We have run out of time and must get this guidebook to the printer. The following article is in very drafty form, but it pulls together some basic information and pre-existing graphics about the eruption of Lava Butte and Lake Benham.

Lava Butte Eruption and Lake Benham

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INTRODUCTION

The Lava Butte eruption produced cinder and spatter cones, a sheet of tephra downwind from the eruption, and a lava flow that buried the old channel of the Deschutes River with over 100 ft (30 m) of lava. The filling of the old river channel resulted in a lake which covered over 15 sq mi (40 sq km) and diverted the Deschutes River into a new channel producing a series waterfalls and small lakes.

LAVA BUTTE ERUPTION

About 7,000 years ago magma began moving up fractures within the Northwest Rift Zone. The first magma to reached the surface was highly gas charged and very fluid. This lava erupted along a 1.5 mi (2.4 km) long fissure as a curtain of fire much like those in Hawaii. These early eruptions probably lasted from a few hours to a few days and formed a series of spatter cones and thin pahoehoe flows along much of the length of the fissure. Today, evidence of these initial eruptions can be found east of U.S. Hwy. 97 in what are known as the Gas-Line Flows (Figure 1).

As the eruption continued, the majority of the fissure sealed off and activity concentrated at the site of Lava Butte. The lava was becoming less fluid, so the escaping gases carried larger quantities of foamy lava fragments (cinders) into the air, which fell back to the ground to build a cone. Due to the prevailing southwest winds, over two-thirds of the cone's volume is north of the crater and the cone's northeast rim was built higher. Also, a deposit of finer cinders was spread mainly to the northeast and is exposed in the highway cuts north of Lava Butte (Figure 2). Charcoal from beneath these fine cinders was used to obtain a 14C date of 6160 ± 65 years (Chitwood and others, 1977).

For the Lava Butte eruption, the flow accounts for 90% of the eruptive volume, the remaining 10% is in the cone (9%) and in the tephra plume (1%). The Paricutin eruption, for comparison, was 35% lava flows and 65% cinder cone and tephra plume (Luhr and Simkin, 1993). The descriptions of the eruption of Paricutin provide many interesting examples of what the Lava Butte eruption must have been like.

As the highly gas charged magma was depleted, magma began to rise up into the cone. The thin south side was not strong enough to contain the fluid magma which began to pour out the side of the cone to form lava flows. The early flows were still quite fluid and spread over five miles to the west and north. Over the following months to years, numerous overlapping flows spread to cover more than 9 mi^2 (23 km^2) and the cone reached a final height of 500 ft (150 m).

LAKE BENHAM

To the west the Lava Butte Flow entered the channel of the Deschutes River at several places. In some areas the flows filled the river's old canyon with over 100 ft (30 m) of lava. This lava dam resulted in a large lake (Lake Benham) which extended upstream to the La Pine State Recreation Area (Figure 3). When the lake filled, it found an outlet across a low divide in an ancient lava dome nearly two million years old. The resulting new channel extends from Benham Falls to Dillon Falls.

Some work has been done on the geologic history of Lake Benham by Jay Bowerman (pers. comm.) and Pfister (1992). This work has resulted in three 14C age-dates which give an indication of the interesting history of the lake. The first date came from one of several tree stumps which are exposed in the bed of the Deschutes River channel at low water during the winter. These stumps occur about 8 ft (2.4 m) below the current surface of the Great Meadow at Sunriver and are rooted in Mazama pumice. Wood believed to be from the outermost rings of the tree was dated at about 6,800 years old (≈6,000 ^{14}C yrs B.P.). The second date came from abundant plant material at the base of the diatomaceous lake sediments which bury the tree stumps. This material resulted in an age of about 6,700 years old (5,890 ^{14}C yrs B.P.) The final date came from plant material near the top of the diatomaceous lake sediments. This material yielded an age of about 1,900 years old (1,950 ^{14}C yrs B.P.) This last date is especially subject to contamination by modern roots which would result in an age that is too young.

Some elevations of importance to the discussion of Lake Benham include:

1. current elevation of river floor at top of Benham Falls is about 4,145 feet;
2. original elevation of saddle through which the Deschutes River cut to form Benham Falls is estimated to have been 4,180 feet;
3. the elevation to which the river could easily and

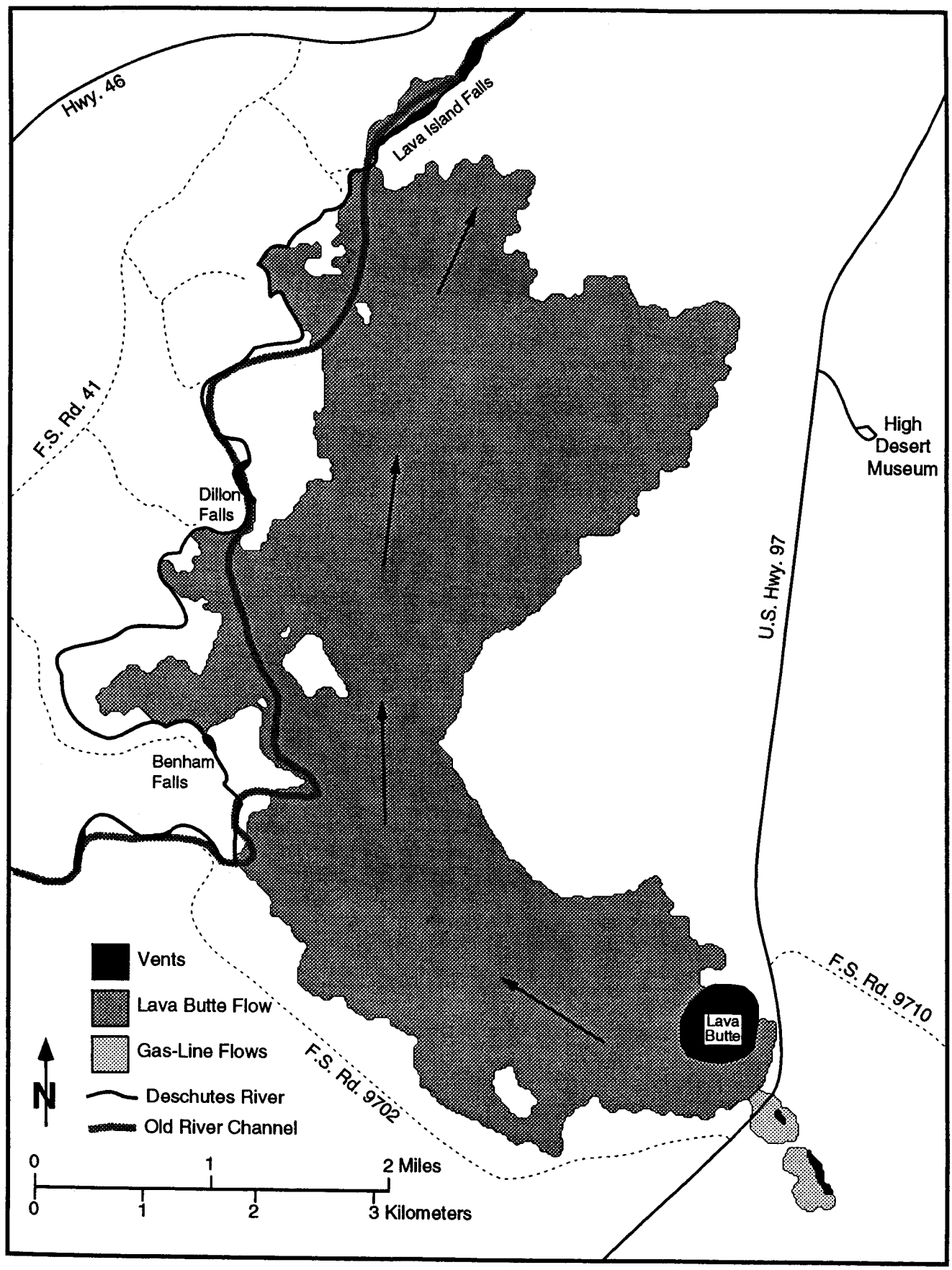

Figure 1. Lava Butte and Gas-Line Flows

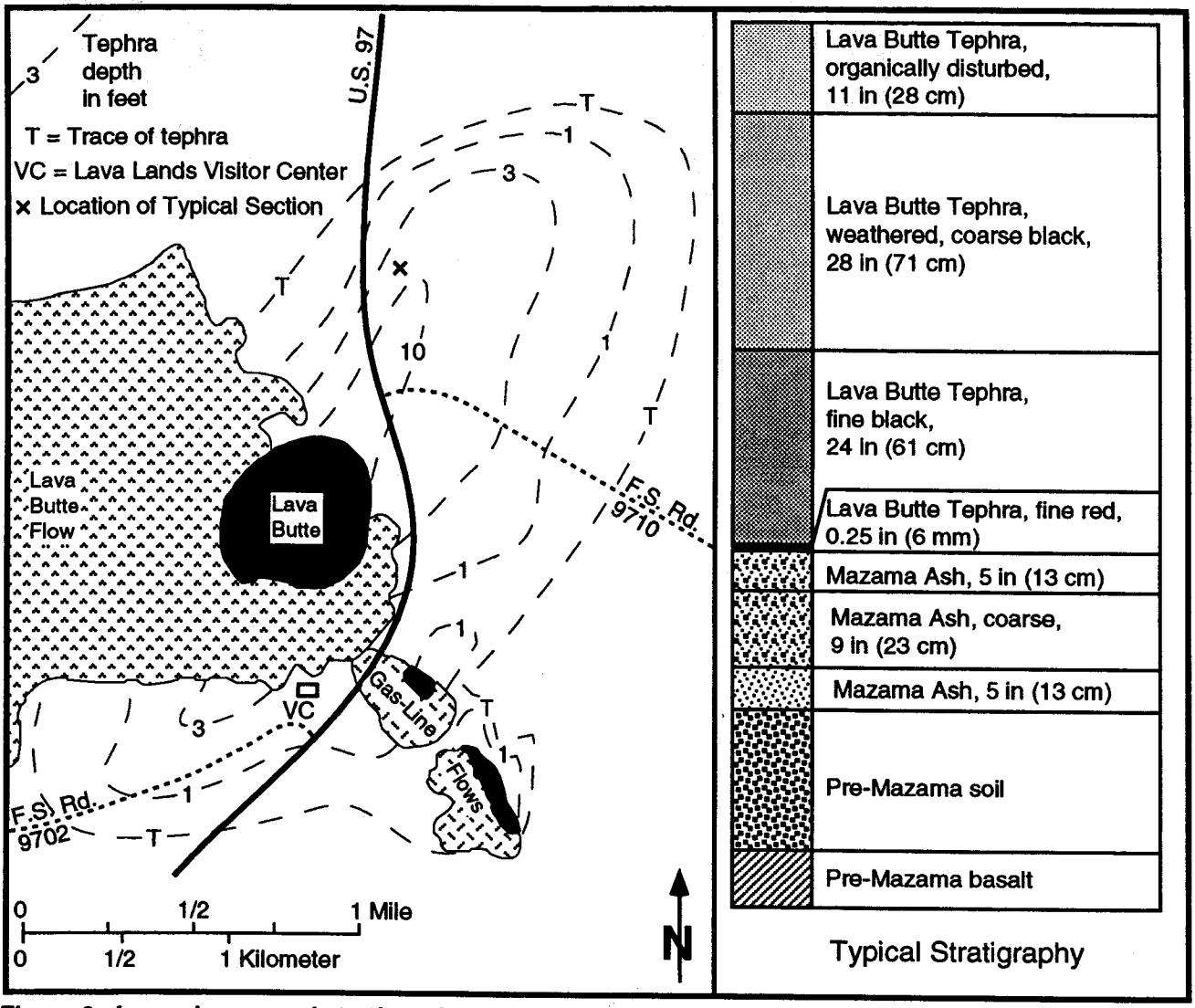

Figure 2. Isopach map and stratigraphy near Lava Butte.

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.

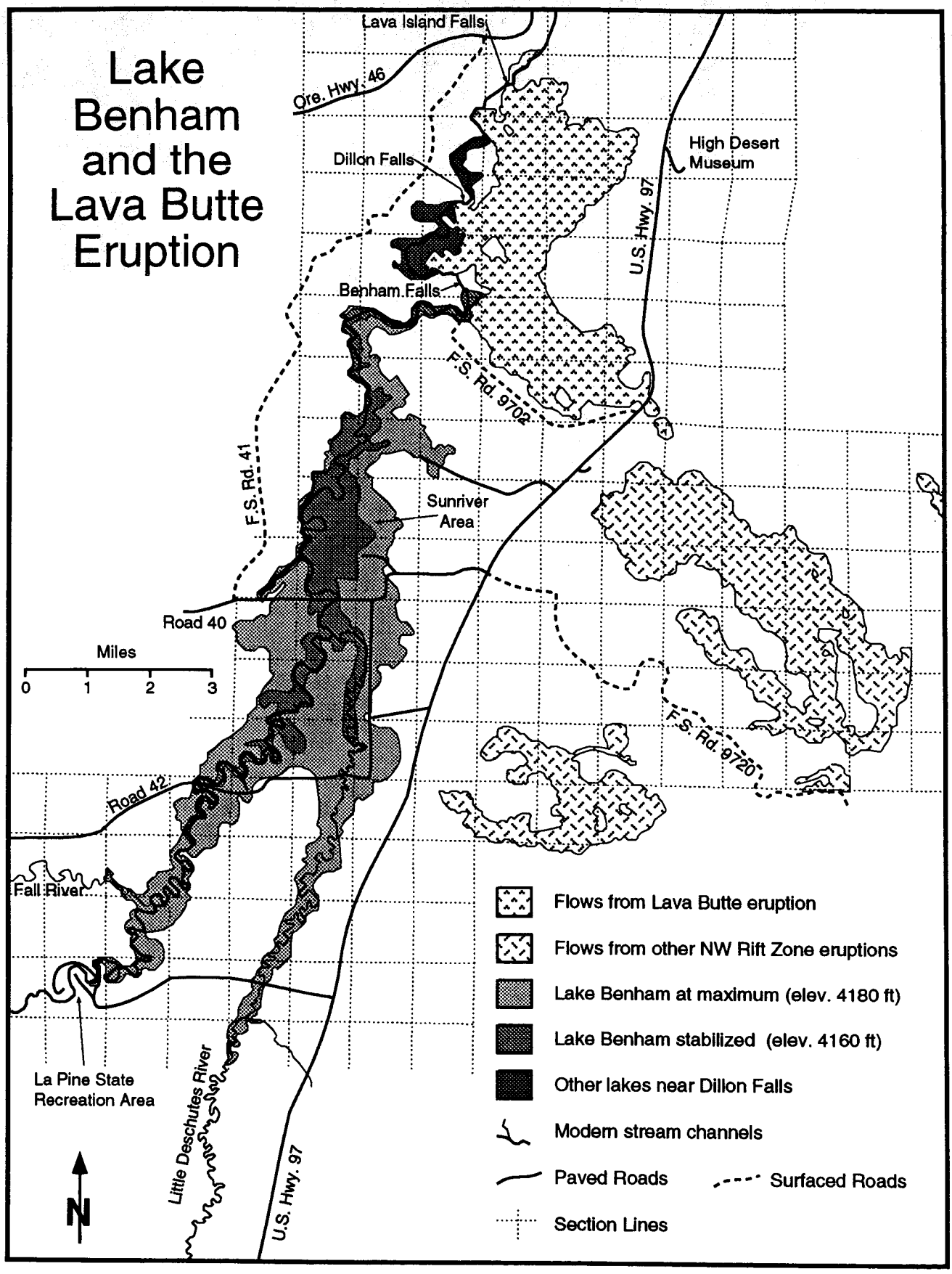

Figure 3. Lake Benham

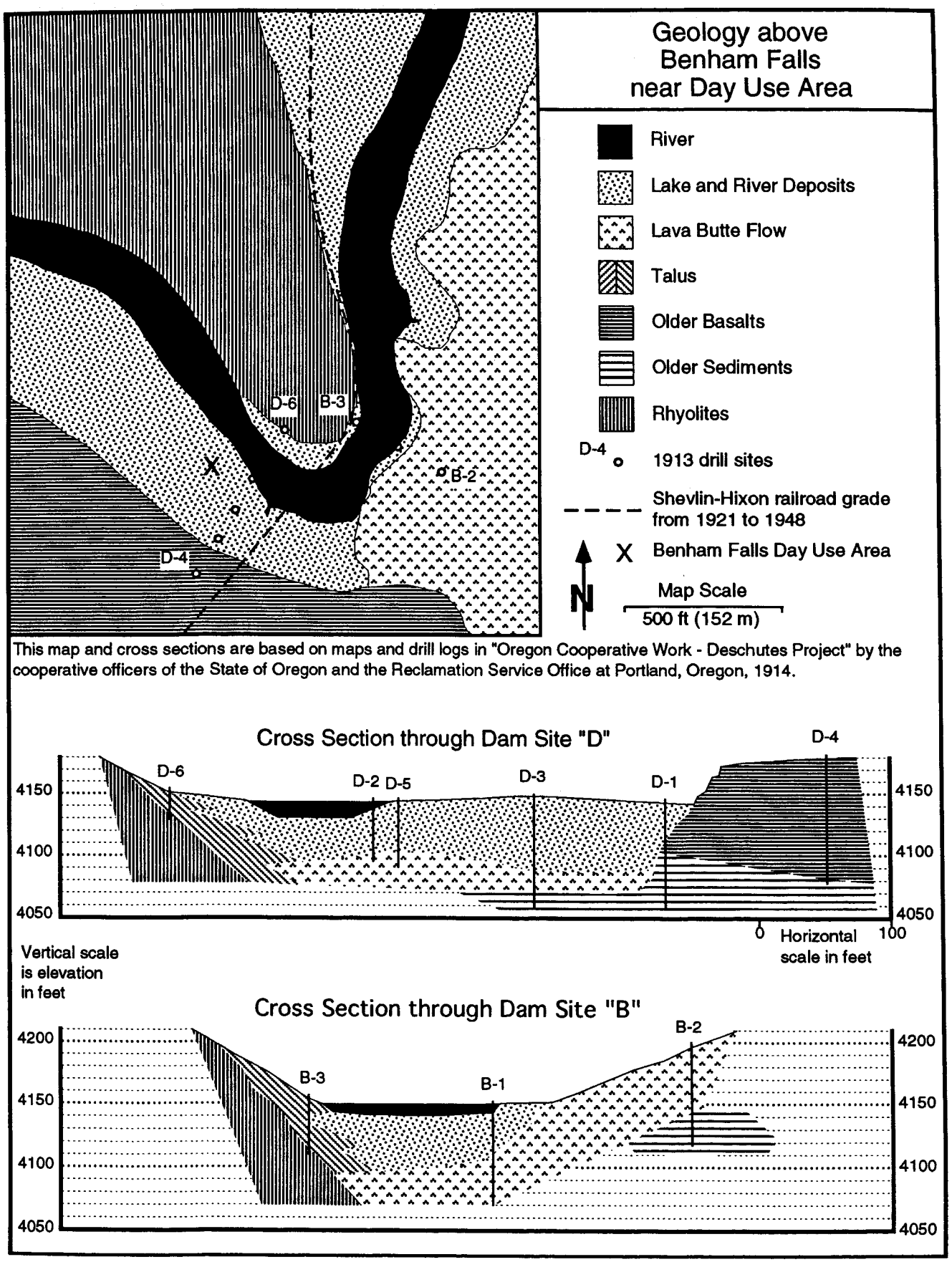

Figure 4. Cross sections through proposed dam sites near Benham Falls.

Table I. Original information from 1913 drilling at Benham Falls Dam Site.

Benham Falls Dam Sites - Site "B"
All depths in feet below surface elevation.

Hole B-1. Bed of river 4,143.5 feet. Located on west slope of the buried gorge.

0.0 - 7.0 --- Water.
7.0 - 15.0 --- Buff mud or silt - (chiefly diatomite)
5.0 - 22.0 --- Medium fine sand (color red and gray)(some fine gravel).
22.0 - 32.0 --- Gray clay and mud (and diatomite). All water returned above 32.
32.0 - 38.0 --- Loose broken lava with sand.
32.0 - 38.0 --- Part of water returned.
38.0 - 53.0 --- Broken lava rock (hard).
38.0 - 53.0 --- All water lost.
53.0 - 73.5 --- Solid lava rock with close seams.
53.0 - 73.5 --- All water returned.
(32 to bottom all dense, hard, black lava of the typical "brick-bat" variety. 30% core).

Hole B-2. Surface elevation 4,195.5 feet. Located in old gorge of the river, now filled with "brick-bat" lava.

0.0 - 32.0 --- Porous lava rock (shattered "brick-bat" lava)
32.0 - 41.0 --- Hard lava rock (shattered into fragments - "brick-bat" lava)
41.0 - 49.0 --- Boulders (hard rock lava - "brick-bat" lava)
49.0 - 65.0 --- Black sand mixed with fragments of lava rock.
65.0 - 75.0 --- Black sand mixed with pumice and fragments of oxidized lava.
75.0 - 78.0 --- Same as 49-65.
(49-78 = old river bed deposits)

Hole B-3. Surface elevation 4,153.6 feet. Located on west or rhyolite slope of the old gorge.

0.0 - 20.0 --- Loose rock and soil.
0.0 - 78.0 --- All water lost.
20.0 - 23.0 --- Fine sand. (lost)
23.0 - 37.0 --- Same as 0-20 (no sample).
37.0 - 41.0 --- Hard lava rock, typical light gray rhyolite.
37.0 - 41.0 --- All water returned.

Benham Falls Dam Sites - Site "D"
All depths in feet below surface elevation.

Hole D-1. Surface elevation 4,142.0 feet. Located in the old gorge, near right bluff.

0.0 - 5.0 --- Top soil and pumice sand.
--- All water returned 0-5.
5.0 - 15.0 --- Coarse sand.
--- All water lost 5-15.
15.0 - 25.0 --- Fine black sand.
--- About one-half of water returned 15-25.
25.0 - 32.0 --- Mud or silt (diatomite)?
32.0 - 36.0 --- Lava rock.
--- All water returned 25-36.
36.0 --- All water lost through seam.
36.0 - 39.0 --- Lava rock. Lava fresh and dense 32-39.
36.0 - 39.0 --- All water returned 36-39.
39.0 --- All water lost through seam.
39.0 - 42.0 --- Blue clay. (No sample.)
39.0 - 47.0 --- All water returned 39-47.
42.0 - 47.0 --- Medium sand and pea gravel. Much pumice.
47.0 - 50.0 --- Same as 42-47. Much pumice.
47.0 - 50.0 --- About one-half of water returned.
50.0 - 55.0 --- Fine to coarse sand, mixed composition.
50.0 - 63.0 --- All water returned.
55.0 - 63.0 --- Lava boulders (rhyolite).
63.0 -65.0 --- Coarse sand, with broken rock.
63.0 -65.0 --- All water lost.
65.0 - 70.0 --- Diatomite, mixed with gritty material.
65.0 - 70.0 --- All water returned.
70.0 - 85.0 --- Coarse sand, with broken rock.
70.0 - 85.0 --- All water lost.

Hole D-2. Surface elevation 4,143.0 feet. Located in the old gorge of the river.

0.0 - 7.0 --- Water.
0.0 - 48.0 --- All water lost.
7.0 - 20.0 --- Medium sand.
20.0 - 45.0 --- Mud or silt diatomite.
45.0 - 48.0 --- Gravel and broken lava rock. No sample.

Hole D-3. Surface elevation 4,147.5 feet. Located near middleof the old gorge.

0.0 - 5.0 --- Top soil (sandy).
0.0 - 65.0 --- All water returned.
5.0 - 12.0 --- Medium black speckled sand.
12.0 - 22.0 --- Coarse sand and pumice.

22.0 - 34.0 --- Medium sand and pumice.
34.0 - 65.0 --- Mud and silt, mixed with fine sand (diatomite?).
65.0 - 77.0 --- Broken lava rock and sand. No sample.
65.0 - 77.0 --- All water lost 65-77.
77.0 - 80.0 --- Coarse black sand, mixed with clay (diatomite?).
77.0 - 80.0 --- All water returned.
80.0-89.0 --- Soft, porous lava rock, shattered and mixed with sand. No sample.
80.0-89.0 --- About one-half of water returned.

Hole D-4. Surface elevation 4,179.0 feet. On right bluff of the old gorge, the basalt is, apparently very unsettled, more so than in Hole A-5 at Minor's Cabin, because nearer the brink of the bluff.

0.0 - 2.0 --- Top soil (sandy). No sample.
0.0 - 33.0 --- All water returned.
2.0 - 26.0 --- Lava boulders, surface soil and sand. No sample.
26.0 - 33.0 --- Lava rock (solid).
33.0 - 33.5 --- Fissure in rock, all water lost. Sand.
33.5 - 37.0 --- Lava rock (solid), all water returned.
37.0 - 38.0 --- Fissure in rock, filled with loose sand and pumice, all water lost.
38.0 - 45.0 --- Lava rock, solid, all water returned.
45.0 - 45.5 --- Fissure in rock, filled with loose sand and pumice, all water lost. No sample.
45.5 - 69.5 --- Lava rock (solid), all water returned.
69.5 - 70.0 --- Fissure, lost all water.
70.0 - 79.0 --- Lava rock (solid, coarse grained).
70.0 - 87.0 --- All water returned.
79.0 - 87.0 --- Lava rock (porous). Oxidized.
87.0 - 87.5 --- Seam filled with black sand, lost all water. No sample.
87.5 - 90.0 --- Lava rock (solid).
87.5 - 98.0 --- All water returned.
90.0 - 94.0 --- Porous rock (with clay pockets). No sample.
94.0 - 97.0 --- Loose broken lava rock.
97.0 - 98.0 --- Sand with pumice and broken lava rock.
98.0-100.0 --- Same as 97-98. All water lost.

Hole D-5. Surface elevation 4,144.0 feet.

0.0 - 15.0 --- Fine black sand, mixed with pumice.
0.0 - 39.0 --- All water returned.
15.0 - 35.0 --- Fine black sand. (silt)
35.0 - 39.0 --- Fine sand and silt (diatomite?).
39.0 - 41.0 --- Coarse sand and silt.
39.0 - 53.0 --- About one-half of water lost.
41.0 - 53.0 --- Lava rock shattered and fissured, dense and black (brick-bats).

Hole D-6. Surface elevation 4,151.0 feet.

0.0- 11.0 --- Small broken rock (surface slide). All water lost.
11.0 - 12.0 --- Gray clay (diatomite). All water returned.
12.0 - 16.0 --- Same as 0 to 11.
12.0 - 22.0 --- All water lost.
16.0 - 20.0 --- Small broken rock, with clay and sand (surface slide).
20.0 - 22.0 --- Large broken rock (surface slide). The "broken rock" (16-22) is rhyolite.

REFERENCES

Chitwood, L.A., Jensen, R.A., and Groh, E.A., 1977, The age of Lava Butte: The Ore Bin, v. 39, no. 10, p. 157-164.

Cooperative Officers of the State of Oregon and the Reclamation Service Office, 1914, Oregon Cooperative Work - Deschutes Project: Portland Oregon, p. 51-58, 98-101.

Crosby, W.O., 1919, Report on the Benham Falls Project of the Deschutes River Drainage, Oregon: U. S. Reclamation Service, 99 p.

Luhr, J.F., and Simkin, T., eds., 1993, Paricutin, The volcano born in a Mexican Cornfield: Phoenix, Arizona, Geoscience Press, Inc., 427 p.

Pfister, C., 1992, The Great Meadow Lake: Its Origins and Nature, Research Spectrum, v. ?, p. 41-43