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

PRESENTATION TO THE NUCLEAR WASTE TECHNICAL REVIEW BOARD

SUBJECT: REGIONAL SATURATED-ZONE STUDIES

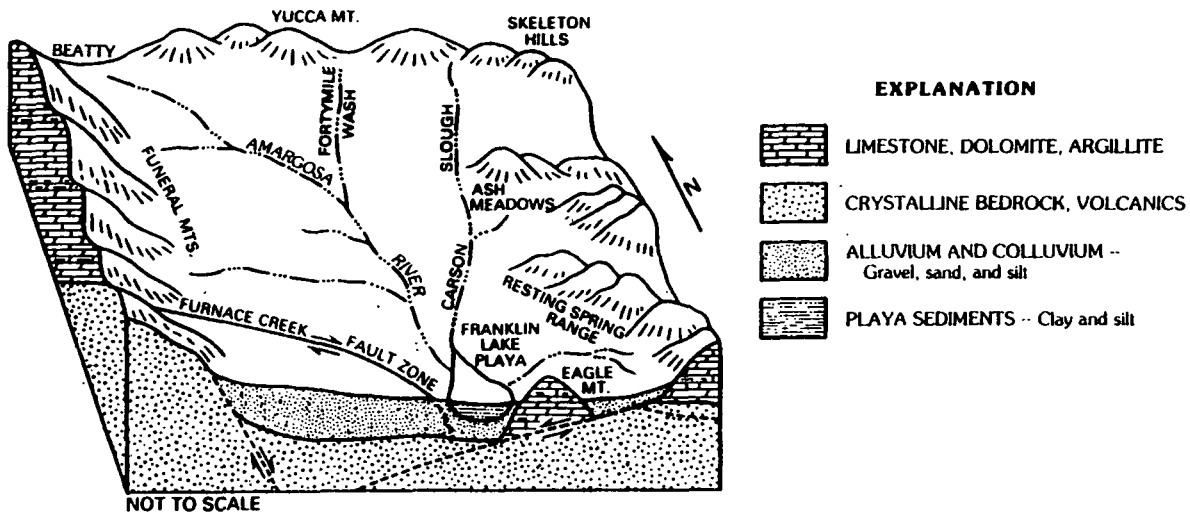
PRESENTER: DR. JOHN CZARNECKI

PRESENTER'S TITLE AND ORGANIZATION: CHIEF OF SATURATED-ZONE STUDIES
YUCCA MOUNTAIN PROJECT
U.S. GEOLOGICAL SURVEY
DENVER, COLORADO

PRESENTER'S TELEPHONE NUMBER: (303) 236-5176

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

GENERALIZED STRUCTURE AND LITHOLOGY IN THE STUDY AREA

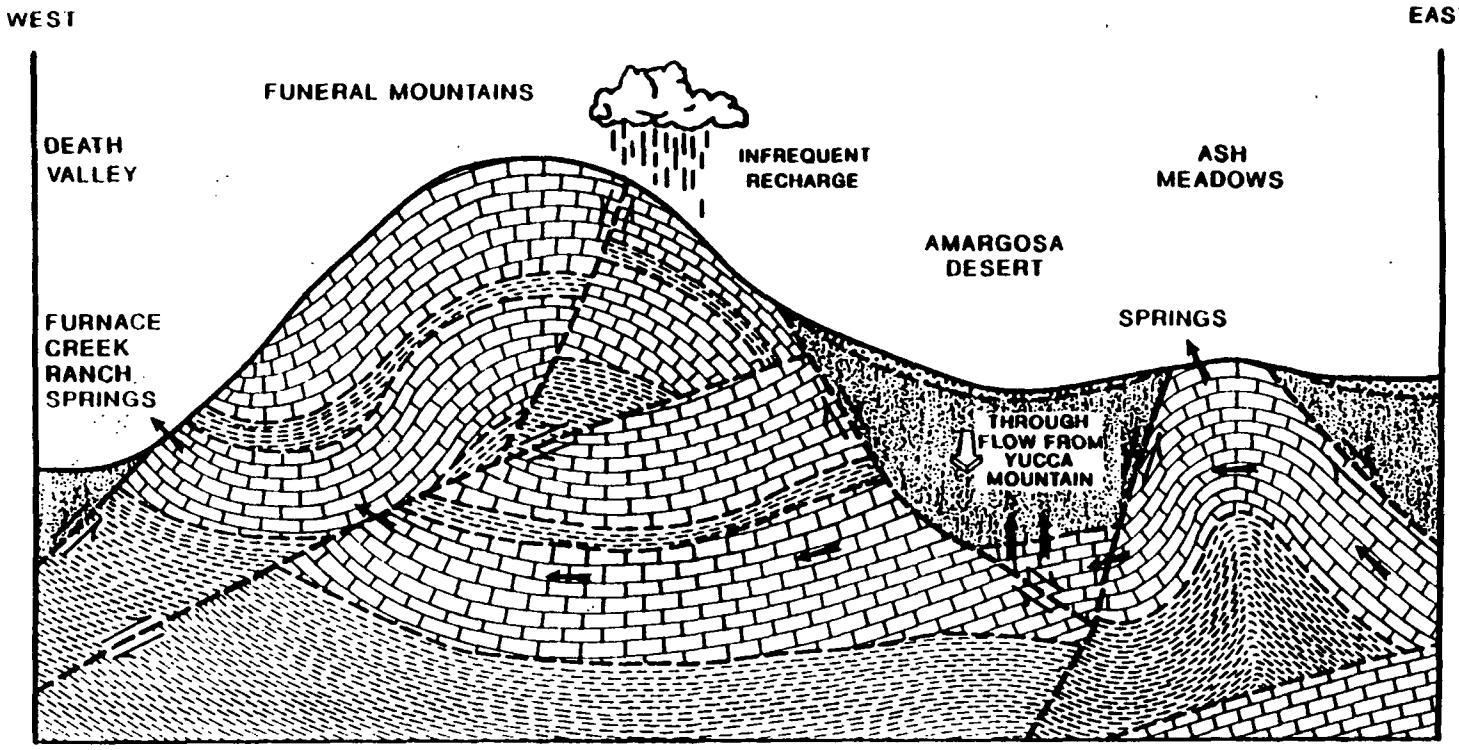


HGRZJC5P.125.NWTRB/6-25/27-91

Regional Saturated-Zone Overview

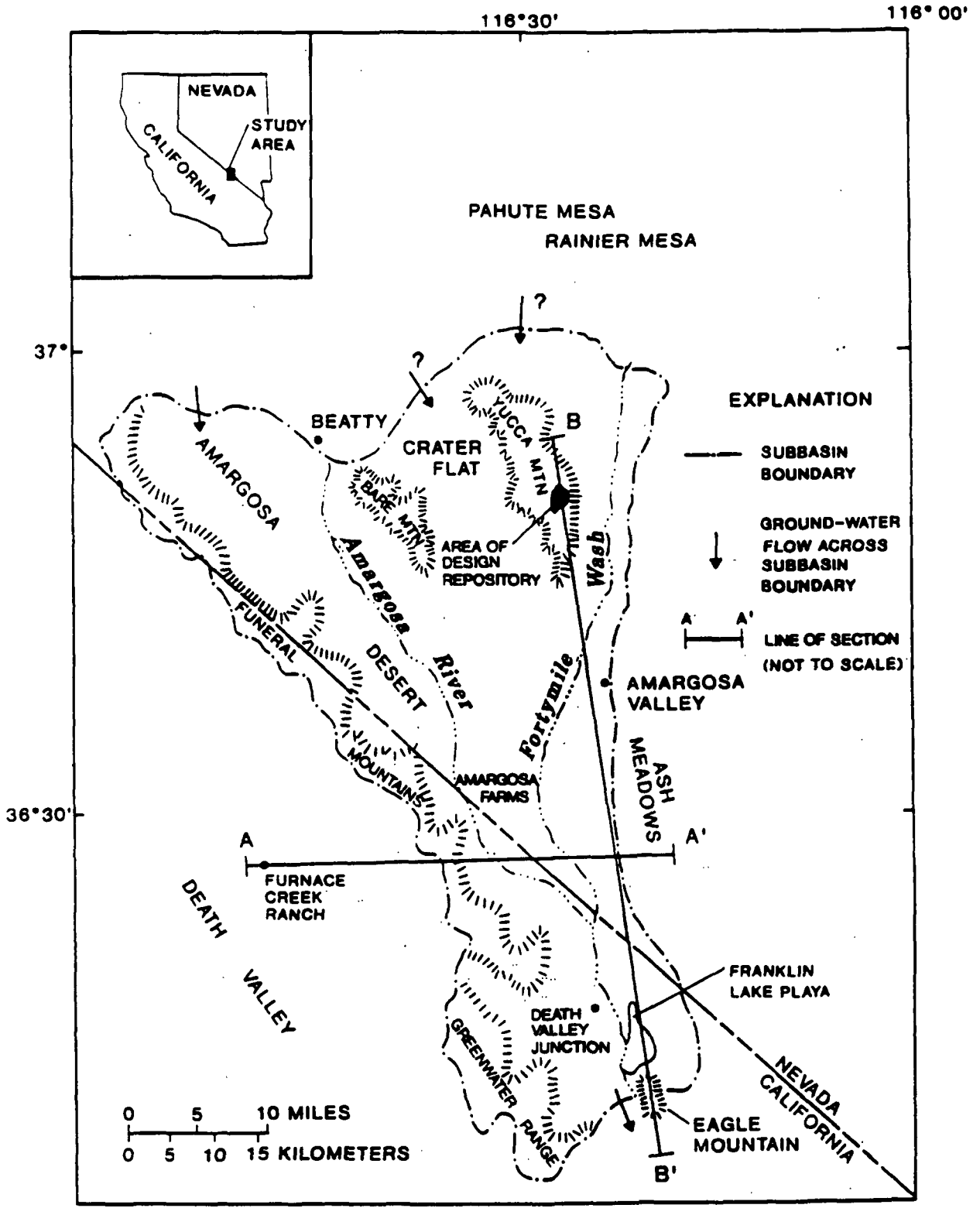
- Flow system geometry
- Potentiometric surface
- Ground-water flow
- Recharge
- Discharge

IDEALIZED GEOHYDROLOGIC SECTION FROM DEATH VALLEY TO ASH MEADOWS, SHOWING GENERAL DIRECTIONS OF GROUND-WATER FLOW

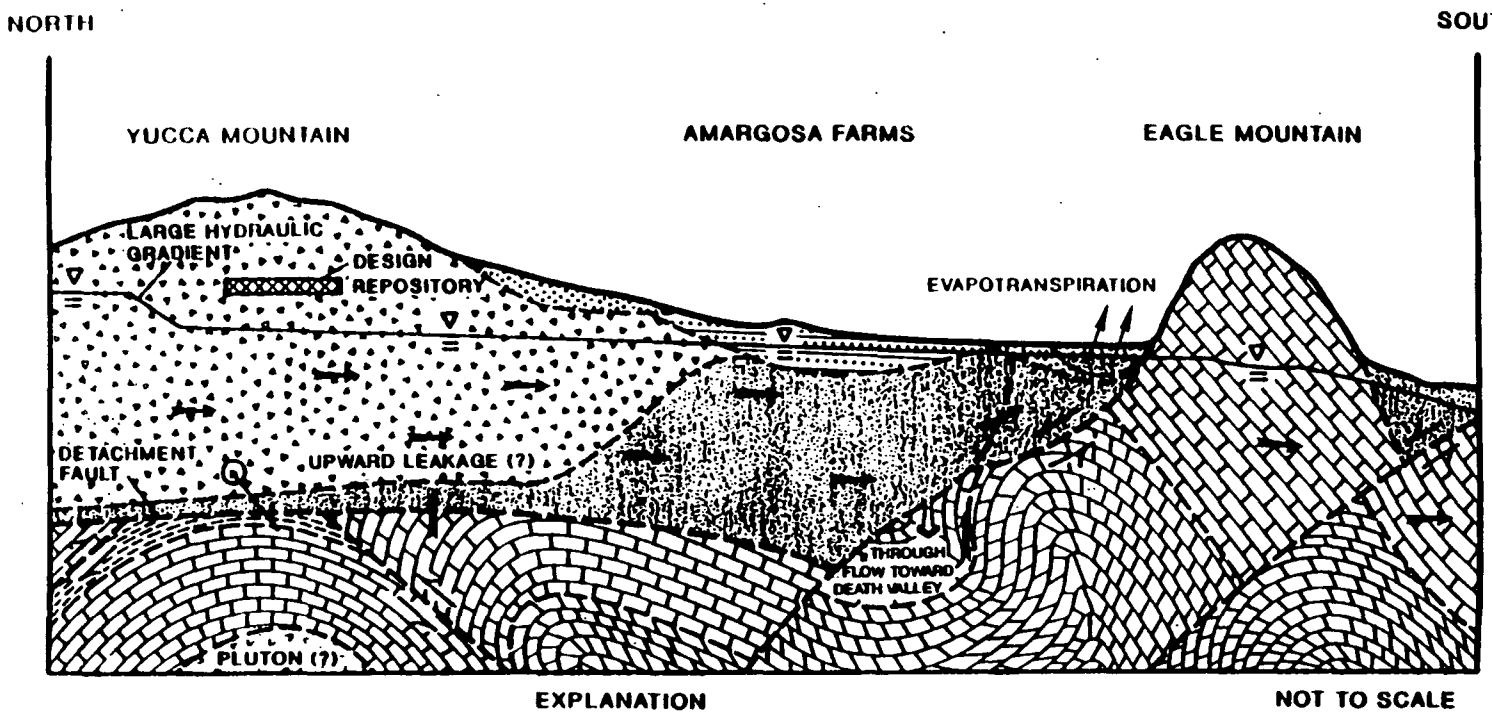


HGRZJC5P.125.NWTRB/6-25/27-91

LOCATION OF YUCCA MOUNTAIN AND GROUND-WATER STUDY AREA



IDEALIZED GEOHYDROLOGIC SECTION FROM YUCCA MOUNTAIN TO EAGLE MOUNTAIN, SHOWING GENERAL DIRECTIONS OF GROUND-WATER FLOW



EXPLANATION

NOT TO SCALE

- QUATERNARY SURFICIAL DEPOSITS
- PLAYA SEDIMENTS
- TERTIARY CARBONATE ROCKS
- TERTIARY VOLCANIC ROCKS
- UNDIFFERENTIATED TERTIARY SEDIMENTARY ROCKS
- UNDIFFERENTIATED PALEOZOIC CLASTIC ROCKS (UPPER CLASTIC AQUITARD)
- PALEOZOIC CARBONATE AQUIFER
- UNDIFFERENTIATED EARLY PALEOZOIC AND LATE PRECAMBRIAN ROCKS (LOWER CLASTIC AQUITARD)
- IGNEOUS INTRUSIVE ROCKS
- INFERRED CONTACT
- INFERRED FAULT
- GENERAL DIRECTION OF GROUND-WATER FLOW
- WATER TABLE
- DETACHMENT FAULT

(GEOLOGY COMPILED BY K. FOX, U.S. GEOLOGICAL SURVEY)

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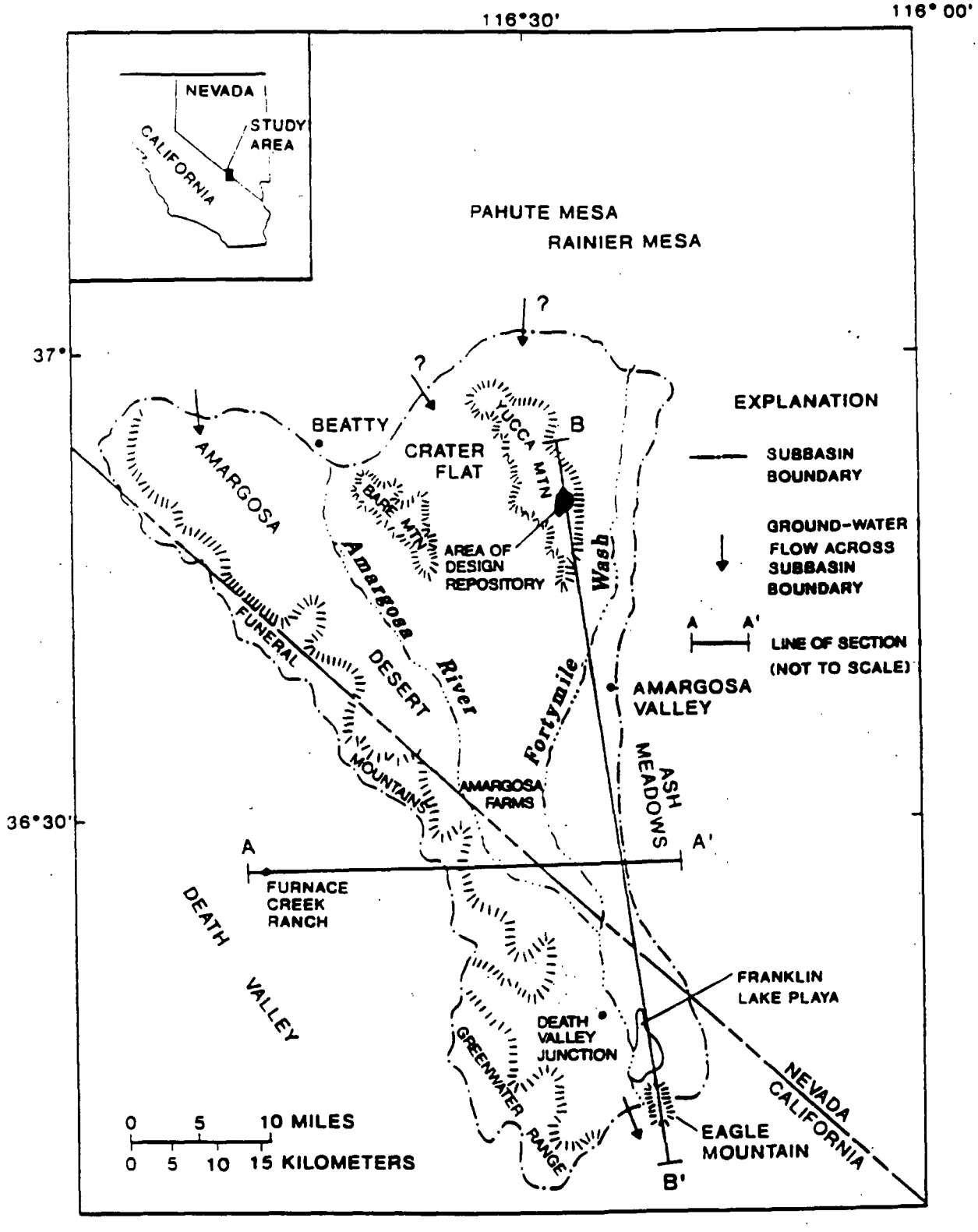
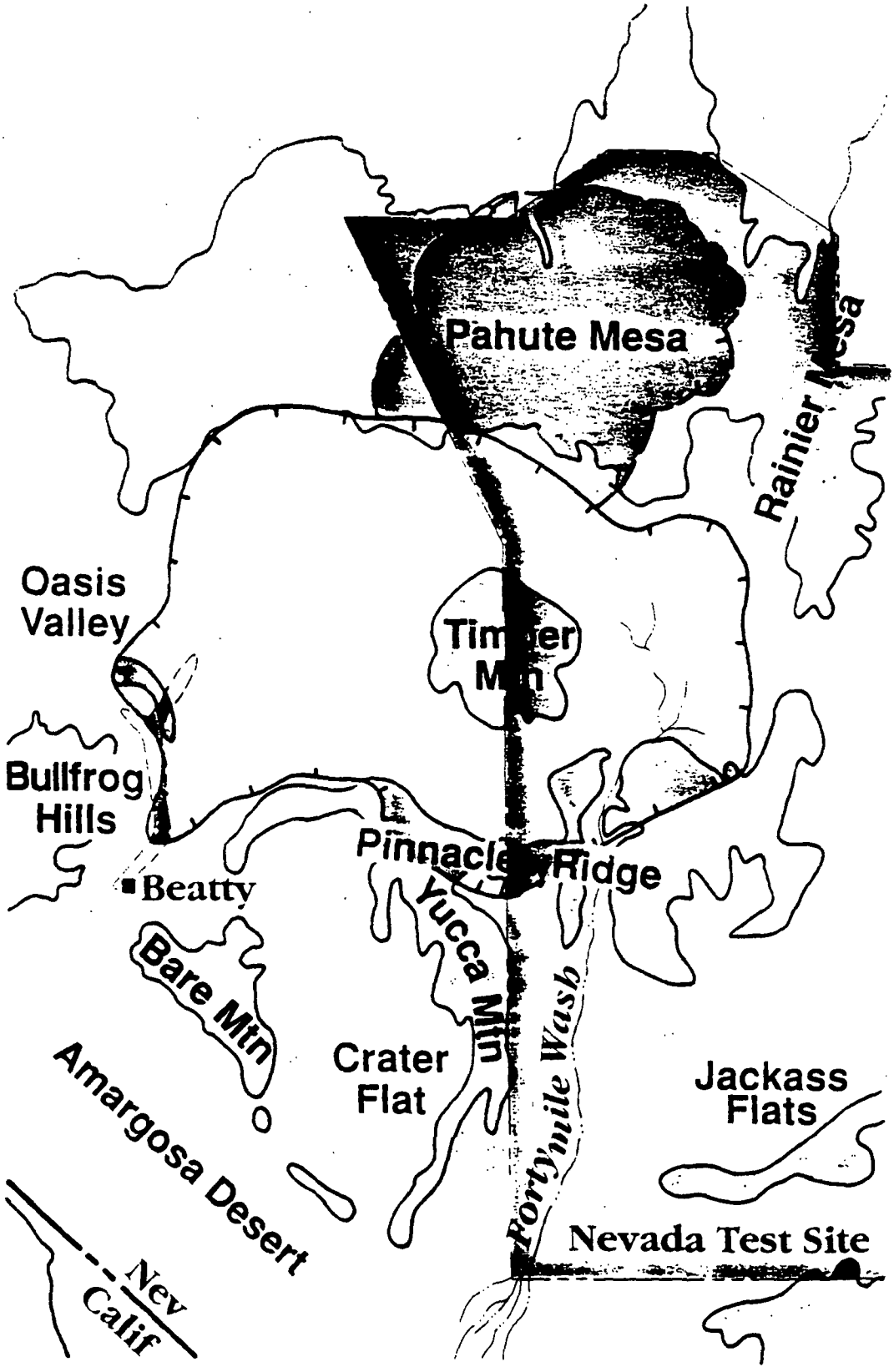
LOCATION OF YUCCA MOUNTAIN AND GROUND-WATER STUDY AREA




Pahute Mesa
Rainier Mesa
Oasis Valley
Timber Mtn
Bullfrog Hills
Pinnacle Ridge
Beatty
Yucca Mtn
Bare Mtn
Crater Flat
Amargosa Desert
Nev
Calif
Fortymile Wash
Jackass Flats
Nevada Test Site

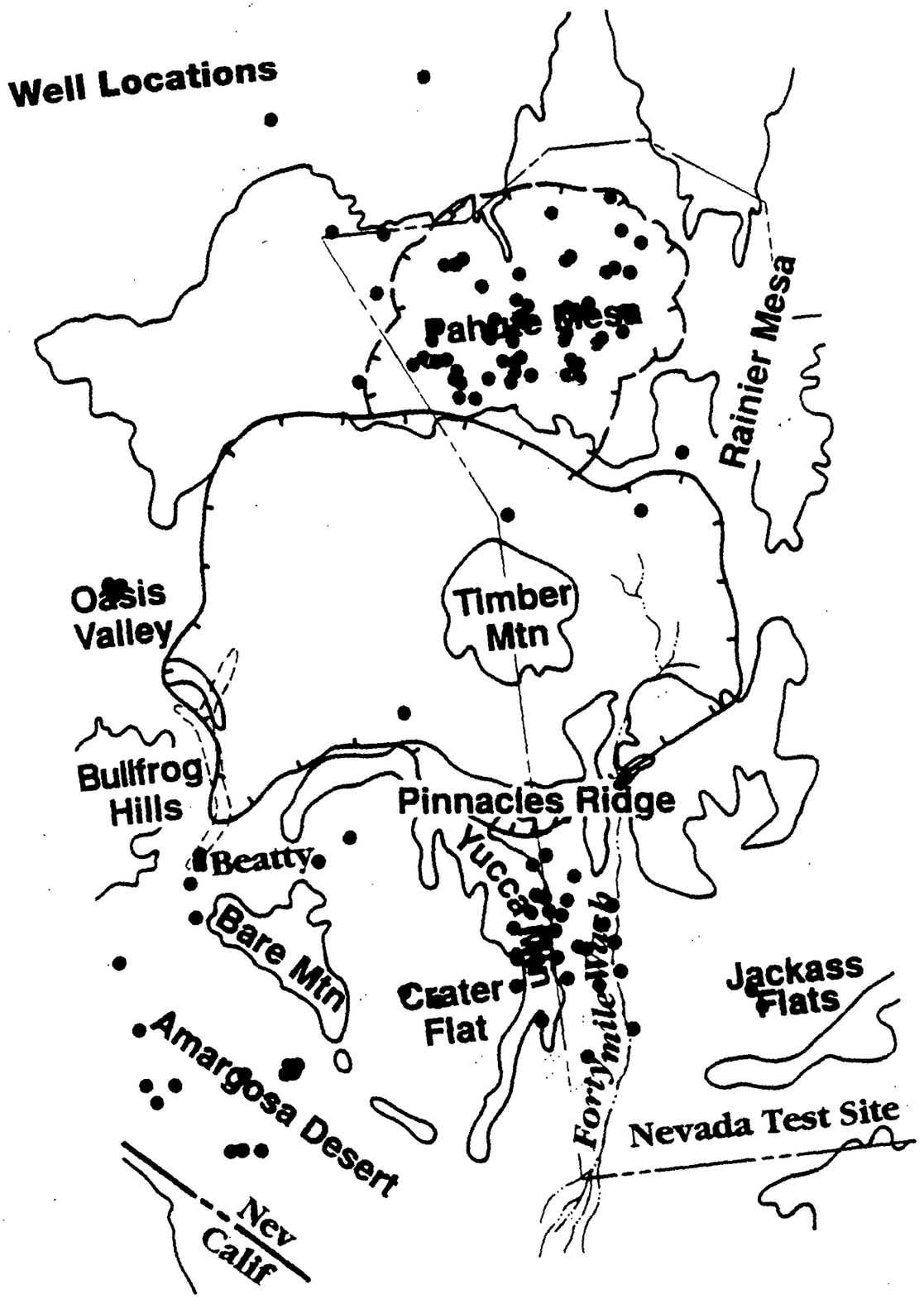
Uncertainties in Sub-basin

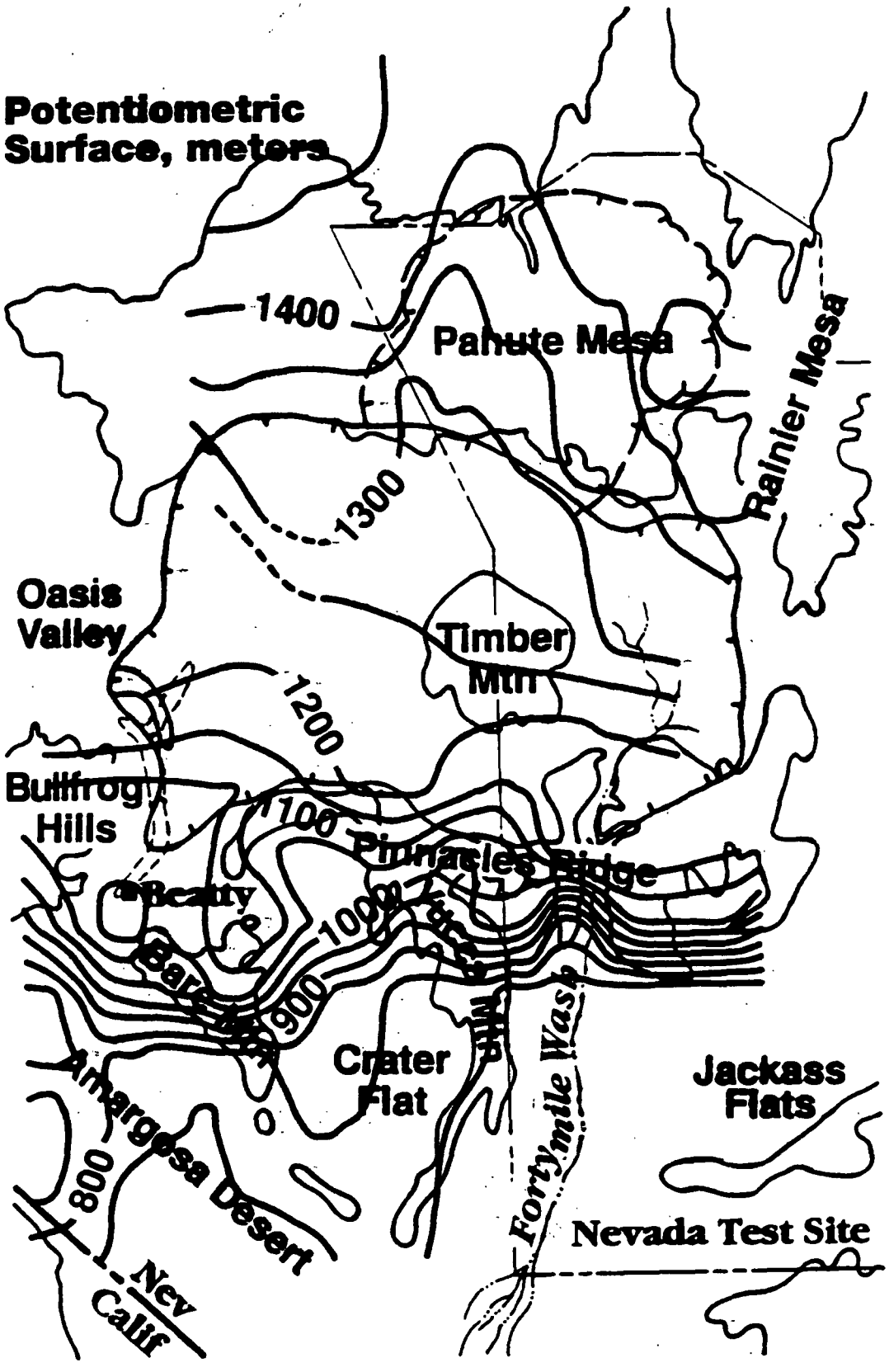
- Does water from beneath Yucca Mountain flow to Death Valley via a carbonate-rock "window" beneath the Funeral Mountains?
- From where and by what flow paths does water from beneath Yucca Mt. originate?

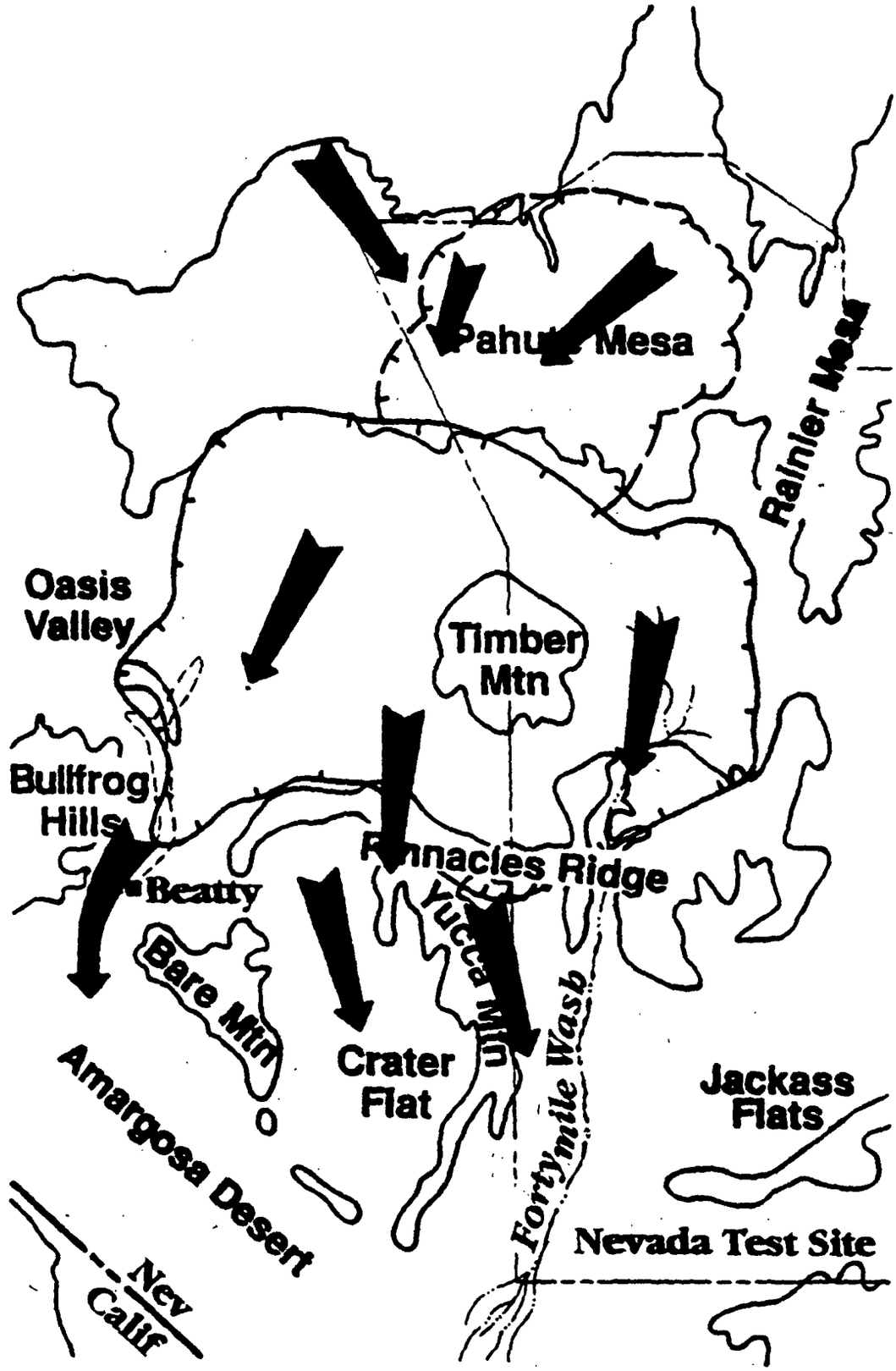
PHOTO OF PAHUTE MESA

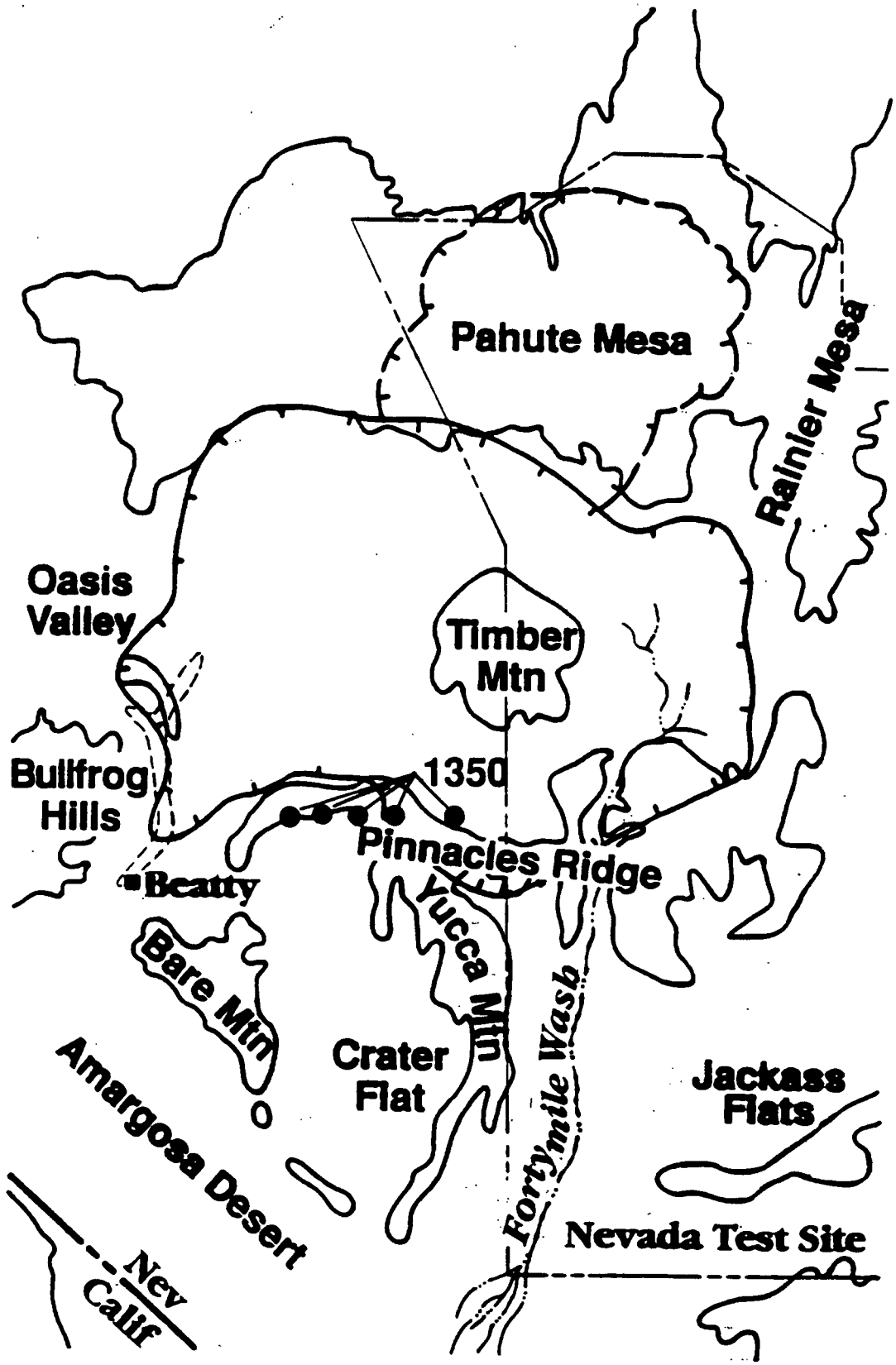
Possible Sources of Recharge to Yucca Mountain

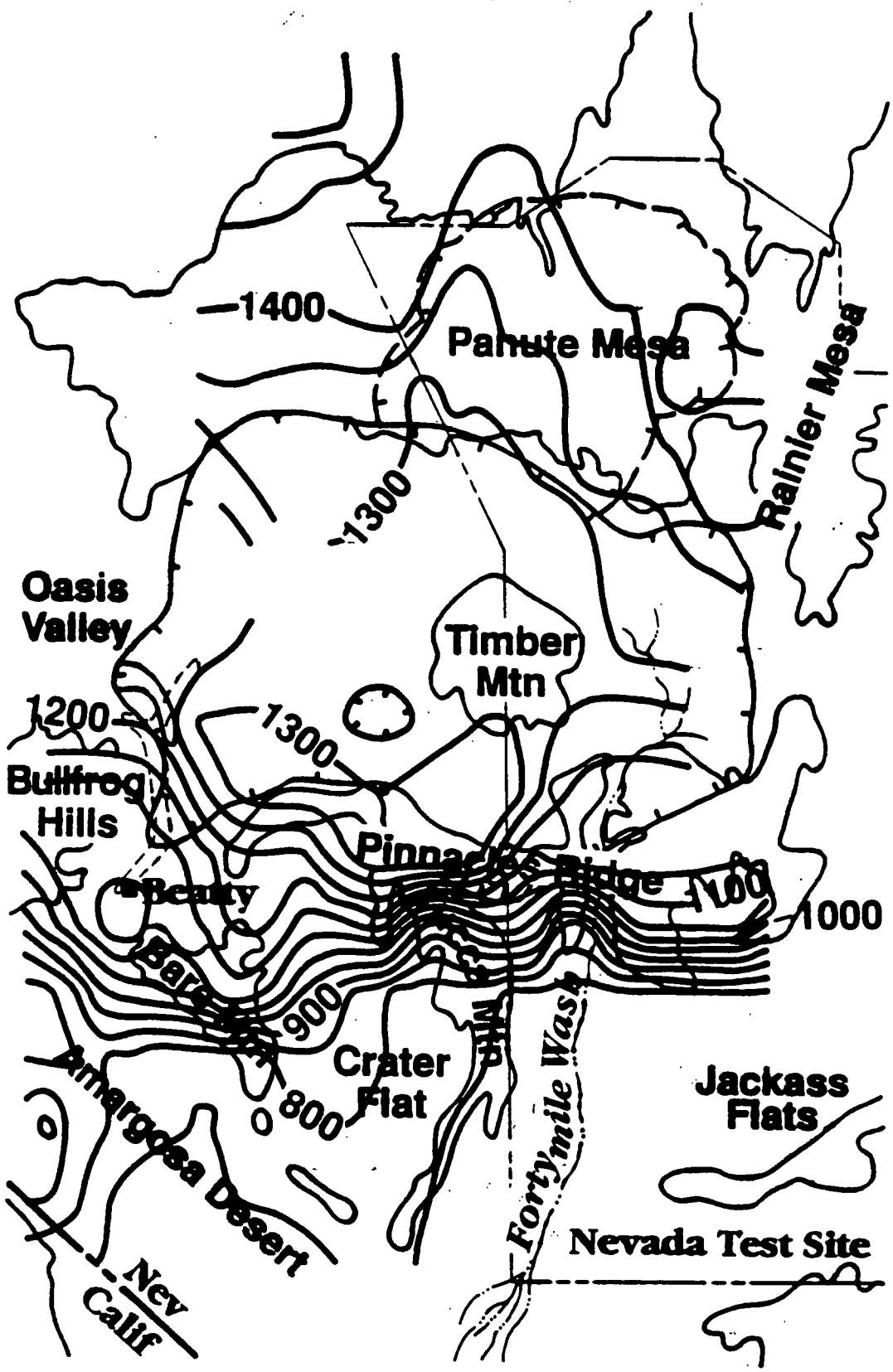
- Pahute and Rainier Mesas (50%)
- Fortymile Wash (and other washes) (40%)
- Paleo-recharge at Crater Flat and Yucca Mountain
- Upward flow from Paleozoic and Precambrian rocks

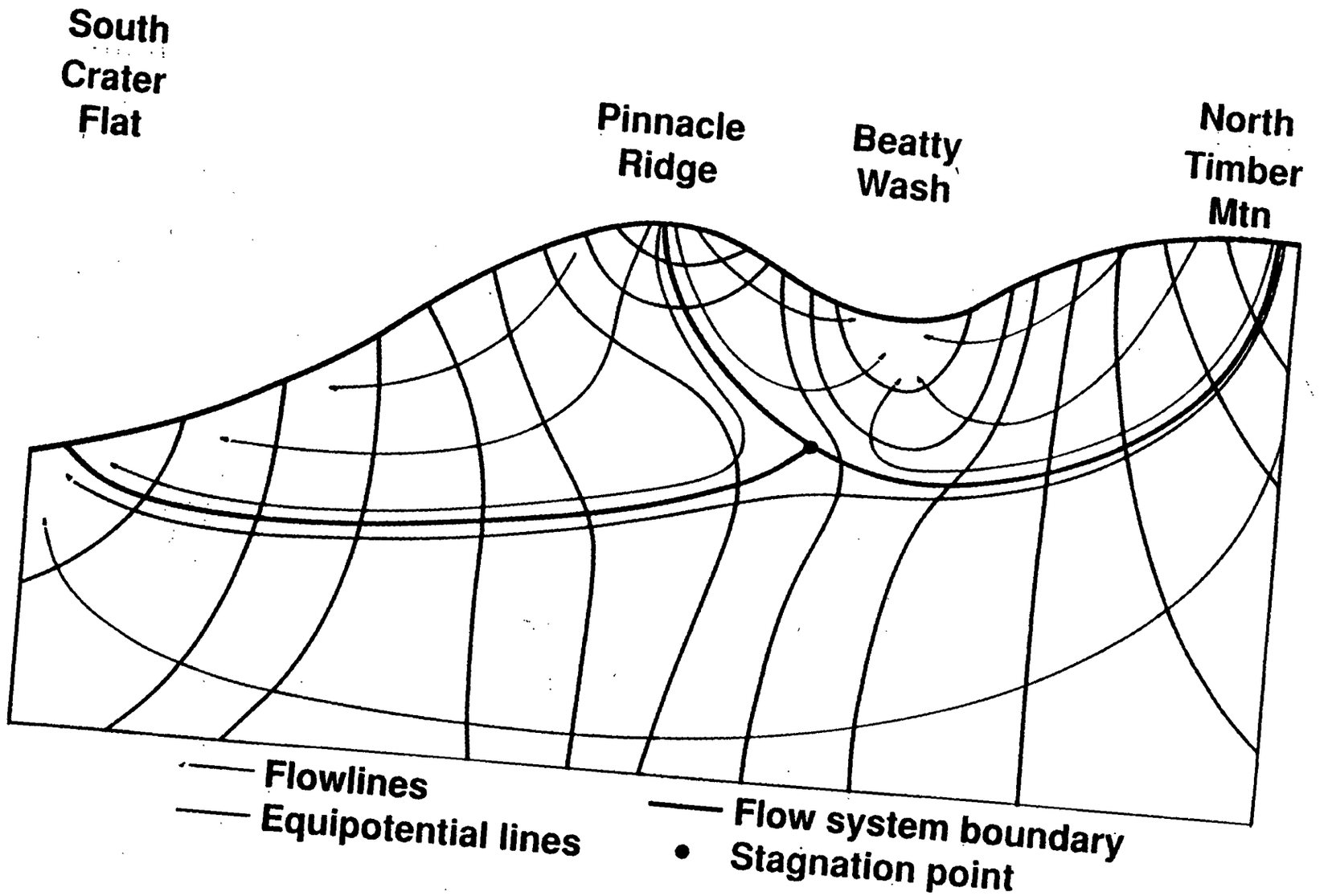

Well Locations
Rainier Mesa
Oasis Valley
Timber Mtn
Bullfrog Hills
Pinnacles Ridge
Beatty
Yucca
Bare Mtn
Crater Flat
Jackass Flats
Amargosa Desert
Nevada Test Site
Nev
Calif


Potentiometric Surface, meters
1400
Pahute Mesa
Rainier Mesa
1300
Oasis Valley
Timber Mtn
1200
Bullfrog Hills
1100
Pinnacles Ridge
Beatty
1000
900
Crater Flat
Jackass Flats
Amargosa Desert
800
Nev
Calif
Fortymile Wash
Nevada Test Site


Oasis Valley
Timber Mtn
Bullfrog Hills
Beatty
Bare Mtn
Crater Flat
Yucca Mtn
Fortymile Wash
Jackass Flats
Amargosa Desert
Nevada Test Site
Nev
Calif

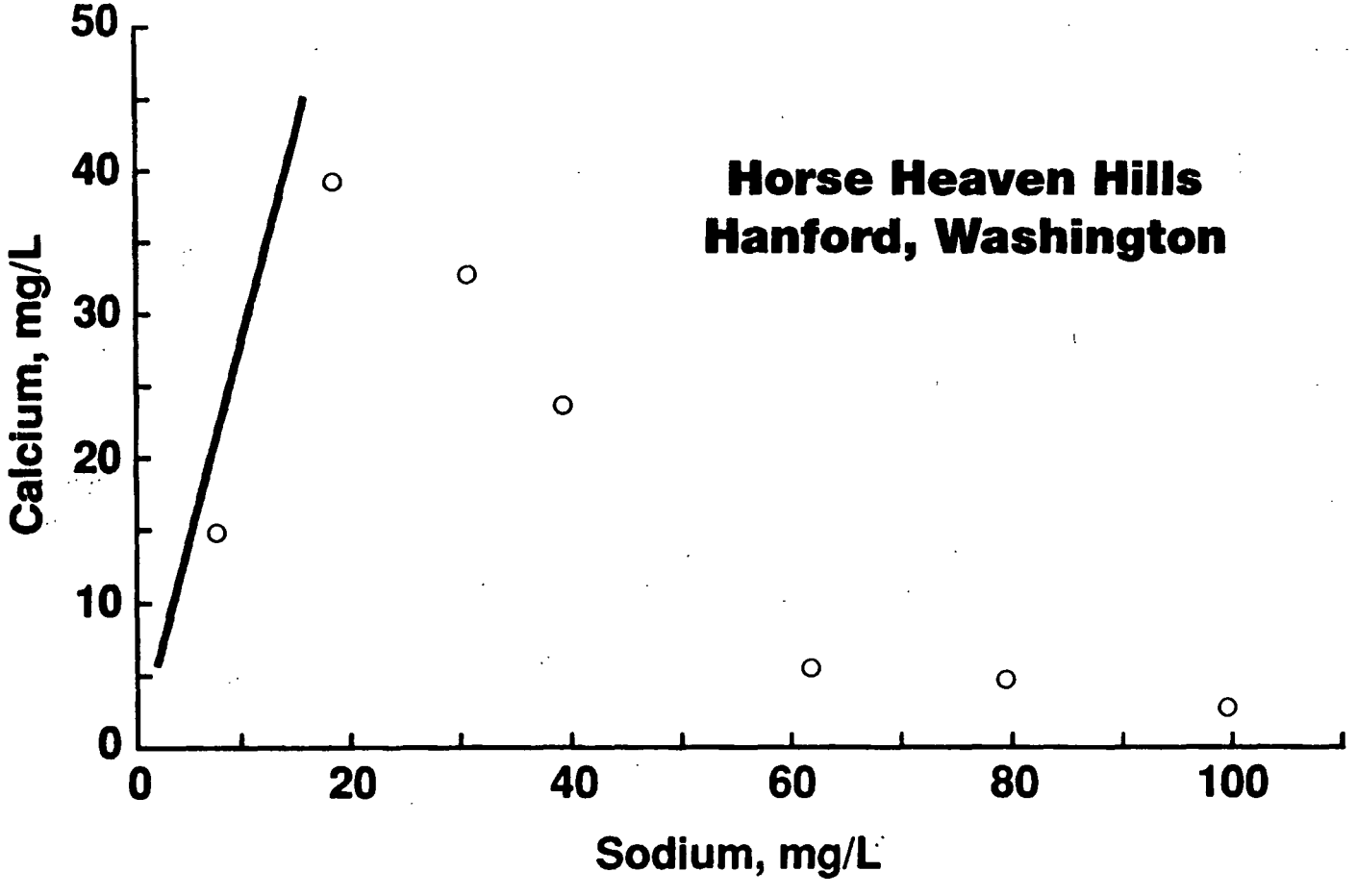

Pahute Mesa
Rainier Mesa
Oasis Valley
Timber Mtn
Bullfrog Hills
1350
Pinnacles Ridge
Beatty
Yucca Mtn
Bare Mtn
Crater Flat
Fortymile Wash
Jackass Flats
Amargosa Desert
Nevada Test Site
Nev
Calif


1400
Pahute Mesa
Rainier Mesa
1300
Oasis Valley
Timber Mtn
1200
1300
Bullfrog Hills
Pinnacles Ridge
1100
1000
900
Crater Flat
800
Jackass Flats
Amargosa Desert
Fortymile Wash
Nevada Test Site
Nev
Calif


South
Crater
Flat
Pinnacle
Ridge
Beatty
Wash
North
Timber
Mtn
Flowlines
Equipotential lines
Flow system boundary
Stagnation point

Factors Affecting Hydrochemistry

- Ground water/rock interactions
- Reactions within unsaturated zone
- Mixing of waters with different origins
- Location within flow system
- Evaporation
- Contamination



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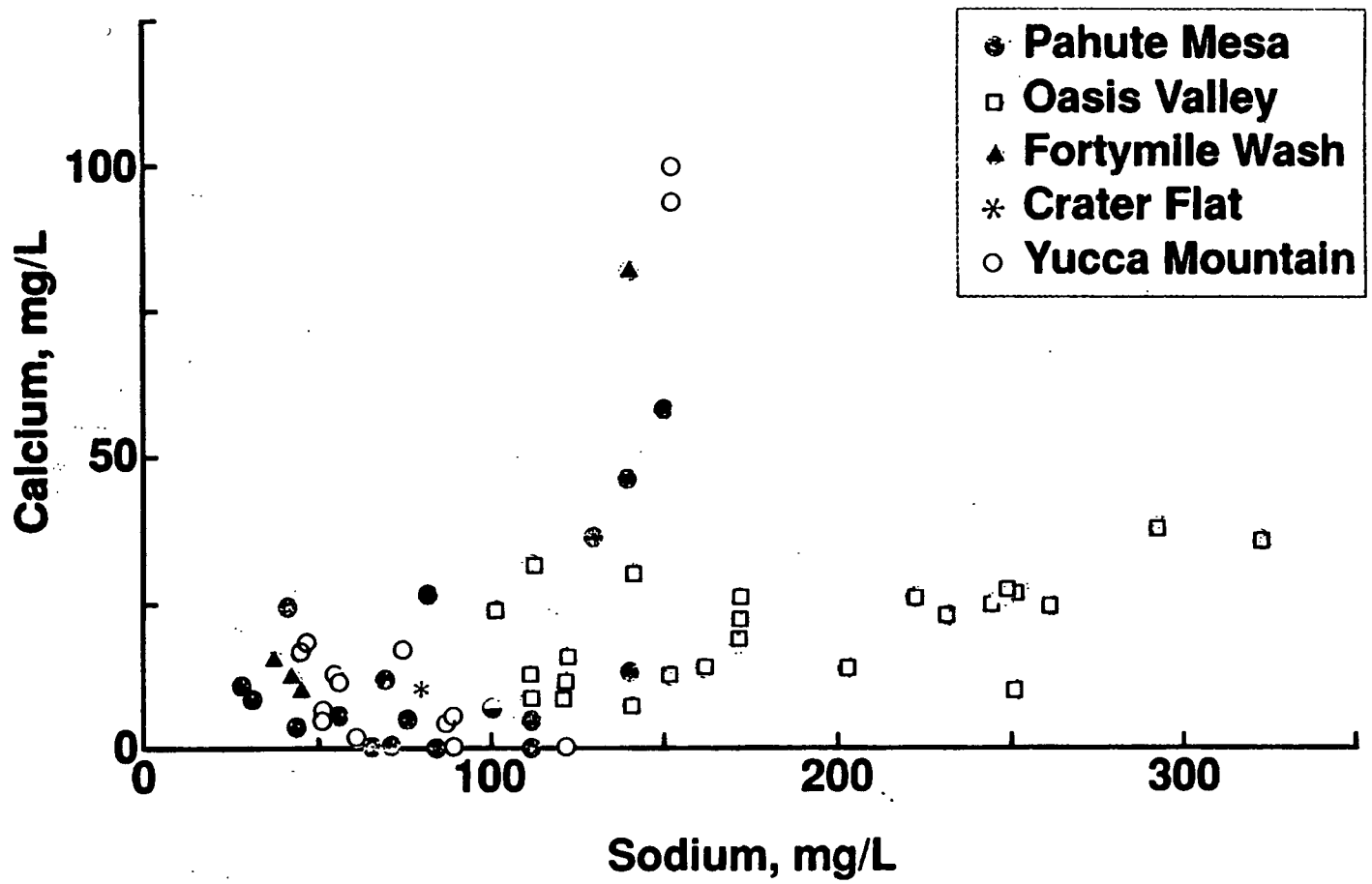

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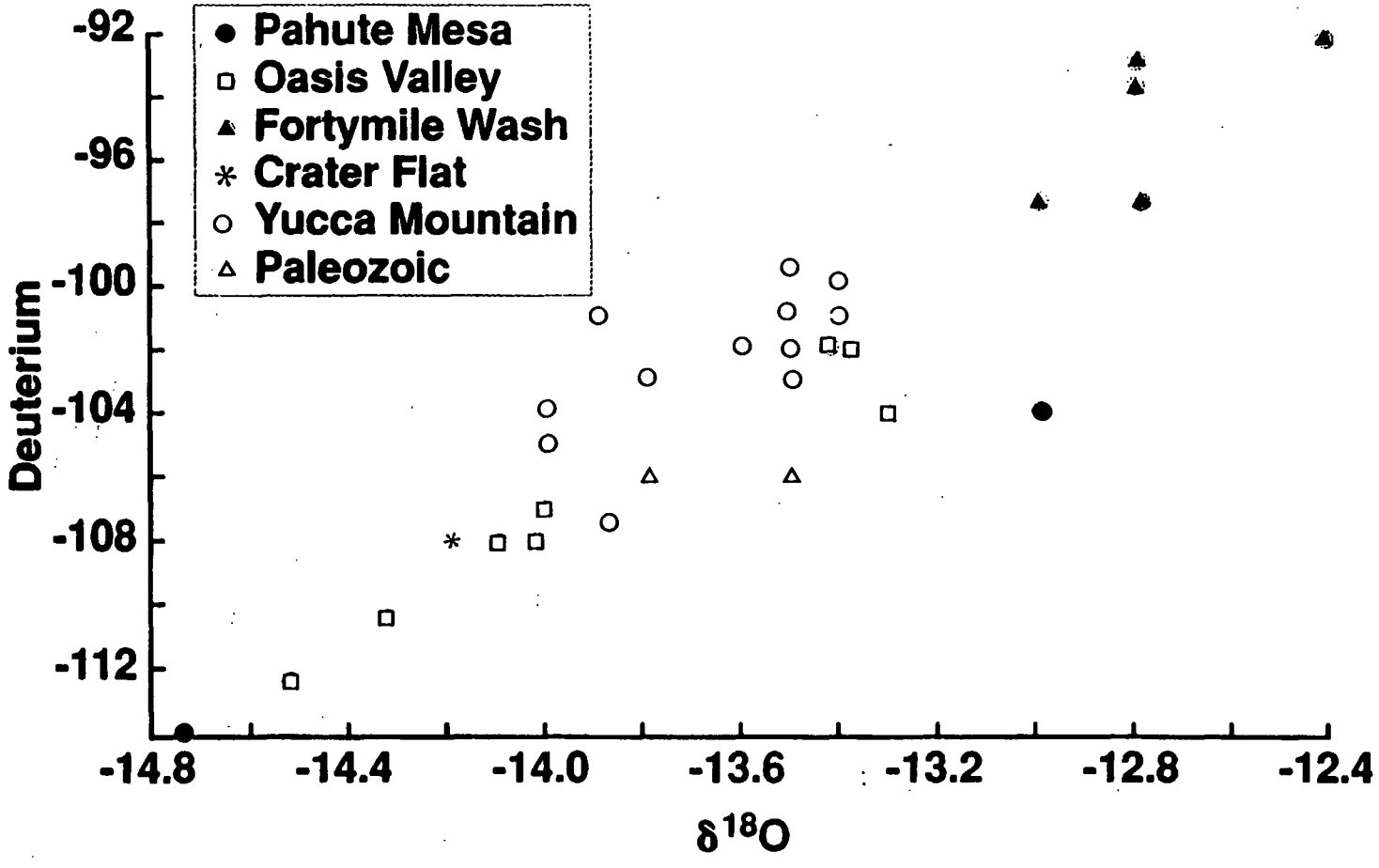

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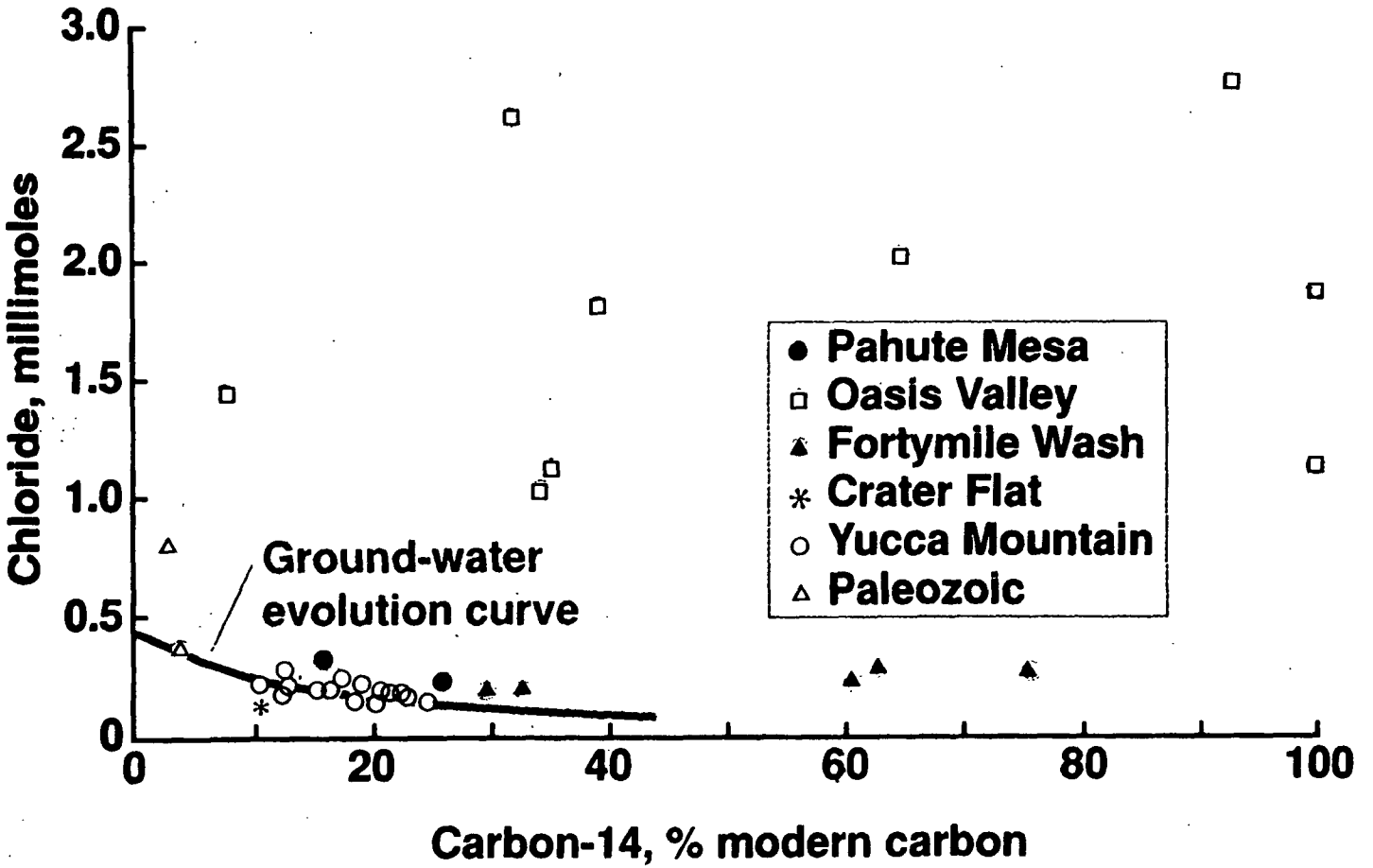

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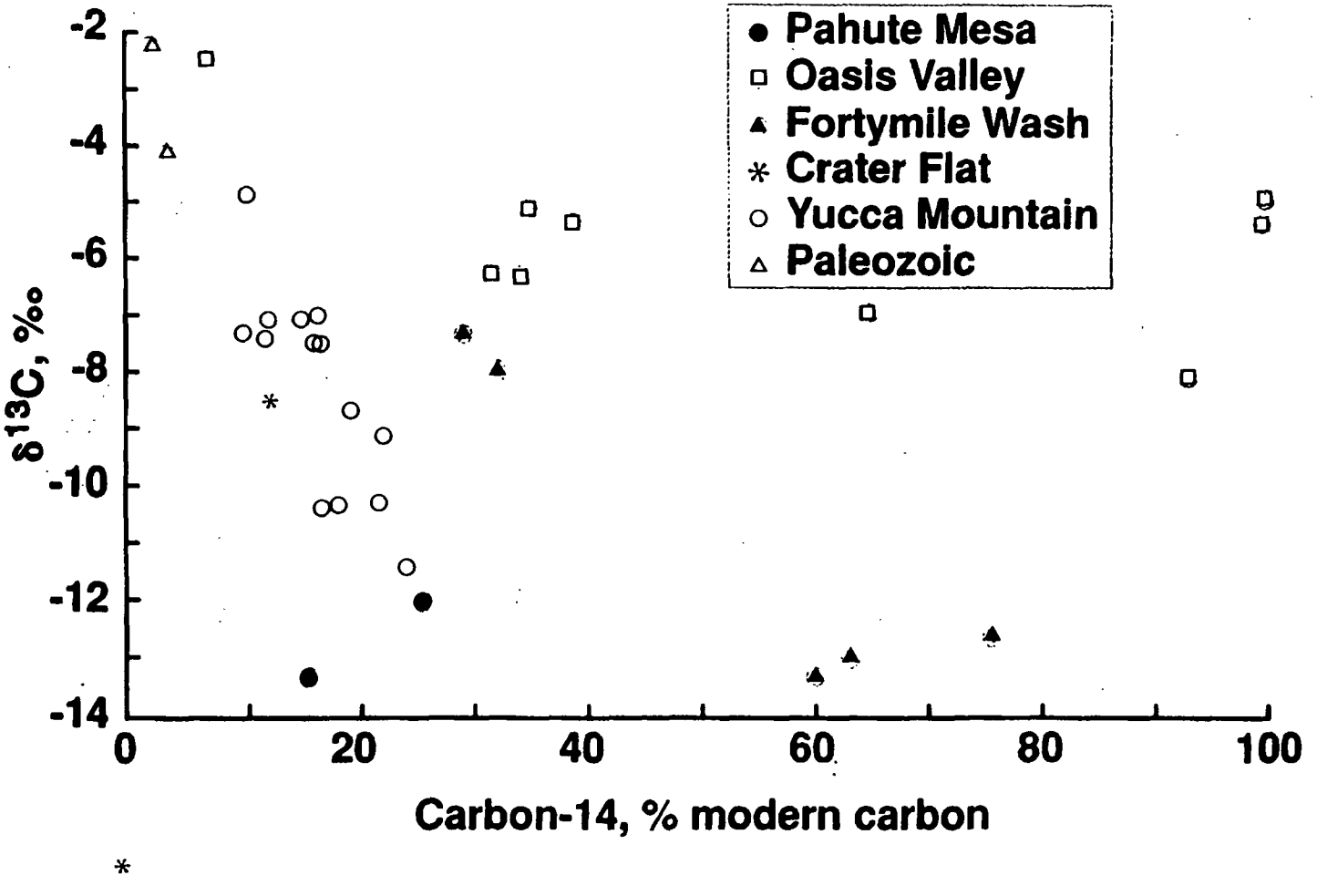

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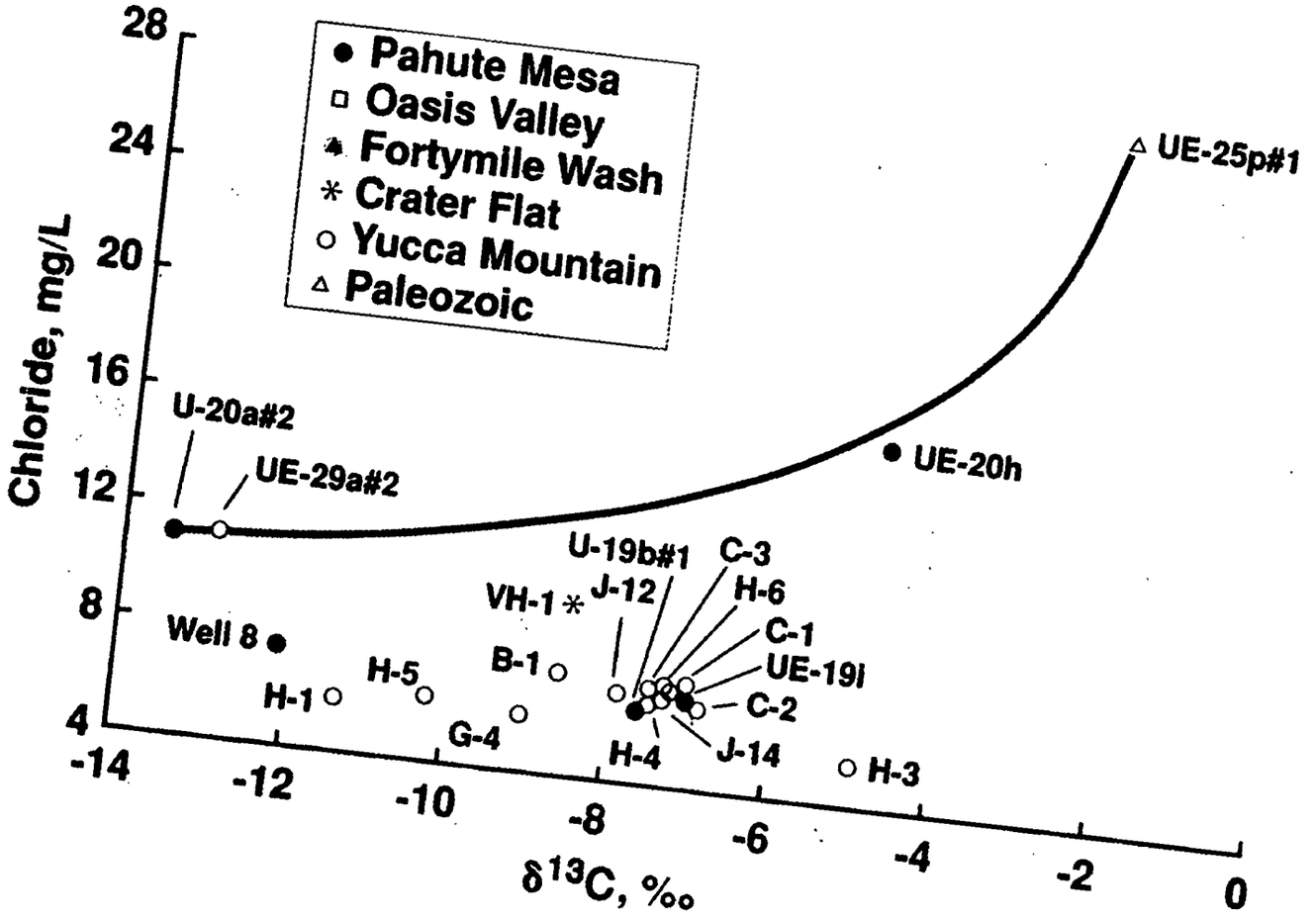

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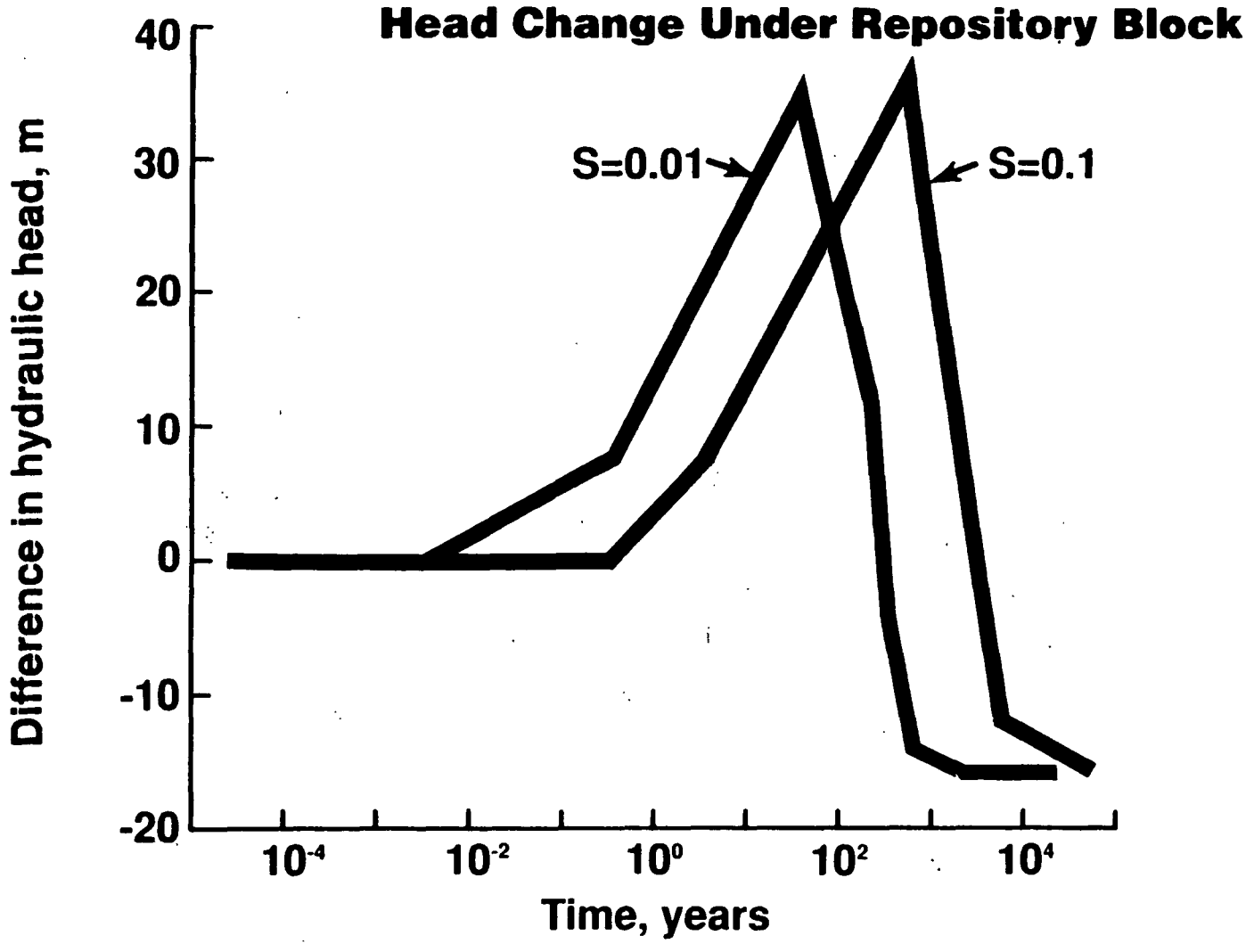
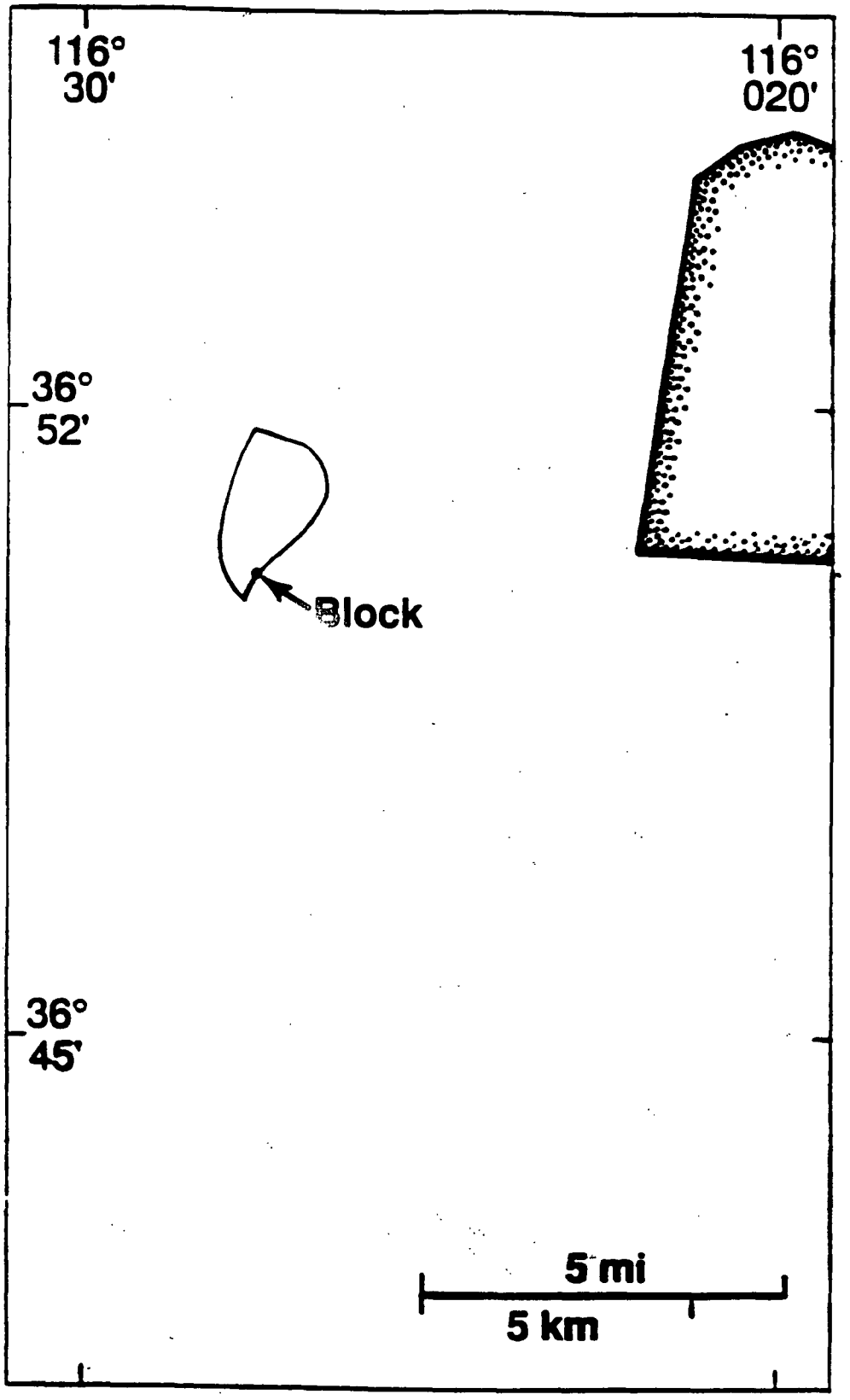
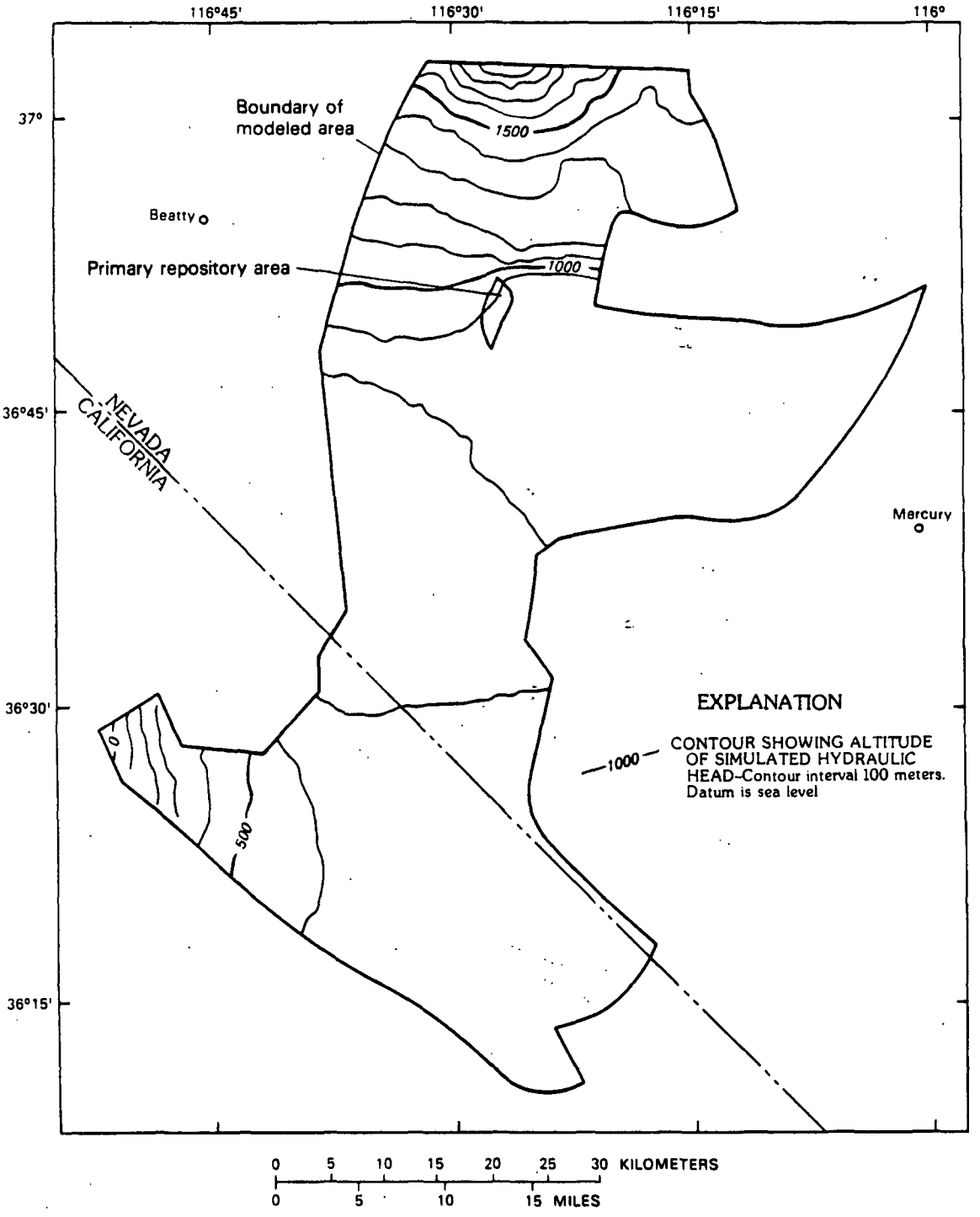
Conclusions

- Water from Pahute Mesa possibly does not flow to Yucca Mountain
- If water from Pahute Mesa flows to Yucca Mountain, it is likely mixed with Fortymile Wash water
- Local recharge and contributions from deeper sources are probably minor
- More data is needed


Head Change Under Repository Block
Difference in hydraulic head, m
40
30
20
10
0
-10
-20
S=0.01
S=0.1
10-4
10-2
100
102
104
Time, years

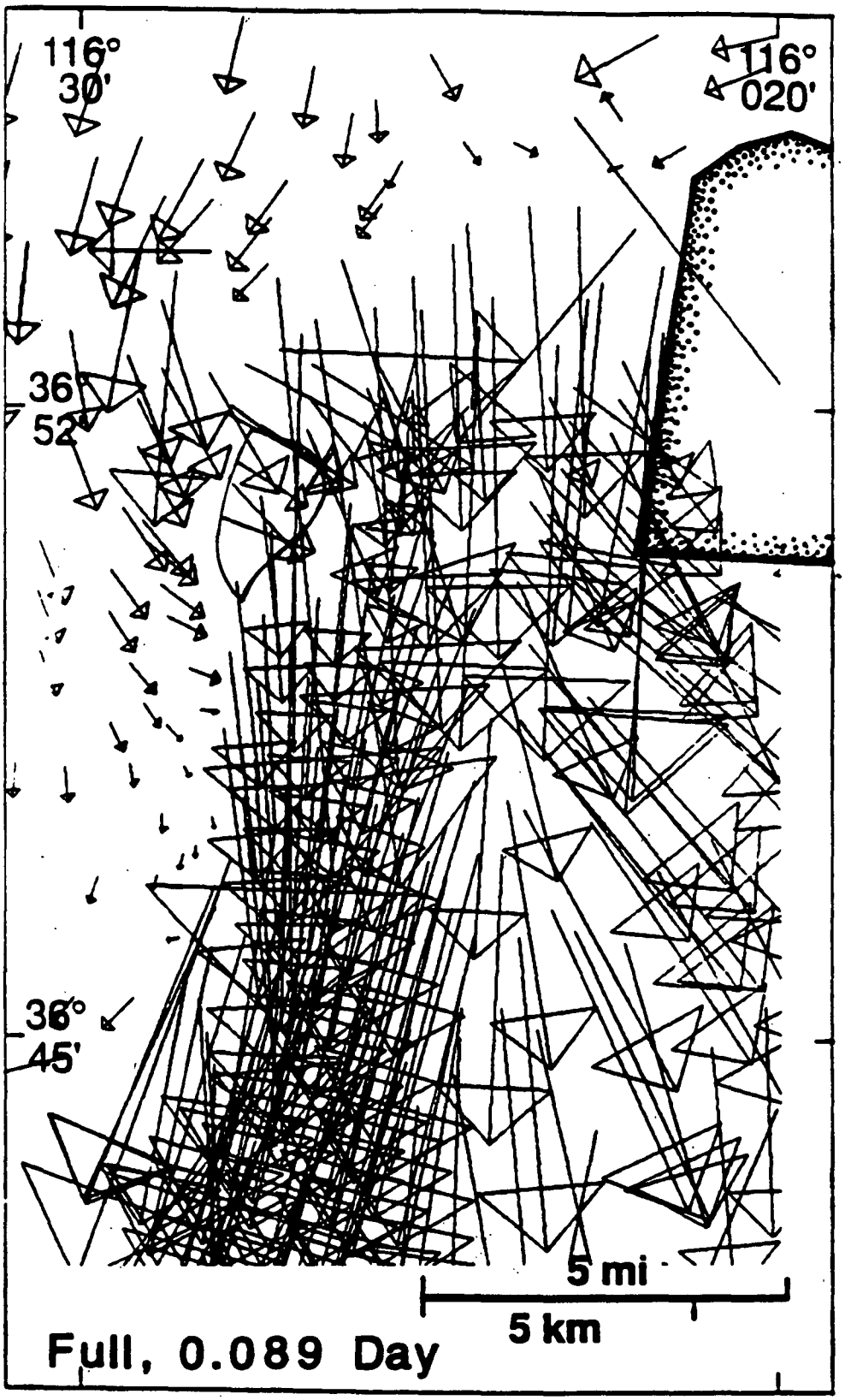

116°
30'
116°
020'
36°
52'
Block
36°
45'
5 mi
5 km

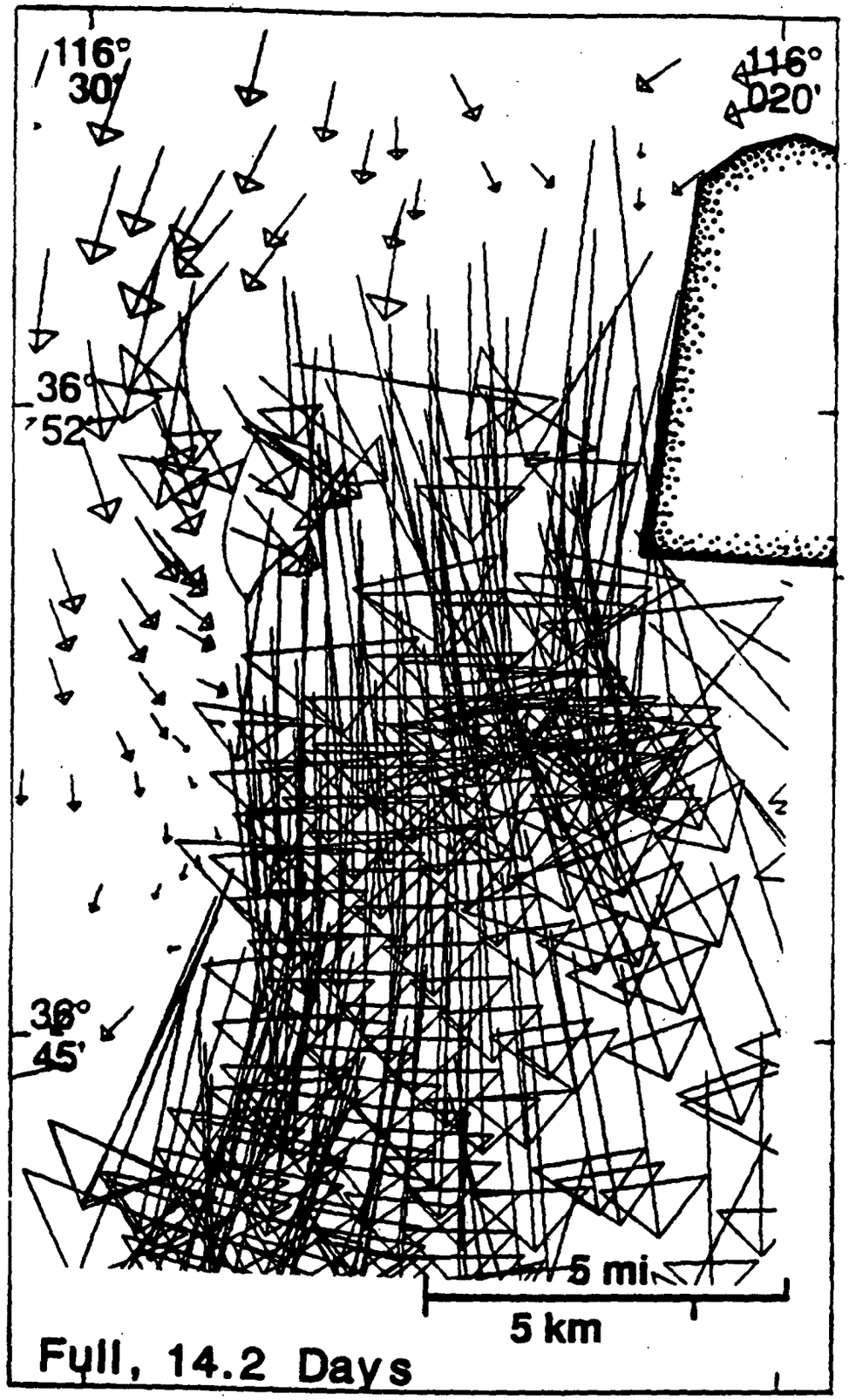
SIMULATED HYDRAULIC HEAD FOR SIMULATION INVOLVING A 100-PERCENT INCREASE IN PRECIPITATION

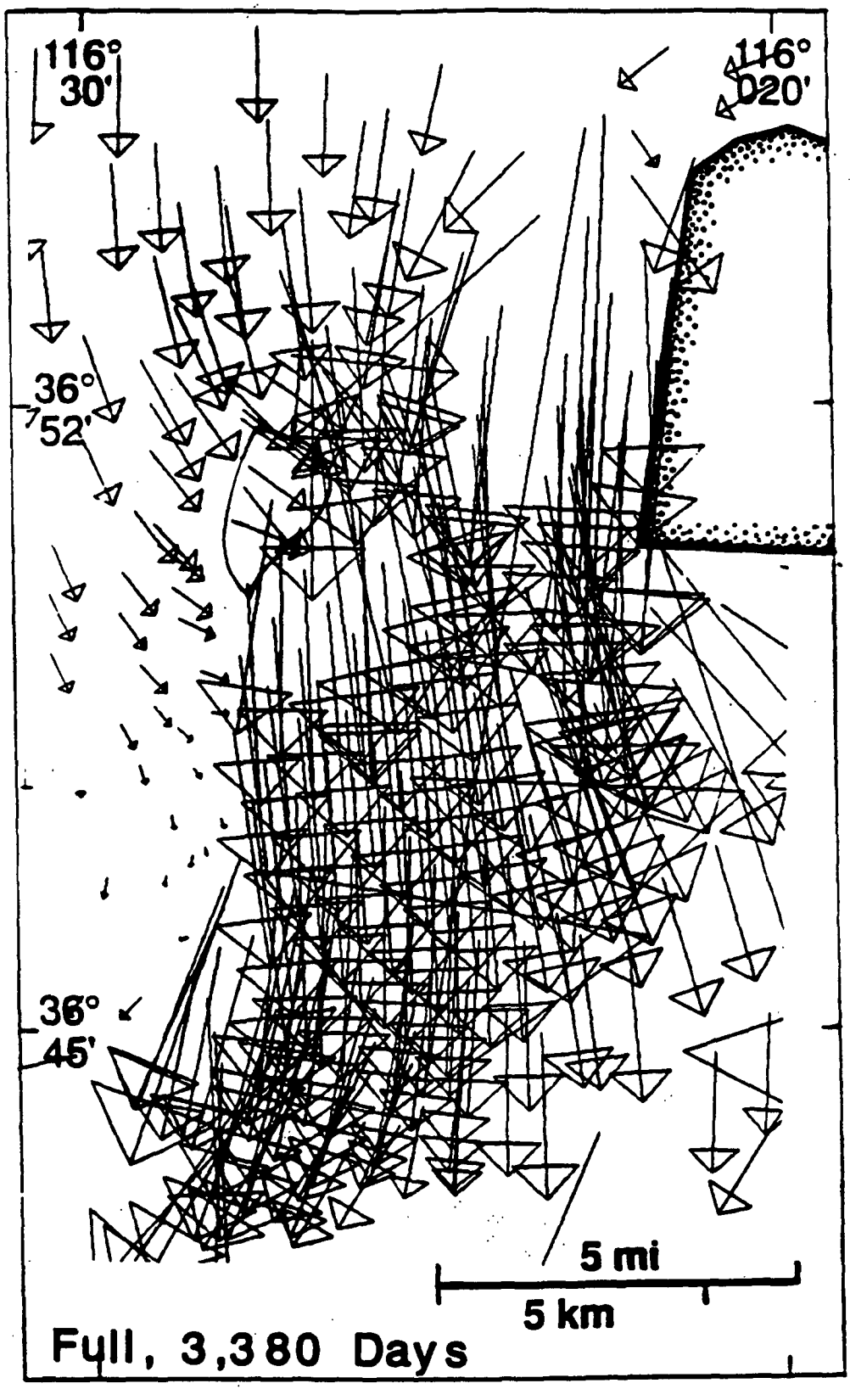


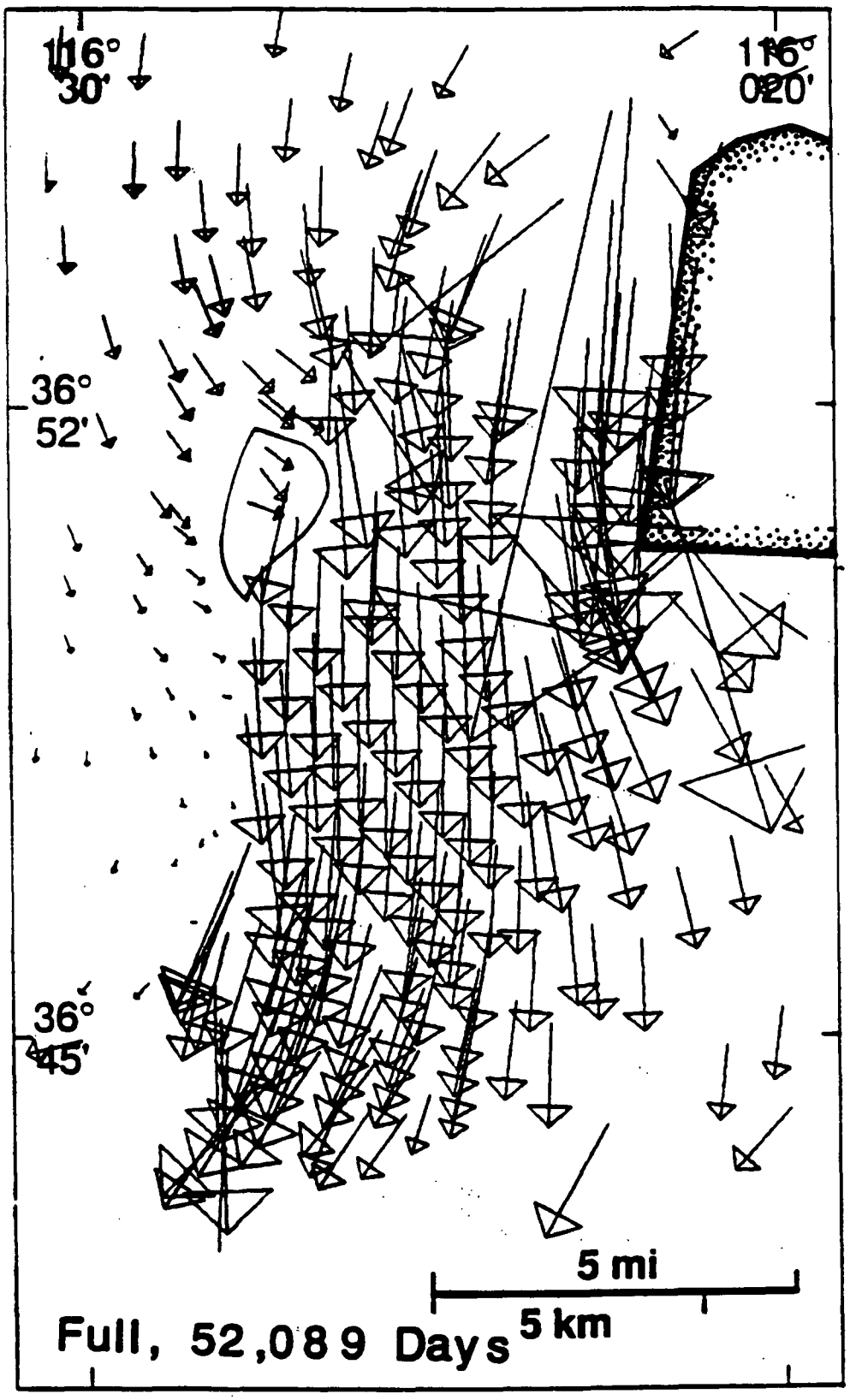
Simulation

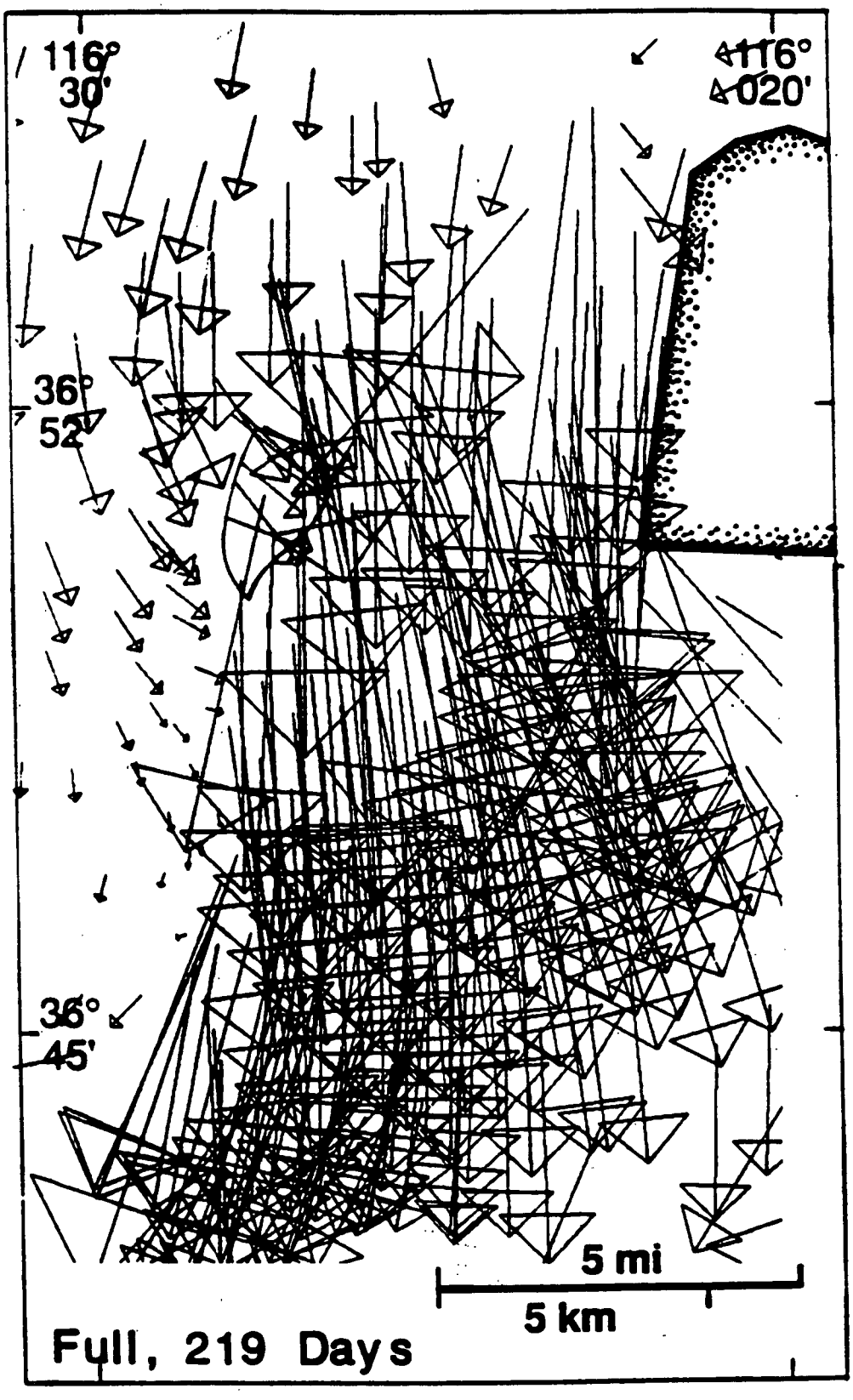
- Recharge is fifteen times modern and continues through simulation
- System is at steady state at start of simulation
- Hydrologic barrier is removed at start of simulation

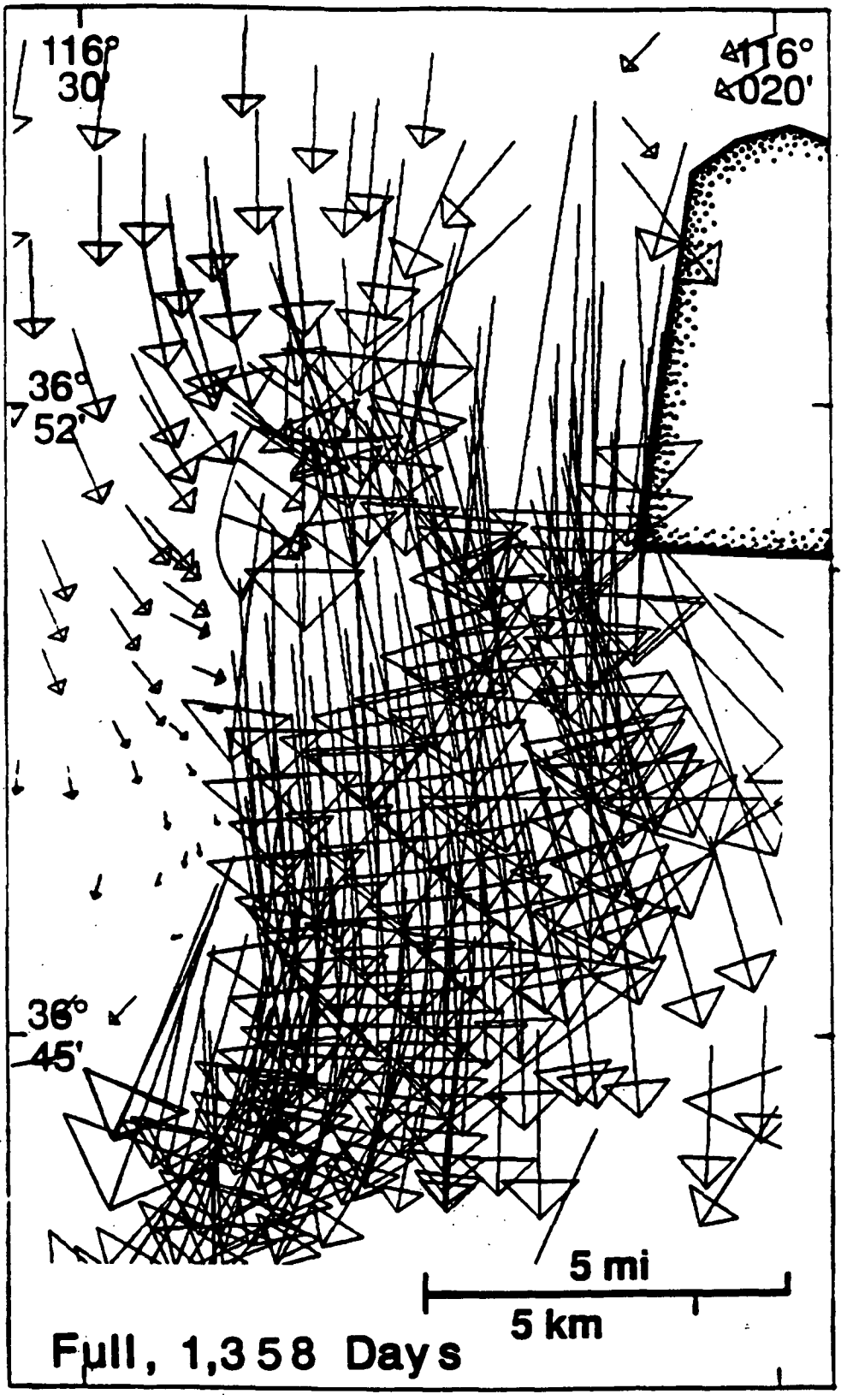

116°
30'
116°
020'
36°
52'
36°
45'
5 mi
5 km
Full, 0.089 Day

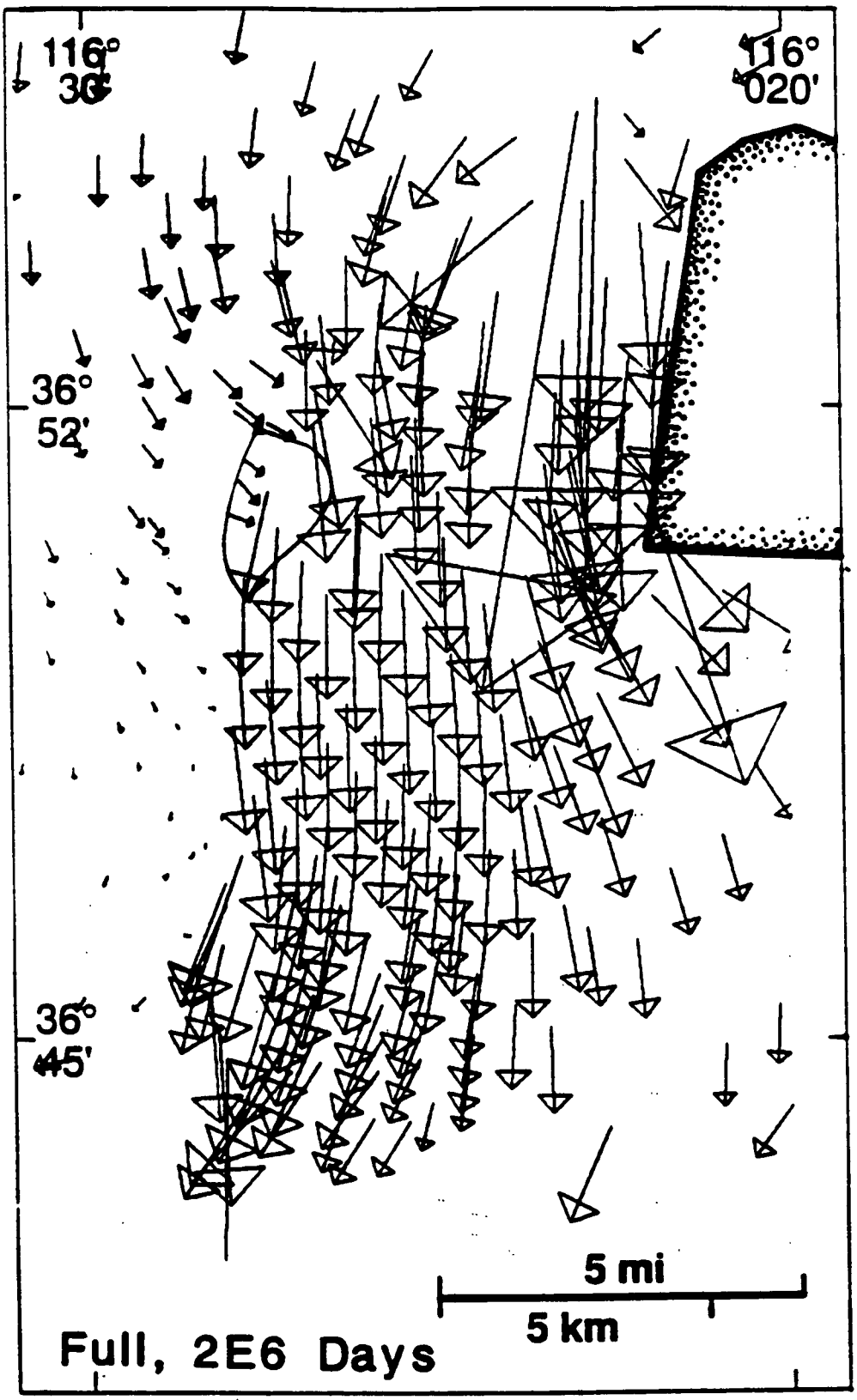

116°
30'
116°
20'
36°
52'
36°
45'
5 mi
5 km
Full, 14.2 Days

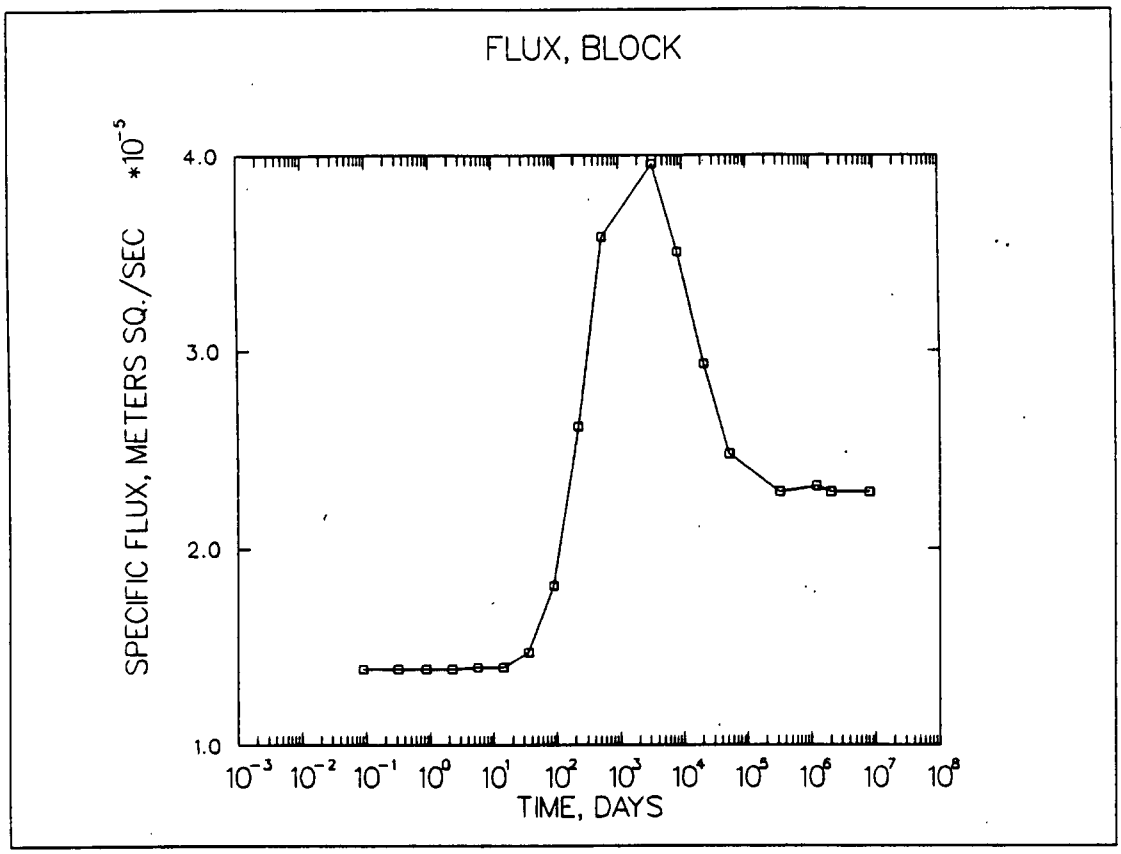

116°
30'
116°
D20'
36°
52'
36°
45'
5 mi
5 km
Full, 3,380 Days

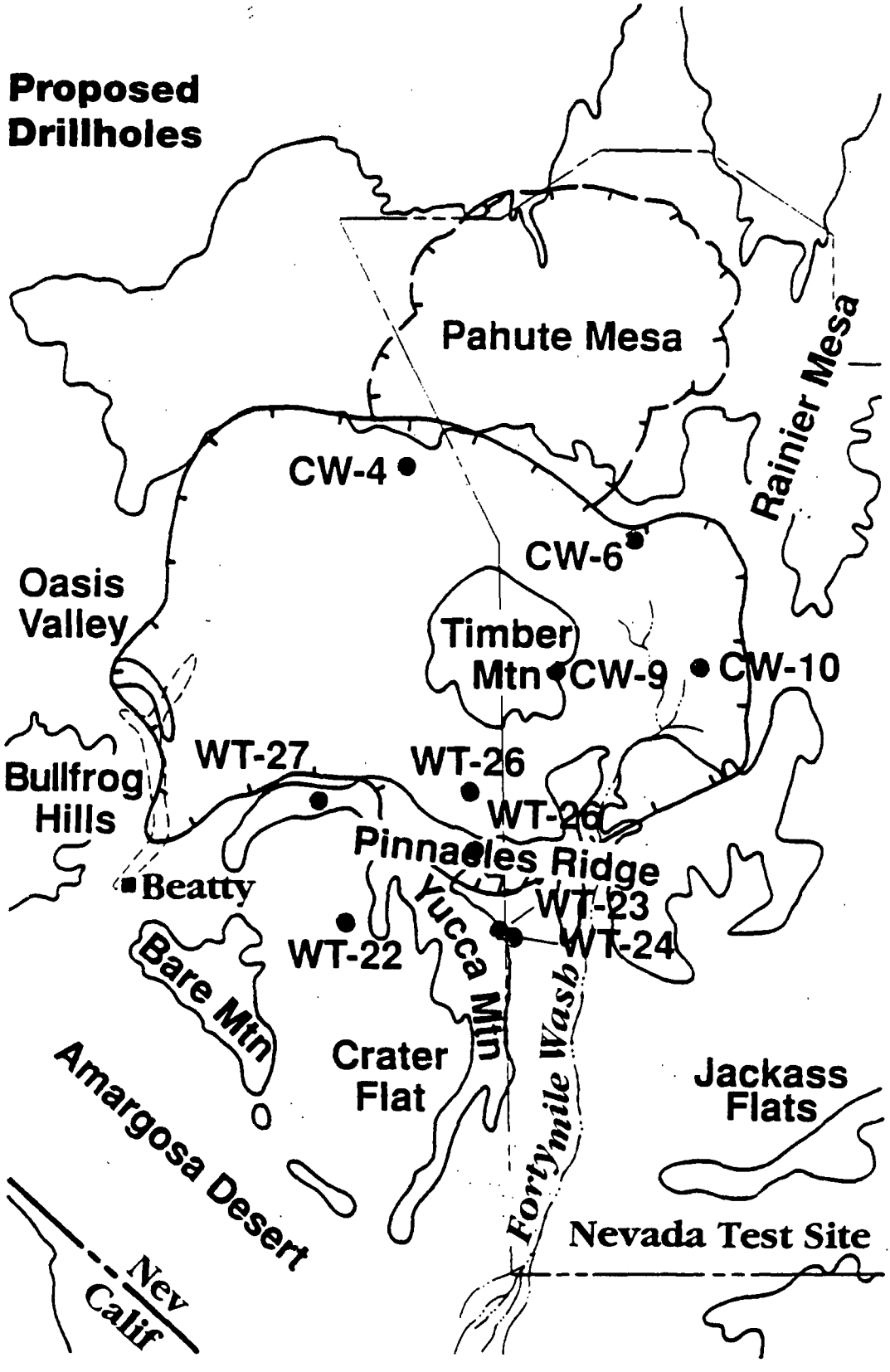

116°
30'
116°
020'
36°
52'
36°
45'
5 mi
5 km
Full, 52,089 Days


116°
30'
116°
020'
36°
52'
36°
45'
5 mi
5 km
Full, 219 Days


116°
30'
116°
020'
36°
52'
36°
45'
5 mi
5 km
Full, 1,358 Days


116°
36'
116°
020'
36°
52'
36°
45'
5 mi
5 km
Full, 2E6 Days

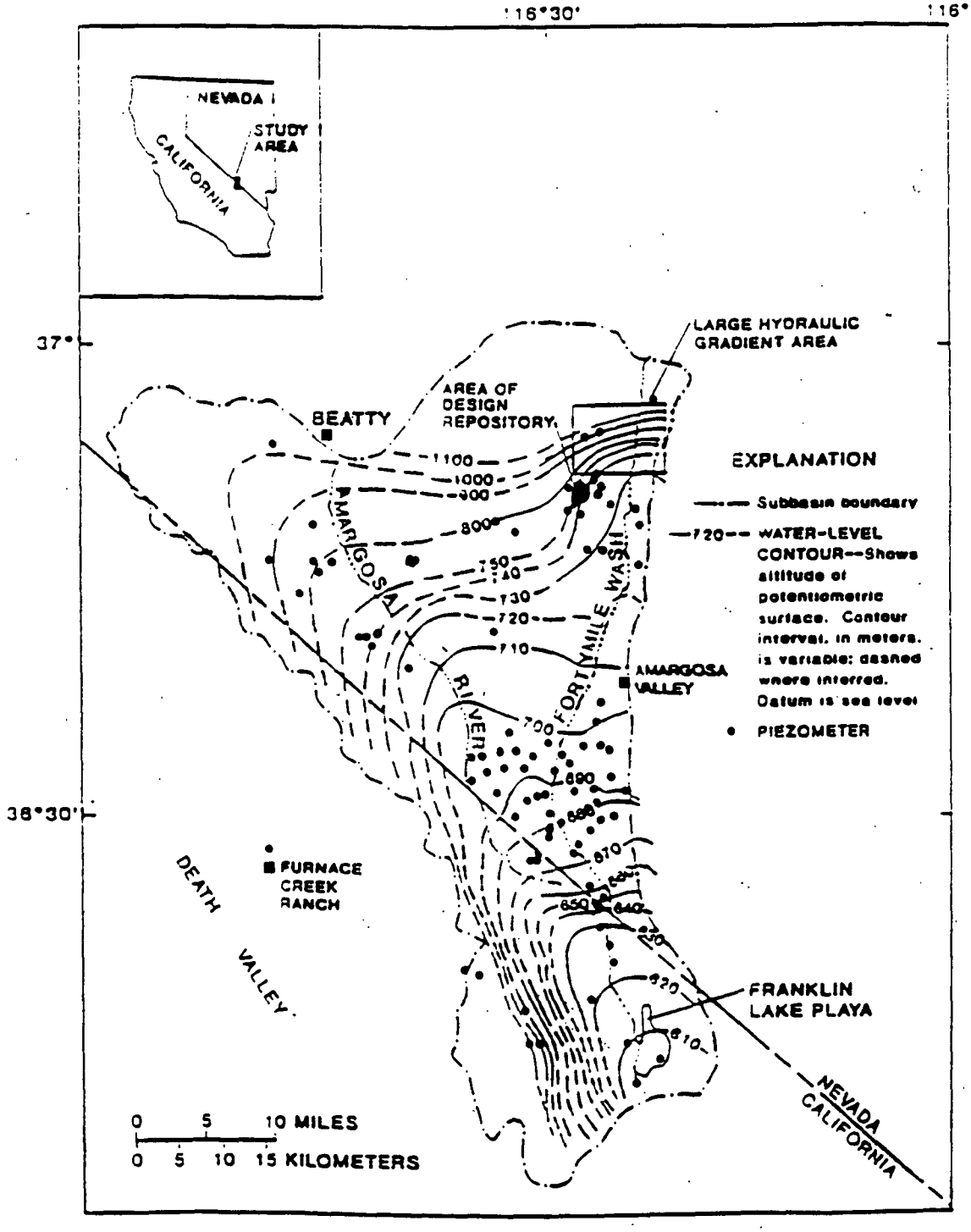

FLUX, BLOCK
SPECIFIC FLUX, METERS SQ./SEC *10^-5
4.0
3.0
2.0
1.0
10^-3 10^-2 10^-1 10^0 10^1 10^2 10^3 10^4 10^5 10^6 10^7 10^8
TIME, DAYS

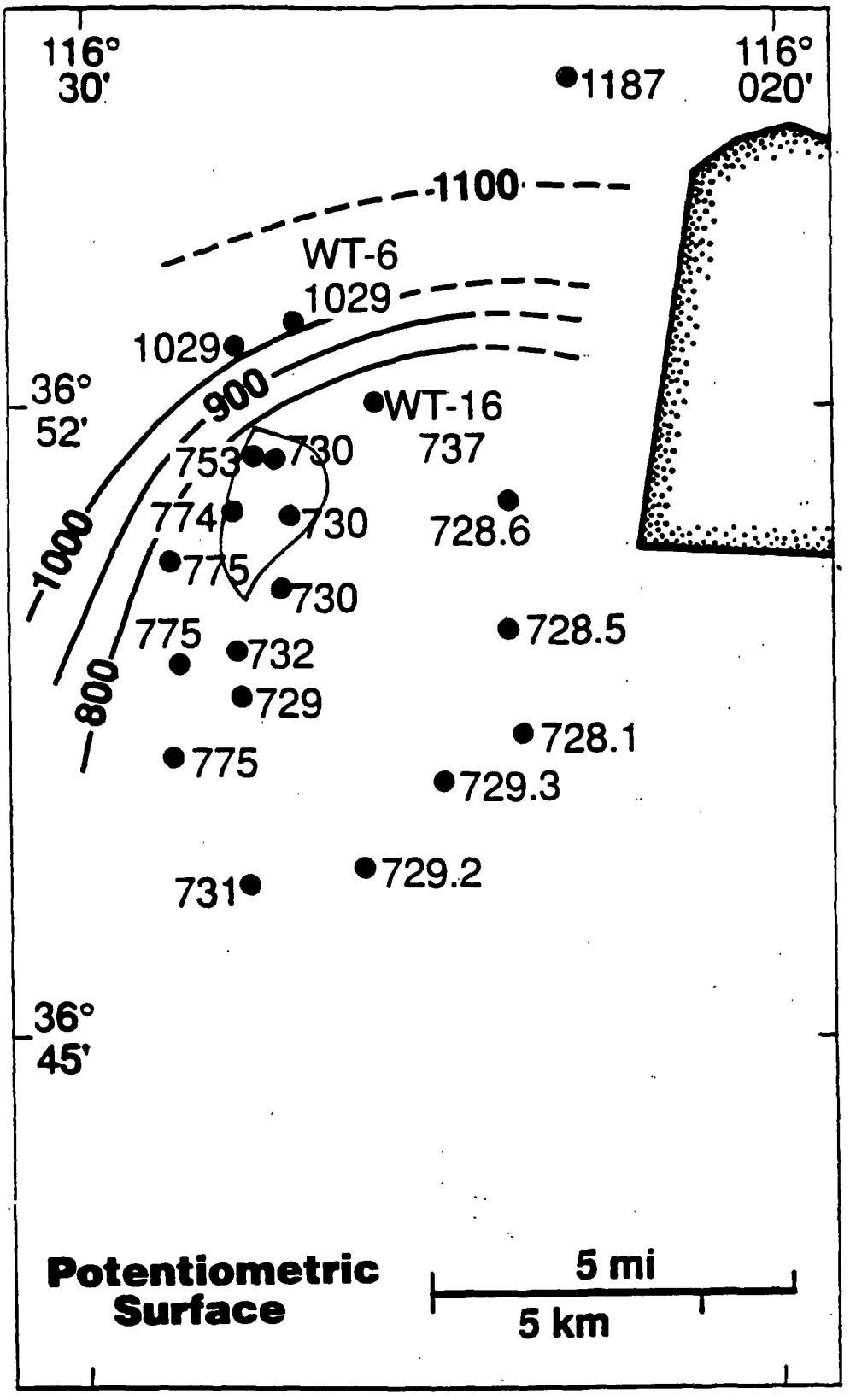

Proposed Drillholes
Pahute Mesa
Rainier Mesa
CW-4
CW-6
Oasis Valley
Timber Mtn
CW-9
CW-10
WT-27
WT-26
WT-26C
Bullfrog Hills
Pinnacles Ridge
Beatty
Yucca Mtn
WT-23
WT-24
WT-22
Bare Mtn
Crater Flat
Fortymile Wash
Jackass Flats
Amargosa Desert
Nevada Test Site
Nev
Calif

Large Hydraulic Gradient

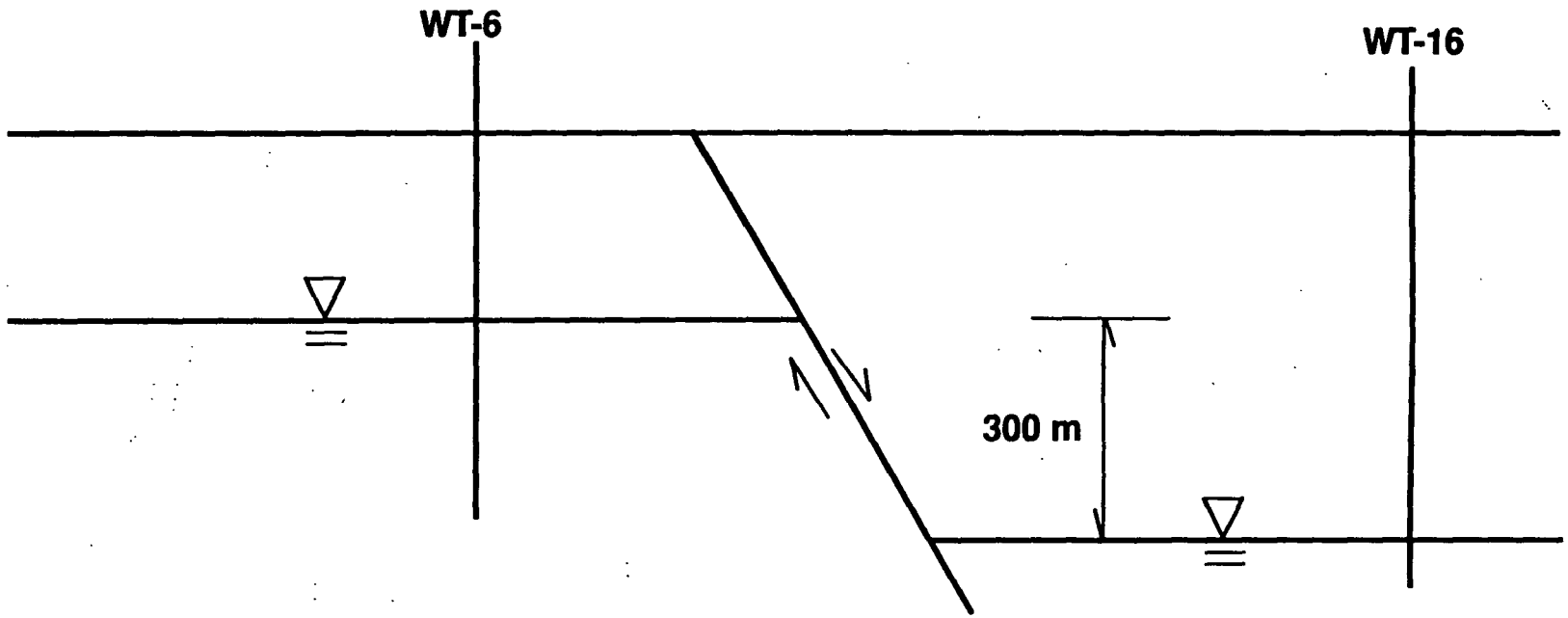
- Site feature: 300 m/2,000 m
- Potentially structurally controlled
- Potentially tectonically alterable
- Immediately upgradient from design repository area

POTENTIOMETRIC SURFACE IN THE GROUND-WATER STUDY AREA




116°
30'
116°
020'
1187
1100
WT-6
1029
1029
900
36°
52'
WT-16
753
730
737
774
730
728.6
775
730
1000
775
732
728.5
800
729
728.1
775
729.3
729.2
731
36°
45'
Potentiometric
Surface
5 mi
5 km

FAULT PLANE



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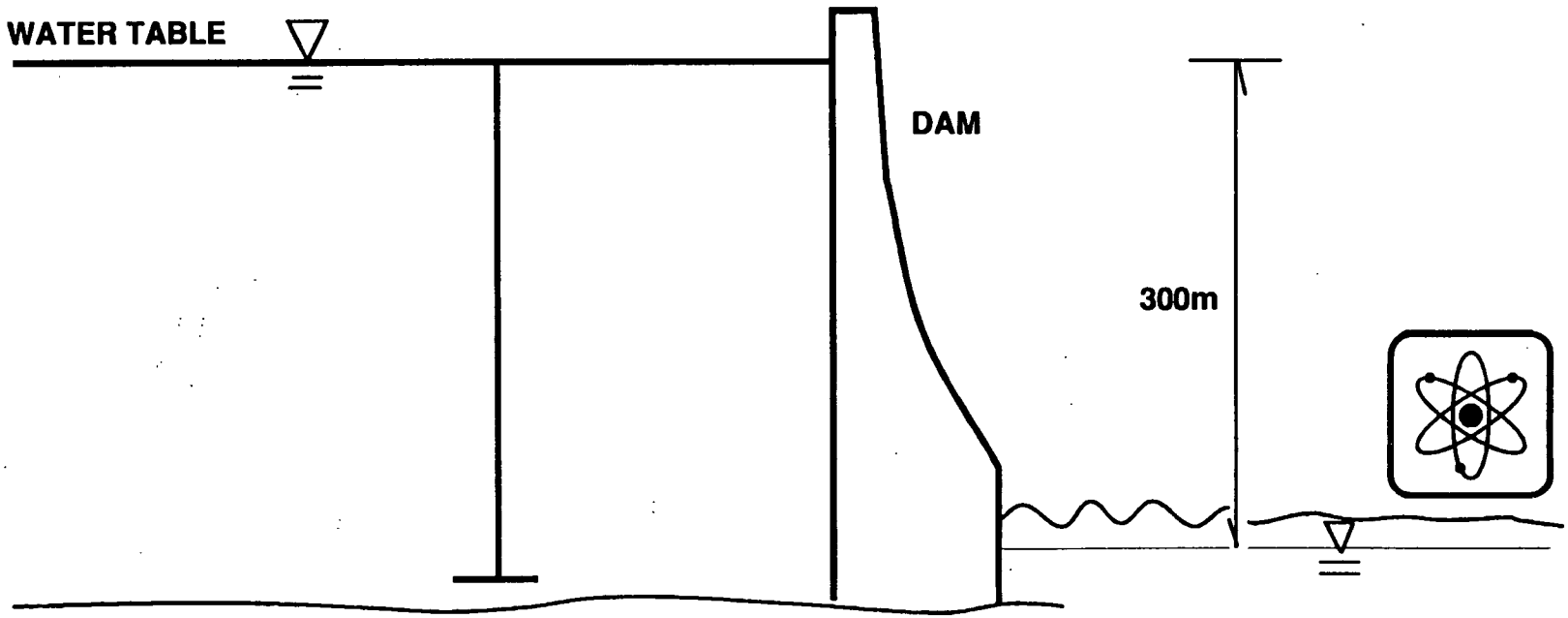
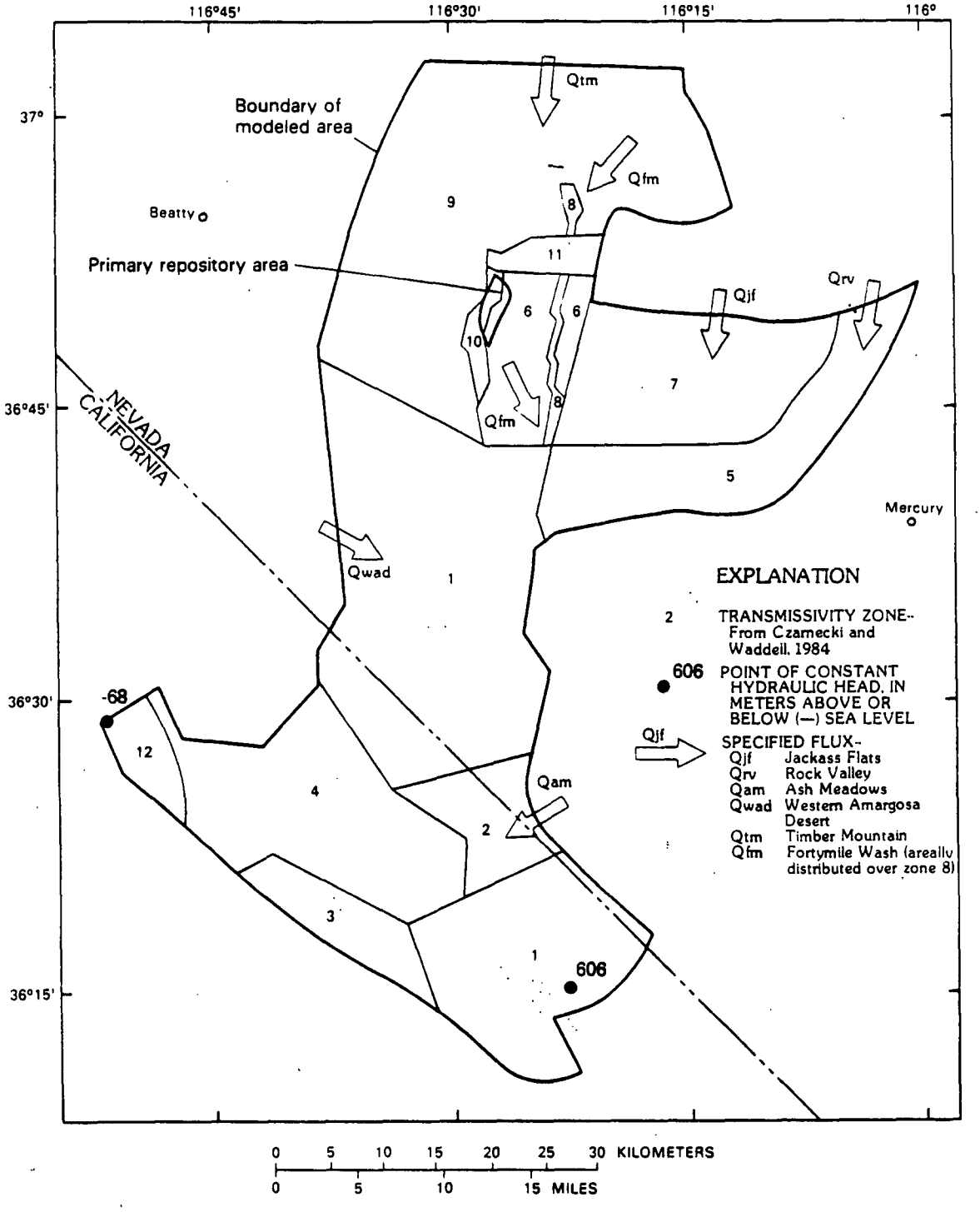
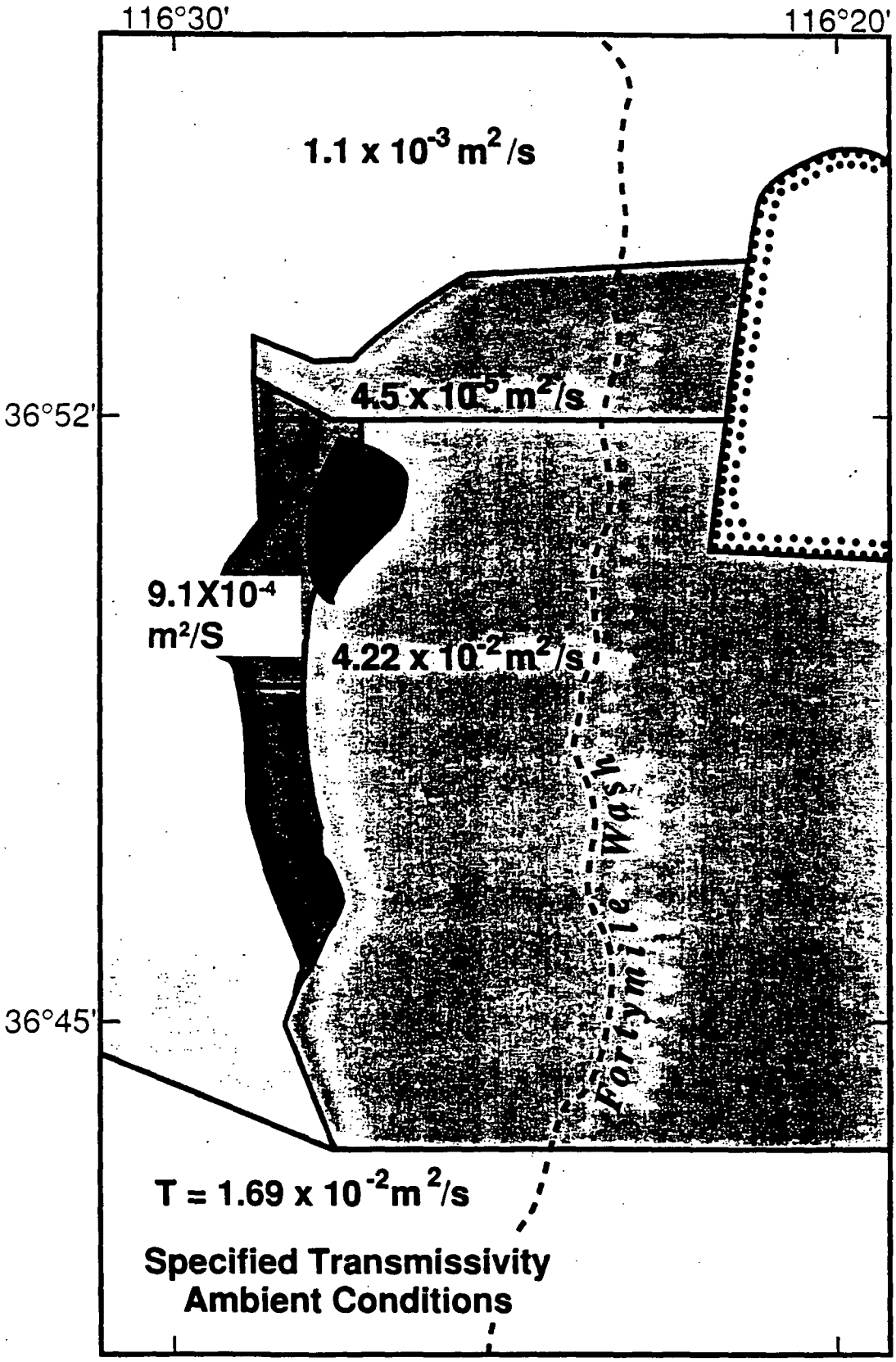
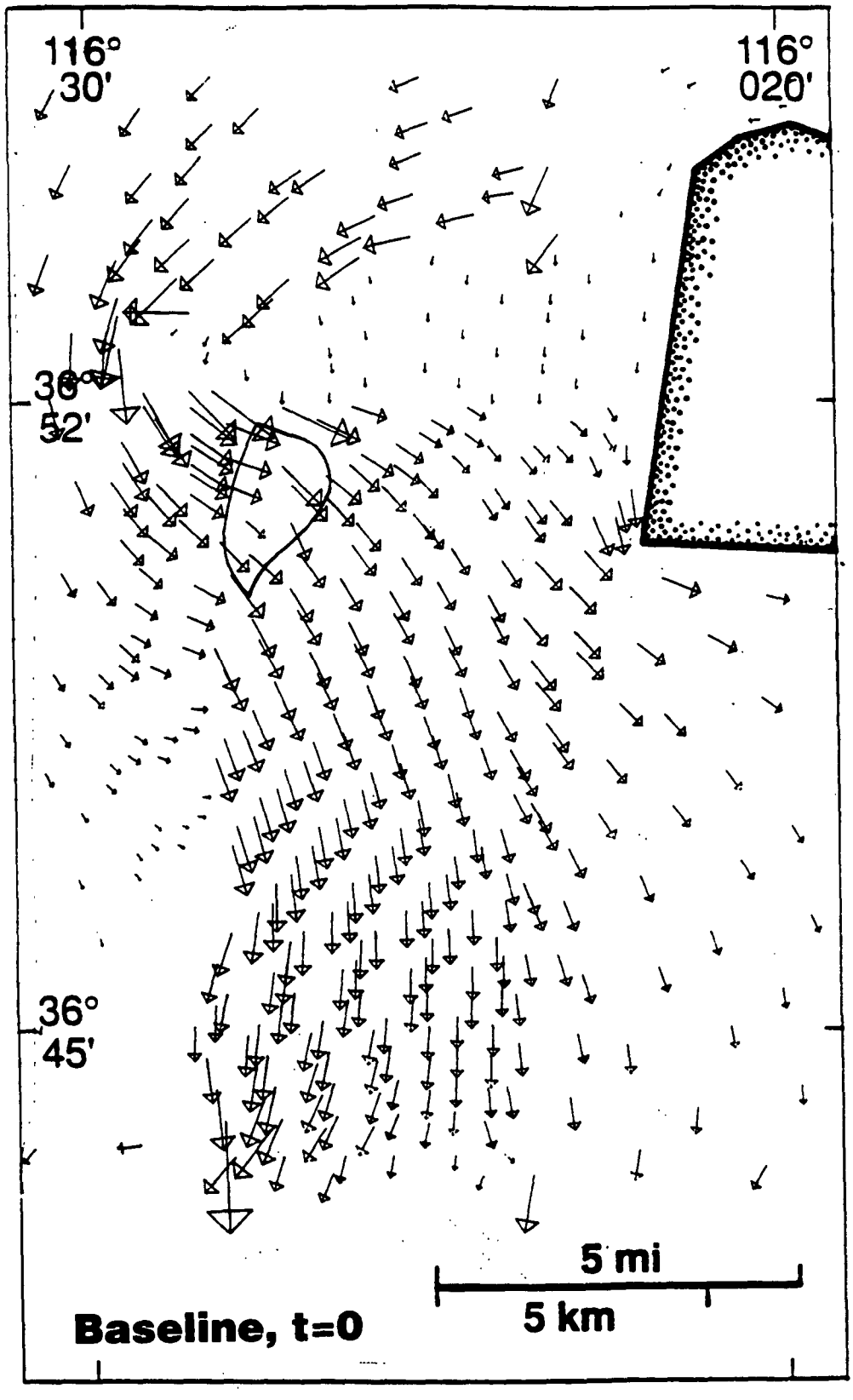


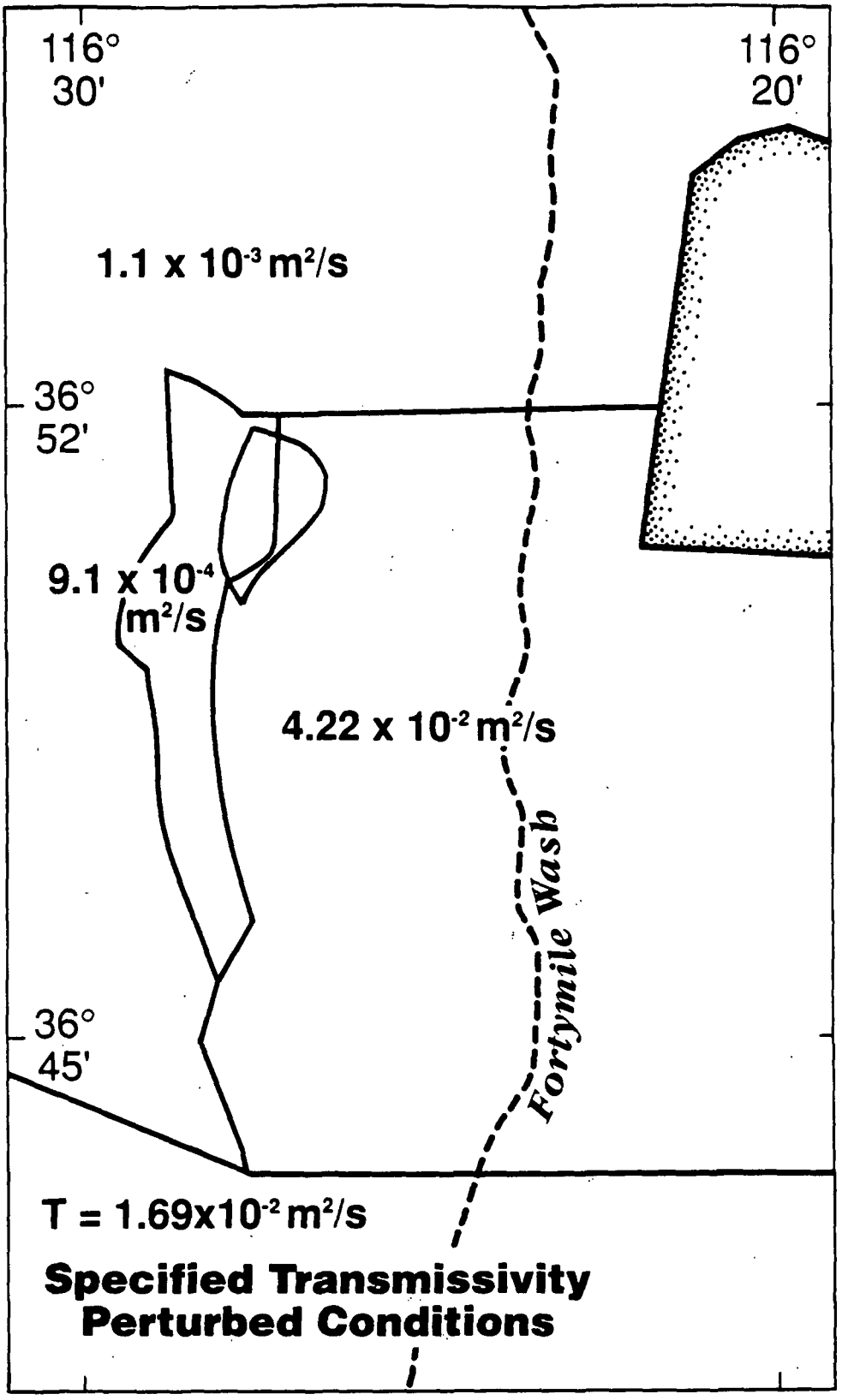
HGRZJC5P.125.NWTRB/6-25/27-91

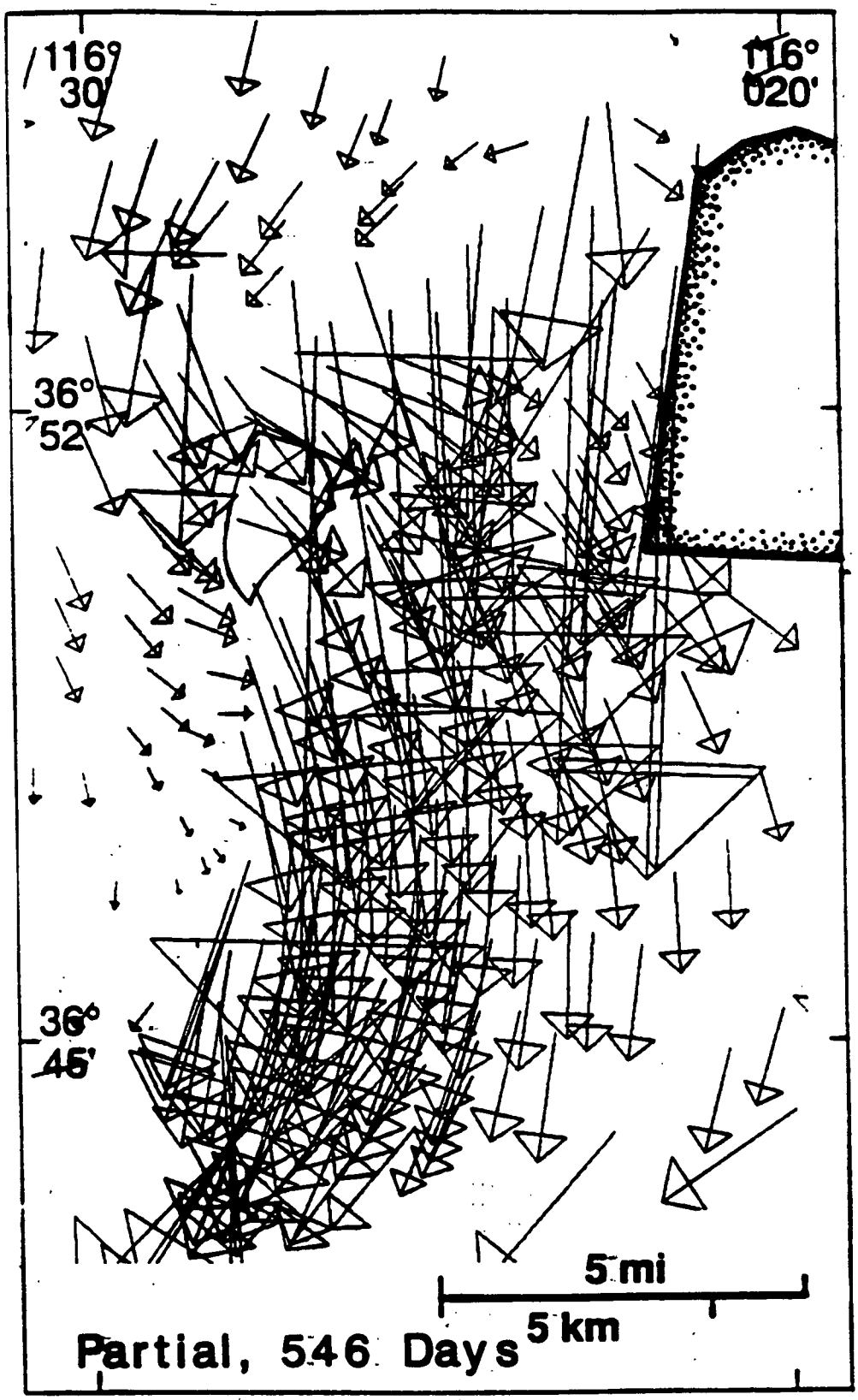
MODEL BOUNDARY FLUXES, CONSTANT-HEAD NODES, AND TRANSMISSIVITY ZONES

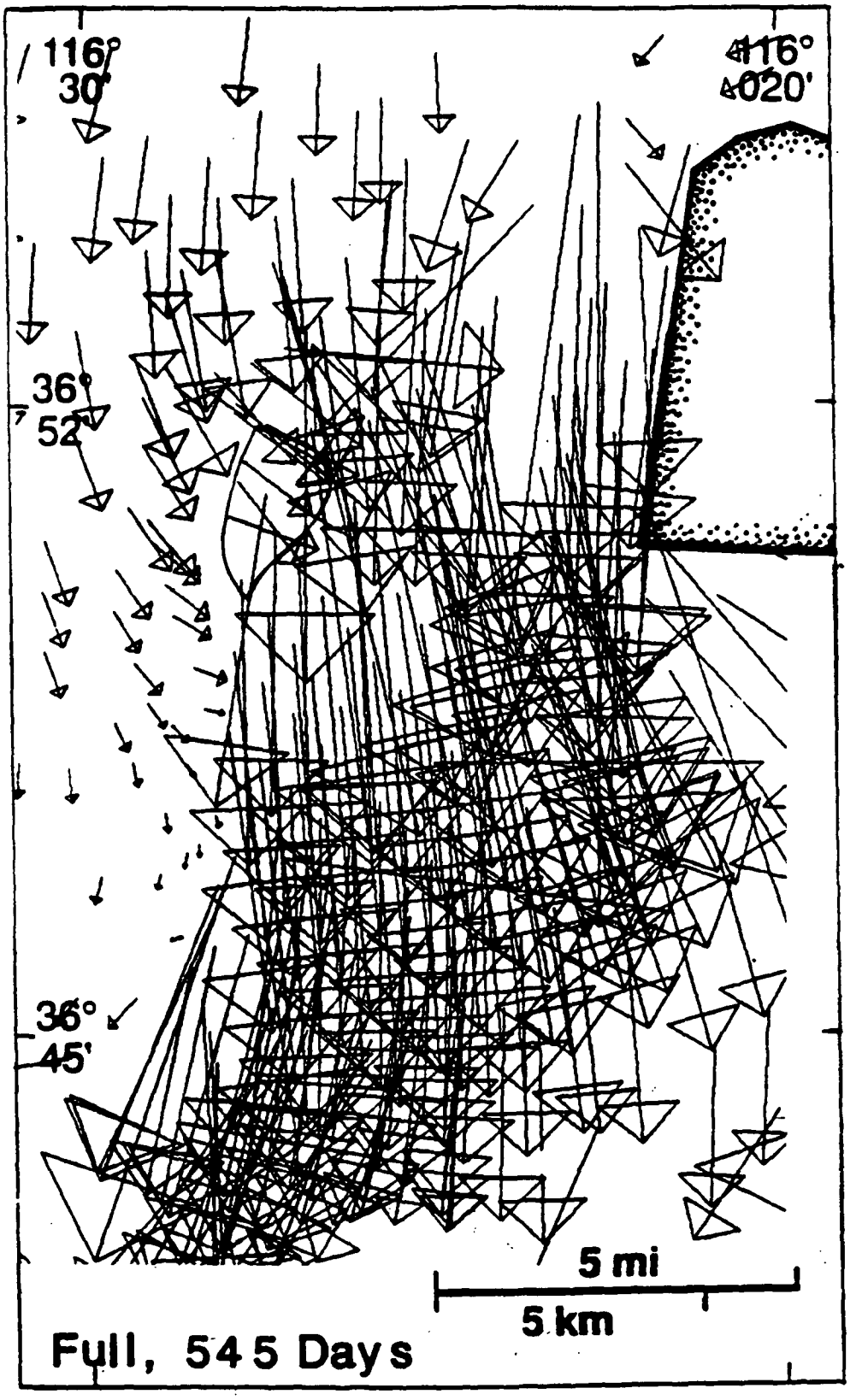


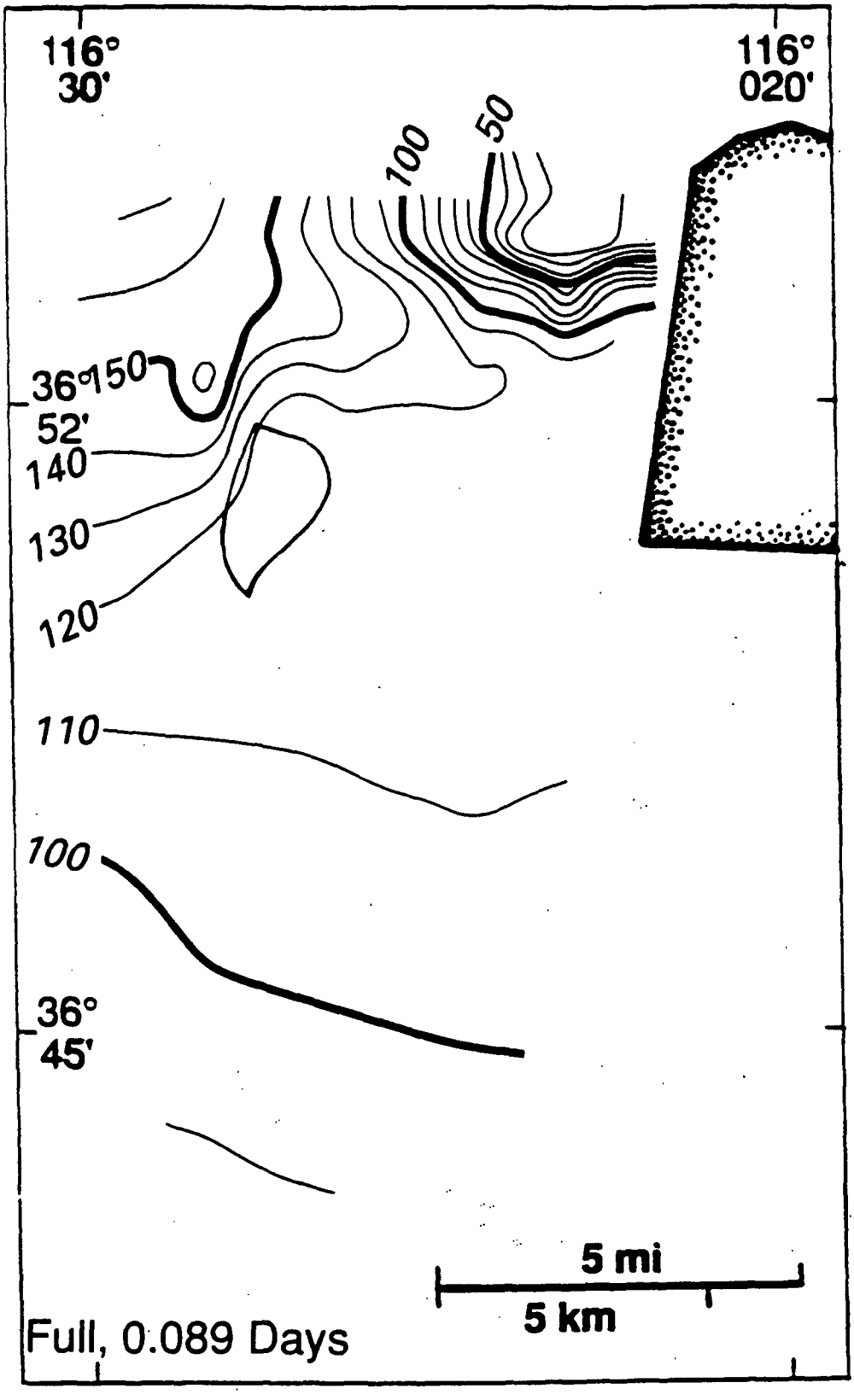

116°30'
116°20'
36°52'
36°45'
1.1 x 10-3 m2/s
4.5 x 10-5 m2/s
9.1X10-4 m2/S
4.22 x 10-2 m2/s
Forty mile Wash
T = 1.69 x 10-2m2/s
Specified Transmissivity
Ambient Conditions

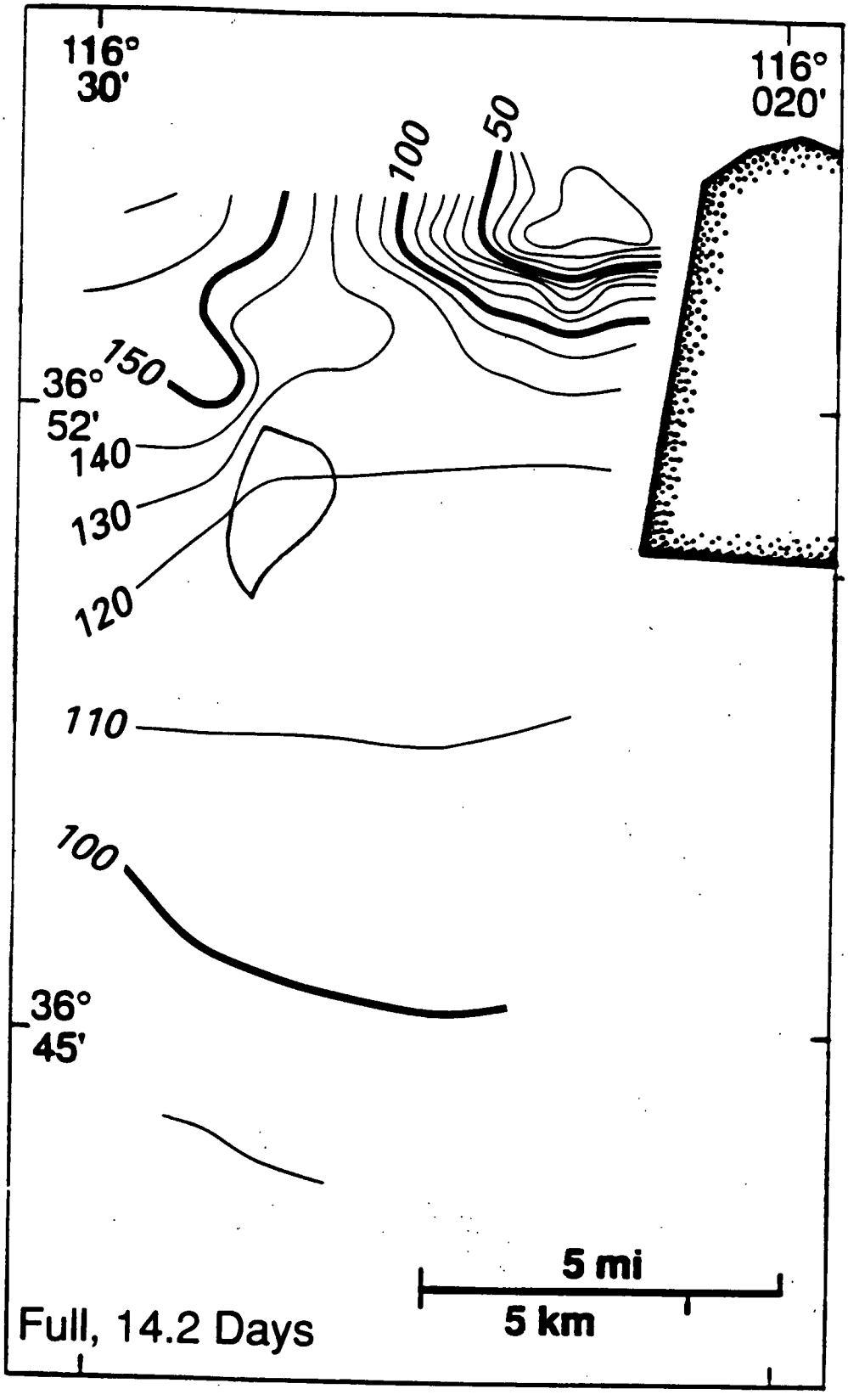

116°
30'
116°
020'
36°
52'
36°
45'
5 mi
5 km
Baseline, t=0

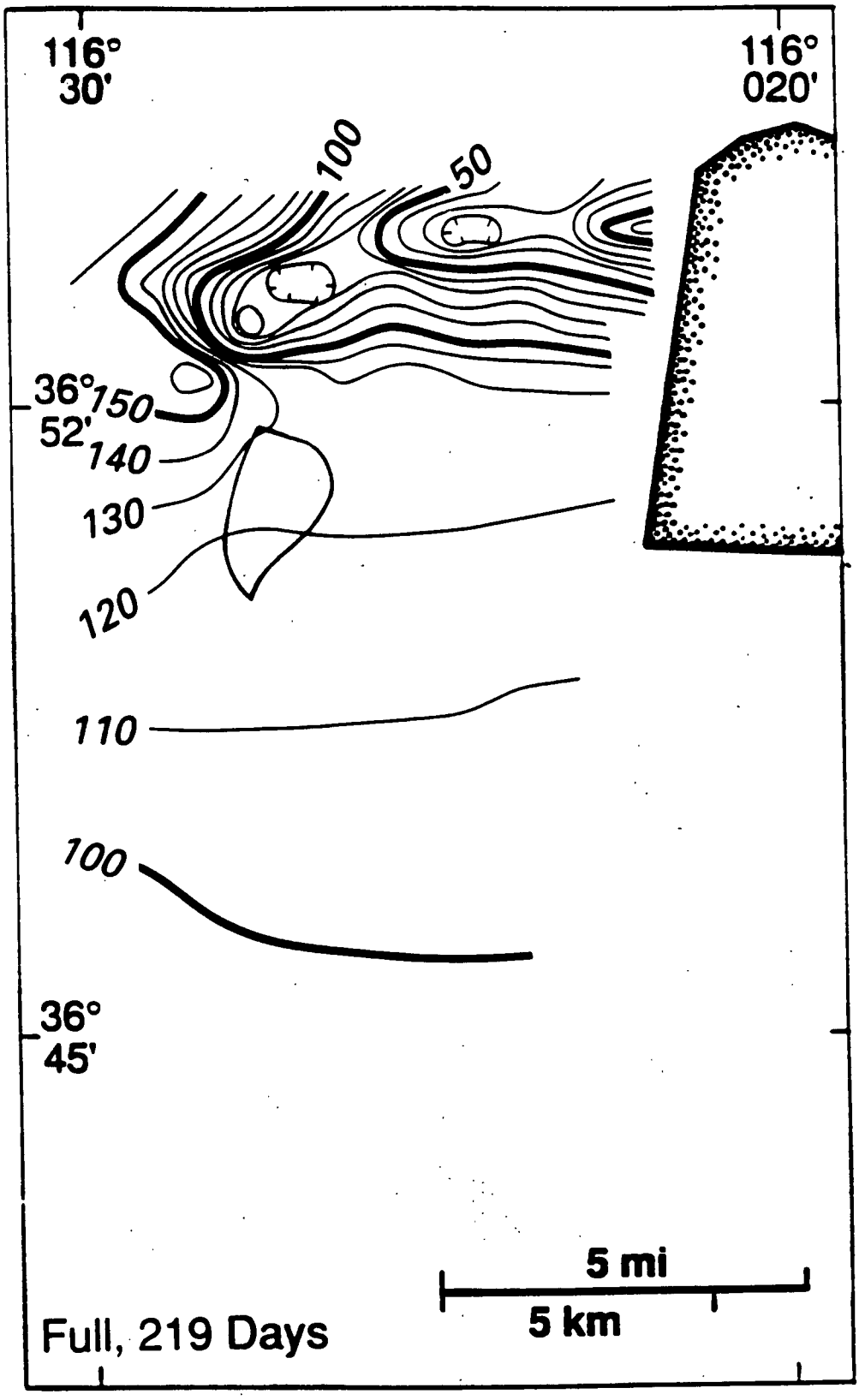

116° 30'
116° 20'
1.1 x 10⁻³ m²/s
36° 52'
9.1 x 10⁻⁴ m²/s
4.22 x 10⁻² m²/s
Fortymile Wash
36° 45'
T = 1.69x10⁻² m²/s
Specified Transmissivity
Perturbed Conditions

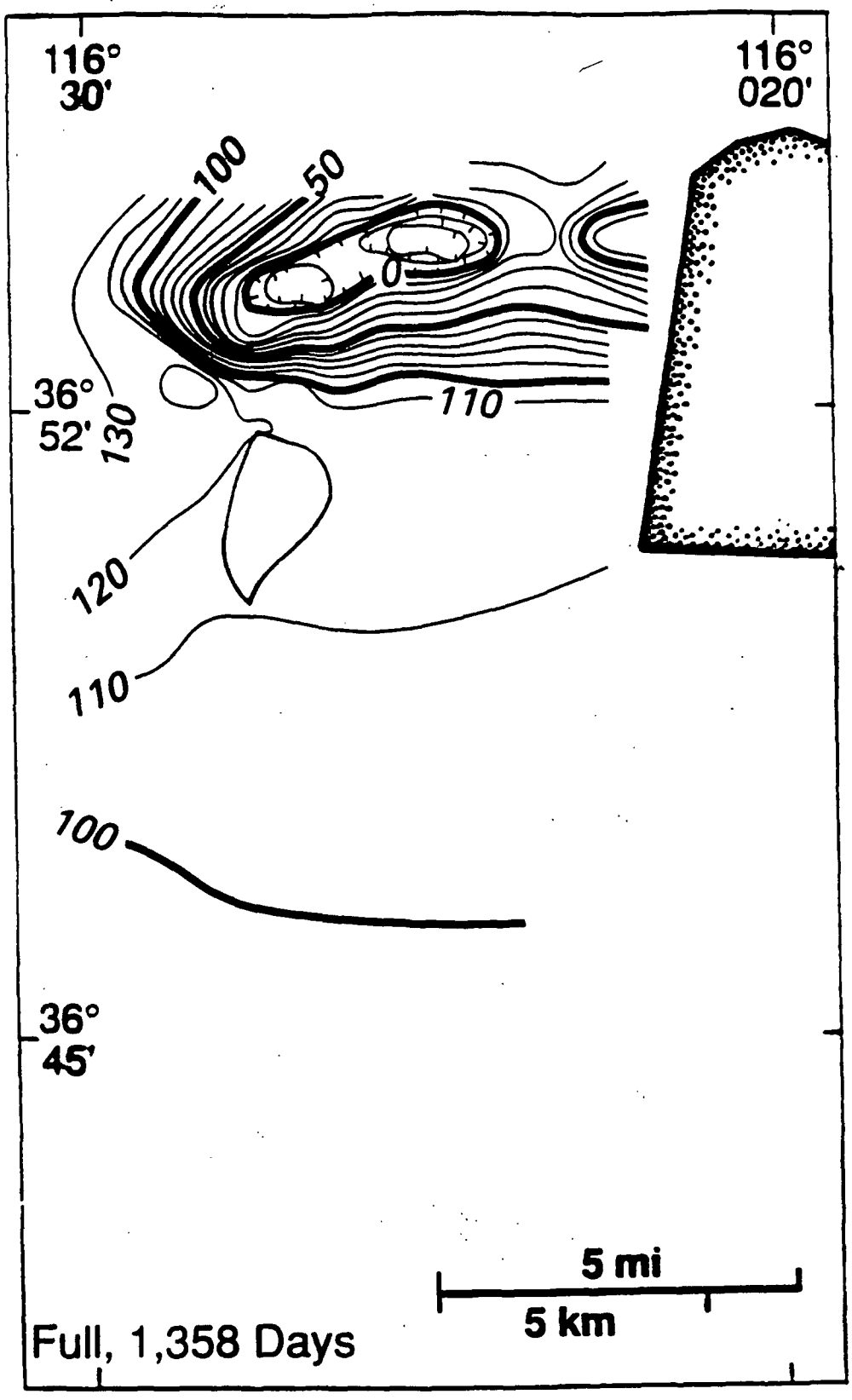

116°
30'
116°
020'
36°
52'
36°
45'
5 mi
5 km
Partial, 546 Days

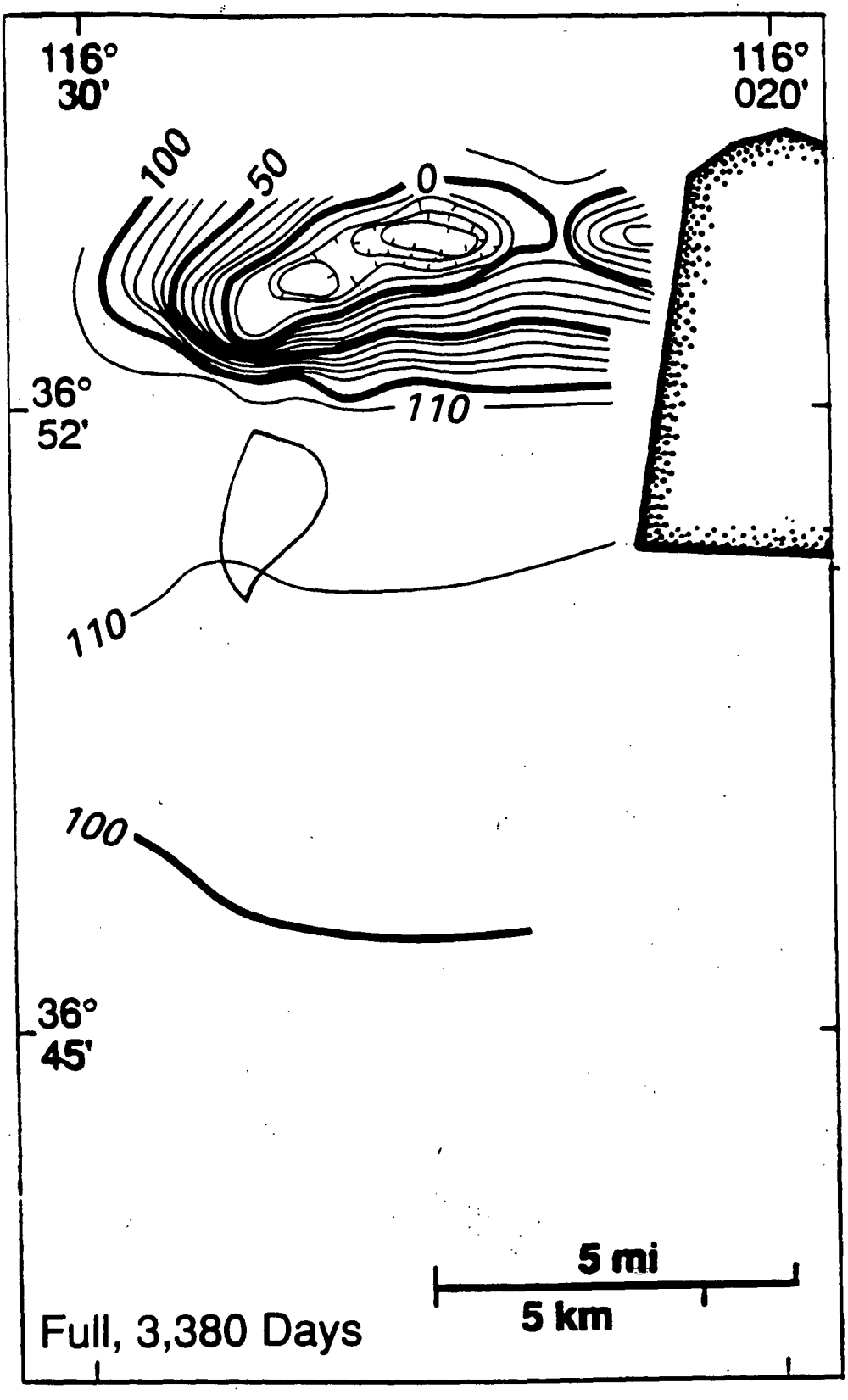

116°
30'
116°
020'
36°
52'
36°
45'
5 mi
5 km
Full, 545 Days

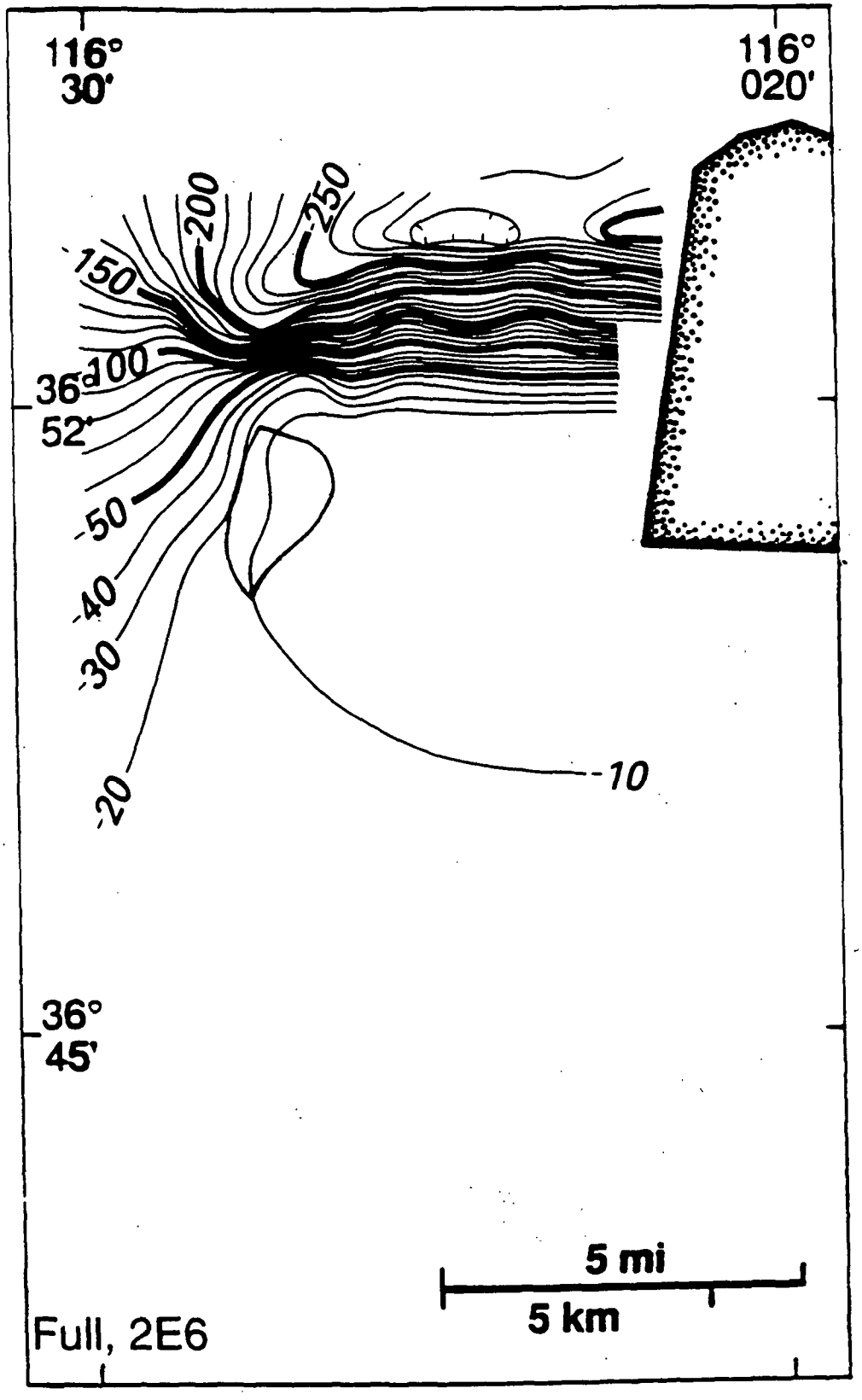

116°
30'
116°
020'
100
50
36°
52'
150
140
130
120
110
100
36°
45'
5 mi
5 km
Full, 0.089 Days

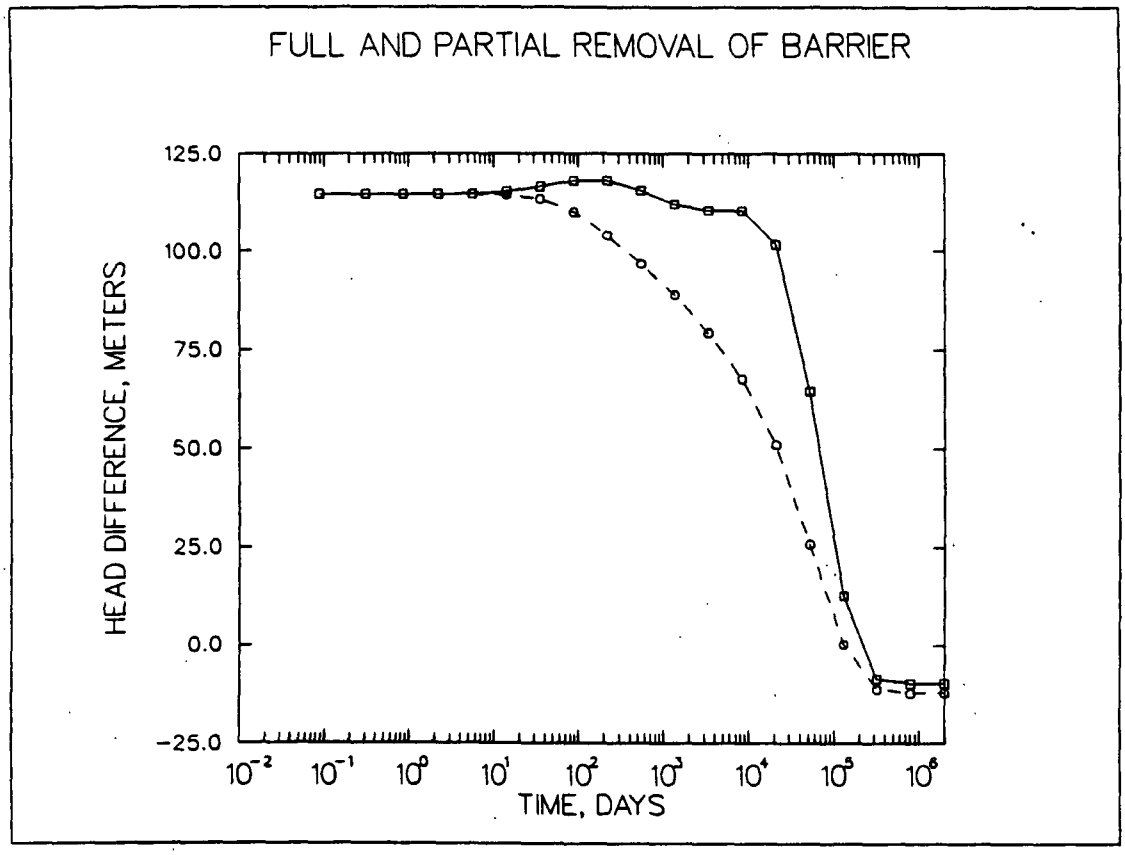

116°
30'
116°
020'
100
50
150
36°
52'
140
130
120
110
100
36°
45'
5 mi
5 km
Full, 14.2 Days


116°
30'
116°
020'
100
50
36°
52'
150
140
130
120
110
100
36°
45'
5 mi
5 km
Full, 219 Days


116°
30'
116°
020'
100
50
0
110
36°
52'
130
120
110
100
36°
45'
5 mi
5 km
Full, 1,358 Days


116°
30'
116°
020'
100
50
0
110
36°
52'
110
100
36°
45'
5 mi
5 km
Full, 3,380 Days


116°
30'
116°
020'
250
200
150
100
36°
52'
50
40
30
20
10
36°
45'
5 mi
5 km
Full, 2E6


FULL AND PARTIAL REMOVAL OF BARRIER
HEAD DIFFERENCE, METERS
125.0
100.0
75.0
50.0
25.0
0.0
-25.0
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
10^{5}
10^{6}
TIME, DAYS

Summary

- Water-level rise is dominated by increased recharge, not by abrupt increase in hydraulic conductivity
- Full removal of barrier results in larger increase in head versus a partial removal of barrier

Summary (continued)

- Maximum ground-water flux beneath repository occurs several years after the removal of barrier
- Repository apparently would not flood from water-table rise

Evidence of Recharge in Fortymile Wash

- Elevated tritium level
  UZN-92: ~160 TU (31 m TD)
  UE-29a#1: 200 pCi/L (65.5 m TD)
  UE-29a#2: 37 pCi/L (421.5 m TD)

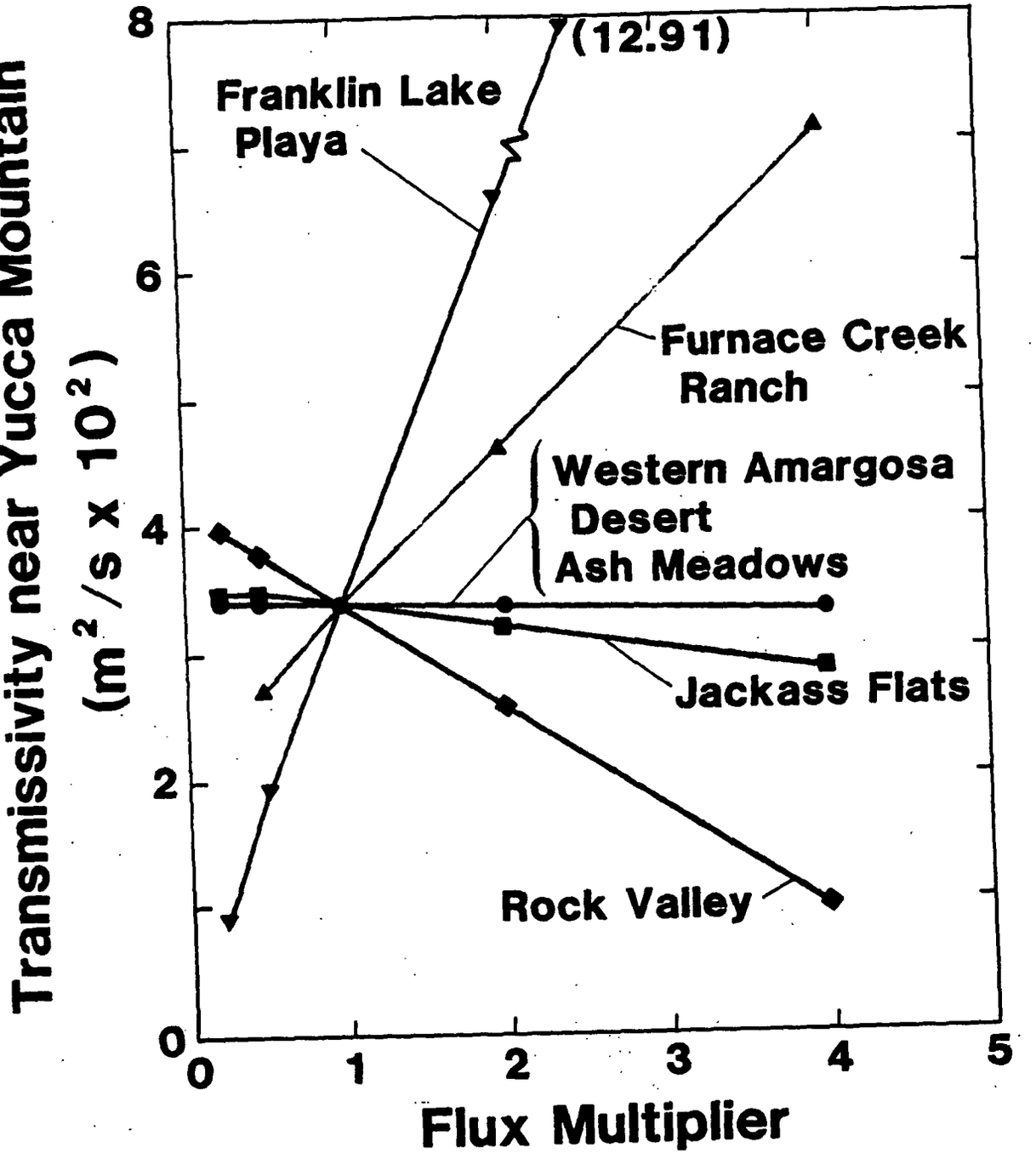
- Carbon-14
  UE-29a#1: 75.3 pmC
  UE-29a#2: 62.3 pmC

- Hydraulic head: 4 m decrease with depth

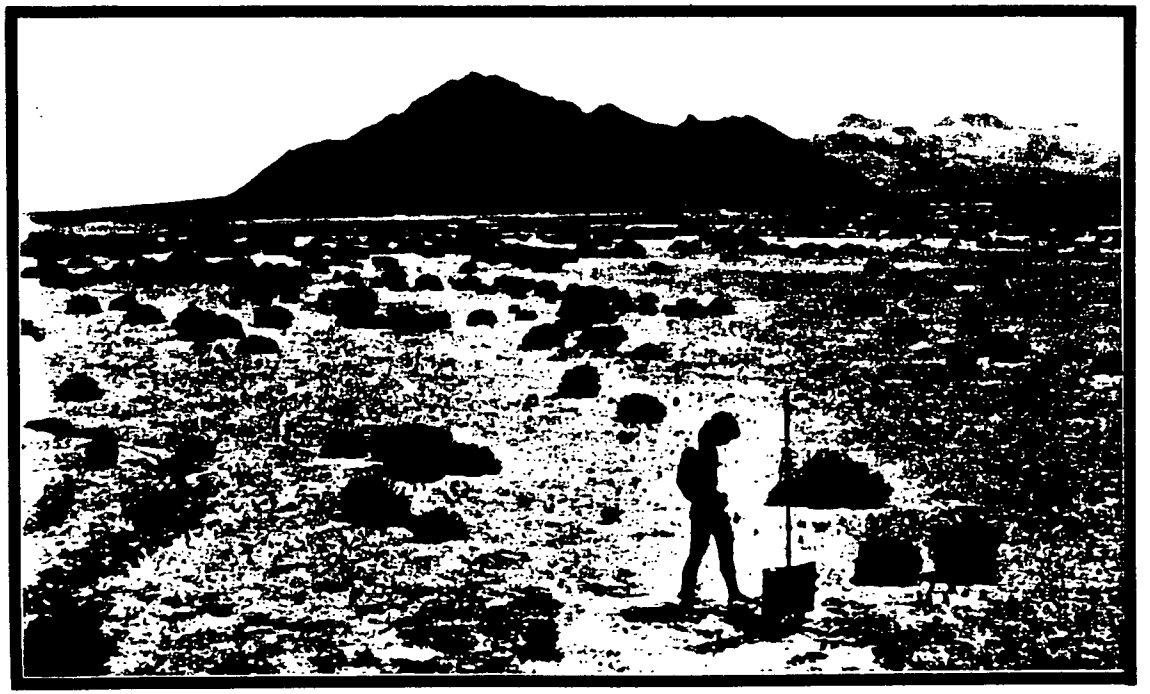
Fortymile Wash Activity

- FM series holes (3)
- FMN series neutron holes (20-30)
- Ponding and infiltration testing
- Hydrochemical sampling
- Hydraulic testing

PHOTO OF FRANKLIN LAKE PLAYA


(12.91)
Franklin Lake Playa
Furnace Creek Ranch
Western Amargosa Desert
Ash Meadows
Jackass Flats
Rock Valley
Transmissivity near Yucca Mountain (m²/s x 10²)
Flux Multiplier
0
2
4
6
8
0
1
2
3
4
5

EDDY-CORRELATION SITE 1



EDDY-CORRELATION SITE 2

PHOTO OF TRUCK STUCK IN MUD AT FRANKLIN LAKE PLAYA

Discharge at Franklin Lake Playa

- Bare soil evaporation: 1 to 3 mm/d
- Area of discharge not well defined
- Yucca Mountain ET measurements may provide baseline discharge from xeriphytes

PHOTO OF WATER-LEVEL MONITORING AT FRANKLIN LAKE PLAYA

HGRZJC5P.125.NWTRB/6-25/27-91

Methods to Refine Areal Extent of Evapotranspiration

- Piezometer and tensiometer nests
- Bowen ratio stations
- Phreatophyte mapping