Final Report on Qualification of the $^{40}Ar/^{39}Ar$ Volcanism Data Using Procedure: YAP-SIII.1Q/Rev.3/ICN 0.

Qualification Team:

[signature] // 3-11-99
Paul R. Dixon, Ph.D., Chairperson — Date
NEPO/Los Alamos National Laboratory

[signature] // 3-11-99
John Savino, Ph.D., — Date
MTS/Golder Associates

[signature] // 3-11-99
Pat Auer, B.S., M.B.A. — Date
OQA/MACTEC

[signature] // 3/11/99
Darrell Porter, Ph.D. — Date
NEPO/SAIC

Approvals:

[signature] // 3/14/99
Gail Abend — Date
Technical Data Management Data Qualification Point of Contact

102

Report on Qualification of the $^{40}Ar/^{39}Ar$ Volcanism Data Using Procedure YAP-SIII.1Q/Rev.3/ICN 0.

Executive Summary:

This report describes the approach and results of an assessment of the qualification status of $^{40}Ar/^{39}Ar$ age data submitted to the Technical Data Management System (TDMS) by Los Alamos National Laboratory (LANL) and reported in the Level 3 Milestone Report 3781MR1, "Synthesis of Volcanism Studies for the Yucca Mountain Site Characterization Project," (VSR), dated February 6, 1998. The $^{40}Ar/^{39}Ar$ analytical data services were procured by LANL from two nationally recognized laboratories: the Department of Earth and Environmental Sciences at Lehigh University (LU) in Bethlehem, Pennsylvania; and the New Mexico Bureau of Mines (NMBM) in Socorro, New Mexico. These laboratories were chosen because they have established reputations in the argon age dating field and supply commercial-grade $^{40}Ar/^{39}Ar$ dating services. The $^{40}Ar/^{39}Ar$ age dates developed and reported by LANL from the analytical data supplied by these two laboratories are identified by the LANL Principal Investigator as qualified data in Table 1.1 of the VSR and in the TDMS. This qualification status, however, was determined by the Office of Quality Assurance (OQA) to be incorrect, as outlined in the following.

In September 1996, the OQA conducted a performance-based audit (YM-ARP-96-014) of the LANL volcanism program. As a result of the audit, a deficiency report (YM-96-D-107), dealing with the qualification status of data reported in the 1996 draft VSR, was issued. Subsequently, OQA conducted a verification exercise of the corrective action undertaken by LANL to close the deficiency report. The results of the OQA verification are documented in the letter from Horton to Foust, dated February 6, 1998. In this letter, the OQA staff noted that the $^{40}Ar/^{39}Ar$ data reported in the VSR were acquired using a quality control sample plan process prior to that process being endorsed in the Quality Assurance Requirements and Description document (QARD), Appendix C. Because of this condition, the OQA staff concluded that the age data obtained from Lehigh University and NMBM were acquired outside the Office of Civilian Radioactive Waste Management Quality Assurance Program and were not eligible to be labeled as qualified without successfully completing a Yucca Mountain Administrative Procedure SIII.1 qualification exercise.

On November 18, 1998, the procedure YAP-SIII.1Q, Rev 3/ICN 0, "Qualification of Unqualified Data" became effective and the Office of Project Execution directed that the volcanism data sets reported in the VSR and identified in deficiency report YM-96-D-107 be evaluated for qualification using the revised procedure. In compliance with the procedure, a four-member data qualification team was organized and a Data Qualification Plan was written and submitted to the Technical Data Management Data Qualification Point of Contact for review and approval. YAP-SIII.1Q, Attachment 3, provides for one or a combination of methods that can be used to qualify data. The Data Qualification Team selected the combination of "Equivalent QA Program" and "Corroborating Data." These methods were chosen to evaluate that the LANL sample plan used

to collect the age data is consistent with the sampling plan requirements in Appendix C.2.3 of the QARD and to show that comparison of the $^{40}Ar/^{39}Ar$ age dates with other geochronologic data sets substantiates the LANL results.

The Data Qualification Team evaluated all pertinent Scientific Notebooks and Attachments for definition of the LANL sample plan methodology, the consistent application of the methodology, adequacy of documentation, and traceability of the documentation to the TDMS. Based on the results of the team's evaluation, the Data Qualification Team recommends that the $^{40}Ar/^{39}Ar$ age data identified in Table 1.1 of the final version of the VSR be accepted as qualified. This recommendation, if accepted, results in no change to the QA classification of the age data in Table 1.1 and in the TDMS.

Scope of Task:

The purpose of this task is to evaluate the qualification status of the $^{40}Ar/^{39}Ar$ age data in Chapters 2 and 4 of the Volcanism Summary and Synthesis Report (VSR, Level 3 Milestone Report 3781MR1) that address age distributions of volcanic centers near Yucca Mountain. Attachment A to this report is Version 5 of theYAP-SIII.1Q, Rev.3/ICN 0 Data Qualification Plan used in this report to evaluate the quality of the $^{40}Ar/^{39}Ar$ age data.

Data Sets for Qualification:

As explained in the Data Qualification Plan in Attachment A to this report, the data identified for qualification under YAP-SIII.1Q are $^{40}Ar/^{39}Ar$ ages of volcanic units in the YMR. Table 1 provides traceability to the Technical Data Management System (TDMS), the Technical Information Center (TIC), and the Records Processing Center (RPC) of the $^{40}Ar/^{39}Ar$ and corroborating data sets used in this qualification process.

Table 1: Traceability of Data and Supporting Documentation

1. LANL Scientific Notebooks	
TWS-EES-13-LV-12-89-05	NNA.19940607.0177
TWS-EES-13-07-93-044	MOL.19980217.0262
TWS-EES-13-07-93-044, Attachment 1	MOL.19980217.0264
2. LANL $^{40}Ar/^{39}Ar$ Age Data	
Analytical results from New Mexico Bureau of Mines and Lehigh University included in Appendices 2.1 and 2.2 in the VSR	Data Tracking Number (DTN) LAFP831811AQ97.001 MOL.19971110.0113
Table 2.B from VSR: Summary of $^{40}Ar/^{39}Ar$ Ages for all volcanic centers excluding Site and Engineering Properties of Lathrop Wells	DTN: LAFP831811AQ97.001 SEP # S97552_041

Table 2.C from VSR: Summary of whole-rock $^{40}Ar/^{39}Ar$ results from Lathrop Wells using different reduction methods	DTN: LAFP831811AQ97.001 SEP # S97552_042
Table 2.D from VSR: Summary of xenolith Sanadine plateau $^{40}Ar/^{39}Ar$ ages from NMBM	DTN: LAFP831811AQ97.001 SEP # S97552_043

3. LANL Corroborating Data

Table 2.4 from VSR: Summary of cosmogenic ^{3}He data and ages from Lathrop Wells	DTN: LAFP831851DN98.001 SEP # S98247_001 MOL.19980819.0369
U-Th concentration and isotopic measurements for basalts of the Yucca Mountain region	DTN: LAFP831851AN97.004 MOL.19971111.0047 MOL.19971111.0048 SEP #'s S97555_001 through _006

4. Additional Corroborating Data Sources

Fleck, R.J., B.D. Turrin, D.A. Sawyer, R.G. Warren, D.E. Champion, M.R. Hudson, and S.A. Minor, "Age and Character of Basaltic Rocks of the Yucca Mountain Region, Southern Nevada," Journal of Geophysical Research, **101**, p 8205-8227, 1996. **Technical Information Center TIC Catalog # 234626**

Zreda, M.G., F.M. Phillips, P.W. Kubik, P. Sharma and D. Elmore, "Cosmogenic ^{36}Cl Dating of a Young Basaltic Eruption Complex, Lathrop Wells, Nevada," Geology, **21**, p 57-60, 1993. **TIC Catalog # 225192**

5. Supporting Documentation

LANL Audit # YM-ARP-96-14	MOL.19961220.0058
VSR (Level 3 Milestone Report 3781MR1)	MOL. 19980722.0048

6. References

Heizler, M.T., F.V. Perry, B.M. Crowe, L. Peters, and R. Appelt, "The age of Lathrop Wells volcanic center: An $^{40}Ar/^{39}Ar$ dating investigation," Journal of Geophysical Research, **104**, p. 767-804, 1999.

Turrin, B.D., D. Champion, and R.J. Fleck, "$^{40}Ar/^{39}Ar$ Age of the Lathrop Wells Volcanic Center, Yucca Mountain, Nevada," Science, **253**, p. 654-657, 1991.

Turrin, B.D., "Oral Presentation to the United States Nuclear Waste Technical Review Board, Panel on Structural Geology and Geoengineering, Meeting on Volcanism," Las Vegas, Nevada (September 15, 1992, p 222-273).

The Expertise of the Review Team:

Chairperson: Dr. Paul R. Dixon (M&O NEPO). Dr. Dixon has a Ph.D in Geochemistry from Yale University and 15 years professional experience in collecting and evaluating related geochemical and isotopic information where statistical approaches to data analysis were used as a normal practice for data QA/QC. He has expertise in the content of the subject matter being reviewed and he is also the M&O Geochemistry Technical Lead for the Natural Environment Program Office (NEPO) which managed the collection of the volcanism data.

Team Member: Pat Auer (OQA). Mr.Auer has a B.S. in Metallurgical Engineering from the University of Arizona and MBA from the University of Nevada, Las Vegas. He has 11 years experience in QA issues relating to auditing, procurement, QC, program and procedure development, and vendor auditing. Mr. Auer participated in the initial development of guidelines for QC sample plan purchases intended to invoke QARD Appendix C. He also developed the recommended outlines for the QC sample plan in conjunction with NEPO, the USGS and LANL.

Team Member: Dr. John Savino (MTS). Dr. Savino obtained a Ph.D (Geophysics-Seismology) from Columbia University in 1971. Between 1971 and 1991, he worked on earthquake prediction, earthquake-explosion seismology, and plate tectonics. In December 1991 he joined the YMP as an advisor to DOE on various geophysical site investigation projects including the Probabilistic Volcanic Hazards Analysis, which is of particular relevance to this data qualification effort. Dr. Savino was also a member of the performance based audit team that reviewed the volcanism data and issued the deficiency report YM-96-D-107.

Team Member: Dr. Darrell Porter. Dr. Porter has a Ph.D in Mineral Engineering from the University of Minnesota in 1972 and over 30 years experience in the earth sciences. He has been associated with the development and implementation of the YMP QA program since 1985 and is intimately familiar with the use of Scientific Notebooks, traceability of scientific results, requirements for the procurement of quality services and the use of the sample plan approach for accepting analytical services from a non-Q supplier as permitted in the QARD.

The Method(s) of Qualification and Selected Option Rational:

The methods selected for qualification of the $^{40}Ar/^{39}Ar$ age data are the "Equivalent QA Program" and "Corroborating Data" listed in Attachment 3 of procedure YAP-SIII.1Q/Rev.3/ICN 0. These combined methods were chosen to verify that the sample plan used to collect the data is consistent with the sampling plan requirements in Appendix C.2.3 of the QARD and implemented in accordance with QAP-7-3. In addition, this approach was also chosen because the data collection records, including equipment calibration and personnel, as well as documentation of the technical/administrative procedures used to collect the data are available as per Attachment 4 of procedure YAP-SIII.1Q/Rev.3/ICN 0. The guidelines listed in Attachments 3 and 4 were compared to the sample plan developed during this process.

Evaluation Criteria:

The data were reviewed for technical correctness based on Los Alamos National Laboratory scientific notebook procedures (LANL-YMP-QP-03.5)) and closure of DR-YM-96-D-106 (that concurs review of the scientific notebooks). The data evaluation criteria are largely based on the rational for accepting analytical data by considering corroborating data. This approach is an alternative to one that assumes the data are acceptable when produced by an analytical vendor who has demonstrated the acceptable application of a documented quality assurance program. To make this evaluation, it is necessary to examine the specification of methodology for examining the data, and evaluation of other controls adopted by the principal investigator for deciding data acceptability, including corroborative data. Criteria and statements of our review findings are presented below with the QARD requirements:

1. <u>The Number and Quality of Control Samples and Approach to be Used for Submitting these (blind, duplicate, spike, etc)</u>

- *Distribution of the control samples among the sample set submitted for analysis:*

Since there are no recognized standards available for $^{40}Ar/^{39}Ar$ age dating, the PI used blind duplicate samples of selected basalt rock samples from the Yucca Mountain region to test for precision of analytical results (Table 2, columns 1 and 6). All duplicate samples referred to in Table 2 were submitted as blinds.

Table 2 Data Summary Table (Attached at end of document)

- *Anonymity of control standard identity:*

Anonymity of control standards could not be established since there were none available. However, review of the PI's scientific notebooks indicated that the PI consistently submitted blind duplicates for analyses (Table 2, columns 1,5, and 6).

- *The use of replicates as part of the evaluation:*

Analytical results for the replicate samples were evaluated for consistency of analyses and precision. (Table 2, column 8).

- *Disposition of sample remnants:*

$^{40}Ar/^{39}Ar$ age dating tests are destructive, resulting in a meltdown and destruction of the submitted sample. Any non-analyzed sample remnants (leftovers) were returned to the Sample Management Facility as noted in the sample logbooks TWS-EES-13-LV-12-89-04, TWS-EES-13-LV-04-91-01, and LA-EES-13-05-94-006.

- *Establishment of population of standards in a sample set:*

Not applicable due to unavailability of standards.

2. <u>The Preparation and Analysis of Quality Control Samples, or Identification of the Source, e.g., Nationally Recognized Standards</u>

- *Adequacy of sample control of traceability between source of sample and the data set results:*

The remaining criteria in this section could not be evaluated due to lack of a nationally recognized (NIST) control standard for $^{40}Ar/^{39}Ar$ age dating. Replicate analyses were used to determine precision of laboratory results and to ensure consistent results. The PI compared his age dates with results from other studies. These studies involved both similar techniques and completely independent techniques. In a later section of this report the data qualification team considered corroborating data as an additional method of qualifying the LANL argon age data.

- *Adequacy of the preparation and analysis of quality controls samples, or identification of the source, e.g., nationally recognized standards:*

Not applicable because no National Standards are available.

- *Adequacy of purchased standards:*

Not applicable.

- *Were other non-purchased standards or methods evaluated for applicable control standards:*

A commonly analyzed volcanic rock was used to estimate precision of the measurements. The basalt sample chosen for this analysis came from the southeast Crater Flat volcanic unit. Several studies of this unit (see corroborating data section) have resulted in a commonly accepted age of 3.75 Ma. However, while this age is "commonly accepted," it should not be confused with nationally recognized standards. It served a very useful purpose in LANL's sample plan process by providing a quality check on LU versus NMBM. Refer to Table 2 for the split sample from southeast Crater Flat submitted to LU and the NMBM on 10/07/94 to compare the quality (reproducibility) of age dates from the two laboratories. The results from LU for this sample are described on page 564 of Attachment 1 to TWS-EES-13-07-93-044 in a report dated May 11, 1995. LU reported a total fusion age of 3.88 ± 0.45 Ma for this sample. Their preferable (in terms of an age estimate) step-heating experiment failed to produce any results. NMBM, however, reported a step-heating age of 3.75 ± 0.04 Ma, in excellent agreement with the commonly accepted value. Thus, in Table 2 (column 8, Sample CF6-17-94-1BMC) the LU results are rejected, while the NMBM results are accepted.

- *What was established for a standard if one were not available:*

Not applicable.

3. Acceptance Criteria

- *Are specifications for analysis of results documented and adequate?*

Scientific notebooks (TWS-EES-13-LV-12-89-05 and TWS-EES-13-07-93-044 including Attachment 1) were examined for the following: traceability of samples from LANL to the vendor (Lehigh University or the New Mexico Bureau of Mines) and the return of $^{40}Ar/^{39}Ar$ analytical data to LANL; consistency in the application of technical acceptance criteria to the analytical data; the use of sample blinds, replicates, and splits for estimates of data reproducibility and precision; and identification of a statement of acceptance or rejection of the age data by the Principal Investigator. The results of the team's examination are summarized in Table 2, for all analytical data included in Chapters 2 and 4 of the VSR and in the TDMS.

- *What controls were used on statistical analysis, i.e., confidence limits or No. of Standard Deviations?*

The $^{40}Ar/^{39}Ar$ age data generated at Lehigh University and the New Mexico Bureau of Mines are specified to two or three significant figures in the scientific notebooks (TWS-EES-13-LV-12-89-05 and TWS-EES-13-07-93-044) and in the data tables in Chapter 2 of the VSR. Confidence limits on the age data from Lehigh University and the New Mexico Bureau of Mines were reported as one sigma internal and two sigma internal, respectively. The age data in the VSR were reported as two sigma internal. The number of significant figures and reported confidence limits used are in accord with results reported from other investigations (see corroborative data below).

- *Was professional judgement a part of the geochemist's determination of the appropriateness of the data?*

As described under the following bullet, the Principal Investigator made extensive use of corroborative data to determine the appropriateness of the age data.

- *Was corroborative data used as part of the geochemist's determination of the appropriateness of the data?*

In many sections of the scientific notebooks (TWS-EES-13-LV-12-89-05 and TWS-EES-13-07-93-044), the Principal Investigator notes that evaluation of the accuracy of the $^{40}Ar/^{39}Ar$ age data from Lehigh University and the New Mexico Bureau of Mines will ultimately be based on a comparison with data obtained from other geochronological dating methods. As explained in a previous section of this report, the significance of this data input requirement arises because of the unavailability of a calibration standard for $^{40}Ar/^{39}Ar$ dating.

As described in the VSR (Chapter 2), two approaches are adopted depending upon the range of ages of the volcanic rock samples. For rock samples in the range 300ka to about 5 Ma, the principal investigator compared his age data with ages obtained by Fleck et al. (1996). With the exception of Thirsty Mesa (where the results are based on $^{40}Ar/^{39}Ar$), the Fleck et al., ages are based on K-Ar analysis. The study by Fleck et al., included most of the volcanic centers reported in the VSR (with the exception of the sample from the well in the Amargosa Valley). Note that the Fleck et al., K-Ar data are unqualified.

For rock samples from Lathrop Wells, the LANL Principal Investigator compared his results to age data obtained from ^{3}He, ^{36}CL, U-Th disequilibrium, $^{40}Ar/^{39}Ar$ laser fusion (Turrin et al., 1991), and K-Ar (Fleck et al., 1996) techniques. The ^{3}He and U-Th disequilibrium dating analyses were performed at LANL by PIs Jane Poths and Michael Murrell, respectively, while the ^{36}Cl analysis was reported in Zreda et al., 1993. All the comparative data sets for Lathrop Wells are unqualified.

<u>Volcanic Centers in the 300ka to 5 Ma Range:</u>

A summary of ages for all volcanic centers considered in the LANL investigation is given in Chapter 2, Table 2.B, of the VSR. The volcanic centers include Thirsty Mesa, a possible buried cone in the Amargosa Valley (anomaly B), southeast Crater Flat, Buckboard Mesa, the Crater Flat area, Hidden Cone and Little Black Peak. Fleck et al summarize their results for all the aforementioned centers, with the exception of the buried basalt in the Amargosa Valley, in Table 2, page 8213, of their paper. Table 3, below, compares the LANL and Fleck et al., results. The uncertainties for the LANL ages and Fleck et al., are specified at the two sigma (standard deviation) and one sigma levels, respectively. The main point from the data in Table 1 is that there is no statistically significant difference between the ages of the volcanic centers. This is evident when both data sets are compared with two sigma uncertainties, rather than the one-sigma uncertainties reported in Fleck et al. (1996). The complete reference to the Fleck et al. (1996) paper and traceability to the LANL data in the Technical Data Management System are listed in Table 1.

Table 3 Comparison of $^{40}Ar/^{39}Ar$ Ages

Geologic Unit	LANL Ages (Ma)[a]	Fleck et al., 1996 Ages(Ma)[b]
Thirsty Mesa	4.78±0.03	4.68±0.03[c]
Southeast Crater Flat	3.75±0.04	3.73±0.02
Buckboard Mesa (Main flow)	3.15±0.08	2.87±0.06
Little Cones	0.77±0.04 to .91±0.09	1.042±0.045
Red Cone	0.92±0.06 to 1.08±0.04	0.977±0.027
Black Cone	1.10±0.05	0.986±0.047
Makani Cone	1.16±0.10	1.076±0.026

a – confidence limits are 2 sigma
b – confidence limits are 1 sigma
c - age based on Ar/Ar

In the case of the Amargosa Valley, the age reported in the VSR based on analytical data from Lehigh University is 3.85 ± 0.05 (two sigma) Ma. Turrin (1992, p. 231) reported an $^{40}Ar/^{39}Ar$ age of a basalt sample from an exploratory drill hole at this site of 4.4 ± 0.07 Ma. In the FY96 and FY97 revisions to the VSR, the authors state that they regard the difference in the apparent ages of the basalt samples as insignificant. They "favor" the age of 3.85 Ma because this age is close to the age of the basalt of southeast Crater Flat (Table 3).

Lathrop Wells:

Corroborative data for the Lathrop Wells volcanic center includes ^{36}CL (Zreda et al., 1993), ^{3}He (LANL – Jane Poths), and U-Th (LANL – Michael Murrell). On page 2-83 of the VSR, the PI points out that the samples analyzed with the NMBM $^{40}Ar/^{39}Ar$ technique included modified whole rock (phenocrysts removed) and partially melted sanidine from Lathrop Wells tuff xenoliths. He emphasizes that the basalt whole-rock and xenolith sanidine represent completely independent systems for estimating the age of the Lathrop Wells volcanic center and concordance in age determinations using these two systems would suggest with a high degree of confidence that an accurate age has been determined. The whole-rock and sanidine ages reported on page 2-84 of the VSR, based on the analytical data in Appendix 2.2 from the NMBM (Attachment 1 to TWS-EES-13-07-93-044), are ≅ 75 ± 10 ka and ≅ 79 ± 4 ka, respectively, indicating concordance of ages to within the statistical uncertainty of the measurements.

As noted on page 2-106 of the VSR, Zreda et al.(1993) concluded from their ^{36}Cl work that the age of the volcanic center is 81 ±7 ka, while the LANL ^{3}He measurements indicate(pages 76-79 of TWS-EES-13-07-93-044) an age of the cone of about 80 ka. U-Th measurements reported on pages 2-86 through 2-89 of the VSR indicate a range of ages from 50 ±15 ka to140 ± 40 ka, where the uncertainties are one sigma. Thus, the preferred age of the Lathrop Wells center referred to on page 2-84, Figure 2.B of the VSR, 75 ± 10 ka, is concordant with the ages from the cosmogenic and U/Th data, at the two sigma level.

Figure 2.B in the VSR is a comparison of individual $^{40}Ar/^{39}Ar$ ages determined by LANL and ages reported by Turrin et al. (1991). The Turrin et al ages are based on a whole-rock laser fusion technique, which is subject to a different set of analytical problems (Heizler et al., 1999) that are beyond the scope of this report. The data from the NMBM indicate that the preferred age of the Lathrop Wells volcanic center is based on reproducible measurements with relatively small analytical errors which are within the two sigma uncertainty of 29 of the 32 measurements reported by Turrin et al. How one combines the individual Turrin et al measurements (simple mean, weighted mean) is a subject of continuing debate. As noted in Heizler et al., error estimates given by the Monte Carlo approach of the Turrin et al., data yield very high uncertainties, thus providing no statistical evidence that the Turrin et al data are significantly different from the LANL argon ages.

Fleck et al. (1996) combined all the K-Ar and $^{40}Ar/^{39}Ar$ ages available for Lathrop Wells (Turrin et al., 1995) and reported a best estimate age and error, based on a Monte Carlo error analysis, of 120 ± 58 (2 sigma) and 129 ± 74 (2 sigma) ka for two populations of measurements. These ages are not significantly different from the LANL results (75 ± 10 ka) given the large uncertainty associated with the K-Ar ages.

Thus, we conclude that there is concurrence between the LANL argon ages and the other geochronological results, within the uncertainty of the data, and that the corroborating data provides added confidence in the final LANL results.

The complete reference to the papers by Turrin et al.(1991), Turrin (1992), Heizler et al.(1999), and Zreda et al.(1993), and traceability of the LANL data sets in the Technical Data Management System are listed in Table1.

4. <u>How the Number of Quality Control Samples, the Approach, and Acceptance Criteria Provide Confidence in the Accuracy/Precision of the Data.</u>

- *Rationale of the sample plan compared with the context or premise of the QARD authority for use of a sample plan in lieu of ensuring analytic data quality through vendor controls:*

The sample plan methodology (Appendix C.2.3 of the QARD) of ensuring data quality was not in place at the time the Principal Investigator approached LU and the NMBM. However, the LANL PI developed and applied a quality control sample plan that was based on good industry practice. As described in the preceding bullet, the Principal Investigator made use of corroborative data from other geochronologic techniques to substantiate the $^{40}Ar/^{39}Ar$ age data. As noted in Table 2, except for the ash sample from the Solitario Canyon fault, the corroborative acceptance criterion # 13 is common to all samples submitted by the LANL Principal Investigator to the laboratories for analysis.

- *Adequacy of sample control relative to traceability between source of sample and the analytical results.*

Refer to Tables 1 and 2.

- *Order of plotting results for analysis.*

Not Applicable

- *Qualification of the data analyst.*

Frank Perry received his Ph.D. in Geology (emphasis on isotope geochemistry) at the University of California, Los Angeles, in 1988. He has 18 years experience in the fields of igneous petrology, isotope geochemistry, volcanic geology, and the geochronology of volcanic rocks. He also has published numerous professional papers in the areas of petrology, geochemistry, volcanology, and geochronology.

5. <u>Ensure That Quality Control Analytical Results are Received and Evaluated Against Acceptance Criteria, Prior to Use of Data</u>

- *Results received and evaluated against acceptance criteria.*

Column 7 in Table 2 gives a detailed accounting on a sample-by-sample basis for the particular acceptance criteria considered upon receipt of the analytical data from either Lehigh University or the NMBM. The acceptance criteria are numbered and reproduced verbatim in the footnote to this table from the PI's scientific notebooks identified in column 8 of Table 2.

- *Specification of data reporting requirements*

As related to the fourth bullet below, on one example from the Project Reference Information System (RIS), data reporting requirements were limited to specifying the inclusion of "analytical results" and "precision values for analyses" in the Volcanism Summary and Synthesis Report.

- *Adequacy of the applicable procurement documents*

Procurement documents examined showed all procurements were made by Purchase Requisition that had an attached acceptance plan. This acceptance plan incorporated a statement of the data sought, justification for vendor selected, that a blind duplicate was included to test the analytical precision, and that a report should include "analytical results and precision values for analyses". While this procurement documentation falls short of a Q procurement document as required at the time used, it is acceptable, except for the use of quality control standards, which are required in the current QARD, Appendix C.2.3 requirements.

- *Consistency of the sample plan documentation in the LANL scientific notebooks:*

Portions of scientific notebooks TWS- EES-13-07-93-044 and TWS- EES-13-LV-12-89-05, that relate to the sample submittals and acceptance criteria for the $^{40}Ar/^{39}Ar$ analytical data, were reviewed and found to be complete and consistent. As indicated in Table 2, each sample was assigned a unique alphanumeric identification and further identified by the particular volcanic center from which the sample was originally obtained. Acceptance plans describing the evaluation criteria to be applied to the analytical data results are included in the scientific notebooks. The plans were consistent in describing the rock sample, its identification, the testing required, and a statement of acceptable range. An additional acceptance statement consisted of a post-receipt criteria that specified potential subsequent corroboration with other testing methods stated as follows: "Acceptance may possibly include cross-checking by other geochronologic methods."

- *Reevaluate adequacy of a typical sample plan used in the course of the pertinent studies including appropriate calculations:*

The sample plans used to procure the analytical services in question from Lehigh University and NMBM are adequate in all areas except the use of quality control samples as required by Appendix C.2.3.A.2. There is no known standard for $^{40}Ar/^{39}Ar$ dating, therefore, a known, or other control sample could not be submitted with each sample lot to ensure accurate results. Precision of results was determined by submitting replicate samples.

Evaluation Criteria:

A. Criticality of the standards quality.

Not applicable because no National standard exists.

B. Match of analytical data scatter to that of the standard.

While there are no standards available, the analytical results from LU and the NMBM were determined by the PI to specified in the notebooks referenced in the report.

C. Confidence required (justified) in acceptability of data.

The Ar/Ar age data generated at Lehigh University and the New Mexico Bureau of Mines are specified to two or three significant figures in the scientific notebooks (TWS-EES-13-LV-12-89-05 and TWS-EES-13-07-93-044) and in the data tables in Chapter 2 of the VSR. Confidence limits on the age data from Lehigh University and the New Mexico Bureau of Mines were reported as one sigma internal and two sigma internal, respectively. The age dates in the VSR were reported as two sigma internal. The number of significant figures and reported confidence limits are in accord with results reported from other investigations (see corroborative data sections).

D. Accuracy of results to that needed.

Due to the lack of standards as previously mentioned, accuracy of the data can not be addressed.

E. *History and confidence in the contracted analytical services.*

The Principal Investigator, in discussions with the data qualification team, explained that Lehigh University and the New Mexico Bureau of Mines were selected to make analytical measurements because of their renowned expertise in $^{40}Ar/^{39}Ar$ age dating. Both laboratories have supplied $^{40}Ar/^{39}Ar$ dating on a commercial basis and the analytical techniques used by the laboratories have been fully documented in the peer-reviewed geologic literature. A pertinent reference for Lehigh University is: C.P. Chamberlain, P.K. Zeitler, and E. Erickson, "Constraints on the Tectonic Evolution of the Northwestern Himalayan from Geochronologic and Petrologic Studies of Babusar Pass, Pakistan," Journal of Geology , Vol. 99, pp. 829-849, 1991. Lehigh

University was eventually dropped due to an unacceptable turn-around time for the analytical data.

F. Equivalence of data collection with QARD Appendix C.2.3.
The sample plans used by LANL to procure the analytical services in question from Lehigh University and NMBM are adequate in all areas except the use of quality control standards as required by Appendix C.2.3.A.2. There is no known standard for $^{40}Ar/^{39}Ar$ dating, therefore, a known, or other control sample could not be submitted with each sample lot to ensure accurate results. Precision of results was determined by submitting replicate samples.

G. Verification that a sufficient quantity of corroborative data are available.
The corroborative data sources listed in Table 1 were reviewed by team members and determined to contain sufficient data from the different volcanic centers.

H. Inferences drawn for corroborative data are identified, justified and documented.
Refer to the earlier section on corroborative data and Table 1.

I. Prior peer or other professional review of the data and their results.
All the data reviewed for this report are contained in the VSR which is a DOE Level 3 report. This means that the data contained within the report have undergone Laboratory (LANL), M&O and DOE technical reviews before final acceptance of the Level 3 milestone to the TDB.

J. Extent and reliability of documentation associated with the data.
Reference to Tables 1 and 2 indicate that the supporting documentation associated with the $^{40}Ar/^{39}Ar$ age data is extensive and readily available through the TDMS or the peer reviewed open literature.

Data generated by the Evaluation:

Not Applicable

Evaluation Results:

The relevant information contained in the references listed in Table 1 were reviewed to determine if the data acquisition, development, and processing steps are adequately documented and if the necessary documentation has been submitted to the TDMS. As noted in Table 1, all the relevant documentation has been submitted and is available through the Record Processing Center, the TDMS (via the Intranet), or the Technical Information Center.

Review of the data acquisition, development, and processing steps are summarized in Table 2. With the exception of samples LW141FVP, LW142FVP, LW154FVP, LW157FVP, LW159FVP, LW160FVP, and HD1070-5, we were able to track each sample that appears in the VSR from the date of sample submittal to the vendor to the date of acceptance or rejection of the resulting analytical data by the Principal Investigator. As noted in Table 2, the problems with the samples mentioned above have to do with either the absence of a clear acceptance or rejection statement of the analytical data (i.e., LW141FVP and LW142FVP) or the mention in the scientific notebook of a submittal data for reanalysis of samples LW154FVP, LW157FVP, LW159FVP, and LW160FVP and the original submittal date of sample HD1070-5. It is important to note, however, that detailed analytical data for all seven samples are contained in the 1105 page Attachment 1 to Scientific Notebook TWS-EES-13-07-93-044.

To check the reliability of the data we compared the analytical data reported in Appendix 2.1 in the VSR for six samples analyzed by Lehigh University and a random selection of 12 samples analyzed by the NMBM and reported in Appendix 2.2 of the VSR with the corresponding data sets in Attachment 1 to TWS-EES-13-07-93-044 that were submitted to the TDMS (see Table 1 for the Data Tracking Number). All data compare exactly (e.g., various argon isotope ratios specified to four significant figures).

A final point concerns the succession of age dates for the volcanic centers addressed in this evaluation. The LANL Principal Investigator is very explicit from the first submittal of samples for dating in June 1992 to the receipt of the "final" data set in August 1997 that age dates would not be accepted as final until he was satisfied with the analytical data and had completed a comparison with corroborative age dates. Pages 76-83 of Scientific Notebook TWS-EES-13-07-93-044 contain an excellent summary of the succession of the data and an explanation of which data sets are final. Pages 76-79 give a description of the final ^{3}He data set determined at LANL which the Principal Investigator uses as corroborative data for the $^{40}Ar/^{39}Ar$ age dates. The final ^{3}He data are those given in Table 2.4 of the VSR. A detailed justification for the acceptance as "final" of the $^{40}Ar/^{39}Ar$ age dates from the NMBM is discussed on pages 80-83. The age dates accepted as final in the scientific notebook are the same data submitted to the TDMS and included in the VSR and, as noted by the Principal Investigator, supercede data in all previous reports.

Team Recommendation of Data Quality Status:

The Data Qualification Team recommends that the $^{40}Ar/^{39}Ar$ age data obtained by LANL from Lehigh University and the New Mexico Bureau of Mines and included in Chapters 2 (Tables 2.1, 2.A, 2.B, 2.C, and 2.D and Appendices 2.1 and 2.2) and 4 (Figure 4.18) of the VSR Level 3 deliverable (3781MR1) be accepted as qualified data.

Rationale for Abandoning any Qualification Method:

No planned qualification method was abandoned.

Table 2

Sample ID No.	Geologic Unit	Date samples sent	Vendor	SN No. & Page No.	Description of Sample Types Submitted	Acceptance Criteria Applied to Analytical Data	Date Analytical Data Received and Evaluated in Scientific Notebook	Data Accept or Rejected l Principal Investigator
Well 25-1-BMC	Amargosa Valley	6/17/92	Lehigh University	TWS-EES-13-LV-12-89-05, pages 38 and 39	One blind replicate of BC1FVP (blind #BC3aFVP) and two splits of each sample	Numbers 1, 11, and 13 in the footnote to this table	5/7/93, pages 41 and 42 of TWS-EES-13-LV-12-89-05	Accepted
NE-10-1-92-1-BMC *	Thirsty Mesa							Accepted
NE-10-1-92-2-BMC *								Accepted
LW102FVP (Not in VSR)	Lathrop Wells							Rejected
LW20FVP							LW102FVP data preliminarily accepted on 5/7/93; additional data received 11/18/93 and reported in Attachment 1 to TWS-EES-13-07-93-044 (rejected)	Rejected
CF15FVP	Little Cones							Accepted
BC6FVP	Black Cone							Accepted
BC12FVP								Accepted
BC1FVP								Accepted
CF10FVP	SE Crater Flat							Accepted
CF12FVP								Accepted
CF14FVP								Accepted
LW138FVP (Not in VSR)	Lathrop Wells	10/12/93	New Mexico Bureau of Mines	TWS-EES-13-07-93-044 Pages 11 and 12 for 10/12/93 sample set submission	Duplicate split of each sample submitted	Numbers 2, 12, and 13 in footnote applied to both sample sets	12/20/95, page 51#	Rejected
LW139FVP (Not in VSR)							12/20/95, page 51	Rejected
LW140FVP							12/20/95, page 51	Accepted
LW141FVP (Not in VSR)							12/20/95, page 51	(Rejected)+
LW142FVP (Not in VSR)							12/20/95, page 51	(Rejected)+
LW143FVP		Reanalysis requested for samples 139, 140, 143, 145 on 9/16/95		TWS-EES-13-07-93-044 Page 49 for 9/16/95 sample set submission			12/20/95, page 51	Accepted
LW145FVP	Little Cones						12/20/95, page 51	Accepted
LW146FVP							5/8/95, page 40	Accepted
LW147FVP							5/8/95, page 40	Accepted
LW149FVP	Red Cone						5/8/95, pages 39-41	Accepted
RC1FVP	Red Cone	1/19/94	New Mexico Bureau of Mines	TWS-EES-13-07-93-044 Page 39	Split sample	Numbers 2, 12, and 13 in footnote	5/8/95, pages 39-41	Accepted
RC4FVP								Accepted
LW154FVP	Lathrop Wells	10/7/94	New Mexico Bureau of Mines	TWS-EES-13-07-93-044 Page 31	Multiple splits of each sample submitted. Whole rock and xenolith sanadine samples submitted	Numbers 3, 4, 12 and 13 in footnote applied to both sample sets	7/19/96, page 64	Accepted
LW155FVP (Not in VSR)							7/19/96, page 64	(Rejected)+
LW156FVP (Not in VSR)							7/19/96, page 64	(Rejected)+
LW157FVP		Reanalysis requested for samples 154, 157, 159, 160; date not found					7/19/96, page 64	Accepted
LW158FVP (Not in VSR)							7/19/96, page 64	(Rejected)+
LW159FVP							7/19/96, page 64	Accepted
LW160FVP							7/19/96, page 64	Accepted
SB90-8-20-1BMC	Little Black Peak				Duplicate split		5/8/95, page 41	Accepted

..ble 2

Sample ID No.	Geologic Unit	Date samples sent	Vendor	SN No. & Page No.	Description of Sample Types Submitted	Acceptance Criteria Applied to Analytical Data	Date Analytical Data Received and Evaluated in Scientific Notebook	Data Accep... or Rejected Principal Investigator
CF6-17-94-1BMC	SE Crater Flat	10/7/94	New Mexico Bureau of Mines & Lehigh University	TWS-EES-13-07-93-044, page 32	Split sample to each lab for check on reproducibility of results	Numbers 4, 5, 12 and 13 in footnote	5/8/95, NMBM data analyzed on page 40 9/8/95, Lehigh data analyzed on pages 47-49	NMBM d... accepted Lehigh da... Rejected
BB1FVP	Buckboard Mesa	10/7/94	Lehigh University	TWS-EES-13-07-93-044 Page 32	Duplicate split of each sample submitted	Numbers 4, 5, 12 and 13 in footnote	9/8/95, pages 47-49	Accepted
BB4FVP							9/8/95, pages 47-49	Accepted
MC7-18-94-1BMC *	Makani Cone						9/8/95, pages 47-49	Accepted
MC7-18-94-3BBMC *							9/8/95, pages 47-49	Accepted
RC7-18-94-4BMC	Black Cone						9/8/95, pages 47-49	Accepted
LBP14FVP (Not in VSR)	Little Black Peak Cone	1/22/96	New Mexico Bureau of Mines	TWS-EES-13-07-93-044 Page 52	Two samples from Hidden Cone to assess precision	Numbers 8, 9, 10, 12, and 13 in footnote	8/23/97, page 81	Rejected
HC17FVP	Hidden Cone						7/19/96, page 63	Accepted
SB5-24-95-1BMC							7/19/96, page 63	Accepted
LW169FVP	Lathrop Wells						7/19/96, page 64	Accepted
HD1070-5	Solitario Canyon	Not Found	New Mexico Bureau of Mines	TWS-EES-13-07-93-044	Ash from Solitario Canyon fault trench	Not Found	7/19/96, page 63	Discussed Chapter 4 ... VSR

* Samples NE-10-1-92-1-BMC and NE-10-1-92-2-BMC are identified as NE-10-1-91-1-BMC and NE-10-1-91-2-BMC, respectively, in Tables 2.1 and 2.B in the VSR. Samples MC7-18-94-1BMC and MC7-18-94-3BBMC are identified as MC7-18-94-1A-BMC and MC7-18-94-3B-BMC, respectively, in Tables 2.A and 2.B in the VSR.

\+ It is not clear from the Scientific Notebook why the samples LW141FVP and LW142FVP were rejected – no age dates are included for these samples in the VSR.

\# Scientific Notebook TWS-EES-13-07-93-044 applies to all analytical data evaluated after July 1993.

++ Samples LW155FVP, LW156FVP, and LW158FVP were apparently not submitted for reanalysis because of redundancy of information. LW155FVP and LW156FVP are from the same outcrop as sample LW154FVP which was reanalyzed and included in the VSR. LW158FVP is from the same flow as LW159FVP.

The following acceptance criteria are taken verbatim from the relevant pages of Scientific Notebooks TWS-EES-13-LV-12-89-05 and TWS-EES-13-07-93-044.

1 – Two splits of mineral separates or whole rock fractions of each sample will be irradiated and analyzed for Ar isotopes to test for reproducibility of results. Results will be accepted in terms of analytical reproducibility if the $^{40}Ar/^{39}Ar$ dates produced from each split are within reported analytical precision of each other.

2 – In most cases, several tuff xenoliths from a particular basalt unit will be analyzed to test for reproducibility of results and to test how a different xenoliths reacted thermally to inclusion within basalt. This will provide duplicate analysis of samples and an internal means to judge the precision of the Ar/Ar results. Dating of basalts will include samples from basalt centers where samples have previously been dated at Lehigh University under the LANL YMP QA program. This will allow comparison of results from two independent $^{40}Ar/^{39}Ar$ laboratories.

ble 2

3 -- 3 basalt whole rocks from basalt unit Ql2 will be analyzed to test for reproducibility of results. This will provide duplicate analysis of samples and an internal means to judge the precision of the Ar/Ar results. Tuff xenoliths from Ql2 were previously dated at NMBM, which will allow comparison of results using two independent sample types.

4 – We will continue to submit samples for $^{40}Ar/^{39}Ar$ dating to both NMBM and Lehigh University in order to have an independent assessment of the accuracy of results from each laboratory. In this case, a split of sample CF6-17-94-1BMC will be submitted to both laboratories.

5 – Of the six basalt samples submitted, four of them will be analyzed in duplicate using sample splits. The remaining two will also be dating in duplicate using the step-heating method, from which an integrated total fusion age can be calculated. This will provide duplicate analysis of samples and an internal means to judge the precision of the Ar/Ar results.

6 – In most cases, several sanidines from a particular eruptive unit will be analyzed to test for reproducibility of results and to test how different sanidines reacted thermally to inclusion within basalt. This will provide duplicate analyses of samples and an internal means to judge the precision of the Ar/Ar results.

7 - Sanidines will be analyzed from the same suite of tuff xenoliths that have been previously dated at NMBM. This will allow comparison with previous results to assess long-term reproducibility of results.

8 – Requester will assure that all required analytical information has been supplied.

9 – Basalts will be dated using the step-heating method, allowing examination of $^{40}Ar/^{39}Ar$ systematics over a range of degassing temperatures. This will provide an internal means to judge the quality and precision of the $^{40}Ar/^{39}Ar$ results.

10 – The four samples submitted will include two samples from separate flows at Hidden Cone. These samples should yield very close to the same $^{40}Ar/^{39}Ar$ age which will allow us to assess precision. Likewise, one sample is from Little Black Peak. A previous sample from Little Black Peak has been dated by NMBM and this second sample should yield the same $^{40}Ar/^{39}Ar$ age, again allowing us to assess the precision of $^{40}Ar/^{39}Ar$.

11 – Ar isotopic ratios must fall within normal parameters expected for young basaltic rocks unaffected by extraneous geologic processes (e.g., contamination, alteration).

12 – Ar isotopic ratios must fall within normal parameters expected for young rocks unaffected by extraneous geologic processes (e.g., contamination, alteration). This will include evaluation of the data using Ar isochron plots.

13 – Final acceptance of a date will be a long-term process that will take into account all geologic constraints gathered during site characterization studies. Acceptance may possibly include cross-checking by other geochronologic methods.

Attachment A

Qualification of the $^{40}Ar/^{39}Ar$ Volcanism Data Using Procedure YAP-SIII.1Q/Rev. 3/ICN 0 Data Qualification Plan

5.1.4b)1) Data sets to be Evaluated

Attached are the unqualified data sets approved by the AMOPE (see e-mail dated 11-24-98: Dick Spence (AMOPE) to Gail Abend (POC)). The data set to be qualified by this procedure is the $^{40}Ar/^{39}Ar$ data from chapters 2 and 4 of the Volcanism Summary and Synthesis Report (Level 3 Milestone Report 38781MR1). This data set was determined to be of the high importance to a panel of M&O and DOE representatives convened in November 1997. Also included with the attached data are the relevant sections of the Los Alamos National Laboratory (LANL) scientific notebooks used in the collection of the data. Qualification of the remaining data sets in the 11-24-98 e-mail from the AMOPE to the POC will be performed after the completion of the $^{40}Ar/^{39}Ar$ data set.

5.1.4b)2) Method of Qualification

The chosen methods for qualification of this data are the "Equivalent QA Program" and "Corroborating Data" listed in Attachment 3 of procedure YAP-SIII.1Q/Rev.3/ICN 0. This method was chosen to validate that the sampling plan used to collect the data is consistent with the sampling plan requirements in Appendix C.2.3 of the QARD and implemented in accordance with QAP-7-3. This method was chosen because the data collection records, including equipment calibration and personnel, as well as documentation of the technical/administrative procedures used to collect the data are available as per Attachment 4 of procedure YAP-SIII.1Q/Rev.3/ICN 0. The guidelines listed in Attachments 3 and 4 will be compared to the sample plan developed during this process.

5.1.4b)3) Qualifications and Personnel make up of the Review team

Chairperson: Dr. Paul R. Dixon (M&O NEPO). Dr. Dixon has a Ph.D in Geochemistry from Yale University and 15 years professional experience in collecting and evaluating related geochemical and isotopic information where statistical approaches to data analysis were used as a normal practice for data QA/QC. He has expertise in the content of the subject matter being reviewed and he is also the M&O Geochemistry Technical Lead for the Natural Environment Program Office (NEPO) which managed the collection of the volcanism data.

Team Member: Pat Auer (OQA). Mr. Auer has a B.S. in Metallurgical Engineering from the University of Arizona and MBA from the University of Las Vegas. He has 11 years experience in QA issues relating to auditing, procurement, QC, program and procedure development and vendor auditing. Mr. Auer participated in the initial development of guidelines for QC sample plan purchases intended to invoke QARD Appendix C. He also developed the recommended outlines for the QC sample plan in conjunction with NEPO, the USGS and LANL.

Team Member: Dr. John Savino (MTS). Dr. Savino obtained a Ph.D (Geophysics-Seismology) from Columbia University in 1971. Between 1971 and 1991, he worked on earthquake prediction, earthquake-explosion seismology, and plate tectonics. In December 1991 he joined the YMP as an advisor to DOE on various geophysical site investigations involving the two most significant projects: the Probabilistic Volcanic Hazards Analysis and the Probabilistic Seismic Hazard Analysis. Dr. Savino was also a member of the performance based audit team that reviewed the volcanism data and issued the deficiency report YM-96-D-107.

Team Member: Darrell Porter. Dr. Porter has a Ph.D in Mineral Engineering from the University of Minnesota in 1972 and over 30 years experience in the earth sciences. He has been associated with the development and implementation of the YMP QA program since 1985 and is intimately familiar with the use of Scientific Notebooks, traceability of scientific results, requirements for the procurement of quality services and the use of the sample plan approach for accepting analytical services from a non-Q supplier as permitted in the QARD.

5.1.4b)4) Data Review Criteria

The data will be reviewed for technical correctness based on Los Alamos National Laboratory scientific notebook procedures (LANL-YMP-QP-03.5)) and closure of DR-YM-96-D-106. The data evaluation criteria will be largely based on the rational for accepting analytical data by considering the data's accuracy based on a statistical approach of how the data were produced. This method will be used as an alternative to one that assumes the data is acceptable when produced by an analytical vendor who has demonstrated the acceptable application of a documented quality assurance program. To make this evaluation, it is necessary to examine the specification of methodology for examining the data, and evaluation of other controls adopted by the principal investigator for deciding data acceptability. Criteria will include:

A. CONTENT OF SAMPLE PLAN

- Consistency of the sample plan documentation in the LANL scientific notebooks
- Rationale of the sample plan compared with the context or premise of the QARD authority for use of a sample plan in lieu of ensuring analytic data quality through vendor controls
- Distribution of the control samples among the sample set submitted for analysis
- Anonymity of control standard identity
- The use of replicates as part of the evaluation
- Disposition of sample remnants

B ACCEPTABILITY OF CONTROL STANDARDS

- Adequacy of the number of quality control samples and approach used for submitting them
- Adequacy of the preparation and analysis of quality controls samples, or identification of the source, e.g., nationally recognized standards
- Adequacy of purchased standards

- Were other non-purchased standards methods considered or evaluated for applicable control standards
- What was established for a standard if one were not available
- Establishment of population of standards in a sample set

C ANALYSIS OF RESULTS

- What was the order of plotting results for analysis?
- Are specifications for analysis of results documented and adequate?
- What controls were used on statistical analysis, i.e., confidence limits or No. of Standard Deviations?
- Was professional judgement a part of the geochemist's determination of the appropriateness of the data?
- Reevaluate adequacy of a typical sample plan used in the course of the pertinent studies including appropriate calculations.
- Was corroborative data used as part of the geochemist's determination of the appropriateness of the data?

D. ACCEPTANCE DOCUMENTATION

- Results received and evaluated against acceptance criteria
- Specification of data reporting requirements
- Adequacy of sample control relative to traceability between source of sample and the data set results
- Adequacy of the applicable procurement documents
- Qualification of the data analyst
- Review documentation from DR-YM-96-D-107 verification concerning identical pertinent records
- History of data collection oversight activities both internal and external

Item 5.1.4b)5) Recommendation criteria for changing data qualification status.

A. Criticality of the standards quality.
B. Match of analytical data scatter to that of the standard.
C. Confidence required (justified) in acceptability of data.
D. Accuracy of results to that needed.
E. History and confidence in the contracted analytical services.
F. Equivalence of data collection with QARD Appendix C.2.3.
G. Verification that a sufficient quantity of corroborative is available.
H. Inferences drawn for corroborative data are identified, justified and documented.
I. Prior peer or other professional review of the data and their results.
J. Extent and reliability of the documentation associated with the data.

Item 5.1.4b)6) Schedule for completing work

11-30-98 Finalized qualification plan with team and submit to POC.

12-1-98 Obtain approval from the AMOPE on the submitted plan. With approval of the plan, begin review of LANL scientific notebooks and other appropriate data. Verify the traceability of the data being reviewed within the technical data base records processing center

12-2-98 Decision point by team if additional members are needed to qualify the data. Data generator, Frank Perry, available for consultation.

12-3-98 Finalize input to qualification report on the $^{40}Ar/^{39}Ar$ data. Data generator, Frank Perry, available for consultation.

12-4-98 Submit completed qualification report on the $^{40}Ar/^{39}Ar$ data to the POC.

12-9-98 After receiving approval from the AMOPE on our Qualification report on the $^{40}Ar/^{39}Ar$ data, the team will complete a plan to qualify the remaining volcanism data sets by 12-14-98.

12-14-98 Finalize qualification plan for remaining volcanism data sets with existing team and submit to POC.

2-1-99 Submit completed qualification report for remaining volcanism data sets to the POC on or before this date.

Watershed	Location of discharge cell UTM easting meters	UTM northing meters	number of cells	watershed area km^2	average elevation meters	maximum elevation meters	minimum elevation meters	average soil depth meters	average slope	maximum slope
Drill Hole Wash	553871	4074693	44490	40.04	1253	1782	1004	3.04	11.1	40
Dune Wash	553871	4070973	19683	17.71	1178	1504	956	2.90	12.0	34
Yucca Wash	554621	4079373	45332	40.80	1463	1959	1071	2.15	15.7	46
Solitario Canyon #1	544721	4072203	13146	11.83	1348	1683	1061	1.77	14.0	37
Solitario Canyon #2	544691	4074153	349	0.31	1145	1177	1121	5.87	2.6	7
Solitario Canyon #4	544721	4074633	1016	0.91	1195	1367	1133	3.63	9.3	30
Plug Hill	544781	4071393	7375	6.64	1171	1486	1039	3.89	9.4	35
Jet Ridge #1	544691	4078023	4848	4.36	1502	1784	1265	1.80	18.1	35
Jet Ridge #2	544721	4075953	803	0.72	1343	1455	1183	1.01	18.0	35
Jet Ridge #3	544721	4075293	422	0.38	1228	1392	1152	3.51	10.1	30
Total			137464	123.72						

Table 1. Watershed model domains used for net infiltration simulations

Stream gage ID	Watershed above Gage	Gage location		Drainage area above gage (km^2)	Period of record	Location of nearest model cell defining upstream drainage		Number of model cells	Model area (km^2)
		UTM easting (meters)	UTM northing (meters)			UTM easting (meters)	UTM northing (meters)		
1025125356	Wren Wash	548657	4079217	0.60	1994-95	548651	4079223	636	0.57
102512531	Pagany Wash near prow	549270	4080206	1.22	1994-95	549281	4080213	1684	1.52
102512533	Pagany Wash #1 (near UZ-4)	550315	4079380	2.12	1993-95	550301	4079283	2415	2.17
102512535	Drillhole Wash above UZ-1	548405	4079924	1.37	1994-95	548411	4079913	1735	1.56
102512537	Split Wash below Quac Canyon	549183	4078079	0.85	1994-95	549191	4078023	970	0.87

Table 2. Stream gages used for model calibration and the corresponding calibration watershed model domains

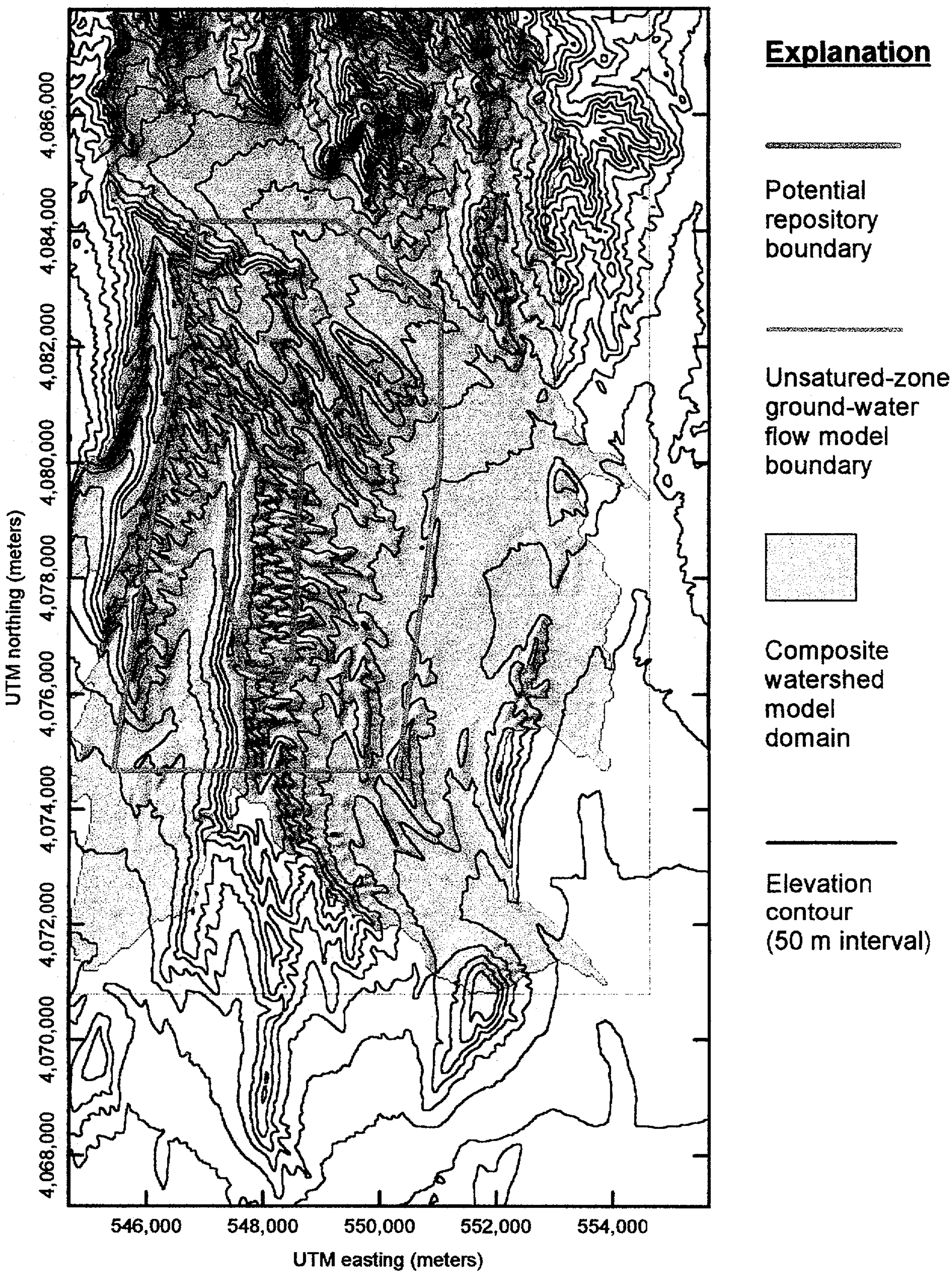
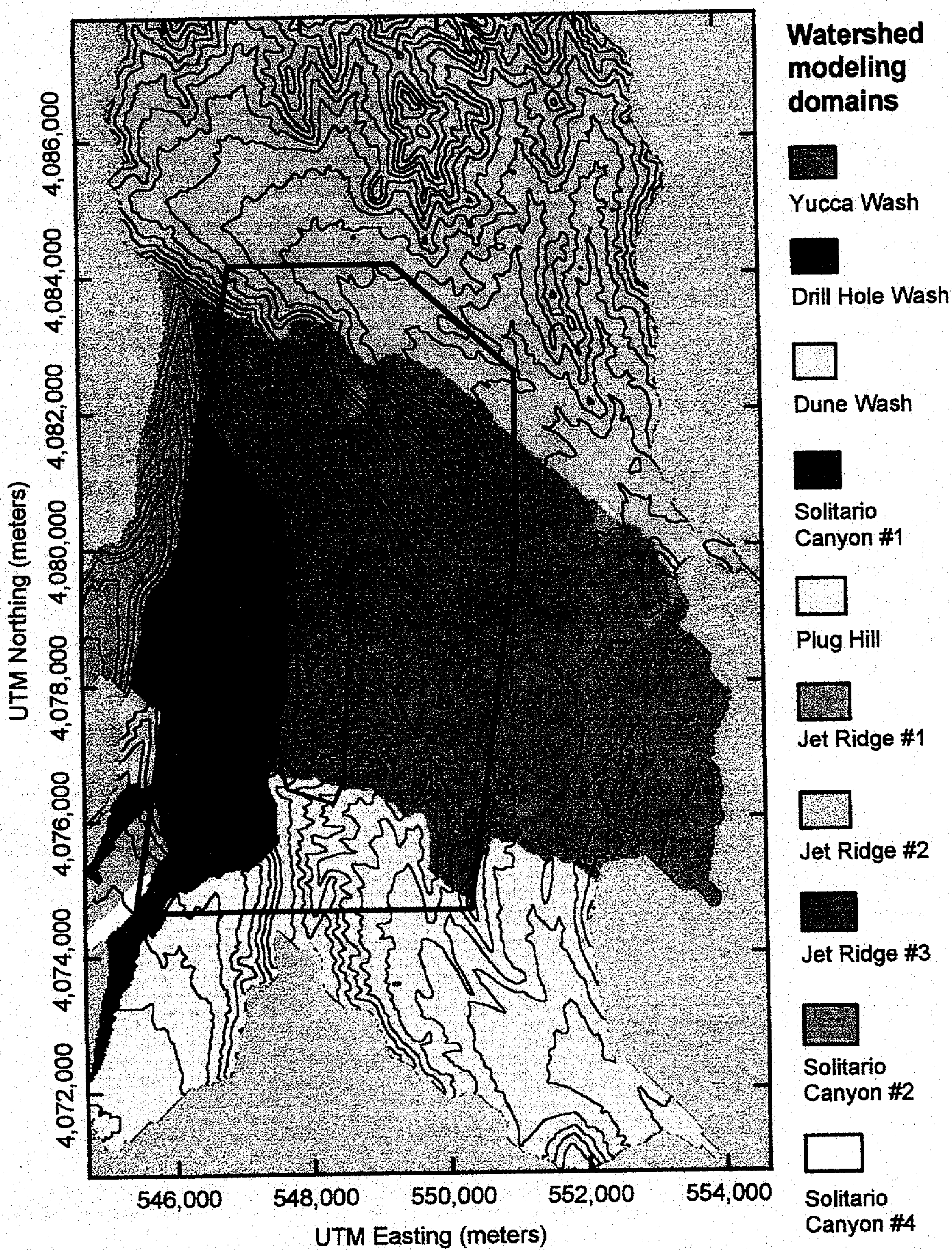


Figure 1. Total area of composite watershed model domain, consisting of 10 separate watershed model domains.



elevation contour interval = 50 meters

Figure 2. Boundaries of 10 watershed modeling domains overlying and adjacent to the area of the unsaturated-zone ground-water flow model.

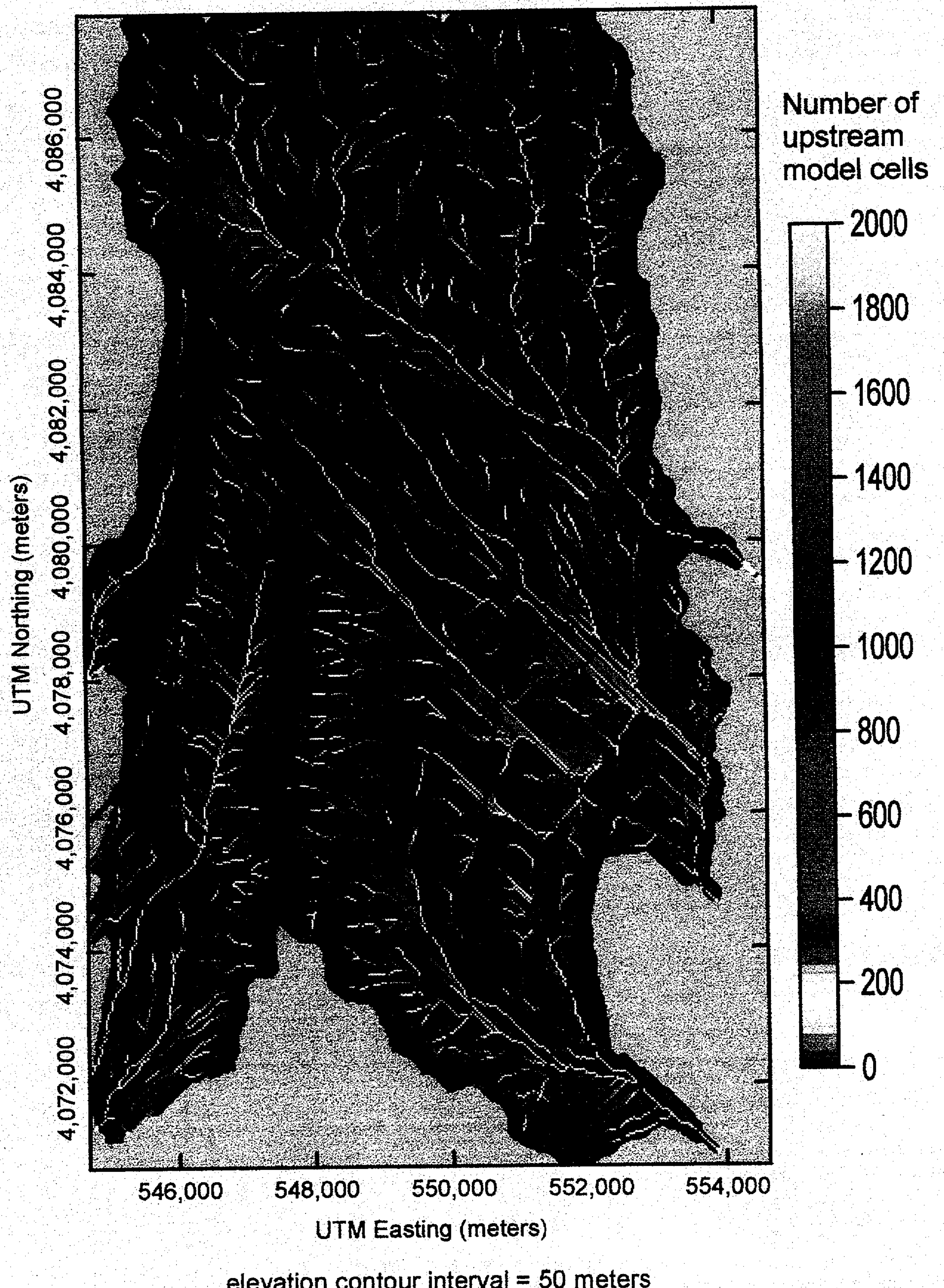


Figure 3. Channel network generated using the 30-meter DEM (white shading indicates grid cells with more than 2,000 upstream cells).

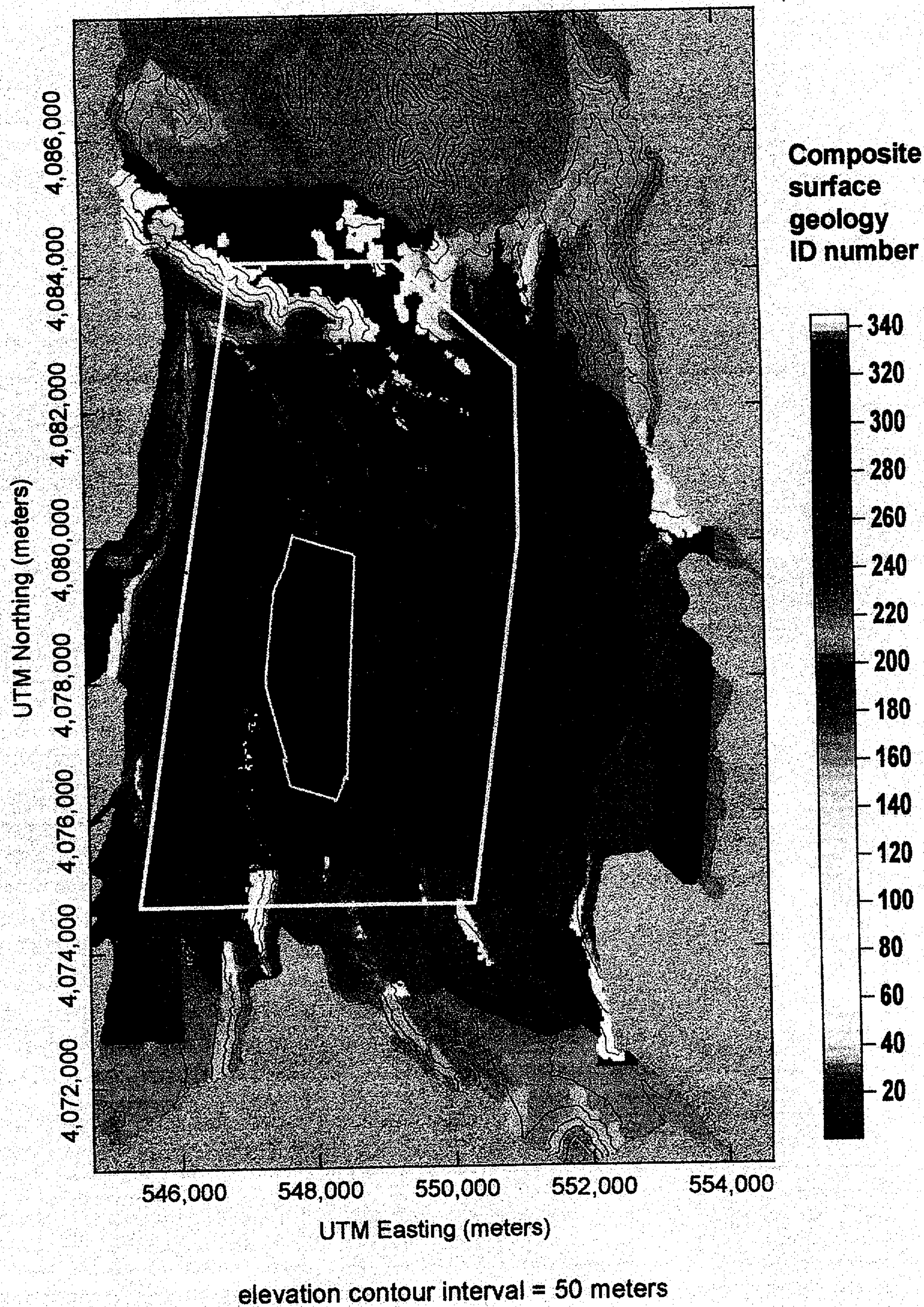


Figure 4. Up-dated surface geology ID numbers using a composite of the 1998 Day and others, the 1984 Scott and Bonk, and the 1965 Christiansen and Lipman geologic map coverages.

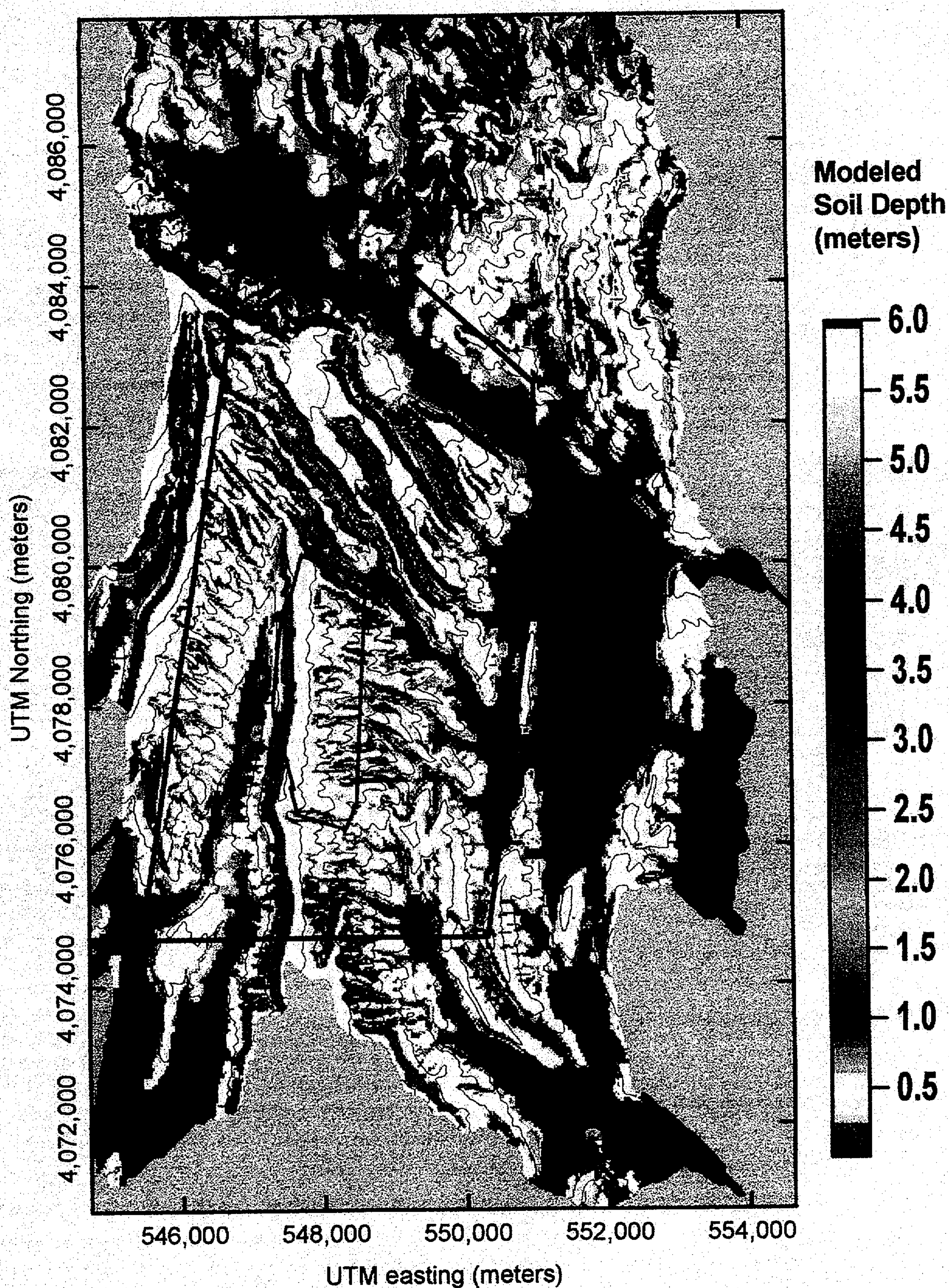


Figure 5. Modeled soil depth using 4 mapped depth classes and ground-surface slope calculated using the 30-meter DEM (gray shading indicates soil depths greater than 6 meters).

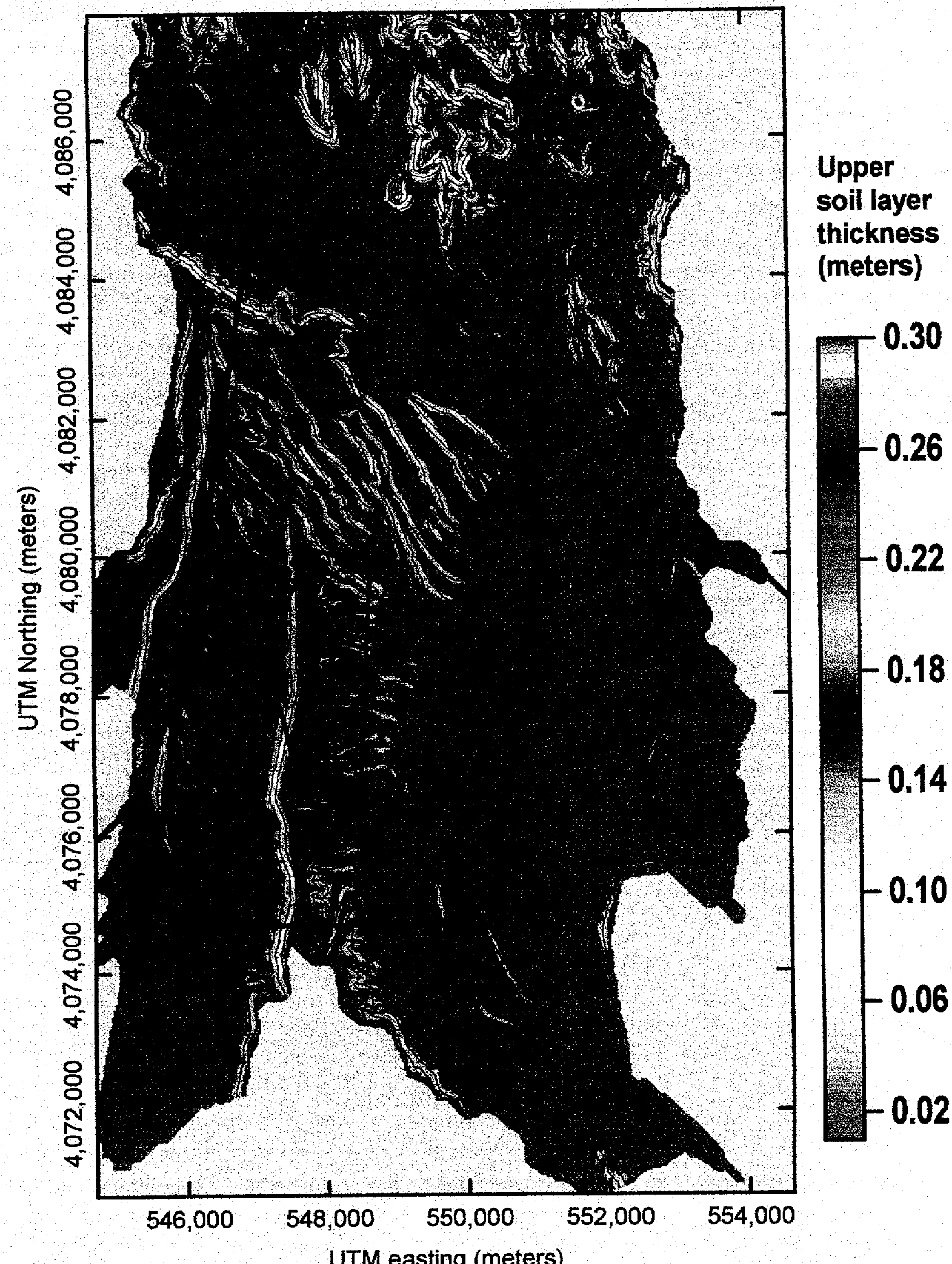


Figure 6. Upper soil layer thickness using a 4-layer cascading bucket model (colored areas indicate shallow soil locations where the upper layer is equal to the total soil depth, while gray shading indicates a uniform thickness of 0.3 meters).

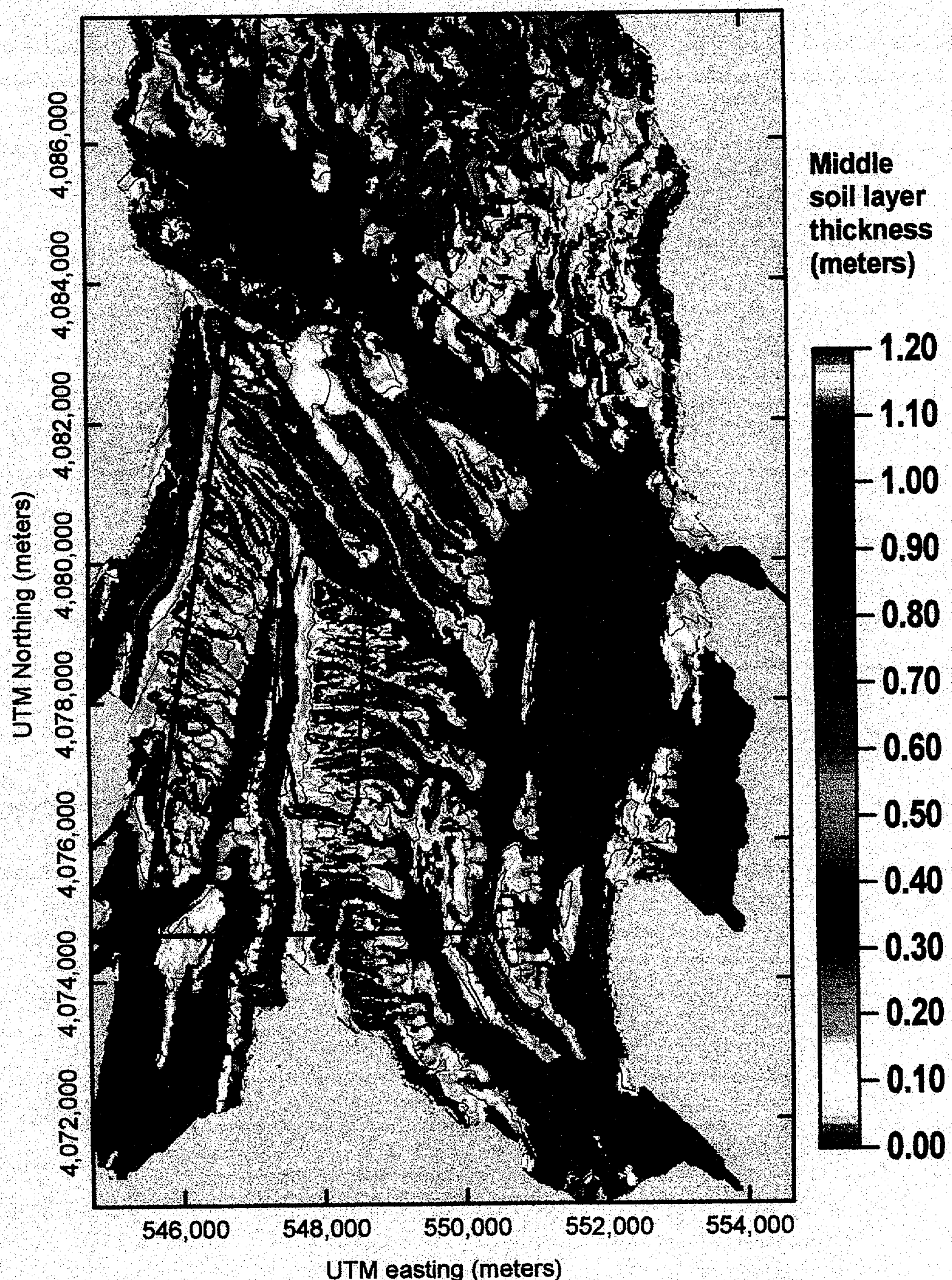


Figure 7. Middle soil layer thickness using a 4-layer cascading bucket model (gray shading indicates a uniform thickness of 1.2 meters).

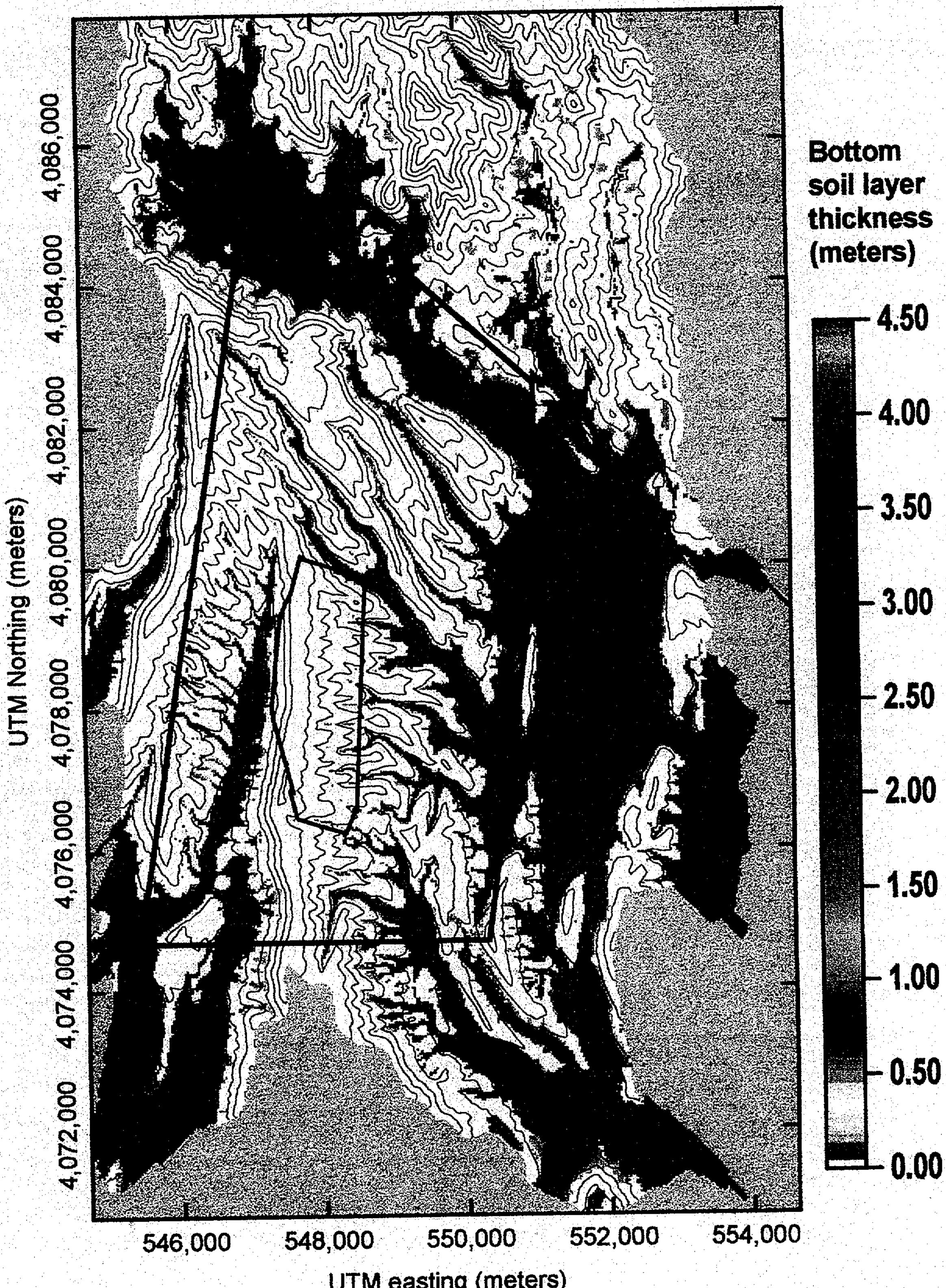


Figure 8. Bottom soil layer thickness using a 4-layer cascading bucket model (gray shading indicates a uniform thickness of 4.5 meters, white shading indicates a thickness of 0 meters).

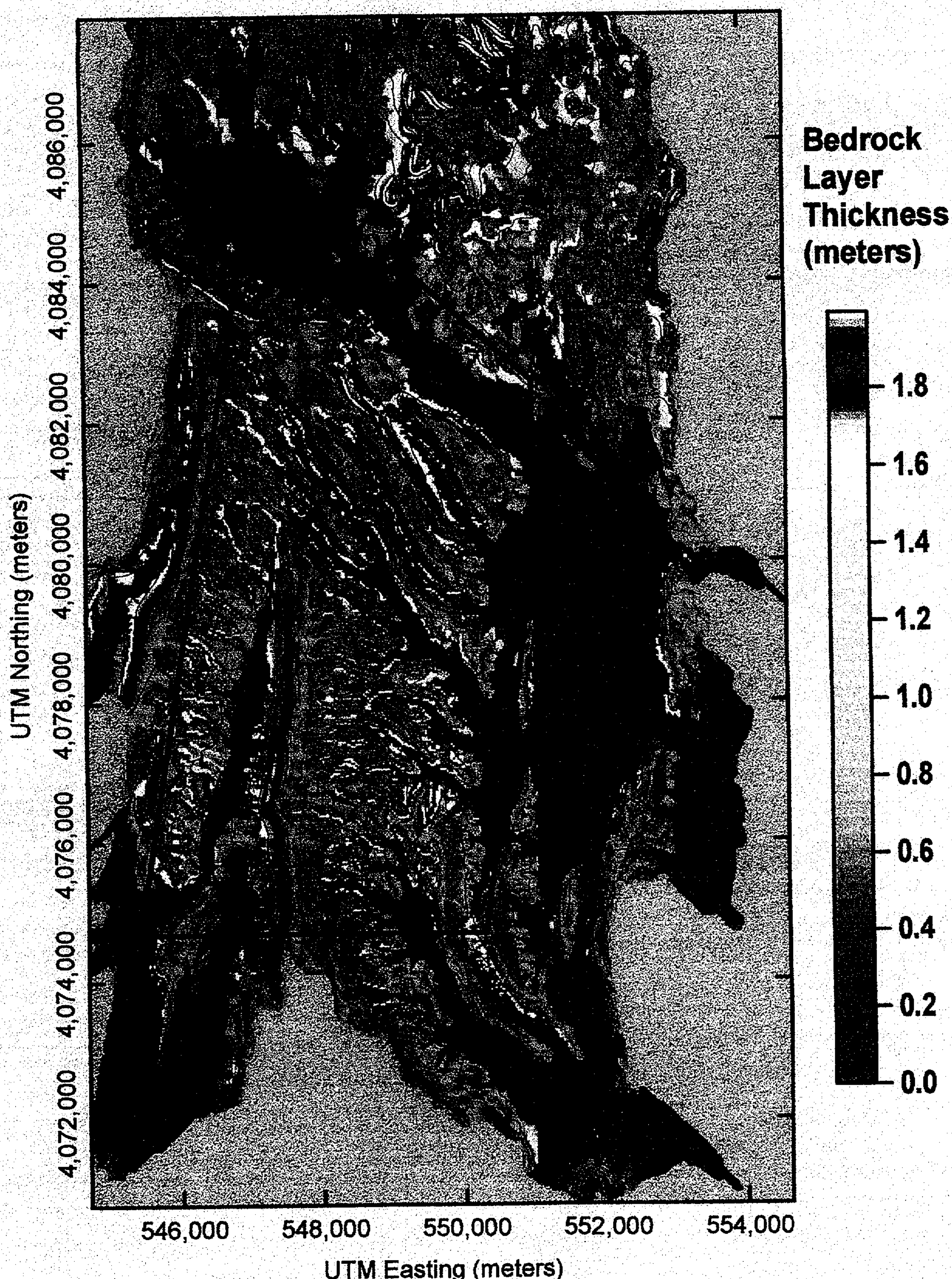


Figure 9. Bedrock layer thickness using a 4-layer cascading bucket model (gray shading indicates a thickness of 0 meters).

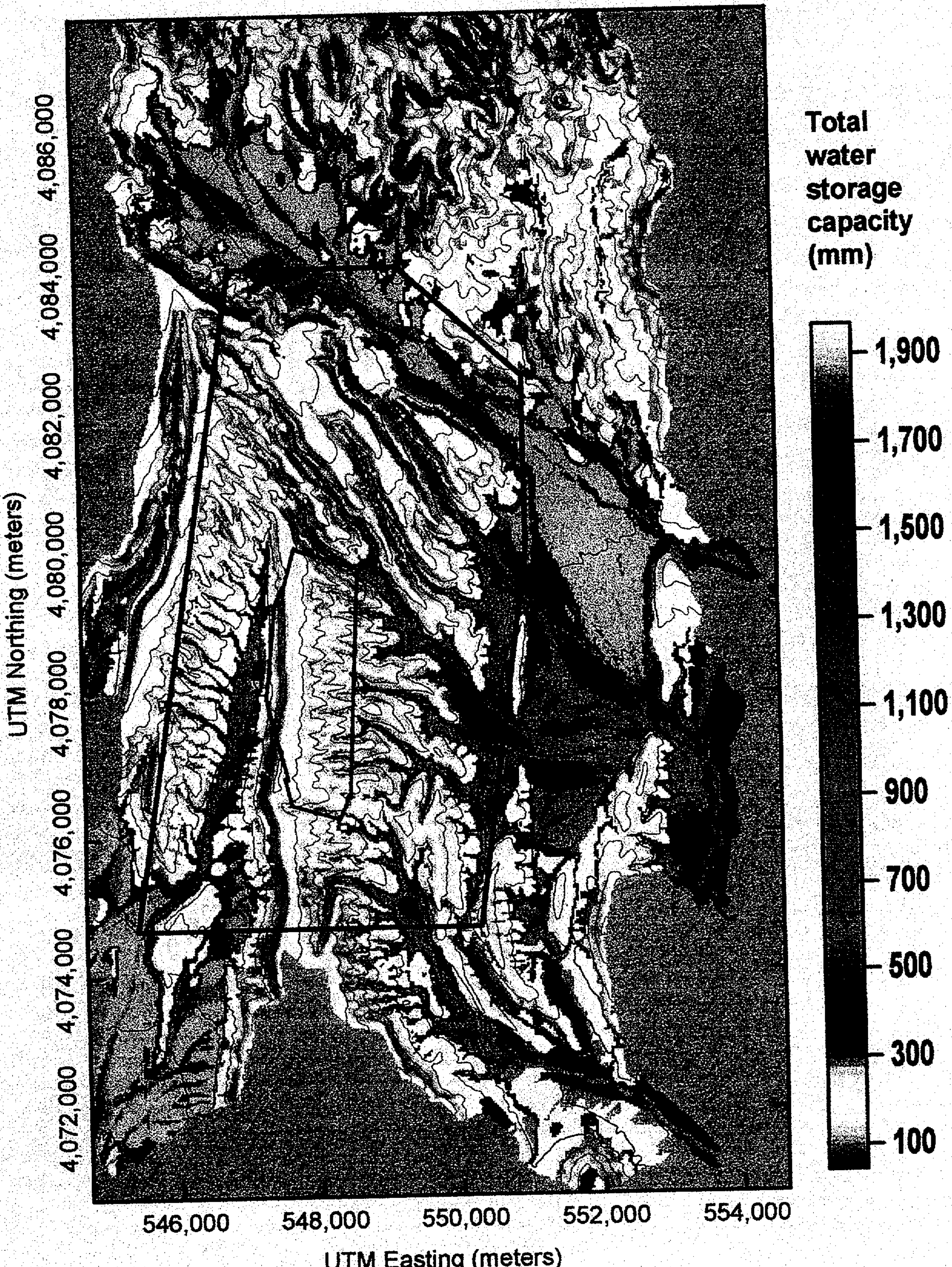


Figure 10. Total water storage capacity using new soil depths and a multi-layer cascading bucket modification for modeling the effective root zone.

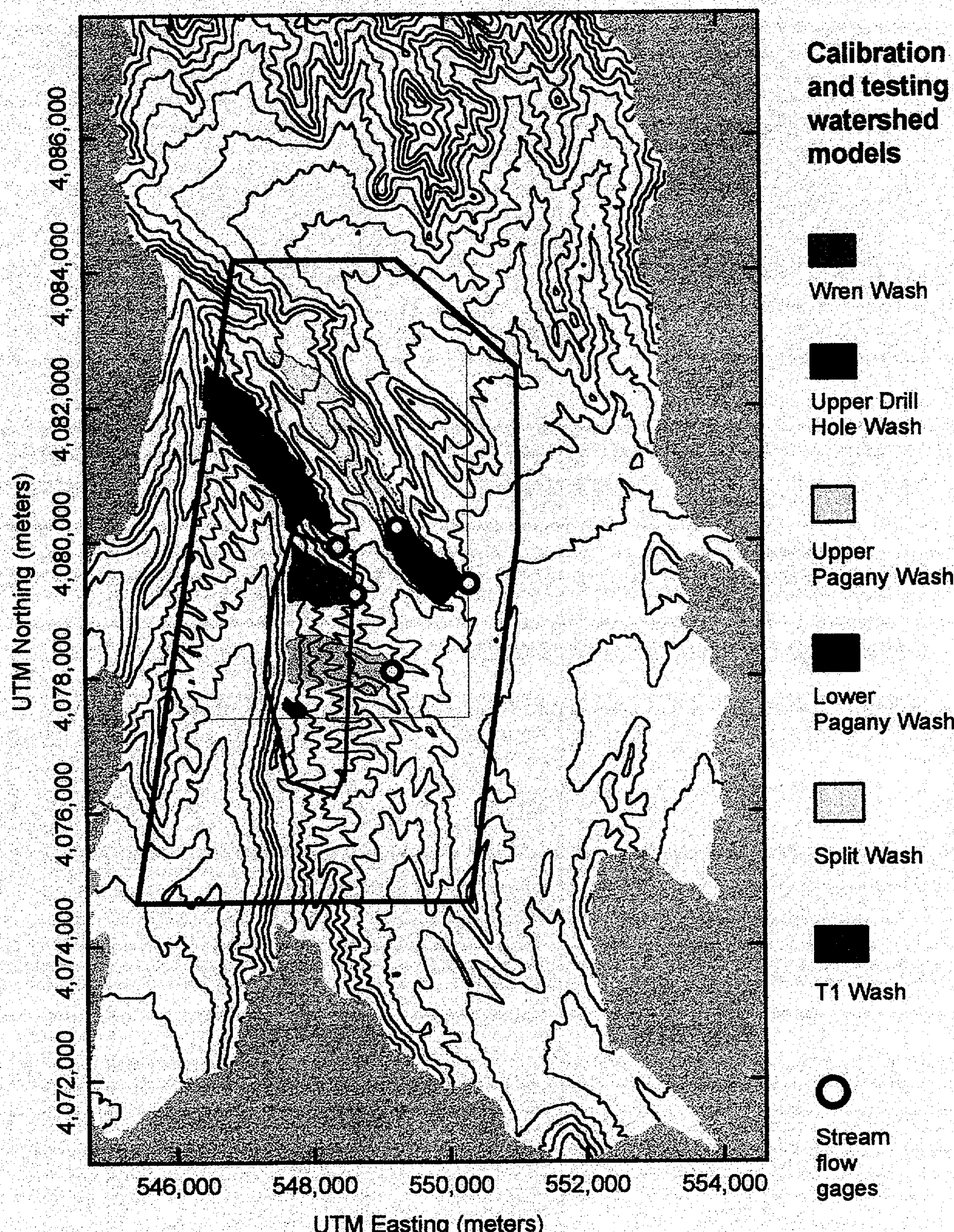


Figure 11. Location of calibration and testing watershed models, and location of stream flow gages used for model calibration.

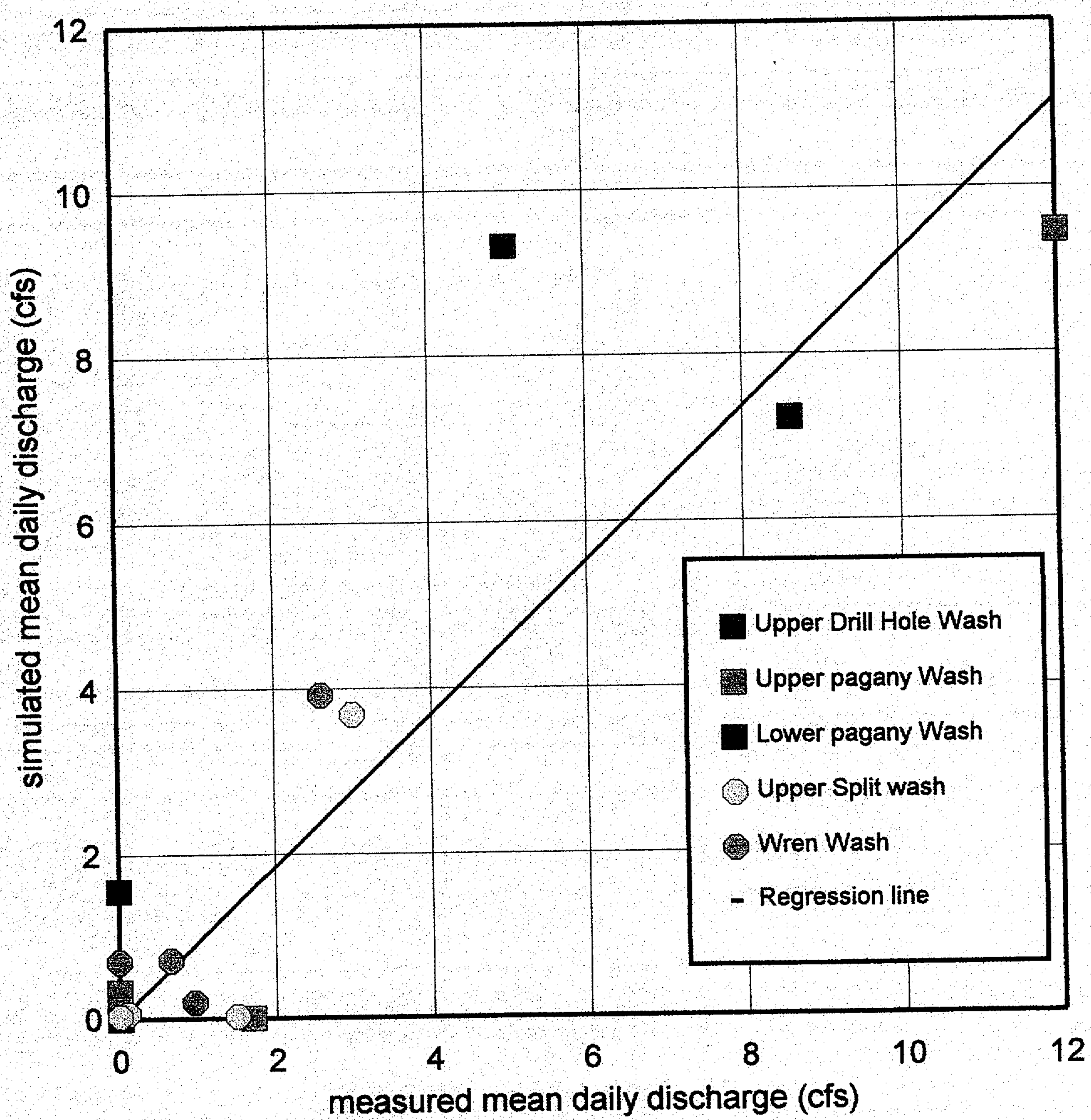


Figure 12. Model calibration results

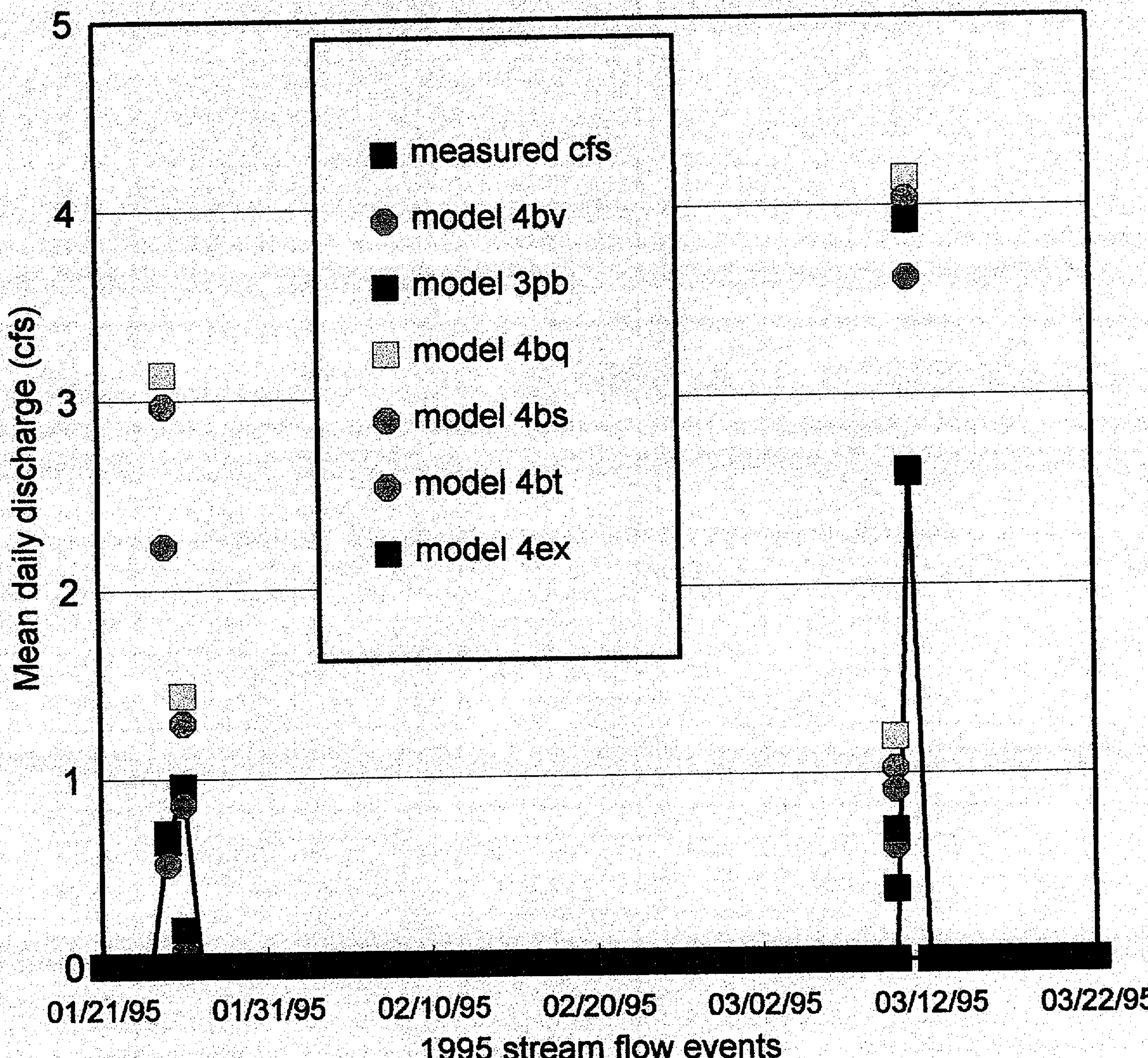


Figure 13. Wren Wash model calibration
(selected model identified as 4ex)

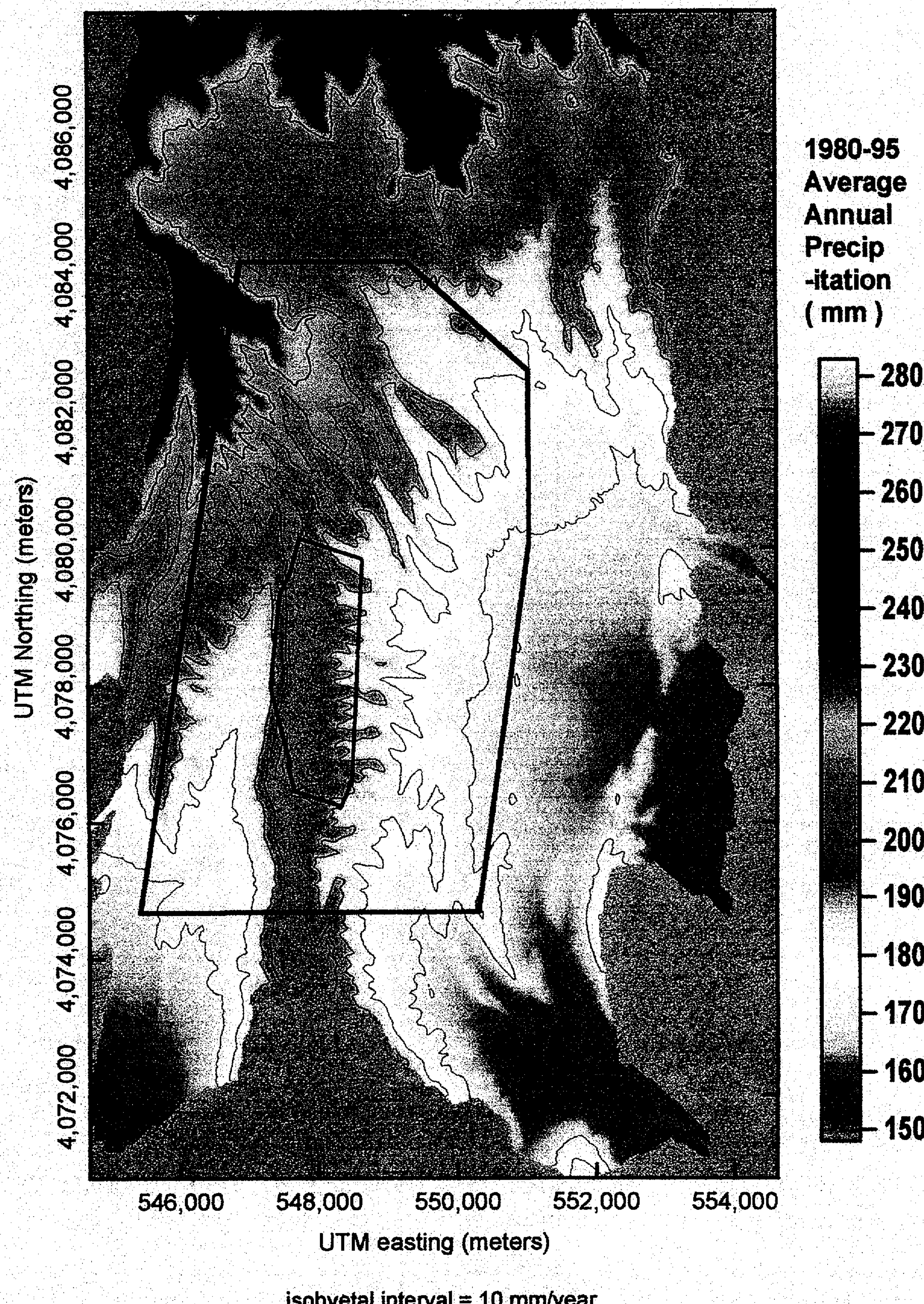


Figure 14. Modeled 1980 - 1995 average annual precipitation.

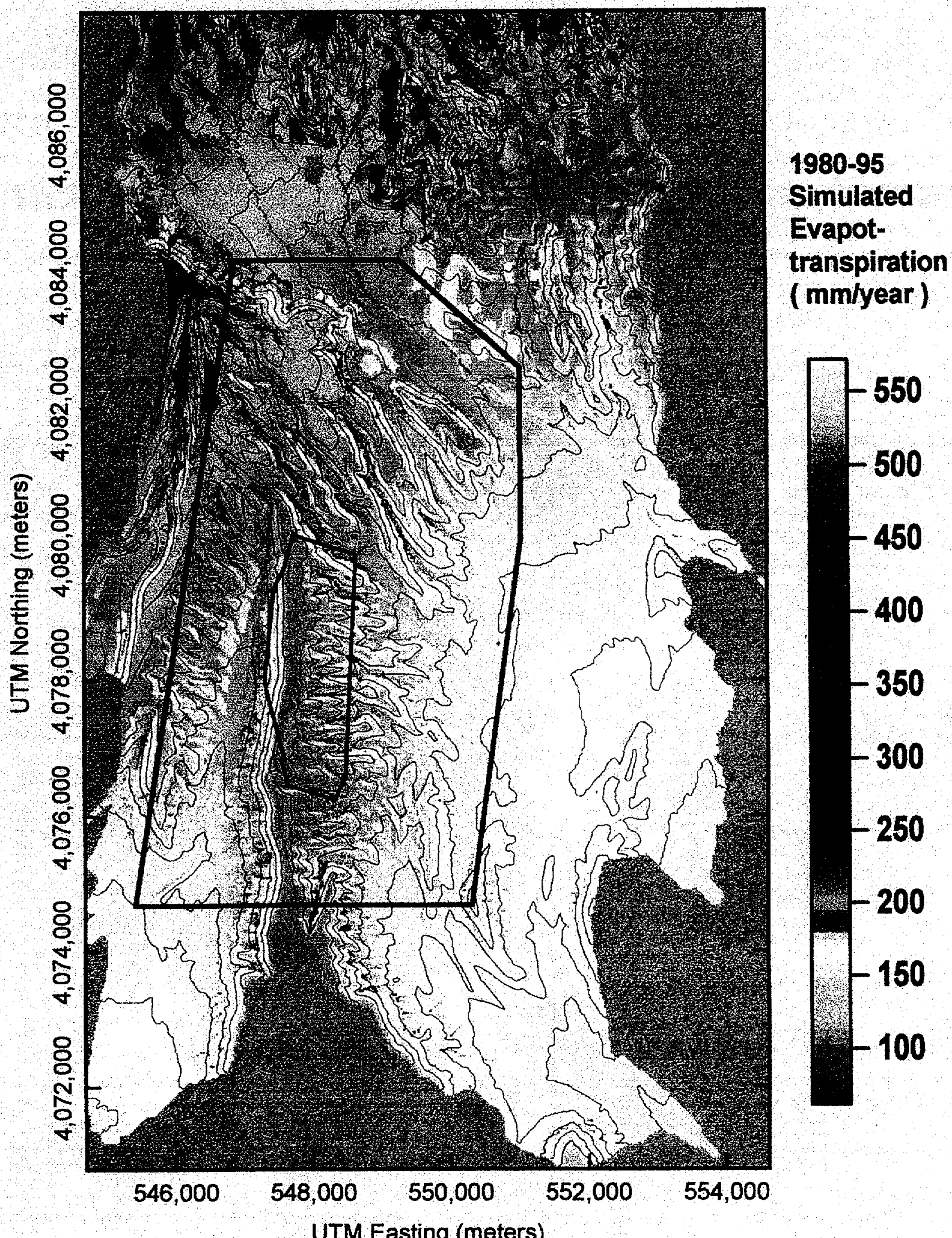


Figure 15. Simulated 1980 - 1995 average annual evapotranspiration.

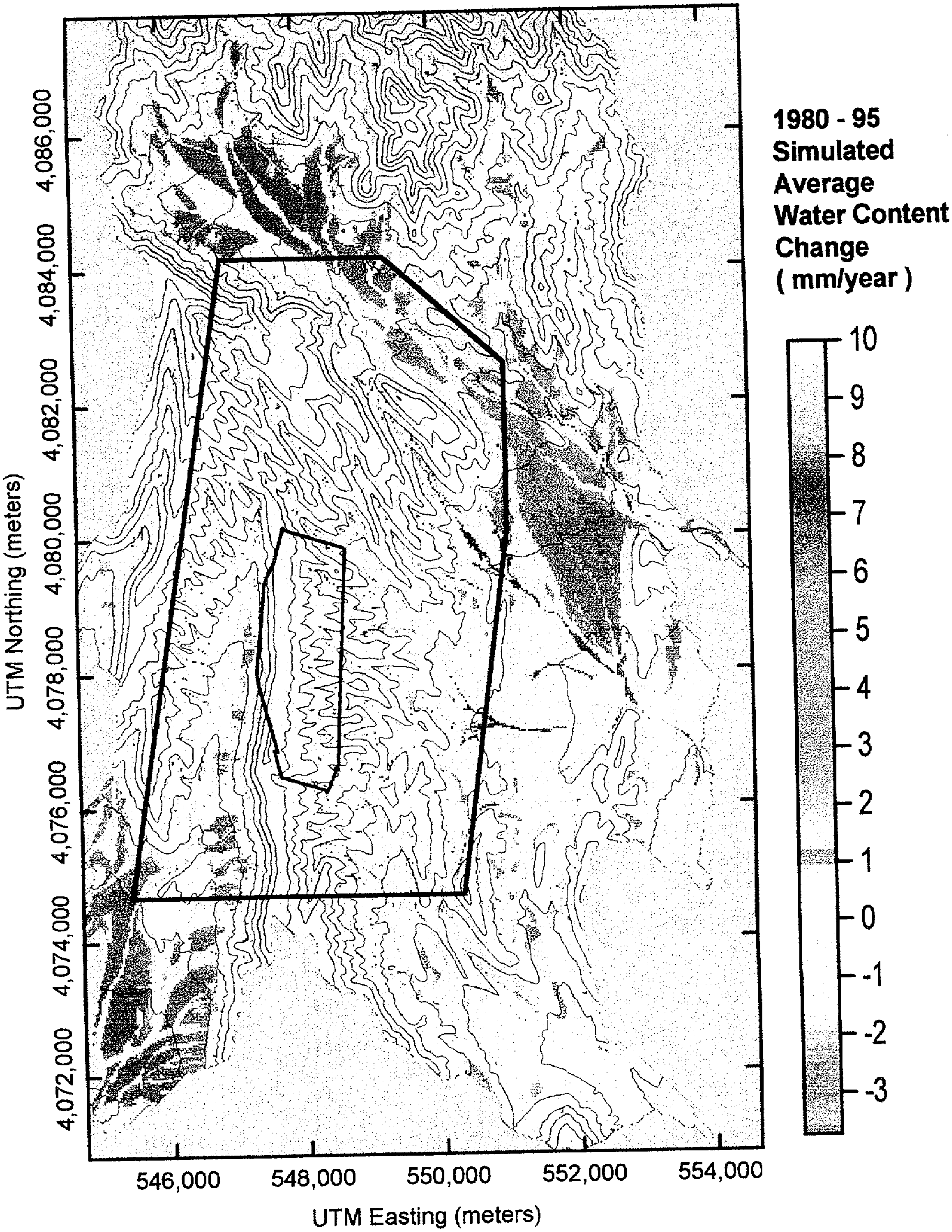


Figure 16. Simulated 1980 - 1995 soil and bedrock average water content change (white shading indicates values greater than 10 mm/year).

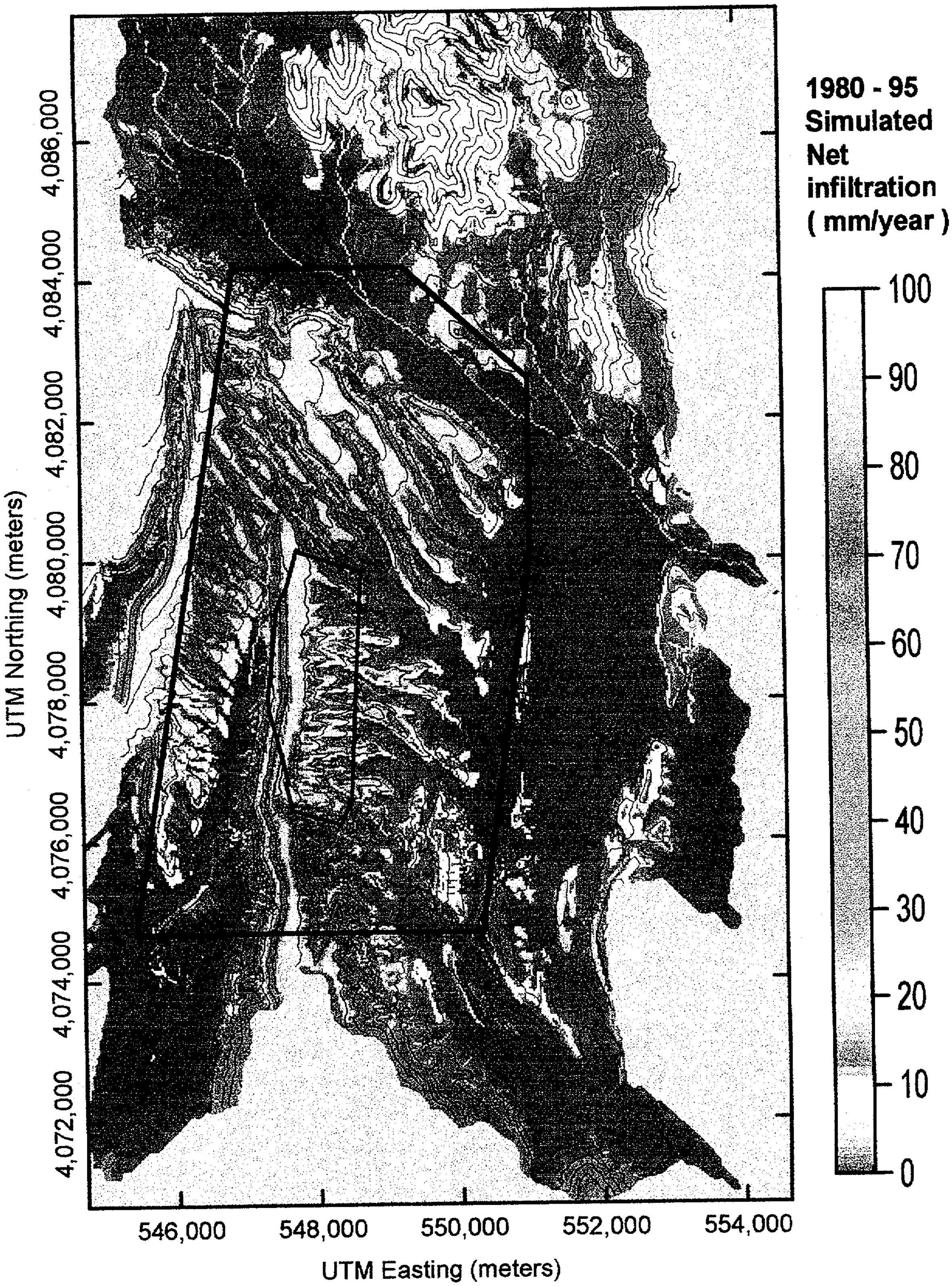


Figure 17. 1980 - 1995 simulated net infiltration (white shading indicates values greater than 100 mm/year).

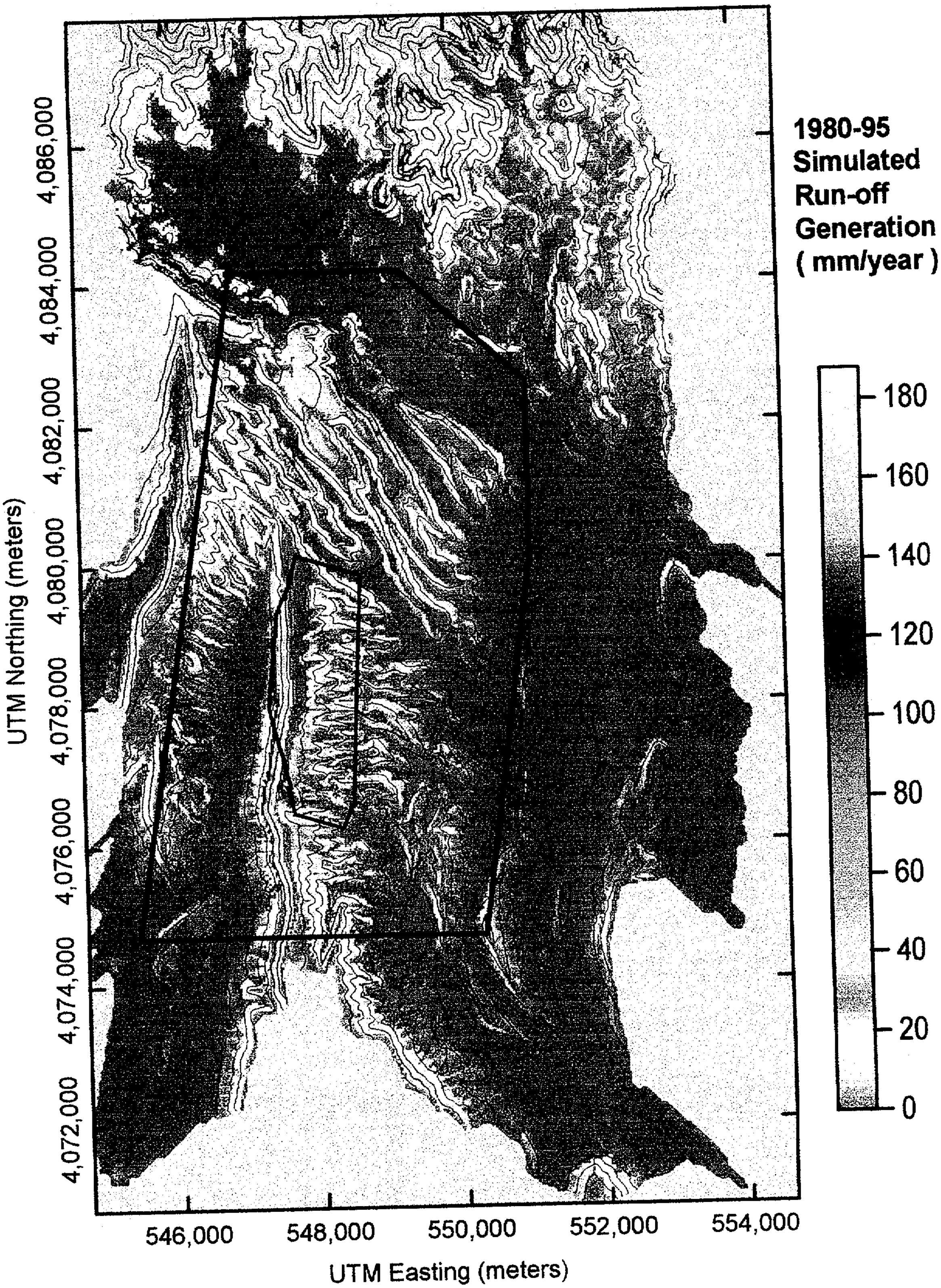


Figure 18. 1980 - 1995 Simulated run-off generation (excess precipitation).

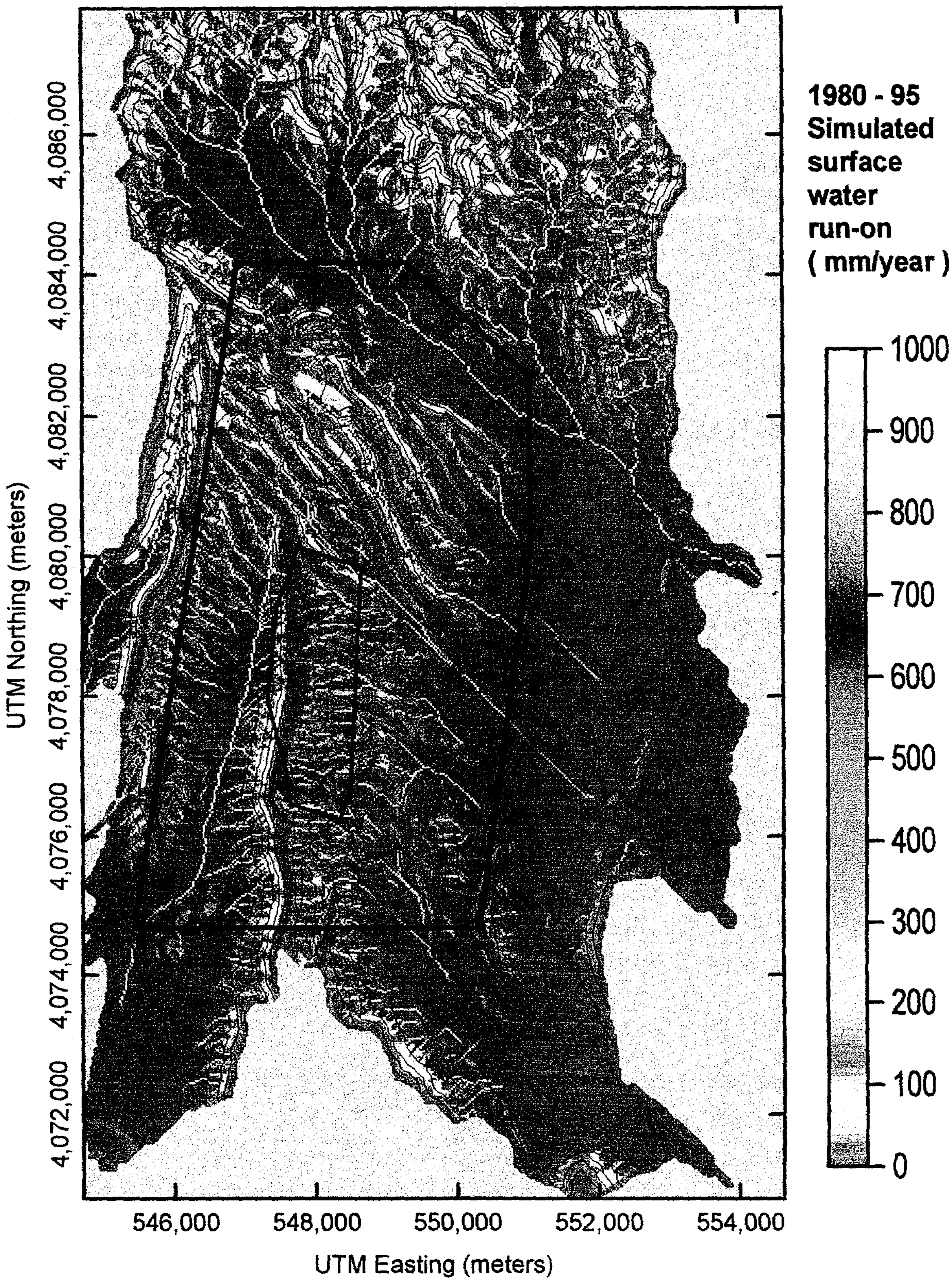


Figure 19. 1980 - 1995 simulated average surface water run-on depth (white shading indicates values greater than 1,000 mm/year).

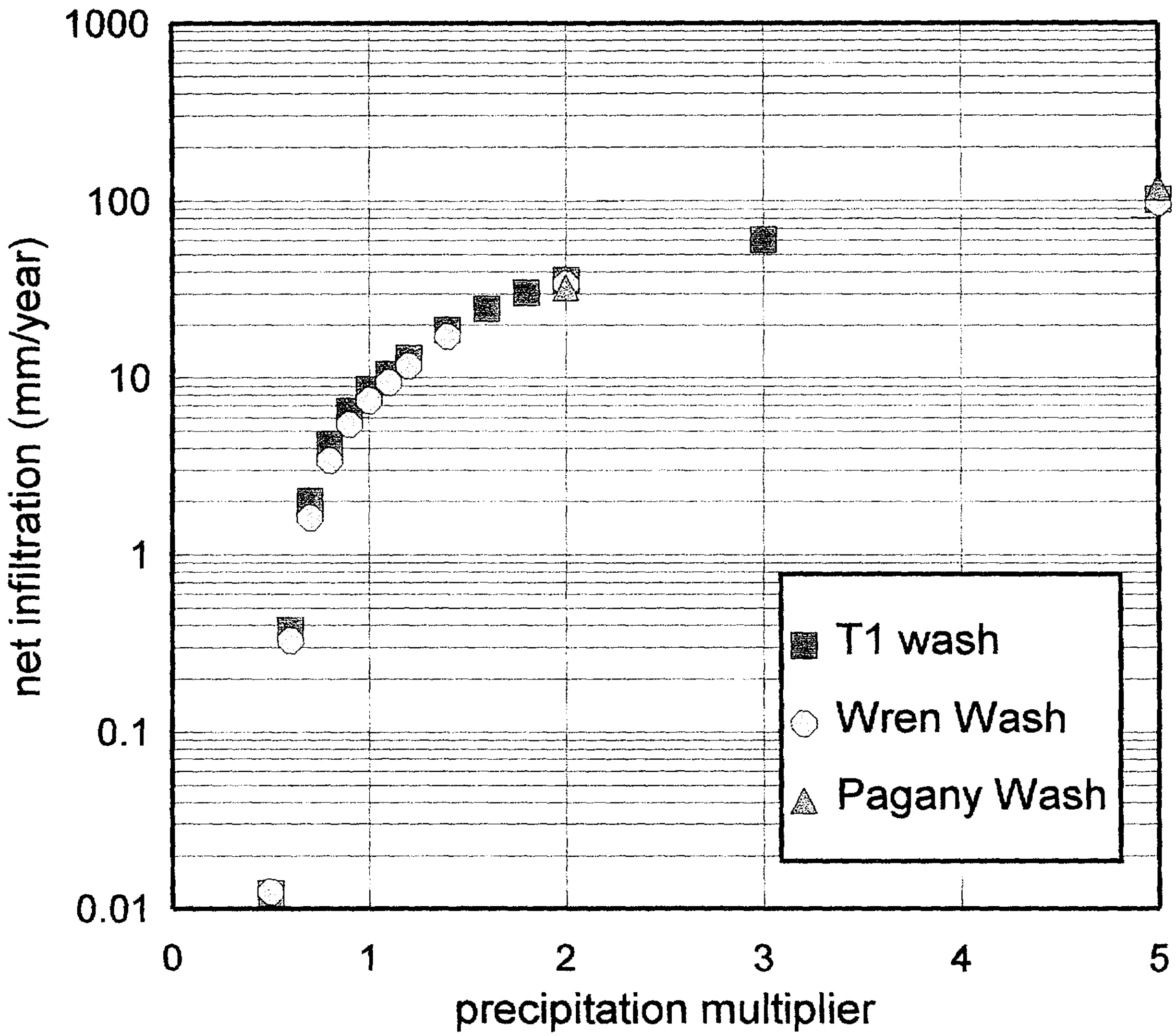


Figure 20. Variability of net infiltration as a function of precipitation.

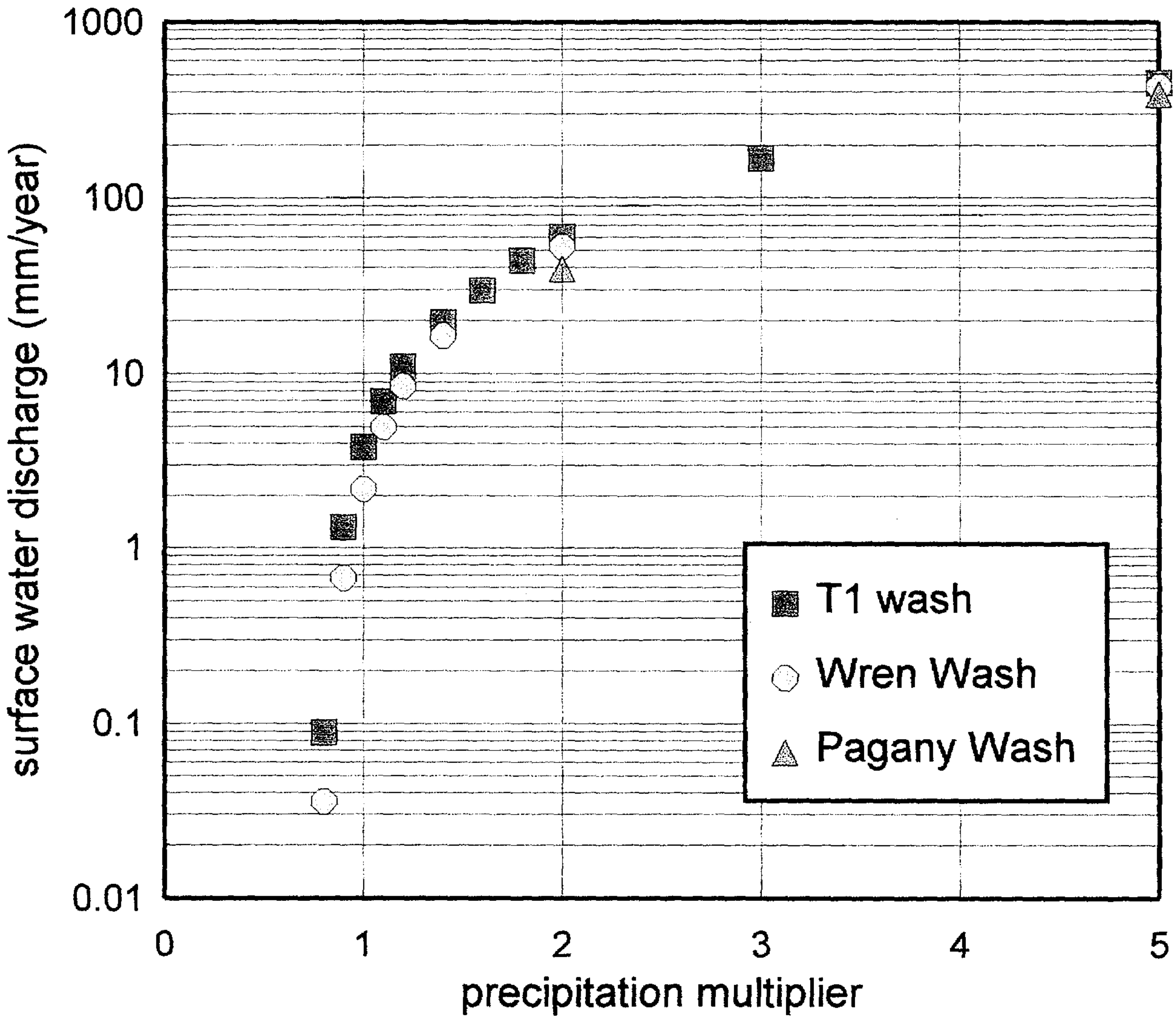


Figure 21. Variability of surface water discharge
as a function of precipitation

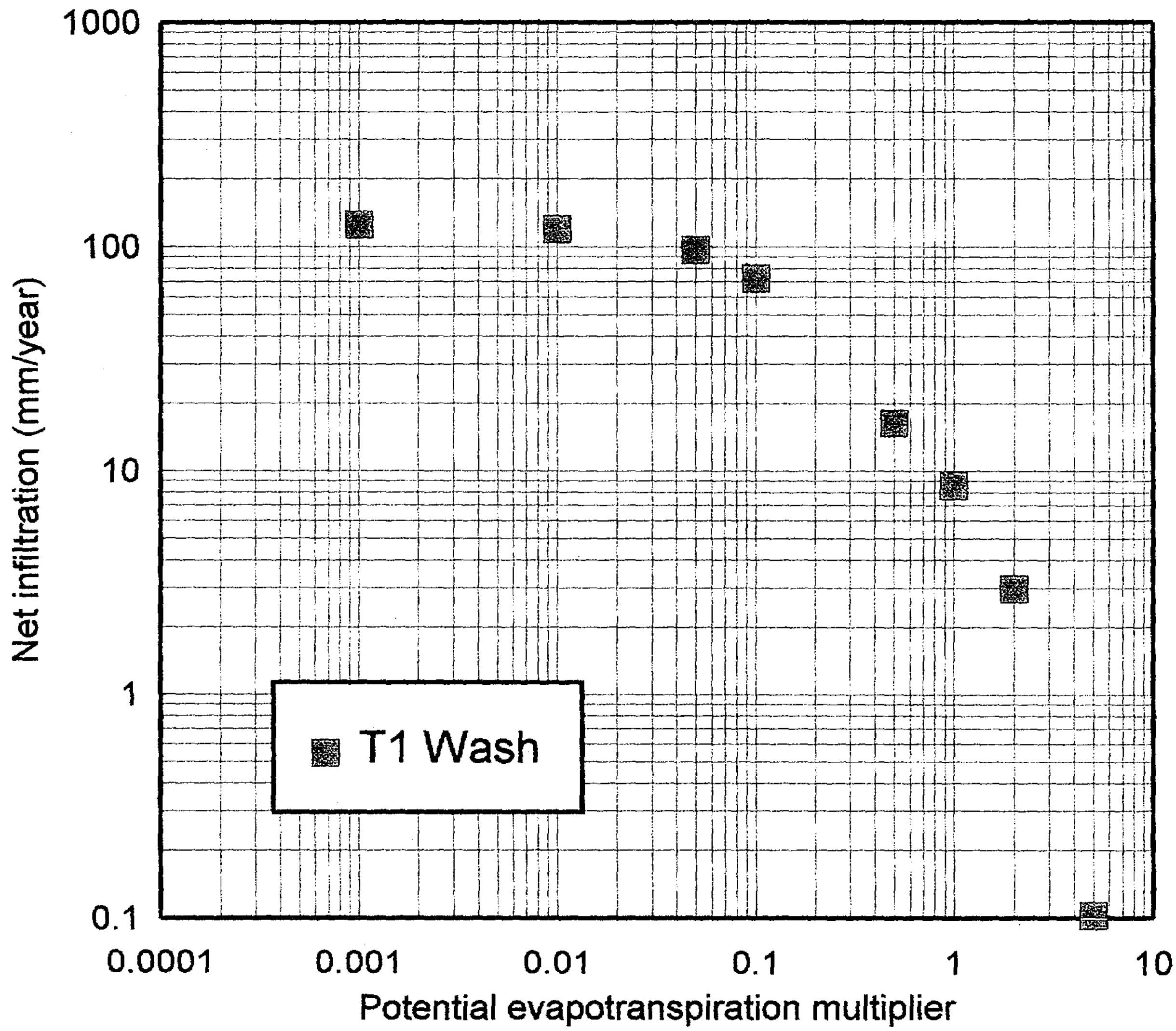


Figure 23. Variability of net infiltration
as a function of potential evapotranspiration

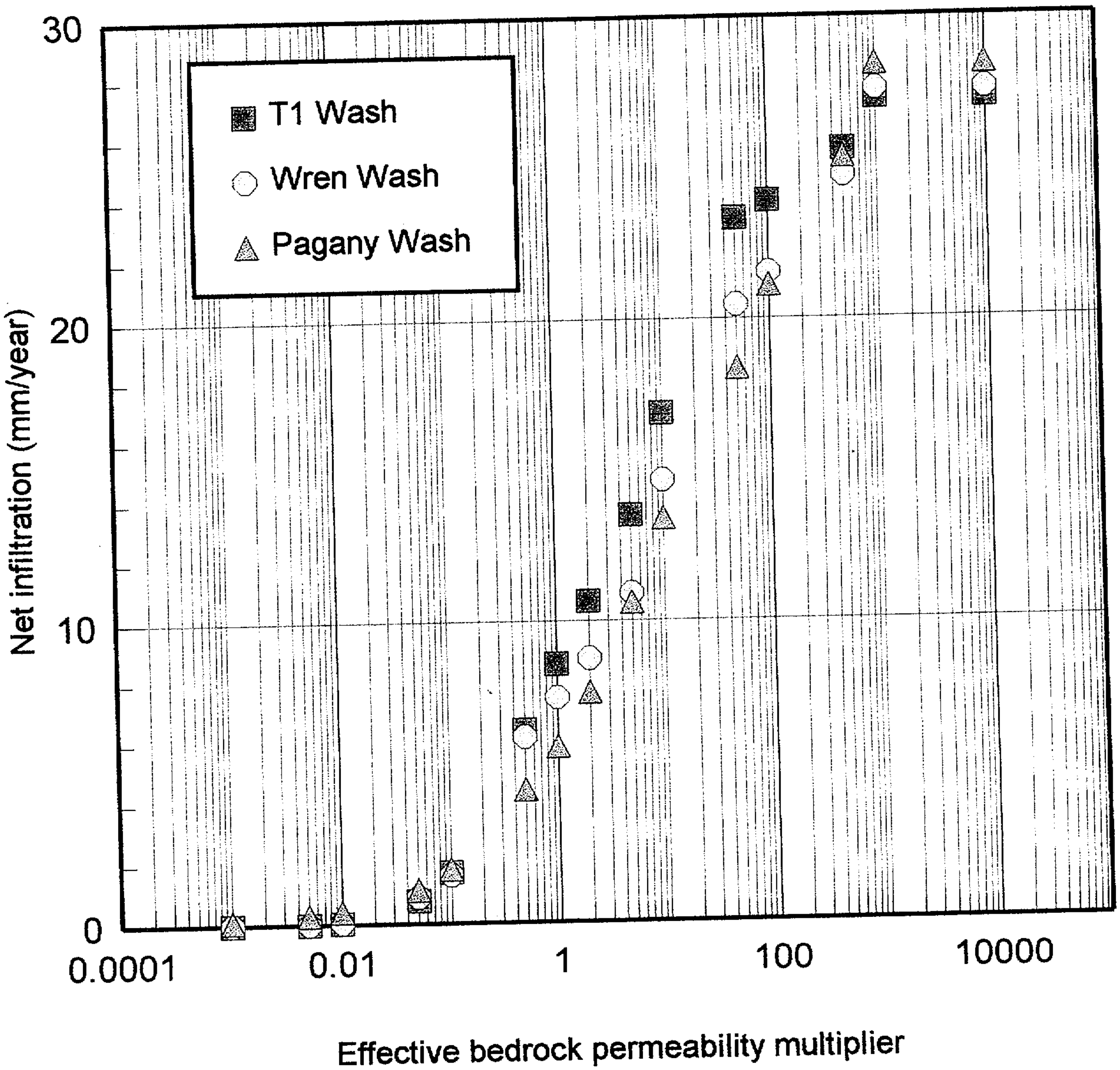


Figure 24. Variability of net infiltration as a function of effective bedrock permeability

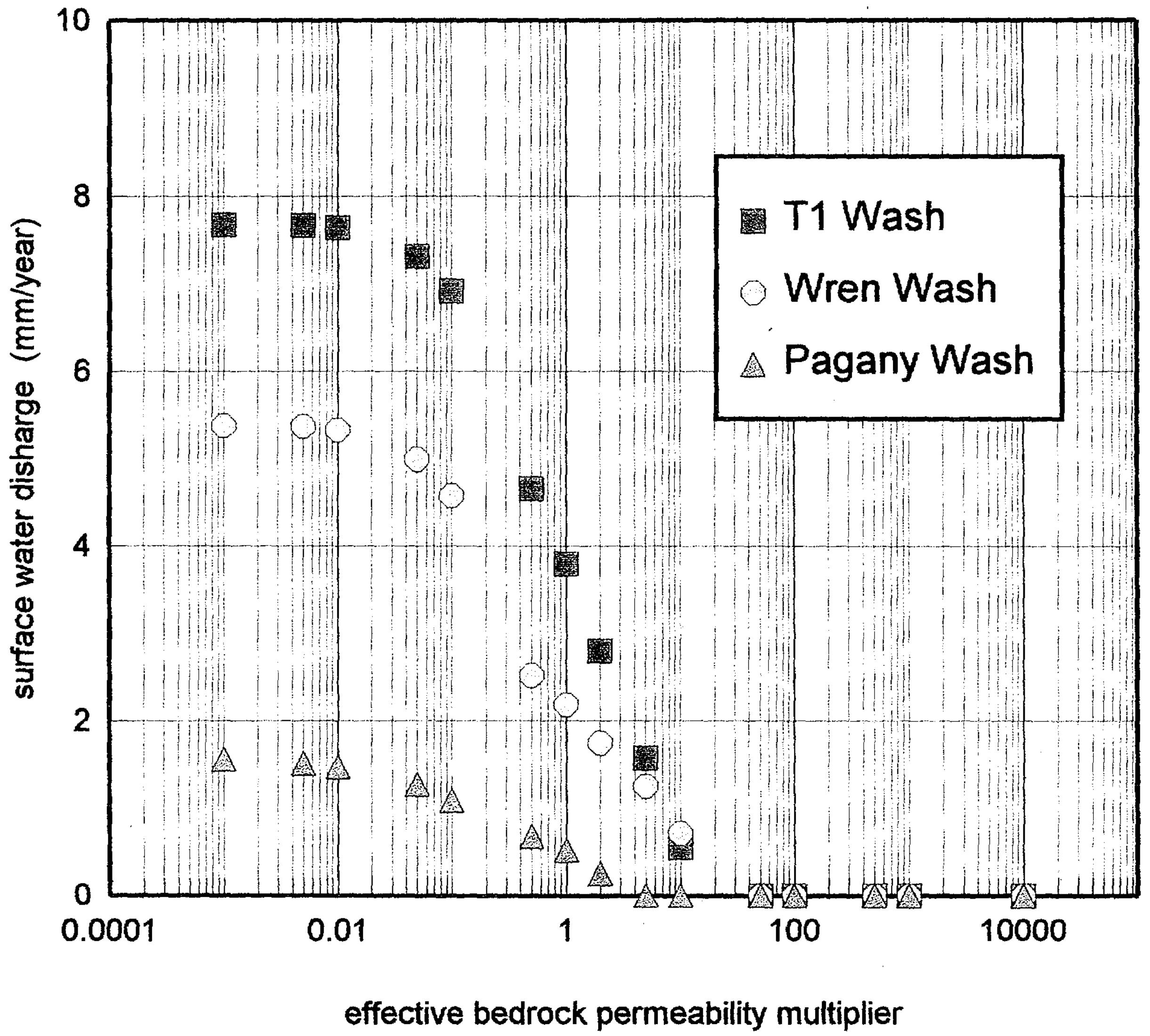


Figure 25. Variability of surface water discharge as a function of bedrock permeability.

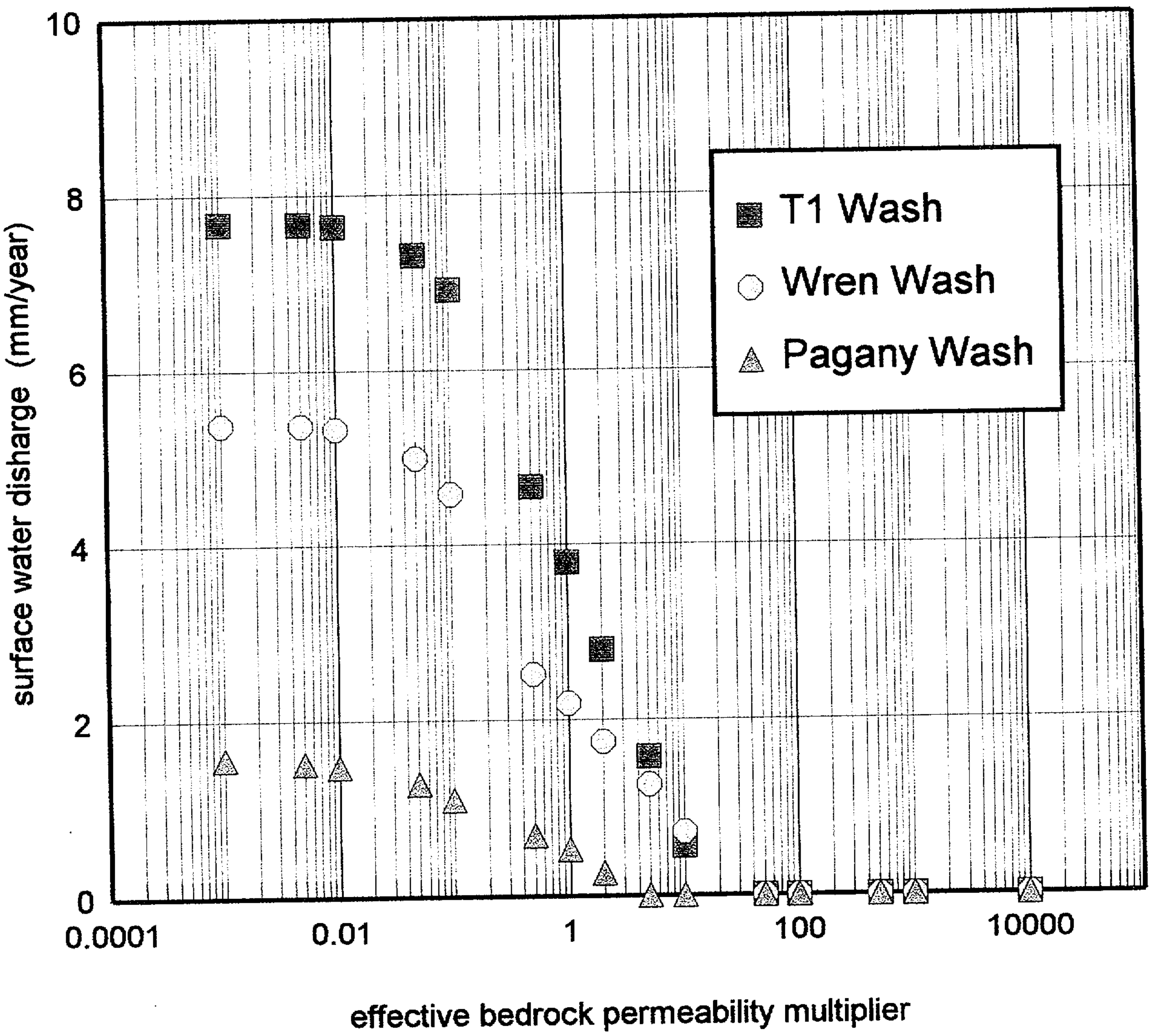


Figure 25. Variability of surface water discharge as a function of bedrock permeability.

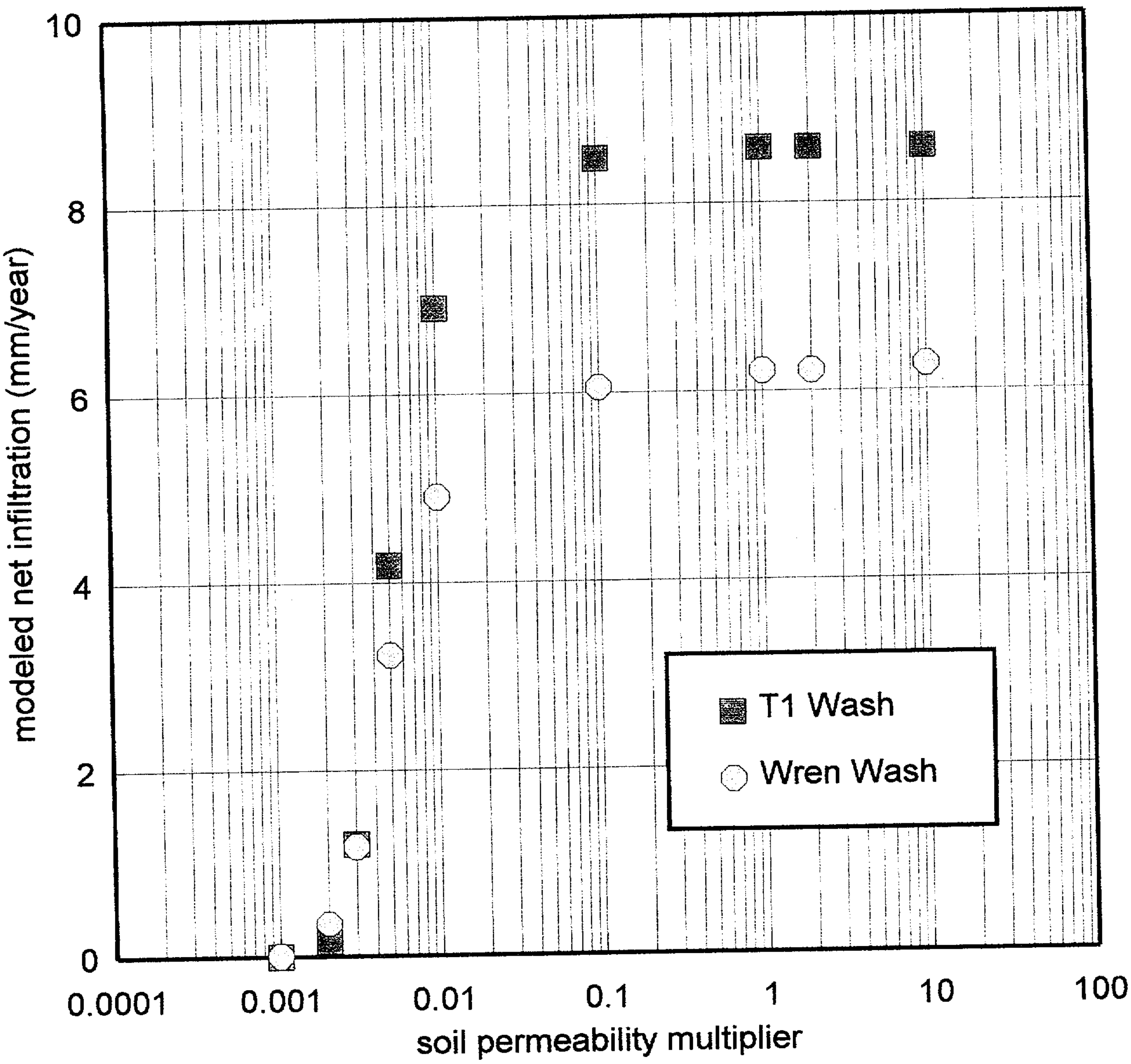


Figure 26. Variability of net infiltration as a function of soil permeability

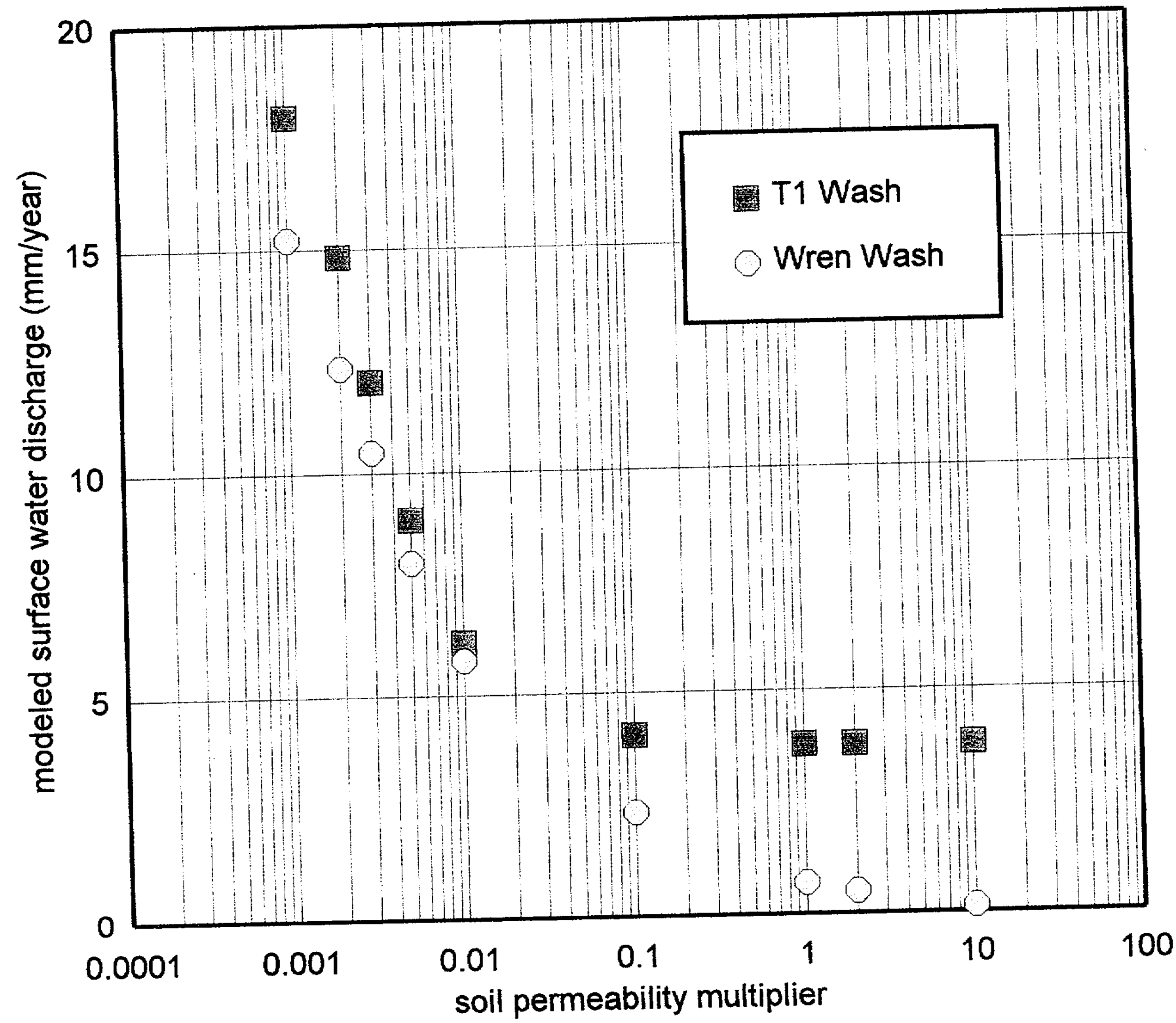


Figure 27. Variability of surface water discharge as a function of soil permeability

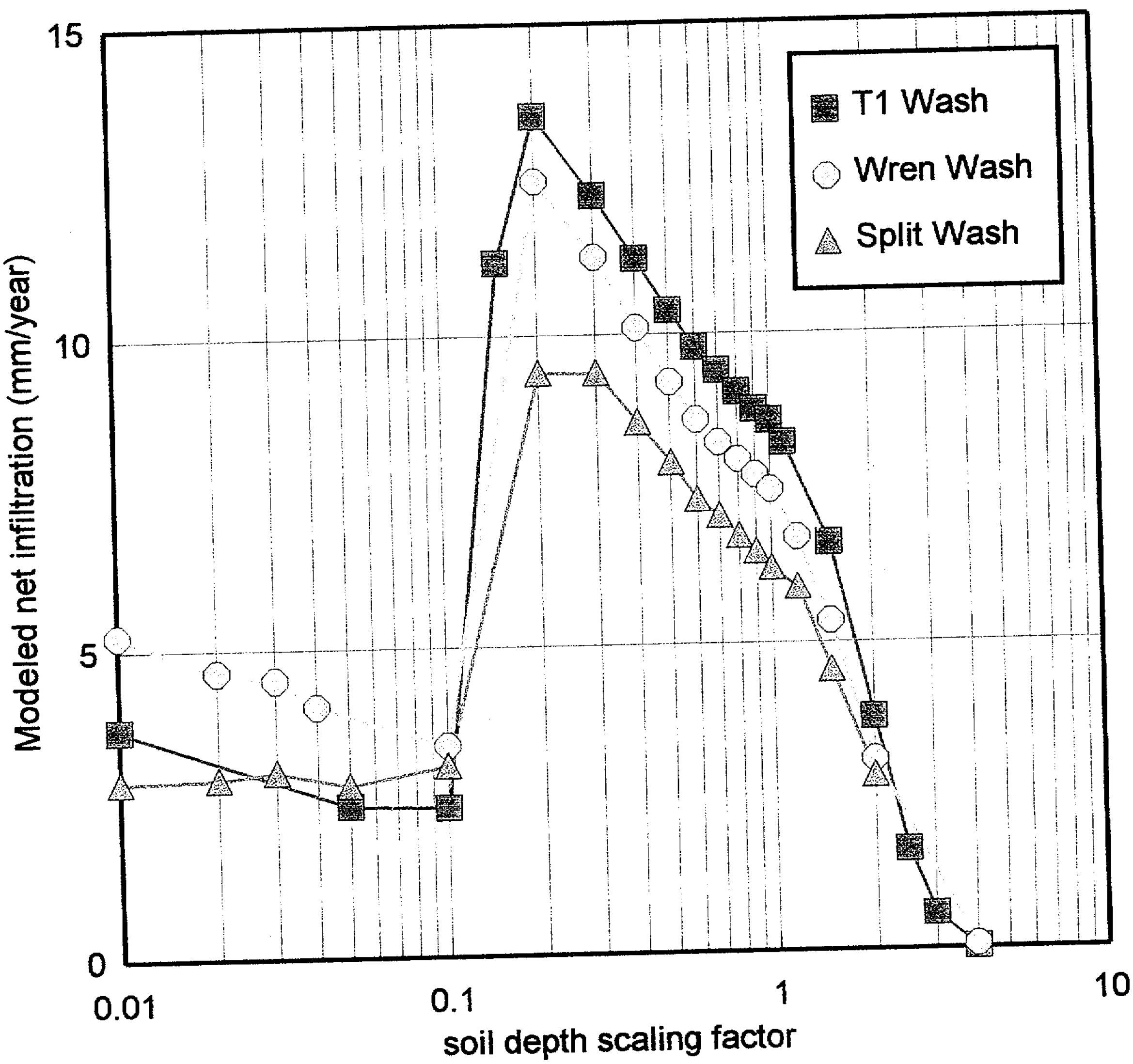


Figure 28. Variability of net infiltration as a function of soil depth

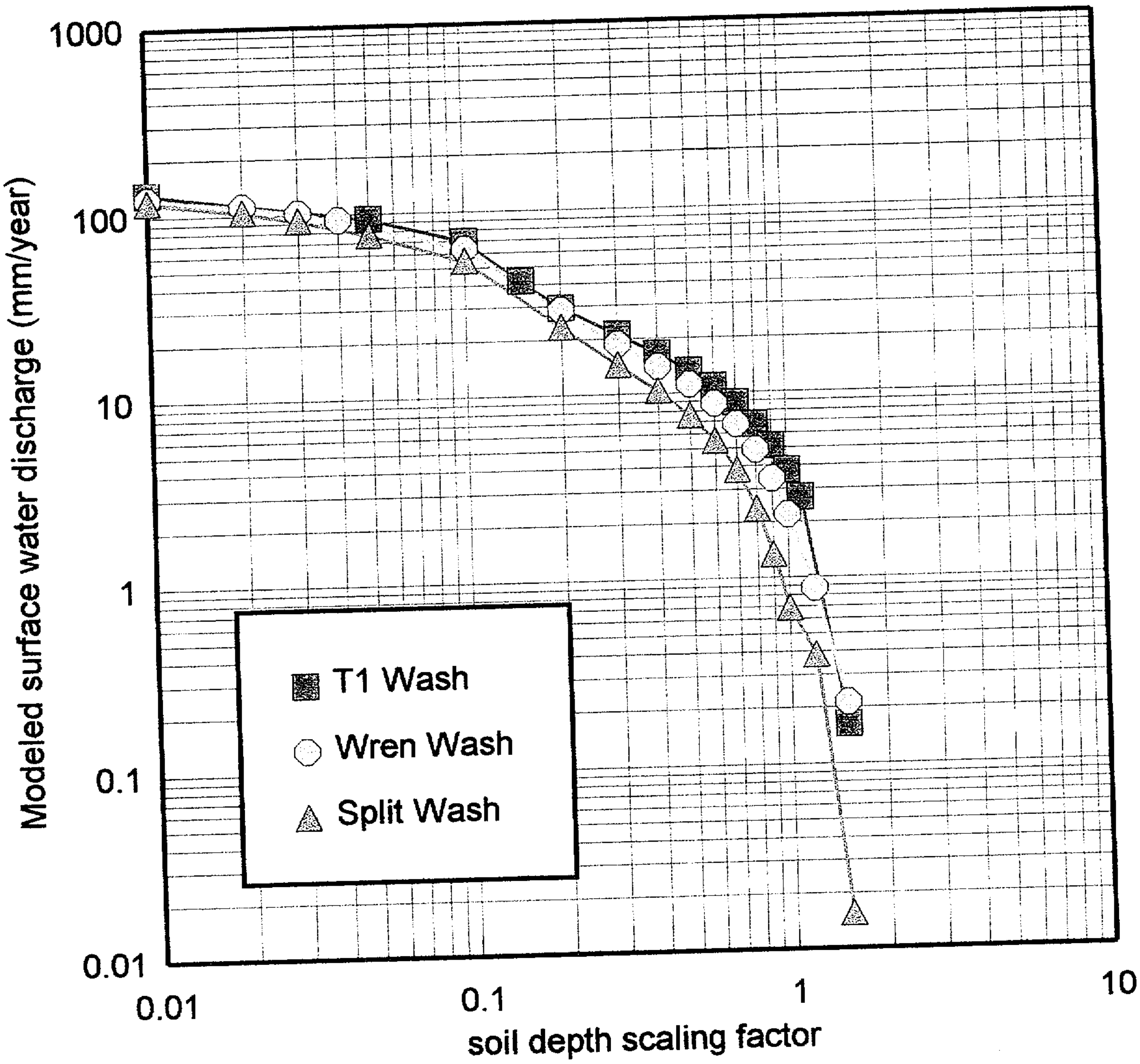


Figure 29. Variability of surface water discharge as a function of soil depth

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

LAS VEGAS OFFICE
U.S. NRC On-Site Reps.
P.O. Box 371048
Las Vegas, NV 89137-1048

Fax: (702) 794-5051

Verify: 794-5047 - Bill Belke
794-5046 - Chad Glenn
794-5053 - Vivian

Name: Neil Coleman

Organization: NRC

Fax: 301-415-5399

Phone:

From:

Date:

Subject:

Pages: 2

Total number of pages, including cover sheet

Comments:

FYI – Survey info for Nye Co. wells

3/17/99

QA:L

M&O FIELD SURVEY DEPARTMENT, YMP
SURVEY OF NYE COUNTY EWDP BOREHOLES

A Global Positioning System (GPS) survey of the location of 9 Nye County Early Warning Drilling Program (EWDP) boreholes was performed on March 8th & 10th, 1999. The M&O procedure for this work is NWI-ESF-008Q. Tabulated below are the location values obtained by this survey.

LATITUDE/LONGITUDE DATUM IS NAD-83, ELEVATION NGVD-29:

BOREHOLE ID	LATITUDE	LONGITUDE	CASING ELEVATION	GROUND/PAD ELEVATION
NC-EWDP-01D	NOT FOUND			
NC-EWDP-01DX	36°42'33.526"N	116°35'18.003"W	803.84m	803.23m
NC-EWDP-01S	36°42'33.385"N	116°35'17.880"W	803.95m	803.26m
NC-EWDP-02D	36°39'38.521"N	116°27'56.834"W	801.21m	801.21m
NC-EWDP-03D	36°40'53.597"N	116°32'17.049"W	799.15m	798.33m
NC-EWDP-03S	36°40'53.614"N	116°32'17.180"W	798.74m	798.28m
NC-EWDP-05S	36°40'11.529"N	116°22'37.071"W	839.90m	839.35m
NC-EWDP-09S	36°41'44.613"N	116°33'46.723"W	N/A (STAKE)	797.31m
NC-EWDP-09SX	36°41'44.566"N	116°33'46.769"W	798.00m	797.31m
NC-WASHBURN 1X	36°39'50.772"N	116°25'26.835"W	824.13m	823.48m

---

NORTHING/EASTING DATUM IS NAD-27, ELEVATION NGVD-29:

BOREHOLE ID	NORTHING	EASTING	CASING ELEVATION	GROUND/PAD ELEVATION
NC-EWDP-01D	NOT FOUND			
NC-EWDP-01DX	N 713,168.75	E 523,221.16	2637.26'	2635.24'
NC-EWDP-01S	N 713,154.47	E 523,231.17	2637.64'	2635.37'
NC-EWDP-02D	N 695,524.31	E 559,178.31	2628.65'	2628.65
NC-EWDP-03D	N 703,079.66	E 537,968.09	2621.89'	2619.19
NC-EWDP-03S	N 703,081.33	E 537,957.36	2620.53'	2619.03'
NC-EWDP-05S	N 698,929.01	E 585,219.64	2755.58'	2753.78'
NC-EWDP-09S	N 708,229.72	E 530,658.53	N/A (STAKE)	2615.85'
NC-EWDP-09SX	N 708,224.85	E 530,654.85	2618.11'	2615.86'
NC-WASHBURN 1X	N696,791.48	E 571,395.78	2703.84'	2701.69'