23. | 25. | 59. | 67. | 73. | 17. | 34 |
| 17 | 62. | 38. | 68. | 52. | 2.  | 75. | 20 |
| 18 | 7.  | 14. | 42. | 26. | 9.  | 51. | 19 |
| 19 | 48. | 3.  | 12. | 7.  | 25. | 39. | 47 |
| 20 | 12. | 27. | 14. | 55. | 30. | 3.  | 1  |
| 21 | 6.  | 7.  | 5.  | 31. | 62. | 66. | 16 |
| 22 | 55. | 57. | 22. | 9.  | 33. | 55. | 54 |
| 23 | 34. | 64. | 40. | 10. | 70. | 21. | 26 |
| 24 | 18. | 53. | 72. | 11. | 66. | 41. | 74 |
| 25 | 64. | 39. | 6.  | 38. | 28. | 61. | 25 |
| 26 | 21. | 35. | 64. | 13. | 26. | 26. | 41 |
| 27 | 70. | 4.  | 60. | 14. | 60. | 30. | 52 |
| 28 | 72. | 17. | 62. | 69. | 38. | 37. | 43 |
| 29 | 35. | 36. | 74. | 43. | 54. | 15. | 29 |
| 30 | 54. | 73. | 23. | 28. | 58. | 60. | 22 |
| 31 | 47. | 37. | 52. | 30. | 27. | 25. | 60 |
| 32 | 44. | 33. | 30. | 21. | 32. | 57. | 40 |
| 33 | 73. | 10. | 44. | 71. | 52. | 32. | 46 |
| 34 | 2.  | 47. | 66. | 23. | 23. | 59. | 51 |
| 35 | 40. | 52. | 3.  | 63. | 14. | 24. | 32 |
| 36 | 19. | 59. | 15. | 34. | 10. | 58. | 39 |
| 37 | 74. | 44. | 70. | 16. | 63. | 42. | 45 |
| 38 | 43. | 68. | 36. | 8.  | 39. | 63. | 66 |
| 39 | 75. | 46. | 31. | 32. | 65. | 73. | 3  |
| 40 | 53. | 70. | 58. | 33. | 6.  | 19. | 37 |
| 41 | 16. | 29. | 2.  | 72. | 13. | 36. | 64 |
| 42 | 59. | 22. | 19. | 3.  | 35. | 64. | 44 |
| 43 | 27. | 54. | 61. | 70. | 45. | 34. | 56 |
| 44 | 29. | 60. | 10. | 37. | 40. | 53. | 13 |
| 45 | 30. | 49. | 51. | 17. | 74. | 33. | 36 |
| 46 | 58. | 31. | 25. | 36. | 43. | 72. | 67 |
| 47 | 20. | 9.  | 11. | 59. | 48. | 10. | 18 |
| 48 | 41. | 61. | 41. | 40. | 21. | 20. | 7  |
| 49 | 28. | 50. | 35. | 50. | 41. | 67. | 49 |
| 50 | 17. | 20. | 67. | 57. | 8.  | 8.  | 5  |
| 51 | 46. | 1.  | 34. | 54. | 4.  | 13. | 28 |
| 52 | 37. | 34. | 21. | 4.  | 55. | 28. | 9  |
| 53 | 56. | 40. | 28. | 1.  | 57. | 50. | 11 |

|    |     |     |     |     |     |     |    |
|----|-----|-----|-----|-----|-----|-----|----|
| 54 | 31. | 15. | 1.  | 41. | 17. | 48. | 31 |
| 55 | 71. | 8.  | 56. | 60. | 36. | 49. | 38 |
| 56 | 1.  | 58. | 54. | 45. | 68. | 6.  | 61 |
| 57 | 38. | 48. | 33. | 22. | 49. | 69. | 21 |
| 58 | 10. | 16. | 48. | 15. | 67. | 71. | 2  |
| 59 | 11. | 24. | 43. | 47. | 5.  | 56. | 65 |
| 60 | 66. | 72. | 17. | 20. | 3.  | 7.  | 73 |
| 61 | 22. | 69. | 27. | 18. | 75. | 22. | 62 |
| 62 | 13. | 67. | 39. | 62. | 7.  | 45. | 59 |
| 63 | 57. | 65. | 20. | 56. | 22. | 2.  | 33 |
| 64 | 63. | 28. | 47. | 46. | 50. | 16. | 75 |
| 65 | 15. | 23. | 26. | 68. | 72. | 74. | 50 |
| 66 | 33. | 30. | 4.  | 73. | 56. | 54. | 63 |
| 67 | 52. | 56. | 69. | 29. | 15. | 65. | 58 |
| 68 | 24. | 41. | 75. | 58. | 16. | 70. | 35 |
| 69 | 61. | 5.  | 57. | 5.  | 24. | 14. | 17 |
| 70 | 32. | 21. | 8.  | 6.  | 59. | 31. | 71 |
| 71 | 68. | 43. | 7.  | 25. | 20. | 38. | 53 |
| 72 | 49. | 75. | 49. | 51. | 34. | 27. | 42 |
| 73 | 36. | 63. | 37. | 48. | 19. | 52. | 8  |
| 74 | 26. | 74. | 46. | 42. | 29. | 23. | 4  |
| 75 | 60. | 11. | 53. | 2.  | 12. | 5.  | 48 |

RANKS OF LATIN HYPERCUBE SAMPLE INPUT VECTORS

| RUN NO. | X(21) |
|---------|-------|
| 1       | 69.   |
| 2       | 56.   |
| 3       | 69.   |
| 4       | 69.   |
| 5       | 30.   |
| 6       | 69.   |
| 7       | 5.    |
| 8       | 45.   |
| 9       | 5.    |
| 10      | 69.   |
| 11      | 56.   |
| 12      | 45.   |
| 13      | 15.   |
| 14      | 15.   |
| 15      | 45.   |
| 16      | 30.   |
| 17      | 69.   |
| 18      | 30.   |

|    |     |
|----|-----|
| 19 | 30. |
| 20 | 15. |
| 21 | 30. |
| 22 | 45. |
| 23 | 30. |
| 24 | 69. |
| 25 | 30. |
| 26 | 69. |
| 27 | 45. |
| 28 | 45. |
| 29 | 5.  |
| 30 | 56. |
| 31 | 56. |
| 32 | 30. |
| 33 | 5.  |
| 34 | 56. |
| 35 | 69. |
| 36 | 45. |
| 37 | 56. |
| 38 | 30. |
| 39 | 30. |
| 40 | 45. |
| 41 | 15. |
| 42 | 69. |
| 43 | 30. |
| 44 | 45. |
| 45 | 5.  |
| 46 | 30. |
| 47 | 30. |
| 48 | 15. |
| 49 | 15. |
| 50 | 69. |
| 51 | 30. |
| 52 | 5.  |
| 53 | 56. |
| 54 | 69. |
| 55 | 30. |
| 56 | 56. |
| 57 | 15. |
| 58 | 69. |
| 59 | 15. |
| 60 | 30. |

|    |     |
|----|-----|
| 61 | 5.  |
| 62 | 30. |
| 63 | 56. |
| 64 | 45. |
| 65 | 69. |
| 66 | 56. |
| 67 | 30. |
| 68 | 30. |
| 69 | 45. |
| 70 | 30. |
| 71 | 15. |
| 72 | 5.  |
| 73 | 5.  |
| 74 | 56. |
| 75 | 15. |

HISTOGRAM FOR VARIABLE NO. 1      NORMAL      DISTRIBUTION

| MIDPOINT       | FREQ. |          |
|----------------|-------|----------|
| -0.5000000E-02 | 1     | X        |
| 0.5000000E-02  | 1     | X        |
| 0.1500000E-01  | 0     |          |
| 0.2500000E-01  | 2     | XX       |
| 0.3500000E-01  | 2     | XX       |
| 0.4500000E-01  | 3     | XXX      |
| 0.5500000E-01  | 4     | XXXX     |
| 0.6500001E-01  | 5     | XXXXX    |
| 0.7500000E-01  | 7     | XXXXXXXX |
| 0.8500000E-01  | 6     | XXXXXX   |
| 0.9500000E-01  | 6     | XXXXXX   |
| 0.1050000      | 7     | XXXXXXXX |
| 0.1150000      | 7     | XXXXXXXX |
| 0.1250000      | 6     | XXXXXX   |
| 0.1350000      | 5     | XXXXXX   |
| 0.1450000      | 4     | XXXX     |
| 0.1550000      | 3     | XXX      |
| 0.1650000      | 2     | XX       |
| 0.1750000      | 2     | XX       |
| 0.1850000      | 1     | X        |
| 0.1950000      | 1     | X        |

75

| MIN            | MAX       | RANGE     | MEAN          | MEDIAN    | VAR  |
|----------------|-----------|-----------|---------------|-----------|------|
| -0.2235174E-07 | 0.2000000 | 0.2000001 | 0.9982305E-01 | 0.1000560 | 0.17 |

HISTOGRAM FOR VARIABLE NO. 2 NORMAL DISTRIBUTION

| MIDPOINT | FREQ. |          |
|----------|-------|----------|
| 586.5001 | 1     | X        |
| 609.5001 | 1     | X        |
| 632.5001 | 2     | XX       |
| 655.5001 | 2     | XX       |
| 678.5001 | 3     | XXX      |
| 701.5001 | 4     | XXXX     |
| 724.5001 | 4     | XXXX     |
| 747.5001 | 6     | XXXXXX   |
| 770.5001 | 7     | XXXXXXXX |
| 793.5001 | 6     | XXXXXX   |
| 816.5001 | 7     | XXXXXXXX |
| 839.5001 | 7     | XXXXXXXX |
| 862.5001 | 6     | XXXXXX   |
| 885.5001 | 5     | XXXXX    |
| 908.5001 | 4     | XXXX     |
| 931.5001 | 3     | XXX      |
| 954.5001 | 3     | XXX      |
| 977.5001 | 1     | X        |
| 1000.500 | 1     | X        |
| 1023.500 | 1     | X        |
| 1046.500 | 1     | X        |

75

| MIN      | MAX      | RANGE    | MEAN     | MEDIAN   | VAR |
|----------|----------|----------|----------|----------|-----|
| 585.3286 | 1042.000 | 456.6714 | 809.8748 | 808.8511 | 966 |

HISTOGRAM FOR VARIABLE NO. 3 NORMAL DISTRIBUTION

| MIDPOINT       | FREQ. |          |
|----------------|-------|----------|
| -0.3899998E-01 | 1     | X        |
| -0.3299998E-01 | 1     | X        |
| -0.2699999E-01 | 0     |          |
| -0.2099999E-01 | 2     | XX       |
| -0.1499999E-01 | 2     | XX       |
| -0.8999996E-02 | 4     | XXXX     |
| -0.2999999E-02 | 4     | XXXX     |
| 0.2999999E-02  | 5     | XXXXX    |
| 0.8999996E-02  | 5     | XXXXX    |
| 0.1499999E-01  | 7     | XXXXXXXX |
| 0.2099999E-01  | 7     | XXXXXXXX |
| 0.2699999E-01  | 7     | XXXXXXXX |

|               |   |         |
|---------------|---|---------|
| 0.3299998E-01 | 7 | XXXXXXX |
| 0.3899998E-01 | 6 | XXXXXX  |
| 0.4499998E-01 | 4 | XXXX    |
| 0.5099998E-01 | 4 | XXXX    |
| 0.5699997E-01 | 3 | XXX     |
| 0.6299997E-01 | 3 | XXX     |
| 0.6899997E-01 | 1 | X       |
| 0.7499997E-01 | 1 | X       |
| 0.8099996E-01 | 1 | X       |

75

| MIN            | MAX           | RANGE     | MEAN          | MEDIAN        | VAR  |
|----------------|---------------|-----------|---------------|---------------|------|
| -0.3673701E-01 | 0.8326402E-01 | 0.1200010 | 0.2322436E-01 | 0.2336514E-01 | 0.63 |

HISTOGRAM FOR VARIABLE NO. 4 LOGNORMAL DISTRIBUTION

| MIDPOINT      | FREQ. |                                      |
|---------------|-------|--------------------------------------|
| 0.4699997E-01 | 27    | XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX |
| 0.1409999     | 17    | XXXXXXXXXXXXXXXXXXXXXXXXXXXX         |
| 0.2349999     | 10    | XXXXXXXXXXXX                         |
| 0.3289998     | 6     | XXXXXX                               |
| 0.4229998     | 3     | XXX                                  |
| 0.5169997     | 3     | XXX                                  |
| 0.6109996     | 2     | XX                                   |
| 0.7049996     | 1     | X                                    |
| 0.7989995     | 1     | X                                    |
| 0.8929994     | 1     | X                                    |
| 0.9869993     | 1     | X                                    |
| 1.080999      | 0     |                                      |
| 1.174999      | 1     | X                                    |
| 1.268999      | 0     |                                      |
| 1.362999      | 0     |                                      |
| 1.456999      | 0     |                                      |
| 1.550999      | 0     |                                      |
| 1.644999      | 0     |                                      |
| 1.738999      | 1     | X                                    |
| 1.832999      | 0     |                                      |
| 1.926999      | 1     | X                                    |

75

| MIN           | MAX      | RANGE    | MEAN      | MEDIAN    | VAR  |
|---------------|----------|----------|-----------|-----------|------|
| 0.9999994E-02 | 1.894962 | 1.884962 | 0.2694961 | 0.1486647 | 0.12 |

HISTOGRAM FOR VARIABLE NO. 5 LOGNORMAL DISTRIBUTION

| MIDPOINT | FREQ. |
|----------|-------|
|----------|-------|





|          |    |   |
|----------|----|---|
| 40300.00 | 0  |   |
| 42900.00 | 0  |   |
| 45500.00 | 0  |   |
| 48100.00 | 0  |   |
| 50700.00 | 0  |   |
| 53300.00 | 1  | X |
|          | 75 |   |

| MIN           | MAX      | RANGE    | MEAN     | MEDIAN   | VAR  |
|---------------|----------|----------|----------|----------|------|
| 0.9999979E-04 | 52500.10 | 52500.10 | 1033.231 | 2.212465 | 0.37 |

HISTOGRAM FOR VARIABLE NO. 7 UNIFORM DISTRIBUTION

| MIDPOINT       | FREQ. |       |
|----------------|-------|-------|
| -0.5144998     | 1     | X     |
| -0.4654998     | 3     | XXX   |
| -0.4164998     | 4     | XXXX  |
| -0.3674998     | 4     | XXXX  |
| -0.3184998     | 3     | XXX   |
| -0.2694998     | 4     | XXXX  |
| -0.2204998     | 4     | XXXX  |
| -0.1714998     | 3     | XXX   |
| -0.1224999     | 5     | XXXXX |
| -0.7349989E-01 | 3     | XXX   |
| -0.2449990E-01 | 4     | XXXX  |
| 0.2450008E-01  | 3     | XXX   |
| 0.7350007E-01  | 4     | XXXX  |
| 0.1225001      | 4     | XXXX  |
| 0.1715000      | 3     | XXX   |
| 0.2205000      | 4     | XXXX  |
| 0.2695000      | 3     | XXX   |
| 0.3185000      | 4     | XXXX  |
| 0.3675000      | 4     | XXXX  |
| 0.4165000      | 4     | XXXX  |
| 0.4655000      | 3     | XXX   |
| 0.5145000      | 1     | X     |
|                | 75    |       |

| MIN        | MAX       | RANGE     | MEAN          | MEDIAN         | VAR  |
|------------|-----------|-----------|---------------|----------------|------|
| -0.4935275 | 0.4952782 | 0.9888058 | 0.1103552E-03 | -0.4317144E-02 | 0.83 |

HISTOGRAM FOR VARIABLE NO. 8 UNIFORM DISTRIBUTION

| MIDPOINT      | FREQ. |      |
|---------------|-------|------|
| 0.2449999E-01 | 3     | XXX  |
| 0.7349998E-01 | 4     | XXXX |

|           |   |      |
|-----------|---|------|
| 0.1225000 | 4 | XXXX |
| 0.1715000 | 4 | XXXX |
| 0.2204999 | 3 | XXX  |
| 0.2694999 | 4 | XXXX |
| 0.3184999 | 4 | XXXX |
| 0.3674999 | 4 | XXXX |
| 0.4164999 | 4 | XXXX |
| 0.4654999 | 3 | XXX  |
| 0.5144999 | 3 | XXX  |
| 0.5634999 | 4 | XXXX |
| 0.6124998 | 3 | XXX  |
| 0.6614998 | 4 | XXXX |
| 0.7104998 | 4 | XXXX |
| 0.7594997 | 4 | XXXX |
| 0.8084997 | 4 | XXXX |
| 0.8574997 | 3 | XXX  |
| 0.9064996 | 4 | XXXX |
| 0.9554996 | 3 | XXX  |
| 1.004500  | 2 | XX   |

75

| MIN           | MAX       | RANGE     | MEAN      | MEDIAN    | VAR  |
|---------------|-----------|-----------|-----------|-----------|------|
| 0.3375098E-02 | 0.9870160 | 0.9836408 | 0.5003692 | 0.4948947 | 0.83 |

HISTOGRAM FOR VARIABLE NO. 9 UNIFORM DISTRIBUTION

| MIDPOINT | FREQ.  |
|----------|--------|
| 12.00000 | 2 XX   |
| 36.00001 | 3 XXX  |
| 60.00002 | 4 XXXX |
| 84.00002 | 4 XXXX |
| 108.0000 | 4 XXXX |
| 132.0000 | 4 XXXX |
| 156.0000 | 3 XXX  |
| 180.0000 | 4 XXXX |
| 204.0000 | 4 XXXX |
| 228.0000 | 3 XXX  |
| 252.0000 | 4 XXXX |
| 276.0000 | 3 XXX  |
| 300.0000 | 4 XXXX |
| 324.0000 | 4 XXXX |
| 348.0000 | 4 XXXX |
| 372.0000 | 3 XXX  |
| 396.0000 | 4 XXXX |



|          |   |   |
|----------|---|---|
| 253.5000 | 0 |   |
| 292.5000 | 1 | X |
| 331.5000 | 1 | X |
| 370.5000 | 0 |   |
| 409.5000 | 0 |   |
| 448.5000 | 1 | X |
| 487.5000 | 0 |   |
| 526.4999 | 0 |   |
| 565.4999 | 0 |   |
| 604.4999 | 0 |   |
| 643.4999 | 0 |   |
| 682.4999 | 0 |   |
| 721.4999 | 1 | X |
| 760.4999 | 1 | X |

75

| MIN           | MAX      | RANGE    | MEAN     | MEDIAN        | VAR |
|---------------|----------|----------|----------|---------------|-----|
| 0.1271550E-05 | 773.3129 | 773.3129 | 46.09647 | 0.2964271E-01 | 197 |

HISTOGRAM FOR VARIABLE NO. 12 LOGUNIFORM DISTRIBUTION

| MIDPOINT      | FREQ. |                              |
|---------------|-------|------------------------------|
| 0.1350000E+15 | 26    | XXXXXXXXXXXXXXXXXXXXXXXXXXXX |
| 0.4050000E+15 | 11    | XXXXXXXXXXXX                 |
| 0.6750001E+15 | 7     | XXXXXXX                      |
| 0.9450001E+15 | 4     | XXXX                         |
| 0.1215000E+16 | 4     | XXXX                         |
| 0.1485000E+16 | 3     | XXX                          |
| 0.1755000E+16 | 3     | XXX                          |
| 0.2025000E+16 | 1     | X                            |
| 0.2295000E+16 | 3     | XXX                          |
| 0.2565001E+16 | 1     | X                            |
| 0.2835001E+16 | 2     | XX                           |
| 0.3105001E+16 | 1     | X                            |
| 0.3375001E+16 | 1     | X                            |
| 0.3645001E+16 | 2     | XX                           |
| 0.3915001E+16 | 1     | X                            |
| 0.4185002E+16 | 1     | X                            |
| 0.4455002E+16 | 1     | X                            |
| 0.4725002E+16 | 1     | X                            |
| 0.4995002E+16 | 1     | X                            |
| 0.5265002E+16 | 0     |                              |
| 0.5535002E+16 | 1     | X                            |

75

| MIN           | MAX           | RANGE         | MEAN          | MEDIAN        | VAR  |
|---------------|---------------|---------------|---------------|---------------|------|
| 0.5950341E+14 | 0.5433227E+16 | 0.5373723E+16 | 0.1202509E+16 | 0.5745110E+15 | 0.19 |

HISTOGRAM FOR VARIABLE NO. 13      USER SUPPLIED      DISTRIBUTION

| MIDPOINT  | FREQ. |            |
|-----------|-------|------------|
| -7.980001 | 1     | X          |
| -7.700001 | 1     | X          |
| -7.420001 | 2     | XX         |
| -7.140000 | 2     | XX         |
| -6.860000 | 1     | X          |
| -6.580000 | 5     | XXXXX      |
| -6.300000 | 9     | XXXXXXXXXX |
| -6.020000 | 9     | XXXXXXXXXX |
| -5.739999 | 10    | XXXXXXXXXX |
| -5.459999 | 10    | XXXXXXXXXX |
| -5.179999 | 8     | XXXXXXXXXX |
| -4.899999 | 10    | XXXXXXXXXX |
| -4.619998 | 0     |            |
| -4.339998 | 1     | X          |
| -4.059998 | 1     | X          |
| -3.779998 | 0     |            |
| -3.499998 | 1     | X          |
| -3.219998 | 1     | X          |
| -2.939998 | 1     | X          |
| -2.659998 | 0     |            |
| -2.379998 | 2     | XX         |
|           | 75    |            |

| MIN       | MAX       | RANGE    | MEAN      | MEDIAN    | VAR |
|-----------|-----------|----------|-----------|-----------|-----|
| -7.930552 | -2.311468 | 5.619084 | -5.605802 | -5.680040 | 1.0 |

HISTOGRAM FOR VARIABLE NO. 14      USER SUPPLIED      DISTRIBUTION

| MIDPOINT  | FREQ. |    |
|-----------|-------|----|
| -12.42000 | 1     | X  |
| -12.06000 | 1     | X  |
| -11.70000 | 1     | X  |
| -11.34000 | 1     | X  |
| -10.98000 | 1     | X  |
| -10.62000 | 1     | X  |
| -10.26000 | 1     | X  |
| -9.900001 | 2     | XX |
| -9.540001 | 1     | X  |
| -9.180001 | 1     | X  |

|           |   |            |
|-----------|---|------------|
| -8.820002 | 5 | XXXXX      |
| -8.460002 | 5 | XXXXX      |
| -8.100002 | 5 | XXXXX      |
| -7.740002 | 5 | XXXXX      |
| -7.380002 | 5 | XXXXX      |
| -7.020002 | 4 | XXXX       |
| -6.660002 | 5 | XXXXX      |
| -6.300002 | 8 | XXXXXXXXXX |
| -5.940001 | 7 | XXXXXXXXXX |
| -5.580001 | 8 | XXXXXXXXXX |
| -5.220001 | 7 | XXXXXXXXXX |

75

| MIN       | MAX       | RANGE    | MEAN      | MEDIAN    | VAR |
|-----------|-----------|----------|-----------|-----------|-----|
| -12.25908 | -5.048095 | 7.210989 | -7.399879 | -7.033592 | 3.2 |

HISTOGRAM FOR VARIABLE NO. 15      USER SUPPLIED      DISTRIBUTION

| MIDPOINT  | FREQ. |            |
|-----------|-------|------------|
| -8.745000 | 1     | X          |
| -8.415000 | 3     | XXX        |
| -8.085000 | 4     | XXXX       |
| -7.755000 | 3     | XXX        |
| -7.425000 | 4     | XXXX       |
| -7.095000 | 2     | XX         |
| -6.765000 | 4     | XXXX       |
| -6.435000 | 3     | XXX        |
| -6.105000 | 3     | XXX        |
| -5.775001 | 3     | XXX        |
| -5.445001 | 3     | XXX        |
| -5.115001 | 4     | XXXX       |
| -4.785001 | 2     | XX         |
| -4.455001 | 4     | XXXX       |
| -4.125001 | 2     | XX         |
| -3.795001 | 4     | XXXX       |
| -3.465001 | 3     | XXX        |
| -3.135001 | 5     | XXXXX      |
| -2.805001 | 7     | XXXXXXXXXX |
| -2.475001 | 5     | XXXXX      |
| -2.145001 | 6     | XXXXXX     |

75

| MIN       | MAX       | RANGE    | MEAN      | MEDIAN    | VAR |
|-----------|-----------|----------|-----------|-----------|-----|
| -8.595756 | -2.010489 | 6.585267 | -4.991785 | -4.790796 | 4.2 |

HISTOGRAM FOR VARIABLE NO. 16      USER SUPPLIED      DISTRIBUTION

| MIDPOINT      | FREQ. |                |
|---------------|-------|----------------|
| 0.6239996E-01 | 1     | X              |
| 0.7199995E-01 | 1     | X              |
| 0.8159994E-01 | 0     |                |
| 0.9119993E-01 | 2     | XX             |
| 0.1007999     | 6     | XXXXXX         |
| 0.1103999     | 5     | XXXXX          |
| 0.1199999     | 12    | XXXXXXXXXXXXXX |
| 0.1295999     | 5     | XXXXX          |
| 0.1391999     | 6     | XXXXXX         |
| 0.1487999     | 5     | XXXXX          |
| 0.1583999     | 8     | XXXXXXXXXX     |
| 0.1679999     | 4     | XXXX           |
| 0.1775999     | 9     | XXXXXXXXXXXX   |
| 0.1871999     | 2     | XX             |
| 0.1967999     | 1     | X              |
| 0.2063999     | 5     | XXXXX          |
| 0.2159999     | 1     | X              |
| 0.2255999     | 0     |                |
| 0.2351999     | 1     | X              |
| 0.2447999     | 0     |                |
| 0.2543999     | 1     | X              |

75

| MIN           | MAX       | RANGE     | MEAN      | MEDIAN    | VAR  |
|---------------|-----------|-----------|-----------|-----------|------|
| 0.5809073E-01 | 0.2498642 | 0.1917735 | 0.1468146 | 0.1439133 | 0.14 |

HISTOGRAM FOR VARIABLE NO. 17      USER SUPPLIED      DISTRIBUTION

| MIDPOINT | FREQ. |            |
|----------|-------|------------|
| 22.00000 | 1     | X          |
| 26.00000 | 7     | XXXXXXXXXX |
| 30.00000 | 7     | XXXXXXXXXX |
| 34.00000 | 6     | XXXXXX     |
| 38.00000 | 5     | XXXXX      |
| 42.00000 | 4     | XXXX       |
| 46.00000 | 2     | XX         |
| 50.00000 | 4     | XXXX       |
| 54.00000 | 2     | XX         |
| 58.00000 | 5     | XXXXX      |
| 62.00000 | 4     | XXXX       |
| 65.99999 | 2     | XX         |
| 69.99999 | 3     | XXX        |



|          |   |      |
|----------|---|------|
| 73.99999 | 2 | XX   |
| 77.99999 | 3 | XXX  |
| 81.99999 | 4 | XXXX |
| 85.99999 | 3 | XXX  |
| 89.99999 | 3 | XXX  |
| 93.99999 | 3 | XXX  |
| 97.99999 | 3 | XXX  |
| 102.0000 | 2 | XX   |

75

|          |          |          |          |          |     |
|----------|----------|----------|----------|----------|-----|
| MIN      | MAX      | RANGE    | MEAN     | MEDIAN   | VAR |
| 23.37967 | 103.3688 | 79.98914 | 57.02769 | 55.78229 | 582 |

HISTOGRAM FOR VARIABLE NO. 18 USER SUPPLIED DISTRIBUTION

|          |       |                  |
|----------|-------|------------------|
| MIDPOINT | FREQ. |                  |
| 2.299999 | 3     | XXX              |
| 6.899998 | 4     | XXXX             |
| 11.50000 | 13    | XXXXXXXXXXXXXXXX |
| 16.09999 | 3     | XXX              |
| 20.69999 | 2     | XX               |
| 25.29999 | 2     | XX               |
| 29.89999 | 5     | XXXXX            |
| 34.49999 | 3     | XXX              |
| 39.09999 | 3     | XXX              |
| 43.69999 | 3     | XXX              |
| 48.29998 | 7     | XXXXXXX          |
| 52.89998 | 3     | XXX              |
| 57.49998 | 3     | XXX              |
| 62.09998 | 2     | XX               |
| 66.69998 | 2     | XX               |
| 71.29998 | 3     | XXX              |
| 75.89998 | 3     | XXX              |
| 80.49998 | 2     | XX               |
| 85.09998 | 1     | X                |
| 89.69997 | 5     | XXXXX            |
| 94.29997 | 3     | XXX              |

75

|          |          |          |          |          |     |
|----------|----------|----------|----------|----------|-----|
| MIN      | MAX      | RANGE    | MEAN     | MEDIAN   | VAR |
| 1.497821 | 94.20219 | 92.70438 | 42.20030 | 40.65907 | 796 |

HISTOGRAM FOR VARIABLE NO. 19 USER SUPPLIED DISTRIBUTION

|               |       |        |
|---------------|-------|--------|
| MIDPOINT      | FREQ. |        |
| 0.4200000E-01 | 6     | XXXXXX |

|               |    |              |
|---------------|----|--------------|
| 0.7000001E-01 | 0  |              |
| 0.9800001E-01 | 4  | XXXX         |
| 0.1260000     | 0  |              |
| 0.1540000     | 6  | XXXXXX       |
| 0.1820000     | 5  | XXXXX        |
| 0.2100000     | 5  | XXXXX        |
| 0.2380000     | 12 | XXXXXXXXXXXX |
| 0.2660000     | 5  | XXXXX        |
| 0.2940000     | 5  | XXXXX        |
| 0.3220000     | 0  |              |
| 0.3500000     | 5  | XXXXX        |
| 0.3780000     | 6  | XXXXXX       |
| 0.4060000     | 0  |              |
| 0.4340000     | 6  | XXXXXX       |
| 0.4620000     | 0  |              |
| 0.4900000     | 0  |              |
| 0.5180000     | 0  |              |
| 0.5460000     | 5  | XXXXX        |
| 0.5740000     | 0  |              |
| 0.6020000     | 5  | XXXXX        |

75

| MIN           | MAX       | RANGE     | MEAN      | MEDIAN    | VAR  |
|---------------|-----------|-----------|-----------|-----------|------|
| 0.5080000E-01 | 0.6096000 | 0.5588000 | 0.2934133 | 0.2508300 | 0.23 |

HISTOGRAM FOR VARIABLE NO. 20 USER SUPPLIED DISTRIBUTION

| MIDPOINT | FREQ. |                              |
|----------|-------|------------------------------|
| 0.975000 | 23    | XXXXXXXXXXXXXXXXXXXXXXXXXXXX |
| 1.125000 | 0     |                              |
| 1.275000 | 0     |                              |
| 1.425000 | 0     |                              |
| 1.575000 | 0     |                              |
| 1.725000 | 0     |                              |
| 1.875000 | 0     |                              |
| 2.025000 | 10    | XXXXXXXXXX                   |
| 2.175000 | 0     |                              |
| 2.325000 | 0     |                              |
| 2.475000 | 0     |                              |
| 2.625000 | 0     |                              |
| 2.775000 | 0     |                              |
| 2.925000 | 16    | XXXXXXXXXXXXXXXXXXXX         |
| 3.075001 | 0     |                              |
| 3.225001 | 0     |                              |

|          |          |                              |          |          |     |
|----------|----------|------------------------------|----------|----------|-----|
| 3.375001 | 0        |                              |          |          |     |
| 3.525001 | 0        |                              |          |          |     |
| 3.675001 | 0        |                              |          |          |     |
| 3.825001 | 0        |                              |          |          |     |
| 3.975001 | 26       | XXXXXXXXXXXXXXXXXXXXXXXXXXXX |          |          |     |
|          | 75       |                              |          |          |     |
| MIN      | MAX      | RANGE                        | MEAN     | MEDIAN   | VAR |
| 1.000000 | 4.000000 | 3.000000                     | 2.600000 | 3.000000 | 1.5 |

HISTOGRAM FOR VARIABLE NO. 21 USER SUPPLIED DISTRIBUTION

| MIDPOINT  | FREQ.    |                          |          |          |     |
|-----------|----------|--------------------------|----------|----------|-----|
| -8.750003 | 9        | XXXXXXXXXX               |          |          |     |
| -6.250002 | 0        |                          |          |          |     |
| -3.750002 | 0        |                          |          |          |     |
| -1.250001 | 0        |                          |          |          |     |
| 1.250000  | 10       | XXXXXXXXXX               |          |          |     |
| 3.750000  | 0        |                          |          |          |     |
| 6.250001  | 0        |                          |          |          |     |
| 8.750002  | 20       | XXXXXXXXXXXXXXXXXXXXXXXX |          |          |     |
| 11.25000  | 0        |                          |          |          |     |
| 13.75000  | 0        |                          |          |          |     |
| 16.25000  | 0        |                          |          |          |     |
| 18.75000  | 0        |                          |          |          |     |
| 21.25000  | 0        |                          |          |          |     |
| 23.75000  | 11       | XXXXXXXXXXXX             |          |          |     |
| 26.25000  | 0        |                          |          |          |     |
| 28.75000  | 0        |                          |          |          |     |
| 31.25000  | 0        |                          |          |          |     |
| 33.75000  | 11       | XXXXXXXXXXXX             |          |          |     |
| 36.25000  | 0        |                          |          |          |     |
| 38.75000  | 14       | XXXXXXXXXXXXXXXX         |          |          |     |
|           | 75       |                          |          |          |     |
| MIN       | MAX      | RANGE                    | MEAN     | MEDIAN   | VAR |
| -10.00000 | 40.00000 | 50.00000                 | 17.02667 | 8.000000 | 285 |

CORRELATIONS AMONG INPUT VARIABLES CREATED BY THE LATIN HYPERCUBE SAMPLE FOR RAW

|   |         |         |         |        |         |         |        |
|---|---------|---------|---------|--------|---------|---------|--------|
| 1 | 1.0000  |         |         |        |         |         |        |
| 2 | -0.0032 | 1.0000  |         |        |         |         |        |
| 3 | 0.9989  | 0.0019  | 1.0000  |        |         |         |        |
| 4 | -0.0092 | -0.0049 | -0.0089 | 1.0000 |         |         |        |
| 5 | 0.1866  | 0.4724  | 0.1932  | 0.1200 | 1.0000  |         |        |
| 6 | -0.0006 | -0.0854 | -0.0086 | 0.6445 | -0.0410 | 1.0000  |        |
| 7 | -0.0444 | -0.0011 | -0.0442 | 0.0065 | -0.0789 | -0.0746 | 1.0000 |

|    |         |         |         |         |         |         |         |         |         |     |
|----|---------|---------|---------|---------|---------|---------|---------|---------|---------|-----|
| 8  | -0.0145 | 0.0228  | -0.0149 | 0.0453  | -0.1155 | 0.1400  | 0.5860  | 1.0000  |         |     |
| 9  | 0.0355  | -0.0039 | 0.0359  | -0.0253 | -0.1721 | 0.1551  | 0.5991  | 0.5854  | 1.0000  |     |
| 10 | -0.0674 | -0.0364 | -0.0707 | -0.0522 | -0.0289 | -0.0377 | -0.1039 | -0.0414 | -0.0494 | 1.  |
| 11 | -0.0284 | 0.0467  | -0.0337 | -0.1098 | -0.0345 | -0.0540 | 0.0512  | 0.0634  | 0.0174  | 0.  |
| 12 | 0.0034  | -0.0143 | 0.0110  | -0.0599 | -0.1400 | -0.0680 | -0.0872 | -0.0197 | -0.0227 | -0. |
| 13 | 0.0000  | 0.0032  | -0.0005 | 0.1273  | -0.0830 | -0.0104 | -0.0333 | -0.0557 | -0.0727 | -0. |
| 14 | 0.0378  | -0.0254 | 0.0321  | 0.0447  | -0.0911 | 0.0487  | 0.0180  | 0.0273  | 0.0140  | -0. |
| 15 | 0.0023  | 0.0020  | 0.0005  | -0.1283 | -0.0367 | -0.1504 | 0.0331  | -0.0109 | 0.0029  | -0. |
| 16 | 0.0153  | -0.0096 | 0.0187  | 0.0245  | -0.1840 | -0.1111 | 0.0328  | 0.0056  | -0.0213 | 0.  |
| 17 | 0.0167  | 0.0024  | 0.0206  | -0.0950 | -0.1932 | -0.0936 | -0.0510 | 0.0257  | -0.0330 | 0.  |
| 18 | 0.0132  | -0.0157 | 0.0152  | 0.0210  | -0.0703 | -0.1367 | -0.0055 | 0.0364  | 0.0380  | 0.  |
| 19 | 0.0403  | -0.0042 | 0.0394  | 0.0418  | -0.1963 | 0.1154  | -0.0661 | -0.0373 | -0.0532 | 0.  |
| 20 | -0.0254 | -0.0230 | -0.0279 | -0.0535 | -0.0455 | 0.0306  | -0.0103 | 0.0427  | 0.0327  | 0.  |
| 21 | -0.0372 | 0.0278  | -0.0343 | -0.1442 | -0.0818 | -0.0823 | 0.0023  | -0.0307 | -0.0256 | -0. |
|    | 1       | 2       | 3       | 4       | 5       | 6       | 7       | 8       | 9       |     |

VARIABLES

CORRELATIONS AMONG INPUT VARIABLES CREATED BY THE LATIN HYPERCUBE SAMPLE FOR RAW

|    |        |         |         |        |        |        |  |  |  |  |
|----|--------|---------|---------|--------|--------|--------|--|--|--|--|
| 16 | 1.0000 |         |         |        |        |        |  |  |  |  |
| 17 | 0.0187 | 1.0000  |         |        |        |        |  |  |  |  |
| 18 | 0.0070 | 0.0301  | 1.0000  |        |        |        |  |  |  |  |
| 19 | 0.0409 | -0.0216 | 0.0478  | 1.0000 |        |        |  |  |  |  |
| 20 | 0.0122 | 0.0311  | 0.0285  | 0.1002 | 1.0000 |        |  |  |  |  |
| 21 | 0.0378 | -0.0171 | -0.0212 | 0.0407 | 0.0773 | 1.0000 |  |  |  |  |
|    | 16     | 17      | 18      | 19     | 20     | 21     |  |  |  |  |

VARIABLES

CORRELATIONS AMONG INPUT VARIABLES CREATED BY THE LATIN HYPERCUBE SAMPLE FOR RANK

|    |         |         |         |         |         |         |         |         |         |     |
|----|---------|---------|---------|---------|---------|---------|---------|---------|---------|-----|
| 1  | 1.0000  |         |         |         |         |         |         |         |         |     |
| 2  | -0.0330 | 1.0000  |         |         |         |         |         |         |         |     |
| 3  | 0.9990  | -0.0300 | 1.0000  |         |         |         |         |         |         |     |
| 4  | -0.0212 | 0.0265  | -0.0190 | 1.0000  |         |         |         |         |         |     |
| 5  | -0.0226 | 0.9431  | -0.0168 | 0.0129  | 1.0000  |         |         |         |         |     |
| 6  | -0.0075 | 0.1110  | -0.0110 | 0.7785  | 0.0576  | 1.0000  |         |         |         |     |
| 7  | -0.0305 | -0.0233 | -0.0269 | -0.0141 | -0.0106 | 0.0150  | 1.0000  |         |         |     |
| 8  | -0.0094 | 0.0119  | -0.0075 | 0.0164  | -0.0033 | -0.0195 | 0.5857  | 1.0000  |         |     |
| 9  | 0.0257  | 0.0081  | 0.0263  | -0.0108 | 0.0068  | -0.0449 | 0.5976  | 0.5861  | 1.0000  |     |
| 10 | -0.0148 | -0.0252 | -0.0170 | 0.0013  | 0.0096  | -0.0424 | -0.0395 | 0.0313  | 0.0040  | 1.  |
| 11 | 0.0360  | -0.0192 | 0.0335  | -0.0059 | -0.0027 | 0.0014  | 0.0008  | 0.0449  | 0.0149  | 0.  |
| 12 | 0.0193  | 0.0008  | 0.0272  | 0.0008  | -0.0272 | -0.0264 | -0.0037 | 0.0228  | 0.0154  | -0. |
| 13 | 0.0262  | -0.0368 | 0.0312  | -0.0038 | -0.0404 | 0.0072  | -0.0003 | 0.0418  | -0.0031 | -0. |
| 14 | 0.0539  | 0.0170  | 0.0487  | 0.0165  | 0.0042  | 0.0105  | 0.0190  | -0.0316 | -0.0072 | -0. |
| 15 | -0.0229 | 0.0152  | -0.0222 | -0.0282 | 0.0178  | 0.0372  | 0.0333  | -0.0026 | 0.0161  | -0. |
| 16 | -0.0012 | 0.0158  | 0.0005  | 0.0128  | 0.0275  | -0.0166 | 0.0230  | 0.0040  | -0.0376 | 0.  |

|    |         |         |         |         |         |         |         |         |         |     |
|----|---------|---------|---------|---------|---------|---------|---------|---------|---------|-----|
| 17 | 0.0368  | 0.0388  | 0.0358  | 0.0733  | 0.0333  | 0.0609  | -0.0328 | 0.0366  | -0.0205 | -0. |
| 18 | 0.0091  | 0.0424  | 0.0107  | -0.0183 | 0.0667  | -0.0438 | -0.0078 | 0.0077  | 0.0323  | 0.  |
| 19 | 0.0478  | 0.0078  | 0.0463  | 0.0283  | 0.0388  | 0.0093  | -0.0535 | -0.0578 | -0.0578 | 0.  |
| 20 | -0.0033 | -0.0189 | -0.0050 | 0.0103  | -0.0432 | -0.0556 | 0.0023  | 0.0570  | 0.0418  | -0. |
| 21 | -0.0169 | 0.0076  | -0.0145 | -0.0182 | -0.0220 | -0.0600 | -0.0037 | -0.0319 | 0.0005  | 0.  |
|    | 1       | 2       | 3       | 4       | 5       | 6       | 7       | 8       | 9       |     |

VARIABLES

CORRELATIONS AMONG INPUT VARIABLES CREATED BY THE LATIN HYPERCUBE SAMPLE FOR RANK

|    |         |         |         |        |        |        |  |  |  |  |
|----|---------|---------|---------|--------|--------|--------|--|--|--|--|
| 16 | 1.0000  |         |         |        |        |        |  |  |  |  |
| 17 | 0.0657  | 1.0000  |         |        |        |        |  |  |  |  |
| 18 | 0.0173  | 0.0235  | 1.0000  |        |        |        |  |  |  |  |
| 19 | 0.0726  | 0.0015  | 0.0455  | 1.0000 |        |        |  |  |  |  |
| 20 | -0.0085 | 0.0171  | 0.0172  | 0.0347 | 1.0000 |        |  |  |  |  |
| 21 | 0.0388  | -0.0084 | -0.0329 | 0.0245 | 0.0663 | 1.0000 |  |  |  |  |
|    | 16      | 17      | 18      | 19     | 20     | 21     |  |  |  |  |

VARIABLES

## OUTPUT FILE FOR LHS TEST 2

RANDOM SEED = 933090934

NUMBER OF VARIABLES = 21

NUMBER OF OBSERVATIONS = 200

THE SAMPLE INPUT VECTORS WILL BE PRINTED ALONG WITH THEIR CORRESPONDING RANKS

HISTOGRAMS OF THE ACTUAL SAMPLE WILL BE PLOTTED FOR EACH INPUT VARIABLE

THE CORRELATION MATRICES (RAW DATA AND RANK CORRELATIONS) WILL BE PRINTED

| VARIABLE | DISTRIBUTION               | RANGE                     | LABEL        |          |     |
|----------|----------------------------|---------------------------|--------------|----------|-----|
| 1        | NORMAL                     | 0.0000E+00 TO 0.2000      | GLOBAL       | DISPPERC |     |
| 2        | NORMAL                     | 577.0 TO 1042.            | WEP203       | QRF M2CS |     |
| 3        | NORMAL                     | -3.6737E-02 TO 8.3264E-02 | WEP203       | QRF M2TC |     |
| 4        | LOGNORMAL                  | 1.0000E-02 TO 2.130       | TESTMAT1     | TESTPRP1 |     |
| 5        | LOGNORMAL                  | 1.0000E-03 TO 3.450       | TESTMAT2     | TESTPRP2 |     |
| 6        | LOGNORMAL                  | 1.0000E-04 TO 5.250       | TESTMAT3     | TESTPRP3 |     |
| 7        | UNIFORM                    | -0.5000 TO 0.5000         | CANISTER     | EFFCAREA |     |
| 8        | UNIFORM                    | 0.0000E+00 TO 1.000       | CANISTER     | BACFRC   |     |
| 9        | UNIFORM                    | 12.50 TO 500.0            | PU           | KDFE     |     |
| 10       | LOGUNIFORM                 | 1.0000E-17 TO 1.0000E-11  | GCERAMIC     | CORATEOX |     |
| 11       | LOGUNIFORM                 | 1.0000E-06 TO 1000.       | CANISTER     | EFFDAREA |     |
| 12       | LOGUNIFORM                 | 5.6000E+13 TO 5.6000E+15  | IN825        | CORATEOX |     |
| 13       | USER SUPPLIED DISTRIBUTION |                           | (CUMULATIVE) | NP       |     |
| 14       | USER SUPPLIED DISTRIBUTION |                           | (CUMULATIVE) | PU       |     |
| 15       | USER SUPPLIED DISTRIBUTION |                           | (CUMULATIVE) | U        |     |
| 16       | USER SUPPLIED DISTRIBUTION |                           | (DATA)       | Culebra  | Por |
| 17       | USER SUPPLIED DISTRIBUTION |                           | (DATA)       | TESTMAT1 | TES |
| 18       | USER SUPPLIED DISTRIBUTION |                           | (DATA)       | TESTMAT2 | TES |

|    |                            |         |          |   |
|----|----------------------------|---------|----------|---|
| 19 | USER SUPPLIED DISTRIBUTION | (DELTA) | BOREHOLE | D |
| 20 | USER SUPPLIED DISTRIBUTION | (DELTA) | DRZ 0    | R |
| 21 | USER SUPPLIED DISTRIBUTION | (DELTA) | S HALITE | G |

LATIN HYPERCUBE SAMPLE INPUT VECTORS

| RUN NO. | X(1)       | X(2)      | X(3)       | X(4)      | X(5)      | X(6)      | X(7)      |
|---------|------------|-----------|------------|-----------|-----------|-----------|-----------|
| 1       | 1.235E-01  | 1.042E+03 | -3.674E-02 | 9.992E-02 | 3.618E-02 | 3.374E-02 | -7.274E-0 |
| 2       | 6.190E-02  | 6.652E+02 | 3.490E-02  | 3.209E-02 | 1.001E-01 | 1.585E-03 | -2.251E-0 |
| 3       | 5.547E-02  | 9.072E+02 | 1.724E-02  | 1.762E-01 | 1.377E-02 | 2.227E-03 | 1.747E-0  |
| 4       | 8.605E-02  | 7.613E+02 | -2.449E-02 | 2.689E-01 | 5.811E-02 | 4.993E-04 | -3.674E-0 |
| 5       | 1.108E-01  | 7.199E+02 | 2.987E-02  | 3.008E-01 | 1.495E-01 | 1.493E-01 | 4.474E-0  |
| 6       | 8.892E-02  | 6.929E+02 | 2.568E-02  | 2.241E-02 | 4.505E-02 | 1.000E-04 | 4.521E-0  |
| 7       | 8.076E-02  | 7.488E+02 | 2.317E-02  | 4.905E-02 | 1.251E-03 | 1.099E-01 | 2.292E-0  |
| 8       | 1.693E-01  | 7.749E+02 | 6.951E-02  | 2.007E-01 | 1.573E-02 | 1.574E-01 | -4.335E-0 |
| 9       | 1.335E-01  | 9.396E+02 | 8.326E-02  | 2.729E-01 | 2.825E-01 | 8.356E-03 | 1.921E-0  |
| 10      | 8.934E-02  | 7.115E+02 | 3.041E-02  | 2.213E-01 | 1.523E-01 | 3.800E+00 | -5.883E-0 |
| 11      | 5.151E-02  | 1.035E+03 | -2.745E-02 | 2.922E-01 | 9.953E-01 | 4.846E-01 | 4.259E-0  |
| 12      | 1.447E-01  | 7.866E+02 | 3.694E-02  | 8.817E-02 | 7.530E-03 | 3.345E-01 | -4.470E-0 |
| 13      | 8.524E-02  | 8.739E+02 | 2.120E-02  | 3.339E-02 | 3.126E-01 | 2.323E-03 | 4.977E-0  |
| 14      | 1.331E-01  | 8.486E+02 | 3.230E-02  | 2.418E-01 | 8.887E-02 | 3.022E-01 | 4.097E-0  |
| 15      | 6.962E-02  | 7.719E+02 | 3.108E-02  | 8.954E-02 | 2.113E-02 | 1.357E-02 | 7.379E-0  |
| 16      | 9.675E-02  | 7.505E+02 | 1.226E-02  | 4.067E-02 | 1.015E-01 | 5.941E-03 | -3.643E-0 |
| 17      | 7.054E-02  | 7.633E+02 | 2.651E-02  | 1.389E-01 | 1.151E-01 | 1.015E-02 | -3.102E-0 |
| 18      | 1.199E-01  | 8.083E+02 | 8.326E-02  | 1.032E-01 | 1.931E-02 | 5.121E-03 | -4.198E-0 |
| 19      | 7.627E-02  | 7.297E+02 | 1.785E-02  | 1.126E-01 | 8.170E-03 | 3.043E-02 | -3.496E-0 |
| 20      | 9.095E-02  | 7.174E+02 | 2.273E-02  | 7.000E-02 | 2.378E-01 | 1.534E-02 | -1.518E-0 |
| 21      | 1.144E-01  | 7.343E+02 | -4.114E-03 | 1.673E-01 | 2.036E-01 | 2.391E-02 | -3.741E-0 |
| 22      | 8.160E-02  | 1.042E+03 | 3.070E-02  | 3.785E-02 | 2.532E-01 | 2.121E-03 | -2.484E-0 |
| 23      | 7.562E-02  | 8.286E+02 | 5.388E-02  | 3.674E-02 | 4.205E-03 | 5.192E-01 | 3.959E-0  |
| 24      | 1.152E-01  | 7.463E+02 | 6.064E-03  | 5.809E-02 | 4.802E-01 | 4.824E-02 | -4.291E-0 |
| 25      | 1.320E-01  | 1.011E+03 | 5.699E-02  | 6.466E-02 | 1.357E-03 | 3.988E-03 | 3.031E-0  |
| 26      | 9.773E-03  | 9.241E+02 | 3.157E-02  | 5.825E-01 | 1.646E-02 | 3.821E-04 | 3.797E-0  |
| 27      | 1.643E-02  | 8.060E+02 | 2.974E-02  | 2.325E-02 | 6.776E-02 | 1.007E-03 | 1.891E-0  |
| 28      | 1.317E-01  | 7.001E+02 | 3.966E-02  | 6.744E-02 | 1.166E-02 | 2.870E-02 | 1.521E-0  |
| 29      | 1.051E-01  | 8.688E+02 | 5.733E-02  | 1.082E-01 | 5.403E-02 | 4.641E-04 | 2.592E-0  |
| 30      | 1.123E-01  | 7.797E+02 | 1.532E-02  | 2.130E+00 | 1.000E-03 | 1.737E-03 | 2.878E-0  |
| 31      | -2.235E-08 | 8.325E+02 | 2.846E-02  | 7.115E-02 | 6.067E-02 | 1.811E-02 | -2.292E-0 |
| 32      | 9.707E-02  | 8.920E+02 | 4.596E-02  | 1.844E-01 | 4.189E-01 | 9.866E-03 | 3.887E-0  |
| 33      | 1.609E-01  | 5.890E+02 | 4.025E-02  | 1.251E+00 | 6.592E-03 | 5.785E-03 | -4.590E-0 |
| 34      | 1.023E-01  | 9.153E+02 | 4.231E-03  | 3.409E-01 | 1.929E-01 | 1.276E+00 | -3.997E-0 |
| 35      | 1.662E-01  | 8.875E+02 | 1.597E-02  | 1.298E+00 | 3.001E-02 | 1.558E-01 | 2.361E-0  |
| 36      | 1.114E-01  | 8.222E+02 | 5.465E-02  | 4.533E-02 | 7.660E-02 | 3.343E-02 | 4.751E-0  |
| 37      | 6.481E-02  | 8.554E+02 | 5.198E-02  | 7.100E-01 | 2.972E-01 | 6.609E-04 | 2.957E-0  |

|    |           |           |            |           |           |           |           |
|----|-----------|-----------|------------|-----------|-----------|-----------|-----------|
| 38 | 1.247E-01 | 1.002E+03 | 6.418E-02  | 2.641E-01 | 3.089E-02 | 2.441E-04 | -2.902E-0 |
| 39 | 1.205E-02 | 8.041E+02 | -1.248E-03 | 7.416E-01 | 1.796E-02 | 9.172E-03 | 3.219E-0  |
| 40 | 1.042E-01 | 7.815E+02 | 1.979E-02  | 1.269E-01 | 1.669E-01 | 3.485E-03 | 2.440E-0  |
| 41 | 1.298E-01 | 6.253E+02 | 3.333E-02  | 2.438E-01 | 4.663E-02 | 2.571E-02 | -1.525E-0 |
| 42 | 3.396E-02 | 7.834E+02 | -2.558E-02 | 7.269E-02 | 1.621E+00 | 3.247E-02 | 3.055E-0  |
| 43 | 9.784E-02 | 7.940E+02 | -1.133E-02 | 5.476E-02 | 3.450E+00 | 5.289E-02 | -3.412E-0 |
| 44 | 1.063E-01 | 6.199E+02 | -1.656E-02 | 5.055E-01 | 1.706E-01 | 4.350E-03 | 7.826E-0  |
| 45 | 1.008E-01 | 7.318E+02 | 2.757E-02  | 7.732E-02 | 2.971E-03 | 1.159E-01 | 2.078E-0  |
| 46 | 1.742E-01 | 7.653E+02 | 2.996E-03  | 3.226E-01 | 1.392E-02 | 1.126E-02 | 1.212E-0  |
| 47 | 7.847E-02 | 7.625E+02 | 3.436E-02  | 5.954E-02 | 5.993E-03 | 2.081E-01 | -4.378E-0 |
| 48 | 1.045E-01 | 9.132E+02 | 2.006E-02  | 2.448E-02 | 1.496E-02 | 7.444E-03 | 1.082E-0  |
| 49 | 1.127E-01 | 8.514E+02 | 1.622E-02  | 3.942E-01 | 1.190E-01 | 7.038E-02 | 4.239E-0  |
| 50 | 1.461E-01 | 8.707E+02 | 4.241E-02  | 2.946E-02 | 6.450E-01 | 2.027E-02 | 3.043E-0  |
| 51 | 8.296E-02 | 8.011E+02 | 2.256E-02  | 2.061E-01 | 3.424E-02 | 9.235E-02 | 7.736E-0  |
| 52 | 4.772E-02 | 7.662E+02 | -1.875E-02 | 6.000E-01 | 1.076E-01 | 1.918E-03 | -2.216E-0 |
| 53 | 6.588E-02 | 8.221E+02 | 5.724E-03  | 1.119E-01 | 2.212E-02 | 7.784E-02 | -1.854E-0 |
| 54 | 9.587E-02 | 6.732E+02 | 1.889E-03  | 6.948E-01 | 2.520E-03 | 1.937E-01 | 1.009E-0  |
| 55 | 1.511E-01 | 6.873E+02 | 2.337E-02  | 1.058E-01 | 2.458E+00 | 2.485E-02 | -4.634E-0 |
| 56 | 9.176E-02 | 9.597E+02 | 3.283E-02  | 8.497E-02 | 5.265E-03 | 3.446E-03 | -3.362E-0 |
| 57 | 7.959E-02 | 6.828E+02 | 3.882E-03  | 8.770E-02 | 4.180E-02 | 4.646E-02 | 1.296E-0  |
| 58 | 1.755E-01 | 8.410E+02 | 2.473E-02  | 1.222E-01 | 3.034E-01 | 2.567E-01 | 5.468E-0  |
| 59 | 5.854E-02 | 8.393E+02 | 7.869E-02  | 5.159E-01 | 5.777E-01 | 1.799E-01 | 4.729E-0  |
| 60 | 8.372E-02 | 8.309E+02 | -2.901E-03 | 1.457E-02 | 2.321E-02 | 1.215E-01 | -1.325E-0 |
| 61 | 1.084E-01 | 8.447E+02 | 3.821E-02  | 4.592E-01 | 7.450E-02 | 1.224E-02 | -1.821E-0 |
| 62 | 2.000E-01 | 7.147E+02 | -2.205E-03 | 1.632E-02 | 2.764E-01 | 7.953E-02 | 6.325E-0  |
| 63 | 2.518E-02 | 7.374E+02 | 5.557E-02  | 9.516E-02 | 1.830E-01 | 7.479E-04 | 1.514E-0  |
| 64 | 4.900E-02 | 8.857E+02 | 3.863E-02  | 5.059E-02 | 9.330E-02 | 1.606E-02 | 3.286E-0  |
| 65 | 2.150E-02 | 9.063E+02 | 4.931E-02  | 3.023E-02 | 4.551E-01 | 1.655E-01 | 1.693E-0  |
| 66 | 6.348E-02 | 8.722E+02 | 5.288E-02  | 8.456E-01 | 3.750E-02 | 1.044E-02 | -2.105E-0 |
| 67 | 6.674E-02 | 7.930E+02 | -3.267E-02 | 1.277E-02 | 8.493E-02 | 4.296E-02 | -3.331E-0 |
| 68 | 8.188E-02 | 6.723E+02 | 6.641E-02  | 1.232E-01 | 9.800E-03 | 6.672E-02 | -3.523E-0 |
| 69 | 1.116E-01 | 7.357E+02 | 3.627E-02  | 1.601E+00 | 1.752E-02 | 5.456E-03 | 4.328E-0  |
| 70 | 7.427E-02 | 8.195E+02 | 4.767E-02  | 1.591E-01 | 9.559E-01 | 2.272E-02 | -1.238E-0 |
| 71 | 1.217E-01 | 6.425E+02 | 5.133E-03  | 7.992E-02 | 8.300E-02 | 1.685E-02 | 8.779E-0  |
| 72 | 1.526E-01 | 6.354E+02 | 4.030E-02  | 1.103E-02 | 5.323E-02 | 2.973E-02 | 1.420E-0  |
| 73 | 1.441E-01 | 5.770E+02 | 1.354E-02  | 1.432E-01 | 4.919E-02 | 1.305E-02 | 2.149E-0  |
| 74 | 9.912E-02 | 6.578E+02 | 4.094E-02  | 9.877E-02 | 3.289E-02 | 2.319E-04 | 3.847E-0  |
| 75 | 1.790E-01 | 9.612E+02 | 3.136E-02  | 1.102E+00 | 2.411E-02 | 1.939E-02 | 3.611E-0  |
| 76 | 1.067E-01 | 6.904E+02 | 5.168E-02  | 2.684E-02 | 3.245E-01 | 1.001E-01 | -4.466E-0 |
| 77 | 7.499E-02 | 7.059E+02 | 1.910E-02  | 2.832E-02 | 8.638E-02 | 6.118E-03 | -2.323E-0 |
| 78 | 1.056E-01 | 8.050E+02 | 1.440E-02  | 1.184E-01 | 9.754E-02 | 6.610E-03 | -3.762E-0 |
| 79 | 7.276E-02 | 7.915E+02 | 2.439E-02  | 2.564E-01 | 7.089E-01 | 5.250E+00 | -1.923E-0 |

|     |            |           |            |           |           |           |           |
|-----|------------|-----------|------------|-----------|-----------|-----------|-----------|
| 80  | 5.521E-02  | 8.023E+02 | 3.737E-02  | 1.013E+00 | 2.841E-02 | 2.509E-03 | 1.123E-0  |
| 81  | 1.242E-01  | 7.958E+02 | 2.539E-02  | 4.154E-01 | 1.371E-01 | 9.290E-02 | 3.426E-0  |
| 82  | 9.239E-02  | 9.945E+02 | 2.136E-02  | 5.597E-02 | 1.805E-02 | 1.258E-03 | -1.409E-0 |
| 83  | 6.796E-02  | 9.415E+02 | -1.288E-02 | 2.123E-01 | 3.968E-02 | 6.253E-02 | 2.756E-0  |
| 84  | 4.628E-02  | 7.433E+02 | -3.674E-02 | 1.898E-01 | 4.980E-02 | 1.322E-04 | -4.117E-0 |
| 85  | 1.494E-01  | 8.462E+02 | 8.566E-03  | 6.649E-01 | 6.321E-02 | 4.034E-04 | -3.314E-0 |
| 86  | 6.024E-02  | 8.828E+02 | 4.365E-02  | 1.725E-01 | 6.182E-02 | 2.964E-03 | -4.890E-0 |
| 87  | 3.778E-02  | 9.503E+02 | 3.417E-02  | 2.468E-01 | 3.693E-01 | 1.252E-01 | -1.752E-0 |
| 88  | 1.681E-01  | 7.285E+02 | -2.161E-02 | 4.016E-01 | 3.786E-02 | 6.461E-01 | -2.411E-0 |
| 89  | 1.276E-01  | 8.470E+02 | 2.863E-02  | 8.187E-02 | 6.025E-01 | 2.317E-01 | -4.646E-0 |
| 90  | 1.037E-01  | 7.187E+02 | 1.674E-02  | 8.625E-02 | 8.397E-01 | 3.073E-04 | -4.039E-0 |
| 91  | 9.325E-02  | 7.065E+02 | 4.306E-02  | 3.498E-02 | 3.526E-03 | 6.452E-02 | -8.943E-0 |
| 92  | 1.231E-01  | 8.893E+02 | 3.659E-02  | 1.013E-01 | 4.036E-03 | 5.750E-02 | 2.657E-0  |
| 93  | 1.354E-01  | 8.361E+02 | 1.375E-02  | 1.636E-01 | 1.928E+00 | 1.384E-01 | 2.464E-0  |
| 94  | -2.235E-08 | 7.775E+02 | 2.720E-02  | 3.459E-01 | 4.334E-02 | 4.750E-03 | 9.732E-0  |
| 95  | 3.542E-02  | 7.473E+02 | 1.328E-02  | 2.294E-01 | 2.638E-02 | 5.358E-02 | -6.405E-0 |
| 96  | 6.127E-02  | 8.938E+02 | 7.021E-03  | 3.301E-02 | 4.789E-03 | 1.954E-01 | -4.910E-0 |
| 97  | 7.343E-02  | 6.045E+02 | 1.185E-02  | 5.563E-01 | 7.218E-02 | 1.312E-02 | -3.832E-0 |
| 98  | 5.650E-02  | 6.957E+02 | 7.636E-04  | 6.427E-01 | 3.450E+00 | 3.770E-03 | 1.452E-0  |
| 99  | 1.224E-01  | 8.734E+02 | 1.077E-02  | 1.000E-02 | 5.538E-02 | 1.839E-02 | -1.340E-0 |
| 100 | 1.307E-01  | 8.113E+02 | 5.093E-02  | 1.046E+00 | 3.267E-02 | 7.695E-03 | 2.160E-0  |
| 101 | 8.041E-02  | 9.315E+02 | 7.010E-02  | 3.900E-01 | 2.062E-02 | 4.091E-02 | 5.814E-0  |
| 102 | 8.683E-02  | 7.754E+02 | -3.238E-03 | 5.222E-02 | 2.584E-01 | 5.539E-04 | 3.350E-0  |
| 103 | 1.501E-01  | 9.365E+02 | 4.406E-02  | 1.098E-01 | 7.997E-02 | 2.650E-03 | -4.419E-0 |
| 104 | 7.487E-02  | 8.539E+02 | 3.516E-02  | 1.339E-01 | 3.638E-03 | 5.250E+00 | 1.615E-0  |
| 105 | 1.089E-01  | 8.198E+02 | 3.203E-02  | 7.637E-02 | 8.174E-01 | 6.822E-03 | -2.501E-0 |
| 106 | 7.712E-02  | 7.223E+02 | 2.922E-02  | 2.337E-01 | 2.295E-03 | 3.602E-02 | 2.320E-0  |
| 107 | 9.276E-02  | 7.588E+02 | 4.200E-02  | 2.550E-02 | 9.500E-02 | 1.764E-03 | 4.812E-0  |
| 108 | 1.365E-01  | 6.488E+02 | -5.608E-03 | 1.600E-01 | 2.075E-03 | 4.256E-02 | 2.012E-0  |
| 109 | 1.620E-01  | 9.464E+02 | -6.902E-03 | 1.327E-01 | 1.242E-02 | 1.527E+00 | 4.857E-0  |
| 110 | 1.169E-01  | 8.241E+02 | 1.871E-02  | 1.141E-01 | 1.889E-02 | 3.906E-02 | -4.201E-0 |
| 111 | 7.127E-02  | 7.582E+02 | 1.882E-02  | 1.251E-01 | 1.171E-01 | 1.120E-02 | -9.182E-0 |
| 112 | 1.102E-01  | 7.979E+02 | 1.749E-02  | 3.281E-01 | 3.892E-02 | 3.921E-03 | 3.596E-0  |
| 113 | 8.493E-02  | 7.825E+02 | 4.984E-02  | 8.789E-01 | 1.627E-01 | 4.470E-02 | -3.932E-0 |
| 114 | 1.077E-01  | 7.785E+02 | 7.608E-02  | 1.705E-02 | 6.900E-03 | 7.174E-01 | -2.180E-0 |
| 115 | 7.170E-02  | 1.023E+03 | 4.735E-02  | 3.304E-01 | 4.536E-03 | 5.667E-03 | 4.591E-0  |
| 116 | 2.263E-02  | 8.415E+02 | 9.656E-03  | 1.365E-01 | 1.550E-02 | 2.209E+00 | -1.724E-0 |
| 117 | 8.268E-02  | 7.686E+02 | 5.019E-02  | 7.387E-02 | 1.552E-01 | 3.727E-01 | -2.836E-0 |
| 118 | 1.597E-01  | 7.531E+02 | 4.832E-02  | 1.871E-01 | 1.049E-01 | 8.005E-03 | 2.506E-0  |
| 119 | 2.771E-02  | 7.334E+02 | -1.016E-02 | 4.457E-01 | 3.589E-02 | 1.113E+00 | 3.463E-0  |
| 120 | 1.194E-01  | 8.580E+02 | 1.112E-02  | 9.253E-02 | 8.107E-02 | 1.744E-02 | -1.609E-0 |
| 121 | 1.260E-01  | 8.267E+02 | -9.074E-03 | 8.267E-02 | 1.973E-01 | 2.864E-01 | 4.503E-0  |



|     |           |           |            |           |           |           |           |
|-----|-----------|-----------|------------|-----------|-----------|-----------|-----------|
| 122 | 9.359E-02 | 8.320E+02 | 1.034E-02  | 3.762E-01 | 1.718E-01 | 4.047E-01 | -4.837E-0 |
| 123 | 8.718E-02 | 7.016E+02 | -1.577E-02 | 1.802E-01 | 1.372E+00 | 9.860E-02 | 3.923E-0  |
| 124 | 1.352E-01 | 8.375E+02 | 3.538E-02  | 3.794E-01 | 6.580E-02 | 8.381E-04 | -6.502E-0 |
| 125 | 4.953E-02 | 6.006E+02 | 5.313E-02  | 3.976E-02 | 4.248E-01 | 1.777E-01 | -2.749E-0 |
| 126 | 1.559E-01 | 8.562E+02 | -1.980E-02 | 6.138E-02 | 1.332E-01 | 1.110E-01 | 3.958E-0  |
| 127 | 7.774E-02 | 8.807E+02 | 1.966E-02  | 1.797E+00 | 1.122E-01 | 5.562E-01 | -4.652E-0 |
| 128 | 1.343E-01 | 9.124E+02 | 2.361E-02  | 3.517E-01 | 4.018E-01 | 2.863E-03 | -1.264E-0 |
| 129 | 9.531E-02 | 7.708E+02 | 3.769E-02  | 1.406E-01 | 1.060E-02 | 1.257E-02 | -9.856E-0 |
| 130 | 5.728E-02 | 8.608E+02 | 5.895E-02  | 1.451E-01 | 2.674E-02 | 2.809E-02 | 4.656E-0  |
| 131 | 6.833E-02 | 7.871E+02 | 4.341E-02  | 2.032E-01 | 2.654E-01 | 4.795E-02 | 4.409E-0  |
| 132 | 4.504E-02 | 9.041E+02 | 2.081E-02  | 1.519E-01 | 6.375E-03 | 1.416E-03 | -3.247E-0 |
| 133 | 3.872E-02 | 9.498E+02 | 6.453E-02  | 4.243E-01 | 1.306E-02 | 3.915E-01 | -4.764E-0 |
| 134 | 1.427E-01 | 9.537E+02 | -1.347E-02 | 2.352E-01 | 1.676E-02 | 9.732E-04 | -3.292E-0 |
| 135 | 1.430E-01 | 7.955E+02 | -2.178E-04 | 4.424E-02 | 1.000E-03 | 5.929E-01 | -3.557E-0 |
| 136 | 8.800E-02 | 8.975E+02 | -3.501E-02 | 4.107E-02 | 1.815E-03 | 1.427E-01 | 3.730E-0  |
| 137 | 1.141E-01 | 9.196E+02 | 1.125E-02  | 1.646E-01 | 4.608E-02 | 2.258E+00 | 4.104E-0  |
| 138 | 1.383E-01 | 8.099E+02 | 2.796E-03  | 2.174E-01 | 4.036E-02 | 1.936E-03 | 3.504E-0  |
| 139 | 1.415E-01 | 7.986E+02 | -7.101E-03 | 8.029E-01 | 2.882E-02 | 1.436E-02 | 2.714E-0  |
| 140 | 3.026E-02 | 8.839E+02 | 8.320E-02  | 2.504E-01 | 1.418E+00 | 4.391E-01 | 2.377E-0  |
| 141 | 9.870E-02 | 8.526E+02 | 6.502E-03  | 4.523E-01 | 2.083E-01 | 8.444E-02 | -1.654E-0 |
| 142 | 1.971E-01 | 8.999E+02 | 1.511E-03  | 2.160E-01 | 9.010E-02 | 1.132E-03 | -1.177E-0 |
| 143 | 6.977E-02 | 7.083E+02 | 2.193E-02  | 4.888E-01 | 6.437E-02 | 5.098E-02 | -2.236E-0 |
| 144 | 9.976E-02 | 9.096E+02 | -6.137E-03 | 7.934E-01 | 3.793E-01 | 3.751E-02 | -4.974E-0 |
| 145 | 9.798E-02 | 7.257E+02 | 2.500E-02  | 9.775E-02 | 6.610E-01 | 4.576E-03 | 8.259E-0  |
| 146 | 1.286E-01 | 9.866E+02 | 2.227E-02  | 1.168E-01 | 1.169E+00 | 1.542E-03 | -2.667E-0 |
| 147 | 9.005E-02 | 8.771E+02 | -3.926E-03 | 6.510E-02 | 3.451E-01 | 9.480E-03 | -4.507E-0 |
| 148 | 4.048E-02 | 8.370E+02 | -1.698E-02 | 1.043E-01 | 1.299E-02 | 1.500E-02 | 1.164E-0  |
| 149 | 9.425E-02 | 8.145E+02 | 4.887E-02  | 5.377E-02 | 1.990E-02 | 1.053E-01 | 3.315E-0  |
| 150 | 1.375E-01 | 7.885E+02 | 4.686E-02  | 1.307E-01 | 2.363E-02 | 6.440E-03 | 4.872E-0  |
| 151 | 1.388E-01 | 7.440E+02 | 3.394E-03  | 1.781E-01 | 2.750E-02 | 3.473E-02 | 2.237E-0  |
| 152 | 1.266E-01 | 6.677E+02 | -3.689E-04 | 2.605E-01 | 9.163E-03 | 3.376E-01 | -2.082E-0 |
| 153 | 5.301E-02 | 9.246E+02 | 4.482E-02  | 1.465E-01 | 1.210E-02 | 2.677E-02 | 6.780E-0  |
| 154 | 4.136E-02 | 8.127E+02 | -1.436E-02 | 5.666E-02 | 5.055E-02 | 2.367E-03 | 1.284E-0  |
| 155 | 1.028E-01 | 8.172E+02 | 6.132E-02  | 3.162E-01 | 1.255E-01 | 8.649E-03 | -2.772E-0 |
| 156 | 1.255E-01 | 9.207E+02 | 2.055E-02  | 9.656E-01 | 5.680E-02 | 8.078E-02 | 1.780E-0  |
| 157 | 1.000E-01 | 8.625E+02 | 4.003E-04  | 4.296E-02 | 6.929E-02 | 1.331E-01 | -1.990E-0 |
| 158 | 1.401E-01 | 8.253E+02 | 5.967E-02  | 1.981E-01 | 7.427E-01 | 2.369E-01 | -4.078E-0 |
| 159 | 1.093E-01 | 8.794E+02 | 1.566E-02  | 1.000E-02 | 1.225E-01 | 9.901E-01 | 3.663E-0  |
| 160 | 4.414E-02 | 7.415E+02 | 6.198E-02  | 1.490E-01 | 7.059E-02 | 2.878E+00 | -7.831E-0 |
| 161 | 5.958E-02 | 9.751E+02 | 7.255E-03  | 3.023E-01 | 1.443E-02 | 1.811E-04 | -1.094E-0 |
| 162 | 1.471E-01 | 9.834E+02 | -2.253E-02 | 4.708E-01 | 4.282E-02 | 7.279E-02 | -2.615E-0 |
| 163 | 3.146E-02 | 8.768E+02 | 1.647E-02  | 4.352E-02 | 2.144E-01 | 5.984E-02 | 3.135E-0  |

|     |           |           |            |           |           |           |           |
|-----|-----------|-----------|------------|-----------|-----------|-----------|-----------|
| 164 | 1.573E-01 | 7.139E+02 | 2.405E-02  | 2.130E+00 | 5.199E-01 | 7.436E-02 | -2.973E-0 |
| 165 | 2.000E-01 | 8.677E+02 | -4.869E-03 | 6.323E-02 | 9.261E-03 | 8.105E-01 | -3.164E-0 |
| 166 | 7.907E-02 | 7.401E+02 | 3.363E-02  | 1.556E-01 | 7.468E-03 | 1.878E-02 | -2.385E-0 |
| 167 | 4.320E-02 | 8.151E+02 | -9.000E-03 | 1.205E-01 | 1.017E-02 | 3.126E-02 | -2.686E-0 |
| 168 | 1.132E-01 | 7.896E+02 | 9.854E-03  | 6.232E-01 | 5.443E-01 | 9.462E-01 | 4.917E-0  |
| 169 | 1.281E-01 | 7.671E+02 | 7.184E-02  | 4.294E-01 | 4.822E-01 | 3.866E-02 | -2.564E-0 |
| 170 | 6.408E-02 | 8.648E+02 | 1.276E-02  | 1.689E-01 | 5.397E-03 | 2.220E-01 | -1.380E-0 |
| 171 | 1.535E-01 | 9.707E+02 | 2.617E-02  | 4.857E-02 | 2.522E-02 | 5.631E-02 | -2.025E-0 |
| 172 | 1.017E-01 | 9.331E+02 | 8.937E-03  | 1.891E-02 | 2.963E-02 | 3.115E-03 | -5.126E-0 |
| 173 | 1.924E-01 | 8.917E+02 | 6.736E-02  | 6.662E-02 | 1.765E-01 | 4.928E-03 | -4.739E-0 |
| 174 | 1.014E-01 | 8.964E+02 | -1.087E-02 | 2.770E-01 | 1.865E-01 | 8.900E-04 | 9.200E-0  |
| 175 | 6.726E-02 | 8.655E+02 | -1.363E-03 | 6.851E-02 | 5.189E-02 | 6.741E-04 | -2.857E-0 |
| 176 | 1.835E-01 | 7.237E+02 | 1.248E-02  | 1.950E-01 | 1.068E-02 | 1.343E-03 | -3.861E-0 |
| 177 | 1.156E-01 | 8.281E+02 | 1.482E-02  | 1.551E+00 | 4.772E-02 | 1.631E-02 | 4.359E-0  |
| 178 | 1.206E-01 | 6.761E+02 | 1.806E-02  | 1.287E-01 | 1.455E-01 | 2.730E-03 | -1.470E-0 |
| 179 | 9.513E-02 | 8.344E+02 | 3.317E-02  | 3.595E-01 | 1.426E-01 | 1.676E+00 | 2.929E-0  |
| 180 | 1.716E-01 | 7.727E+02 | 4.152E-02  | 1.948E-02 | 8.529E-03 | 1.219E-03 | -1.566E-0 |
| 181 | 1.175E-01 | 7.549E+02 | 3.911E-02  | 6.023E-02 | 5.921E-02 | 8.658E-02 | 1.384E-0  |
| 182 | 5.189E-02 | 7.854E+02 | -7.922E-03 | 2.271E-01 | 2.262E-02 | 1.063E-02 | -8.416E-0 |
| 183 | 1.548E-01 | 6.793E+02 | 4.668E-03  | 1.831E-01 | 2.541E-02 | 1.000E-04 | 4.636E-0  |
| 184 | 1.881E-01 | 8.168E+02 | 5.569E-02  | 2.816E-01 | 1.350E-01 | 2.788E-01 | -1.021E-0 |
| 185 | 1.577E-01 | 8.080E+02 | 8.005E-03  | 2.871E-01 | 7.484E-02 | 3.212E-03 | 1.328E-0  |
| 186 | 1.402E-01 | 9.293E+02 | 2.162E-03  | 7.480E-02 | 3.192E-02 | 2.079E-02 | -9.535E-0 |
| 187 | 6.233E-02 | 7.524E+02 | 9.059E-03  | 1.540E-01 | 1.123E+00 | 2.672E-01 | 2.897E-0  |
| 188 | 1.184E-01 | 6.307E+02 | 6.254E-02  | 3.552E-02 | 3.441E-02 | 4.132E-03 | 2.624E-0  |
| 189 | 5.375E-02 | 6.522E+02 | 3.579E-02  | 3.108E-01 | 5.663E-03 | 2.114E-02 | 1.965E-0  |
| 190 | 9.076E-02 | 8.432E+02 | 4.507E-02  | 4.691E-02 | 1.063E-01 | 2.591E-02 | 4.036E-0  |
| 191 | 1.162E-01 | 6.585E+02 | 7.682E-03  | 9.140E-02 | 2.205E-01 | 8.754E-03 | 4.175E-0  |
| 192 | 1.293E-01 | 8.005E+02 | 5.856E-02  | 3.659E-01 | 8.476E-03 | 2.342E-02 | -1.137E-0 |
| 193 | 6.067E-03 | 5.770E+02 | 3.893E-02  | 5.428E-01 | 2.308E-01 | 2.172E-02 | -3.879E-0 |
| 194 | 1.071E-01 | 8.504E+02 | 4.554E-02  | 5.265E-01 | 1.287E-01 | 6.179E-02 | -3.085E-0 |
| 195 | 8.427E-02 | 6.851E+02 | 2.784E-02  | 9.470E-02 | 1.126E-02 | 7.709E-01 | 2.821E-0  |
| 196 | 1.638E-01 | 7.560E+02 | 4.140E-02  | 5.120E-02 | 3.046E+00 | 1.170E-02 | 4.275E-0  |
| 197 | 8.768E-02 | 6.985E+02 | 1.408E-02  | 5.683E-01 | 3.024E-03 | 4.418E-03 | 3.153E-0  |
| 198 | 1.478E-01 | 8.605E+02 | 2.883E-02  | 7.916E-02 | 2.448E-01 | 7.275E-03 | 1.564E-0  |
| 199 | 1.181E-01 | 9.022E+02 | 2.639E-02  | 2.103E-01 | 2.151E-02 | 7.087E-03 | -3.040E-0 |
| 200 | 1.209E-01 | 9.684E+02 | 2.699E-02  | 2.115E-02 | 3.507E-01 | 1.410E-02 | 1.843E-0  |

LATIN HYPERCUBE SAMPLE INPUT VECTORS

| RUN NO. | X(11)     | X(12)     | X(13)      | X(14)      | X(15)      | X(16)     | X(17)    |
|---------|-----------|-----------|------------|------------|------------|-----------|----------|
| 1       | 3.592E-02 | 1.311E+15 | -5.777E+00 | -7.762E+00 | -8.284E+00 | 6.991E-02 | 5.797E+0 |
| 2       | 1.061E-04 | 1.501E+15 | -5.451E+00 | -6.320E+00 | -7.122E+00 | 1.618E-01 | 8.955E+0 |
| 3       | 4.793E-02 | 3.171E+14 | -6.057E+00 | -7.623E+00 | -6.011E+00 | 1.042E-01 | 4.328E+0 |

|    |           |           |            |            |            |           |          |
|----|-----------|-----------|------------|------------|------------|-----------|----------|
| 4  | 6.679E-01 | 1.164E+15 | -6.369E+00 | -8.668E+00 | -5.054E+00 | 1.711E-01 | 6.871E+0 |
| 5  | 3.410E-02 | 1.193E+15 | -2.779E+00 | -7.715E+00 | -6.151E+00 | 2.075E-01 | 5.600E+0 |
| 6  | 1.990E+01 | 1.595E+14 | -5.036E+00 | -8.998E+00 | -8.391E+00 | 1.420E-01 | 3.158E+0 |
| 7  | 3.548E-01 | 3.656E+14 | -3.977E+00 | -6.594E+00 | -5.859E+00 | 1.126E-01 | 6.246E+0 |
| 8  | 1.502E-03 | 1.985E+15 | -3.762E+00 | -6.626E+00 | -4.764E+00 | 1.238E-01 | 9.884E+0 |
| 9  | 2.087E-03 | 7.113E+14 | -5.860E+00 | -6.710E+00 | -3.361E+00 | 1.973E-01 | 2.346E+0 |
| 10 | 1.066E+00 | 1.824E+15 | -5.243E+00 | -6.771E+00 | -4.188E+00 | 1.791E-01 | 2.463E+0 |
| 11 | 1.364E+01 | 3.292E+15 | -4.846E+00 | -8.212E+00 | -4.706E+00 | 1.448E-01 | 8.226E+0 |
| 12 | 1.249E-05 | 1.190E+14 | -6.191E+00 | -7.259E+00 | -7.343E+00 | 1.822E-01 | 2.893E+0 |
| 13 | 1.540E-06 | 6.855E+14 | -7.203E+00 | -7.740E+00 | -3.057E+00 | 1.244E-01 | 7.310E+0 |
| 14 | 6.150E+01 | 2.030E+14 | -6.580E+00 | -6.951E+00 | -3.530E+00 | 1.293E-01 | 6.112E+0 |
| 15 | 4.875E-05 | 4.106E+14 | -4.979E+00 | -6.542E+00 | -6.387E+00 | 1.140E-01 | 8.398E+0 |
| 16 | 1.923E+02 | 3.788E+14 | -4.826E+00 | -7.642E+00 | -6.056E+00 | 1.781E-01 | 2.814E+0 |
| 17 | 6.938E+00 | 1.099E+15 | -7.747E+00 | -7.350E+00 | -4.860E+00 | 1.206E-01 | 7.136E+0 |
| 18 | 2.356E+02 | 5.568E+15 | -7.857E+00 | -1.194E+01 | -3.868E+00 | 2.047E-01 | 5.563E+0 |
| 19 | 3.333E+02 | 6.646E+13 | -4.805E+00 | -7.772E+00 | -6.024E+00 | 1.625E-01 | 9.767E+0 |
| 20 | 1.406E+02 | 4.467E+14 | -5.837E+00 | -1.175E+01 | -5.125E+00 | 1.780E-01 | 3.360E+0 |
| 21 | 5.488E+02 | 9.590E+13 | -7.683E+00 | -7.557E+00 | -2.570E+00 | 1.273E-01 | 5.896E+0 |
| 22 | 5.905E+01 | 1.853E+14 | -6.565E+00 | -5.147E+00 | -5.803E+00 | 1.190E-01 | 3.068E+0 |
| 23 | 3.562E-06 | 7.662E+14 | -6.151E+00 | -7.895E+00 | -7.795E+00 | 1.259E-01 | 4.632E+0 |
| 24 | 3.414E-05 | 9.439E+13 | -5.215E+00 | -7.609E+00 | -4.921E+00 | 1.287E-01 | 5.356E+0 |
| 25 | 1.927E-04 | 4.139E+15 | -4.856E+00 | -7.470E+00 | -7.786E+00 | 2.034E-01 | 4.799E+0 |
| 26 | 4.022E-04 | 3.796E+15 | -6.246E+00 | -5.762E+00 | -7.226E+00 | 9.583E-02 | 9.149E+0 |
| 27 | 2.981E-03 | 5.081E+14 | -3.622E+00 | -7.851E+00 | -8.144E+00 | 2.513E-01 | 5.963E+0 |
| 28 | 1.081E-05 | 5.973E+14 | -6.037E+00 | -7.250E+00 | -7.198E+00 | 2.192E-01 | 9.271E+0 |
| 29 | 1.822E-01 | 2.468E+15 | -6.226E+00 | -8.444E+00 | -3.734E+00 | 2.150E-01 | 1.007E+0 |
| 30 | 9.620E-02 | 2.930E+15 | -6.528E+00 | -1.234E+01 | -4.812E+00 | 1.071E-01 | 8.358E+0 |
| 31 | 2.771E+02 | 1.715E+14 | -5.906E+00 | -6.838E+00 | -3.838E+00 | 1.595E-01 | 2.363E+0 |
| 32 | 3.279E+00 | 7.969E+13 | -6.078E+00 | -8.127E+00 | -4.460E+00 | 2.097E-01 | 3.669E+0 |
| 33 | 1.065E-03 | 2.734E+14 | -4.787E+00 | -8.069E+00 | -6.823E+00 | 6.133E-02 | 5.773E+0 |
| 34 | 1.250E+01 | 6.911E+13 | -5.988E+00 | -7.900E+00 | -7.164E+00 | 2.323E-01 | 1.032E+0 |
| 35 | 2.483E-05 | 6.297E+14 | -4.772E+00 | -8.098E+00 | -5.696E+00 | 1.453E-01 | 8.544E+0 |
| 36 | 8.916E+01 | 3.363E+14 | -4.872E+00 | -7.927E+00 | -4.074E+00 | 1.795E-01 | 7.078E+0 |
| 37 | 8.249E-01 | 6.442E+13 | -6.318E+00 | -1.041E+01 | -8.536E+00 | 1.227E-01 | 7.842E+0 |
| 38 | 6.494E+00 | 9.849E+14 | -5.139E+00 | -7.304E+00 | -8.499E+00 | 1.094E-01 | 9.327E+0 |
| 39 | 3.196E-05 | 1.347E+14 | -3.264E+00 | -7.415E+00 | -2.741E+00 | 1.097E-01 | 3.048E+0 |
| 40 | 6.754E+02 | 6.244E+14 | -4.942E+00 | -7.975E+00 | -6.189E+00 | 1.327E-01 | 8.808E+0 |
| 41 | 6.523E-03 | 1.131E+14 | -5.790E+00 | -8.424E+00 | -2.162E+00 | 9.898E-02 | 7.955E+0 |
| 42 | 3.438E-06 | 2.971E+15 | -4.928E+00 | -7.793E+00 | -7.633E+00 | 1.085E-01 | 4.691E+0 |
| 43 | 3.486E-03 | 2.393E+15 | -5.592E+00 | -8.857E+00 | -3.562E+00 | 1.109E-01 | 2.529E+0 |
| 44 | 3.910E-01 | 7.846E+14 | -5.383E+00 | -6.985E+00 | -2.484E+00 | 1.214E-01 | 4.863E+0 |
| 45 | 2.355E-01 | 1.262E+15 | -4.799E+00 | -5.354E+00 | -3.427E+00 | 1.692E-01 | 4.105E+0 |

|    |           |           |            |            |            |           |          |
|----|-----------|-----------|------------|------------|------------|-----------|----------|
| 46 | 4.314E+01 | 7.018E+14 | -5.824E+00 | -7.547E+00 | -6.711E+00 | 1.795E-01 | 3.702E+0 |
| 47 | 2.606E-01 | 1.201E+14 | -6.449E+00 | -6.643E+00 | -6.889E+00 | 2.037E-01 | 5.444E+0 |
| 48 | 7.744E-06 | 4.414E+14 | -5.529E+00 | -6.790E+00 | -5.647E+00 | 9.684E-02 | 2.966E+0 |
| 49 | 9.982E+02 | 2.153E+14 | -6.486E+00 | -6.573E+00 | -8.383E+00 | 1.274E-01 | 8.181E+0 |
| 50 | 1.640E-01 | 1.401E+15 | -5.374E+00 | -7.572E+00 | -4.226E+00 | 1.617E-01 | 8.123E+0 |
| 51 | 2.037E-06 | 8.555E+14 | -4.823E+00 | -6.869E+00 | -7.297E+00 | 1.054E-01 | 3.001E+0 |
| 52 | 1.079E+02 | 9.110E+14 | -6.132E+00 | -7.273E+00 | -5.673E+00 | 1.463E-01 | 6.053E+0 |
| 53 | 1.365E-02 | 4.184E+15 | -7.262E+00 | -7.688E+00 | -7.262E+00 | 1.894E-01 | 2.933E+0 |
| 54 | 6.048E-04 | 3.352E+15 | -7.557E+00 | -7.588E+00 | -6.803E+00 | 8.000E-02 | 3.510E+0 |
| 55 | 2.370E-06 | 1.450E+15 | -3.880E+00 | -7.382E+00 | -3.325E+00 | 1.279E-01 | 5.181E+0 |
| 56 | 7.366E-04 | 2.479E+14 | -5.743E+00 | -7.370E+00 | -5.417E+00 | 1.790E-01 | 5.084E+0 |
| 57 | 8.492E-03 | 7.545E+14 | -5.883E+00 | -8.010E+00 | -3.579E+00 | 1.617E-01 | 8.737E+0 |
| 58 | 1.866E-01 | 1.356E+15 | -6.002E+00 | -8.715E+00 | -4.784E+00 | 1.220E-01 | 9.407E+0 |
| 59 | 3.344E-04 | 1.079E+14 | -5.121E+00 | -6.011E+00 | -7.930E+00 | 1.438E-01 | 7.668E+0 |
| 60 | 1.273E-01 | 9.948E+13 | -5.903E+00 | -8.160E+00 | -8.102E+00 | 8.825E-02 | 3.764E+0 |
| 61 | 4.371E-06 | 3.027E+15 | -5.721E+00 | -9.212E+00 | -4.359E+00 | 1.784E-01 | 8.690E+0 |
| 62 | 1.260E+00 | 1.715E+15 | -5.473E+00 | -6.685E+00 | -5.426E+00 | 1.008E-01 | 3.298E+0 |
| 63 | 7.236E-05 | 3.423E+15 | -6.357E+00 | -6.672E+00 | -2.192E+00 | 1.638E-01 | 6.516E+0 |
| 64 | 9.565E-03 | 4.596E+15 | -5.419E+00 | -1.140E+01 | -6.331E+00 | 1.435E-01 | 4.021E+0 |
| 65 | 7.815E-02 | 2.796E+15 | -2.086E+00 | -7.659E+00 | -8.597E+00 | 1.787E-01 | 3.534E+0 |
| 66 | 1.512E+01 | 4.699E+15 | -5.002E+00 | -1.219E+01 | -5.497E+00 | 1.213E-01 | 3.643E+0 |
| 67 | 2.288E-04 | 2.531E+14 | -6.209E+00 | -8.759E+00 | -6.350E+00 | 1.456E-01 | 3.786E+0 |
| 68 | 2.055E-04 | 1.437E+15 | -6.119E+00 | -7.403E+00 | -8.318E+00 | 1.182E-01 | 4.875E+0 |
| 69 | 1.906E-05 | 2.549E+15 | -4.894E+00 | -8.286E+00 | -5.195E+00 | 2.255E-01 | 2.490E+0 |
| 70 | 3.280E-04 | 9.124E+13 | -5.176E+00 | -8.865E+00 | -3.112E+00 | 9.745E-02 | 3.343E+0 |
| 71 | 2.763E-04 | 5.302E+14 | -5.101E+00 | -7.665E+00 | -6.216E+00 | 1.793E-01 | 2.548E+0 |
| 72 | 2.349E-02 | 4.348E+15 | -5.866E+00 | -8.768E+00 | -5.764E+00 | 1.400E-01 | 3.110E+0 |
| 73 | 1.165E-05 | 1.556E+14 | -6.441E+00 | -7.437E+00 | -4.898E+00 | 1.769E-01 | 2.726E+0 |
| 74 | 5.145E+02 | 1.131E+15 | -4.905E+00 | -8.573E+00 | -5.963E+00 | 1.060E-01 | 5.633E+0 |
| 75 | 1.642E-03 | 1.683E+14 | -5.749E+00 | -5.838E+00 | -7.674E+00 | 1.405E-01 | 2.416E+0 |
| 76 | 1.166E-03 | 2.125E+15 | -5.394E+00 | -7.822E+00 | -7.863E+00 | 1.616E-01 | 5.997E+0 |
| 77 | 9.659E-01 | 1.005E+14 | -7.945E+00 | -5.231E+00 | -8.464E+00 | 6.382E-02 | 3.224E+0 |
| 78 | 9.315E-04 | 4.469E+15 | -5.490E+00 | -6.428E+00 | -6.576E+00 | 1.752E-01 | 5.690E+0 |
| 79 | 9.439E-05 | 5.007E+15 | -5.643E+00 | -5.062E+00 | -8.255E+00 | 1.784E-01 | 3.376E+0 |
| 80 | 4.229E-05 | 2.670E+14 | -2.401E+00 | -6.927E+00 | -5.610E+00 | 1.144E-01 | 8.968E+0 |
| 81 | 4.597E+01 | 9.490E+14 | -6.550E+00 | -5.708E+00 | -7.541E+00 | 1.409E-01 | 8.171E+0 |
| 82 | 1.252E-06 | 4.178E+14 | -6.046E+00 | -1.213E+01 | -3.462E+00 | 1.041E-01 | 3.730E+0 |
| 83 | 1.396E-05 | 3.480E+15 | -5.307E+00 | -8.049E+00 | -2.123E+00 | 1.782E-01 | 8.487E+0 |
| 84 | 1.137E-01 | 1.326E+15 | -5.498E+00 | -6.722E+00 | -4.292E+00 | 2.259E-01 | 8.618E+0 |
| 85 | 8.218E-06 | 5.406E+14 | -4.100E+00 | -7.510E+00 | -7.516E+00 | 1.549E-01 | 6.758E+0 |
| 86 | 4.583E+00 | 6.094E+13 | -5.503E+00 | -8.933E+00 | -3.639E+00 | 1.219E-01 | 4.462E+0 |
| 87 | 1.142E+02 | 1.037E+14 | -4.446E+00 | -8.805E+00 | -6.220E+00 | 1.223E-01 | 2.976E+0 |

|     |           |           |            |            |            |           |          |
|-----|-----------|-----------|------------|------------|------------|-----------|----------|
| 88  | 1.572E-02 | 3.020E+14 | -6.175E+00 | -7.738E+00 | -4.104E+00 | 1.504E-01 | 3.398E+0 |
| 89  | 2.899E+01 | 8.762E+13 | -6.160E+00 | -6.831E+00 | -7.966E+00 | 1.756E-01 | 7.572E+0 |
| 90  | 1.851E-06 | 1.160E+14 | -6.333E+00 | -7.958E+00 | -4.544E+00 | 1.648E-01 | 9.702E+0 |
| 91  | 3.247E+01 | 7.920E+14 | -6.463E+00 | -6.999E+00 | -2.268E+00 | 1.204E-01 | 6.431E+0 |
| 92  | 1.140E+00 | 6.505E+14 | -6.019E+00 | -8.958E+00 | -5.299E+00 | 1.312E-01 | 2.624E+0 |
| 93  | 6.916E+01 | 2.246E+15 | -6.128E+00 | -8.170E+00 | -5.736E+00 | 1.228E-01 | 4.244E+0 |
| 94  | 5.317E-05 | 6.394E+13 | -5.687E+00 | -7.230E+00 | -6.730E+00 | 1.982E-01 | 7.778E+0 |
| 95  | 5.063E-03 | 6.138E+14 | -6.269E+00 | -8.269E+00 | -4.575E+00 | 1.459E-01 | 5.113E+0 |
| 96  | 1.875E+01 | 4.285E+15 | -5.019E+00 | -6.567E+00 | -2.809E+00 | 1.210E-01 | 3.821E+0 |
| 97  | 1.573E-04 | 2.329E+14 | -6.179E+00 | -8.949E+00 | -8.049E+00 | 1.617E-01 | 3.849E+0 |
| 98  | 5.298E+01 | 4.864E+15 | -6.505E+00 | -8.699E+00 | -4.613E+00 | 1.263E-01 | 4.481E+0 |
| 99  | 4.525E-01 | 3.173E+15 | -5.109E+00 | -8.552E+00 | -3.607E+00 | 1.786E-01 | 3.189E+0 |
| 100 | 4.401E+00 | 9.542E+14 | -6.919E+00 | -8.466E+00 | -8.008E+00 | 8.647E-02 | 6.121E+0 |
| 101 | 3.135E-02 | 8.691E+14 | -5.320E+00 | -6.661E+00 | -3.513E+00 | 1.676E-01 | 6.639E+0 |
| 102 | 9.117E-06 | 1.751E+14 | -6.756E+00 | -8.739E+00 | -5.383E+00 | 1.618E-01 | 5.277E+0 |
| 103 | 4.743E-01 | 3.147E+15 | -4.964E+00 | -7.911E+00 | -4.417E+00 | 1.066E-01 | 6.997E+0 |
| 104 | 1.341E-03 | 3.921E+15 | -5.077E+00 | -9.553E+00 | -5.788E+00 | 1.463E-01 | 3.031E+0 |
| 105 | 3.897E-05 | 3.740E+15 | -5.656E+00 | -5.151E+00 | -7.017E+00 | 1.196E-01 | 3.541E+0 |
| 106 | 5.441E+00 | 1.246E+15 | -5.514E+00 | -7.305E+00 | -6.863E+00 | 1.583E-01 | 5.856E+0 |
| 107 | 5.604E-03 | 1.565E+15 | -7.076E+00 | -6.064E+00 | -6.099E+00 | 1.345E-01 | 5.031E+0 |
| 108 | 6.191E+02 | 1.510E+15 | -5.231E+00 | -8.134E+00 | -8.566E+00 | 1.366E-01 | 8.858E+0 |
| 109 | 2.748E-02 | 5.162E+14 | -7.322E+00 | -8.789E+00 | -8.177E+00 | 2.071E-01 | 8.265E+0 |
| 110 | 1.414E-04 | 2.350E+14 | -5.090E+00 | -7.009E+00 | -4.268E+00 | 1.640E-01 | 2.591E+0 |
| 111 | 1.074E-06 | 3.539E+14 | -5.239E+00 | -8.508E+00 | -5.274E+00 | 2.052E-01 | 4.079E+0 |
| 112 | 2.094E-01 | 1.038E+15 | -3.500E+00 | -6.858E+00 | -2.824E+00 | 2.471E-01 | 3.268E+0 |
| 113 | 1.128E+01 | 1.476E+14 | -6.090E+00 | -6.221E+00 | -7.559E+00 | 1.617E-01 | 7.418E+0 |
| 114 | 1.517E-02 | 4.824E+14 | -7.603E+00 | -8.523E+00 | -3.676E+00 | 1.879E-01 | 6.211E+0 |
| 115 | 7.981E-04 | 7.391E+13 | -5.293E+00 | -7.489E+00 | -4.684E+00 | 1.390E-01 | 6.022E+0 |
| 116 | 7.946E+01 | 2.232E+14 | -4.890E+00 | -8.821E+00 | -4.829E+00 | 1.559E-01 | 1.001E+0 |
| 117 | 4.276E-02 | 7.657E+13 | -5.558E+00 | -1.016E+01 | -5.215E+00 | 1.234E-01 | 8.022E+0 |
| 118 | 1.828E-02 | 3.944E+14 | -5.968E+00 | -6.811E+00 | -6.417E+00 | 7.610E-02 | 3.430E+0 |
| 119 | 6.713E-03 | 1.975E+14 | -5.433E+00 | -6.944E+00 | -4.007E+00 | 1.230E-01 | 1.038E+0 |
| 120 | 1.030E-01 | 4.581E+14 | -4.346E+00 | -1.125E+01 | -7.749E+00 | 1.077E-01 | 2.503E+0 |
| 121 | 2.622E-03 | 3.696E+15 | -6.937E+00 | -7.107E+00 | -3.165E+00 | 1.156E-01 | 5.374E+0 |
| 122 | 2.678E-04 | 5.856E+14 | -5.892E+00 | -8.196E+00 | -6.512E+00 | 1.616E-01 | 8.480E+0 |
| 123 | 1.648E-05 | 5.873E+13 | -5.175E+00 | -8.242E+00 | -2.948E+00 | 1.782E-01 | 3.448E+0 |
| 124 | 3.960E-06 | 1.051E+15 | -6.539E+00 | -6.530E+00 | -5.162E+00 | 1.451E-01 | 1.011E+0 |
| 125 | 1.181E-04 | 1.691E+15 | -6.009E+00 | -8.634E+00 | -6.427E+00 | 1.114E-01 | 1.021E+0 |
| 126 | 1.359E-01 | 1.100E+14 | -6.347E+00 | -8.231E+00 | -4.617E+00 | 1.333E-01 | 2.839E+0 |
| 127 | 1.662E-04 | 1.086E+15 | -5.805E+00 | -7.071E+00 | -3.705E+00 | 1.049E-01 | 4.405E+0 |
| 128 | 3.621E+01 | 8.287E+13 | -5.634E+00 | -8.644E+00 | -4.323E+00 | 1.936E-01 | 3.909E+0 |
| 129 | 2.476E+00 | 6.668E+14 | -4.958E+00 | -7.703E+00 | -3.383E+00 | 8.127E-02 | 7.248E+0 |

|     |           |           |            |            |            |           |          |
|-----|-----------|-----------|------------|------------|------------|-----------|----------|
| 130 | 2.797E-01 | 1.898E+14 | -5.334E+00 | -7.156E+00 | -2.347E+00 | 1.305E-01 | 7.195E+0 |
| 131 | 3.857E-03 | 3.390E+14 | -5.951E+00 | -1.005E+01 | -2.933E+00 | 1.248E-01 | 3.138E+0 |
| 132 | 1.123E-06 | 5.495E+14 | -7.788E+00 | -8.586E+00 | -7.474E+00 | 2.057E-01 | 3.917E+0 |
| 133 | 4.041E-03 | 7.336E+13 | -6.295E+00 | -7.866E+00 | -3.807E+00 | 9.984E-02 | 2.859E+0 |
| 134 | 4.518E-04 | 7.882E+13 | -5.606E+00 | -7.191E+00 | -6.463E+00 | 1.788E-01 | 2.760E+0 |
| 135 | 2.324E+02 | 2.584E+15 | -5.461E+00 | -6.967E+00 | -4.954E+00 | 2.363E-01 | 4.971E+0 |
| 136 | 6.516E-02 | 1.761E+15 | -5.848E+00 | -7.171E+00 | -7.106E+00 | 1.527E-01 | 5.926E+0 |
| 137 | 6.115E-05 | 3.727E+14 | -6.477E+00 | -1.036E+01 | -7.601E+00 | 1.629E-01 | 9.646E+0 |
| 138 | 5.404E-02 | 2.821E+14 | -6.287E+00 | -6.454E+00 | -3.907E+00 | 1.187E-01 | 3.246E+0 |
| 139 | 2.162E-06 | 3.263E+14 | -5.548E+00 | -7.141E+00 | -5.866E+00 | 1.032E-01 | 3.194E+0 |
| 140 | 2.174E+00 | 1.018E+15 | -5.580E+00 | -9.152E+00 | -7.829E+00 | 6.859E-02 | 3.320E+0 |
| 141 | 8.076E-03 | 1.405E+14 | -6.212E+00 | -7.817E+00 | -5.096E+00 | 1.617E-01 | 9.206E+0 |
| 142 | 2.875E-05 | 6.250E+13 | -5.769E+00 | -8.401E+00 | -7.662E+00 | 2.420E-01 | 3.088E+0 |
| 143 | 6.666E-05 | 5.127E+15 | -6.427E+00 | -8.303E+00 | -8.337E+00 | 1.624E-01 | 4.746E+0 |
| 144 | 1.613E-05 | 2.426E+14 | -5.150E+00 | -7.196E+00 | -8.197E+00 | 1.783E-01 | 2.712E+0 |
| 145 | 4.040E+02 | 1.876E+14 | -6.265E+00 | -5.656E+00 | -3.755E+00 | 1.426E-01 | 9.083E+0 |
| 146 | 8.087E+02 | 2.206E+15 | -5.924E+00 | -8.915E+00 | -7.729E+00 | 1.642E-01 | 7.432E+0 |
| 147 | 3.706E+02 | 1.516E+14 | -5.015E+00 | -7.040E+00 | -3.262E+00 | 1.617E-01 | 9.494E+0 |
| 148 | 1.067E-02 | 2.094E+14 | -5.265E+00 | -9.383E+00 | -7.354E+00 | 1.474E-01 | 8.581E+0 |
| 149 | 5.337E-04 | 2.824E+15 | -5.535E+00 | -8.326E+00 | -4.049E+00 | 1.232E-01 | 2.648E+0 |
| 150 | 1.616E+01 | 5.693E+13 | -5.982E+00 | -8.728E+00 | -7.909E+00 | 1.783E-01 | 2.772E+0 |
| 151 | 5.974E-06 | 1.051E+14 | -4.871E+00 | -6.904E+00 | -4.519E+00 | 9.811E-02 | 8.670E+0 |
| 152 | 3.179E-01 | 8.886E+14 | -5.203E+00 | -8.094E+00 | -6.619E+00 | 1.063E-01 | 7.890E+0 |
| 153 | 2.917E+00 | 1.647E+14 | -5.713E+00 | -1.089E+01 | -2.631E+00 | 1.229E-01 | 2.383E+0 |
| 154 | 1.793E+02 | 3.140E+14 | -5.052E+00 | -7.214E+00 | -5.257E+00 | 1.818E-01 | 4.139E+0 |
| 155 | 4.599E-04 | 5.289E+15 | -6.100E+00 | -1.059E+01 | -5.893E+00 | 1.447E-01 | 9.581E+0 |
| 156 | 9.606E+00 | 3.979E+14 | -3.042E+00 | -7.028E+00 | -4.114E+00 | 2.043E-01 | 2.329E+0 |
| 157 | 6.904E-06 | 8.986E+13 | -2.454E+00 | -8.896E+00 | -6.538E+00 | 1.154E-01 | 9.933E+0 |
| 158 | 2.138E-02 | 1.449E+14 | -6.239E+00 | -8.063E+00 | -6.573E+00 | 1.166E-01 | 8.317E+0 |
| 159 | 1.511E+00 | 2.875E+14 | -5.197E+00 | -8.490E+00 | -6.772E+00 | 1.211E-01 | 5.247E+0 |
| 160 | 1.128E-02 | 5.641E+14 | -5.156E+00 | -8.625E+00 | -6.908E+00 | 2.029E-01 | 3.867E+0 |
| 161 | 4.517E+02 | 4.673E+14 | -5.407E+00 | -5.556E+00 | -6.679E+00 | 1.168E-01 | 4.256E+0 |
| 162 | 1.673E+02 | 1.916E+15 | -7.003E+00 | -8.369E+00 | -5.513E+00 | 1.648E-01 | 6.795E+0 |
| 163 | 2.244E-03 | 1.782E+15 | -6.799E+00 | -7.119E+00 | -5.030E+00 | 1.350E-01 | 3.602E+0 |
| 164 | 5.448E-01 | 2.204E+14 | -5.364E+00 | -8.381E+00 | -6.289E+00 | 1.443E-01 | 2.449E+0 |
| 165 | 6.373E-04 | 2.370E+15 | -5.699E+00 | -6.800E+00 | -3.881E+00 | 1.222E-01 | 6.705E+0 |
| 166 | 2.050E-05 | 8.189E+13 | -3.244E+00 | -7.061E+00 | -4.151E+00 | 2.063E-01 | 8.435E+0 |
| 167 | 6.714E-02 | 2.587E+14 | -7.363E+00 | -1.153E+01 | -5.944E+00 | 1.021E-01 | 4.570E+0 |
| 168 | 2.207E+01 | 2.736E+15 | -2.185E+00 | -8.978E+00 | -4.979E+00 | 1.392E-01 | 9.505E+0 |
| 169 | 8.257E+02 | 4.949E+15 | -5.065E+00 | -7.357E+00 | -8.231E+00 | 1.217E-01 | 2.910E+0 |
| 170 | 3.735E+00 | 1.435E+14 | -5.731E+00 | -7.997E+00 | -4.389E+00 | 1.663E-01 | 1.019E+0 |
| 171 | 2.886E-06 | 1.865E+15 | -5.662E+00 | -7.535E+00 | -3.956E+00 | 1.208E-01 | 5.664E+0 |

|     |           |           |            |            |            |           |          |
|-----|-----------|-----------|------------|------------|------------|-----------|----------|
| 172 | 1.819E-03 | 2.016E+15 | -5.676E+00 | -7.098E+00 | -7.983E+00 | 1.052E-01 | 9.098E+0 |
| 173 | 2.350E-05 | 8.640E+13 | -5.935E+00 | -8.427E+00 | -3.285E+00 | 1.511E-01 | 8.074E+0 |
| 174 | 2.740E-06 | 5.428E+15 | -5.616E+00 | -8.877E+00 | -7.034E+00 | 1.224E-01 | 5.863E+0 |
| 175 | 4.575E-03 | 3.473E+14 | -5.353E+00 | -8.336E+00 | -7.461E+00 | 1.363E-01 | 2.790E+0 |
| 176 | 8.124E-02 | 4.009E+15 | -2.669E+00 | -8.486E+00 | -5.542E+00 | 9.258E-02 | 3.468E+0 |
| 177 | 4.838E-06 | 4.951E+14 | -6.384E+00 | -5.954E+00 | -5.340E+00 | 1.254E-01 | 6.279E+0 |
| 178 | 5.649E+00 | 8.351E+14 | -2.836E+00 | -8.833E+00 | -2.528E+00 | 1.604E-01 | 7.513E+0 |
| 179 | 2.299E+00 | 6.740E+13 | -5.960E+00 | -5.388E+00 | -4.673E+00 | 1.385E-01 | 5.735E+0 |
| 180 | 7.365E-01 | 7.205E+13 | -4.993E+00 | -6.885E+00 | -6.948E+00 | 1.177E-01 | 5.537E+0 |
| 181 | 1.744E+00 | 1.323E+14 | -6.311E+00 | -8.264E+00 | -2.020E+00 | 1.034E-01 | 3.692E+0 |
| 182 | 1.388E+02 | 4.339E+14 | -5.569E+00 | -7.501E+00 | -6.663E+00 | 1.012E-01 | 2.683E+0 |
| 183 | 1.399E+00 | 7.381E+14 | -6.344E+00 | -1.107E+01 | -6.122E+00 | 1.781E-01 | 8.761E+0 |
| 184 | 1.512E-06 | 1.276E+14 | -5.797E+00 | -8.180E+00 | -7.403E+00 | 1.486E-01 | 7.991E+0 |
| 185 | 7.985E-05 | 1.591E+15 | -5.279E+00 | -7.449E+00 | -7.065E+00 | 1.919E-01 | 6.181E+0 |
| 186 | 3.004E+02 | 8.266E+14 | -6.492E+00 | -6.183E+00 | -3.204E+00 | 1.782E-01 | 6.320E+0 |
| 187 | 5.752E-06 | 2.334E+15 | -6.684E+00 | -6.513E+00 | -7.243E+00 | 1.858E-01 | 4.065E+0 |
| 188 | 1.880E+00 | 1.301E+14 | -4.757E+00 | -6.753E+00 | -6.264E+00 | 1.226E-01 | 6.544E+0 |
| 189 | 8.359E+00 | 2.061E+15 | -6.520E+00 | -8.540E+00 | -5.588E+00 | 1.722E-01 | 2.611E+0 |
| 190 | 6.238E-01 | 1.782E+14 | -4.567E+00 | -6.743E+00 | -3.447E+00 | 1.132E-01 | 6.928E+0 |
| 191 | 3.942E+01 | 2.751E+14 | -4.926E+00 | -8.029E+00 | -8.061E+00 | 1.634E-01 | 3.586E+0 |
| 192 | 2.001E-02 | 1.230E+14 | -7.469E+00 | -8.602E+00 | -3.978E+00 | 1.740E-01 | 3.996E+0 |
| 193 | 2.649E-03 | 2.175E+15 | -6.414E+00 | -5.493E+00 | -5.448E+00 | 1.792E-01 | 4.048E+0 |
| 194 | 2.582E+01 | 2.671E+15 | -5.436E+00 | -8.356E+00 | -4.241E+00 | 1.781E-01 | 3.964E+0 |
| 195 | 4.558E-02 | 5.775E+13 | -6.393E+00 | -9.777E+00 | -8.443E+00 | 1.233E-01 | 5.719E+0 |
| 196 | 9.421E-04 | 2.065E+14 | -6.406E+00 | -8.675E+00 | -6.983E+00 | 1.619E-01 | 6.245E+0 |
| 197 | 3.364E+00 | 1.224E+15 | -5.330E+00 | -7.331E+00 | -5.079E+00 | 2.017E-01 | 7.718E+0 |
| 198 | 9.142E+00 | 1.641E+15 | -5.276E+00 | -7.955E+00 | -7.411E+00 | 1.681E-01 | 6.367E+0 |
| 199 | 9.915E+01 | 3.586E+15 | -6.069E+00 | -7.838E+00 | -2.406E+00 | 1.458E-01 | 8.897E+0 |
| 200 | 1.018E-04 | 2.998E+14 | -5.044E+00 | -6.613E+00 | -4.484E+00 | 1.419E-01 | 9.820E+0 |

LATIN HYPERCUBE SAMPLE INPUT VECTORS

| RUN NO. | X(21)     |
|---------|-----------|
| 1       | 3.400E+01 |
| 2       | 4.000E+01 |
| 3       | 2.300E+01 |
| 4       | 4.000E+01 |
| 5       | 8.000E+00 |
| 6       | 2.300E+01 |
| 7       | 2.300E+01 |
| 8       | 2.300E+01 |
| 9       | 8.000E+00 |
| 10      | 4.000E+01 |
| 11      | 4.000E+01 |

12 2.300E+01  
13 2.300E+01  
14 3.400E+01  
15 8.000E+00  
16 2.300E+01  
17 2.300E+01  
18 2.300E+01  
19 -1.000E+01  
20 2.000E+00  
21 4.000E+01  
22 8.000E+00  
23 4.000E+01  
24 2.000E+00  
25 8.000E+00  
26 2.000E+00  
27 3.400E+01  
28 4.000E+01  
29 -1.000E+01  
30 4.000E+01  
31 3.400E+01  
32 2.300E+01  
33 3.400E+01  
34 8.000E+00  
35 4.000E+01  
36 8.000E+00  
37 4.000E+01  
38 -1.000E+01  
39 8.000E+00  
40 4.000E+01  
41 3.400E+01  
42 8.000E+00  
43 3.400E+01  
44 2.300E+01  
45 2.300E+01  
46 2.000E+00  
47 2.000E+00  
48 8.000E+00  
49 8.000E+00  
50 8.000E+00  
51 2.300E+01  
52 4.000E+01  
53 8.000E+00



54 2.000E+00  
55 3.400E+01  
56 8.000E+00  
57 2.300E+01  
58 -1.000E+01  
59 8.000E+00  
60 3.400E+01  
61 8.000E+00  
62 2.000E+00  
63 -1.000E+01  
64 8.000E+00  
65 8.000E+00  
66 4.000E+01  
67 8.000E+00  
68 2.000E+00  
69 2.000E+00  
70 -1.000E+01  
71 8.000E+00  
72 -1.000E+01  
73 8.000E+00  
74 8.000E+00  
75 2.300E+01  
76 -1.000E+01  
77 2.000E+00  
78 4.000E+01  
79 8.000E+00  
80 3.400E+01  
81 -1.000E+01  
82 -1.000E+01  
83 2.000E+00  
84 -1.000E+01  
85 4.000E+01  
86 3.400E+01  
87 8.000E+00  
88 3.400E+01  
89 8.000E+00  
90 2.300E+01  
91 8.000E+00  
92 2.300E+01  
93 2.000E+00  
94 4.000E+01  
95 -1.000E+01

96 2.300E+01  
97 2.000E+00  
98 3.400E+01  
99 3.400E+01  
100 8.000E+00  
101 4.000E+01  
102 4.000E+01  
103 3.400E+01  
104 2.000E+00  
105 8.000E+00  
106 8.000E+00  
107 4.000E+01  
108 -1.000E+01  
109 2.300E+01  
110 4.000E+01  
111 8.000E+00  
112 2.300E+01  
113 8.000E+00  
114 4.000E+01  
115 -1.000E+01  
116 3.400E+01  
117 8.000E+00  
118 2.000E+00  
119 -1.000E+01  
120 -1.000E+01  
121 8.000E+00  
122 2.000E+00  
123 3.400E+01  
124 4.000E+01  
125 4.000E+01  
126 2.300E+01  
127 2.300E+01  
128 2.000E+00  
129 3.400E+01  
130 2.000E+00  
131 4.000E+01  
132 3.400E+01  
133 2.000E+00  
134 4.000E+01  
135 2.300E+01  
136 8.000E+00  
137 4.000E+01

138 -1.000E+01  
139 -1.000E+01  
140 3.400E+01  
141 -1.000E+01  
142 2.300E+01  
143 4.000E+01  
144 8.000E+00  
145 3.400E+01  
146 2.300E+01  
147 8.000E+00  
148 8.000E+00  
149 2.300E+01  
150 8.000E+00  
151 8.000E+00  
152 4.000E+01  
153 3.400E+01  
154 3.400E+01  
155 -1.000E+01  
156 -1.000E+01  
157 8.000E+00  
158 8.000E+00  
159 8.000E+00  
160 4.000E+01  
161 4.000E+01  
162 8.000E+00  
163 8.000E+00  
164 2.000E+00  
165 3.400E+01  
166 2.000E+00  
167 2.000E+00  
168 2.300E+01  
169 3.400E+01  
170 2.000E+00  
171 4.000E+01  
172 3.400E+01  
173 2.300E+01  
174 2.000E+00  
175 8.000E+00  
176 3.400E+01  
177 4.000E+01  
178 2.000E+00  
179 -1.000E+01

180 -1.000E+01  
 181 3.400E+01  
 182 8.000E+00  
 183 4.000E+01  
 184 2.300E+01  
 185 -1.000E+01  
 186 8.000E+00  
 187 2.000E+00  
 188 4.000E+01  
 189 8.000E+00  
 190 2.300E+01  
 191 4.000E+01  
 192 3.400E+01  
 193 3.400E+01  
 194 8.000E+00  
 195 4.000E+01  
 196 -1.000E+01  
 197 -1.000E+01  
 198 8.000E+00  
 199 8.000E+00  
 200 8.000E+00

RANKS OF LATIN HYPERCUBE SAMPLE INPUT VECTORS

| RUN NO. | X(1) | X(2) | X(3) | X(4) | X(5) | X(6) | X(7) |
|---------|------|------|------|------|------|------|------|
| 1       | 142. | 200. | 2.   | 75.  | 79.  | 114. | 86   |
| 2       | 38.  | 15.  | 135. | 19.  | 124. | 26.  | 55   |
| 3       | 31.  | 168. | 82.  | 113. | 41.  | 32.  | 135  |
| 4       | 75.  | 63.  | 7.   | 141. | 100. | 11.  | 27   |
| 5       | 120. | 38.  | 121. | 147. | 141. | 158. | 190  |
| 6       | 80.  | 25.  | 108. | 11.  | 88.  | 2.   | 101  |
| 7       | 66.  | 55.  | 100. | 35.  | 3.   | 150. | 146  |
| 8       | 190. | 73.  | 193. | 122. | 46.  | 160. | 14   |
| 9       | 157. | 181. | 200. | 142. | 164. | 67.  | 139  |
| 10      | 81.  | 33.  | 122. | 129. | 142. | 198. | 89   |
| 11      | 26.  | 198. | 5.   | 146. | 190. | 181. | 109  |
| 12      | 171. | 82.  | 141. | 67.  | 25.  | 175. | 92   |
| 13      | 74.  | 149. | 94.  | 21.  | 167. | 33.  | 200  |
| 14      | 156. | 131. | 128. | 134. | 119. | 174. | 182  |
| 15      | 48.  | 71.  | 124. | 68.  | 56.  | 83.  | 115  |
| 16      | 94.  | 56.  | 67.  | 27.  | 125. | 57.  | 28   |
| 17      | 50.  | 65.  | 111. | 97.  | 130. | 73.  | 38   |
| 18      | 136. | 100. | 200. | 77.  | 53.  | 53.  | 17   |
| 19      | 59.  | 43.  | 84.  | 83.  | 26.  | 110. | 31   |

|    |      |      |      |      |      |      |     |
|----|------|------|------|------|------|------|-----|
| 20 | 84.  | 36.  | 99.  | 53.  | 158. | 87.  | 70  |
| 21 | 127. | 46.  | 29.  | 110. | 153. | 102. | 26  |
| 22 | 67.  | 200. | 123. | 25.  | 160. | 31.  | 51  |
| 23 | 58.  | 116. | 177. | 24.  | 14.  | 182. | 108 |
| 24 | 128. | 53.  | 51.  | 43.  | 177. | 126. | 15  |
| 25 | 155. | 196. | 181. | 48.  | 4.   | 46.  | 107 |
| 26 | 4.   | 175. | 126. | 178. | 47.  | 8.   | 176 |
| 27 | 6.   | 98.  | 120. | 12.  | 107. | 19.  | 138 |
| 28 | 154. | 28.  | 148. | 51.  | 36.  | 108. | 104 |
| 29 | 110. | 145. | 182. | 80.  | 97.  | 10.  | 152 |
| 30 | 123. | 77.  | 76.  | 200. | 2.   | 27.  | 158 |
| 31 | 2.   | 119. | 116. | 54.  | 102. | 92.  | 96  |
| 32 | 95.  | 160. | 163. | 117. | 174. | 72.  | 178 |
| 33 | 185. | 3.   | 149. | 194. | 22.  | 56.  | 9   |
| 34 | 105. | 172. | 47.  | 154. | 151. | 192. | 21  |
| 35 | 188. | 157. | 78.  | 195. | 71.  | 159. | 105 |
| 36 | 121. | 111. | 178. | 32.  | 113. | 113. | 196 |
| 37 | 42.  | 136. | 174. | 184. | 165. | 13.  | 160 |
| 38 | 144. | 195. | 189. | 140. | 72.  | 6.   | 42  |
| 39 | 5.   | 96.  | 35.  | 185. | 50.  | 70.  | 165 |
| 40 | 108. | 78.  | 90.  | 91.  | 145. | 43.  | 149 |
| 41 | 152. | 7.   | 131. | 135. | 90.  | 104. | 97  |
| 42 | 13.  | 80.  | 6.   | 55.  | 195. | 112. | 162 |
| 43 | 96.  | 88.  | 18.  | 40.  | 200. | 128. | 32  |
| 44 | 112. | 6.   | 13.  | 172. | 146. | 48.  | 116 |
| 45 | 102. | 44.  | 114. | 59.  | 9.   | 152. | 142 |
| 46 | 192. | 66.  | 44.  | 151. | 42.  | 77.  | 125 |
| 47 | 62.  | 64.  | 134. | 44.  | 20.  | 166. | 13  |
| 48 | 109. | 171. | 91.  | 13.  | 44.  | 64.  | 122 |
| 49 | 124. | 133. | 79.  | 162. | 132. | 137. | 185 |
| 50 | 172. | 146. | 155. | 17.  | 183. | 96.  | 161 |
| 51 | 70.  | 94.  | 98.  | 124. | 76.  | 145. | 102 |
| 52 | 23.  | 67.  | 11.  | 179. | 128. | 29.  | 56  |
| 53 | 43.  | 110. | 50.  | 82.  | 58.  | 140. | 63  |
| 54 | 93.  | 18.  | 41.  | 183. | 8.   | 164. | 121 |
| 55 | 177. | 23.  | 101. | 79.  | 197. | 103. | 8   |
| 56 | 85.  | 187. | 129. | 64.  | 17.  | 42.  | 33  |
| 57 | 64.  | 21.  | 46.  | 66.  | 85.  | 124. | 103 |
| 58 | 193. | 125. | 105. | 88.  | 166. | 170. | 111 |
| 59 | 34.  | 124. | 197. | 173. | 181. | 163. | 195 |
| 60 | 71.  | 117. | 32.  | 5.   | 60.  | 153. | 74  |
| 61 | 116. | 128. | 144. | 169. | 111. | 79.  | 64  |

|     |      |      |      |      |      |      |     |
|-----|------|------|------|------|------|------|-----|
| 62  | 200. | 35.  | 33.  | 6.   | 163. | 141. | 113 |
| 63  | 9.   | 48.  | 179. | 72.  | 149. | 15.  | 131 |
| 64  | 24.  | 156. | 145. | 36.  | 121. | 88.  | 166 |
| 65  | 7.   | 167. | 169. | 18.  | 176. | 161. | 134 |
| 66  | 40.  | 147. | 175. | 188. | 80.  | 74.  | 58  |
| 67  | 44.  | 87.  | 4.   | 4.   | 117. | 122. | 34  |
| 68  | 68.  | 17.  | 191. | 89.  | 31.  | 136. | 30  |
| 69  | 122. | 47.  | 139. | 197. | 49.  | 54.  | 187 |
| 70  | 55.  | 108. | 166. | 106. | 189. | 100. | 76  |
| 71  | 139. | 10.  | 49.  | 61.  | 116. | 90.  | 118 |
| 72  | 178. | 9.   | 150. | 3.   | 96.  | 109. | 129 |
| 73  | 170. | 2.   | 71.  | 99.  | 92.  | 81.  | 143 |
| 74  | 99.  | 13.  | 151. | 74.  | 75.  | 5.   | 177 |
| 75  | 194. | 188. | 125. | 193. | 62.  | 95.  | 173 |
| 76  | 113. | 24.  | 173. | 15.  | 168. | 148. | 11  |
| 77  | 57.  | 30.  | 88.  | 16.  | 118. | 58.  | 54  |
| 78  | 111. | 97.  | 74.  | 86.  | 123. | 60.  | 25  |
| 79  | 53.  | 86.  | 104. | 138. | 185. | 200. | 62  |
| 80  | 30.  | 95.  | 142. | 191. | 68.  | 35.  | 123 |
| 81  | 143. | 90.  | 107. | 164. | 138. | 146. | 169 |
| 82  | 86.  | 194. | 95.  | 41.  | 51.  | 22.  | 72  |
| 83  | 46.  | 182. | 17.  | 126. | 83.  | 134. | 156 |
| 84  | 22.  | 51.  | 2.   | 119. | 93.  | 3.   | 18  |
| 85  | 175. | 129. | 57.  | 182. | 104. | 9.   | 94  |
| 86  | 36.  | 154. | 158. | 112. | 103. | 39.  | 3   |
| 87  | 15.  | 185. | 133. | 136. | 171. | 154. | 65  |
| 88  | 189. | 42.  | 9.   | 163. | 81.  | 185. | 52  |
| 89  | 148. | 130. | 117. | 62.  | 182. | 168. | 91  |
| 90  | 107. | 37.  | 81.  | 65.  | 188. | 7.   | 20  |
| 91  | 88.  | 31.  | 156. | 22.  | 11.  | 135. | 83  |
| 92  | 141. | 158. | 140. | 76.  | 13.  | 131. | 154 |
| 93  | 160. | 121. | 72.  | 108. | 196. | 156. | 150 |
| 94  | 2.   | 75.  | 113. | 155. | 87.  | 51.  | 120 |
| 95  | 14.  | 54.  | 70.  | 131. | 65.  | 129. | 88  |
| 96  | 37.  | 161. | 53.  | 20.  | 16.  | 165. | 2   |
| 97  | 54.  | 5.   | 66.  | 176. | 110. | 82.  | 24  |
| 98  | 32.  | 26.  | 39.  | 181. | 200. | 44.  | 130 |
| 99  | 140. | 148. | 63.  | 2.   | 98.  | 93.  | 98  |
| 100 | 153. | 102. | 172. | 192. | 74.  | 65.  | 144 |
| 101 | 65.  | 178. | 194. | 161. | 55.  | 120. | 112 |
| 102 | 76.  | 74.  | 31.  | 38.  | 161. | 12.  | 168 |
| 103 | 176. | 180. | 159. | 81.  | 114. | 36.  | 12  |

|     |      |      |      |      |      |      |     |
|-----|------|------|------|------|------|------|-----|
| 104 | 56.  | 135. | 136. | 95.  | 12.  | 200. | 133 |
| 105 | 117. | 109. | 127. | 58.  | 187. | 61.  | 50  |
| 106 | 60.  | 39.  | 119. | 132. | 7.   | 116. | 147 |
| 107 | 87.  | 62.  | 154. | 14.  | 122. | 28.  | 197 |
| 108 | 161. | 11.  | 27.  | 107. | 6.   | 121. | 141 |
| 109 | 186. | 183. | 25.  | 94.  | 38.  | 193. | 198 |
| 110 | 131. | 112. | 86.  | 84.  | 52.  | 119. | 16  |
| 111 | 51.  | 61.  | 87.  | 90.  | 131. | 76.  | 82  |
| 112 | 119. | 91.  | 83.  | 152. | 82.  | 45.  | 172 |
| 113 | 73.  | 79.  | 170. | 189. | 144. | 123. | 22  |
| 114 | 115. | 76.  | 196. | 7.   | 23.  | 186. | 57  |
| 115 | 52.  | 197. | 165. | 153. | 15.  | 55.  | 192 |
| 116 | 8.   | 126. | 60.  | 96.  | 45.  | 195. | 66  |
| 117 | 69.  | 69.  | 171. | 56.  | 143. | 177. | 44  |
| 118 | 184. | 58.  | 167. | 118. | 126. | 66.  | 151 |
| 119 | 10.  | 45.  | 20.  | 167. | 78.  | 191. | 170 |
| 120 | 135. | 138. | 64.  | 70.  | 115. | 91.  | 68  |
| 121 | 146. | 114. | 21.  | 63.  | 152. | 173. | 191 |
| 122 | 89.  | 118. | 62.  | 159. | 147. | 179. | 4   |
| 123 | 77.  | 29.  | 14.  | 115. | 193. | 147. | 179 |
| 124 | 159. | 123. | 137. | 160. | 106. | 16.  | 87  |
| 125 | 25.  | 4.   | 176. | 26.  | 175. | 162. | 46  |
| 126 | 181. | 137. | 10.  | 46.  | 136. | 151. | 180 |
| 127 | 61.  | 153. | 89.  | 198. | 129. | 183. | 7   |
| 128 | 158. | 170. | 102. | 156. | 173. | 38.  | 75  |
| 129 | 92.  | 70.  | 143. | 98.  | 33.  | 80.  | 99  |
| 130 | 33.  | 140. | 184. | 100. | 66.  | 107. | 194 |
| 131 | 47.  | 83.  | 157. | 123. | 162. | 125. | 189 |
| 132 | 21.  | 166. | 93.  | 103. | 21.  | 24.  | 36  |
| 133 | 16.  | 184. | 190. | 165. | 40.  | 178. | 5   |
| 134 | 168. | 186. | 16.  | 133. | 48.  | 18.  | 35  |
| 135 | 169. | 89.  | 37.  | 31.  | 2.   | 184. | 29  |
| 136 | 79.  | 163. | 3.   | 28.  | 5.   | 157. | 175 |
| 137 | 126. | 173. | 65.  | 109. | 89.  | 196. | 183 |
| 138 | 163. | 101. | 43.  | 128. | 84.  | 30.  | 171 |
| 139 | 167. | 92.  | 24.  | 187. | 69.  | 85.  | 155 |
| 140 | 11.  | 155. | 198. | 137. | 194. | 180. | 148 |
| 141 | 98.  | 134. | 52.  | 168. | 154. | 143. | 67  |
| 142 | 198. | 164. | 40.  | 127. | 120. | 20.  | 77  |
| 143 | 49.  | 32.  | 96.  | 171. | 105. | 127. | 100 |
| 144 | 100. | 169. | 26.  | 186. | 172. | 117. | 1   |
| 145 | 97.  | 41.  | 106. | 73.  | 184. | 50.  | 117 |

|     |      |      |      |      |      |      |     |
|-----|------|------|------|------|------|------|-----|
| 146 | 150. | 193. | 97.  | 85.  | 192. | 25.  | 47  |
| 147 | 82.  | 151. | 30.  | 49.  | 169. | 71.  | 10  |
| 148 | 17.  | 122. | 12.  | 78.  | 39.  | 86.  | 124 |
| 149 | 90.  | 104. | 168. | 39.  | 54.  | 149. | 167 |
| 150 | 162. | 84.  | 164. | 93.  | 61.  | 59.  | 110 |
| 151 | 164. | 52.  | 45.  | 114. | 67.  | 115. | 145 |
| 152 | 147. | 16.  | 36.  | 139. | 29.  | 176. | 59  |
| 153 | 28.  | 176. | 160. | 101. | 37.  | 106. | 114 |
| 154 | 18.  | 103. | 15.  | 42.  | 94.  | 34.  | 126 |
| 155 | 106. | 107. | 186. | 150. | 134. | 68.  | 45  |
| 156 | 145. | 174. | 92.  | 190. | 99.  | 142. | 136 |
| 157 | 101. | 141. | 38.  | 29.  | 108. | 155. | 61  |
| 158 | 165. | 113. | 185. | 121. | 186. | 169. | 19  |
| 159 | 118. | 152. | 77.  | 2.   | 133. | 190. | 174 |
| 160 | 20.  | 50.  | 187. | 102. | 109. | 197. | 85  |
| 161 | 35.  | 191. | 54.  | 148. | 43.  | 4.   | 79  |
| 162 | 173. | 192. | 8.   | 170. | 86.  | 138. | 48  |
| 163 | 12.  | 150. | 80.  | 30.  | 155. | 132. | 163 |
| 164 | 182. | 34.  | 103. | 200. | 179. | 139. | 41  |
| 165 | 200. | 144. | 28.  | 47.  | 30.  | 188. | 37  |
| 166 | 63.  | 49.  | 132. | 105. | 24.  | 94.  | 53  |
| 167 | 19.  | 105. | 22.  | 87.  | 32.  | 111. | 95  |
| 168 | 125. | 85.  | 61.  | 180. | 180. | 189. | 199 |
| 169 | 149. | 68.  | 195. | 166. | 178. | 118. | 49  |
| 170 | 41.  | 142. | 69.  | 111. | 18.  | 167. | 73  |
| 171 | 179. | 190. | 109. | 34.  | 63.  | 130. | 60  |
| 172 | 104. | 179. | 58.  | 8.   | 70.  | 40.  | 90  |
| 173 | 197. | 159. | 192. | 50.  | 148. | 52.  | 6   |
| 174 | 103. | 162. | 19.  | 143. | 150. | 17.  | 119 |
| 175 | 45.  | 143. | 34.  | 52.  | 95.  | 14.  | 43  |
| 176 | 195. | 40.  | 68.  | 120. | 34.  | 23.  | 93  |
| 177 | 129. | 115. | 75.  | 196. | 91.  | 89.  | 188 |
| 178 | 137. | 19.  | 85.  | 92.  | 140. | 37.  | 71  |
| 179 | 91.  | 120. | 130. | 157. | 139. | 194. | 159 |
| 180 | 191. | 72.  | 153. | 9.   | 28.  | 21.  | 69  |
| 181 | 132. | 59.  | 147. | 45.  | 101. | 144. | 128 |
| 182 | 27.  | 81.  | 23.  | 130. | 59.  | 75.  | 84  |
| 183 | 180. | 20.  | 48.  | 116. | 64.  | 2.   | 193 |
| 184 | 196. | 106. | 180. | 144. | 137. | 172. | 80  |
| 185 | 183. | 99.  | 56.  | 145. | 112. | 41.  | 127 |
| 186 | 166. | 177. | 42.  | 57.  | 73.  | 97.  | 81  |
| 187 | 39.  | 57.  | 59.  | 104. | 191. | 171. | 106 |



|     |      |      |      |      |      |      |     |
|-----|------|------|------|------|------|------|-----|
| 188 | 134. | 8.   | 188. | 23.  | 77.  | 47.  | 153 |
| 189 | 29.  | 12.  | 138. | 149. | 19.  | 98.  | 140 |
| 190 | 83.  | 127. | 161. | 33.  | 127. | 105. | 181 |
| 191 | 130. | 14.  | 55.  | 69.  | 156. | 69.  | 184 |
| 192 | 151. | 93.  | 183. | 158. | 27.  | 101. | 78  |
| 193 | 3.   | 2.   | 146. | 175. | 157. | 99.  | 23  |
| 194 | 114. | 132. | 162. | 174. | 135. | 133. | 39  |
| 195 | 72.  | 22.  | 115. | 71.  | 35.  | 187. | 157 |
| 196 | 187. | 60.  | 152. | 37.  | 198. | 78.  | 186 |
| 197 | 78.  | 27.  | 73.  | 177. | 10.  | 49.  | 164 |
| 198 | 174. | 139. | 118. | 60.  | 159. | 63.  | 132 |
| 199 | 133. | 165. | 110. | 125. | 57.  | 62.  | 40  |
| 200 | 138. | 189. | 112. | 10.  | 170. | 84.  | 137 |

RANKS OF LATIN HYPERCUBE SAMPLE INPUT VECTORS

| RUN NO. | X(11) | X(12) | X(13) | X(14) | X(15) | X(16) | X(17) |
|---------|-------|-------|-------|-------|-------|-------|-------|
| 1       | 102.  | 137.  | 91.   | 100.  | 11.   | 4.    | 109   |
| 2       | 46.   | 143.  | 120.  | 183.  | 50.   | 129.  | 176   |
| 3       | 105.  | 76.   | 66.   | 109.  | 88.   | 23.   | 79    |
| 4       | 130.  | 132.  | 38.   | 42.   | 120.  | 145.  | 134   |
| 5       | 101.  | 133.  | 195.  | 103.  | 83.   | 190.  | 102   |
| 6       | 163.  | 46.   | 157.  | 21.   | 7.    | 97.   | 37    |
| 7       | 124.  | 82.   | 186.  | 175.  | 93.   | 37.   | 123   |
| 8       | 71.   | 155.  | 188.  | 173.  | 130.  | 71.   | 192   |
| 9       | 74.   | 111.  | 84.   | 168.  | 177.  | 178.  | 2     |
| 10      | 134.  | 152.  | 138.  | 164.  | 149.  | 166.  | 7     |
| 11      | 159.  | 177.  | 174.  | 71.   | 131.  | 103.  | 158   |
| 12      | 25.   | 33.   | 54.   | 132.  | 43.   | 172.  | 25    |
| 13      | 5.    | 109.  | 12.   | 101.  | 184.  | 72.   | 141   |
| 14      | 174.  | 56.   | 20.   | 152.  | 171.  | 81.   | 118   |
| 15      | 38.   | 87.   | 162.  | 178.  | 75.   | 39.   | 162   |
| 16      | 185.  | 84.   | 175.  | 108.  | 86.   | 152.  | 22    |
| 17      | 153.  | 130.  | 4.    | 127.  | 126.  | 51.   | 138   |
| 18      | 187.  | 200.  | 2.    | 4.    | 160.  | 185.  | 101   |
| 19      | 190.  | 8.    | 177.  | 99.   | 87.   | 133.  | 190   |
| 20      | 182.  | 91.   | 86.   | 5.    | 117.  | 151.  | 46    |
| 21      | 195.  | 24.   | 5.    | 113.  | 191.  | 77.   | 112   |
| 22      | 173.  | 52.   | 21.   | 199.  | 94.   | 48.   | 33    |
| 23      | 13.   | 114.  | 58.   | 92.   | 27.   | 75.   | 84    |
| 24      | 35.   | 23.   | 141.  | 110.  | 124.  | 80.   | 97    |
| 25      | 51.   | 187.  | 173.  | 119.  | 28.   | 182.  | 87    |
| 26      | 58.   | 184.  | 49.   | 190.  | 47.   | 11.   | 180   |
| 27      | 78.   | 96.   | 189.  | 94.   | 16.   | 200.  | 114   |

|    |      |      |      |      |      |      |     |
|----|------|------|------|------|------|------|-----|
| 28 | 23.  | 103. | 68.  | 133. | 48.  | 193. | 182 |
| 29 | 117. | 165. | 51.  | 56.  | 164. | 192. | 195 |
| 30 | 111. | 172. | 24.  | 1.   | 128. | 30.  | 161 |
| 31 | 188. | 49.  | 79.  | 159. | 161. | 119. | 3   |
| 32 | 145. | 16.  | 64.  | 77.  | 140. | 191. | 58  |
| 33 | 68.  | 69.  | 179. | 80.  | 60.  | 1.   | 108 |
| 34 | 158. | 10.  | 72.  | 91.  | 49.  | 196. | 199 |
| 35 | 32.  | 106. | 180. | 78.  | 98.  | 105. | 166 |
| 36 | 177. | 78.  | 171. | 89.  | 153. | 169. | 137 |
| 37 | 132. | 7.   | 43.  | 12.  | 3.   | 64.  | 149 |
| 38 | 152. | 125. | 148. | 130. | 4.   | 33.  | 183 |
| 39 | 34.  | 39.  | 191. | 122. | 189. | 34.  | 32  |
| 40 | 197. | 105. | 165. | 86.  | 82.  | 84.  | 173 |
| 41 | 85.  | 31.  | 90.  | 58.  | 198. | 15.  | 151 |
| 42 | 12.  | 173. | 166. | 98.  | 33.  | 32.  | 85  |
| 43 | 79.  | 164. | 107. | 30.  | 170. | 35.  | 10  |
| 44 | 125. | 115. | 126. | 150. | 193. | 56.  | 88  |
| 45 | 120. | 136. | 178. | 196. | 175. | 144. | 75  |
| 46 | 170. | 110. | 87.  | 114. | 64.  | 170. | 60  |
| 47 | 121. | 34.  | 31.  | 172. | 58.  | 183. | 99  |
| 48 | 20.  | 90.  | 113. | 163. | 100. | 12.  | 28  |
| 49 | 200. | 59.  | 28.  | 176. | 8.   | 78.  | 157 |
| 50 | 116. | 140. | 127. | 112. | 148. | 127. | 155 |
| 51 | 7.   | 119. | 176. | 157. | 44.  | 26.  | 30  |
| 52 | 179. | 122. | 59.  | 131. | 99.  | 110. | 117 |
| 53 | 92.  | 188. | 11.  | 105. | 45.  | 175. | 27  |
| 54 | 62.  | 178. | 7.   | 111. | 61.  | 6.   | 52  |
| 55 | 9.   | 142. | 187. | 124. | 178. | 79.  | 94  |
| 56 | 64.  | 65.  | 94.  | 125. | 108. | 165. | 92  |
| 57 | 88.  | 113. | 82.  | 84.  | 169. | 126. | 171 |
| 58 | 118. | 139. | 71.  | 39.  | 129. | 59.  | 184 |
| 59 | 57.  | 29.  | 149. | 187. | 23.  | 100. | 146 |
| 60 | 114. | 25.  | 80.  | 75.  | 17.  | 9.   | 62  |
| 61 | 15.  | 174. | 96.  | 19.  | 143. | 161. | 170 |
| 62 | 136. | 149. | 118. | 169. | 107. | 17.  | 43  |
| 63 | 42.  | 179. | 39.  | 170. | 197. | 136. | 128 |
| 64 | 89.  | 192. | 123. | 7.   | 77.  | 99.  | 71  |
| 65 | 109. | 170. | 200. | 107. | 1.   | 163. | 53  |
| 66 | 160. | 193. | 160. | 2.   | 105. | 55.  | 57  |
| 67 | 53.  | 66.  | 53.  | 36.  | 76.  | 106. | 63  |
| 68 | 52.  | 141. | 61.  | 123. | 10.  | 46.  | 89  |
| 69 | 29.  | 166. | 169. | 66.  | 115. | 194. | 8   |

|     |      |      |      |      |      |      |     |
|-----|------|------|------|------|------|------|-----|
| 70  | 56.  | 22.  | 144. | 29.  | 183. | 13.  | 45  |
| 71  | 55.  | 98.  | 151. | 106. | 81.  | 168. | 11  |
| 72  | 98.  | 190. | 83.  | 35.  | 96.  | 93.  | 35  |
| 73  | 24.  | 45.  | 32.  | 121. | 125. | 150. | 18  |
| 74  | 194. | 131. | 168. | 48.  | 89.  | 27.  | 103 |
| 75  | 72.  | 48.  | 93.  | 189. | 31.  | 94.  | 5   |
| 76  | 69.  | 158. | 125. | 96.  | 25.  | 121. | 115 |
| 77  | 133. | 26.  | 1.   | 197. | 5.   | 2.   | 40  |
| 78  | 66.  | 191. | 117. | 182. | 68.  | 148. | 105 |
| 79  | 44.  | 196. | 103. | 200. | 12.  | 160. | 47  |
| 80  | 37.  | 68.  | 198. | 154. | 101. | 40.  | 177 |
| 81  | 171. | 123. | 22.  | 191. | 36.  | 95.  | 156 |
| 82  | 3.   | 88.  | 67.  | 3.   | 173. | 22.  | 61  |
| 83  | 26.  | 180. | 133. | 82.  | 199. | 156. | 165 |
| 84  | 113. | 138. | 116. | 167. | 145. | 195. | 168 |
| 85  | 21.  | 99.  | 185. | 116. | 37.  | 116. | 132 |
| 86  | 149. | 4.   | 115. | 25.  | 167. | 58.  | 81  |
| 87  | 180. | 27.  | 183. | 33.  | 80.  | 61.  | 29  |
| 88  | 94.  | 74.  | 56.  | 102. | 152. | 113. | 48  |
| 89  | 166. | 20.  | 57.  | 160. | 22.  | 149. | 145 |
| 90  | 6.   | 32.  | 42.  | 87.  | 137. | 140. | 189 |
| 91  | 167. | 116. | 30.  | 149. | 196. | 50.  | 127 |
| 92  | 135. | 107. | 69.  | 23.  | 111. | 83.  | 14  |
| 93  | 175. | 161. | 60.  | 74.  | 97.  | 65.  | 77  |
| 94  | 39.  | 6.   | 99.  | 134. | 63.  | 179. | 148 |
| 95  | 83.  | 104. | 47.  | 67.  | 136. | 108. | 93  |
| 96  | 162. | 189. | 158. | 177. | 188. | 53.  | 64  |
| 97  | 49.  | 62.  | 55.  | 24.  | 19.  | 124. | 65  |
| 98  | 172. | 194. | 26.  | 40.  | 135. | 76.  | 82  |
| 99  | 126. | 176. | 150. | 49.  | 168. | 162. | 38  |
| 100 | 148. | 124. | 16.  | 55.  | 20.  | 8.   | 119 |
| 101 | 100. | 120. | 132. | 171. | 172. | 142. | 130 |
| 102 | 22.  | 50.  | 18.  | 37.  | 109. | 130. | 96  |
| 103 | 127. | 175. | 163. | 90.  | 141. | 29.  | 136 |
| 104 | 70.  | 185. | 153. | 17.  | 95.  | 109. | 31  |
| 105 | 36.  | 183. | 102. | 198. | 54.  | 49.  | 54  |
| 106 | 150. | 135. | 114. | 129. | 59.  | 118. | 110 |
| 107 | 84.  | 145. | 13.  | 186. | 85.  | 86.  | 91  |
| 108 | 196. | 144. | 140. | 76.  | 2.   | 89.  | 174 |
| 109 | 99.  | 97.  | 10.  | 34.  | 15.  | 189. | 159 |
| 110 | 48.  | 63.  | 152. | 148. | 146. | 137. | 12  |
| 111 | 1.   | 81.  | 139. | 52.  | 112. | 186. | 74  |

|     |      |      |      |      |      |      |     |
|-----|------|------|------|------|------|------|-----|
| 112 | 119. | 127. | 190. | 158. | 187. | 199. | 42  |
| 113 | 157. | 43.  | 63.  | 184. | 35.  | 128. | 142 |
| 114 | 93.  | 94.  | 6.   | 51.  | 166. | 174. | 121 |
| 115 | 65.  | 13.  | 134. | 118. | 132. | 91.  | 116 |
| 116 | 176. | 61.  | 170. | 32.  | 127. | 117. | 194 |
| 117 | 103. | 14.  | 110. | 14.  | 114. | 70.  | 153 |
| 118 | 95.  | 85.  | 74.  | 161. | 74.  | 5.   | 49  |
| 119 | 86.  | 55.  | 122. | 153. | 155. | 67.  | 200 |
| 120 | 112. | 92.  | 184. | 8.   | 29.  | 31.  | 9   |
| 121 | 76.  | 182. | 15.  | 142. | 182. | 42.  | 98  |
| 122 | 54.  | 102. | 81.  | 72.  | 71.  | 122. | 164 |
| 123 | 28.  | 3.   | 145. | 69.  | 185. | 155. | 50  |
| 124 | 14.  | 128. | 23.  | 179. | 116. | 104. | 196 |
| 125 | 47.  | 148. | 70.  | 44.  | 73.  | 36.  | 198 |
| 126 | 115. | 30.  | 40.  | 70.  | 134. | 85.  | 23  |
| 127 | 50.  | 129. | 88.  | 144. | 165. | 24.  | 80  |
| 128 | 168. | 18.  | 104. | 43.  | 144. | 177. | 67  |
| 129 | 143. | 108. | 164. | 104. | 176. | 7.   | 140 |
| 130 | 122. | 54.  | 130. | 139. | 195. | 82.  | 139 |
| 131 | 80.  | 79.  | 76.  | 15.  | 186. | 73.  | 36  |
| 132 | 2.   | 100. | 3.   | 47.  | 38.  | 187. | 68  |
| 133 | 81.  | 12.  | 45.  | 93.  | 162. | 16.  | 24  |
| 134 | 59.  | 15.  | 106. | 137. | 72.  | 164. | 19  |
| 135 | 186. | 167. | 119. | 151. | 123. | 197. | 90  |
| 136 | 107. | 150. | 85.  | 138. | 51.  | 115. | 113 |
| 137 | 40.  | 83.  | 29.  | 13.  | 34.  | 134. | 188 |
| 138 | 106. | 71.  | 46.  | 181. | 158. | 47.  | 41  |
| 139 | 8.   | 77.  | 111. | 140. | 92.  | 20.  | 39  |
| 140 | 141. | 126. | 108. | 20.  | 26.  | 3.   | 44  |
| 141 | 87.  | 40.  | 52.  | 97.  | 118. | 125. | 181 |
| 142 | 33.  | 5.   | 92.  | 59.  | 32.  | 198. | 34  |
| 143 | 41.  | 197. | 33.  | 65.  | 9.   | 132. | 86  |
| 144 | 27.  | 64.  | 147. | 136. | 14.  | 159. | 17  |
| 145 | 192. | 53.  | 48.  | 192. | 163. | 98.  | 178 |
| 146 | 198. | 160. | 78.  | 26.  | 30.  | 138. | 143 |
| 147 | 191. | 44.  | 159. | 146. | 180. | 123. | 185 |
| 148 | 90.  | 58.  | 137. | 18.  | 42.  | 111. | 167 |
| 149 | 61.  | 171. | 112. | 64.  | 154. | 68.  | 15  |
| 150 | 161. | 1.   | 73.  | 38.  | 24.  | 158. | 20  |
| 151 | 18.  | 28.  | 172. | 155. | 138. | 14.  | 169 |
| 152 | 123. | 121. | 142. | 79.  | 67.  | 28.  | 150 |
| 153 | 144. | 47.  | 97.  | 10.  | 190. | 66.  | 4   |

|     |      |      |      |      |      |      |     |
|-----|------|------|------|------|------|------|-----|
| 154 | 184. | 75.  | 155. | 135. | 113. | 171. | 76  |
| 155 | 60.  | 198. | 62.  | 11.  | 91.  | 102. | 187 |
| 156 | 156. | 86.  | 193. | 147. | 151. | 184. | 1   |
| 157 | 19.  | 21.  | 197. | 27.  | 70.  | 41.  | 193 |
| 158 | 97.  | 42.  | 50.  | 81.  | 69.  | 43.  | 160 |
| 159 | 138. | 72.  | 143. | 53.  | 62.  | 54.  | 95  |
| 160 | 91.  | 101. | 146. | 45.  | 57.  | 181. | 66  |
| 161 | 193. | 93.  | 124. | 193. | 65.  | 44.  | 78  |
| 162 | 183. | 154. | 14.  | 61.  | 104. | 139. | 133 |
| 163 | 75.  | 151. | 17.  | 141. | 121. | 87.  | 56  |
| 164 | 128. | 60.  | 128. | 60.  | 78.  | 101. | 6   |
| 165 | 63.  | 163. | 98.  | 162. | 159. | 60.  | 131 |
| 166 | 30.  | 17.  | 192. | 145. | 150. | 188. | 163 |
| 167 | 108. | 67.  | 9.   | 6.   | 90.  | 19.  | 83  |
| 168 | 164. | 169. | 199. | 22.  | 122. | 92.  | 186 |
| 169 | 199. | 195. | 154. | 126. | 13.  | 57.  | 26  |
| 170 | 147. | 41.  | 95.  | 85.  | 142. | 141. | 197 |
| 171 | 11.  | 153. | 101. | 115. | 157. | 52.  | 104 |
| 172 | 73.  | 156. | 100. | 143. | 21.  | 25.  | 179 |
| 173 | 31.  | 19.  | 77.  | 57.  | 179. | 114. | 154 |
| 174 | 10.  | 199. | 105. | 28.  | 53.  | 62.  | 111 |
| 175 | 82.  | 80.  | 129. | 63.  | 39.  | 88.  | 21  |
| 176 | 110. | 186. | 196. | 54.  | 103. | 10.  | 51  |
| 177 | 16.  | 95.  | 37.  | 188. | 110. | 74.  | 124 |
| 178 | 151. | 118. | 194. | 31.  | 192. | 120. | 144 |
| 179 | 142. | 9.   | 75.  | 195. | 133. | 90.  | 107 |
| 180 | 131. | 11.  | 161. | 156. | 56.  | 45.  | 100 |
| 181 | 139. | 38.  | 44.  | 68.  | 200. | 21.  | 59  |
| 182 | 181. | 89.  | 109. | 117. | 66.  | 18.  | 16  |
| 183 | 137. | 112. | 41.  | 9.   | 84.  | 154. | 172 |
| 184 | 4.   | 36.  | 89.  | 73.  | 41.  | 112. | 152 |
| 185 | 43.  | 146. | 135. | 120. | 52.  | 176. | 120 |
| 186 | 189. | 117. | 27.  | 185. | 181. | 157. | 125 |
| 187 | 17.  | 162. | 19.  | 180. | 46.  | 173. | 73  |
| 188 | 140. | 37.  | 181. | 165. | 79.  | 63.  | 129 |
| 189 | 154. | 157. | 25.  | 50.  | 102. | 146. | 13  |
| 190 | 129. | 51.  | 182. | 166. | 174. | 38.  | 135 |
| 191 | 169. | 70.  | 167. | 83.  | 18.  | 135. | 55  |
| 192 | 96.  | 35.  | 8.   | 46.  | 156. | 147. | 70  |
| 193 | 77.  | 159. | 34.  | 194. | 106. | 167. | 72  |
| 194 | 165. | 168. | 121. | 62.  | 147. | 153. | 69  |
| 195 | 104. | 2.   | 36.  | 16.  | 6.   | 69.  | 106 |

|     |      |      |      |      |      |      |     |
|-----|------|------|------|------|------|------|-----|
| 196 | 67.  | 57.  | 35.  | 41.  | 55.  | 131. | 122 |
| 197 | 146. | 134. | 131. | 128. | 119. | 180. | 147 |
| 198 | 155. | 147. | 136. | 88.  | 40.  | 143. | 126 |
| 199 | 178. | 181. | 65.  | 95.  | 194. | 107. | 175 |
| 200 | 45.  | 73.  | 156. | 174. | 139. | 96.  | 191 |

RANKS OF LATIN HYPERCUBE SAMPLE INPUT VECTORS

| RUN NO. | X(21) |
|---------|-------|
| 1       | 150.  |
| 2       | 183.  |
| 3       | 120.  |
| 4       | 183.  |
| 5       | 79.   |
| 6       | 120.  |
| 7       | 120.  |
| 8       | 120.  |
| 9       | 79.   |
| 10      | 183.  |
| 11      | 183.  |
| 12      | 120.  |
| 13      | 120.  |
| 14      | 150.  |
| 15      | 79.   |
| 16      | 120.  |
| 17      | 120.  |
| 18      | 120.  |
| 19      | 14.   |
| 20      | 40.   |
| 21      | 183.  |
| 22      | 79.   |
| 23      | 183.  |
| 24      | 40.   |
| 25      | 79.   |
| 26      | 40.   |
| 27      | 150.  |
| 28      | 183.  |
| 29      | 14.   |
| 30      | 183.  |
| 31      | 150.  |
| 32      | 120.  |
| 33      | 150.  |
| 34      | 79.   |
| 35      | 183.  |

|    |      |
|----|------|
| 36 | 79.  |
| 37 | 183. |
| 38 | 14.  |
| 39 | 79.  |
| 40 | 183. |
| 41 | 150. |
| 42 | 79.  |
| 43 | 150. |
| 44 | 120. |
| 45 | 120. |
| 46 | 40.  |
| 47 | 40.  |
| 48 | 79.  |
| 49 | 79.  |
| 50 | 79.  |
| 51 | 120. |
| 52 | 183. |
| 53 | 79.  |
| 54 | 40.  |
| 55 | 150. |
| 56 | 79.  |
| 57 | 120. |
| 58 | 14.  |
| 59 | 79.  |
| 60 | 150. |
| 61 | 79.  |
| 62 | 40.  |
| 63 | 14.  |
| 64 | 79.  |
| 65 | 79.  |
| 66 | 183. |
| 67 | 79.  |
| 68 | 40.  |
| 69 | 40.  |
| 70 | 14.  |
| 71 | 79.  |
| 72 | 14.  |
| 73 | 79.  |
| 74 | 79.  |
| 75 | 120. |
| 76 | 14.  |
| 77 | 40.  |

|     |      |
|-----|------|
| 78  | 183. |
| 79  | 79.  |
| 80  | 150. |
| 81  | 14.  |
| 82  | 14.  |
| 83  | 40.  |
| 84  | 14.  |
| 85  | 183. |
| 86  | 150. |
| 87  | 79.  |
| 88  | 150. |
| 89  | 79.  |
| 90  | 120. |
| 91  | 79.  |
| 92  | 120. |
| 93  | 40.  |
| 94  | 183. |
| 95  | 14.  |
| 96  | 120. |
| 97  | 40.  |
| 98  | 150. |
| 99  | 150. |
| 100 | 79.  |
| 101 | 183. |
| 102 | 183. |
| 103 | 150. |
| 104 | 40.  |
| 105 | 79.  |
| 106 | 79.  |
| 107 | 183. |
| 108 | 14.  |
| 109 | 120. |
| 110 | 183. |
| 111 | 79.  |
| 112 | 120. |
| 113 | 79.  |
| 114 | 183. |
| 115 | 14.  |
| 116 | 150. |
| 117 | 79.  |
| 118 | 40.  |
| 119 | 14.  |



|     |      |
|-----|------|
| 120 | 14.  |
| 121 | 79.  |
| 122 | 40.  |
| 123 | 150. |
| 124 | 183. |
| 125 | 183. |
| 126 | 120. |
| 127 | 120. |
| 128 | 40.  |
| 129 | 150. |
| 130 | 40.  |
| 131 | 183. |
| 132 | 150. |
| 133 | 40.  |
| 134 | 183. |
| 135 | 120. |
| 136 | 79.  |
| 137 | 183. |
| 138 | 14.  |
| 139 | 14.  |
| 140 | 150. |
| 141 | 14.  |
| 142 | 120. |
| 143 | 183. |
| 144 | 79.  |
| 145 | 150. |
| 146 | 120. |
| 147 | 79.  |
| 148 | 79.  |
| 149 | 120. |
| 150 | 79.  |
| 151 | 79.  |
| 152 | 183. |
| 153 | 150. |
| 154 | 150. |
| 155 | 14.  |
| 156 | 14.  |
| 157 | 79.  |
| 158 | 79.  |
| 159 | 79.  |
| 160 | 183. |
| 161 | 183. |

|     |      |
|-----|------|
| 162 | 79.  |
| 163 | 79.  |
| 164 | 40.  |
| 165 | 150. |
| 166 | 40.  |
| 167 | 40.  |
| 168 | 120. |
| 169 | 150. |
| 170 | 40.  |
| 171 | 183. |
| 172 | 150. |
| 173 | 120. |
| 174 | 40.  |
| 175 | 79.  |
| 176 | 150. |
| 177 | 183. |
| 178 | 40.  |
| 179 | 14.  |
| 180 | 14.  |
| 181 | 150. |
| 182 | 79.  |
| 183 | 183. |
| 184 | 120. |
| 185 | 14.  |
| 186 | 79.  |
| 187 | 40.  |
| 188 | 183. |
| 189 | 79.  |
| 190 | 120. |
| 191 | 183. |
| 192 | 150. |
| 193 | 150. |
| 194 | 79.  |
| 195 | 183. |
| 196 | 14.  |
| 197 | 14.  |
| 198 | 79.  |
| 199 | 79.  |
| 200 | 79.  |

HISTOGRAM FOR VARIABLE NO. 1      NORMAL      DISTRIBUTION  
MIDPOINT                                  FREQ.

|                |    |                    |
|----------------|----|--------------------|
| -0.5000000E-02 | 2  | XX                 |
| 0.5000000E-02  | 2  | XX                 |
| 0.1500000E-01  | 2  | XX                 |
| 0.2500000E-01  | 4  | XXXX               |
| 0.3500000E-01  | 6  | XXXXXX             |
| 0.4500000E-01  | 9  | XXXXXXXXXX         |
| 0.5500000E-01  | 10 | XXXXXXXXXX         |
| 0.6500001E-01  | 14 | XXXXXXXXXXXXXXXXXX |
| 0.7500000E-01  | 15 | XXXXXXXXXXXXXXXXXX |
| 0.8500000E-01  | 17 | XXXXXXXXXXXXXXXXXX |
| 0.9500000E-01  | 19 | XXXXXXXXXXXXXXXXXX |
| 0.1050000      | 18 | XXXXXXXXXXXXXXXXXX |
| 0.1150000      | 18 | XXXXXXXXXXXXXXXXXX |
| 0.1250000      | 16 | XXXXXXXXXXXXXXXXXX |
| 0.1350000      | 12 | XXXXXXXXXXXXXXXXXX |
| 0.1450000      | 11 | XXXXXXXXXXXXXXXXXX |
| 0.1550000      | 9  | XXXXXXXXXX         |
| 0.1650000      | 6  | XXXXXX             |
| 0.1750000      | 4  | XXXX               |
| 0.1850000      | 2  | XX                 |
| 0.1950000      | 4  | XXXX               |

200

| MIN            | MAX       | RANGE     | MEAN      | MEDIAN        | VAR  |
|----------------|-----------|-----------|-----------|---------------|------|
| -0.2235174E-07 | 0.2000000 | 0.2000001 | 0.1000049 | 0.9989989E-01 | 0.17 |

HISTOGRAM FOR VARIABLE NO. 2 NORMAL DISTRIBUTION

| MIDPOINT | FREQ.               |
|----------|---------------------|
| 586.5001 | 3 XXX               |
| 609.5001 | 3 XXX               |
| 632.5001 | 4 XXXX              |
| 655.5001 | 5 XXXXX             |
| 678.5001 | 8 XXXXXXXX          |
| 701.5001 | 10 XXXXXXXXXXXX     |
| 724.5001 | 14 XXXXXXXXXXXXXXXX |
| 747.5001 | 15 XXXXXXXXXXXXXXXX |
| 770.5001 | 16 XXXXXXXXXXXXXXXX |
| 793.5001 | 18 XXXXXXXXXXXXXXXX |
| 816.5001 | 18 XXXXXXXXXXXXXXXX |
| 839.5001 | 18 XXXXXXXXXXXXXXXX |
| 862.5001 | 17 XXXXXXXXXXXXXXXX |
| 885.5001 | 13 XXXXXXXXXXXXXXXX |
| 908.5001 | 11 XXXXXXXXXXXXXXXX |





|               |          |          |           |               |      |
|---------------|----------|----------|-----------|---------------|------|
| 3.315001      | 0        |          |           |               |      |
| 3.485001      | 2        | XX       |           |               |      |
|               | 200      |          |           |               |      |
| MIN           | MAX      | RANGE    | MEAN      | MEDIAN        | VAR  |
| 0.9999990E-03 | 3.450003 | 3.449003 | 0.2297070 | 0.5865667E-01 | 0.25 |

HISTOGRAM FOR VARIABLE NO. 6 LOGNORMAL DISTRIBUTION

| MIDPOINT      | FREQ.    |  |           |               |      |
|---------------|----------|--|-----------|---------------|------|
| 0.130000      | 170      | XX |           |               |      |
| 0.3900001     | 12       | XXXXXXXXXXXXXX   |           |               |      |
| 0.6500002     | 5        | XXXXXX   |           |               |      |
| 0.9100002     | 3        | XXX  |           |               |      |
| 1.170000      | 2        | XX   |           |               |      |
| 1.430000      | 1        | X  |           |               |      |
| 1.690001      | 1        | X  |           |               |      |
| 1.950001      | 0        |  |           |               |      |
| 2.210001      | 2        | XX   |           |               |      |
| 2.470001      | 0        |  |           |               |      |
| 2.730001      | 0        |  |           |               |      |
| 2.990001      | 1        | X  |           |               |      |
| 3.250001      | 0        |  |           |               |      |
| 3.510001      | 0        |  |           |               |      |
| 3.770001      | 1        | X  |           |               |      |
| 4.030001      | 0        |  |           |               |      |
| 4.290001      | 0        |  |           |               |      |
| 4.550001      | 0        |  |           |               |      |
| 4.810001      | 0        |  |           |               |      |
| 5.070002      | 0        |  |           |               |      |
| 5.330002      | 2        | XX   |           |               |      |
|               | 200      |  |           |               |      |
| MIN           | MAX      | RANGE  | MEAN      | MEDIAN        | VAR  |
| 0.9999989E-04 | 5.250004 | 5.249904   | 0.2224910 | 0.2307066E-01 | 0.46 |

HISTOGRAM FOR VARIABLE NO. 7 UNIFORM DISTRIBUTION

| MIDPOINT   | FREQ. |            |
|------------|-------|------------|
| -0.4749998 | 10    | XXXXXXXXXX |
| -0.4249999 | 10    | XXXXXXXXXX |
| -0.3749999 | 10    | XXXXXXXXXX |
| -0.3249999 | 10    | XXXXXXXXXX |
| -0.2749999 | 10    | XXXXXXXXXX |
| -0.2249999 | 10    | XXXXXXXXXX |
| -0.1750000 | 10    | XXXXXXXXXX |

|                |    |            |
|----------------|----|------------|
| -0.1250000     | 10 | XXXXXXXXXX |
| -0.7499999E-01 | 10 | XXXXXXXXXX |
| -0.2500001E-01 | 10 | XXXXXXXXXX |
| 0.2499998E-01  | 10 | XXXXXXXXXX |
| 0.7499996E-01  | 10 | XXXXXXXXXX |
| 0.1249999      | 10 | XXXXXXXXXX |
| 0.1749999      | 10 | XXXXXXXXXX |
| 0.2249999      | 10 | XXXXXXXXXX |
| 0.2749999      | 10 | XXXXXXXXXX |
| 0.3249999      | 10 | XXXXXXXXXX |
| 0.3749999      | 10 | XXXXXXXXXX |
| 0.4249998      | 10 | XXXXXXXXXX |
| 0.4749998      | 10 | XXXXXXXXXX |

200

| MIN        | MAX       | RANGE     | MEAN           | MEDIAN        | VAR  |
|------------|-----------|-----------|----------------|---------------|------|
| -0.4974287 | 0.4976968 | 0.9951255 | -0.8040815E-05 | 0.1142050E-02 | 0.83 |

HISTOGRAM FOR VARIABLE NO. 8 UNIFORM DISTRIBUTION

| MIDPOINT      | FREQ. |            |
|---------------|-------|------------|
| 0.2499999E-01 | 10    | XXXXXXXXXX |
| 0.7499997E-01 | 10    | XXXXXXXXXX |
| 0.1250000     | 10    | XXXXXXXXXX |
| 0.1749999     | 10    | XXXXXXXXXX |
| 0.2249999     | 10    | XXXXXXXXXX |
| 0.2749999     | 10    | XXXXXXXXXX |
| 0.3249999     | 10    | XXXXXXXXXX |
| 0.3749999     | 10    | XXXXXXXXXX |
| 0.4249999     | 10    | XXXXXXXXXX |
| 0.4749998     | 10    | XXXXXXXXXX |
| 0.5249999     | 10    | XXXXXXXXXX |
| 0.5749999     | 10    | XXXXXXXXXX |
| 0.6249999     | 10    | XXXXXXXXXX |
| 0.6749999     | 10    | XXXXXXXXXX |
| 0.7249999     | 10    | XXXXXXXXXX |
| 0.7749999     | 10    | XXXXXXXXXX |
| 0.8249999     | 10    | XXXXXXXXXX |
| 0.8749999     | 10    | XXXXXXXXXX |
| 0.9250000     | 10    | XXXXXXXXXX |
| 0.9750000     | 10    | XXXXXXXXXX |

200

| MIN           | MAX       | RANGE     | MEAN      | MEDIAN    | VAR  |
|---------------|-----------|-----------|-----------|-----------|------|
| 0.3748673E-02 | 0.9988270 | 0.9950784 | 0.5002130 | 0.4996909 | 0.83 |







|               |    |                      |
|---------------|----|----------------------|
| 0.7000001E+15 | 18 | XXXXXXXXXXXXXXXXXXXX |
| 0.9800001E+15 | 12 | XXXXXXXXXXXX         |
| 0.1260000E+16 | 9  | XXXXXXXXXX           |
| 0.1540000E+16 | 8  | XXXXXXXXXX           |
| 0.1820000E+16 | 7  | XXXXXXX              |
| 0.2100000E+16 | 6  | XXXXXXX              |
| 0.2380000E+16 | 5  | XXXXXX               |
| 0.2660000E+16 | 5  | XXXXXX               |
| 0.2940000E+16 | 4  | XXXX                 |
| 0.3220000E+16 | 4  | XXXX                 |
| 0.3500000E+16 | 3  | XXX                  |
| 0.3780000E+16 | 3  | XXX                  |
| 0.4060000E+16 | 4  | XXXX                 |
| 0.4340000E+16 | 3  | XXX                  |
| 0.4620000E+16 | 2  | XX                   |
| 0.4900000E+16 | 3  | XXX                  |
| 0.5180000E+16 | 2  | XX                   |
| 0.5460000E+16 | 2  | XX                   |

200

| MIN           | MAX           | RANGE         | MEAN          | MEDIAN        | VAR  |
|---------------|---------------|---------------|---------------|---------------|------|
| 0.5693017E+14 | 0.5568388E+16 | 0.5511457E+16 | 0.1205019E+16 | 0.5567769E+15 | 0.19 |

HISTOGRAM FOR VARIABLE NO. 13      USER SUPPLIED      DISTRIBUTION

| MIDPOINT  | FREQ. |                              |
|-----------|-------|------------------------------|
| -7.975001 | 2     | XX                           |
| -7.685001 | 5     | XXXXX                        |
| -7.395001 | 4     | XXXX                         |
| -7.105001 | 3     | XXX                          |
| -6.815001 | 5     | XXXXX                        |
| -6.525001 | 18    | XXXXXXXXXXXXXXXXXXXX         |
| -6.235001 | 25    | XXXXXXXXXXXXXXXXXXXXXXXXXXXX |
| -5.945001 | 26    | XXXXXXXXXXXXXXXXXXXXXXXXXXXX |
| -5.655001 | 26    | XXXXXXXXXXXXXXXXXXXXXXXXXXXX |
| -5.365001 | 26    | XXXXXXXXXXXXXXXXXXXXXXXXXXXX |
| -5.075001 | 25    | XXXXXXXXXXXXXXXXXXXXXXXXXXXX |
| -4.785001 | 16    | XXXXXXXXXXXXXXXXXXXX         |
| -4.495001 | 2     | XX                           |
| -4.205001 | 2     | XX                           |
| -3.915001 | 2     | XX                           |
| -3.625001 | 3     | XXX                          |
| -3.335001 | 2     | XX                           |
| -3.045002 | 1     | X                            |

|           |   |     |
|-----------|---|-----|
| -2.755002 | 3 | XXX |
| -2.465002 | 2 | XX  |
| -2.175002 | 2 | XX  |

200

| MIN       | MAX       | RANGE    | MEAN      | MEDIAN    | VAR |
|-----------|-----------|----------|-----------|-----------|-----|
| -7.944694 | -2.086470 | 5.858224 | -5.603156 | -5.668708 | 1.0 |

HISTOGRAM FOR VARIABLE NO. 14 USER SUPPLIED DISTRIBUTION

| MIDPOINT  | FREQ. |                              |
|-----------|-------|------------------------------|
| -12.42000 | 1     | X                            |
| -12.06000 | 3     | XXX                          |
| -11.70000 | 2     | XX                           |
| -11.34000 | 2     | XX                           |
| -10.98000 | 2     | XX                           |
| -10.62000 | 1     | X                            |
| -10.26000 | 3     | XXX                          |
| -9.900001 | 2     | XX                           |
| -9.540001 | 2     | XX                           |
| -9.180001 | 2     | XX                           |
| -8.820002 | 23    | XXXXXXXXXXXXXXXXXXXXXXXXXXXX |
| -8.460002 | 23    | XXXXXXXXXXXXXXXXXXXXXXXXXXXX |
| -8.100002 | 23    | XXXXXXXXXXXXXXXXXXXXXXXXXXXX |
| -7.740002 | 23    | XXXXXXXXXXXXXXXXXXXXXXXXXXXX |
| -7.380002 | 23    | XXXXXXXXXXXXXXXXXXXXXXXXXXXX |
| -7.020002 | 23    | XXXXXXXXXXXXXXXXXXXXXXXXXXXX |
| -6.660002 | 22    | XXXXXXXXXXXXXXXXXXXXXXXXXXXX |
| -6.300002 | 5     | XXXXX                        |
| -5.940001 | 5     | XXXXX                        |
| -5.580001 | 4     | XXXX                         |
| -5.220001 | 6     | XXXXXX                       |

200

| MIN       | MAX       | RANGE    | MEAN      | MEDIAN    | VAR |
|-----------|-----------|----------|-----------|-----------|-----|
| -12.33655 | -5.061714 | 7.274833 | -7.853998 | -7.751132 | 1.8 |

HISTOGRAM FOR VARIABLE NO. 15 USER SUPPLIED DISTRIBUTION

| MIDPOINT  | FREQ. |              |
|-----------|-------|--------------|
| -8.745000 | 1     | X            |
| -8.415000 | 11    | XXXXXXXXXXXX |
| -8.085000 | 11    | XXXXXXXXXXXX |
| -7.755000 | 11    | XXXXXXXXXXXX |
| -7.425000 | 11    | XXXXXXXXXXXX |
| -7.095000 | 11    | XXXXXXXXXXXX |

|           |    |              |
|-----------|----|--------------|
| -6.765000 | 11 | XXXXXXXXXXXX |
| -6.435000 | 11 | XXXXXXXXXXXX |
| -6.105000 | 12 | XXXXXXXXXXXX |
| -5.775001 | 10 | XXXXXXXXXXXX |
| -5.445001 | 11 | XXXXXXXXXXXX |
| -5.115001 | 12 | XXXXXXXXXXXX |
| -4.785001 | 10 | XXXXXXXXXXXX |
| -4.455001 | 12 | XXXXXXXXXXXX |
| -4.125001 | 11 | XXXXXXXXXXXX |
| -3.795001 | 11 | XXXXXXXXXXXX |
| -3.465001 | 11 | XXXXXXXXXXXX |
| -3.135001 | 6  | XXXXXX       |
| -2.805001 | 5  | XXXXX        |
| -2.475001 | 6  | XXXXXX       |
| -2.145001 | 5  | XXXXX        |

200

| MIN       | MAX       | RANGE    | MEAN      | MEDIAN    | VAR |
|-----------|-----------|----------|-----------|-----------|-----|
| -8.597218 | -2.020330 | 6.576888 | -5.593116 | -5.628187 | 3.1 |

HISTOGRAM FOR VARIABLE NO. 16      USER SUPPLIED      DISTRIBUTION

| MIDPOINT      | FREQ. |                                      |
|---------------|-------|--------------------------------------|
| 0.6174996E-01 | 2     | XX                                   |
| 0.7124996E-01 | 2     | XX                                   |
| 0.8074996E-01 | 3     | XXX                                  |
| 0.9024996E-01 | 3     | XXX                                  |
| 0.9974995E-01 | 13    | XXXXXXXXXXXX                         |
| 0.1092499     | 15    | XXXXXXXXXXXXXXXX                     |
| 0.1187499     | 32    | XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX |
| 0.1282499     | 14    | XXXXXXXXXXXXXXXX                     |
| 0.1377499     | 13    | XXXXXXXXXXXX                         |
| 0.1472499     | 17    | XXXXXXXXXXXXXXXXXXXX                 |
| 0.1567499     | 6     | XXXXXX                               |
| 0.1662499     | 24    | XXXXXXXXXXXXXXXXXXXXXXXXXXXX         |
| 0.1757499     | 26    | XXXXXXXXXXXXXXXXXXXXXXXXXXXX         |
| 0.1852499     | 5     | XXXXXX                               |
| 0.1947499     | 4     | XXXX                                 |
| 0.2042499     | 11    | XXXXXXXXXXXX                         |
| 0.2137499     | 2     | XX                                   |
| 0.2232499     | 3     | XXX                                  |
| 0.2327499     | 2     | XX                                   |
| 0.2422499     | 1     | X                                    |
| 0.2517499     | 2     | XX                                   |

200

| MIN           | MAX       | RANGE     | MEAN      | MEDIAN    | VAR  |
|---------------|-----------|-----------|-----------|-----------|------|
| 0.6133423E-01 | 0.2512744 | 0.1899402 | 0.1467998 | 0.1440876 | 0.14 |

HISTOGRAM FOR VARIABLE NO. 17 USER SUPPLIED DISTRIBUTION

| MIDPOINT | FREQ. |                      |
|----------|-------|----------------------|
| 22.00000 | 4     | XXXX                 |
| 26.00000 | 17    | XXXXXXXXXXXXXXXXXXXX |
| 30.00000 | 18    | XXXXXXXXXXXXXXXXXXXX |
| 34.00000 | 16    | XXXXXXXXXXXXXXXXXXXX |
| 38.00000 | 15    | XXXXXXXXXXXXXXXXXXXX |
| 42.00000 | 9     | XXXXXXXXXX           |
| 46.00000 | 8     | XXXXXXXXXX           |
| 50.00000 | 7     | XXXXXXXXXX           |
| 54.00000 | 8     | XXXXXXXXXX           |
| 58.00000 | 13    | XXXXXXXXXXXXXXXXXX   |
| 62.00000 | 11    | XXXXXXXXXXXXXXXXXX   |
| 65.99999 | 7     | XXXXXXXXXX           |
| 69.99999 | 6     | XXXXXXX              |
| 73.99999 | 6     | XXXXXXX              |
| 77.99999 | 7     | XXXXXXXXXX           |
| 81.99999 | 10    | XXXXXXXXXXXX         |
| 85.99999 | 10    | XXXXXXXXXXXX         |
| 89.99999 | 8     | XXXXXXXXXX           |
| 93.99999 | 7     | XXXXXXXXXX           |
| 97.99999 | 6     | XXXXXXX              |
| 102.0000 | 7     | XXXXXXXXXX           |

200

| MIN      | MAX      | RANGE    | MEAN     | MEDIAN   | VAR |
|----------|----------|----------|----------|----------|-----|
| 23.28542 | 103.7892 | 80.50382 | 56.95843 | 55.50011 | 577 |

HISTOGRAM FOR VARIABLE NO. 18 USER SUPPLIED DISTRIBUTION

| MIDPOINT   | FREQ. |  |
|------------|-------|--|
| -1.650000  | 8     | XXXXXXXXXX   |
| -0.5500000 | 37    | XX |
| 0.5500000  | 32    | XX |
| 1.650000   | 20    | XXXXXXXXXXXXXXXXXXXXXXXXXXXX                                 |
| 2.750000   | 10    | XXXXXXXXXXXX   |
| 3.850000   | 8     | XXXXXXXXXX   |
| 4.950000   | 9     | XXXXXXXXXXXX   |
| 6.050000   | 5     | XXXXXX   |
| 7.150000   | 4     | XXXX   |

|          |   |           |
|----------|---|-----------|
| 8.250000 | 3 | XXX       |
| 9.350000 | 4 | XXXX      |
| 10.45000 | 3 | XXX       |
| 11.55000 | 7 | XXXXXXX   |
| 12.65000 | 9 | XXXXXXXXX |
| 13.75000 | 7 | XXXXXXX   |
| 14.85000 | 5 | XXXXX     |
| 15.95000 | 5 | XXXXX     |
| 17.05000 | 5 | XXXXX     |
| 18.15000 | 8 | XXXXXXX   |
| 19.25000 | 9 | XXXXXXXXX |
| 20.35000 | 2 | XX        |

200

| MIN       | MAX      | RANGE    | MEAN     | MEDIAN   | VAR |
|-----------|----------|----------|----------|----------|-----|
| -1.207170 | 19.89481 | 21.10198 | 5.795099 | 2.504184 | 46. |

HISTOGRAM FOR VARIABLE NO. 19 USER SUPPLIED DISTRIBUTION

| MIDPOINT     | FREQ. |  |
|--------------|-------|--|
| 0.420000E-01 | 15    | XXXXXXXXXXXXXXXXXXXX                         |
| 0.700000E-01 | 0     |  |
| 0.980000E-01 | 14    | XXXXXXXXXXXXXXXXXXXX                         |
| 0.1260000    | 0     |  |
| 0.1540000    | 14    | XXXXXXXXXXXXXXXXXXXX                         |
| 0.1820000    | 14    | XXXXXXXXXXXXXXXXXXXX                         |
| 0.2100000    | 14    | XXXXXXXXXXXXXXXXXXXX                         |
| 0.2380000    | 29    | XX |
| 0.2660000    | 15    | XXXXXXXXXXXXXXXXXXXX                         |
| 0.2940000    | 13    | XXXXXXXXXXXXXXXXXXXX                         |
| 0.3220000    | 0     |  |
| 0.3500000    | 15    | XXXXXXXXXXXXXXXXXXXX                         |
| 0.3780000    | 14    | XXXXXXXXXXXXXXXXXXXX                         |
| 0.4060000    | 0     |  |
| 0.4340000    | 14    | XXXXXXXXXXXXXXXXXXXX                         |
| 0.4620000    | 0     |  |
| 0.4900000    | 0     |  |
| 0.5180000    | 0     |  |
| 0.5460000    | 14    | XXXXXXXXXXXXXXXXXXXX                         |
| 0.5740000    | 0     |  |
| 0.6020000    | 15    | XXXXXXXXXXXXXXXXXXXX                         |

200

| MIN           | MAX       | RANGE     | MEAN      | MEDIAN    | VAR  |
|---------------|-----------|-----------|-----------|-----------|------|
| 0.5080000E-01 | 0.6096000 | 0.5588000 | 0.2948792 | 0.2651150 | 0.24 |

HISTOGRAM FOR VARIABLE NO. 20      USER SUPPLIED      DISTRIBUTION

| MIDPOINT | FREQ.    |  |          |          |     |
|----------|----------|--|----------|----------|-----|
| 0.975000 | 60       | XX |          |          |     |
| 1.125000 | 0        |  |          |          |     |
| 1.275000 | 0        |  |          |          |     |
| 1.425000 | 0        |  |          |          |     |
| 1.575000 | 0        |  |          |          |     |
| 1.725000 | 0        |  |          |          |     |
| 1.875000 | 0        |  |          |          |     |
| 2.025000 | 30       | XX                         |          |          |     |
| 2.175000 | 0        |  |          |          |     |
| 2.325000 | 0        |  |          |          |     |
| 2.475000 | 0        |  |          |          |     |
| 2.625000 | 0        |  |          |          |     |
| 2.775000 | 0        |  |          |          |     |
| 2.925000 | 40       | XX         |          |          |     |
| 3.075001 | 0        |  |          |          |     |
| 3.225001 | 0        |  |          |          |     |
| 3.375001 | 0        |  |          |          |     |
| 3.525001 | 0        |  |          |          |     |
| 3.675001 | 0        |  |          |          |     |
| 3.825001 | 0        |  |          |          |     |
| 3.975001 | 70       | XX |          |          |     |
|          | 200      |  |          |          |     |
| MIN      | MAX      | RANGE  | MEAN     | MEDIAN   | VAR |
| 1.000000 | 4.000000 | 3.000000   | 2.600000 | 3.000000 | 1.5 |

HISTOGRAM FOR VARIABLE NO. 21      USER SUPPLIED      DISTRIBUTION

| MIDPOINT  | FREQ. |  |  |  |  |
|-----------|-------|--|--|--|--|
| -8.750003 | 26    | XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                                 |  |  |  |
| -6.250002 | 0     |  |  |  |  |
| -3.750002 | 0     |  |  |  |  |
| -1.250001 | 0     |  |  |  |  |
| 1.250000  | 26    | XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                                 |  |  |  |
| 3.750000  | 0     |  |  |  |  |
| 6.250001  | 0     |  |  |  |  |
| 8.750002  | 52    | XX |  |  |  |
| 11.25000  | 0     |  |  |  |  |
| 13.75000  | 0     |  |  |  |  |
| 16.25000  | 0     |  |  |  |  |
| 18.75000  | 0     |  |  |  |  |

```

21.25000      0
23.75000     30  XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
26.25000      0
28.75000      0
31.25000      0
33.75000     30  XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
36.25000      0
38.75000     36  XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
                200

```

| MIN       | MAX      | RANGE    | MEAN     | MEDIAN   | VAR |
|-----------|----------|----------|----------|----------|-----|
| -10.00000 | 40.00000 | 50.00000 | 16.79000 | 8.000000 | 289 |

CORRELATIONS AMONG INPUT VARIABLES CREATED BY THE LATIN HYPERCUBE SAMPLE FOR RAW

```

1  1.0000
2  0.0057  1.0000
3  0.0007 -0.0037  1.0000
4  0.0592 -0.0277  0.0036  1.0000
5 -0.0016 -0.0607 -0.0530 -0.0436  1.0000
6 -0.0841  0.0207  0.0152 -0.0331 -0.0104  1.0000
7 -0.0211 -0.0006 -0.0025  0.0369  0.0078  0.0191  1.0000
8 -0.0325  0.0127 -0.0151 -0.0530  0.0220 -0.0425 -0.0179  1.0000
9 -0.0069  0.0248 -0.0010 -0.0768  0.0575  0.0681  0.0138 -0.0123  1.0000
10 -0.0317  0.0599  0.0621 -0.0237  0.0247 -0.0407 -0.1063 -0.0208  0.0266  1.
11  0.0317  0.0090 -0.0414 -0.0610  0.0330 -0.0750 -0.0417  0.0079  0.0714  0.
12 -0.0335  0.0318  0.0421  0.0265  0.1490  0.1309 -0.0478 -0.0411  0.0277  0.
13 -0.0083 -0.0083  0.0035  0.0506 -0.0011  0.0137  0.0534  0.0229 -0.0175 -0.
14  0.0137 -0.0204 -0.0386 -0.0357 -0.0384  0.0112  0.0072  0.0480 -0.0039 -0.
15 -0.0106  0.0073  0.0091 -0.0375  0.0212 -0.0795  0.0044  0.0086 -0.0265 -0.
16  0.0073  0.0008 -0.0134 -0.0734 -0.0768  0.1064 -0.0328  0.0099 -0.0176 -0.
17  0.0330  0.0233  0.0188 -0.0187 -0.0715 -0.0194 -0.0091 -0.0259 -0.0111  0.
18  0.0288 -0.0147  0.0037 -0.0115  0.0196 -0.0871  0.0188  0.0046  0.0206 -0.
19 -0.0178 -0.0003  0.0286 -0.0155  0.0247 -0.0421 -0.0247  0.0031 -0.0224  0.
20  0.0297 -0.0220  0.0047  0.0470  0.0313 -0.0441  0.0137  0.0037  0.0103  0.
21 -0.0241 -0.0529  0.0025  0.0420  0.0159  0.0462 -0.0469 -0.0277 -0.0247 -0.
                1      2      3      4      5      6      7      8      9

```

VARIABLES

CORRELATIONS AMONG INPUT VARIABLES CREATED BY THE LATIN HYPERCUBE SAMPLE FOR RAW

```

16  1.0000
17  0.0212  1.0000
18  0.0646 -0.0171  1.0000
19  0.0105 -0.0064 -0.0021  1.0000
20 -0.0315 -0.0598  0.0432  0.0103  1.0000
21 -0.0416 -0.0136  0.0221  0.0071 -0.0355  1.0000

```





THE SAMPLE INPUT VECTORS WILL BE PRINTED ALONG WITH THEIR CORRESPONDING RANKS  
HISTOGRAMS OF THE ACTUAL SAMPLE WILL BE PLOTTED FOR EACH INPUT VARIABLE  
THE CORRELATION MATRICES (RAW DATA AND RANK CORRELATIONS) WILL BE PRINTED

| VARIABLE | DISTRIBUTION               | RANGE         | LABEL        |             |          |
|----------|----------------------------|---------------|--------------|-------------|----------|
| 1        | NORMAL                     | 5.0000E-02 TO | 0.2000       | GLOBAL      | DISPPERC |
| 2        | LOGNORMAL                  | 1.0000E-02 TO | 100.0        | COLLOID     | CONC     |
| 3        | UNIFORM                    | 4.8000E-02 TO | 9.600        | WAS AREA    | TAUFAIL  |
| 4        | LOGUNIFORM                 | 1.0000E-17 TO | 1.0000E-12   | WAS AREA    | SPPERM   |
| 5        | USER SUPPLIED DISTRIBUTION |               | (CUMULATIVE) | BOREHOLE    |          |
| 6        | USER SUPPLIED DISTRIBUTION |               | (DATA)       | CULEBRA POR |          |
| 7        | USER SUPPLIED DISTRIBUTION |               | (DELTA)      | BOREHOLE D  |          |

INPUT RANK CORRELATION MATRIX

|   |        |        |        |        |        |        |
|---|--------|--------|--------|--------|--------|--------|
| 1 | 1.0000 |        |        |        |        |        |
| 2 | 0.0000 | 1.0000 |        |        |        |        |
| 3 | 0.9990 | 0.0000 | 1.0000 |        |        |        |
| 4 | 0.0000 | 0.0000 | 0.0000 | 1.0000 |        |        |
| 5 | 0.0000 | 0.9500 | 0.0000 | 0.0000 | 1.0000 |        |
| 6 | 0.0000 | 0.0000 | 0.0000 | 0.8000 | 0.0000 | 1.0000 |
|   | 1      | 2      | 3      | 4      | 5      | 6      |

VARIABLES

LATIN HYPERCUBE SAMPLE INPUT VECTORS

| RUN NO. | X(1)      | X(2)      | X(3)      | X(4)      | X(5)      | X(6)      | X(7)     |
|---------|-----------|-----------|-----------|-----------|-----------|-----------|----------|
| 1       | 1.513E-01 | 2.679E-01 | 7.622E+00 | 5.768E-13 | 6.905E+00 | 2.048E-01 | 2.191E-0 |
| 2       | 5.678E-02 | 8.812E+00 | 2.050E-01 | 2.381E-14 | 1.207E+01 | 2.035E-01 | 1.016E-0 |
| 3       | 1.708E-01 | 2.590E-02 | 8.869E+00 | 6.471E-15 | 4.680E+00 | 1.397E-01 | 4.445E-0 |
| 4       | 1.528E-01 | 6.707E+00 | 7.790E+00 | 1.652E-14 | 9.321E+00 | 1.460E-01 | 1.016E-0 |
| 5       | 1.548E-01 | 4.771E-01 | 7.887E+00 | 2.416E-15 | 6.983E+00 | 1.261E-01 | 2.286E-0 |
| 6       | 1.003E-01 | 1.124E+00 | 2.163E+00 | 2.967E-16 | 8.299E+00 | 1.252E-01 | 3.048E-0 |
| 7       | 1.381E-01 | 2.813E-01 | 6.417E+00 | 1.076E-17 | 6.521E+00 | 1.049E-01 | 4.445E-0 |
| 8       | 9.516E-02 | 1.292E+00 | 1.739E+00 | 2.106E-14 | 7.755E+00 | 1.633E-01 | 5.588E-0 |
| 9       | 9.371E-02 | 1.764E+00 | 1.542E+00 | 2.411E-13 | 8.653E+00 | 1.559E-01 | 2.286E-0 |
| 10      | 1.394E-01 | 3.279E+00 | 6.365E+00 | 1.308E-16 | 9.846E+00 | 1.126E-01 | 4.445E-0 |
| 11      | 1.291E-01 | 1.241E-01 | 5.344E+00 | 3.323E-13 | 5.039E+00 | 2.063E-01 | 6.096E-0 |
| 12      | 1.256E-01 | 9.872E-01 | 4.839E+00 | 1.288E-17 | 8.131E+00 | 9.729E-02 | 6.096E-0 |
| 13      | 1.648E-01 | 1.449E+01 | 8.404E+00 | 1.412E-15 | 1.456E+01 | 1.355E-01 | 3.810E-0 |
| 14      | 1.272E-01 | 3.573E+00 | 5.054E+00 | 3.896E-17 | 1.004E+01 | 1.232E-01 | 5.588E-0 |
| 15      | 1.465E-01 | 2.691E+01 | 7.247E+00 | 7.787E-16 | 1.093E+01 | 1.177E-01 | 3.048E-0 |
| 16      | 1.307E-01 | 2.160E+01 | 5.408E+00 | 1.504E-13 | 1.250E+01 | 1.371E-01 | 4.445E-0 |
| 17      | 2.000E-01 | 5.165E+00 | 9.514E+00 | 2.151E-17 | 8.617E+00 | 9.193E-02 | 1.016E-0 |
| 18      | 1.694E-01 | 4.127E-01 | 8.733E+00 | 5.136E-13 | 6.619E+00 | 1.795E-01 | 3.492E-0 |
| 19      | 1.433E-01 | 7.694E+00 | 6.928E+00 | 5.381E-14 | 1.033E+01 | 1.617E-01 | 2.191E-0 |
| 20      | 1.564E-01 | 6.363E+01 | 8.060E+00 | 2.650E-13 | 2.253E+01 | 1.617E-01 | 3.810E-0 |

|    |           |           |           |           |           |           |          |
|----|-----------|-----------|-----------|-----------|-----------|-----------|----------|
| 21 | 6.799E-02 | 5.629E+00 | 3.735E-01 | 2.600E-15 | 9.443E+00 | 1.446E-01 | 6.096E-0 |
| 22 | 1.617E-01 | 7.332E-01 | 8.581E+00 | 6.329E-17 | 6.844E+00 | 1.009E-01 | 3.048E-0 |
| 23 | 9.753E-02 | 8.488E-02 | 1.961E+00 | 4.368E-16 | 6.690E+00 | 1.061E-01 | 5.080E-0 |
| 24 | 1.462E-01 | 3.562E-01 | 7.152E+00 | 2.222E-16 | 7.538E+00 | 1.214E-01 | 4.445E-0 |
| 25 | 8.291E-02 | 7.549E-01 | 1.164E+00 | 5.577E-16 | 8.047E+00 | 1.153E-01 | 3.810E-0 |
| 26 | 1.181E-01 | 4.778E-02 | 4.318E+00 | 5.227E-16 | 5.281E+00 | 1.709E-01 | 2.286E-0 |
| 27 | 1.344E-01 | 1.641E+00 | 5.901E+00 | 8.626E-17 | 7.933E+00 | 1.653E-01 | 2.286E-0 |
| 28 | 1.421E-01 | 1.107E+01 | 6.546E+00 | 2.033E-16 | 1.147E+01 | 1.225E-01 | 2.794E-0 |
| 29 | 1.041E-01 | 2.132E-01 | 2.806E+00 | 1.307E-15 | 6.434E+00 | 1.209E-01 | 1.937E-0 |
| 30 | 1.751E-01 | 6.120E-01 | 9.027E+00 | 1.708E-15 | 7.373E+00 | 1.783E-01 | 1.524E-0 |
| 31 | 1.080E-01 | 3.131E-02 | 2.939E+00 | 3.799E-14 | 4.943E+00 | 1.622E-01 | 3.492E-0 |
| 32 | 1.320E-01 | 1.801E+00 | 5.574E+00 | 6.583E-14 | 8.932E+00 | 1.752E-01 | 1.016E-0 |
| 33 | 1.169E-01 | 1.340E-01 | 3.837E+00 | 1.881E-13 | 5.725E+00 | 1.788E-01 | 3.048E-0 |
| 34 | 1.847E-01 | 2.063E+00 | 9.235E+00 | 5.699E-17 | 1.110E+01 | 9.960E-02 | 1.524E-0 |
| 35 | 1.064E-01 | 1.858E+01 | 2.618E+00 | 8.350E-13 | 1.404E+01 | 1.781E-01 | 2.794E-0 |
| 36 | 1.220E-01 | 1.777E-01 | 4.418E+00 | 1.561E-14 | 6.884E+00 | 1.136E-01 | 3.810E-0 |
| 37 | 1.242E-01 | 5.108E-01 | 4.662E+00 | 1.465E-16 | 6.669E+00 | 1.410E-01 | 5.080E-0 |
| 38 | 1.365E-01 | 1.010E+01 | 6.112E+00 | 7.603E-15 | 1.306E+01 | 1.231E-01 | 3.492E-0 |
| 39 | 8.529E-02 | 5.315E-01 | 1.198E+00 | 1.803E-13 | 7.449E+00 | 2.178E-01 | 4.445E-0 |
| 40 | 1.338E-01 | 1.975E+00 | 6.014E+00 | 4.210E-14 | 7.686E+00 | 1.455E-01 | 1.937E-0 |
| 41 | 1.139E-01 | 1.083E-01 | 3.703E+00 | 2.744E-14 | 6.373E+00 | 1.773E-01 | 5.080E-0 |
| 42 | 5.000E-02 | 1.310E+01 | 1.035E-01 | 1.341E-13 | 1.383E+01 | 2.075E-01 | 5.080E-0 |
| 43 | 7.126E-02 | 4.333E+01 | 5.453E-01 | 9.036E-16 | 1.862E+01 | 1.464E-01 | 6.096E-0 |
| 44 | 1.479E-01 | 2.068E-01 | 7.354E+00 | 7.758E-14 | 6.089E+00 | 1.596E-01 | 1.524E-0 |
| 45 | 1.493E-01 | 2.214E+00 | 7.455E+00 | 6.536E-13 | 9.075E+00 | 2.311E-01 | 2.508E-0 |
| 46 | 8.768E-02 | 2.482E+00 | 1.012E+00 | 3.257E-17 | 8.344E+00 | 1.185E-01 | 2.286E-0 |
| 47 | 9.127E-02 | 3.152E-01 | 1.670E+00 | 5.164E-17 | 7.854E+00 | 1.091E-01 | 2.794E-0 |
| 48 | 7.328E-02 | 1.220E+00 | 5.965E-01 | 2.243E-17 | 7.307E+00 | 7.738E-02 | 1.524E-0 |
| 49 | 1.281E-01 | 4.291E+00 | 5.194E+00 | 1.109E-13 | 1.179E+01 | 1.792E-01 | 2.286E-0 |
| 50 | 1.207E-01 | 1.576E-01 | 4.095E+00 | 3.866E-15 | 6.066E+00 | 1.326E-01 | 2.794E-0 |
| 51 | 7.722E-02 | 3.026E+00 | 7.965E-01 | 9.780E-15 | 8.361E+00 | 1.433E-01 | 1.016E-0 |
| 52 | 1.788E-01 | 4.285E-01 | 9.130E+00 | 1.214E-14 | 7.866E+00 | 1.698E-01 | 5.588E-0 |
| 53 | 1.126E-01 | 8.148E-01 | 3.307E+00 | 7.707E-17 | 7.654E+00 | 1.223E-01 | 2.508E-0 |
| 54 | 8.186E-02 | 3.940E+00 | 8.700E-01 | 3.814E-16 | 1.238E+01 | 1.440E-01 | 1.937E-0 |
| 55 | 1.605E-01 | 3.781E-01 | 8.309E+00 | 6.213E-14 | 7.591E+00 | 1.917E-01 | 1.524E-0 |
| 56 | 1.368E-01 | 1.041E+00 | 6.241E+00 | 3.579E-13 | 7.273E+00 | 2.483E-01 | 2.794E-0 |
| 57 | 1.883E-01 | 8.697E-01 | 9.386E+00 | 7.047E-16 | 8.246E+00 | 1.641E-01 | 2.508E-0 |
| 58 | 1.094E-01 | 3.218E-01 | 3.228E+00 | 4.207E-15 | 6.770E+00 | 1.311E-01 | 2.191E-0 |
| 59 | 1.191E-01 | 1.511E+00 | 4.134E+00 | 4.156E-17 | 8.021E+00 | 1.289E-01 | 1.016E-0 |
| 60 | 1.100E-01 | 2.871E+00 | 3.424E+00 | 1.593E-17 | 1.030E+01 | 8.579E-02 | 1.937E-0 |
| 61 | 1.148E-01 | 6.294E+00 | 3.595E+00 | 1.029E-16 | 1.053E+01 | 1.084E-01 | 3.048E-0 |
| 62 | 1.250E-01 | 1.478E-01 | 4.973E+00 | 1.923E-15 | 5.687E+00 | 1.219E-01 | 6.096E-0 |

|    |           |           |           |           |           |           |          |
|----|-----------|-----------|-----------|-----------|-----------|-----------|----------|
| 63 | 1.012E-01 | 2.335E-01 | 2.374E+00 | 8.606E-13 | 6.495E+00 | 1.953E-01 | 3.492E-0 |
| 64 | 9.012E-02 | 9.451E-01 | 1.369E+00 | 2.567E-17 | 7.149E+00 | 1.203E-01 | 3.492E-0 |
| 65 | 1.228E-01 | 6.967E-02 | 4.516E+00 | 1.441E-17 | 6.323E+00 | 1.051E-01 | 2.508E-0 |
| 66 | 1.450E-01 | 4.445E+00 | 6.882E+00 | 1.079E-15 | 9.641E+00 | 1.617E-01 | 5.080E-0 |
| 67 | 1.051E-01 | 1.179E-02 | 2.537E+00 | 2.514E-16 | 4.469E+00 | 1.038E-01 | 2.508E-0 |
| 68 | 1.401E-01 | 1.000E+02 | 6.764E+00 | 5.846E-15 | 1.726E+01 | 1.866E-01 | 6.096E-0 |
| 69 | 9.847E-02 | 5.560E-02 | 1.950E+00 | 4.117E-13 | 5.353E+00 | 2.028E-01 | 3.492E-0 |
| 70 | 1.122E-01 | 8.908E-02 | 3.029E+00 | 5.245E-15 | 7.054E+00 | 1.619E-01 | 5.588E-0 |
| 71 | 1.579E-01 | 5.735E-01 | 8.081E+00 | 1.112E-14 | 7.212E+00 | 1.238E-01 | 1.937E-0 |
| 72 | 1.659E-01 | 6.905E-01 | 8.615E+00 | 8.854E-14 | 7.078E+00 | 1.783E-01 | 4.445E-0 |
| 73 | 1.165E-01 | 1.365E+00 | 3.951E+00 | 3.386E-14 | 7.490E+00 | 1.787E-01 | 2.191E-0 |
| 74 | 1.327E-01 | 2.580E+00 | 5.753E+00 | 1.761E-16 | 8.173E+00 | 5.871E-02 | 1.937E-0 |
| 75 | 1.031E-01 | 1.763E-02 | 2.331E+00 | 3.404E-15 | 4.264E+00 | 1.535E-01 | 2.508E-0 |

RANKS OF LATIN HYPERCUBE SAMPLE INPUT VECTORS

| RUN NO. | X(1) | X(2) | X(3) | X(4) | X(5) | X(6) | X(7) |
|---------|------|------|------|------|------|------|------|
| 1       | 60.  | 19.  | 60.  | 72.  | 23.  | 70.  | 25   |
| 2       | 2.   | 65.  | 2.   | 51.  | 66.  | 69.  | 9    |
| 3       | 70.  | 3.   | 70.  | 43.  | 3.   | 35.  | 62   |
| 4       | 61.  | 63.  | 61.  | 49.  | 54.  | 41.  | 9    |
| 5       | 62.  | 27.  | 62.  | 36.  | 24.  | 29.  | 30   |
| 6       | 17.  | 40.  | 17.  | 23.  | 47.  | 28.  | 46   |
| 7       | 50.  | 20.  | 51.  | 1.   | 16.  | 9.   | 62   |
| 8       | 14.  | 42.  | 14.  | 50.  | 38.  | 51.  | 68   |
| 9       | 13.  | 46.  | 12.  | 66.  | 51.  | 44.  | 30   |
| 10      | 51.  | 55.  | 50.  | 17.  | 57.  | 14.  | 62   |
| 11      | 42.  | 11.  | 42.  | 68.  | 5.   | 71.  | 73   |
| 12      | 39.  | 38.  | 38.  | 2.   | 44.  | 5.   | 73   |
| 13      | 67.  | 69.  | 66.  | 33.  | 72.  | 33.  | 57   |
| 14      | 40.  | 56.  | 40.  | 9.   | 58.  | 26.  | 68   |
| 15      | 57.  | 72.  | 57.  | 29.  | 62.  | 17.  | 46   |
| 16      | 43.  | 71.  | 43.  | 63.  | 68.  | 34.  | 62   |
| 17      | 75.  | 60.  | 75.  | 5.   | 50.  | 4.   | 9    |
| 18      | 69.  | 25.  | 69.  | 71.  | 17.  | 64.  | 52   |
| 19      | 54.  | 64.  | 55.  | 56.  | 60.  | 47.  | 25   |
| 20      | 63.  | 74.  | 63.  | 67.  | 75.  | 48.  | 57   |
| 21      | 3.   | 61.  | 3.   | 37.  | 55.  | 39.  | 73   |
| 22      | 66.  | 33.  | 67.  | 13.  | 21.  | 7.   | 46   |
| 23      | 15.  | 8.   | 16.  | 25.  | 19.  | 11.  | 3    |
| 24      | 56.  | 23.  | 56.  | 21.  | 34.  | 21.  | 62   |
| 25      | 8.   | 34.  | 9.   | 27.  | 43.  | 16.  | 57   |
| 26      | 32.  | 5.   | 34.  | 26.  | 6.   | 55.  | 30   |
| 27      | 47.  | 45.  | 46.  | 15.  | 41.  | 53.  | 30   |

|    |     |     |     |     |     |     |    |
|----|-----|-----|-----|-----|-----|-----|----|
| 28 | 53. | 67. | 52. | 20. | 64. | 24. | 41 |
| 29 | 20. | 17. | 22. | 32. | 14. | 20. | 20 |
| 30 | 71. | 31. | 71. | 34. | 31. | 60. | 14 |
| 31 | 23. | 4.  | 23. | 54. | 4.  | 50. | 52 |
| 32 | 44. | 47. | 44. | 58. | 52. | 56. | 9  |
| 33 | 31. | 12. | 30. | 65. | 9.  | 62. | 46 |
| 34 | 73. | 49. | 73. | 12. | 63. | 6.  | 14 |
| 35 | 22. | 70. | 21. | 74. | 71. | 58. | 41 |
| 36 | 35. | 15. | 35. | 48. | 22. | 15. | 57 |
| 37 | 37. | 28. | 37. | 18. | 18. | 36. | 3  |
| 38 | 48. | 66. | 48. | 44. | 69. | 25. | 52 |
| 39 | 9.  | 29. | 10. | 64. | 32. | 73. | 62 |
| 40 | 46. | 48. | 47. | 55. | 37. | 40. | 20 |
| 41 | 28. | 10. | 29. | 52. | 13. | 57. | 3  |
| 42 | 1.  | 68. | 1.  | 62. | 70. | 72. | 3  |
| 43 | 4.  | 73. | 4.  | 30. | 74. | 42. | 73 |
| 44 | 58. | 16. | 58. | 59. | 11. | 45. | 14 |
| 45 | 59. | 50. | 59. | 73. | 53. | 74. | 36 |
| 46 | 10. | 51. | 8.  | 8.  | 48. | 18. | 30 |
| 47 | 12. | 21. | 13. | 11. | 39. | 13. | 41 |
| 48 | 5.  | 41. | 5.  | 6.  | 30. | 2.  | 14 |
| 49 | 41. | 58. | 41. | 61. | 65. | 63. | 30 |
| 50 | 34. | 14. | 32. | 39. | 10. | 32. | 41 |
| 51 | 6.  | 54. | 6.  | 45. | 49. | 37. | 9  |
| 52 | 72. | 26. | 72. | 47. | 40. | 54. | 68 |
| 53 | 27. | 35. | 26. | 14. | 36. | 23. | 36 |
| 54 | 7.  | 57. | 7.  | 24. | 67. | 38. | 20 |
| 55 | 65. | 24. | 65. | 57. | 35. | 66. | 14 |
| 56 | 49. | 39. | 49. | 69. | 29. | 75. | 41 |
| 57 | 74. | 36. | 74. | 28. | 46. | 52. | 36 |
| 58 | 24. | 22. | 25. | 40. | 20. | 31. | 25 |
| 59 | 33. | 44. | 33. | 10. | 42. | 30. | 9  |
| 60 | 25. | 53. | 27. | 4.  | 59. | 3.  | 20 |
| 61 | 29. | 62. | 28. | 16. | 61. | 12. | 46 |
| 62 | 38. | 13. | 39. | 35. | 8.  | 22. | 73 |
| 63 | 18. | 18. | 19. | 75. | 15. | 67. | 52 |
| 64 | 11. | 37. | 11. | 7.  | 27. | 19. | 52 |
| 65 | 36. | 7.  | 36. | 3.  | 12. | 10. | 36 |
| 66 | 55. | 59. | 54. | 31. | 56. | 46. | 3  |
| 67 | 21. | 1.  | 20. | 22. | 2.  | 8.  | 36 |
| 68 | 52. | 75. | 53. | 42. | 73. | 65. | 73 |
| 69 | 16. | 6.  | 15. | 70. | 7.  | 68. | 52 |

|    |     |     |     |     |     |     |    |
|----|-----|-----|-----|-----|-----|-----|----|
| 70 | 26. | 9.  | 24. | 41. | 25. | 49. | 68 |
| 71 | 64. | 30. | 64. | 46. | 28. | 27. | 20 |
| 72 | 68. | 32. | 68. | 60. | 26. | 59. | 62 |
| 73 | 30. | 43. | 31. | 53. | 33. | 61. | 25 |
| 74 | 45. | 52. | 45. | 19. | 45. | 1.  | 20 |
| 75 | 19. | 2.  | 18. | 38. | 1.  | 43. | 36 |

HISTOGRAM FOR VARIABLE NO. 1 NORMAL DISTRIBUTION

| MIDPOINT      | FREQ. |         |
|---------------|-------|---------|
| 0.4874997E-01 | 1     | X       |
| 0.5624997E-01 | 1     | X       |
| 0.6374996E-01 | 0     |         |
| 0.7124995E-01 | 3     | XXX     |
| 0.7874995E-01 | 2     | XX      |
| 0.8624994E-01 | 3     | XXX     |
| 0.9374993E-01 | 4     | XXXX    |
| 0.1012499     | 6     | XXXXXX  |
| 0.1087499     | 6     | XXXXXX  |
| 0.1162499     | 7     | XXXXXXX |
| 0.1237499     | 7     | XXXXXXX |
| 0.1312499     | 7     | XXXXXXX |
| 0.1387499     | 6     | XXXXXX  |
| 0.1462499     | 6     | XXXXXX  |
| 0.1537499     | 4     | XXXX    |
| 0.1612499     | 4     | XXXX    |
| 0.1687499     | 3     | XXX     |
| 0.1762499     | 2     | XX      |
| 0.1837499     | 1     | X       |
| 0.1912498     | 1     | X       |
| 0.1987498     | 1     | X       |

75

| MIN           | MAX       | RANGE     | MEAN      | MEDIAN    | VAR  |
|---------------|-----------|-----------|-----------|-----------|------|
| 0.4999998E-01 | 0.2000000 | 0.1500000 | 0.1248673 | 0.1250420 | 0.10 |

HISTOGRAM FOR VARIABLE NO. 2 LOGNORMAL DISTRIBUTION

| MIDPOINT | FREQ. |  |
|----------|-------|--|
| 2.499999 | 59    | XX |
| 7.499997 | 6     | XXXXXX   |
| 12.50000 | 4     | XXXX   |
| 17.49999 | 1     | X  |
| 22.49999 | 1     | X  |
| 27.49999 | 1     | X  |
| 32.49999 | 0     |  |
| 37.49999 | 0     |  |

|          |   |   |
|----------|---|---|
| 42.49999 | 1 | X |
| 47.49999 | 0 |   |
| 52.49999 | 0 |   |
| 57.49999 | 0 |   |
| 62.49999 | 1 | X |
| 67.49998 | 0 |   |
| 72.49998 | 0 |   |
| 77.49998 | 0 |   |
| 82.49998 | 0 |   |
| 87.49998 | 0 |   |
| 92.49998 | 0 |   |
| 97.49998 | 0 |   |
| 102.5000 | 1 | X |

75

| MIN           | MAX      | RANGE    | MEAN     | MEDIAN    | VAR |
|---------------|----------|----------|----------|-----------|-----|
| 0.1179351E-01 | 100.0001 | 99.98830 | 5.677361 | 0.9872297 | 214 |

HISTOGRAM FOR VARIABLE NO. 3 UNIFORM DISTRIBUTION

| MIDPOINT  | FREQ. |       |
|-----------|-------|-------|
| 0.2349999 | 3     | XXX   |
| 0.7049998 | 4     | XXXX  |
| 1.175000  | 4     | XXXX  |
| 1.645000  | 3     | XXX   |
| 2.115000  | 4     | XXXX  |
| 2.584999  | 4     | XXXX  |
| 3.054999  | 3     | XXX   |
| 3.524999  | 4     | XXXX  |
| 3.994999  | 4     | XXXX  |
| 4.464999  | 4     | XXXX  |
| 4.934999  | 3     | XXX   |
| 5.404998  | 4     | XXXX  |
| 5.874998  | 3     | XXX   |
| 6.344998  | 5     | XXXXX |
| 6.814998  | 3     | XXX   |
| 7.284997  | 4     | XXXX  |
| 7.754997  | 3     | XXX   |
| 8.224998  | 4     | XXXX  |
| 8.694998  | 4     | XXXX  |
| 9.164998  | 4     | XXXX  |
| 9.634998  | 1     | X     |

75

| MIN       | MAX      | RANGE    | MEAN     | MEDIAN   | VAR |
|-----------|----------|----------|----------|----------|-----|
| 0.1035329 | 9.514432 | 9.410899 | 4.824547 | 4.839019 | 7.5 |

HISTOGRAM FOR VARIABLE NO. 4 LOGUNIFORM DISTRIBUTION

| MIDPOINT      | FREQ. |  |
|---------------|-------|--|
| 0.2149999E-13 | 55    | XX |
| 0.6449998E-13 | 4     | XXXX   |
| 0.1075000E-12 | 2     | XX   |
| 0.1505000E-12 | 2     | XX   |
| 0.1934999E-12 | 2     | XX   |
| 0.2364999E-12 | 1     | X  |
| 0.2794999E-12 | 1     | X  |
| 0.3224999E-12 | 1     | X  |
| 0.3654999E-12 | 1     | X  |
| 0.4084999E-12 | 1     | X  |
| 0.4514999E-12 | 0     |  |
| 0.4944999E-12 | 1     | X  |
| 0.5374999E-12 | 0     |  |
| 0.5804999E-12 | 1     | X  |
| 0.6234999E-12 | 0     |  |
| 0.6664999E-12 | 1     | X  |
| 0.7095000E-12 | 0     |  |
| 0.7525000E-12 | 0     |  |
| 0.7955000E-12 | 0     |  |
| 0.8385000E-12 | 1     | X  |
| 0.8815000E-12 | 1     | X  |

75

| MIN           | MAX           | RANGE         | MEAN          | MEDIAN        | VAR  |
|---------------|---------------|---------------|---------------|---------------|------|
| 0.1076223E-16 | 0.8605560E-12 | 0.8605453E-12 | 0.8621589E-13 | 0.3403765E-14 | 0.34 |

HISTOGRAM FOR VARIABLE NO. 5 USER SUPPLIED DISTRIBUTION

| MIDPOINT | FREQ. |                      |
|----------|-------|----------------------|
| 4.094997 | 2     | XX                   |
| 5.004997 | 5     | XXXXX                |
| 5.914996 | 5     | XXXXX                |
| 6.824996 | 17    | XXXXXXXXXXXXXXXXXXXX |
| 7.734995 | 16    | XXXXXXXXXXXXXXXXXXXX |
| 8.644995 | 8     | XXXXXXXX             |
| 9.554995 | 4     | XXXX                 |
| 10.46499 | 4     | XXXX                 |
| 11.37499 | 4     | XXXX                 |
| 12.28499 | 3     | XXX                  |
| 13.19499 | 1     | X                    |
| 14.10499 | 2     | XX                   |
| 15.01499 | 1     | X                    |
| 15.92499 | 0     |                      |



|          |   |   |
|----------|---|---|
| 16.83499 | 1 | X |
| 17.74499 | 0 |   |
| 18.65499 | 1 | X |
| 19.56499 | 0 |   |
| 20.47499 | 0 |   |
| 21.38499 | 0 |   |
| 22.29499 | 1 | X |

75

| MIN      | MAX      | RANGE    | MEAN     | MEDIAN   | VAR |
|----------|----------|----------|----------|----------|-----|
| 4.263539 | 22.53333 | 18.26979 | 8.638453 | 7.755095 | 10. |

HISTOGRAM FOR VARIABLE NO. 6 USER SUPPLIED DISTRIBUTION

| MIDPOINT      | FREQ.            |
|---------------|------------------|
| 0.6174996E-01 | 1 X              |
| 0.7124996E-01 | 0                |
| 0.8074996E-01 | 1 X              |
| 0.9024996E-01 | 2 XX             |
| 0.9974995E-01 | 4 XXXX           |
| 0.1092499     | 7 XXXXXXX        |
| 0.1187499     | 11 XXXXXXXXXXXXX |
| 0.1282499     | 6 XXXXXX         |
| 0.1377499     | 4 XXXX           |
| 0.1472499     | 6 XXXXXX         |
| 0.1567499     | 3 XXX            |
| 0.1662499     | 10 XXXXXXXXXXXXX |
| 0.1757499     | 9 XXXXXXXXXXXXX  |
| 0.1852499     | 1 X              |
| 0.1947499     | 2 XX             |
| 0.2042499     | 5 XXXXX          |
| 0.2137499     | 1 X              |
| 0.2232499     | 0                |
| 0.2327499     | 1 X              |
| 0.2422499     | 0                |
| 0.2517499     | 1 X              |

75

| MIN           | MAX       | RANGE     | MEAN      | MEDIAN    | VAR  |
|---------------|-----------|-----------|-----------|-----------|------|
| 0.5870660E-01 | 0.2482859 | 0.1895793 | 0.1467121 | 0.1439527 | 0.14 |

HISTOGRAM FOR VARIABLE NO. 7 USER SUPPLIED DISTRIBUTION

| MIDPOINT      | FREQ.    |
|---------------|----------|
| 0.4200000E-01 | 5 XXXXX  |
| 0.7000001E-01 | 0        |
| 0.9800001E-01 | 6 XXXXXX |
| 0.1260000     | 0        |

|           |    |                  |
|-----------|----|------------------|
| 0.1540000 | 5  | XXXXX            |
| 0.1820000 | 6  | XXXXXXX          |
| 0.2100000 | 4  | XXXX             |
| 0.2380000 | 12 | XXXXXXXXXXXXXXXX |
| 0.2660000 | 5  | XXXXX            |
| 0.2940000 | 5  | XXXXX            |
| 0.3220000 | 0  |                  |
| 0.3500000 | 6  | XXXXXXX          |
| 0.3780000 | 4  | XXXX             |
| 0.4060000 | 0  |                  |
| 0.4340000 | 7  | XXXXXXX          |
| 0.4620000 | 0  |                  |
| 0.4900000 | 0  |                  |
| 0.5180000 | 0  |                  |
| 0.5460000 | 4  | XXXX             |
| 0.5740000 | 0  |                  |
| 0.6020000 | 6  | XXXXXXX          |

75

| MIN           | MAX       | RANGE     | MEAN      | MEDIAN    | VAR  |
|---------------|-----------|-----------|-----------|-----------|------|
| 0.5080000E-01 | 0.6096000 | 0.5588000 | 0.2944717 | 0.2508300 | 0.24 |

CORRELATIONS AMONG INPUT VARIABLES CREATED BY THE LATIN HYPERCUBE SAMPLE FOR RAW

|   |         |        |        |        |        |        |        |  |
|---|---------|--------|--------|--------|--------|--------|--------|--|
| 1 | 1.0000  |        |        |        |        |        |        |  |
| 2 | 0.0316  | 1.0000 |        |        |        |        |        |  |
| 3 | 0.9828  | 0.0825 | 1.0000 |        |        |        |        |  |
| 4 | 0.0085  | 0.0298 | 0.0098 | 1.0000 |        |        |        |  |
| 5 | -0.0292 | 0.7781 | 0.0292 | 0.0423 | 1.0000 |        |        |  |
| 6 | -0.0208 | 0.1069 | 0.0253 | 0.5737 | 0.0447 | 1.0000 |        |  |
| 7 | 0.0039  | 0.2746 | 0.0024 | 0.0463 | 0.1181 | 0.0240 | 1.0000 |  |
|   | 1       | 2      | 3      | 4      | 5      | 6      | 7      |  |

VARIABLES

CORRELATIONS AMONG INPUT VARIABLES CREATED BY THE LATIN HYPERCUBE SAMPLE FOR RANK

|   |        |         |        |         |         |        |        |  |
|---|--------|---------|--------|---------|---------|--------|--------|--|
| 1 | 1.0000 |         |        |         |         |        |        |  |
| 2 | 0.0508 | 1.0000  |        |         |         |        |        |  |
| 3 | 0.9993 | 0.0471  | 1.0000 |         |         |        |        |  |
| 4 | 0.0600 | -0.0393 | 0.0604 | 1.0000  |         |        |        |  |
| 5 | 0.0272 | 0.9499  | 0.0229 | -0.0576 | 1.0000  |        |        |  |
| 6 | 0.0331 | -0.0238 | 0.0327 | 0.8124  | -0.0277 | 1.0000 |        |  |
| 7 | 0.0149 | -0.0538 | 0.0103 | 0.0556  | -0.0263 | 0.0066 | 1.0000 |  |
|   | 1      | 2       | 3      | 4       | 5       | 6      | 7      |  |

VARIABLES

## OUTPUT FILE FOR LHS TEST 4

RANDOM SEED = 933090934

NUMBER OF VARIABLES = 21

NUMBER OF OBSERVATIONS = 75

AN INPUT CORRELATION MATRIX HAS BEEN SPECIFIED

THE SAMPLE INPUT VECTORS WILL BE PRINTED ALONG WITH THEIR CORRESPONDING RANKS

HISTOGRAMS OF THE ACTUAL SAMPLE WILL BE PLOTTED FOR EACH INPUT VARIABLE

THE CORRELATION MATRICES (RAW DATA AND RANK CORRELATIONS) WILL BE PRINTED

| VARIABLE | DISTRIBUTION               | RANGE          | LABEL        |          |              |
|----------|----------------------------|----------------|--------------|----------|--------------|
| 1        | UNIFORM                    | 0.0000E+00 TO  | 1.000        | UNIFMAT2 | UNIFPRP2     |
| 2        | NORMAL                     | -3.6737E-02 TO | 8.3264E-02   | NORMMAT3 | NORMPRP3     |
| 3        | LOGNORMAL                  | 1.0000E-03 TO  | 350.0        | LOGNMAT2 | LOGNPRP2     |
| 4        | UNIFORM                    | -0.5000 TO     | 0.5000       | UNIFMAT1 | UNIFPRP1     |
| 5        | USER SUPPLIED DISTRIBUTION |                | (DELTA)      |          | DELTMAT3 D   |
| 6        | UNIFORM                    | 12.50 TO       | 500.0        | UNIFMAT3 | UNIFPRP3     |
| 7        | LOGUNIFORM                 | 1.0000E-17 TO  | 1.0000E-11   | LOGUMAT1 | LOGUPRP1     |
| 8        | USER SUPPLIED DISTRIBUTION |                | (DATA)       |          | DATAMAT2 DAT |
| 9        | NORMAL                     | 0.0000E+00 TO  | 0.2000       | NORMMAT1 | NORMPRP1     |
| 10       | USER SUPPLIED DISTRIBUTION |                | (DELTA)      |          | DELTMAT1 D   |
| 11       | LOGUNIFORM                 | 5.6000E+13 TO  | 5.6000E+15   | LOGUMAT3 | LOGUPRP3     |
| 12       | USER SUPPLIED DISTRIBUTION |                | (CUMULATIVE) |          | CUMMAT1      |
| 13       | NORMAL                     | 577.0 TO       | 1042.        | NORMMAT2 | NORMPRP2     |
| 14       | USER SUPPLIED DISTRIBUTION |                | (CUMULATIVE) |          | CUMMAT3      |
| 15       | LOGNORMAL                  | 1.0000E-02 TO  | 2.130        | LOGNMAT1 | LOGNPRP1     |
| 16       | USER SUPPLIED DISTRIBUTION |                | (DATA)       |          | DATAMAT1 DAT |
| 17       | LOGNORMAL                  | 1.0000E-04 TO  | 5.2500E+04   | LOGNMAT3 | LOGNPRP3     |
| 18       | USER SUPPLIED DISTRIBUTION |                | (DATA)       |          | DATAMAT3 DAT |
| 19       | USER SUPPLIED DISTRIBUTION |                | (CUMULATIVE) |          | CUMMAT2      |
| 20       | LOGUNIFORM                 | 1.0000E-06 TO  | 1000.        | LOGUMAT2 | LOGUPRP2     |
| 21       | USER SUPPLIED DISTRIBUTION |                | (DELTA)      |          | DELTMAT2 D   |

INPUT RANK CORRELATION MATRIX

|   |        |        |        |        |        |        |        |        |        |
|---|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| 1 | 1.0000 |        |        |        |        |        |        |        |        |
| 2 | 0.0000 | 1.0000 |        |        |        |        |        |        |        |
| 3 | 0.9990 | 0.0000 | 1.0000 |        |        |        |        |        |        |
| 4 | 0.0000 | 0.0000 | 0.0000 | 1.0000 |        |        |        |        |        |
| 5 | 0.0000 | 0.9500 | 0.0000 | 0.0000 | 1.0000 |        |        |        |        |
| 6 | 0.0000 | 0.0000 | 0.0000 | 0.8000 | 0.0000 | 1.0000 |        |        |        |
| 7 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 |        |        |
| 8 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.6500 | 1.0000 |        |
| 9 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.6500 | 0.6500 | 1.0000 |
|   | 1      | 2      | 3      | 4      | 5      | 6      | 7      | 8      | 9      |

VARIABLES

LATIN HYPERCUBE SAMPLE INPUT VECTORS

| RUN NO. | X(1) | X(2) | X(3) | X(4) | X(5) | X(6) | X(7) |
|---------|------|------|------|------|------|------|------|
|---------|------|------|------|------|------|------|------|

|    |           |            |           |            |            |           |          |
|----|-----------|------------|-----------|------------|------------|-----------|----------|
| 1  | 8.978E-01 | 1.602E-02  | 1.899E+01 | -1.699E-02 | 8.000E+00  | 2.690E+02 | 2.533E-1 |
| 2  | 5.078E-01 | 1.844E-02  | 8.610E-01 | 1.647E-01  | 8.000E+00  | 2.754E+02 | 2.078E-1 |
| 3  | 6.426E-01 | 4.806E-02  | 1.682E+00 | -5.350E-02 | 4.000E+01  | 1.218E+02 | 8.508E-1 |
| 4  | 3.457E-01 | 1.222E-02  | 1.542E-01 | 4.107E-01  | 2.000E+00  | 4.397E+02 | 8.065E-1 |
| 5  | 3.966E-01 | 1.687E-02  | 2.403E-01 | -9.337E-02 | 8.000E+00  | 4.087E+02 | 1.702E-1 |
| 6  | 7.451E-01 | 6.738E-03  | 3.887E+00 | -1.088E-01 | 8.000E+00  | 1.748E+02 | 3.954E-1 |
| 7  | 6.720E-01 | 4.313E-03  | 1.931E+00 | -4.298E-01 | 2.000E+00  | 4.964E+01 | 4.678E-1 |
| 8  | 6.804E-01 | 1.059E-02  | 2.139E+00 | -7.002E-02 | 8.000E+00  | 1.402E+02 | 4.975E-1 |
| 9  | 7.608E-01 | 6.330E-02  | 4.720E+00 | -4.596E-01 | 4.000E+01  | 2.508E+01 | 2.479E-1 |
| 10 | 8.465E-01 | 2.660E-02  | 8.935E+00 | -3.819E-01 | 8.000E+00  | 3.455E+01 | 1.896E-1 |
| 11 | 8.350E-01 | -2.935E-02 | 9.154E+00 | -1.719E-01 | -1.000E+01 | 1.024E+02 | 3.549E-1 |
| 12 | 2.986E-01 | 3.362E-02  | 1.018E-01 | -4.335E-01 | 3.400E+01  | 7.070E+01 | 8.296E-1 |
| 13 | 9.680E-01 | 1.922E-02  | 7.636E+01 | -2.055E-01 | 8.000E+00  | 2.422E+02 | 4.144E-1 |
| 14 | 2.485E-01 | 3.769E-02  | 1.092E-01 | 4.395E-02  | 4.000E+01  | 1.630E+02 | 1.262E-1 |
| 15 | 1.717E-02 | 6.100E-03  | 1.697E-03 | -7.672E-02 | 8.000E+00  | 2.957E+02 | 2.326E-1 |
| 16 | 5.005E-01 | 4.270E-02  | 6.585E-01 | -2.767E-01 | 2.300E+01  | 1.468E+02 | 1.903E-1 |
| 17 | 9.224E-01 | 4.113E-02  | 2.985E+01 | -3.128E-01 | 4.000E+01  | 2.596E+02 | 4.682E-1 |
| 18 | 4.627E-01 | 1.173E-02  | 4.414E-01 | -2.338E-02 | 8.000E+00  | 3.625E+02 | 2.181E-1 |
| 19 | 5.506E-01 | -3.459E-02 | 7.726E-01 | 2.478E-02  | -1.000E+01 | 3.017E+02 | 1.161E-1 |
| 20 | 9.752E-01 | 7.237E-02  | 1.454E+02 | 4.421E-01  | 4.000E+01  | 3.767E+02 | 4.252E-1 |
| 21 | 1.235E-01 | -2.187E-02 | 2.255E-02 | -3.974E-01 | -1.000E+01 | 1.905E+02 | 1.336E-1 |
| 22 | 4.902E-01 | 1.451E-02  | 4.739E-01 | -3.397E-01 | 2.000E+00  | 4.245E+01 | 1.390E-1 |
| 23 | 5.854E-01 | 2.864E-02  | 1.019E+00 | 4.631E-01  | 8.000E+00  | 4.884E+02 | 9.359E-1 |
| 24 | 8.649E-01 | 3.093E-02  | 1.385E+01 | 1.168E-01  | 2.300E+01  | 2.243E+02 | 3.895E-1 |
| 25 | 5.378E-01 | 4.224E-02  | 6.980E-01 | -2.508E-01 | 3.400E+01  | 1.115E+02 | 1.221E-1 |
| 26 | 6.396E-01 | -2.926E-03 | 1.523E+00 | 1.746E-02  | 2.000E+00  | 1.594E+02 | 9.368E-1 |
| 27 | 3.759E-01 | 2.586E-02  | 2.884E-01 | -1.563E-01 | 2.300E+01  | 2.129E+02 | 2.949E-1 |
| 28 | 3.850E-02 | 2.732E-02  | 3.968E-03 | 1.877E-01  | 2.300E+01  | 1.333E+02 | 1.060E-1 |
| 29 | 5.698E-01 | 3.700E-02  | 9.022E-01 | -4.181E-01 | 4.000E+01  | 2.797E+02 | 1.349E-1 |
| 30 | 4.464E-01 | 2.479E-02  | 4.106E-01 | 2.637E-01  | 8.000E+00  | 4.190E+02 | 5.675E-1 |
| 31 | 5.195E-03 | 1.362E-02  | 1.000E-03 | -4.318E-02 | 8.000E+00  | 2.070E+02 | 5.570E-1 |
| 32 | 9.583E-02 | 1.503E-02  | 1.785E-02 | 4.522E-01  | 2.000E+00  | 4.811E+02 | 7.396E-1 |
| 33 | 4.004E-01 | 5.458E-02  | 3.138E-01 | -1.217E-01 | 4.000E+01  | 3.114E+02 | 3.335E-1 |
| 34 | 1.773E-01 | 4.723E-02  | 4.651E-02 | -1.837E-01 | 3.400E+01  | 3.304E+02 | 6.682E-1 |
| 35 | 6.917E-02 | 3.874E-02  | 1.396E-02 | 1.093E-01  | 3.400E+01  | 2.547E+02 | 3.385E-1 |
| 36 | 5.433E-02 | -1.145E-02 | 7.820E-03 | -4.682E-01 | -1.000E+01 | 6.395E+01 | 8.853E-1 |
| 37 | 9.045E-02 | 2.971E-02  | 1.215E-02 | -1.507E-01 | 2.300E+01  | 3.121E+02 | 5.232E-1 |
| 38 | 4.776E-02 | 2.253E-02  | 6.848E-03 | -3.574E-01 | 8.000E+00  | 5.373E+01 | 1.337E-1 |
| 39 | 9.940E-01 | 8.492E-03  | 3.500E+02 | -2.976E-01 | 8.000E+00  | 2.367E+02 | 9.421E-1 |
| 40 | 7.927E-01 | -8.873E-03 | 5.560E+00 | -4.936E-01 | 2.000E+00  | 9.116E+01 | 2.710E-1 |
| 41 | 2.300E-01 | 6.616E-02  | 5.896E-02 | -3.488E-01 | 4.000E+01  | 1.535E+02 | 1.060E-1 |
| 42 | 8.060E-01 | -8.098E-04 | 6.615E+00 | 7.619E-02  | 8.000E+00  | 2.521E+02 | 1.899E-1 |

|    |           |            |           |            |            |           |          |
|----|-----------|------------|-----------|------------|------------|-----------|----------|
| 43 | 7.475E-01 | 2.310E-02  | 2.935E+00 | 2.587E-01  | 8.000E+00  | 4.240E+02 | 2.132E-1 |
| 44 | 1.477E-01 | 2.060E-02  | 4.305E-02 | 2.249E-01  | 8.000E+00  | 1.765E+02 | 6.681E-1 |
| 45 | 1.971E-01 | 3.127E-03  | 5.825E-02 | 1.387E-01  | 2.300E+01  | 7.164E+01 | 2.307E-1 |
| 46 | 6.081E-01 | 3.066E-02  | 1.413E+00 | 2.780E-01  | 2.300E+01  | 3.403E+02 | 1.094E-1 |
| 47 | 2.584E-01 | -1.648E-03 | 8.788E-02 | -2.199E-01 | 2.000E+00  | 3.055E+01 | 1.843E-1 |
| 48 | 9.160E-01 | 2.144E-02  | 2.313E+01 | -2.668E-01 | 8.000E+00  | 7.806E+01 | 5.946E-1 |
| 49 | 7.154E-01 | -2.434E-02 | 2.822E+00 | 3.255E-01  | -1.000E+01 | 4.107E+02 | 3.083E-1 |
| 50 | 1.396E-01 | 7.560E-04  | 2.989E-02 | 6.392E-03  | 2.000E+00  | 1.845E+02 | 1.899E-1 |
| 51 | 5.274E-01 | 2.732E-03  | 5.980E-01 | 4.870E-01  | 2.000E+00  | 4.977E+02 | 2.552E-1 |
| 52 | 3.205E-01 | -8.243E-03 | 1.925E-01 | -2.384E-01 | -1.000E+01 | 2.282E+02 | 1.564E-1 |
| 53 | 4.734E-01 | 7.737E-02  | 5.265E-01 | -2.306E-01 | 4.000E+01  | 2.167E+02 | 5.913E-1 |
| 54 | 7.326E-01 | 2.379E-02  | 3.568E+00 | 5.337E-02  | 2.300E+01  | 1.946E+02 | 8.042E-1 |
| 55 | 4.154E-01 | 5.339E-02  | 3.488E-01 | 2.894E-01  | 4.000E+01  | 3.540E+02 | 1.154E-1 |
| 56 | 2.215E-01 | -5.701E-03 | 8.443E-02 | 6.219E-02  | 2.000E+00  | 3.459E+02 | 1.394E-1 |
| 57 | 7.746E-01 | 5.810E-02  | 4.288E+00 | 4.229E-01  | 4.000E+01  | 3.958E+02 | 1.295E-1 |
| 58 | 1.659E-01 | 4.985E-02  | 3.709E-02 | 4.043E-01  | 3.400E+01  | 4.617E+02 | 2.323E-1 |
| 59 | 5.949E-01 | 1.960E-02  | 1.163E+00 | 3.512E-01  | 2.300E+01  | 3.324E+02 | 2.890E-1 |
| 60 | 2.819E-01 | 4.465E-02  | 1.433E-01 | -1.304E-01 | 3.400E+01  | 3.727E+02 | 3.861E-1 |
| 61 | 3.139E-01 | 3.213E-02  | 1.809E-01 | 3.764E-01  | 2.300E+01  | 4.344E+02 | 9.502E-1 |
| 62 | 4.270E-01 | 3.985E-02  | 3.590E-01 | 2.462E-01  | 2.300E+01  | 3.973E+02 | 6.551E-1 |
| 63 | 9.524E-01 | 4.578E-02  | 5.515E+01 | 3.355E-01  | 3.400E+01  | 4.528E+02 | 5.257E-1 |
| 64 | 8.914E-01 | -1.636E-02 | 1.797E+01 | 2.059E-01  | -1.000E+01 | 3.852E+02 | 3.350E-1 |
| 65 | 1.090E-01 | 5.678E-02  | 2.367E-02 | 1.436E-01  | 3.400E+01  | 2.919E+02 | 6.056E-1 |
| 66 | 9.399E-01 | 3.561E-02  | 4.214E+01 | 2.159E-01  | 3.400E+01  | 4.436E+02 | 7.581E-1 |
| 67 | 8.727E-01 | 9.816E-03  | 1.218E+01 | 9.807E-02  | 8.000E+00  | 1.056E+02 | 7.063E-1 |
| 68 | 2.680E-01 | 8.221E-03  | 1.283E-01 | 4.843E-01  | 8.000E+00  | 4.744E+02 | 6.324E-1 |
| 69 | 3.658E-01 | 8.326E-02  | 2.608E-01 | -4.780E-01 | 4.000E+01  | 1.292E+01 | 2.688E-1 |
| 70 | 6.150E-01 | 5.162E-02  | 1.298E+00 | 1.754E-01  | 4.000E+01  | 4.690E+02 | 4.512E-1 |
| 71 | 2.053E-01 | 3.511E-02  | 7.205E-02 | 3.549E-01  | 3.400E+01  | 3.223E+02 | 3.834E-1 |
| 72 | 3.508E-01 | 3.270E-02  | 2.107E-01 | 3.090E-01  | 2.300E+01  | 4.558E+02 | 2.271E-1 |
| 73 | 8.220E-01 | -1.439E-02 | 7.339E+00 | -3.226E-01 | -1.000E+01 | 8.870E+01 | 1.623E-1 |
| 74 | 6.575E-01 | 6.134E-02  | 1.853E+00 | -3.763E-01 | 4.000E+01  | 1.254E+02 | 4.454E-1 |
| 75 | 7.018E-01 | -3.923E-03 | 2.556E+00 | 3.846E-01  | -1.000E+01 | 3.647E+02 | 1.654E-1 |

LATIN HYPERCUBE SAMPLE INPUT VECTORS

| RUN NO. | X(11)     | X(12)      | X(13)     | X(14)      | X(15)     | X(16)     | X(17)    |
|---------|-----------|------------|-----------|------------|-----------|-----------|----------|
| 1       | 8.872E+13 | -6.241E+00 | 8.492E+02 | -2.660E+00 | 4.174E-02 | 2.029E-01 | 6.437E+0 |
| 2       | 9.658E+13 | -6.044E+00 | 7.625E+02 | -3.689E+00 | 1.822E-01 | 1.390E-01 | 3.862E-0 |
| 3       | 8.455E+14 | -5.457E+00 | 7.365E+02 | -7.553E+00 | 6.360E-02 | 5.809E-02 | 3.870E+0 |
| 4       | 2.912E+15 | -6.445E+00 | 9.178E+02 | -4.768E+00 | 1.132E-01 | 1.184E-01 | 2.353E-0 |
| 5       | 2.531E+14 | -6.277E+00 | 6.877E+02 | -5.149E+00 | 3.975E-01 | 9.187E-02 | 4.524E-0 |
| 6       | 1.183E+15 | -5.271E+00 | 8.345E+02 | -4.242E+00 | 6.720E-01 | 1.546E-01 | 2.741E-0 |
| 7       | 1.249E+15 | -6.924E+00 | 7.285E+02 | -2.801E+00 | 2.703E-01 | 1.617E-01 | 8.703E+0 |

|    |           |            |           |            |           |           |          |
|----|-----------|------------|-----------|------------|-----------|-----------|----------|
| 8  | 7.050E+14 | -3.655E+00 | 8.084E+02 | -2.595E+00 | 1.736E-01 | 1.265E-01 | 1.830E-0 |
| 9  | 1.291E+14 | -7.640E+00 | 9.983E+02 | -5.982E+00 | 1.397E-01 | 1.790E-01 | 1.278E+0 |
| 10 | 7.428E+13 | -5.551E+00 | 7.887E+02 | -3.278E+00 | 9.242E-01 | 1.042E-01 | 4.324E+0 |
| 11 | 3.391E+15 | -4.828E+00 | 7.802E+02 | -2.106E+00 | 4.637E-01 | 1.527E-01 | 3.360E+0 |
| 12 | 5.803E+14 | -5.847E+00 | 7.104E+02 | -2.554E+00 | 2.475E-01 | 1.616E-01 | 7.171E-0 |
| 13 | 6.401E+13 | -6.421E+00 | 9.055E+02 | -6.284E+00 | 2.019E-01 | 1.087E-01 | 4.221E-0 |
| 14 | 7.086E+13 | -4.958E+00 | 8.679E+02 | -6.881E+00 | 1.000E-02 | 1.453E-01 | 2.864E-0 |
| 15 | 3.679E+15 | -5.152E+00 | 9.664E+02 | -2.053E+00 | 2.091E-01 | 1.063E-01 | 5.112E-0 |
| 16 | 2.255E+14 | -6.049E+00 | 8.867E+02 | -2.459E+00 | 1.211E+00 | 1.165E-01 | 1.261E+0 |
| 17 | 2.402E+15 | -5.658E+00 | 9.346E+02 | -3.308E+00 | 1.166E-02 | 2.499E-01 | 1.360E-0 |
| 18 | 8.396E+13 | -6.379E+00 | 8.224E+02 | -6.119E+00 | 3.679E-02 | 1.630E-01 | 1.177E-0 |
| 19 | 1.008E+15 | -7.611E+00 | 7.045E+02 | -8.069E+00 | 8.599E-02 | 1.451E-01 | 8.775E+0 |
| 20 | 1.110E+14 | -5.994E+00 | 7.205E+02 | -3.166E+00 | 1.078E-01 | 8.774E-02 | 1.000E-0 |
| 21 | 7.833E+13 | -6.729E+00 | 6.503E+02 | -5.605E+00 | 4.282E-01 | 1.894E-01 | 7.377E-0 |
| 22 | 1.611E+15 | -5.102E+00 | 7.538E+02 | -7.913E+00 | 1.192E-01 | 1.716E-01 | 2.624E+0 |
| 23 | 4.254E+14 | -4.876E+00 | 8.164E+02 | -7.787E+00 | 7.859E-01 | 1.211E-01 | 3.678E-0 |
| 24 | 1.627E+14 | -5.210E+00 | 9.749E+02 | -7.708E+00 | 5.384E-01 | 1.461E-01 | 1.619E+0 |
| 25 | 2.715E+15 | -5.648E+00 | 6.612E+02 | -4.791E+00 | 9.795E-02 | 1.787E-01 | 3.439E-0 |
| 26 | 1.981E+14 | -5.757E+00 | 9.090E+02 | -7.511E+00 | 9.242E-02 | 1.231E-01 | 3.557E+0 |
| 27 | 3.931E+15 | -7.263E+00 | 8.917E+02 | -7.325E+00 | 3.780E-01 | 1.288E-01 | 1.956E+0 |
| 28 | 4.423E+15 | -6.312E+00 | 8.990E+02 | -2.334E+00 | 1.482E-01 | 1.435E-01 | 4.991E+0 |
| 29 | 4.564E+14 | -5.736E+00 | 1.024E+03 | -4.292E+00 | 2.848E-01 | 1.149E-01 | 6.471E-0 |
| 30 | 1.463E+15 | -2.989E+00 | 7.582E+02 | -5.864E+00 | 3.407E-01 | 1.784E-01 | 1.968E-0 |
| 31 | 9.576E+14 | -5.712E+00 | 8.567E+02 | -5.633E+00 | 9.303E-02 | 1.230E-01 | 7.821E+0 |
| 32 | 8.230E+14 | -5.814E+00 | 7.839E+02 | -6.640E+00 | 1.140E-01 | 1.781E-01 | 2.932E+0 |
| 33 | 4.694E+15 | -6.509E+00 | 8.312E+02 | -2.255E+00 | 2.551E-01 | 1.331E-01 | 6.857E+0 |
| 34 | 6.252E+13 | -5.404E+00 | 9.215E+02 | -6.407E+00 | 8.062E-02 | 1.783E-01 | 1.545E+0 |
| 35 | 6.487E+14 | -5.265E+00 | 6.231E+02 | -2.704E+00 | 4.944E-02 | 1.226E-01 | 9.958E-0 |
| 36 | 1.692E+14 | -5.054E+00 | 7.235E+02 | -5.269E+00 | 3.903E-02 | 1.782E-01 | 2.571E+0 |
| 37 | 5.228E+15 | -5.492E+00 | 9.522E+02 | -7.123E+00 | 4.547E-01 | 1.491E-01 | 6.398E+0 |
| 38 | 7.409E+14 | -4.770E+00 | 8.045E+02 | -7.959E+00 | 1.513E-01 | 1.791E-01 | 3.183E+0 |
| 39 | 5.289E+15 | -5.441E+00 | 7.864E+02 | -5.467E+00 | 4.941E-01 | 2.183E-01 | 6.558E-0 |
| 40 | 1.432E+15 | -4.084E+00 | 8.825E+02 | -5.312E+00 | 2.762E-02 | 1.195E-01 | 2.045E+0 |
| 41 | 1.415E+14 | -5.935E+00 | 6.035E+02 | -2.203E+00 | 4.737E-02 | 1.409E-01 | 1.929E+0 |
| 42 | 2.075E+15 | -6.143E+00 | 7.419E+02 | -8.433E+00 | 1.283E-01 | 1.804E-01 | 5.299E+0 |
| 43 | 2.797E+14 | -5.199E+00 | 8.948E+02 | -2.279E+00 | 1.901E-01 | 1.386E-01 | 3.793E+0 |
| 44 | 3.128E+14 | -5.007E+00 | 6.945E+02 | -4.981E+00 | 1.579E-01 | 1.654E-01 | 3.479E-0 |
| 45 | 3.369E+14 | -5.332E+00 | 8.537E+02 | -7.078E+00 | 1.715E+00 | 1.360E-01 | 1.609E+0 |
| 46 | 1.879E+15 | -5.867E+00 | 7.647E+02 | -5.082E+00 | 1.771E-01 | 2.076E-01 | 4.808E+0 |
| 47 | 1.805E+14 | -6.554E+00 | 7.033E+02 | -2.938E+00 | 2.140E-01 | 1.052E-01 | 1.022E-0 |
| 48 | 6.828E+14 | -4.975E+00 | 8.200E+02 | -4.644E+00 | 7.307E-02 | 1.211E-01 | 7.581E-0 |
| 49 | 2.945E+14 | -5.323E+00 | 7.998E+02 | -3.536E+00 | 1.652E-01 | 1.962E-01 | 1.204E+0 |

|    |           |            |           |            |           |           |          |
|----|-----------|------------|-----------|------------|-----------|-----------|----------|
| 50 | 1.565E+14 | -6.205E+00 | 9.272E+02 | -3.009E+00 | 3.242E-02 | 1.038E-01 | 3.109E-0 |
| 51 | 9.421E+14 | -7.812E+00 | 7.963E+02 | -3.176E+00 | 2.242E-02 | 1.108E-01 | 4.981E-0 |
| 52 | 5.139E+14 | -5.788E+00 | 7.506E+02 | -8.304E+00 | 2.882E-01 | 1.253E-01 | 1.134E-0 |
| 53 | 1.704E+15 | -5.602E+00 | 7.739E+02 | -8.538E+00 | 3.286E-01 | 1.628E-01 | 2.270E-0 |
| 54 | 3.572E+14 | -6.374E+00 | 5.770E+02 | -4.499E+00 | 6.021E-02 | 1.617E-01 | 7.778E-0 |
| 55 | 4.239E+15 | -6.561E+00 | 8.718E+02 | -2.868E+00 | 1.357E-01 | 1.618E-01 | 2.448E+0 |
| 56 | 5.907E+13 | -5.077E+00 | 8.640E+02 | -4.063E+00 | 6.514E-01 | 9.943E-02 | 9.042E+0 |
| 57 | 5.520E+14 | -5.362E+00 | 7.928E+02 | -6.501E+00 | 2.221E-01 | 2.037E-01 | 1.574E-0 |
| 58 | 9.909E+13 | -6.323E+00 | 8.419E+02 | -7.272E+00 | 5.977E-01 | 2.061E-01 | 4.523E-0 |
| 59 | 1.076E+14 | -6.076E+00 | 8.249E+02 | -3.893E+00 | 2.583E-02 | 1.767E-01 | 2.739E+0 |
| 60 | 3.072E+15 | -3.404E+00 | 7.331E+02 | -6.766E+00 | 1.624E-02 | 1.021E-01 | 5.774E+0 |
| 61 | 2.149E+14 | -4.524E+00 | 7.720E+02 | -6.912E+00 | 2.130E+00 | 1.219E-01 | 1.202E+0 |
| 62 | 1.172E+14 | -4.787E+00 | 8.137E+02 | -2.764E+00 | 2.992E-02 | 1.612E-01 | 6.254E+0 |
| 63 | 1.788E+15 | -4.860E+00 | 7.444E+02 | -3.065E+00 | 7.742E-02 | 7.594E-02 | 1.153E+0 |
| 64 | 2.618E+15 | -5.970E+00 | 8.383E+02 | -3.945E+00 | 2.368E-01 | 1.158E-01 | 5.250E+0 |
| 65 | 1.370E+14 | -6.124E+00 | 7.700E+02 | -2.444E+00 | 9.655E-01 | 2.312E-01 | 1.465E+0 |
| 66 | 4.102E+14 | -5.895E+00 | 6.396E+02 | -2.128E+00 | 3.035E-01 | 1.672E-01 | 1.646E+0 |
| 67 | 1.346E+15 | -5.139E+00 | 9.483E+02 | -5.749E+00 | 5.245E-02 | 1.830E-01 | 5.716E+0 |
| 68 | 2.363E+14 | -5.586E+00 | 1.038E+03 | -2.960E+00 | 5.612E-02 | 2.059E-01 | 1.415E+0 |
| 69 | 2.344E+15 | -7.211E+00 | 8.782E+02 | -8.228E+00 | 8.388E-02 | 1.121E-01 | 7.468E-0 |
| 70 | 3.799E+14 | -6.190E+00 | 6.816E+02 | -8.133E+00 | 3.625E-01 | 1.312E-01 | 1.982E+0 |
| 71 | 3.485E+15 | -5.510E+00 | 6.734E+02 | -6.232E+00 | 6.958E-02 | 1.439E-01 | 2.131E+0 |
| 72 | 1.097E+15 | -2.182E+00 | 8.466E+02 | -3.484E+00 | 1.252E-01 | 1.235E-01 | 4.371E+0 |
| 73 | 5.053E+14 | -4.906E+00 | 8.063E+02 | -3.782E+00 | 6.481E-02 | 1.645E-01 | 8.575E-0 |
| 74 | 2.672E+14 | -2.564E+00 | 8.374E+02 | -4.418E+00 | 1.040E-01 | 1.221E-01 | 1.423E-0 |
| 75 | 2.099E+15 | -6.478E+00 | 8.609E+02 | -8.441E+00 | 4.506E-02 | 9.805E-02 | 1.029E+0 |

LATIN HYPERCUBE SAMPLE INPUT VECTORS

| RUN NO. | X(21)     |
|---------|-----------|
| 1       | 4.000E+00 |
| 2       | 4.000E+00 |
| 3       | 4.000E+00 |
| 4       | 4.000E+00 |
| 5       | 2.000E+00 |
| 6       | 4.000E+00 |
| 7       | 1.000E+00 |
| 8       | 3.000E+00 |
| 9       | 1.000E+00 |
| 10      | 4.000E+00 |
| 11      | 4.000E+00 |
| 12      | 4.000E+00 |
| 13      | 1.000E+00 |
| 14      | 1.000E+00 |

15 3.000E+00  
16 3.000E+00  
17 4.000E+00  
18 3.000E+00  
19 2.000E+00  
20 1.000E+00  
21 3.000E+00  
22 3.000E+00  
23 3.000E+00  
24 4.000E+00  
25 2.000E+00  
26 4.000E+00  
27 3.000E+00  
28 3.000E+00  
29 1.000E+00  
30 4.000E+00  
31 4.000E+00  
32 2.000E+00  
33 1.000E+00  
34 4.000E+00  
35 4.000E+00  
36 3.000E+00  
37 4.000E+00  
38 1.000E+00  
39 2.000E+00  
40 3.000E+00  
41 1.000E+00  
42 4.000E+00  
43 2.000E+00  
44 3.000E+00  
45 1.000E+00  
46 3.000E+00  
47 2.000E+00  
48 1.000E+00  
49 1.000E+00  
50 4.000E+00  
51 2.000E+00  
52 1.000E+00  
53 4.000E+00  
54 4.000E+00  
55 2.000E+00  
56 4.000E+00



57 1.000E+00  
 58 4.000E+00  
 59 1.000E+00  
 60 2.000E+00  
 61 1.000E+00  
 62 1.000E+00  
 63 4.000E+00  
 64 3.000E+00  
 65 4.000E+00  
 66 4.000E+00  
 67 2.000E+00  
 68 2.000E+00  
 69 3.000E+00  
 70 1.000E+00  
 71 1.000E+00  
 72 1.000E+00  
 73 1.000E+00  
 74 4.000E+00  
 75 1.000E+00

RANKS OF LATIN HYPERCUBE SAMPLE INPUT VECTORS

| RUN NO. | X(1) | X(2) | X(3) | X(4) | X(5) | X(6) | X(7) |
|---------|------|------|------|------|------|------|------|
| 1       | 68.  | 30.  | 68.  | 37.  | 30.  | 40.  | 31   |
| 2       | 39.  | 32.  | 42.  | 50.  | 30.  | 41.  | 67   |
| 3       | 49.  | 63.  | 49.  | 34.  | 69.  | 17.  | 12   |
| 4       | 26.  | 26.  | 24.  | 69.  | 15.  | 66.  | 37   |
| 5       | 30.  | 31.  | 28.  | 31.  | 30.  | 61.  | 3    |
| 6       | 56.  | 20.  | 57.  | 30.  | 30.  | 25.  | 58   |
| 7       | 51.  | 18.  | 51.  | 6.   | 15.  | 6.   | 34   |
| 8       | 52.  | 24.  | 52.  | 33.  | 30.  | 20.  | 22   |
| 9       | 58.  | 71.  | 59.  | 4.   | 69.  | 2.   | 43   |
| 10      | 64.  | 42.  | 63.  | 9.   | 30.  | 4.   | 66   |
| 11      | 63.  | 2.   | 64.  | 25.  | 5.   | 14.  | 7    |
| 12      | 23.  | 50.  | 20.  | 5.   | 57.  | 9.   | 62   |
| 13      | 73.  | 33.  | 73.  | 23.  | 30.  | 36.  | 71   |
| 14      | 19.  | 54.  | 21.  | 41.  | 69.  | 24.  | 14   |
| 15      | 2.   | 19.  | 2.   | 32.  | 30.  | 44.  | 68   |
| 16      | 38.  | 59.  | 39.  | 17.  | 46.  | 21.  | 54   |
| 17      | 70.  | 57.  | 70.  | 15.  | 69.  | 39.  | 46   |
| 18      | 35.  | 25.  | 35.  | 36.  | 30.  | 54.  | 30   |
| 19      | 42.  | 1.   | 41.  | 40.  | 5.   | 45.  | 26   |
| 20      | 74.  | 73.  | 74.  | 71.  | 69.  | 57.  | 8    |
| 21      | 10.  | 4.   | 9.   | 8.   | 5.   | 28.  | 65   |

|    |     |     |     |     |     |     |    |
|----|-----|-----|-----|-----|-----|-----|----|
| 22 | 37. | 28. | 36. | 13. | 15. | 5.  | 40 |
| 23 | 44. | 44. | 44. | 73. | 30. | 74. | 63 |
| 24 | 65. | 47. | 66. | 47. | 46. | 33. | 20 |
| 25 | 41. | 58. | 40. | 19. | 57. | 16. | 52 |
| 26 | 48. | 12. | 48. | 39. | 15. | 23. | 75 |
| 27 | 29. | 41. | 30. | 26. | 46. | 31. | 19 |
| 28 | 3.  | 43. | 3.  | 52. | 46. | 19. | 13 |
| 29 | 43. | 53. | 43. | 7.  | 69. | 42. | 15 |
| 30 | 34. | 40. | 34. | 58. | 30. | 63. | 47 |
| 31 | 1.  | 27. | 1.  | 35. | 30. | 30. | 72 |
| 32 | 8.  | 29. | 8.  | 72. | 15. | 73. | 49 |
| 33 | 31. | 67. | 31. | 29. | 69. | 46. | 32 |
| 34 | 14. | 62. | 14. | 24. | 57. | 49. | 11 |
| 35 | 6.  | 55. | 7.  | 46. | 57. | 38. | 45 |
| 36 | 5.  | 7.  | 5.  | 3.  | 5.  | 8.  | 25 |
| 37 | 7.  | 45. | 6.  | 27. | 46. | 47. | 59 |
| 38 | 4.  | 37. | 4.  | 11. | 30. | 7.  | 2  |
| 39 | 75. | 22. | 75. | 16. | 30. | 35. | 38 |
| 40 | 60. | 8.  | 60. | 1.  | 15. | 13. | 6  |
| 41 | 18. | 72. | 16. | 12. | 69. | 22. | 51 |
| 42 | 61. | 14. | 61. | 44. | 30. | 37. | 29 |
| 43 | 57. | 38. | 55. | 57. | 30. | 64. | 42 |
| 44 | 12. | 35. | 13. | 55. | 30. | 26. | 48 |
| 45 | 15. | 17. | 15. | 48. | 46. | 10. | 55 |
| 46 | 46. | 46. | 47. | 59. | 46. | 51. | 1  |
| 47 | 20. | 13. | 19. | 22. | 15. | 3.  | 16 |
| 48 | 69. | 36. | 69. | 18. | 30. | 11. | 23 |
| 49 | 54. | 3.  | 54. | 62. | 5.  | 62. | 44 |
| 50 | 11. | 15. | 11. | 38. | 15. | 27. | 4  |
| 51 | 40. | 16. | 38. | 75. | 15. | 75. | 18 |
| 52 | 25. | 9.  | 26. | 20. | 5.  | 34. | 53 |
| 53 | 36. | 74. | 37. | 21. | 69. | 32. | 60 |
| 54 | 55. | 39. | 56. | 42. | 46. | 29. | 74 |
| 55 | 32. | 66. | 32. | 60. | 69. | 53. | 64 |
| 56 | 17. | 10. | 18. | 43. | 15. | 52. | 27 |
| 57 | 59. | 69. | 58. | 70. | 69. | 59. | 39 |
| 58 | 13. | 64. | 12. | 68. | 57. | 70. | 5  |
| 59 | 45. | 34. | 45. | 64. | 46. | 50. | 69 |
| 60 | 22. | 60. | 23. | 28. | 57. | 56. | 70 |
| 61 | 24. | 48. | 25. | 66. | 46. | 65. | 50 |
| 62 | 33. | 56. | 33. | 56. | 46. | 60. | 73 |
| 63 | 72. | 61. | 72. | 63. | 57. | 68. | 35 |

|    |     |     |     |     |     |     |    |
|----|-----|-----|-----|-----|-----|-----|----|
| 64 | 67. | 5.  | 67. | 53. | 5.  | 58. | 57 |
| 65 | 9.  | 68. | 10. | 49. | 57. | 43. | 10 |
| 66 | 71. | 52. | 71. | 54. | 57. | 67. | 36 |
| 67 | 66. | 23. | 65. | 45. | 30. | 15. | 24 |
| 68 | 21. | 21. | 22. | 74. | 30. | 72. | 61 |
| 69 | 28. | 75. | 29. | 2.  | 69. | 1.  | 56 |
| 70 | 47. | 65. | 46. | 51. | 69. | 71. | 9  |
| 71 | 16. | 51. | 17. | 65. | 57. | 48. | 33 |
| 72 | 27. | 49. | 27. | 61. | 46. | 69. | 17 |
| 73 | 62. | 6.  | 62. | 14. | 5.  | 12. | 41 |
| 74 | 50. | 70. | 50. | 10. | 69. | 18. | 21 |
| 75 | 53. | 11. | 53. | 67. | 5.  | 55. | 28 |

RANKS OF LATIN HYPERCUBE SAMPLE INPUT VECTORS

| RUN NO. | X(11) | X(12) | X(13) | X(14) | X(15) | X(16) | X(1) |
|---------|-------|-------|-------|-------|-------|-------|------|
| 1       | 8.    | 19.   | 50.   | 64.   | 11.   | 68.   | 68   |
| 2       | 9.    | 26.   | 24.   | 49.   | 44.   | 35.   | 6    |
| 3       | 45.   | 45.   | 18.   | 12.   | 18.   | 1.    | 72   |
| 4       | 65.   | 12.   | 65.   | 39.   | 31.   | 18.   | 23   |
| 5       | 25.   | 18.   | 9.    | 35.   | 61.   | 4.    | 27   |
| 6       | 50.   | 51.   | 45.   | 44.   | 69.   | 44.   | 24   |
| 7       | 51.   | 6.    | 16.   | 61.   | 53.   | 47.   | 69   |
| 8       | 42.   | 71.   | 38.   | 65.   | 42.   | 29.   | 10   |
| 9       | 14.   | 2.    | 73.   | 27.   | 37.   | 62.   | 70   |
| 10      | 5.    | 42.   | 32.   | 53.   | 71.   | 9.    | 57   |
| 11      | 67.   | 66.   | 29.   | 74.   | 64.   | 43.   | 55   |
| 12      | 39.   | 32.   | 13.   | 66.   | 51.   | 46.   | 30   |
| 13      | 3.    | 13.   | 63.   | 24.   | 46.   | 12.   | 14   |
| 14      | 4.    | 62.   | 55.   | 19.   | 1.    | 40.   | 12   |
| 15      | 69.   | 55.   | 71.   | 75.   | 47.   | 11.   | 15   |
| 16      | 23.   | 25.   | 59.   | 67.   | 73.   | 17.   | 34   |
| 17      | 62.   | 38.   | 68.   | 52.   | 2.    | 75.   | 20   |
| 18      | 7.    | 14.   | 42.   | 26.   | 9.    | 51.   | 19   |
| 19      | 48.   | 3.    | 12.   | 7.    | 25.   | 39.   | 47   |
| 20      | 12.   | 27.   | 14.   | 55.   | 30.   | 3.    | 1    |
| 21      | 6.    | 7.    | 5.    | 31.   | 62.   | 66.   | 16   |
| 22      | 55.   | 57.   | 22.   | 9.    | 33.   | 55.   | 54   |
| 23      | 34.   | 64.   | 40.   | 10.   | 70.   | 21.   | 26   |
| 24      | 18.   | 53.   | 72.   | 11.   | 66.   | 41.   | 74   |
| 25      | 64.   | 39.   | 6.    | 38.   | 28.   | 61.   | 25   |
| 26      | 21.   | 35.   | 64.   | 13.   | 26.   | 26.   | 41   |
| 27      | 70.   | 4.    | 60.   | 14.   | 60.   | 30.   | 52   |
| 28      | 72.   | 17.   | 62.   | 69.   | 38.   | 37.   | 43   |

|    |     |     |     |     |     |     |    |
|----|-----|-----|-----|-----|-----|-----|----|
| 29 | 35. | 36. | 74. | 43. | 54. | 15. | 29 |
| 30 | 54. | 73. | 23. | 28. | 58. | 60. | 22 |
| 31 | 47. | 37. | 52. | 30. | 27. | 25. | 60 |
| 32 | 44. | 33. | 30. | 21. | 32. | 57. | 40 |
| 33 | 73. | 10. | 44. | 71. | 52. | 32. | 46 |
| 34 | 2.  | 47. | 66. | 23. | 23. | 59. | 51 |
| 35 | 40. | 52. | 3.  | 63. | 14. | 24. | 32 |
| 36 | 19. | 59. | 15. | 34. | 10. | 58. | 39 |
| 37 | 74. | 44. | 70. | 16. | 63. | 42. | 45 |
| 38 | 43. | 68. | 36. | 8.  | 39. | 63. | 66 |
| 39 | 75. | 46. | 31. | 32. | 65. | 73. | 3  |
| 40 | 53. | 70. | 58. | 33. | 6.  | 19. | 37 |
| 41 | 16. | 29. | 2.  | 72. | 13. | 36. | 64 |
| 42 | 59. | 22. | 19. | 3.  | 35. | 64. | 44 |
| 43 | 27. | 54. | 61. | 70. | 45. | 34. | 56 |
| 44 | 29. | 60. | 10. | 37. | 40. | 53. | 13 |
| 45 | 30. | 49. | 51. | 17. | 74. | 33. | 36 |
| 46 | 58. | 31. | 25. | 36. | 43. | 72. | 67 |
| 47 | 20. | 9.  | 11. | 59. | 48. | 10. | 18 |
| 48 | 41. | 61. | 41. | 40. | 21. | 20. | 7  |
| 49 | 28. | 50. | 35. | 50. | 41. | 67. | 49 |
| 50 | 17. | 20. | 67. | 57. | 8.  | 8.  | 5  |
| 51 | 46. | 1.  | 34. | 54. | 4.  | 13. | 28 |
| 52 | 37. | 34. | 21. | 4.  | 55. | 28. | 9  |
| 53 | 56. | 40. | 28. | 1.  | 57. | 50. | 11 |
| 54 | 31. | 15. | 1.  | 41. | 17. | 48. | 31 |
| 55 | 71. | 8.  | 56. | 60. | 36. | 49. | 38 |
| 56 | 1.  | 58. | 54. | 45. | 68. | 6.  | 61 |
| 57 | 38. | 48. | 33. | 22. | 49. | 69. | 21 |
| 58 | 10. | 16. | 48. | 15. | 67. | 71. | 2  |
| 59 | 11. | 24. | 43. | 47. | 5.  | 56. | 65 |
| 60 | 66. | 72. | 17. | 20. | 3.  | 7.  | 73 |
| 61 | 22. | 69. | 27. | 18. | 75. | 22. | 62 |
| 62 | 13. | 67. | 39. | 62. | 7.  | 45. | 59 |
| 63 | 57. | 65. | 20. | 56. | 22. | 2.  | 33 |
| 64 | 63. | 28. | 47. | 46. | 50. | 16. | 75 |
| 65 | 15. | 23. | 26. | 68. | 72. | 74. | 50 |
| 66 | 33. | 30. | 4.  | 73. | 56. | 54. | 63 |
| 67 | 52. | 56. | 69. | 29. | 15. | 65. | 58 |
| 68 | 24. | 41. | 75. | 58. | 16. | 70. | 35 |
| 69 | 61. | 5.  | 57. | 5.  | 24. | 14. | 17 |
| 70 | 32. | 21. | 8.  | 6.  | 59. | 31. | 71 |

|    |     |     |     |     |     |     |    |
|----|-----|-----|-----|-----|-----|-----|----|
| 71 | 68. | 43. | 7.  | 25. | 20. | 38. | 53 |
| 72 | 49. | 75. | 49. | 51. | 34. | 27. | 42 |
| 73 | 36. | 63. | 37. | 48. | 19. | 52. | 8  |
| 74 | 26. | 74. | 46. | 42. | 29. | 23. | 4  |
| 75 | 60. | 11. | 53. | 2.  | 12. | 5.  | 48 |

RANKS OF LATIN HYPERCUBE SAMPLE INPUT VECTORS

| RUN NO. | X(21) |
|---------|-------|
| 1       | 63.   |
| 2       | 63.   |
| 3       | 63.   |
| 4       | 63.   |
| 5       | 29.   |
| 6       | 63.   |
| 7       | 12.   |
| 8       | 42.   |
| 9       | 12.   |
| 10      | 63.   |
| 11      | 63.   |
| 12      | 63.   |
| 13      | 12.   |
| 14      | 12.   |
| 15      | 42.   |
| 16      | 42.   |
| 17      | 63.   |
| 18      | 42.   |
| 19      | 29.   |
| 20      | 12.   |
| 21      | 42.   |
| 22      | 42.   |
| 23      | 42.   |
| 24      | 63.   |
| 25      | 29.   |
| 26      | 63.   |
| 27      | 42.   |
| 28      | 42.   |
| 29      | 12.   |
| 30      | 63.   |
| 31      | 63.   |
| 32      | 29.   |
| 33      | 12.   |
| 34      | 63.   |
| 35      | 63.   |

|    |     |
|----|-----|
| 36 | 42. |
| 37 | 63. |
| 38 | 12. |
| 39 | 29. |
| 40 | 42. |
| 41 | 12. |
| 42 | 63. |
| 43 | 29. |
| 44 | 42. |
| 45 | 12. |
| 46 | 42. |
| 47 | 29. |
| 48 | 12. |
| 49 | 12. |
| 50 | 63. |
| 51 | 29. |
| 52 | 12. |
| 53 | 63. |
| 54 | 63. |
| 55 | 29. |
| 56 | 63. |
| 57 | 12. |
| 58 | 63. |
| 59 | 12. |
| 60 | 29. |
| 61 | 12. |
| 62 | 12. |
| 63 | 63. |
| 64 | 42. |
| 65 | 63. |
| 66 | 63. |
| 67 | 29. |
| 68 | 29. |
| 69 | 42. |
| 70 | 12. |
| 71 | 12. |
| 72 | 12. |
| 73 | 12. |
| 74 | 63. |
| 75 | 12. |

HISTOGRAM FOR VARIABLE NO. 1

UNIFORM

DISTRIBUTION

| MIDPOINT      | FREQ. |       |
|---------------|-------|-------|
| 0.2449999E-01 | 4     | XXXX  |
| 0.7349998E-01 | 4     | XXXX  |
| 0.1225000     | 3     | XXX   |
| 0.1715000     | 3     | XXX   |
| 0.2204999     | 4     | XXXX  |
| 0.2694999     | 4     | XXXX  |
| 0.3184999     | 3     | XXX   |
| 0.3674999     | 4     | XXXX  |
| 0.4164999     | 4     | XXXX  |
| 0.4654999     | 3     | XXX   |
| 0.5144999     | 5     | XXXXX |
| 0.5634999     | 3     | XXX   |
| 0.6124998     | 3     | XXX   |
| 0.6614998     | 5     | XXXXX |
| 0.7104998     | 3     | XXX   |
| 0.7594997     | 4     | XXXX  |
| 0.8084997     | 3     | XXX   |
| 0.8574997     | 4     | XXXX  |
| 0.9064996     | 4     | XXXX  |
| 0.9554996     | 4     | XXXX  |
| 1.004500      | 1     | X     |

75

| MIN           | MAX       | RANGE     | MEAN      | MEDIAN    | VAR  |
|---------------|-----------|-----------|-----------|-----------|------|
| 0.5195054E-02 | 0.9939531 | 0.9887580 | 0.4991933 | 0.5005198 | 0.83 |

HISTOGRAM FOR VARIABLE NO. 2 NORMAL DISTRIBUTION

| MIDPOINT       | FREQ. |         |
|----------------|-------|---------|
| -0.3244999E-01 | 1     | X       |
| -0.2654999E-01 | 2     | XX      |
| -0.2064999E-01 | 1     | X       |
| -0.1474999E-01 | 2     | XX      |
| -0.8849997E-02 | 3     | XXX     |
| -0.2950000E-02 | 5     | XXXXX   |
| 0.2949998E-02  | 4     | XXXX    |
| 0.8849995E-02  | 7     | XXXXXXX |
| 0.1474999E-01  | 6     | XXXXXXX |
| 0.2064999E-01  | 7     | XXXXXXX |
| 0.2654999E-01  | 6     | XXXXXXX |
| 0.3244999E-01  | 7     | XXXXXXX |
| 0.3834999E-01  | 6     | XXXXXXX |
| 0.4424999E-01  | 4     | XXXX    |

|               |   |      |
|---------------|---|------|
| 0.5014998E-01 | 4 | XXXX |
| 0.5604998E-01 | 4 | XXXX |
| 0.6194998E-01 | 2 | XX   |
| 0.6784998E-01 | 1 | X    |
| 0.7374997E-01 | 1 | X    |
| 0.7964997E-01 | 1 | X    |
| 0.8554997E-01 | 1 | X    |

75

| MIN            | MAX           | RANGE     | MEAN          | MEDIAN        | VAR  |
|----------------|---------------|-----------|---------------|---------------|------|
| -0.3458769E-01 | 0.8326402E-01 | 0.1178517 | 0.2336021E-01 | 0.2309605E-01 | 0.64 |

HISTOGRAM FOR VARIABLE NO. 3 LOGNORMAL DISTRIBUTION

| MIDPOINT | FREQ. |  |
|----------|-------|--|
| 8.500001 | 66    | XX |
| 25.50000 | 4     | XXXX   |
| 42.50001 | 1     | X  |
| 59.50001 | 1     | X  |
| 76.50002 | 1     | X  |
| 93.50002 | 0     |  |
| 110.5000 | 0     |  |
| 127.5000 | 0     |  |
| 144.5000 | 1     | X  |
| 161.5000 | 0     |  |
| 178.5000 | 0     |  |
| 195.5000 | 0     |  |
| 212.5000 | 0     |  |
| 229.5000 | 0     |  |
| 246.5000 | 0     |  |
| 263.5000 | 0     |  |
| 280.5000 | 0     |  |
| 297.5000 | 0     |  |
| 314.5000 | 0     |  |
| 331.5000 | 0     |  |
| 348.5000 | 1     | X  |

75

| MIN           | MAX      | RANGE    | MEAN     | MEDIAN    | VAR |
|---------------|----------|----------|----------|-----------|-----|
| 0.9999980E-03 | 350.0006 | 349.9996 | 11.61960 | 0.5980396 | 196 |

HISTOGRAM FOR VARIABLE NO. 4 UNIFORM DISTRIBUTION

| MIDPOINT   | FREQ. |     |
|------------|-------|-----|
| -0.5144998 | 1     | X   |
| -0.4654998 | 3     | XXX |



|                |   |        |
|----------------|---|--------|
| -0.4164998     | 4 | XXXX   |
| -0.3674998     | 4 | XXXX   |
| -0.3184998     | 4 | XXXX   |
| -0.2694998     | 3 | XXX    |
| -0.2204998     | 4 | XXXX   |
| -0.1714998     | 4 | XXXX   |
| -0.1224999     | 3 | XXX    |
| -0.7349989E-01 | 4 | XXXX   |
| -0.2449990E-01 | 3 | XXX    |
| 0.2450008E-01  | 4 | XXXX   |
| 0.7350007E-01  | 3 | XXX    |
| 0.1225001      | 5 | XXXXXX |
| 0.1715000      | 3 | XXX    |
| 0.2205000      | 3 | XXX    |
| 0.2695000      | 5 | XXXXXX |
| 0.3185000      | 3 | XXX    |
| 0.3675000      | 4 | XXXX   |
| 0.4165000      | 3 | XXX    |
| 0.4655000      | 5 | XXXXXX |

75

| MIN        | MAX       | RANGE     | MEAN           | MEDIAN        | VAR  |
|------------|-----------|-----------|----------------|---------------|------|
| -0.4936196 | 0.4869559 | 0.9805755 | -0.1768669E-05 | 0.6391935E-02 | 0.83 |

HISTOGRAM FOR VARIABLE NO. 5 USER SUPPLIED DISTRIBUTION

| MIDPOINT  | FREQ. |                            |
|-----------|-------|----------------------------|
| -8.750003 | 9     | XXXXXXXXXX                 |
| -6.250002 | 0     |                            |
| -3.750002 | 0     |                            |
| -1.250001 | 0     |                            |
| 1.250000  | 10    | XXXXXXXXXX                 |
| 3.750000  | 0     |                            |
| 6.250001  | 0     |                            |
| 8.750002  | 20    | XXXXXXXXXXXXXXXXXXXXXXXXXX |
| 11.25000  | 0     |                            |
| 13.75000  | 0     |                            |
| 16.25000  | 0     |                            |
| 18.75000  | 0     |                            |
| 21.25000  | 0     |                            |
| 23.75000  | 12    | XXXXXXXXXXXX               |
| 26.25000  | 0     |                            |
| 28.75000  | 0     |                            |
| 31.25000  | 0     |                            |

|          |    |                |
|----------|----|----------------|
| 33.75000 | 10 | XXXXXXXXXX     |
| 36.25000 | 0  |                |
| 38.75000 | 14 | XXXXXXXXXXXXXX |
|          | 75 |                |

| MIN       | MAX      | RANGE    | MEAN     | MEDIAN   | VAR |
|-----------|----------|----------|----------|----------|-----|
| -10.00000 | 40.00000 | 50.00000 | 16.88000 | 8.000000 | 282 |

HISTOGRAM FOR VARIABLE NO. 6 UNIFORM DISTRIBUTION

| MIDPOINT | FREQ. |       |
|----------|-------|-------|
| 12.00000 | 1     | X     |
| 36.00001 | 4     | XXXX  |
| 60.00002 | 5     | XXXXX |
| 84.00002 | 3     | XXX   |
| 108.0000 | 3     | XXX   |
| 132.0000 | 4     | XXXX  |
| 156.0000 | 4     | XXXX  |
| 180.0000 | 4     | XXXX  |
| 204.0000 | 3     | XXX   |
| 228.0000 | 4     | XXXX  |
| 252.0000 | 4     | XXXX  |
| 276.0000 | 3     | XXX   |
| 300.0000 | 4     | XXXX  |
| 324.0000 | 4     | XXXX  |
| 348.0000 | 3     | XXX   |
| 372.0000 | 4     | XXXX  |
| 396.0000 | 3     | XXX   |
| 420.0000 | 4     | XXXX  |
| 444.0000 | 5     | XXXXX |
| 468.0000 | 3     | XXX   |
| 492.0000 | 3     | XXX   |
|          | 75    |       |

| MIN      | MAX      | RANGE    | MEAN     | MEDIAN   | VAR |
|----------|----------|----------|----------|----------|-----|
| 12.92320 | 497.7050 | 484.7818 | 256.1264 | 254.6725 | 197 |

HISTOGRAM FOR VARIABLE NO. 7 LOGUNIFORM DISTRIBUTION

| MIDPOINT      | FREQ. |  |
|---------------|-------|--|
| 0.2349999E-12 | 58    | XX |
| 0.7049998E-12 | 5     | XXXXX  |
| 0.1175000E-11 | 2     | XX   |
| 0.1645000E-11 | 0     |  |
| 0.2114999E-11 | 3     | XXX  |
| 0.2584999E-11 | 0     |  |

|               |   |    |
|---------------|---|----|
| 0.3054999E-11 | 1 | X  |
| 0.3524999E-11 | 0 |    |
| 0.3994999E-11 | 2 | XX |
| 0.4464999E-11 | 0 |    |
| 0.4934999E-11 | 0 |    |
| 0.5404998E-11 | 1 | X  |
| 0.5874998E-11 | 0 |    |
| 0.6344998E-11 | 1 | X  |
| 0.6814998E-11 | 0 |    |
| 0.7284998E-11 | 0 |    |
| 0.7754998E-11 | 0 |    |
| 0.8224998E-11 | 1 | X  |
| 0.8694998E-11 | 0 |    |
| 0.9164998E-11 | 1 | X  |

75

| MIN           | MAX           | RANGE         | MEAN          | MEDIAN        | VAR  |
|---------------|---------------|---------------|---------------|---------------|------|
| 0.1093542E-16 | 0.9368482E-11 | 0.9368470E-11 | 0.7344726E-12 | 0.9421005E-14 | 0.32 |

HISTOGRAM FOR VARIABLE NO. 8 USER SUPPLIED DISTRIBUTION

| MIDPOINT | FREQ.      |
|----------|------------|
| 22.00000 | 1 X        |
| 26.00000 | 6 XXXXXX   |
| 30.00000 | 7 XXXXXXXX |
| 34.00000 | 7 XXXXXXXX |
| 38.00000 | 5 XXXXXX   |
| 42.00000 | 4 XXXX     |
| 46.00000 | 3 XXX      |
| 50.00000 | 3 XXX      |
| 54.00000 | 2 XX       |
| 58.00000 | 4 XXXX     |
| 62.00000 | 5 XXXXXX   |
| 65.99999 | 2 XX       |
| 69.99999 | 3 XXX      |
| 73.99999 | 3 XXX      |
| 77.99999 | 2 XX       |
| 81.99999 | 3 XXX      |
| 85.99999 | 5 XXXXXX   |
| 89.99999 | 2 XX       |
| 93.99999 | 3 XXX      |
| 97.99999 | 2 XX       |
| 102.0000 | 3 XXX      |

75

| MIN      | MAX      | RANGE    | MEAN     | MEDIAN   | VAR |
|----------|----------|----------|----------|----------|-----|
| 23.21227 | 102.2718 | 79.05949 | 56.98121 | 54.81532 | 578 |

HISTOGRAM FOR VARIABLE NO. 9 NORMAL DISTRIBUTION

| MIDPOINT       | FREQ. |          |
|----------------|-------|----------|
| -0.4999997E-02 | 1     | X        |
| 0.4999997E-02  | 1     | X        |
| 0.1499999E-01  | 0     |          |
| 0.2499998E-01  | 2     | XX       |
| 0.3499998E-01  | 2     | XX       |
| 0.4499997E-01  | 3     | XXX      |
| 0.5499997E-01  | 5     | XXXXX    |
| 0.6499996E-01  | 4     | XXXX     |
| 0.7499995E-01  | 6     | XXXXXX   |
| 0.8499994E-01  | 7     | XXXXXXXX |
| 0.9499993E-01  | 7     | XXXXXXXX |
| 0.1049999      | 7     | XXXXXXXX |
| 0.1149999      | 6     | XXXXXX   |
| 0.1249999      | 6     | XXXXXX   |
| 0.1349999      | 5     | XXXXX    |
| 0.1449999      | 3     | XXX      |
| 0.1549999      | 4     | XXXX     |
| 0.1649999      | 3     | XXX      |
| 0.1749999      | 0     |          |
| 0.1849999      | 2     | XX       |
| 0.1949998      | 1     | X        |

75

| MIN            | MAX       | RANGE     | MEAN          | MEDIAN        | VAR  |
|----------------|-----------|-----------|---------------|---------------|------|
| -0.2235174E-07 | 0.1996517 | 0.1996517 | 0.9979033E-01 | 0.9963441E-01 | 0.17 |

HISTOGRAM FOR VARIABLE NO. 10 USER SUPPLIED DISTRIBUTION

| MIDPOINT      | FREQ. |            |
|---------------|-------|------------|
| 0.4200000E-01 | 5     | XXXXX      |
| 0.7000001E-01 | 0     |            |
| 0.9800001E-01 | 6     | XXXXXX     |
| 0.1260000     | 0     |            |
| 0.1540000     | 5     | XXXXX      |
| 0.1820000     | 5     | XXXXX      |
| 0.2100000     | 6     | XXXXXX     |
| 0.2380000     | 10    | XXXXXXXXXX |
| 0.2660000     | 6     | XXXXXX     |
| 0.2940000     | 5     | XXXXX      |

|           |   |        |
|-----------|---|--------|
| 0.3220000 | 0 |        |
| 0.3500000 | 6 | XXXXXX |
| 0.3780000 | 5 | XXXXX  |
| 0.4060000 | 0 |        |
| 0.4340000 | 5 | XXXXX  |
| 0.4620000 | 0 |        |
| 0.4900000 | 0 |        |
| 0.5180000 | 0 |        |
| 0.5460000 | 6 | XXXXXX |
| 0.5740000 | 0 |        |
| 0.6020000 | 5 | XXXXX  |

75

| MIN           | MAX       | RANGE     | MEAN      | MEDIAN    | VAR  |
|---------------|-----------|-----------|-----------|-----------|------|
| 0.5080000E-01 | 0.6096000 | 0.5588000 | 0.2950643 | 0.2794000 | 0.24 |

HISTOGRAM FOR VARIABLE NO. 11 LOGUNIFORM DISTRIBUTION

| MIDPOINT      | FREQ. |                              |
|---------------|-------|------------------------------|
| 0.1300000E+15 | 25    | XXXXXXXXXXXXXXXXXXXXXXXXXXXX |
| 0.3900001E+15 | 12    | XXXXXXXXXXXX                 |
| 0.6500001E+15 | 6     | XXXXXX                       |
| 0.9100002E+15 | 5     | XXXXX                        |
| 0.1170000E+16 | 3     | XXX                          |
| 0.1430000E+16 | 3     | XXX                          |
| 0.1690000E+16 | 3     | XXX                          |
| 0.1950000E+16 | 2     | XX                           |
| 0.2210000E+16 | 1     | X                            |
| 0.2470000E+16 | 2     | XX                           |
| 0.2730000E+16 | 2     | XX                           |
| 0.2990001E+16 | 2     | XX                           |
| 0.3250001E+16 | 0     |                              |
| 0.3510001E+16 | 2     | XX                           |
| 0.3770001E+16 | 1     | X                            |
| 0.4030001E+16 | 1     | X                            |
| 0.4290001E+16 | 1     | X                            |
| 0.4550001E+16 | 1     | X                            |
| 0.4810002E+16 | 1     | X                            |
| 0.5070002E+16 | 0     |                              |
| 0.5330002E+16 | 2     | XX                           |

75

| MIN           | MAX           | RANGE         | MEAN          | MEDIAN        | VAR  |
|---------------|---------------|---------------|---------------|---------------|------|
| 0.5907079E+14 | 0.5289056E+16 | 0.5229985E+16 | 0.1195846E+16 | 0.5520103E+15 | 0.19 |

HISTOGRAM FOR VARIABLE NO. 12      USER SUPPLIED      DISTRIBUTION

| MIDPOINT  | FREQ. |            |
|-----------|-------|------------|
| -7.700001 | 3     | XXX        |
| -7.420001 | 0     |            |
| -7.140001 | 2     | XX         |
| -6.860001 | 2     | XX         |
| -6.580000 | 5     | XXXXX      |
| -6.300000 | 9     | XXXXXXXXXX |
| -6.020000 | 9     | XXXXXXXXXX |
| -5.740000 | 10    | XXXXXXXXXX |
| -5.460000 | 10    | XXXXXXXXXX |
| -5.179999 | 9     | XXXXXXXXXX |
| -4.899999 | 9     | XXXXXXXXXX |
| -4.619999 | 1     | X          |
| -4.339999 | 0     |            |
| -4.059999 | 1     | X          |
| -3.779999 | 1     | X          |
| -3.499999 | 1     | X          |
| -3.219999 | 0     |            |
| -2.939999 | 1     | X          |
| -2.659999 | 1     | X          |
| -2.379999 | 0     |            |
| -2.099999 | 1     | X          |

75

| MIN       | MAX       | RANGE    | MEAN      | MEDIAN    | VAR |
|-----------|-----------|----------|-----------|-----------|-----|
| -7.811573 | -2.181874 | 5.629699 | -5.605499 | -5.657501 | 1.0 |

HISTOGRAM FOR VARIABLE NO. 13      NORMAL      DISTRIBUTION

| MIDPOINT | FREQ. |         |
|----------|-------|---------|
| 586.5001 | 1     | X       |
| 609.5001 | 1     | X       |
| 632.5001 | 2     | XX      |
| 655.5001 | 2     | XX      |
| 678.5001 | 3     | XXX     |
| 701.5001 | 4     | XXXX    |
| 724.5001 | 4     | XXXX    |
| 747.5001 | 6     | XXXXXX  |
| 770.5001 | 6     | XXXXXX  |
| 793.5001 | 7     | XXXXXXX |
| 816.5001 | 7     | XXXXXXX |
| 839.5001 | 7     | XXXXXXX |
| 862.5001 | 6     | XXXXXX  |



|           |    |                      |
|-----------|----|----------------------|
| 0.1650000 | 18 | XXXXXXXXXXXXXXXXXXXX |
| 0.2750000 | 9  | XXXXXXXXXX           |
| 0.3850000 | 5  | XXXXX                |
| 0.4949999 | 4  | XXXX                 |
| 0.6050000 | 2  | XX                   |
| 0.7150000 | 1  | X                    |
| 0.8250000 | 1  | X                    |
| 0.9350000 | 2  | XX                   |
| 1.045000  | 0  |                      |
| 1.155000  | 0  |                      |
| 1.265000  | 1  | X                    |
| 1.375000  | 0  |                      |
| 1.485000  | 0  |                      |
| 1.595000  | 0  |                      |
| 1.705000  | 1  | X                    |
| 1.815000  | 0  |                      |
| 1.925000  | 0  |                      |
| 2.035000  | 0  |                      |
| 2.145000  | 1  | X                    |

75

| MIN           | MAX      | RANGE    | MEAN      | MEDIAN    | VAR  |
|---------------|----------|----------|-----------|-----------|------|
| 0.9999994E-02 | 2.130001 | 2.120001 | 0.2732225 | 0.1482280 | 0.13 |

HISTOGRAM FOR VARIABLE NO. 16      USER SUPPLIED      DISTRIBUTION

| MIDPOINT      | FREQ. |              |
|---------------|-------|--------------|
| 0.6239996E-01 | 1     | X            |
| 0.7199995E-01 | 1     | X            |
| 0.8159994E-01 | 0     |              |
| 0.9119993E-01 | 2     | XX           |
| 0.1007999     | 6     | XXXXXX       |
| 0.1103999     | 5     | XXXXX        |
| 0.1199999     | 12    | XXXXXXXXXXXX |
| 0.1295999     | 5     | XXXXX        |
| 0.1391999     | 6     | XXXXXX       |
| 0.1487999     | 5     | XXXXX        |
| 0.1583999     | 8     | XXXXXXXX     |
| 0.1679999     | 4     | XXXX         |
| 0.1775999     | 9     | XXXXXXXXXX   |
| 0.1871999     | 2     | XX           |
| 0.1967999     | 1     | X            |
| 0.2063999     | 5     | XXXXX        |
| 0.2159999     | 1     | X            |



|           |   |   |
|-----------|---|---|
| 0.2255999 | 0 |   |
| 0.2351999 | 1 | X |
| 0.2447999 | 0 |   |
| 0.2543999 | 1 | X |

75

| MIN           | MAX       | RANGE     | MEAN      | MEDIAN    | VAR  |
|---------------|-----------|-----------|-----------|-----------|------|
| 0.5809073E-01 | 0.2498642 | 0.1917735 | 0.1468146 | 0.1439133 | 0.14 |

HISTOGRAM FOR VARIABLE NO. 17 LOGNORMAL DISTRIBUTION

| MIDPOINT | FREQ. |  |
|----------|-------|--|
| 1300.000 | 71    | XX |
| 3900.001 | 1     | X  |
| 6500.001 | 1     | X  |
| 9100.002 | 0     |  |
| 11700.00 | 0     |  |
| 14300.00 | 0     |  |
| 16900.00 | 1     | X  |
| 19500.00 | 0     |  |
| 22100.00 | 0     |  |
| 24700.00 | 0     |  |
| 27300.00 | 0     |  |
| 29900.00 | 0     |  |
| 32500.00 | 0     |  |
| 35100.00 | 0     |  |
| 37700.00 | 0     |  |
| 40300.00 | 0     |  |
| 42900.00 | 0     |  |
| 45500.00 | 0     |  |
| 48100.00 | 0     |  |
| 50700.00 | 0     |  |
| 53300.00 | 1     | X  |

75

| MIN           | MAX      | RANGE    | MEAN     | MEDIAN   | VAR  |
|---------------|----------|----------|----------|----------|------|
| 0.9999979E-04 | 52500.10 | 52500.10 | 1136.518 | 2.447765 | 0.39 |

HISTOGRAM FOR VARIABLE NO. 18 USER SUPPLIED DISTRIBUTION

| MIDPOINT | FREQ. |                  |
|----------|-------|------------------|
| 2.299999 | 3     | XXX              |
| 6.899998 | 4     | XXXX             |
| 11.50000 | 13    | XXXXXXXXXXXXXXXX |
| 16.09999 | 3     | XXX              |
| 20.69999 | 2     | XX               |

|          |   |          |
|----------|---|----------|
| 25.29999 | 2 | XX       |
| 29.89999 | 5 | XXXXXX   |
| 34.49999 | 3 | XXX      |
| 39.09999 | 3 | XXX      |
| 43.69999 | 3 | XXX      |
| 48.29998 | 7 | XXXXXXXX |
| 52.89998 | 3 | XXX      |
| 57.49998 | 3 | XXX      |
| 62.09998 | 2 | XX       |
| 66.69998 | 2 | XX       |
| 71.29998 | 3 | XXX      |
| 75.89998 | 3 | XXX      |
| 80.49998 | 2 | XX       |
| 85.09998 | 1 | X        |
| 89.69997 | 5 | XXXXXX   |
| 94.29997 | 3 | XXX      |

75

|          |          |          |          |          |     |
|----------|----------|----------|----------|----------|-----|
| MIN      | MAX      | RANGE    | MEAN     | MEDIAN   | VAR |
| 1.497821 | 94.20219 | 92.70438 | 42.20030 | 40.65907 | 796 |

HISTOGRAM FOR VARIABLE NO. 19 USER SUPPLIED DISTRIBUTION

| MIDPOINT  | FREQ. |            |
|-----------|-------|------------|
| -12.39500 | 1     | X          |
| -12.02500 | 1     | X          |
| -11.65500 | 2     | XX         |
| -11.28500 | 1     | X          |
| -10.91500 | 1     | X          |
| -10.54500 | 1     | X          |
| -10.17500 | 1     | X          |
| -9.804998 | 2     | XX         |
| -9.434999 | 0     |            |
| -9.064999 | 3     | XXX        |
| -8.694999 | 5     | XXXXXX     |
| -8.324999 | 5     | XXXXXX     |
| -7.954999 | 5     | XXXXXX     |
| -7.584999 | 5     | XXXXXX     |
| -7.214999 | 5     | XXXXXX     |
| -6.844999 | 5     | XXXXXX     |
| -6.474999 | 6     | XXXXXXX    |
| -6.105000 | 8     | XXXXXXXXXX |
| -5.735000 | 7     | XXXXXXXXXX |
| -5.365000 | 8     | XXXXXXXXXX |

-4.995000 3 XXX

75

| MIN       | MAX       | RANGE    | MEAN      | MEDIAN    | VAR |
|-----------|-----------|----------|-----------|-----------|-----|
| -12.46164 | -5.037228 | 7.424414 | -7.410848 | -7.086456 | 3.3 |

HISTOGRAM FOR VARIABLE NO. 20 LOGUNIFORM DISTRIBUTION

| MIDPOINT | FREQ. |  |
|----------|-------|--|
| 20.99999 | 63    | XX |
| 62.99998 | 3     | XXX  |
| 105.0000 | 1     | X  |
| 147.0000 | 2     | XX   |
| 189.0000 | 0     |  |
| 230.9999 | 1     | X  |
| 272.9999 | 0     |  |
| 314.9999 | 1     | X  |
| 356.9999 | 0     |  |
| 398.9999 | 1     | X  |
| 440.9999 | 0     |  |
| 482.9999 | 0     |  |
| 524.9999 | 1     | X  |
| 566.9999 | 0     |  |
| 608.9999 | 0     |  |
| 650.9999 | 0     |  |
| 692.9999 | 0     |  |
| 734.9999 | 1     | X  |
| 776.9999 | 0     |  |
| 818.9999 | 1     | X  |

75

| MIN           | MAX      | RANGE    | MEAN     | MEDIAN        | VAR |
|---------------|----------|----------|----------|---------------|-----|
| 0.1257535E-05 | 831.6160 | 831.6160 | 50.22662 | 0.3609625E-01 | 227 |

HISTOGRAM FOR VARIABLE NO. 21 USER SUPPLIED DISTRIBUTION

| MIDPOINT  | FREQ. |                              |
|-----------|-------|------------------------------|
| 0.9750000 | 22    | XXXXXXXXXXXXXXXXXXXXXXXXXXXX |
| 1.125000  | 0     |                              |
| 1.275000  | 0     |                              |
| 1.425000  | 0     |                              |
| 1.575000  | 0     |                              |
| 1.725000  | 0     |                              |
| 1.875000  | 0     |                              |
| 2.025000  | 12    | XXXXXXXXXXXX                 |
| 2.175000  | 0     |                              |

```

2.325000      0
2.475000      0
2.625000      0
2.775000      0
2.925000     15  XXXXXXXXXXXXXXXXXXXX
3.075001      0
3.225001      0
3.375001      0
3.525001      0
3.675001      0
3.825001      0
3.975001     26  XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
75

```

| MIN      | MAX      | RANGE    | MEAN     | MEDIAN   | VAR |
|----------|----------|----------|----------|----------|-----|
| 1.000000 | 4.000000 | 3.000000 | 2.600000 | 3.000000 | 1.5 |

CORRELATIONS AMONG INPUT VARIABLES CREATED BY THE LATIN HYPERCUBE SAMPLE FOR RAW

```

1  1.0000
2 -0.0403  1.0000
3  0.4040  0.0240  1.0000
4 -0.0224  0.0076 -0.0472  1.0000
5 -0.0455  0.9149  0.0086  0.0090  1.0000
6 -0.0094  0.0745  0.0407  0.7775  0.0637  1.0000
7 -0.0030 -0.0488 -0.0399  0.0228 -0.0460 -0.0159  1.0000
8  0.0058  0.0314 -0.0657  0.0360 -0.0070 -0.0127  0.4476  1.0000
9  0.0069 -0.0070  0.0810 -0.0041 -0.0077 -0.0440  0.4065  0.5927  1.0000
10 -0.0265 -0.0214  0.0014 -0.0086  0.0157 -0.0777  0.0020  0.0704 -0.0026  1.
11 -0.0396  0.0298  0.2601 -0.0427  0.0859  0.0207 -0.1112  0.0403  0.0121 -0.
12  0.0035  0.0403 -0.0047  0.0187  0.0332  0.0371 -0.0081 -0.0152 -0.0059 -0.
13  0.0361 -0.0120 -0.0470 -0.0042 -0.0177  0.0186 -0.0206  0.0034 -0.0337 -0.
14  0.0741 -0.0204  0.0471  0.0252  0.0211  0.0207 -0.0227 -0.0411 -0.0135 -0.
15 -0.0975  0.0152  0.0194  0.0671  0.0315  0.0242 -0.1200  0.0756  0.1001 -0.
16  0.0083 -0.0096  0.1121  0.0054  0.0280  0.0158 -0.0940 -0.0285  0.0155  0.
17  0.1953 -0.1377  0.0104  0.0824 -0.1337  0.0964 -0.0244  0.0390  0.0932 -0.
18  0.0154 -0.0157  0.0183 -0.0047  0.0450 -0.0391  0.0658  0.0276  0.0511  0.
19  0.0091  0.0204  0.0001  0.0440  0.0904  0.0339 -0.0092 -0.0485  0.0141  0.
20  0.0831  0.0508 -0.0404 -0.0592  0.0199 -0.0482 -0.0735 -0.0114  0.0697  0.
21 -0.0408 -0.0115 -0.0897 -0.0744 -0.0171 -0.0692  0.1020 -0.0387  0.0242  0.
      1      2      3      4      5      6      7      8      9

```

VARIABLES

CORRELATIONS AMONG INPUT VARIABLES CREATED BY THE LATIN HYPERCUBE SAMPLE FOR RAW

```

16  1.0000
17 -0.1202  1.0000

```

|    |        |         |         |         |        |        |
|----|--------|---------|---------|---------|--------|--------|
| 18 | 0.0070 | 0.2074  | 1.0000  |         |        |        |
| 19 | 0.0287 | -0.0253 | 0.0563  | 1.0000  |        |        |
| 20 | 0.0666 | 0.0497  | -0.0531 | -0.0974 | 1.0000 |        |
| 21 | 0.0432 | 0.0670  | -0.0219 | -0.0343 | 0.0951 | 1.0000 |
|    | 16     | 17      | 18      | 19      | 20     | 21     |

VARIABLES

CORRELATIONS AMONG INPUT VARIABLES CREATED BY THE LATIN HYPERCUBE SAMPLE FOR RANK

|    |         |         |         |         |         |         |         |         |         |     |
|----|---------|---------|---------|---------|---------|---------|---------|---------|---------|-----|
| 1  | 1.0000  |         |         |         |         |         |         |         |         |     |
| 2  | -0.0330 | 1.0000  |         |         |         |         |         |         |         |     |
| 3  | 0.9990  | -0.0300 | 1.0000  |         |         |         |         |         |         |     |
| 4  | -0.0212 | 0.0265  | -0.0190 | 1.0000  |         |         |         |         |         |     |
| 5  | -0.0128 | 0.9352  | -0.0080 | 0.0003  | 1.0000  |         |         |         |         |     |
| 6  | -0.0075 | 0.1110  | -0.0110 | 0.7785  | 0.0583  | 1.0000  |         |         |         |     |
| 7  | -0.0305 | -0.0233 | -0.0269 | -0.0141 | -0.0349 | 0.0150  | 1.0000  |         |         |     |
| 8  | -0.0094 | 0.0119  | -0.0075 | 0.0164  | -0.0140 | -0.0195 | 0.5857  | 1.0000  |         |     |
| 9  | 0.0257  | 0.0081  | 0.0263  | -0.0108 | 0.0073  | -0.0449 | 0.5976  | 0.5861  | 1.0000  |     |
| 10 | -0.0270 | -0.0214 | -0.0287 | -0.0033 | -0.0156 | -0.0481 | -0.0338 | 0.0273  | 0.0003  | 1.  |
| 11 | 0.0374  | -0.0195 | 0.0348  | -0.0072 | 0.0200  | 0.0012  | 0.0026  | 0.0475  | 0.0151  | 0.  |
| 12 | 0.0193  | 0.0008  | 0.0272  | 0.0008  | -0.0107 | -0.0264 | -0.0037 | 0.0228  | 0.0154  | -0. |
| 13 | 0.0262  | -0.0368 | 0.0312  | -0.0038 | 0.0087  | 0.0072  | -0.0003 | 0.0418  | -0.0031 | -0. |
| 14 | 0.0539  | 0.0170  | 0.0487  | 0.0165  | 0.0262  | 0.0105  | 0.0190  | -0.0316 | -0.0072 | -0. |
| 15 | -0.0229 | 0.0152  | -0.0222 | -0.0282 | -0.0194 | 0.0372  | 0.0333  | -0.0026 | 0.0161  | 0.  |
| 16 | -0.0012 | 0.0158  | 0.0005  | 0.0128  | 0.0440  | -0.0166 | 0.0230  | 0.0040  | -0.0376 | 0.  |
| 17 | 0.0368  | 0.0388  | 0.0358  | 0.0733  | 0.0320  | 0.0609  | -0.0328 | 0.0366  | -0.0205 | -0. |
| 18 | 0.0091  | 0.0424  | 0.0107  | -0.0183 | 0.0646  | -0.0438 | -0.0078 | 0.0077  | 0.0323  | 0.  |
| 19 | 0.0547  | 0.0028  | 0.0530  | 0.0238  | 0.0831  | 0.0108  | -0.0502 | -0.0434 | -0.0525 | 0.  |
| 20 | 0.0249  | -0.0349 | 0.0207  | 0.0031  | -0.0424 | -0.0593 | 0.0245  | 0.0504  | 0.0290  | -0. |
| 21 | -0.0328 | -0.0015 | -0.0295 | -0.0640 | -0.0234 | -0.0599 | 0.0431  | -0.0150 | 0.0229  | 0.  |
|    | 1       | 2       | 3       | 4       | 5       | 6       | 7       | 8       | 9       |     |

VARIABLES

CORRELATIONS AMONG INPUT VARIABLES CREATED BY THE LATIN HYPERCUBE SAMPLE FOR RANK

|    |        |         |         |         |        |        |
|----|--------|---------|---------|---------|--------|--------|
| 16 | 1.0000 |         |         |         |        |        |
| 17 | 0.0657 | 1.0000  |         |         |        |        |
| 18 | 0.0173 | 0.0235  | 1.0000  |         |        |        |
| 19 | 0.0619 | 0.0031  | 0.0472  | 1.0000  |        |        |
| 20 | 0.0002 | -0.0273 | -0.0001 | 0.0127  | 1.0000 |        |
| 21 | 0.0364 | -0.0580 | -0.0424 | -0.0527 | 0.0112 | 1.0000 |
|    | 16     | 17      | 18      | 19      | 20     | 21     |

VARIABLES

## OUTPUT FILE FOR LHS TEST 5

THE PARAMETER CARD NOBS CONTAINS THE NON-NUMERIC CHARACTER T



FORTRAN-like assignment statements and general-purpose commands.

ALGEBRACDB's capabilities used in the CCA PA calculations have been tested. All the capabilities mentioned in this section are tested unless otherwise noted. Properties, attributes, and time step variables can be created, modified, or deleted. The manipulations can be limited to a specified set of nodes or elements or elements blocks.

The user can create or modify the CAMDAT entities based on the values of existing properties, attributes, time step variables, nodal coordinates, time step time, and numeric constants. Certain constants referring to the input CAMDAT file (such as the number of nodes or elements) can also be used. The nodes and elements and element blocks over which operations on the input data are valid can be limited. A value for a specific node or element or element block can be referenced. The values of the first time step or the previous time step can also be referenced.

The following manipulations can be applied to the input data to derive the output data. The manipulations apply to each node or element or element block, if appropriate.

- Addition, subtraction, multiplication, division, and exponentiation.
- Standard FORTRAN functions: AINT, ANINT, ABS, MOD, SIGN, DIM, MIN, MAX, SQRT, EXP, LOG, LOG10, SIN, COS, TAN, ASIN, ACOS, ATAN, ATAN2, SINH, COSH, TANH.
- Integration using the trapezoidal rule or the rectangular rule.
- Conditional assignment (a limited IF-THEN-ELSE capability).
- Addition of the values for all nodes or elements or blocks.
- Minimum or maximum value over all nodes or elements or blocks at each time step.
- Minimum or maximum value over all time steps.
- Location of the minimum and maximum value over all nodes or elements and over all time steps. The node or element number and time step number is also retained.
- Conversion from a nodal variable to an element variable and vice versa.

- Assignment to a compatible data type. For example, a constant can be explicitly assigned to a global variable.

The manipulations can be limited to certain time steps. These time steps are the only ones processed and the only ones written to the output CAMDAT file. The CAMDAT title and information records can be changed. Information about the CAMDAT file can be listed to the output diagnostics file. This is particularly useful if the user is entering instructions interactively.

ALGEBRACDB can accept up to 2,000 assignment statements. There is also a limit on the number of total syntactic entities in all assignment statements (20,000). Each input control file line is limited to 80 characters. These lines may be concatenated, but each assignment statement and command is limited to 256 characters. There is a limit of 2,500 variables. This includes all properties, attributes, and time step variables that are on the input CAMDAT file or are assigned by ALGEBRACDB. There is a limit of 1,000 LIMIT commands. There is a limit of 4,000 ranges specified in all LIMIT statements.

### ***The Input CAMDAT File***

The input CAMDAT file is a binary, sequential file. A detailed description of the CAMDAT file format is given in Chapter 7 of the WIPP PA User's Manual for CAMDAT\_\_LIB, Version 1.22 (WPO #27727). The information that is relevant to ALGEBRACDB is summarized below.

A CAMDAT file may be referred to as a *CDB* or a *CAMDAT database*, but it is not a database in the traditional use of the word. The CAMDAT file may be examined with the GROPECDB program described in the WIPP PA User's Manual for GROPECDB Version 2.12 (WPO #37496).

The CAMDAT file deals with three finite-element entities: nodes, elements, and element blocks. It is important to understand what each of these entities represents and how they are referenced. A finite-difference grid may also be represented in the CAMDAT file; the grid is mapped to the equivalent finite-element mesh.

- A *node* is a specific grid point. Nodes are referenced by their number, which is determined by the order in which the coordinates are listed in the CAMDAT file.
- An *element* is a grid block formed by connecting adjacent nodes. Elements are referenced by their number, which is determined by the order in which



the connectivity is listed in the CAMDAT file.

- Element data are stored in *element* blocks. In WIPP PA, each element block consists of a group of elements representing a different type of material or a layer of strata surrounding the repository. Each element in a particular block has the same material and element type. Element blocks are referenced by a unique integer identifier, but they also have an associated eight-character name.

Four types of information are stored in a CAMDAT file:

- Initialization information (such as the CAMDAT version and sizing information).
- Quality assurance information.
- Model description data, such as finite-element or finite-difference geometry data; geologic, hydrologic, and chemical parameters; and model boundary conditions.
- Analysis results data, such as head, pressure, velocity components, concentrations from source term or transport modules, and particle transport pathways.

Descriptions of each of these types of information follows.

### ***Initialization Information***

The *sizes of all QA and model description information* (such as the number of nodes and elements) are stored in the CAMDAT file. These sizes include the number of QA records and information records, the number of dimensions, nodes, elements, and element blocks, the number of unique attributes and properties, and the length of the boundary condition arrays.

### ***Quality Assurance Information***

The *database title* is an 80-character string describing the data file.

There should be one *QA record* for each code that writes to the file. Each QA record contains the program name (truncated to eight characters), the program version, and the execution date and time of the program.

An *information record* is an 80-character string. A CAMDAT file can contain any number of information records. The contents of the first three information records

are defined by WIPP PA convention.

### ***Model Description***

The *nodal coordinates* of each node in the mesh are stored in the CAMDAT file, along with a label for each dimension.

The *connectivity* for an element is the numbers of each node that must be connected together to form each element. All elements in an element block must be of the same element type (i.e., contain the same number of nodes).

Element block *properties* are material parameters that are constant for a block (e.g., rock density, nuclide partition coefficients) or do not vary at all. Each property has a name for identification. A particular property need not be defined in all element blocks.

Although some properties are stored as element block information, many are stored as element *attributes* to accommodate subtle changes of parameters within the same stratigraphic layer, if necessary. An attribute can vary with each element (e.g., transmissivity, porosity, brine density). Each attribute has a name for identification. A particular attribute need not be defined in all element blocks.

The CAMDAT file can store boundary condition information (e.g., load or fluid pressure conditions) either as a *node set* or an *element side set*. A node set consists of a set of nodes and their associated factors. A side set consists of a set of element sides, the nodes which define the side, and a factor associated with each element side.

### ***Analysis Results***

The analysis results comprise the final section of the CAMDAT file. This section contains analysis results for any number of *time steps*. Time steps are identified by the associated time or time step number. There are four types of variables:

- A *History Variable* has a single value for each time step. These values often apply to the large regions or the entire analysis, such as total energy or mass of the system.  
A history variable may also represent a value for a specific node or element.
- A *Global Variable* has a single value for each time step that includes the values of nodal and element variables. The difference between history variables and global variables is how often the variables are output on the

CAMDAT file as discussed below.

- A *Nodal Variable* has a value for each node in the mesh for each time step that contains nodal and element variables.
- An *Element Variable* has a value for each element in the mesh (typically) for each time step that contains nodal and element variables. An element variable may not be defined in the CAMDAT file for every element block, but most codes used in the WIPP PA define each element variable for all element blocks.

Each variable has an eight-character identifying name.

There are two different types of time steps. A *whole time step* contains the values of all the variables of all four types (history, global, nodal, and element). A *history-only time step*, contains only the history variables. The use of this type of time step allows the analyst to reduce the size of the output file. For example, the program may calculate flow through all elements at intervals and write this information as an element variable. The program may also need to integrate the flow across a boundary. The integration may need more data points than the element variable intervals so the flow across specific boundary locations would be output at more frequent intervals as history variables.

## EPA REVIEW

### a) Any compliance application shall include:

a.1) A description of conceptual models and scenario construction used to support any compliance application.

ALGEBRACDB only manipulates a CAMDAT database file. Conceptual models and scenario construction are not applicable to ALGEBRACDB

a.2) A description of plausible alternative conceptual model(s) seriously considered but not used to support such application, and an explanation of the reason(s) why such model(s) was not deemed to accurately portray performance of the disposal system.

ALGEBRACDB only manipulates a CAMDAT database file. Conceptual models and scenario construction are not applicable to ALGEBRACDB.

a.3) Documentation that:

a.3.i) conceptual models and scenarios reasonably represent possible future states

of the disposal system;

ALGEBRACDB only manipulates a CAMDAT database file. Conceptual models and scenario construction are not applicable to ALGEBRACDB

a.3.ii) mathematical models incorporate equations and boundary conditions which reasonably represent the mathematical formulation of the conceptual models;

ALGEBRACDB only manipulates a CAMDAT database file. Conceptual models and scenario construction are not applicable to ALGEBRACDB

a.3.iii.) numerical models provide numerical schemes which enable the mathematical models to obtain stable solutions;

ALGEBRACDB only manipulates a CAMDAT database file. Conceptual models and scenario construction are not applicable to ALGEBRACDB

a.3.iv) computer models accurately implement the numerical models; i.e., computer codes are free of coding errors and produce stable solutions;

Testing of the ALGEBRACDB indicates that it is free from coding errors.

a.3.v) Conceptual models have under gone peer review according to §194.27.

Peer review is not applicable to this code.

b) Computer codes used to support any compliance application shall be documented in a manner that complies with ASME NQA-2a-1990 addenda, part 2.7, to ASME NQA-2-1989 edition.

Quality assurance documents including the User's Manual, the Requirements Document & Verification and Validation Plan, the Validation Document, and Implementation Document are the QA Packages for 13 PA Codes provided by DOE (Docket: A-93-02, II-G-3, Volume 1). This documentation indicates that the ASME NQA requirements have been met. The functional requirements for ALGEBRACDB are complete and cover the usage of the code in the CCA PA calculations.

c) Documentation of all models and computer codes are included in the CCA. Documentation includes the following (To answer may of these question you may be able to reference section b above):

c.1.) Description of the theoretical backgrounds of each model and the method of analysis or assessment,

The User's Manual (UM) adequately describes the theoretical background of the ALGEBRACDB computer code.

**c.2.) General descriptions of the models;**

*discussions of the limits of the applicability of each model;*

The describes the limits of applicability of the ALGEBRACDB computer code. These limits are listed in the introduction to Appendix A7 of this TSD.

*detailed instruction for executing the computer codes, including hardware and software requirements, Input and output formats with explanations of each input and output variable and parameter;*

Adequate instructions are provided in the UM to execute the ALGEBRACDB computer code and an adequate description of input and output files are also provided.

*listings of input and output files from a sample computer run; and*

These are adequately provided in the ALGEBRACDB UM.

*reports on code verification, bench marking, validation, and QA procedures. (QA documents may help)*

These are adequately provide in the RD/VVP and the VD for the ALGEBRACDB computer code.

**c.3.) Detailed description of the structure of computer codes and complete listings of the source codes;**

A complete listing of the source for ALGEBRACDB is provide in the Implementation Document.

**c.4.) Detailed descriptions of data collection procedures, sources of data, data reduction and analysis, and code input parameter development; Which parameters appear to be important to compliance?**

This does not apply to the ALGEBRACDB computer code because its input parameters are derived from other CCA PA computer codes.

**c.5.) Necessary licenses; and**

No licenses were required for ALGEBRACDB .

**c.6.) An explanation of the manner in which models and computer codes**

incorporate the effects of parameter correlation.

Parameter correlation is not an issue in ALGEBRACDB.

d) The Administrator or the Administrator's authorized representative may verify the results of computer simulations used to support any compliance application by performing independent simulations. Data files, source codes, executable versions of computer software for each model, other material or information needed to permit the Administrator or the Administrator's authorized representative to perform independent simulations, and access to necessary hardware to perform such simulation, shall be provided within 30 calendar days of a request by the Administrator or the Administrator's authorized representative.

DOE identified appropriate contacts and provided the documentation required by EPA for its review of this code.

## Results for Examination of the 10 Test Cases of ALGEBRA

There were 10 test cases to examine 18 functional requirements, 5 external interfaces and 8 additional functionalities which made up the purpose of the ALGEBRA code. There were six main functions for ALGEBRA: Sum, Integrate, Envelope, If, Limit and 21 trigonometric functions (AINT, ANINT, ABS, MOD, DIM, MAX, MIN, SQRT, EXP, LOG, LOG10, SIN, COS, TAN, ASIN, ACOS, ATAN, ATAN2, SINH, COSH, TANH).

Each of the functional requirements was tested once in the 10 test cases. In general, this "one time testing" is sufficient for proper evaluation of the functional requirements. However, if the results of the 10 test cases produced an error, then additional testing would be necessary. This did not occur with any of the ALGEBRA test cases. The test done by DOE on the ALGEBRACDB computer code show that the code is adequate for use in the CCA PA calculations.

## APPENDIX A8 STEPWISE AND PCCSRC COMPUTER CODE EVALUATION

The STEPWISE and PCCSRC computer codes provide the tools to perform sensitivity analysis to determine the important contributors to WIPP performance uncertainty. A Monte Carlo conceptual framework for uncertainty and sensitivity analysis is explained in DOE 1995a, DOE 1995e, Helton 1993, Helton 1994, and Docket: A-93-02, II-G-07. Uncertainty is defined in terms of stochastic and

subjective components. Stochastic uncertainty comes from the different ways that the WIPP disposal system can perform and leads to a complementary cumulative distribution function (CCDF) for the cumulative release. Subjective uncertainty comes from lack of knowledge of the analysts determining performance and leads to a distribution of CCDF's.

Sometimes it is not clear whether an uncertainty is stochastic or subjective. In Section 6.1.4 of the CCA (Docket: A-93-02, II-G-1, Volume I, Chapter 6), it is stated that "For the WIPP, the DOE treats uncertainty associated with significant future human actions as stochastic (for example, drilling for natural resources), and uncertainty in disposal system properties that are subject to ongoing physical processes as subjective (for example, climate change or gas generation)". Scenarios are defined in order to provide a practical way to describe future performance of the disposal system. Scenarios are subsets of similar possible future occurrences that encompass all events considered in determining performance uncertainty.

An individual CCDF is computed from a statistical description of the different ways that the disposal system can perform using the method of importance sampling. The distribution of CCDF's is computed from a statistical description of analyst uncertainty using the Latin hypercube sample (LHS) method.

STEPWISE/PCCSRC determines the sensitivity of the distribution of CCDF's and intermediate variables to input parameters as explained in References DOE 1995a, DOE 1995e, Helton 1993, and Helton 1994. Scatter plot, regression, and correlation methods are used. The sensitivity methods use the same values for the variables of interest and input parameters that are obtained from application of the LHS method.

Scatter plots of variables of interest versus individual input parameters provide qualitative sensitivity information about nonlinear relationships. Quantitative sensitivities are provided by standardized regression coefficients (SRC's) that relate variables of interest to input parameters. The coefficients are standardized relative to the sample variation in the input parameters. If a standardized coefficient for one parameter is twice the size of a standardized coefficient for another parameter, then the variable of interest really is twice as sensitive to the first as it is to the second.

Quantitative sensitivities are also provided by partial correlation coefficients (PCC's) that determine the correlations of the variables of interest to the input

parameters. The partial correlation is computed between the parts of the variable of interest and the input parameter that have been corrected to remove terms that are correlated with other more highly correlated input parameters. PCC's are particularly convenient to quantify sensitivities for variables of interest that are functions of space or time.

SRC's are obtained using stepwise regression to relate variables of interest to input parameters based on the sample values from the LHS method used to determine the distribution of CCDF's. Stepwise regression performs a step-by-step procedure to select the subset of input parameters that best explains the variability in the variable of interest. The regression can be performed by including and eliminating input parameters in each step, only eliminating input parameters through backward steps, or only including parameters through forward steps. Regression sensitivities to nonlinear functions of input parameters can be determined where the form of the nonlinear function may be suggested by the qualitative information from scatter plots.

For nonlinear situations, both regression and partial correlation can be performed on input parameter ranks rather than on the parameter values. The parameter sample values are replaced by the parameter rank that is one for the smallest sample, two for the next smallest, and so forth. Regression produces standardized rank regression coefficients (SRRC's) and correlation analysis produces partial rank correlation coefficients (PRCC's).

## EPA REVIEW

### a) Any compliance application shall include:

a.1) A description of the conceptual models and scenario construction used to support any compliance application.

Since the purpose of these codes is to perform sensitivity analyses, descriptions of scenario construction and conceptual models is not applicable.

a.2) A description of plausible alternative conceptual model(s) seriously considered but not used, and an explanation of the reason(s) why such model(s) was not deemed to accurately portray performance of the disposal system.

The summary of WIPP results in Docket: A-93-02, II-G-07 refers to Helton 1993 for explanation of the uncertainty and sensitivity methods. Helton 1993 considers the alternative formulations of differential analysis, response surface methodology,



and Fourier amplitude sensitivity test. It is concluded that the Monte Carlo method is the most widely applicable to problems that arise in performance assessment for radioactive waste disposal.

Differential analysis is inherently local, and it is difficult to implement the derivatives required by the method. Response surface methodology requires a simple response surface approximation to the original model, but this is difficult for the complex models that are appropriate for the WIPP disposal system. The Fourier method is highly specialized and difficult to implement. The Monte Carlo method accounts directly for nonlinear relationships, only requires multiple model evaluations to implement, does not require special simplifications of the original model, and is amenable to sensitivity analysis using stepwise regression and partial correlation methods.

### **a.3) Documentation that:**

#### **a.3.i) Conceptual models and scenarios reasonably represent possible future states of the disposal system,**

As explained in References DOE 1995a and DOE 1995e, the STEPWISE/PCCSRC codes determine the sensitivity of variables computed by other WIPP codes to input parameters. The other WIPP codes model physical phenomena and scenarios so a reasonable representation of possible future states is dependent on these other codes.

#### **a.3.ii) mathematical models incorporate equations and boundary conditions which reasonably represent the mathematical formulation of the conceptual models,**

References DOE 1995a and DOE 1995e describe regression and partial correlation equations for representing model sensitivities. The representations include nonlinear transformations on the input variables and the use of parameter rank instead of the parameter values. These are appropriate equations for the wide variety of sensitivity analyses needed for a system of the complexity of the WIPP.

#### **a.3.iii) numerical models provide numerical schemes which enable the mathematical models to obtain stable solutions**

References DOE 1995a, DOE 1995f, Docket: A-93-02, II-G-07, Helton 1993, and Helton 1994 describe well known numerical methods for stepwise regression and partial correlation analysis. The behavior of these methods has been understood for many years in statistical communities. It has been well established that these

methods produce stable solutions.

a.3.iv) computer models accurately implement the numerical models; i.e., computer codes are free of coding errors and produce stable solutions,

The Validation Documents (DOE 1996b and 1995f) show that the codes have been adequately tested for errors.

a.3.v) conceptual models have undergone peer review according to §194.27.

STEPWISE/PCCSRC provide sensitivities of other WIPP codes that are based on conceptual models that have undergone peer review as described in Docket: A-93-02, II-G-1, Volume XII, Appendix PEER, PEER 1).

b) Computer codes used to support any compliance application shall be documented in a manner that complies with ASME NQA-2a-1990 addenda, part 2.7, to ASME NQA-2-1989 edition.

The User's Manuals of References DOE 1995a and 1995e are complete and provide the kind of information needed to understand and run the codes. Functional requirements for STEPWISE and PCCSRC are contained in these User's Manuals and in the Requirements Documents of References DOE 1996a, DOE 1995b, and DOE 1996c. The requirements are complete and adequate for use of the codes in the WIPP PA. STEPWISE is required to perform several types of stepwise regression for the input parameters, specified nonlinear functions of the input parameters, and ranks of the input parameters. STEPWISE is also required to produce scatter plots. PCCSRC is required to compute partial correlation coefficients (PCC's) and SRC's for the input parameters, specified nonlinear functions of the input parameters, and ranks of the input parameters.

Testing for STEPWISE and PCCSRC is described in References DOE 1996a, DOE 1995b, DOE 1996b, DOE 1995c, DOE 1996c, and DOE 1995f. Statistical results were tested by comparing with the Statistical Analysis System (SAS) software.

Originally three functional tests were performed for STEPWISE and the acceptance criteria were met. These tests verified stepwise regression on raw and ranked data, forcing an independent variable into the regression, dropping an observation, backward and forward stepping, transformations on input variables, and plotting features. However, two errors were later discovered so two additional test were performed.

In Version 2.20 of STEPWISE when a variable was dropped from the regression,

the  $R^2$  value used to make decisions about dropping variables was incorrectly assigned to the next variable. This problem was fixed in Version 2.21. An additional test was performed to verify that decisions about dropping or including variables are made correctly. Also, an intermittent plotting error was fixed, and an additional test was performed for verification.

Four functional tests were performed for PCCSRC and the acceptance criteria were met. Partial Correlation Coefficients (PCC's) and Standardized Regression Coefficients (SRC's) were calculated on raw and ranked data sets, transformations on input variables were performed, and data sets were used which span multiple step intervals.

The Implementation Documents of References DOE 1995d and DOE 1995g provide adequate detail on the source codes for STEPWISE and PCCSRC.

c) Documentation of all models and computer codes included as part of any compliance application performance calculation shall be provided. Such documentation shall include, but shall not be limited to:

c.1) Description of the theoretical backgrounds of each model and the method of analysis or assessment,

References DOE 1995a, DOE 1995e, Helton 1993, and Docket: A-93-02, II-G-07 provide detailed descriptions of the theoretical background for STEPWISE/PCCSRC. The documentation explains how the empirical methods of STEPWISE/PCCSRC are used to obtain the sensitivities of performance uncertainties computed in a Monte Carlo framework. Alternative methods such as differential analysis are considered. However, DOE explains that these alternative empirical methods are not as well suited to the complex nature of the physical and statistical models for the disposal system.

c.2) General descriptions of the models; discussions of the limits of applicability of each model; detailed instructions for executing the computer codes, including hardware and software requirements, input and output formats with explanations of each input and output variable and parameter (e.g., parameter name and units); listing of input files from a sample computer run; and reports on code verification, benchmarking, validation, and quality assurance procedures;

Complete descriptions of the empirical regression and correlation models used by STEPWISE/PCCSRC are contained in References DOE 1995a and DOE 1995e.

**c.3) Detailed description of the structure of computer codes and complete listings of the source codes;**

Complete Implementation Documents are provided in References DOE 1995d and DOE 1995g. These documents provide a full listing of the source codes.

**c.4) Detailed descriptions of data collection procedures, sources of data, data reduction and analysis, and code input parameter development**

As explained in References DOE 1995a and DOE 1995e, STEPWISE/PCCSRC use regression and correlation methods to determine sensitivities of performance uncertainties to input parameters. The inputs to STEPWISE/PCCSRC are the values for variables of interest and input parameters computed as output of the Latin hypercube sampling (LHS) used to compute disposal system uncertainties.

**c.5) Any necessary licenses**

No licenses are required.

**c.6) An explanation of the manner in which models and computer codes incorporate the effects of parameter correlation**

As explained in Appendix PAR, Section PAR.4 (Docket: A-93-02, II-G-1, Volume XI) and in Helton 1993, parameter correlation is incorporated in the LHS method for determining disposal system uncertainty. STEPWISE/PCCSRC use the LHS results to determine the sensitivities of the uncertainty.

**d) The Administrator or the Administrator's authorized representative may verify the results of computer simulations used to support any compliance application by performing independent simulations. Data files, source codes, executable versions of computer software for each model, other material or information needed to permit the Administrator or the Administrator's authorized representative to perform independent simulations, and access to necessary hardware to perform such simulation, shall be provided within 30 calendar days of a request by the Administrator or the Administrator's authorized representative.**

DOE identified appropriate contacts and provided the documentation required by EPA for its review of these codes.

## REFERENCES

DOE (U.S. Department of Energy) 1995a. WIPP PA User's Manual for

STEPWISE (Version 2.20) Document Version 1.00 WPO # 27768, November 1, 1995.

DOE (U.S. Department of Energy) 1996a. WIPP PA Requirements Document & Verification and Validation Plan for STEPWISE (Version 2.21) Document Version 1.01, WPO # 42250, November 21, 1996.

DOE (U.S. Department of Energy) 1995b. WIPP PA Requirements Document & Verification and Validation Plan for STEPWISE (Version 2.20) Document Version 1.00, WPO # 27767, November 1, 1995.

DOE (U.S. Department of Energy) 1996b. WIPP PA Validation Document for STEPWISE (Version 2.21) Document Version 1.01, WPO # 42252, November 21, 1996.

DOE (U.S. Department of Energy) 1995c. WIPP PA Validation Document for STEPWISE (Version 2.20) Document Version 1.00, WPO # 27770, November 11, 1995.

DOE (U.S. Department of Energy) 1995d. WIPP PA Implementation Document for STEPWISE (Version 2.20) Document Version 1.0, WPO # 27769, December, 1995.

DOE (U.S. Department of Energy) 1995e. WIPP PA User's Manual for PCCSRC (Version 2.21) Document Version 1.0 WPO # 27773, November 1, 1995.

DOE (U.S. Department of Energy) 1996c. WIPP PA Requirements Document & Verification and Validation Plan for PCCSRC (Version 2.21) Document Version 1.00, WPO # 27772, June 3, 1996.

DOE (U.S. Department of Energy) 1995f. WIPP PA Validation Document for PCCSRC (Version 2.21) Document Version 1.00, WPO # 27775, November 1, 1995.

DOE (U.S. Department of Energy) 1995g. WIPP PA Implementation Document for PCCSRC (Version 2.21) Document Version 1.0, WPO # 27774, November 11, 1995.

Helton, J., 1993. "Uncertainty and Sensitivity Analysis Techniques for Use in Performance Assessment for Radioactive Waste Disposal", *Reliability Engineering and System Safety*, Vol. 42, pp. 327-367.

Helton, J., 1994. "Treatment of Uncertainty in Performance Assessments for

Complex Systems”, *Risk Analysis*, Vol.14, No.4.

See Appendix B(14) for listing of docketed references.

Intro

## Endnotes

### **1 (Popup - Popup)**

Peer Review is discussed in [Section 7](#) of this TSD.

### **2 (Popup - Appendix B - Not available)**

Appendix B of the Technical Support Document is not available electronically.

### **3 (Popup - Appendix B - Not available)**

Appendix B of the Technical Support Document is not available electronically.

### **4 (Popup - Appendix B - Not available)**

Appendix B of the Technical Support Document is not available electronically.

### **5 (Popup - Popup)**

Final versions of these draft reports are filed in Category V-B:

V-B-12 [Technical Support Document for Section 194.23: Parameter Report](#)

V-B-13 [Technical Support Document for Section 194.23: Sensitivity Analysis Report](#)

V-B-14 [Technical Support Document for Section 194.23: Parameter Justification Report](#)

### **6 (Popup - Popup)**

This section appears to be missing from the final document.

### **7 (Popup - Popup)**

This section appears to be missing from the final document.

### **8 (Popup - Popup)**

This section appears to be missing from the final document.

### **9 (Popup - Popup)**

This section appears to be missing from the final document.

### **10 (Popup - Popup)**

This section appears to be missing from the final document.

**11 (Popup - Popup)**

This section appears to be missing from the final document.

**12 (Popup - Popup)**

This section appears to be missing from the final document.

**13 (Popup - Popup)**

This section appears to be missing from the final document.

**14 (Popup - Appendix B - Not available)**

Appendix B of the Technical Support Document is not available electronically.