U.S. DEPARTMENT OF ENERGY
OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT

# PRESENTATION TO THE NUCLEAR WASTE TECHNICAL REVIEW BOARD

## SUBJECT: CHARACTERIZATION OF INFILTRATION

**PRESENTER:** DR. ALAN FLINT

**PRESENTER'S TITLE AND ORGANIZATION:** HYDROLOGIST
U.S. GEOLOGICAL SURVEY
MERCURY, NEVADA

**PRESENTER'S TELEPHONE NUMBER:** (702) 295-5805

REGISTRY HOTEL, DENVER, COLORADO
JUNE 25-27, 1991

# PURPOSE

- TO COLLECT NECESSARY INFORMATION TO DETERMINE THE CHARACTER OF THE UPPER BOUNDARY CONDITIONS FOR WATER FLUX AT YUCCA MOUNTAIN, BOTH PHYSICAL AND STATE HYDROLOGIC VARIABLES, WITH ENOUGH RESOLUTION FOR ADEQUATE USE OF HYDROLOGIC MODELS

# OBJECTIVES

- o TO CHARACTERIZE INFILTRATION RELATED HYDROLOGIC PROPERTIES AND CONDITIONS OF THE SURFICIAL SOILS AND ROCKS COVERING YUCCA MOUNTAIN

- o TO CHARACTERIZE THE PRESENT DAY INFILTRATION PROCESSES AND NET INFILTRATION RATE IN SURFICIAL SOILS AND ROCKS COVERING YUCCA MOUNTAIN

- o TO CHARACTERIZE INFILTRATION PROCESSES UNDER SIMULATED WETTER CONDITIONS IN THE SURFICIAL SOILS AND ROCKS COVERING YUCCA MOUNTAIN

REVIEW OF NWTRB MEETING - DECEMBER 11$^{TH}$, 1989, DENVER

- OUTLINE
- CONCEPTUAL MODEL

CHARACTERIZATION OF SURFICIAL MATERIALS

- OVERVIEW OF THE YUCCA MOUNTAIN AREA
- CURRENT AND FUTURE WORK

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- REGIONAL ESTIMATE OF RECHARGE
- LOCAL ESTIMATE OF RECHARGE
- PAGANY WASH STUDY

CHARACTERIZATION OF ARTIFICIAL INFILTRATION

- ARTIFICIAL INFILTRATION CONTROL PLOT STUDIES

VARIABLE INFILTRATION INPUT TO PA/SITE MODEL

- HOURLY TO THOUSAND YEAR EVENTS

SUMMARY

# CHARACTERIZATION OF UNSATURATED ZONE INFILTRATION

## METHODS

- CHARACTERIZATION OF SURFICIAL MATERIALS
  - PHYSICAL AND HYDROLOGIC PROPERTIES
  - SURFACE AND BOREHOLE GEOPHYSICS
  - MAPPING (GIS)

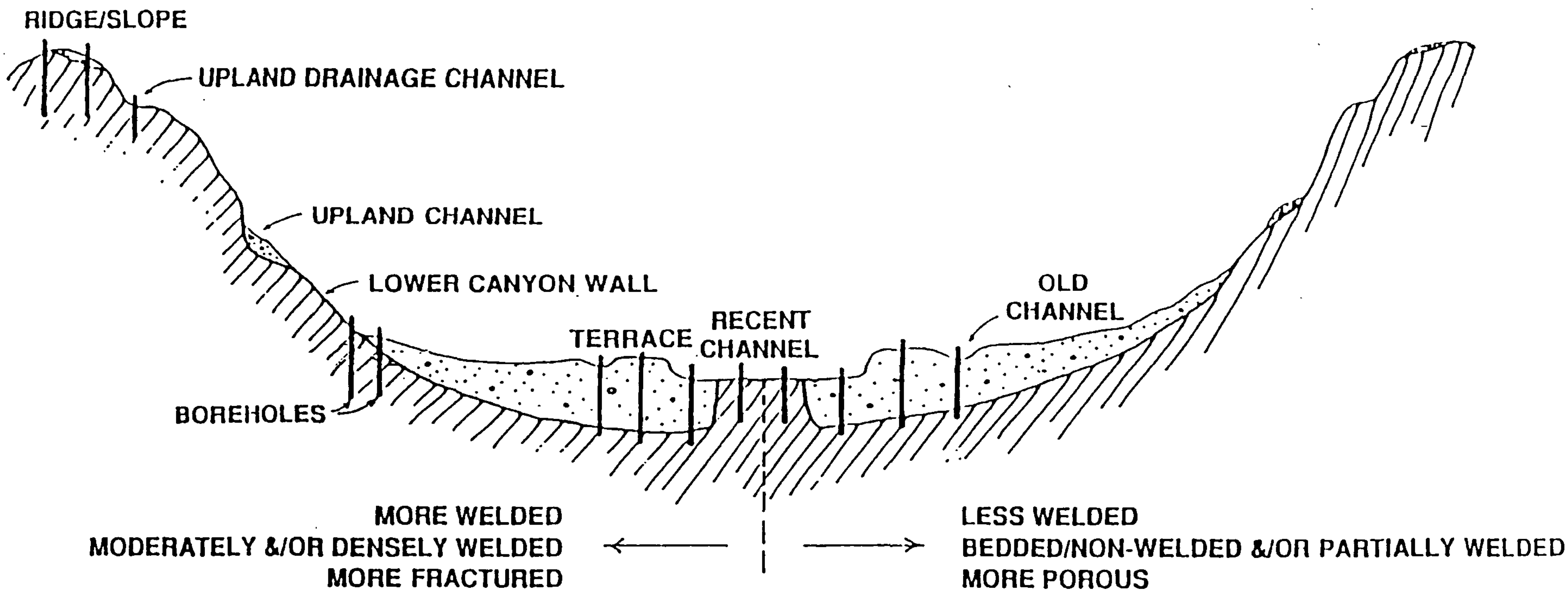
- CHARACTERIZATION OF NATURAL INFILTRATION
  - PRECIPITATION
  - EVAPOTRANSPIRATION
  - NEUTRON LOGGING
  - GEOCHEMISTRY
    * TRITIUM
    * DEL $^{18}O$/DEL $^{2}H$
    * $^{14}C$, PMC

- CHARACTERIZATION OF ARTIFICIAL INFILTRATION
  - INFILTROMETER STUDY
  - SMALL PLOT RAINFALL SIMULATION
  - LARGE PLOT RAINFALL SIMULATION
  - PONDING

**"A SENSIBLE PHILOSOPHY CONTROLLED BY A RELEVANT SET OF CONCEPTS SAVES SO MUCH RESEARCH TIME THAT IT CAN NEARLY ACT AS A SUBSTITUTE FOR GENIUS."**

N. W. PIRIE, *CONCEPTS OUT OF CONTEXT*

# GENERALIZED TOPOGRAPHIC SETTINGS AND HYDROGEOLOGIC CONDITIONS



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**"I GET IT", SAID LEORA, "YOUR JOB WILL ONLY TAKE ABOUT 28 HOURS A DAY, THE REST OF THE TIME YOU'RE PERFECTLY WELCOME TO SPEND ON RESEARCH, UNLESS, OF COURSE, SOMEBODY INTERRUPTS YOU."**

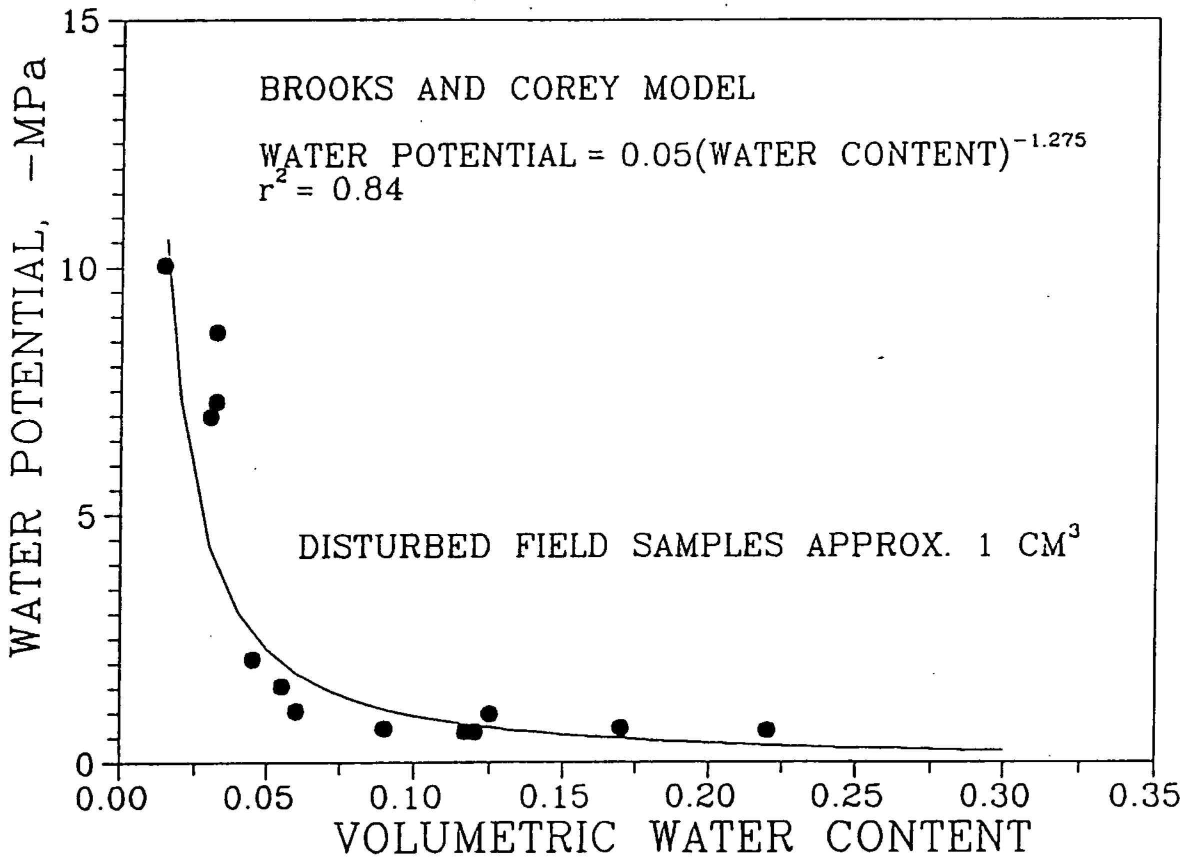
SINCLAIR LEWIS, *ARROWSMITH*

# INTRODUCTION OF COLOR MAP OF YUCCA MOUNTAIN

| SOIL PHYSICAL PROPERTIES[1] | MEAN | STD DEV | CV (%) |
|---|---|---|---|
| Cobbles (%) >75mm | 15.3 | 8.29 | 54.5 |
| Clay (%) | 13.2 | 4.66 | 35.4 |
| Silt (%) | 26.1 | 5.18 | 19.9 |
| Sand (%) | 60.8 | 5.38 | 8.9 |
| BULK DENSITY ($g/cm^3$) | | | |
| Fine soil <2mm | 1.24 | 0.086 | 7.0 |
| Total soil | 1.56 | 0.087 | 5.6 |
| K sat (cm/s)[2] | $5.7*10^{-4}$ | $2.2*10^{-5}$ | 3.8 |

[1] From Schmidt, M.R., A.L. Flint, and K. Kolm (199X)
[2] Estimate based on Campbell (1985)

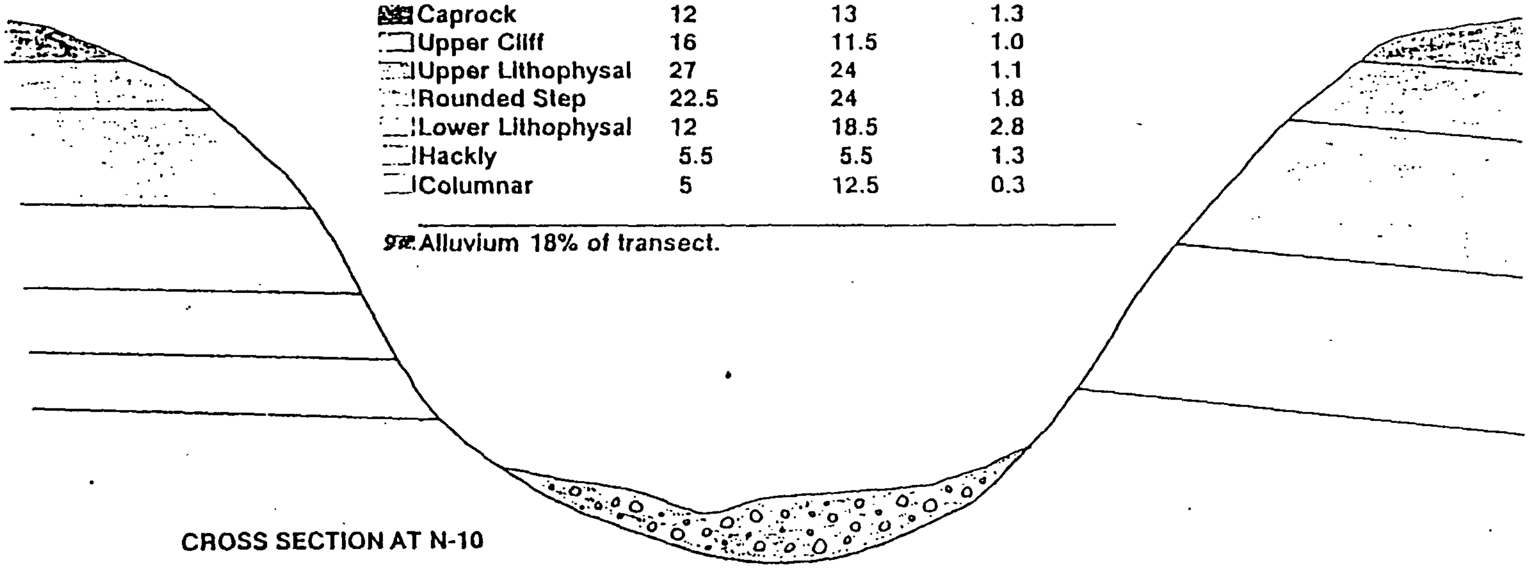
# MOISTURE RETENTION OF ALLUVIUM USING THERMOCOUPLE PSYCHROMETRY



## PAGANY WASH TRANSECT

| UNIT | % OF UNIT IN TRANSECT | % OF UNIT EXPOSED | FRACTURE DENSITY (F/m) |
|---|---|---|---|
| Caprock | 12 | 13 | 1.3 |
| Upper Cliff | 16 | 11.5 | 1.0 |
| Upper Lithophysal | 27 | 24 | 1.1 |
| Rounded Step | 22.5 | 24 | 1.8 |
| Lower Lithophysal | 12 | 18.5 | 2.8 |
| Hackly | 5.5 | 5.5 | 1.3 |
| Columnar | 5 | 12.5 | 0.3 |

Alluvium 18% of transect.



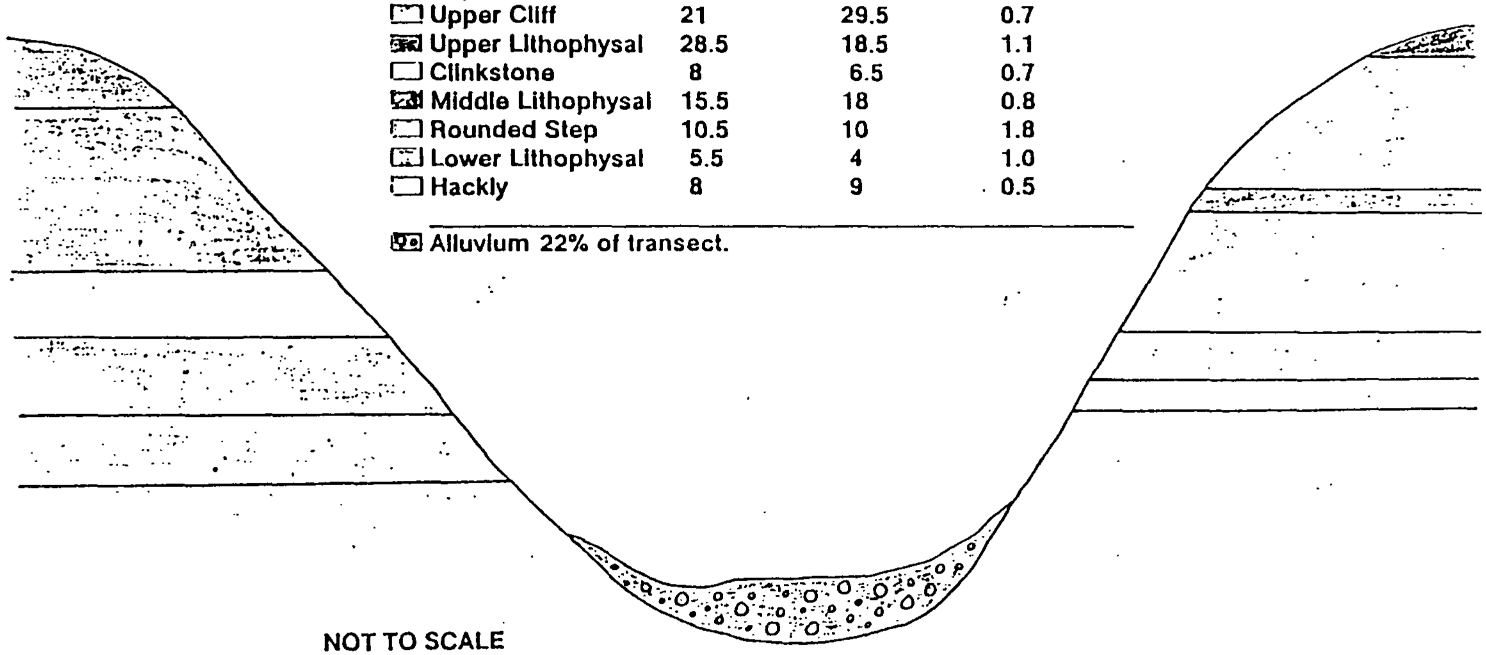
CROSS SECTION AT N-10

NOT TO SCALE

## SPLIT WASH TRANSECT

| UNIT | % OF UNIT IN TRANSECT | % OF UNIT EXPOSED | FRACTURE DENSITY (F/m) |
|---|---|---|---|
| Caprock | 3 | 4.5 | 0.1 |
| Upper Cliff | 21 | 29.5 | 0.7 |
| Upper Lithophysal | 28.5 | 18.5 | 1.1 |
| Clinkstone | 8 | 6.5 | 0.7 |
| Middle Lithophysal | 15.5 | 18 | 0.8 |
| Rounded Step | 10.5 | 10 | 1.8 |
| Lower Lithophysal | 5.5 | 4 | 1.0 |
| Hackly | 8 | 9 | 0.5 |

Alluvium 22% of transect.



| Geologic Map Unit | Welding | DRILL HOLE WASH WATERSHED (41 km²) % of Area | % Exposed Bedrock | % of Area Exposed Bedrock | Fracture Density (Fx/m) | SURFACE ABOVE REPOSITORY BLOCK (6 km²) % of Area | % Exposed Bedrock | % of Area Exposed Bedrock | Fracture Density (Fx/m) |
|---|---|---|---|---|---|---|---|---|---|
| Paintbrush Tuff | | | | | | | | | |
| Tiva Canyon Member | | | | | | | | | |
| Caprock | M | 11.3 | 23.8 | 2.7 | 1.0 | 7.8 | 8.7 | 0.7 | 0.2 |
| Upper Cliff | M | 4.2 | 8.2 | 0.3 | 0.7 | 8.6 | 9.6 | 0.8 | 0.6 |
| Upper Lithophysal | D | 13.4 | 26.9 | 3.6 | 0.8 | 31.1 | 35.0 | 10.9 | 0.9 |
| Clinkstone | D | 4.1 | 8.2 | 0.3 | 1.6 | 14.7 | 16.6 | 2.4 | 1.7 |
| Rounded Step | D | 4.5 | 8.9 | 0.4 | 2.0 | 13.0 | 14.6 | 1.9 | 2.1 |
| Lower Lithophysal | D | 3.0 | 6.0 | 0.2 | 1.9 | 9.4 | 10.5 | 1.0 | 0.5 |
| Hackly | D | 2.9 | 5.7 | 0.2 | 1.7 | 0.5 | 0.6 | <0.1 | 0.9 |
| Columnar | D | 1.7 | 3.2 | 0.1 | 0.5 | 0.8 | 0.9 | <0.1 | --- |
| Yucca Mountain Member | N-M | 1.6 | 3.0 | <0.1 | --- | --- | --- | --- | --- |
| Pah Canyon Member | N-M | 1.0 | 1.8 | <0.1 | --- | 1.0 | 1.2 | <0.1 | --- |
| Topopah Spring Member | | | | | | | | | |
| Undifferentiated | N | 0.4 | 0.7 | <0.1 | --- | 0.3 | 0.3 | <0.1 | --- |
| Caprock | M | 0.1 | 0.1 | <0.1 | --- | 0.3 | 0.3 | <0.1 | --- |
| Bedded/Reworked Tuffs | N | 1.7 | 3.5 | 0.1 | --- | 1.6 | 1.7 | <0.1 | --- |
| Alluvium/Colluvium | --- | 50.1 | --- | 0 | --- | 10.9 | --- | 0 | --- |
| Total Bedrock | | 49.9 | | | | 89.1 | | | |
| Total Exposed Bedrock | | | | 8.0 | | | | 17.7 | |

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SUMMARY

# CURRENT AND FUTURE WORK

- o SAMPLING, TEST AND MAPPING OF PHYSICAL AND HYDROLOGIC PROPERTIES (CURRENT WORK)
  - ALLUVIUM
  - SOIL COVER
  - SURFACE AND SUBSURFACE BEDROCK

- o ESTIMATE OF SURFICIAL UNITS FOR 3–D HYDROLOGIC FLOW MODEL (CURRENT WORK)

- o VERTICAL VARIABILITY (CURRENT AND FUTURE WORK)
  - INVERSE MODELING FOR HYDROLOGIC PROPERTIES (CURRENT WORK)
  - MEASUREMENTS FROM NEUTRON HOLE CORES (FUTURE WORK)

- o SOIL THICKNESS MAP (CURRENT AND FUTURE WORK)
  - BOREHOLE CONTACTS (CURRENT WORK)
  - SURFACE GEOPHYSICS (FUTURE WORK)

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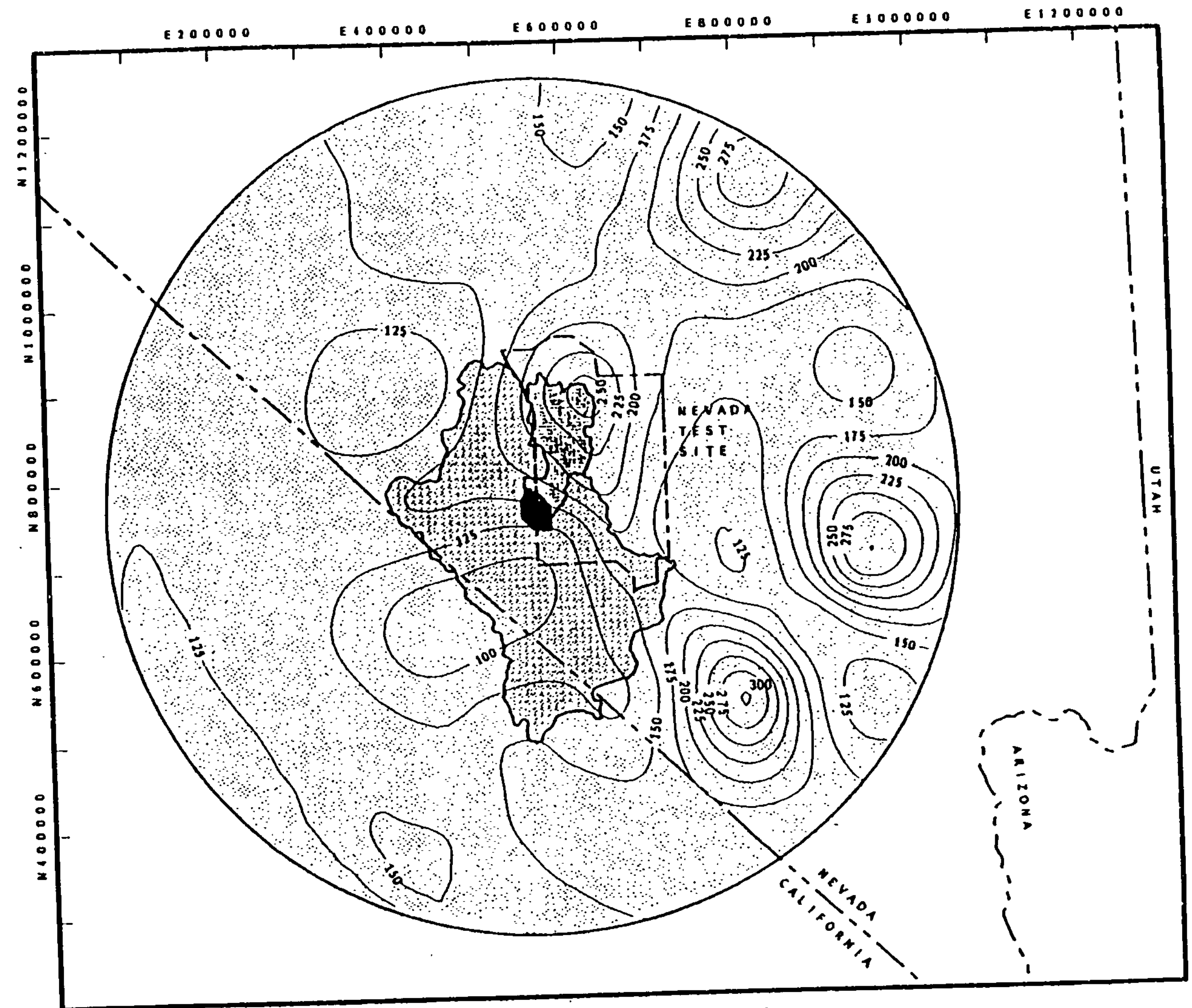
# KRIGED PRECIPITATION ESTIMATE FOR SOUTHERN NEVADA




EXPLANATION

Study Area 1

Study Area 2, Fortymile Canyon Watershed

Study Area 3, Upper Amargosa River Watershed

Study Area 4, 150 km Radius

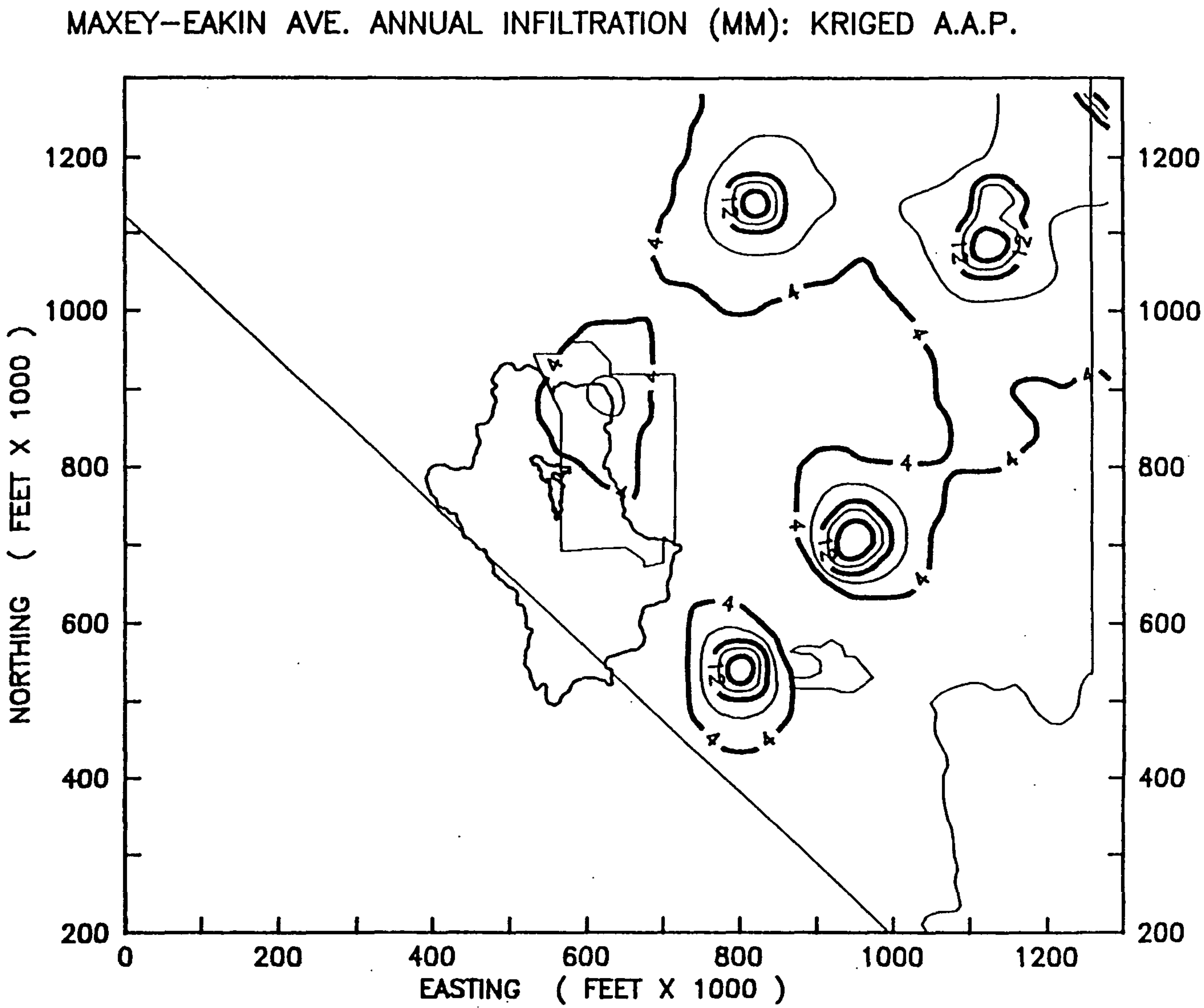
ISOHYETS ARE IN MILLIMETERS

N

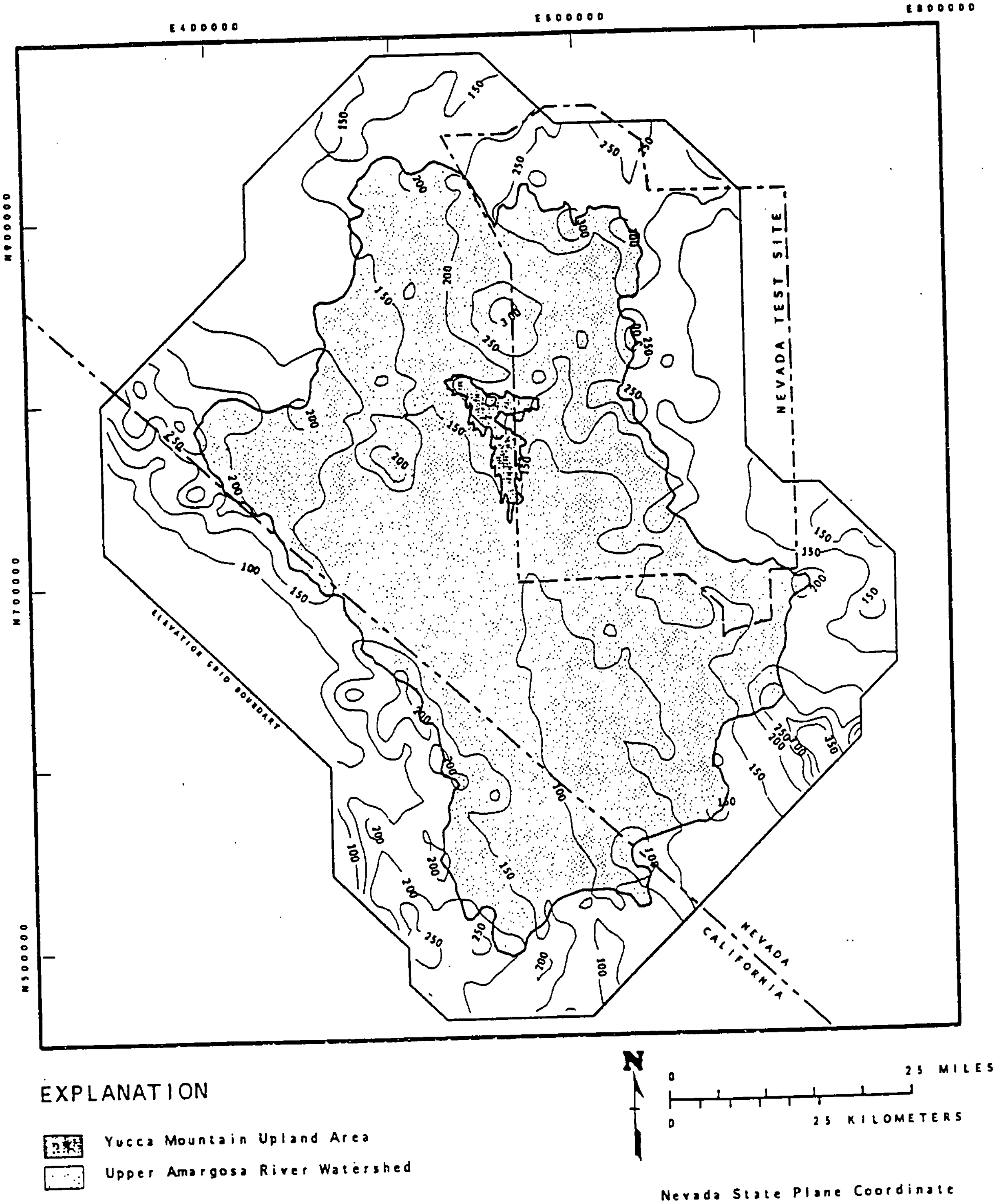
0 50 MILES

0 50 KILOMETERS

Nevada State Plane Coordinate System, Central Zone


MAXEY–EAKIN AVE. ANNUAL INFILTRATION (MM): KRIGED A.A.P.
NORTHING ( FEET X 1000 )
EASTING ( FEET X 1000 )
0
200
400
600
800
1000
1200
4
12

# COKRIGED PRECIPITATION ESTIMATE FOR THE UPPER AMARGOSA RIVER WATERSHED




EXPLANATION

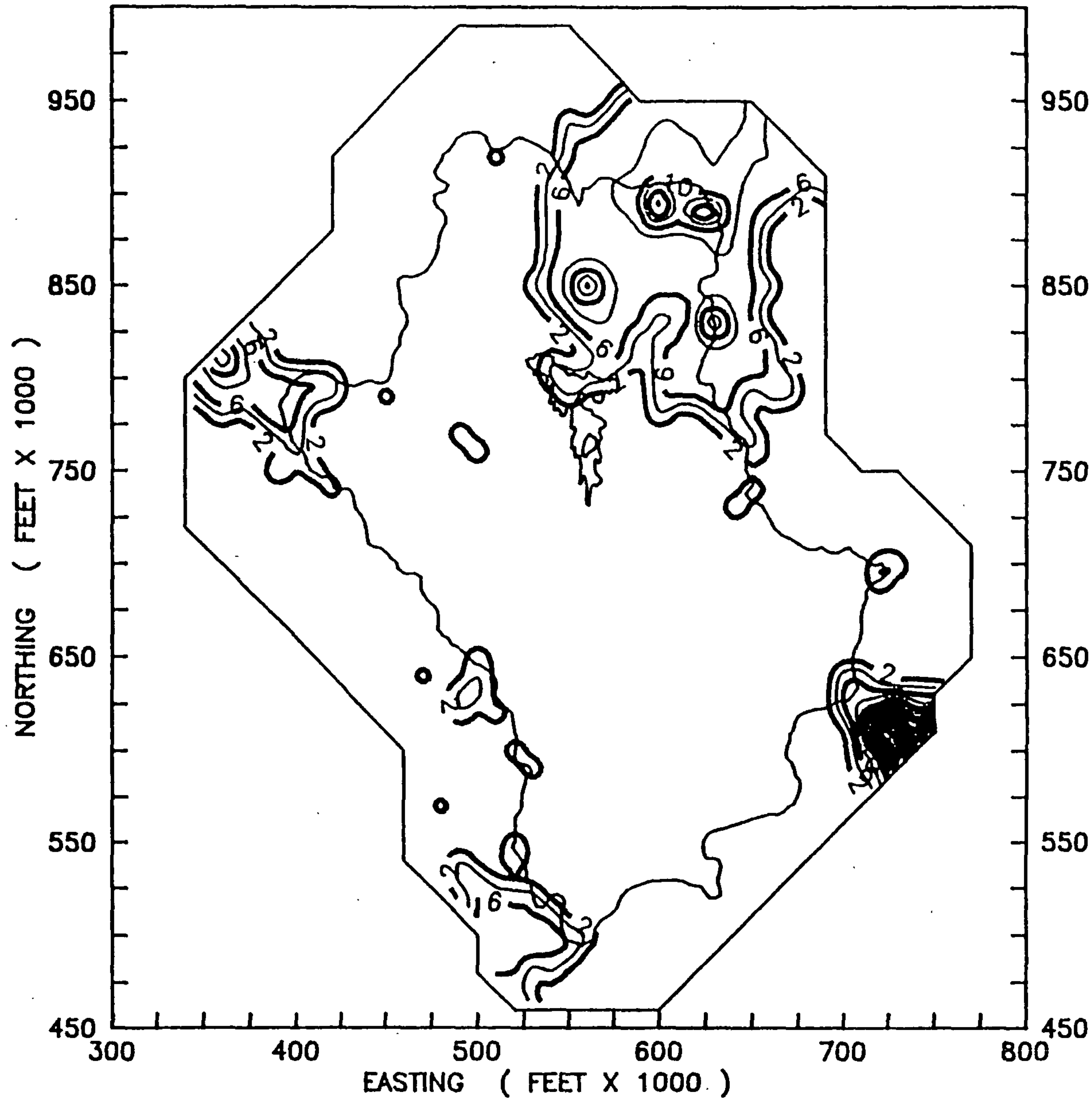
Yucca Mountain Upland Area

Upper Amargosa River Watershed

ISOHYETS ARE IN MILLIMETERS

Nevada State Plane Coordinate System, Central Zone

MAXEY–EAKIN AVERAGE ANNUAL INFILTRATION ( MM )



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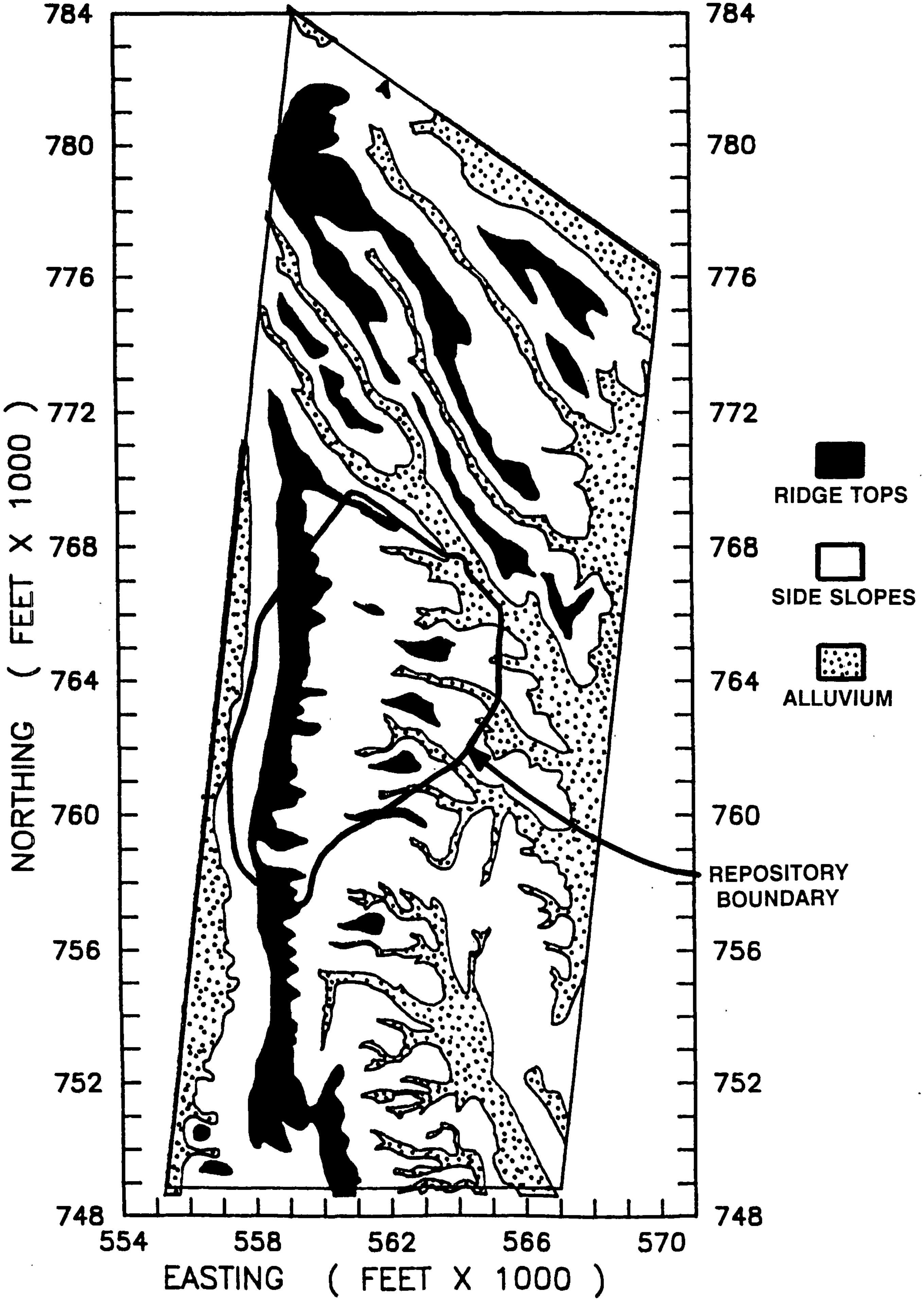
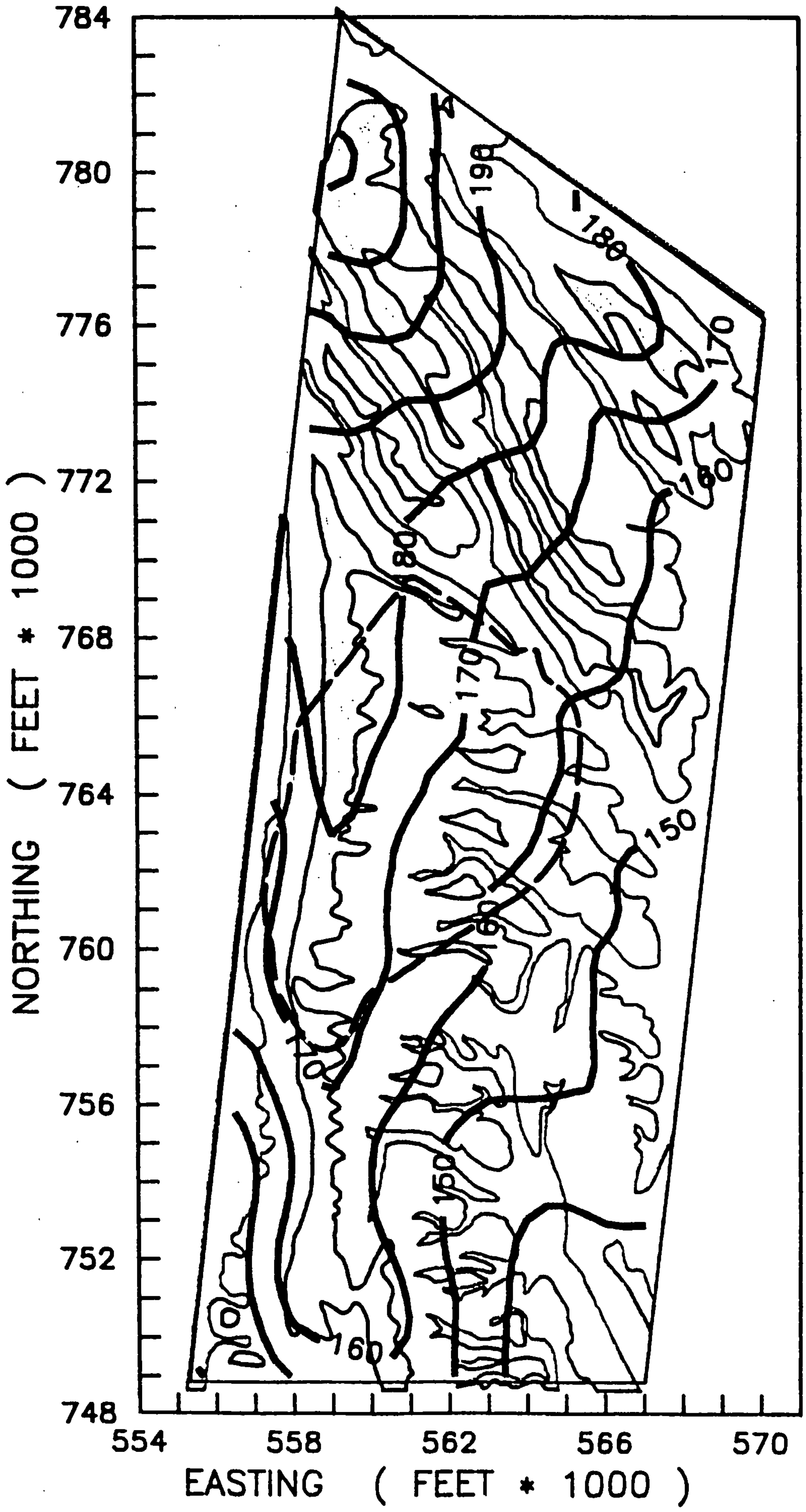
# 3D FLOW MODEL SURFICIAL BOUNDARIES



COKRIGED AVERAGE ANNUAL PRECIP ( MM )



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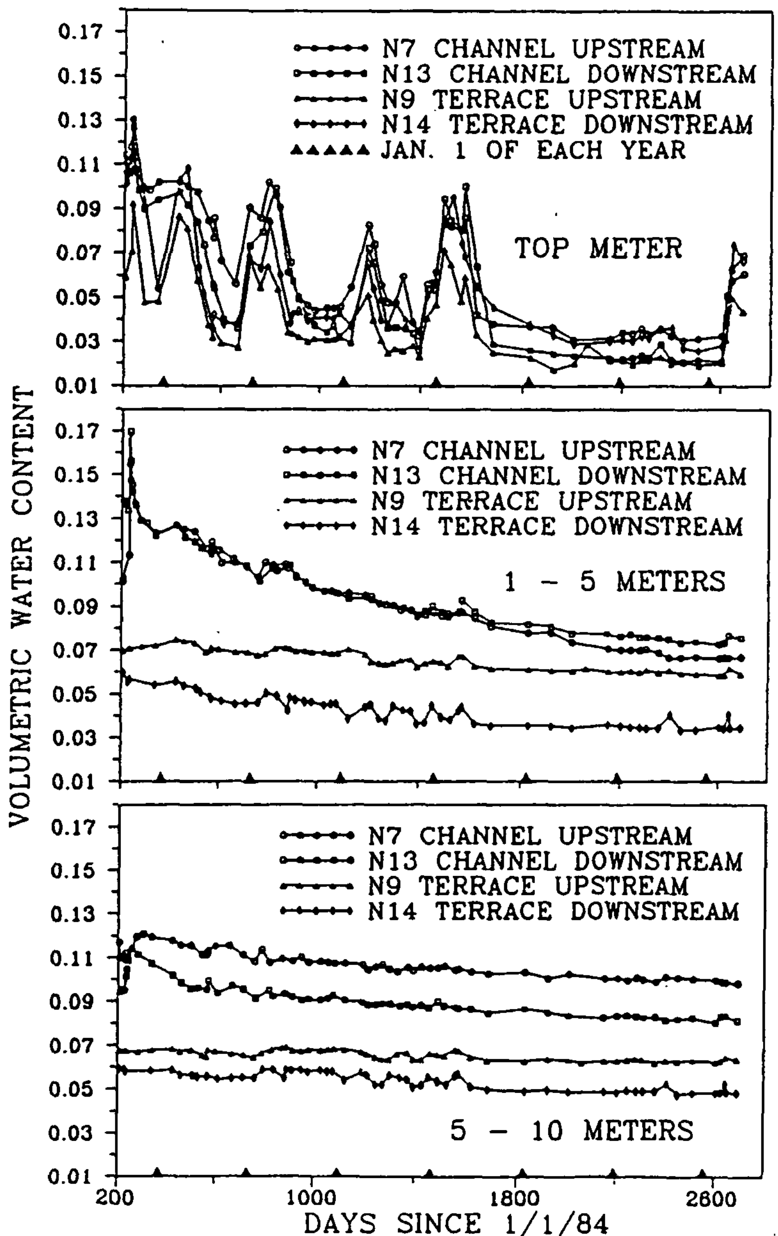
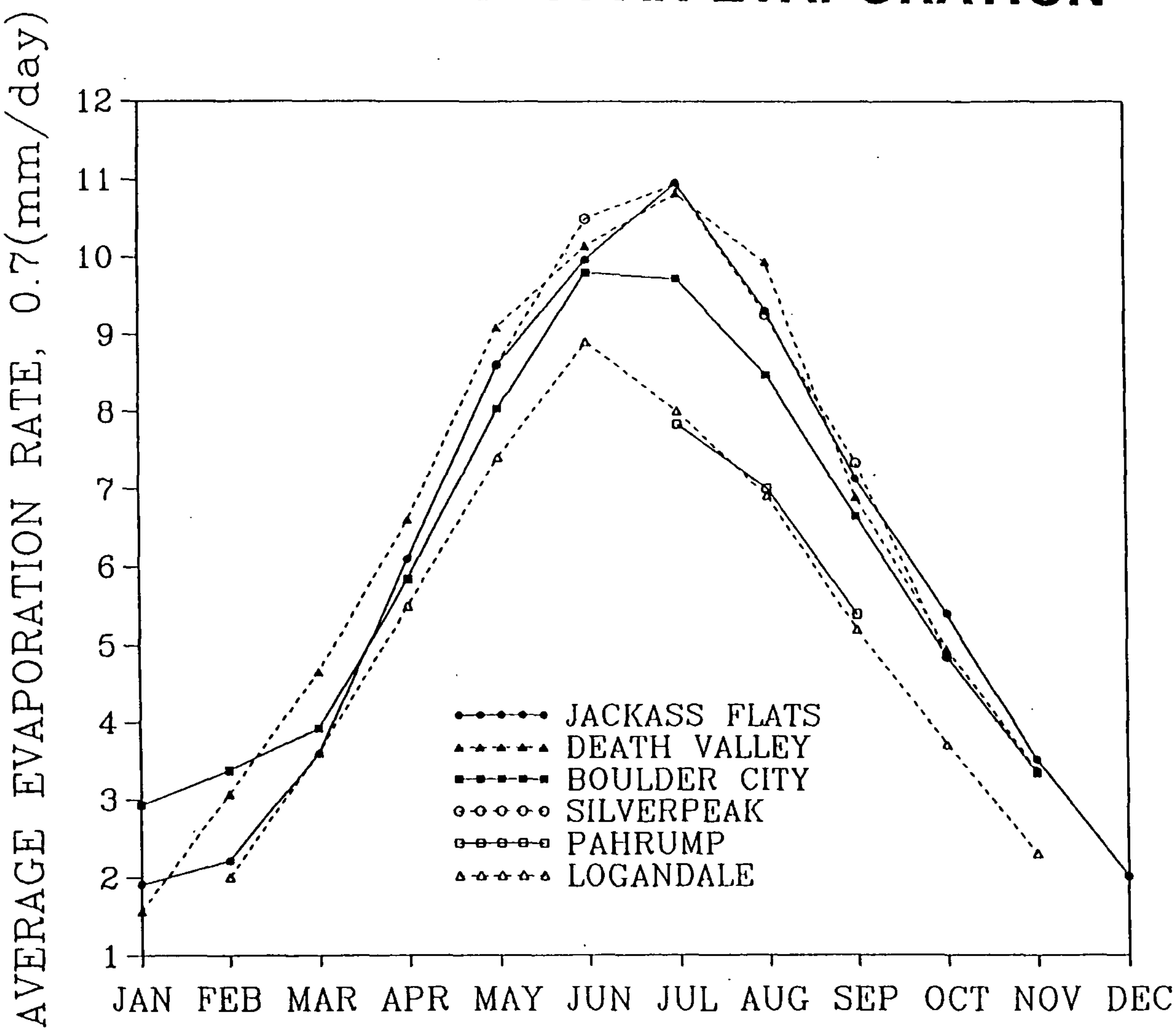
# PAGANY WASH NEUTRON HOLES



PHOTOGRAPH OF CLASS A EVAPORATION PAN

# 1990 CLASS A PAN EVAPORATION



## PHOTOGRAPH OF BOWEN RATIO EVAPOTRANSPIRATION STATION IN PAGANY WASH

**PHOTOGRAPHS OF VEGETATION IN DRILL HOLE WASH IN 1984 FOLLOWING SEVERAL WET YEARS, IN 1990 FOLLOWING 5 YEARS OF DROUGHT, AND IN 1991 FOLLOWING ONE WET SPRING**

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# PHOTOGRAPH OF TEST CELL "C" INFILTRATION TEST PLOT

# PHOTOGRAPH OF TOPOPAH WASH BOREHOLE INSTRUMENTATION

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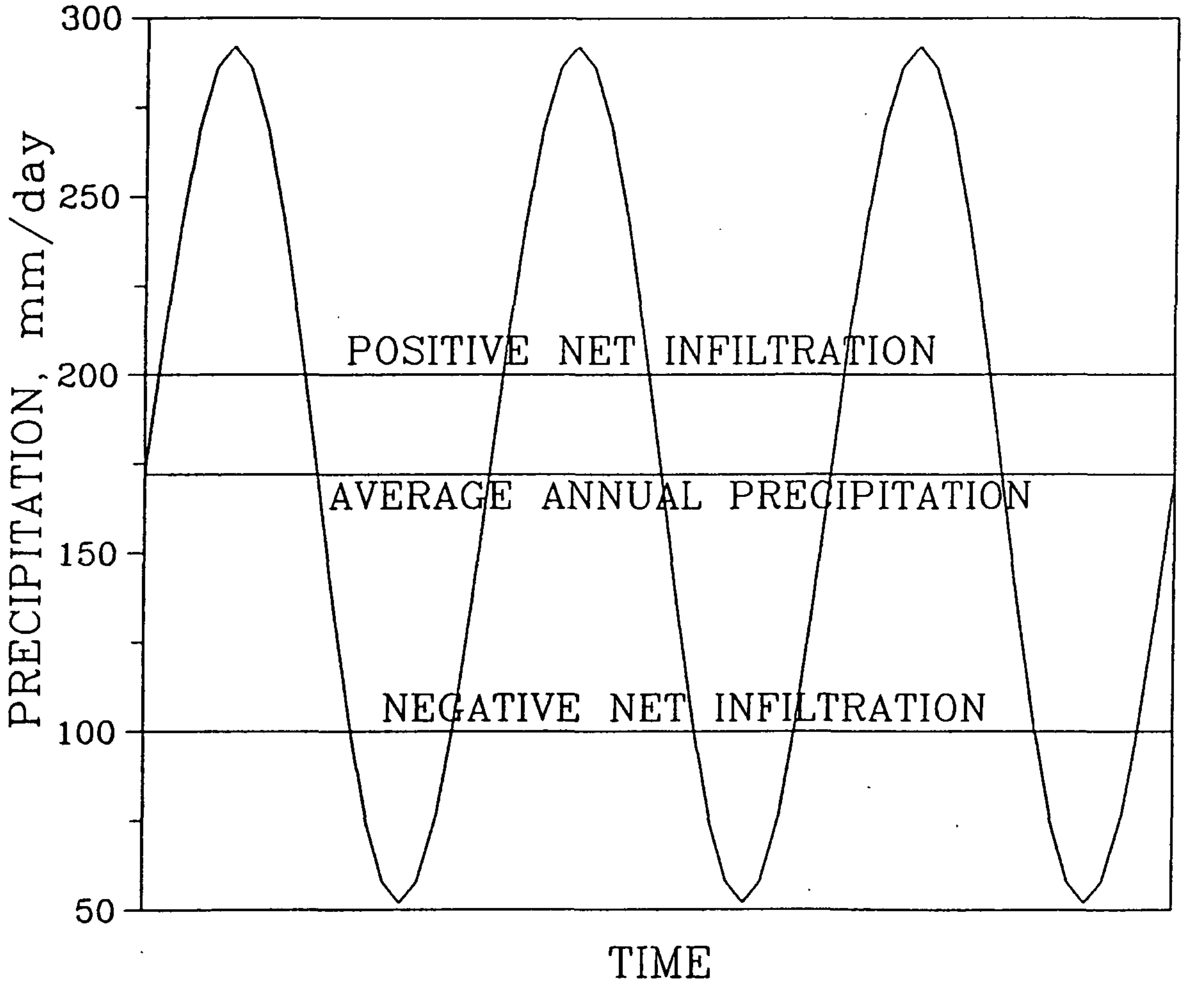
# CYCLES OF PRECIPITATION INPUT FOR NET INFILTRATION



# SUMMARY

- o CURRENT UNDERSTANDING OF PROCESSES IS REQUIRED

- o DEFINE CHARACTER OF UPPER FLUX BOUNDARY CONDITIONS

  - DEVELOP CONCEPTUAL MODEL AND ALTERNATIVES
  - DEVELOP SAMPLING AND MEASUREMENT SCHEME
  - COLLECT AND ANALYZE DATA
  - ITERATE

- o DESIGN MODELS FOR CURRENT AND FUTURE CLIMATIC CONDITIONS