GEOLOGIC MAP OF OREGON

By

George W. Walker and Norman S. MacLeod

1991

H I N G

SCALE 1:500 000
1 inch equals approximately 8 miles (13 kilometers)
1 centimeter equals approximately 5 kilometers (3 miles)

10 0 10 20 30 40 MILES

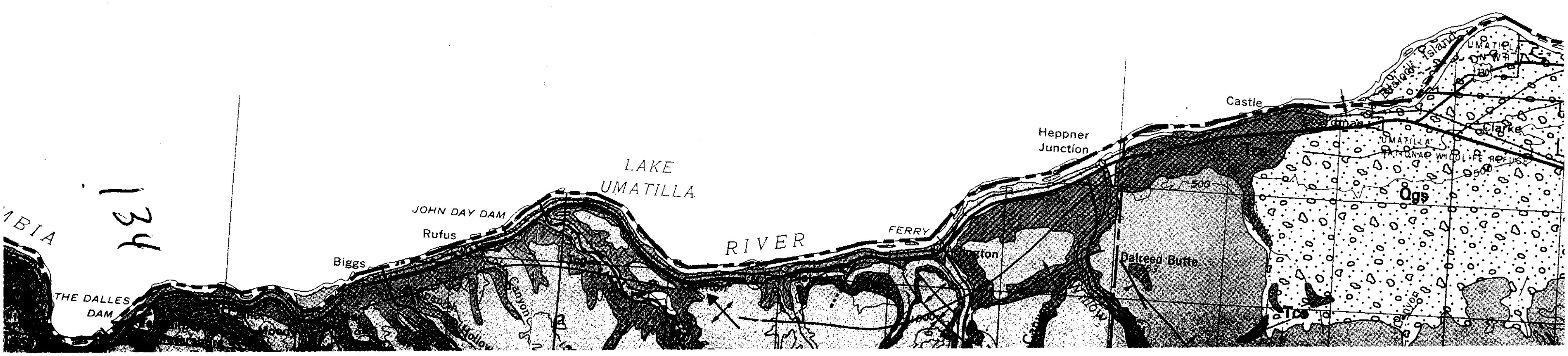
10 0 10 20 30 40 50 KILOMETERS

CONTOUR INTERVAL 500 FEET
BATHYMETRIC CONTOUR INTERVAL 100 METERS
NATIONAL GEODETIC VERTICAL DATUM OF 1929

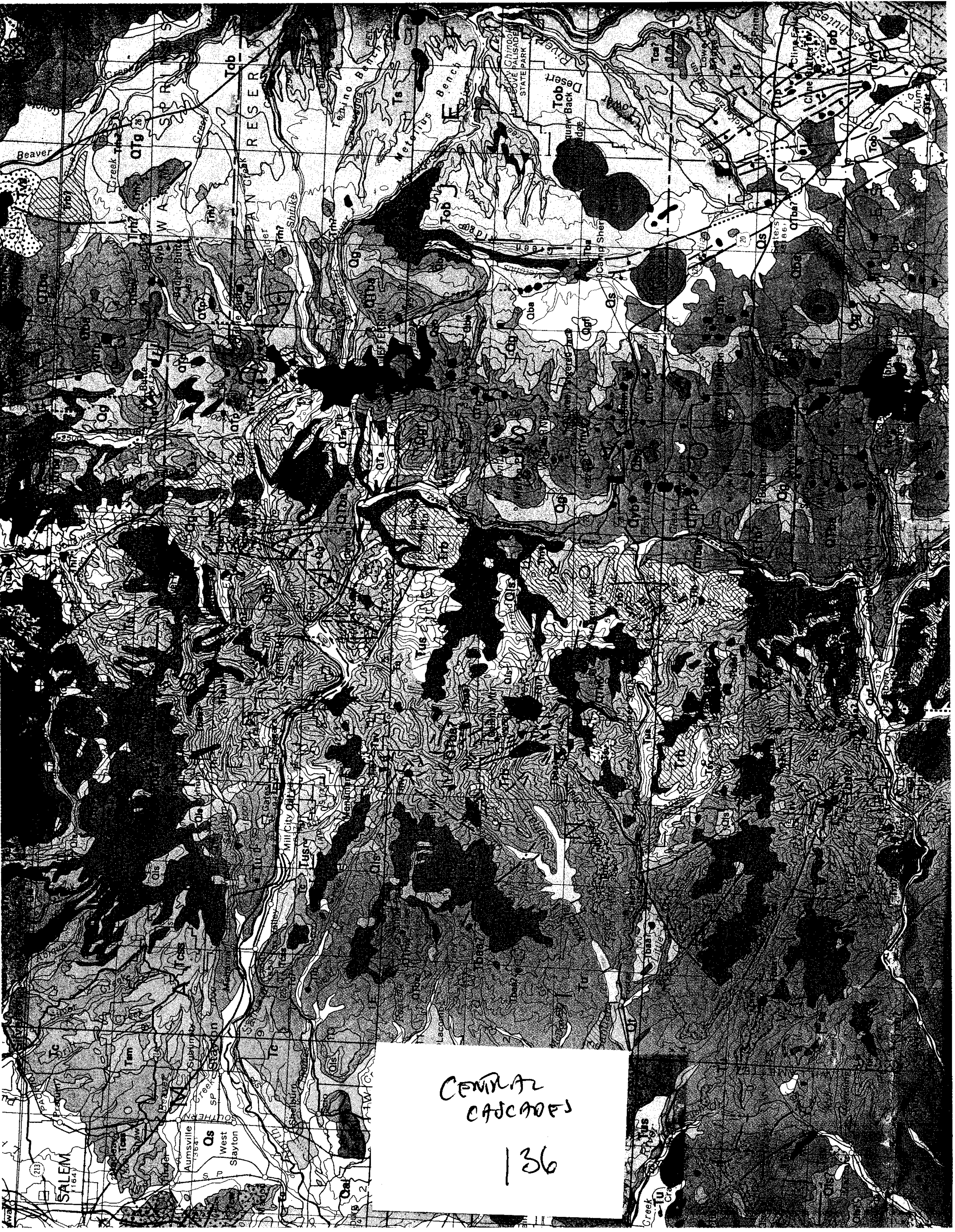
121° 120°

E (ZONE 10)

134

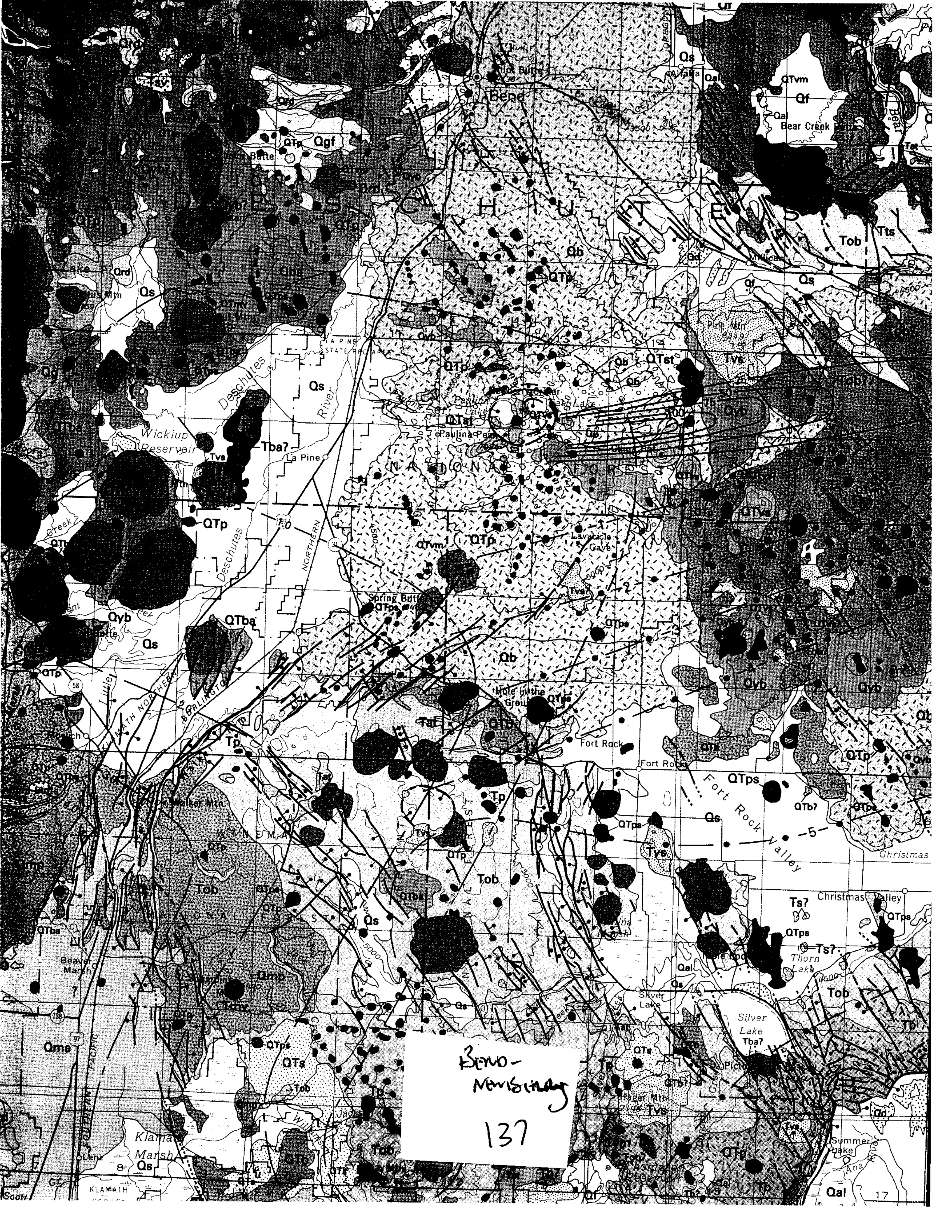



PORTLAND
Hillsboro
Forest Grove
Beaverton
Tillamook
Tualatin
Tigard
Sherwood
Newberg
Wilsonville
Canby
Dayton
St Paul
Donald
Hubbard
Woodburn
West Woodburn
Gervais
Mount Angel
Sheridan
Grand Ronde
Ballston
Perrydale
Keizer
SALEM
Rickreall
Independence
Monmouth
Silverton
Aumsville
West Stayton
Stayton
Buena Vista
Talbot
Jefferson
Millersburg
Adair Village
ALBANY
CORVALLIS
Lebanon
Eddyville
Nashville
Burnt Woods
Crabtree
Lacomb
Mehama
Sublimity
Macksburg
Needy
Yoder
Monitor
Scotts Mills
Shelburn
Tallman
Philomath
Summit
Hoskins
Kings Valley
Pedee
Airlie
Carlton
Lafayette
Bellevue
Whiteson
Wapato
Gaston
Laurel
Farmington
Cornelius
Aloha
Reedville
Verboort
Orenco
Chemawa
Brooks
Hopmere
Waconda
Shaw
Macleay
Turner
Marion
Sodaville
Brownsville
Logsden
Blodgett
Wren
Harlan
Nortons
Chitwood
Elk City
Aurora
Barlow
Butteville
Liberal
Marquam
Pratum
Springbrook
Qal
Qs
Tss
Tc
Tsd
Tsr
Qt
Qls
Tcw
Tsm
Tcss
Tfe
Tus
Tu
QTs
Ttvm?
Tss?
QTg
Tbaa?
Tt
Tim
MID - WILLAMETTE
135

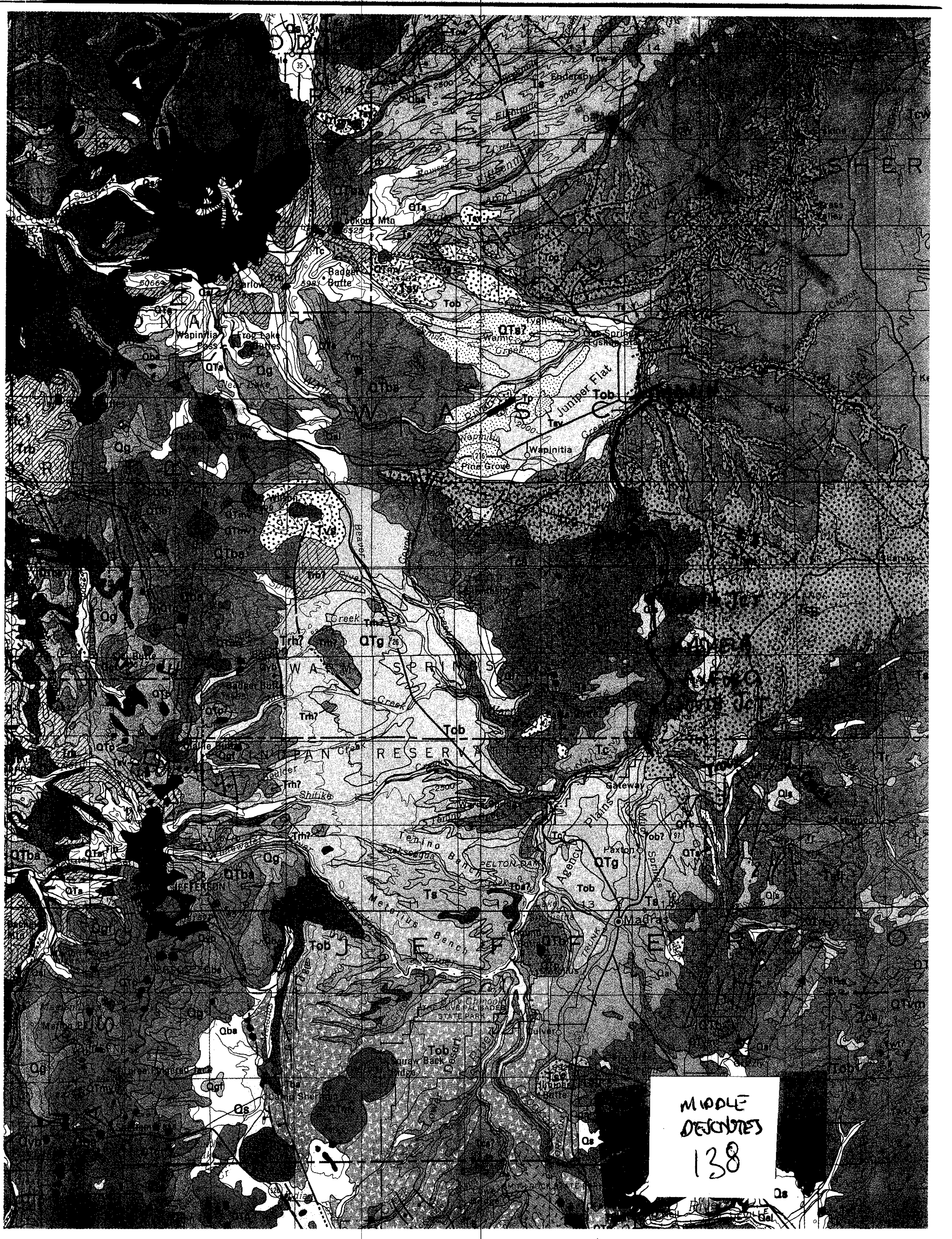


CENTRAL CASCADES

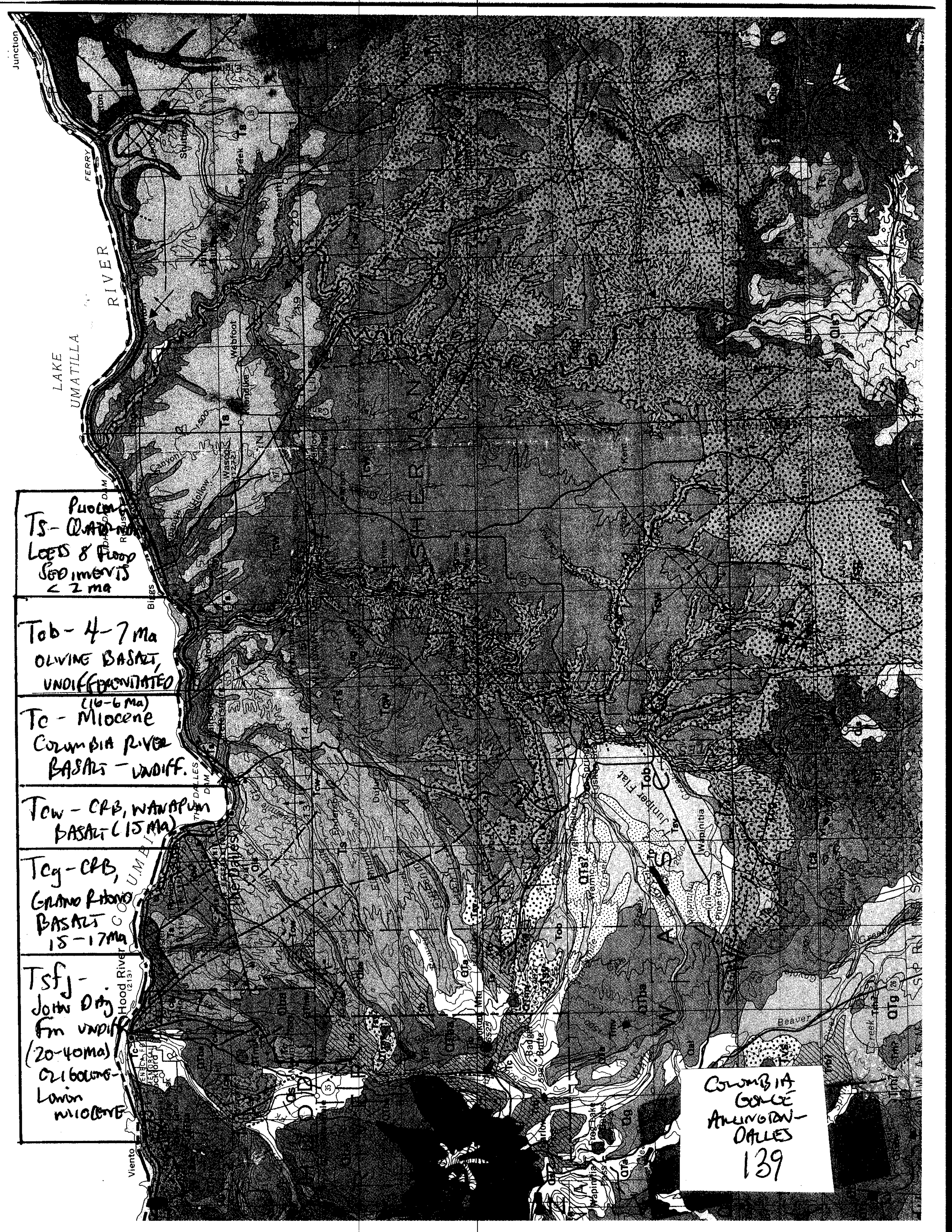
136



Bend-Newberry
137



MIDDLE DESCHUTES
138


Junction
FERRY
RIVER
LAKE UMATILLA
Webfoot
Wasco
Biggs
DALLES DAM
The Dalles
Hood River
Viento
Juniper Flat
Wapinitia
Beaver
SHERMAN
Pliocene
Ts - Quaternary
Loess & Flood Sediments
< 2 ma
Tob - 4-7 ma
Olivine Basalt, Undifferentiated
(16-6 Ma)
Tc - Miocene
Columbia River Basalt - Undiff.
Tcw - CRB, Wanapum Basalt (15 Ma)
Tcg - CRB, Grand Ronde Basalt 15-17 ma
Tsfj - John Day Fm undiff (20-40 ma) Oligocene - Lower Miocene
Columbia Gorge Arlington - Dalles
139

COLUMBIA GORGE
HOOD R. – PDX
140

basaltic flows that extends along the axis of the High Lava Plains province. The young basaltic belt extends from Jordan Craters near the Idaho border to the basaltic eruptions of Newberry and includes Diamond Craters near Burns and Devils Garden flows NE of Fort Rock.

In places the older rising basaltic magma encountered ground water, which caused fragmentation of the basalt and violent steam explosions. Where the explosions were of moderate intensity, basaltic tuff cones and tuff rings formed including Fort Rock and Table Mountain. More violent steam explosions blasted out prominent craters such as Hole-in-the-Ground.

Newberry is surrounded by a complexly faulted terrain (Figure 6). The NE-trending Walker Rim Fault Zone cuts Newberry's southern flank but offsets only its older flows. The Tumalo Fault Zone offsets older flows on the lower NW flank and extends northwestward into the Cascade Range at Green Ridge. Newberry lavas cover the relationship between these two fault zones, but they may represent one curving fault system. The Brothers Fault Zone extends across the extreme NE flank but it does not appear to offset surficial Newberry lavas. It probably extends at depth to join the Tumalo and Walker Rim Fault Zones.

NEWBERRY'S FLANKS

Newberry Volcano is among the largest Quaternary volcanoes in the lower 48 states. It covers an oval area (20 mi (32 km) east- west by 30 mi (48 km) north-south) in excess of 500 sq mi (1300 sq km) (Figure 1). Lavas from Newberry extend northward many tens of miles beyond the volcano (Figure 6). The oval shape of Newberry results from the distribution of vents and lava flows of basaltic andesite, basalt, and minor andesite along the length of the volcano. In contrast, dacitic to rhyolitic volcanism has been focused in the central part. Pyroclastic- flow deposits are most widely exposed on the east and west flanks of the volcano, as are nearly all the dacitic to rhyolitic domes and lava flows (Figure 7). These gently sloping flanks consist of basalt and basaltic andesite flows, andesitic to rhyolitic ash-flow and air-fall tuffs and other types of pyroclastic deposits, dacite to rhyolite domes and flows, and alluvial sediments produced during periods of erosion of the volcano.

The north and south flanks of Newberry are almost exclusively veneered by basalt and basaltic andesite flows and associated vents. Individual flows are a few ft to 100 ft (1 to 30 m) thick and cover areas of less than a sq mi to tens of sq mi (1 to 100 sq km). The NW flank of Newberry Volcano has long been a zone of weakness as shown by the large number of cinder cones and flows of varying ages that are found along it. A water well drilled for the Lava Lands Visitor Center shows that the older lavas of the Northwest Rift Zone are over 400 ft (120 m) thick there and overlie what is believed to be the Tumalo Tuff (Table III). The flank flows can be divided into two groups based on their age relative to the 7,600 year old Mazama Ash (6,845±50 14C years) from Crater Lake, about 70 mi (110 km) to the SW. The youngest flows overlie Mazama Ash and were erupted over a short period of time about 7,000 years ago (6,100 14C years). The older flows are covered by Mazama Ash; surface features on some flows (such as the North Kawak Flow) suggest a relatively young age, perhaps 9,000 to 15,000 years, others are likely several tens to hundreds of thousands of years old.

More than 400 cinder cones and fissure vents have

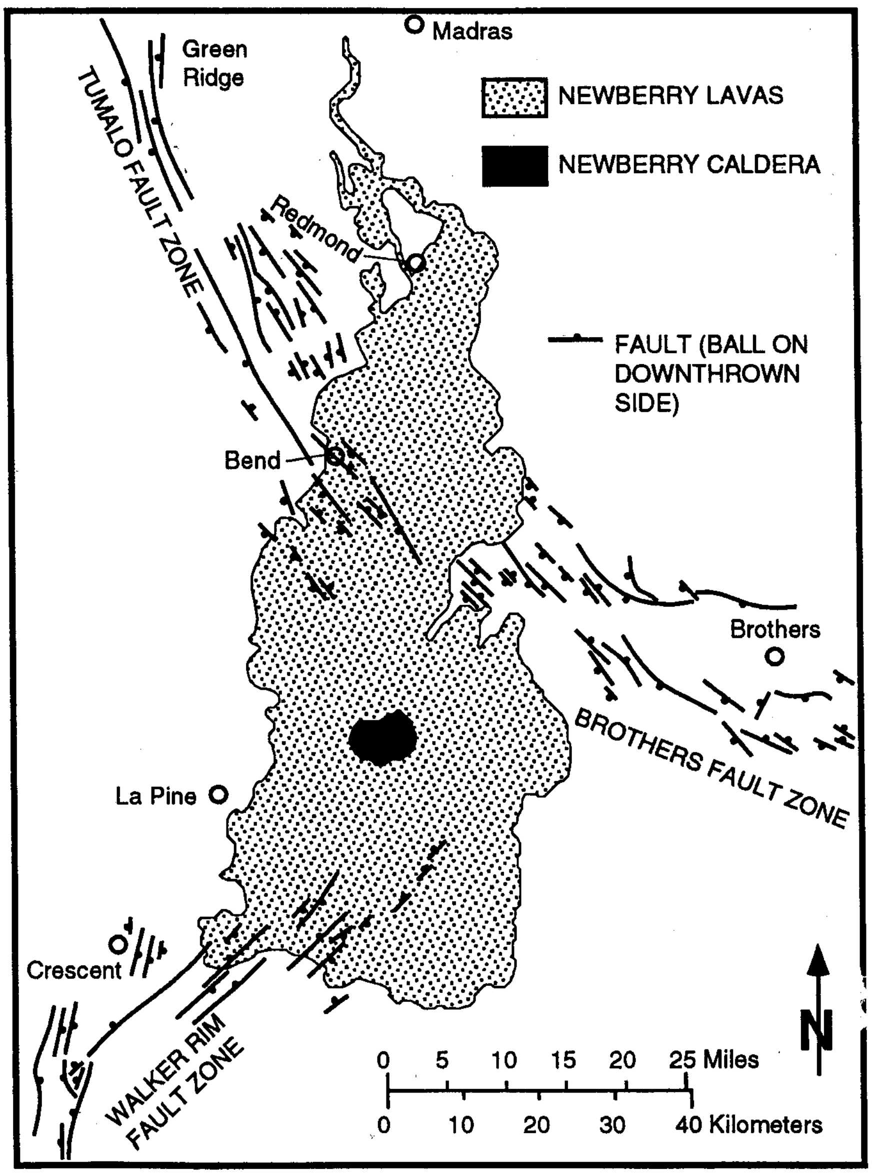


Figure 6 -- Extent of lavas from Newberry Volcano.

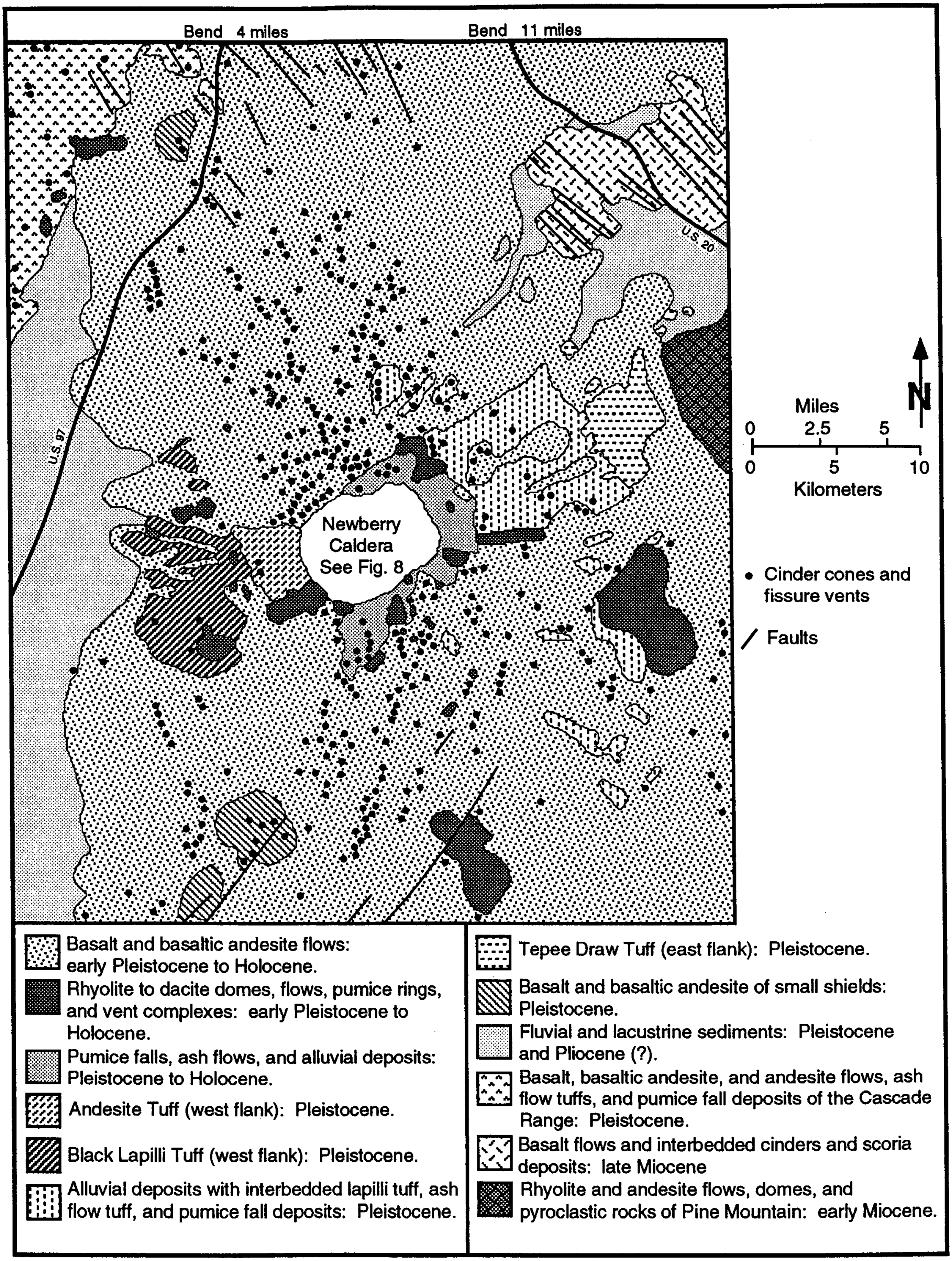


Figure 7 -- Generalized geologic map of Newberry Volcano.

Table II – Summary of calendar and carbon-14 ages from Newberry Volcano area. **

Dated Feature	Carbon- 14 age[1] (14C yr B.P.)	Reference	Weighted mean age (14C yr B.P.)	Calibrated age[2] (calendar yrB.P.)
BIG OBSIDIAN ERUPTIVE PERIOD				
Big Obsidian Flow	No 14C date[3]			
Paulina Lake Ashflow	1,270±60	Pearson and others (1966)	1,310±40[4]	1,260±90
	1,340±60	Robinson and Trimble (1983)		
	1,390±200	Meyer Rubin, in Peterson and Groh (1969)		
	2,054±230	Libby (1952)		
Newberry Pumice (pumice-fall deposits)	1,720±250	Spiker and others (1978)	1,580±110	1,460±110
	1,550±120	Robinson and Trimble (1983)		
EAST LAKE ERUPTIVE PERIOD				
East Lake Obsidian Flows	No 14C date[5]			
TERRACE DEPOSITS AT LITTLE CRATER CAMPGROUND				
Terrace Deposits	4,300±100	Robinson and Trimble (1983)	4,300±100	4,860±200
NORTHWEST RIFT ERUPTIVE PERIOD				
Lava Butte Flow	6,160±70	Chitwood and others (1977), Robinson and Trimble (1981)	6,160±70	7,020±140
Gas-Line Flows	5,800±150	Chitwood and others (1977); Robinson and Trimble (1981)	6,100±60	6,940±80
	6,150±65	Robinson (1977); Chitwood and others (1977)		
North Sugarpine Flow	5,870±60	Robinson and Trimble (1981)	5,870±60	6,720±80
Forest Road Flow	5,960±100	Peterson and Groh (1969)	5,960±100	6,810±130
Lava Cast Forest Flow	6,150±210	Peterson and Groh (1969)	6,320±110	7,210±150
	6,380±130	Peterson and Groh (1969)		
Lava Cascade Flow	5,800±100	Peterson and Groh (1969)	5,800±100	6,640±160
North Summit Flow	6,090±60	Peterson and Groh (1969)	6,090±60	6,910±100
Surveyor Flow	5,835±195	Swanberg and others (1988)	6,030±90	6,880±120
	6,080±100	Peterson and Groh (1969)		
INTERLAKE ERUPTIVE PERIOD				
Central Pumice Cone	No 14C date[6]			

143

Game Hut Obsidian Flow	No 14C date[7]			
Interlake Obsidian Flow	No 14C date[8]			
East Lake Tephra	6,220±200 6,500±300 6,550±300	Meyer Rubin and W.E. Scott, unpublished data, 1985. Meyer Rubin, in Linneman (1990) Meyer Rubin, in Linneman (1990)	6,400±130	7,270±120
<u>CLIMATIC ERUPTION OF MT. MAZAMA</u>				
Mazama Ash	6,845±50[9]	Bacon (1983)	6,845±50	7,630±50
<u>NEWBERRY CRATER ARCHAEOLOGY</u>				
Oldest domestic structure	8,460±110 8,540±90 8,670±110	Connolly (1999) Connolly (1999) Connolly (1999)	8,555±62[10]	9,530±40
Earliest dated human occupation	9,920±470	Connolly (1999)	9,920±470	11,010±1300
<u>EAST RIM ERUPTIVE PERIOD</u>				
East Rim Fissure	10,000±500	Meyer Rubin, in Linneman (1990)	10,000±500	11,160±1200
<u>FORT ROCK CAVE ARCHAEOLOGY</u>				
Earliest dated human occupation	13,200±720	Bedwell (1973)	13,200±720	15,740±1100

** Modified from MacLeod and others (1995).
[1] Carbon-14 ages based on Libby half-life of 5,568 yrs. Years before present (yr B.P.) measured from 1950 A.D.
[2] Generalized from program in Stuiver and Reimer (1993) that computes intercepts and range (one confidence interval). Radiocarbon age curve not linear and may have multiple possible calendar ages (intercepts) for a given carbon-14 age. Calibrated age as reported here is midpoint between oldest and youngest intercepts rounded to nearest ten years; reported error is range (one confidence interval as calculated by the program).
[3] Hydration-rind age of 1,400 calendar years in Friedman (1977) is too old based on stratigraphic position. Big Obsidian Flow overlies Paulina Lake Ashflow which has a calibrated age of 1,260 calendar years.
[4] Weighted mean age does not include Libby's (1952) determination of 2,054 yr B.P.
[5] Hydration-rind age of 3,500 calendar years in Friedman (1977).
[6] Hydration-rind age of 4,500 calendar years in Friedman (1977) is too young based on stratigraphic position. Central Pumice Cone deposits lie between East Lake Tephra and North Summit Flow which have calibrated ages of 7,270 and 6,910 calendar years respectively.
[7] Hydration-rind age of 6,700 calendar years in Friedman (1977) is too young based on stratigraphic position. Flow is younger than Central Pumice Cone. Central Pumice Cone deposits lie between East Lake Tephra and North Summit Flow which have calibrated ages of 7,270 and 6,910 calendar years respectively.
[8] Hydration-rind age of 6,700 calendar years in Friedman (1977) is too young based on stratigraphic position. Flow is younger than Central Pumice Cone. Central Pumice Cone deposits lie between East Lake Tephra and North Summit Flow which have calibrated ages of 7,270 and 6,910 calendar years respectively.
[9] Weighted mean age of four charcoal samples (Bacon, 1983): 6,780±100; 6,830±110; 6,880±70; 6,840±100.
[10] Weighted mean age of three charcoal samples from burnt house posts (Connolly (1999).

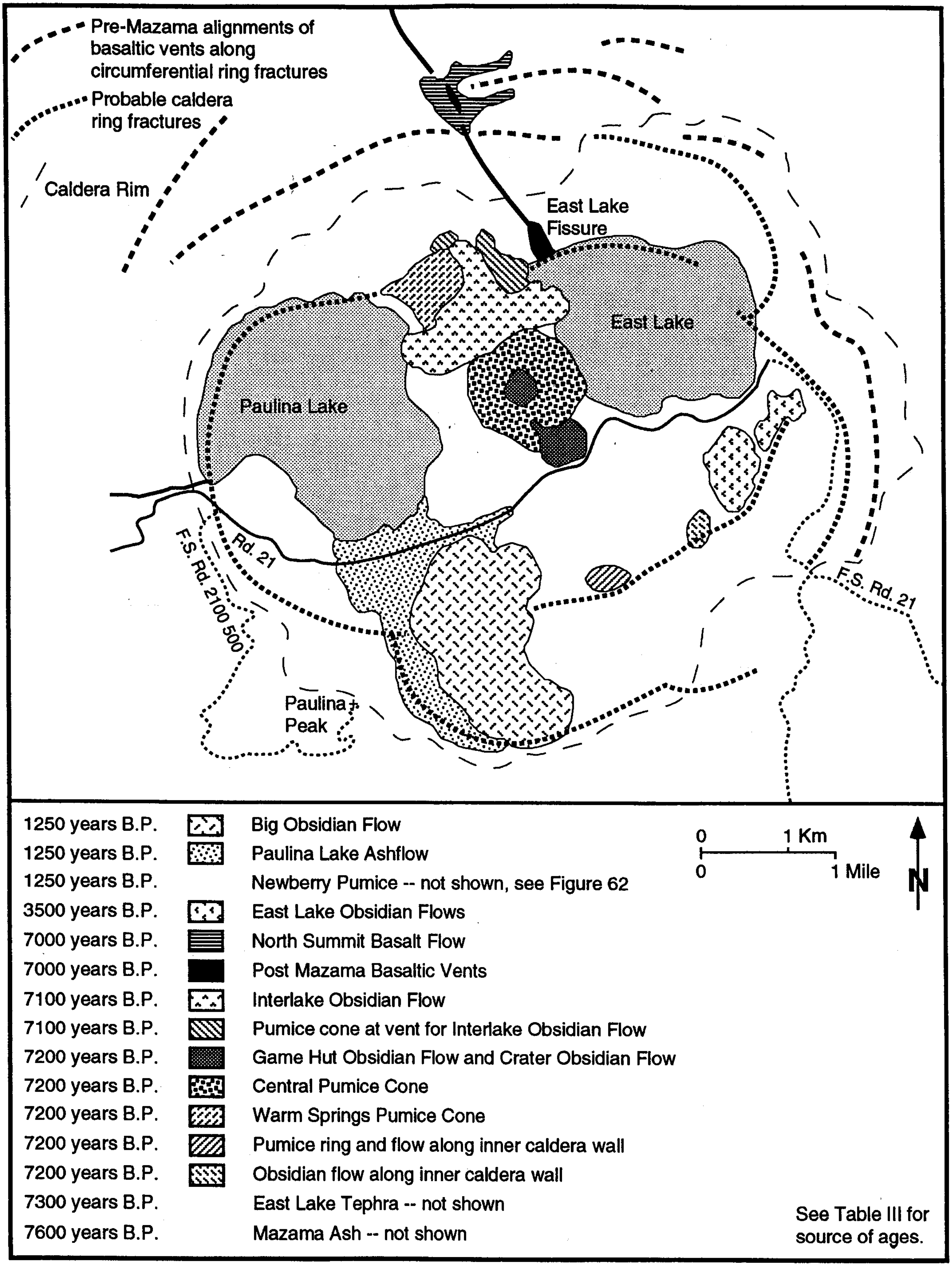


Figure 68 -- Post-Mazama volcanism in Newberry Caldera.

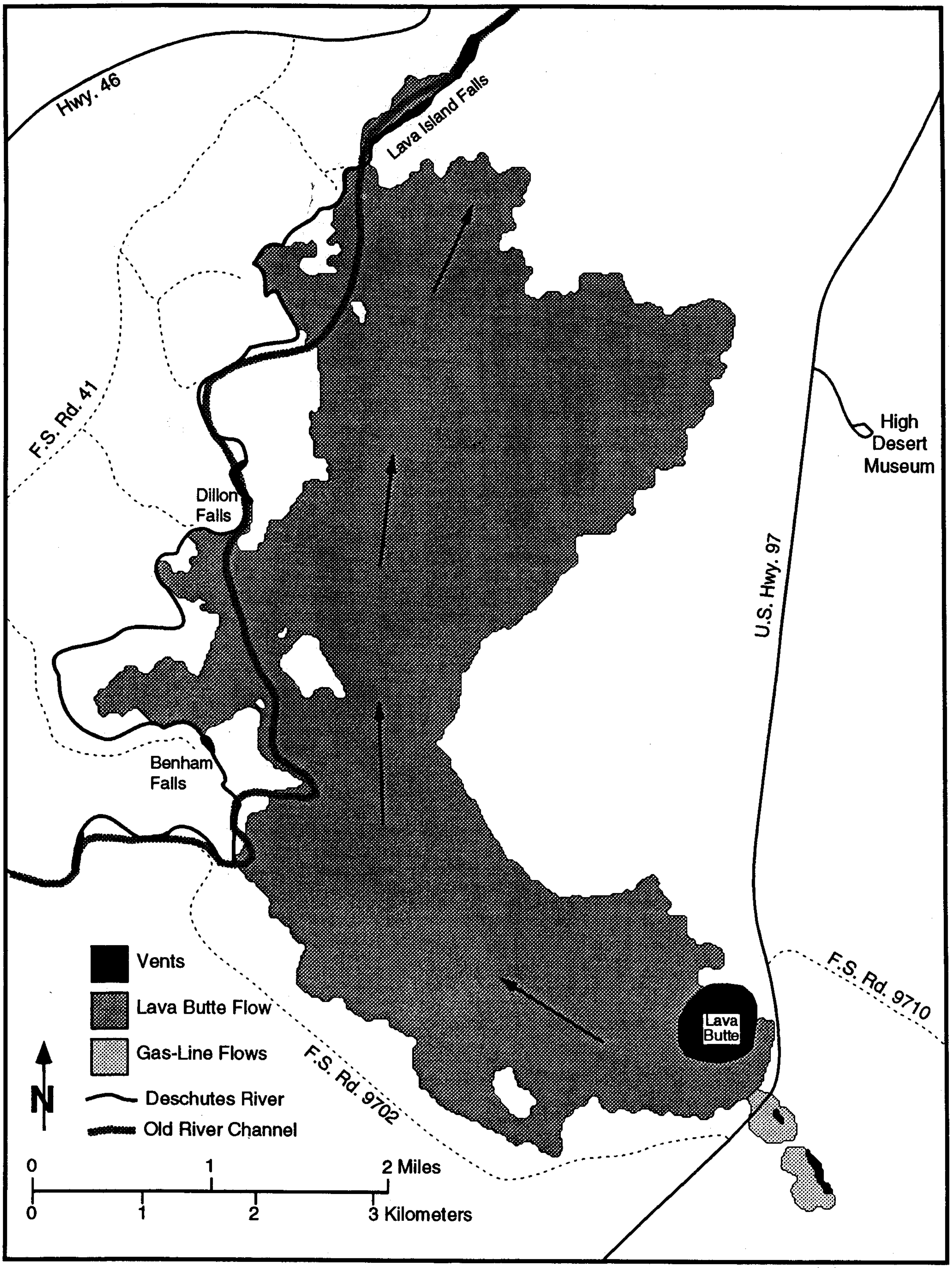


Figure 1. Lava Butte and Gas-Line Flows

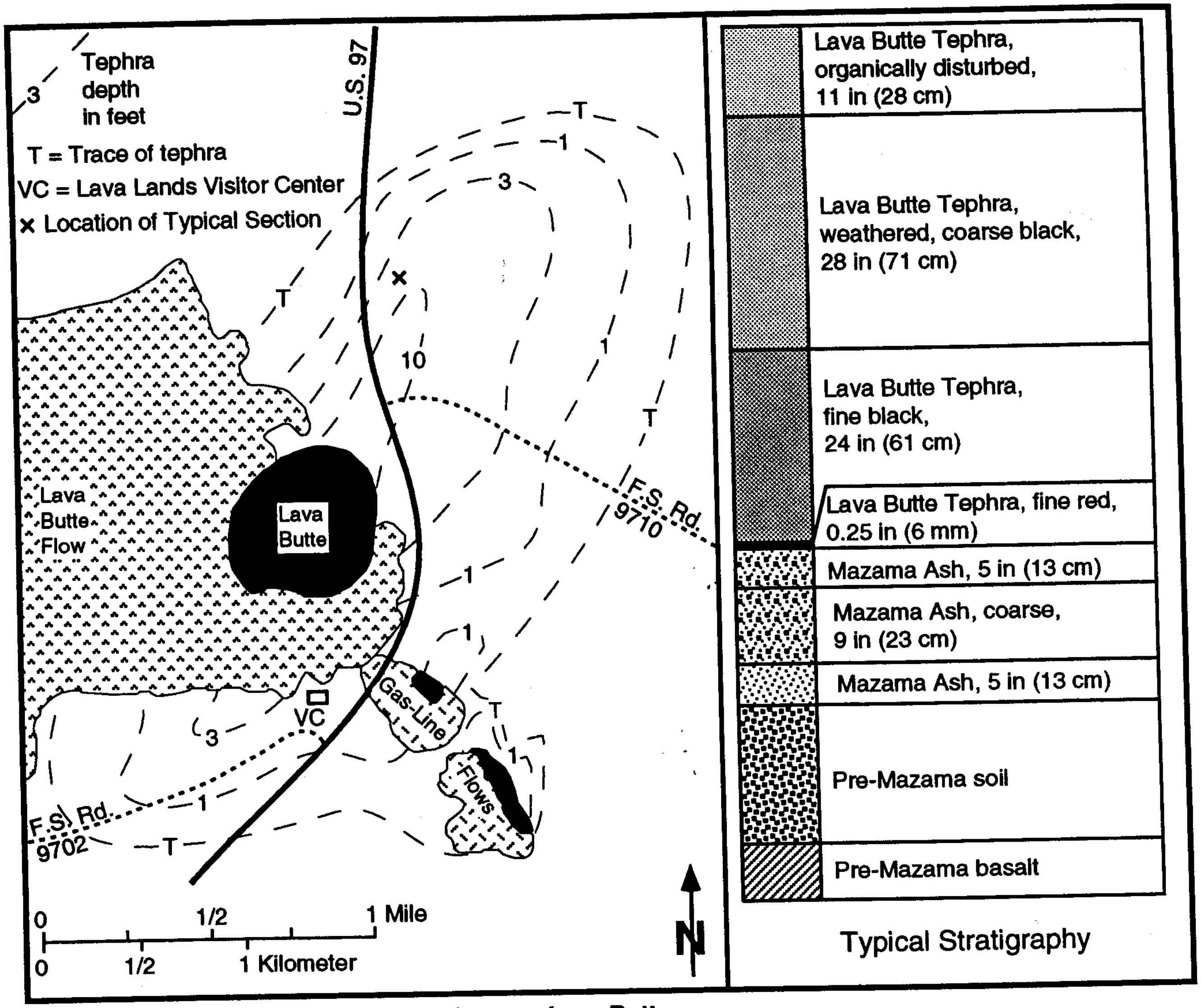


Figure 2. Isopach map and stratigraphy near Lava Butte.

quickly cut the weathered rocks of the saddle to is estimated at 4,160 feet;

4. the elevation of the river channel at Benham Falls Day Use site prior to the eruption of Lava Butte is known from drilling to have been about 80 ft (24 m) deeper than today (about 4,070 feet) (Figure 4 and Table I); and
5. the elevation of the meadows at Sunriver are about 4,155 feet.

Following the damming of the river by the Lava Butte Flow, water began to backup in the old channel. How fast the water rose is unknown and dependent on how badly the lava dam leaked. Even today hydrologic studies have shown that significant amounts of water are lost into the lavas above Benham Falls. Probably within 200 years (possibly much less) though the lake's surface had risen at least 80 ft (24 m) to drowned the forest in the Sunriver area (elev. ≈4,150 feet). By the time the lake reached its probable maximum surface elevation (4,180 feet), it extended upstream for 30 mi (48 km) and had a surface area of 17 sq mi (48 sq km). As the lake spilled over to start the formation of Benham Falls, the water would have downcut rapidly into the deeply weathered 1.8 m.y. old rhyolite dome until less weathered rock was encountered (estimated elevation 4,160 feet). At this time a shallow lake extended upstream for 19 mi (31 km) and had a surface area of 5 sq mi (13 sq km). This shallow lake was the likely source of the diatomaceous lake sediments that have been dated as ranging in age from 6,700 to 1,900 years old. Over the years as the river slowly downcut at Benham Falls, the lake became smaller and finally disappeared. The river now cuts into the sediments of Lake Benham.

As the lake was drained by the formation of Benham Falls, other small lakes were formed above and below Dillon Falls where the flows from Lava Butte had created other dams. Studies of these smaller basins could yield important clues to the timing of events at Lake Benham.

147

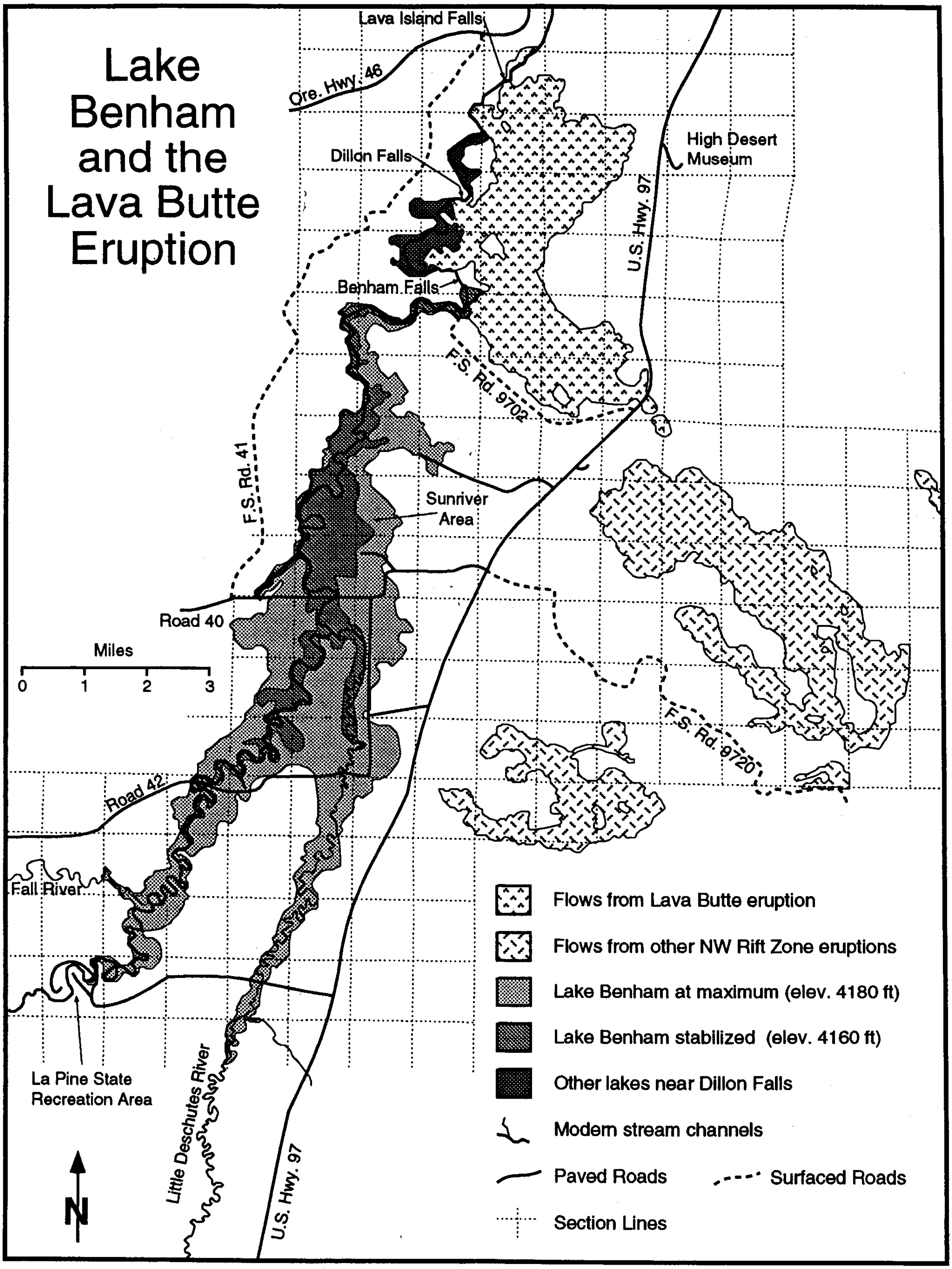


Figure 3. Lake Benham

148

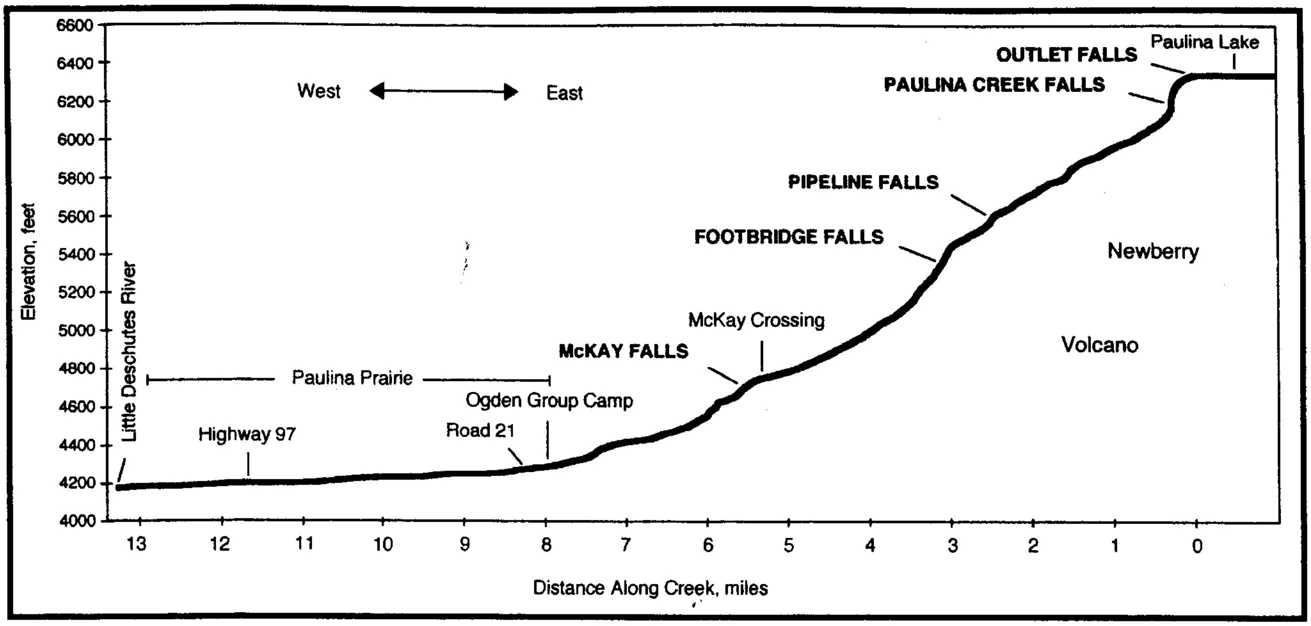


Figure 2. Profile of Paulina Creek showing waterfalls and other features.

PAULINA CREEK

Paulina Creek begins as outflow from Paulina Lake at elevation 6332 ft (1930.5 m) and discharges into the Little Deschutes River 13.3 river miles (21.4 km) to the west at elevation 4177 ft (1273 m) (Fig. 2). For the first 8 miles, Paulina Creek's gradient averages 2.5° (range 1° to 7°). The creek has eroded 30-100 ft (9 to 30 m) into andesitic ash-flow and air-fall deposits (Qat), basaltic andesite (Qba), rhyolite (Qer and Qrd), and unconsolidated sediments (Qs) (MacLeod and others, 1995).

Beginning at river mile 8 at Ogden Group Camp (elevation 4300 ft, 1311 m), the creek flows onto the upper end of Paulina Prairie, a paleo-floodplain with a gradient of 0.25° that extends to the Little Deschutes River. Along its 5-mile (8 km) length, Paulina Prairie broadens to 2500 ft (760 m).

Paulina Creek cascades over several free-falling waterfalls. The largest is Paulina Creek Falls, a scenic double falls, located only 1250 ft (380 m) downstream from the outlet of Paulina Lake. This waterfall and four others are useful for estimating peak discharge during the flood. Most waterfalls have no names, so we have informally named them Outlet Falls (for falls immediately below the outlet of Paulina Lake), Pipeline Falls (for an old wood-stave pipeline nearby), Footbridge Falls (for a well-used pedestrian and horse bridge upstream), and McKay Falls (for McKay Crossing, a well-known vehicle bridge upstream). All waterfalls occur in basaltic andesite (Qba) except Paulina Creek Falls, which occurs in andesitic tuff (Qat) (MacLeod and others, 1995).

The mean annual discharge of Paulina Creek is 18 ft^3/s (0.51 m^3/s) with minor additions and losses along the first 8 miles (Morgan and others, 1997). The range of mean monthly discharge was 4 to 36 ft^3/s, which is largely due to storage and releases for irrigation and to variations in precipitation.

PAULINA LAKE

Paulina Lake fills the western of two basins in Newberry caldera with 250,000 ac-ft (308 hm^3) of water (Johnson and others, 1985). The surface area is 1531 ac (620 ha) and maximum depth is 250 ft (76.2 m). The lake is roughly circular with a diameter of approximately 9200 ft (2800 m). From 1899 to the present, a small irrigation dam constructed at the lake's outlet has controlled lake level (Fig. 3). Surface elevation varies from about 6331 to 6334 ft (1930-1931 m). The elevation of the andesitic tuff sill that controlled lake level before 1899 is about 6328 ft (1929 m).

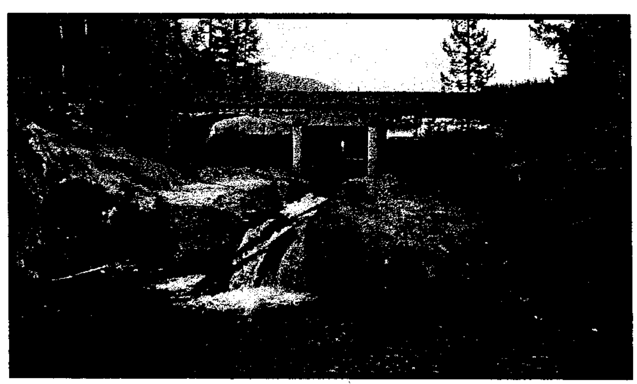
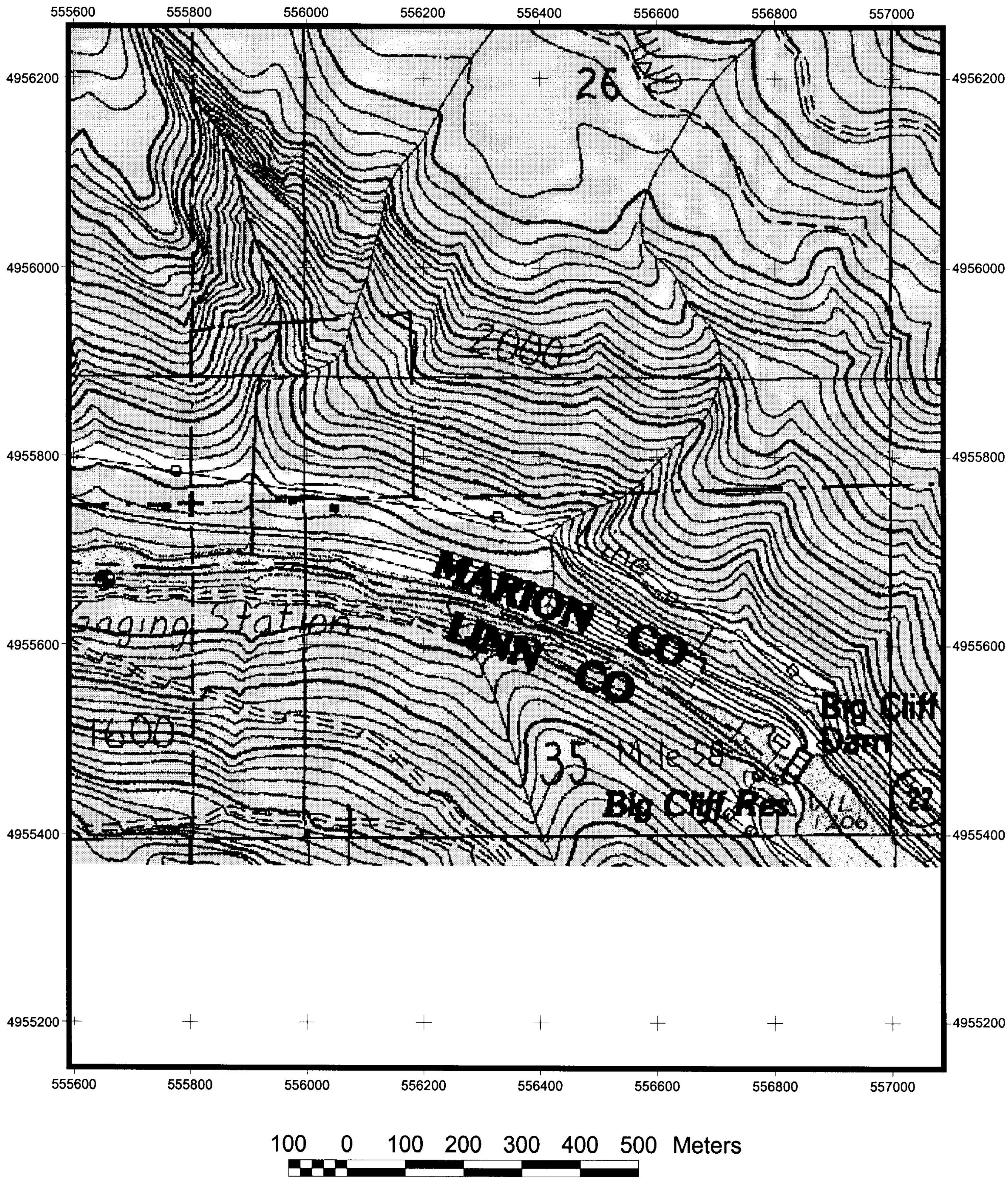


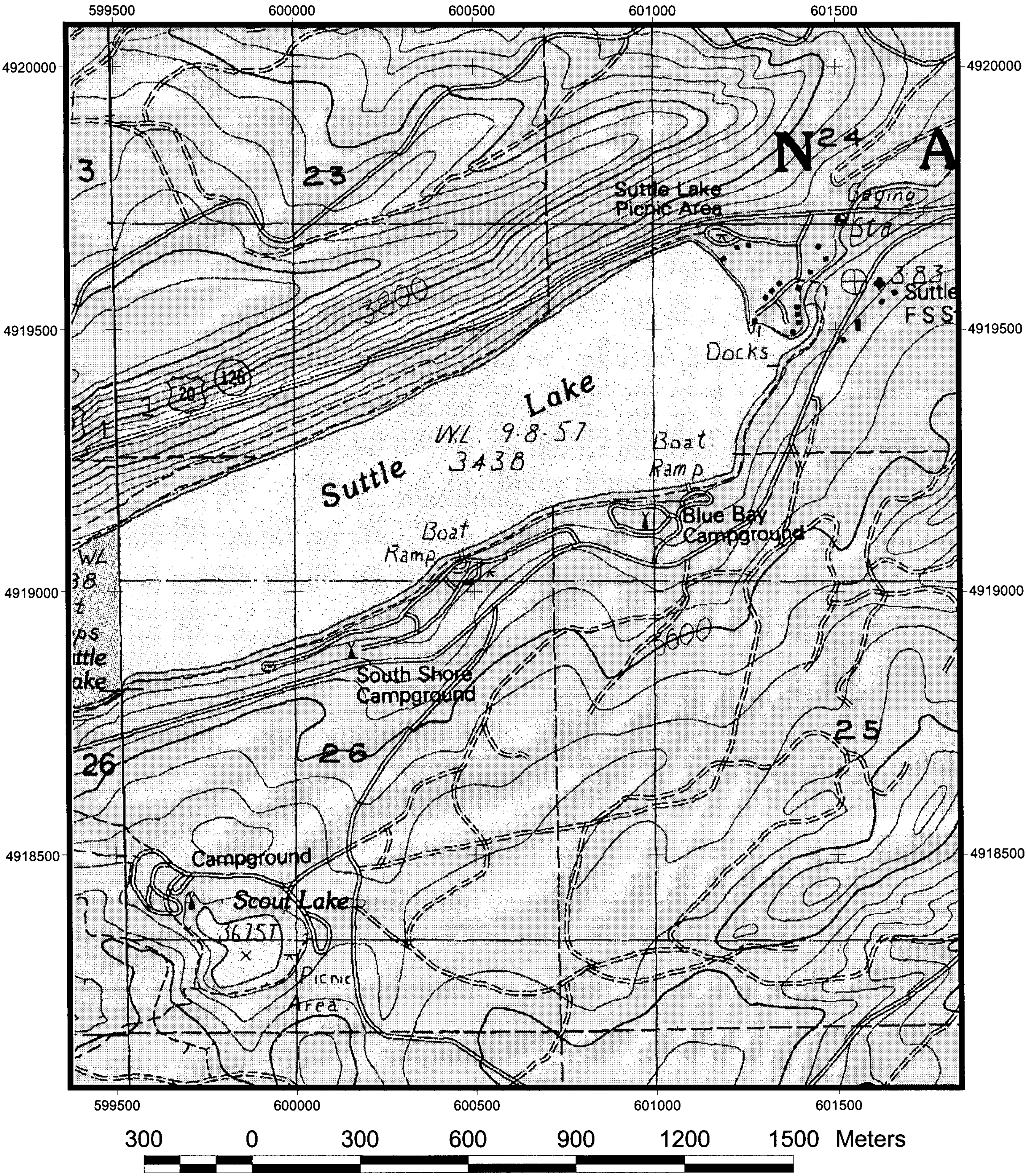
Figure 3. Outlet of Paulina Lake with Outlet Falls in foreground. A concrete dam under the bridge allows storage of irrigation water. The dam is constructed on the andesitic tuff sill that controls the natural level of the lake.

Topographic and Soil Maps of Select Field Stops

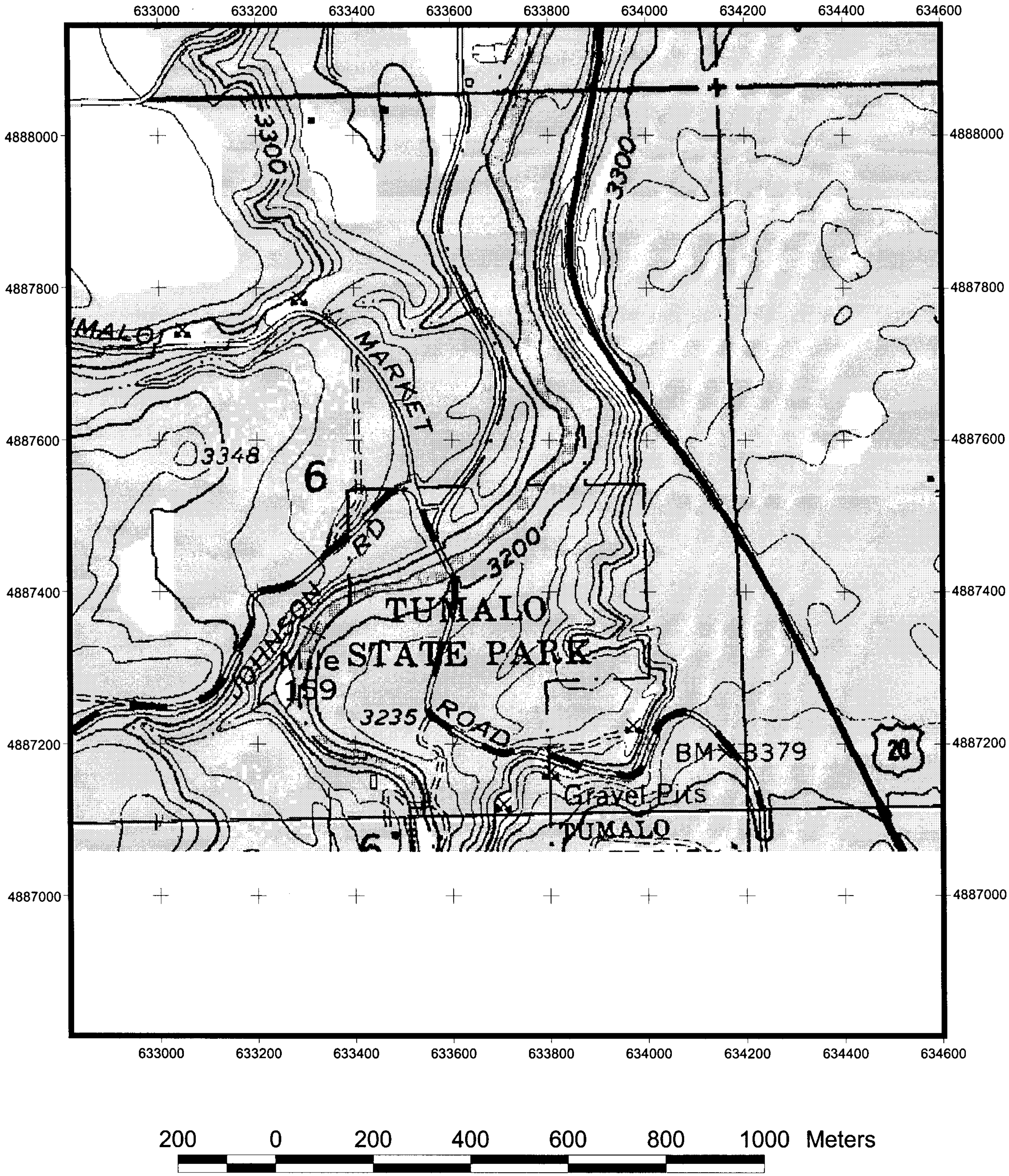
Stop 1-2 Detroit Dam / Santiam River



Stop 1-4 Suttle Lake Topo Base

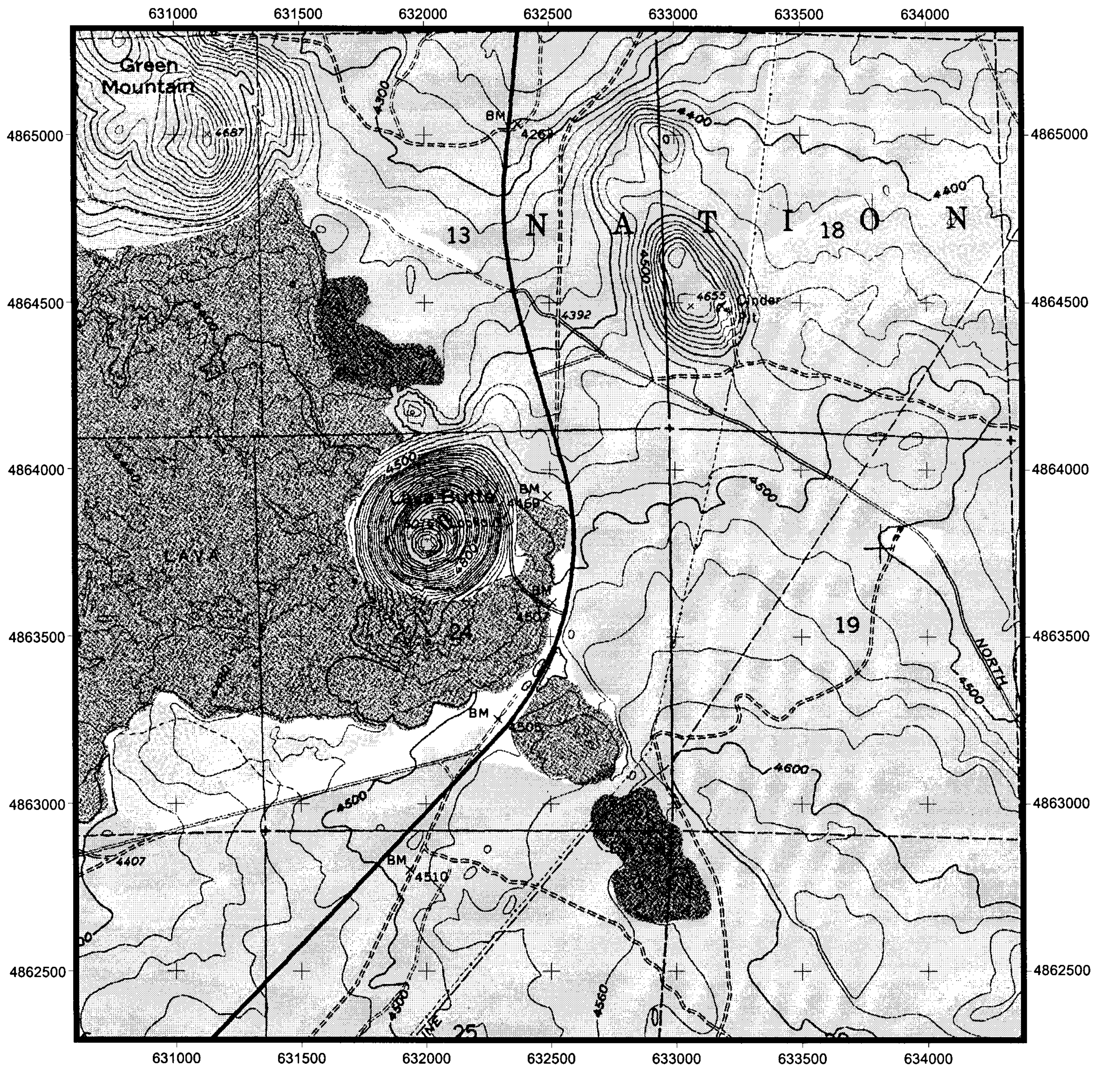


Stop 1-5 Tumalo State Park



155

Stop 1-6 Lava Butte



500 0 500 1000 1500 2000 Meters