**Verlot peat area**

The Verlot peat area was investigated by Rigg, accompanied by C. E. Torrence and D. Tunstall, August 13 to 15, 1926. The following description is based on field notes made at that time, supplemented by some explanations.

The peat area was estimated at 15 to 20 acres. Its location was estimated to be about 2 miles south of the old Mackie station (an abandoned sawmill) on the old Monte Cristo Branch (now abandoned) of the Northern Pacific Railway. The location of Mackie is shown on Forest Service maps of the Snoqualmie National Forest. The peat is probably in sec. 25 or 36, T. 30 N., R. 8 E. It was reached from the station by a rather steep, rocky wet trail which extended over the mountainous region and down to the Pilchuck River. The elevation of the peat area was estimated at between 2,500 and 3,000 feet. It is in the Snoqualmie National Forest. The topography of the region is shown on the Stillaguamish quadrangle. Probably this peat area can now be reached by the trail from the highway near the Verlot Ranger Station.

The peat area consisted of a sphagnum bog of perhaps 10 acres and a series of small sphagnum bogs at about the same level. Probably there was some slow drainage from them during the rainy season. All the bogs were crossed by the trail. They were surrounded by rather gentle forested slopes.

The bogs had the flora of herbs and shrubs commonly found in sphagnum bogs and adjacent marshes in the lowlands of the Puget Sound region. *Sphagnum* was growing vigorously, and it had formed hummocks. Several ponds in the bogs had the flora of aquatic herbs commonly found in lowland lakes in the region. The trees in the bogs were western white pine and mountain hemlock. The pines ranged in height from 1 foot or less up to 10 feet or more. The hemlocks ranged from 1 to 30 feet or more in height, and there were many larger dead conifers which were apparently of this species.

The depth and character of the peat and muck were investigated by digging with a small shovel and by thrusting a pole down to the dark yellow clay on which the peat rested. The layer of sphagnum peat was 2 feet thick, and the layer of fibrous peat and muck under it was 4 feet thick.

**Lake Ketchum peat area**

The Lake Ketchum peat area (19 acres) is in secs. 6 and 7, T. 32 N., R. 4 E., about 3 miles north of East Stanwood by State Highway IE and a crooked dead-end road up a steep slope. The deposit borders the north shore of the lake (map, fig. 193). The lake and the topography of the region surrounding it are shown on the Mount Vernon quadrangle. The elevation of the peat is about 175 feet above sea level, and it is less than 2 miles from the shore of Skagit Bay. It lies in a depression in glacial drift of the region. The lake has no surface outlet. On the soil map of Snohomish County (Anderson et al., 1947) the area is mapped as Greenwood peat and Carbondale muck.

The peat area is partly sphagnum bog and partly swamp forest. All of it is very wet, and there is a pond of open water in the sphagnum bog between holes 2 and 3. The sphagnum bog has the usual vegetation of bog shrubs and herbaceous species. Living *Sphagnum* is abundant in the bog and also in the brushy (Labrador tea and hardhack) area near the lake. Some of the forest is a dense growth of rather large cedar and spruce trees. In other places there are large alder trees and some hemlock, dogwood, and cascara. Much of the forest has a dense undergrowth of shrubs which include Labrador tea and devils club. Skunk cabbage is abundant in some places.

The profile extends 1,700 feet in a northerly direction from the lake but changes direction twice. The sphagnum is wet, mostly raw, and yellow to dark brown. Its maximum depth (12 feet) classes it among the deeper deposits of sphagnum in the state. The leaves and twigs of heath plants (Labrabor tea and other species), which form a layer 4 feet thick near the lake, show very little decay. The woody peat is dark brown. The muck is black. The fibrous peat is brown and wet. The sedimentary peat is olive. Field determinations of acidity in holes 1 and 2 show the usual decrease in acidity with increasing depth. The sphagnum peat near the surface is strongly acidic (pH 3.5 to 3.8), and the sedimentary peat and sand at the bottom are rather weakly acidic (pH 5.0 to 5.3).

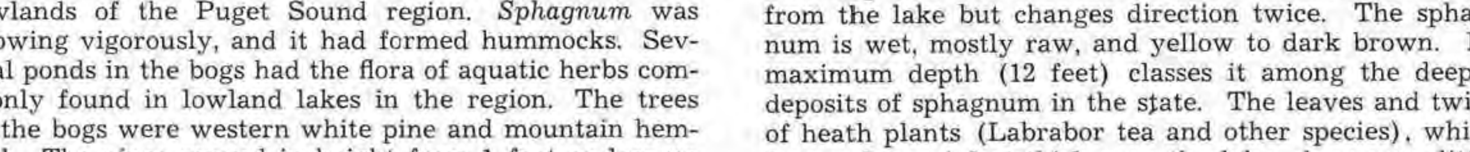


FIGURE 193.—Map and profile of Lake Ketchum peat area (19 acres). Map adapted from U. S. Department of Agriculture soil map of Snohomish County and U. S. Army Map Service photomosaic.

Pumicite was found only in holes 1 and 4, but it is somewhat dispersed in the sedimentary peat in hole 1, and it may be present in holes 2 and 3 but so dispersed that it was not recognized in the field examination. In hole 1 it is yellow and forms a layer 1 inch thick. In hole 4 it is brown and forms a layer ½ inch thick. The deposit rests on sand which is dark gray where pure but is black where it is in contact with muck.

The sphagnum in this deposit might be used locally, but the bog is so soft that floating equipment would probably have to be used in removing it, and some road construction might be necessary.

### Blackman Lake peat area

Blackman Lake peat area (13 acres) is in sec. 7, T. 28 N., R. 6 E., about a mile north of Snohomish. It borders the south shore of Blackman Lake, which on some maps is called Stillaguamish Lake. A county road crosses the peat (map, fig. 194).

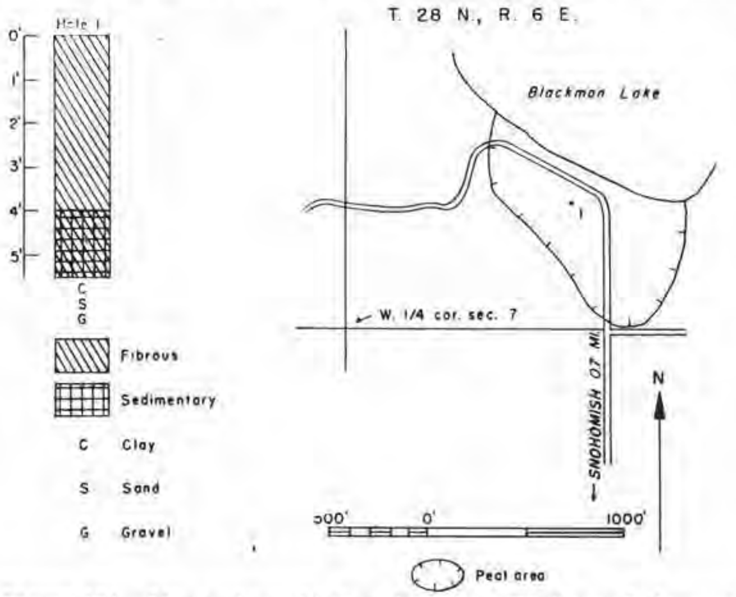


FIGURE 194.—Map and graphic log of a hole in Blackman Lake peat area (13 acres). Map adapted from U. S. Department of Agriculture soil map of Snohomish County.

Stillaguamish Lake and the topography of the surrounding region are shown on the Everett quadrangle. The elevation of the peat is about 145 feet above sea level, and the slopes around the lake are gentle. A stream flows from the lake to the Snohomish River.

On the soil map of Snohomish County (Anderson et al., 1947) the peat area is mapped as Mukilteo peat. A hole about 200 feet south of the lake shore shows 4 feet of brown decomposed fibrous peat and 1½ feet of an olive-colored mixture of fibrous and sedimentary peat. Under this is 4 inches of lake mud, then 8 inches of blue clay, and then sand and gravel. The water of the lake is rather weakly acidic (pH 5.0).

The vegetation in the vicinity of this hole consists mainly of hardhack and rushes. The presence of *Dulichium* indicates that the area must, in the past, have been wetter than it is now. Evergreen blackberry also occurs, and it is characteristic of waste land.

### Lake Goodwin peat area

The Lake Goodwin peat area (12 acres) is in sec. 22, T. 31 N., R. 4 E., about 10 miles by road northwest of Marysville and about 8 airline miles southeast of Stanwood. It is about ¼ mile northeast of the lake shore (map, fig. 195). A county road passes near it. The topography of the region is shown on the Stanwood quadrangle. The elevation of the lake is 324 feet above sea level, and the peat area is about 50 feet above the level of the lake. The peat lies in an undrained depression in the glacial drift of the region. On the soil map of Snohomish County (Anderson et al., 1947) it is mapped as Greenwood peat.

This peat area is a sphagnum bog which is in the shrub stage of development and into which there has been some invasion of forest trees. This is not a typical sphagnum bog, because *Sphagnum*, as indicated in figure 195, has played only a minor part in its development. However,

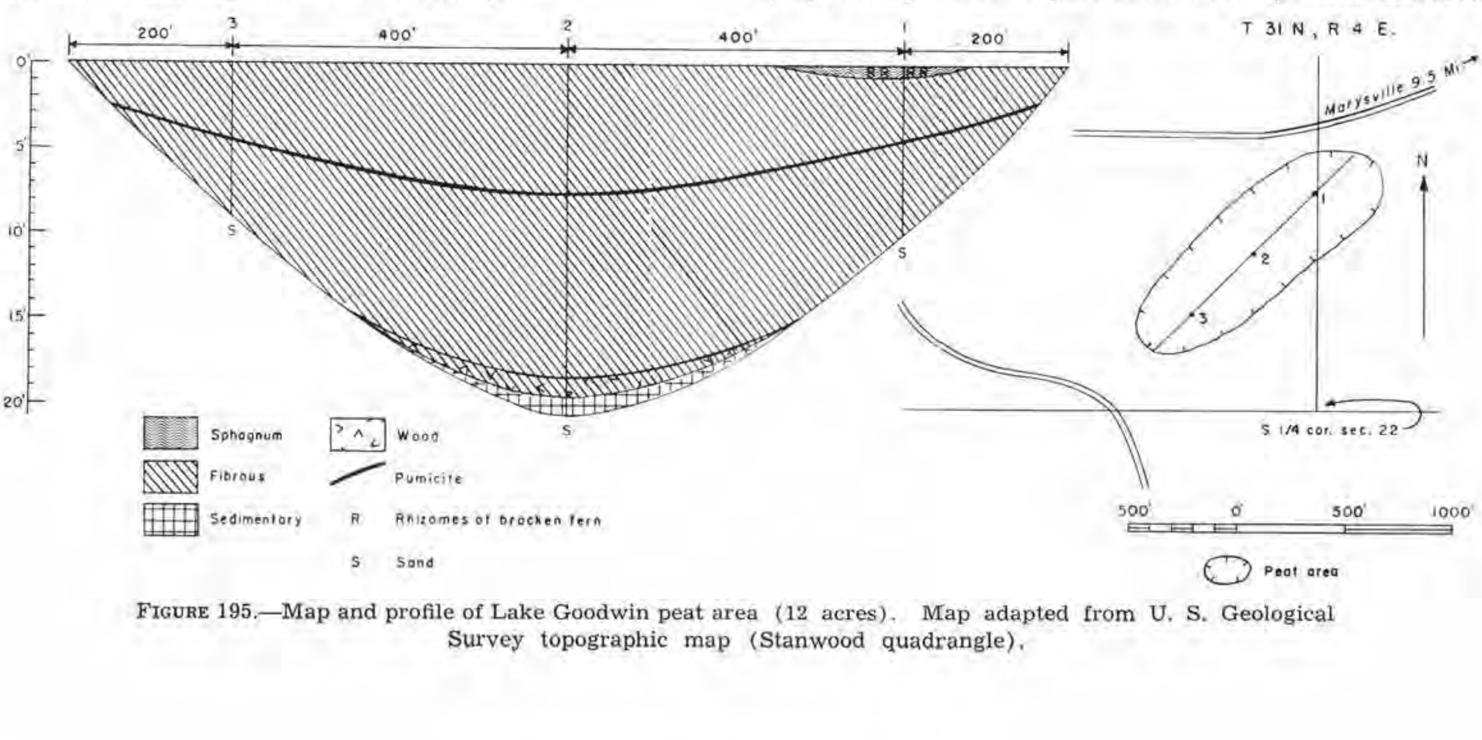


FIGURE 195.—Map and profile of Lake Goodwin peat area (12 acres). Map adapted from U. S. Geological Survey topographic map (Stanwood quadrangle).

fire at some time in the past has interfered with the development of the bog, and it is not known how much *Sphagnum* may have been destroyed by fire.

The dominant shrubs are Labrador tea and a species of huckleberry, but there is some salal. *Sphagnum* grows among the shrubs. The northwestern border of the bog is covered with hardhack, and there are some small dead (burned) conifers. One large living white pine 2 feet in diameter and 85 feet tall stands near the center of the bog, and there are scattered white pines up to 6 inches in diameter at other places. Some small cedar trees and some crab apple trees grow in the southwestern part of the bog. Bracken fern grows with these.

The profile, 1,200 feet long, extends lengthwise of the bog. The deposit (fig. 195) consists mainly of brown to dark-brown decomposed fibrous peat. Sphagnum peat occurs only at hole 1. The layer is only 1 foot thick and is mixed with rhizomes of bracken ferns. The sedimentary peat which forms a thin layer at the bottom of hole 2 is brown. Woody peat is mixed with fibrous peat in a thin layer just over the sedimentary peat. It seems probable that this was washed in. Brown pumicite forms a layer ½ to 1 inch thick. The deposit rests on sand.

#### Fuller peat area

The Fuller peat area (12 acres) is in the SE¼NW¼ sec. 21, T. 27 N., R. 5 E., about 5 miles by road northeast of Bothel and about 5 miles east of Alderwood Manor. The topography of the region is shown on the Everett quadrangle. The elevation of the peat is just over 400 feet above sea level. It lies in a depression in the glacial drift of the region, and the land near it is 25 feet or more above the level of the peat. On the soil map of Snohomish County (Anderson et al., 1947) the area is mapped as Mukilteo peat.

A considerable amount of peat has been excavated and marketed in bulk by the Fuller Humus Company, 220 East 117th Street, Seattle. The operation was active when the peat was examined in August 1949. Much of the vegetation had been disturbed by the operations connected with the removal of the peat, but sedges still remained.

The fibrous peat is about 7 feet deep at the east side of the excavation. One hole bored about 125 feet west of the west side of the excavation shows 5 feet of brown moderately decomposed fibrous peat resting on blue clay. A layer of yellow-brown pumicite is 2 inches thick.

#### Lake Forest Park peat area

The Lake Forest Park peat area (10 acres, estimated) is in sec. 34, T. 27 N., R. 4 E., about 3½ miles northeast of Lake Forest Park, which is on the shore of Lake Washington just north of Seattle. The topography of the region is shown on the Edmonds quadrangle. The elevation of the peat is a little over 300 feet above sea level. The deposit lies in an only superficially drained depression in the glacial drift of the region. On the soil map of Snohomish County (Anderson et al., 1947) it is shown as a part of an area of Mukilteo peat.

This peat area has been much modified by the removal of peat for marketing in bulk by Evergreen Garden and Landscape Material, whose address is 17050 Brookside Boulevard, Seattle. In its natural state the area was a sphagnum bog with a natural "marginal ditch" on the north and south sides and a swampy area on the east and the west. A profile of this peat was published by Rigg and Richardson (1938), and figure 196 is redrawn from that profile. Most of the material shown as lake mud would probably be called sedimentary peat if the criteria now used were applied. The sphagnum is graded on the von Post scale mentioned in chapter II (p. 5).

#### Chase Lake (Esperance) peat area

The Chase Lake (Esperance) peat area (estimated 10 acres) is in sec. 30, T. 27 N., R. 4 E., about 2 miles southeast of Edmonds. It surrounds Chase Lake. A county road crosses the lake and the peat on a bridge (map, fig. 197).

The deposit is shown on the soil map of Snohomish County (Anderson et al., 1947) as Mukilteo peat, with Carbondale muck at the eastern end. Chase Lake and the topography of the surrounding region are shown on the Edmonds quadrangle. The elevation of the peat and the

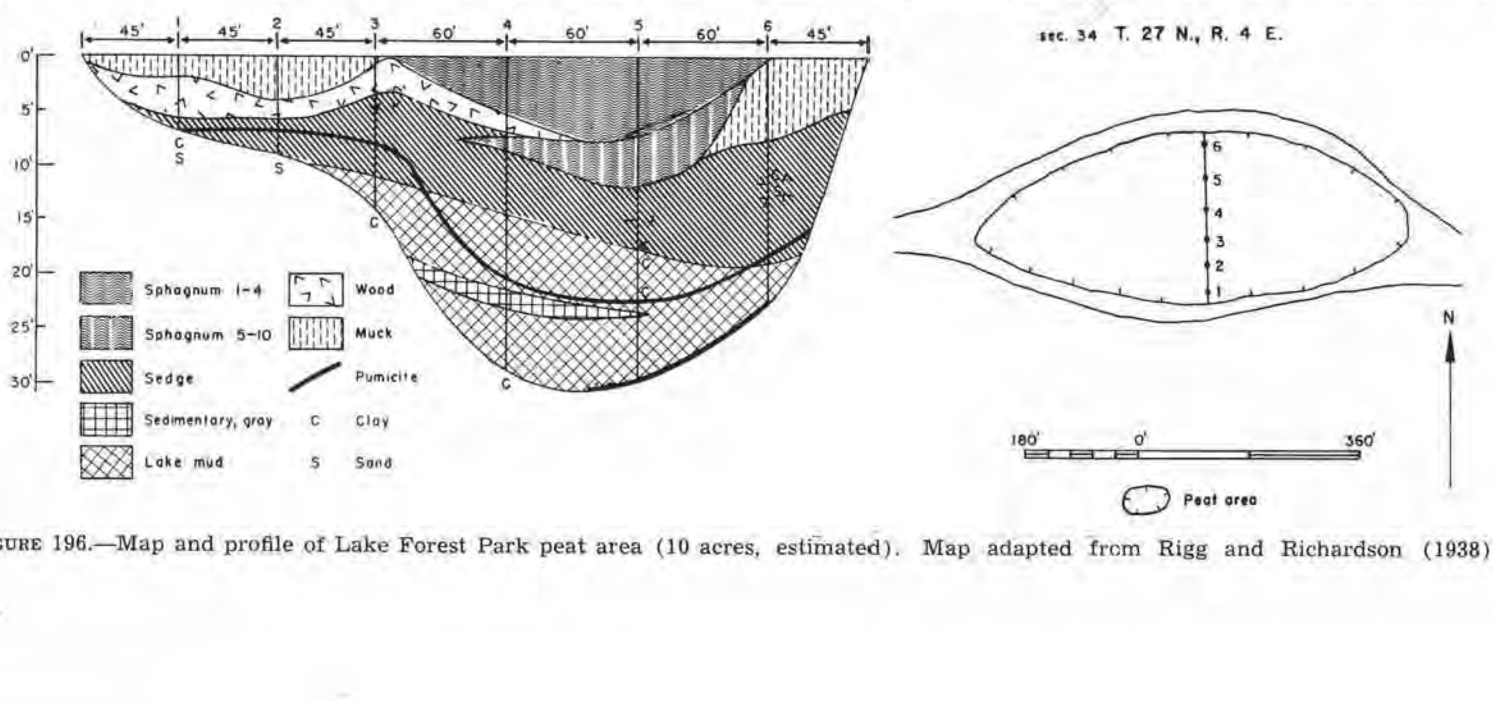


FIGURE 196.—Map and profile of Lake Forest Park peat area (10 acres, estimated). Map adapted from Rigg and Richardson (1938)

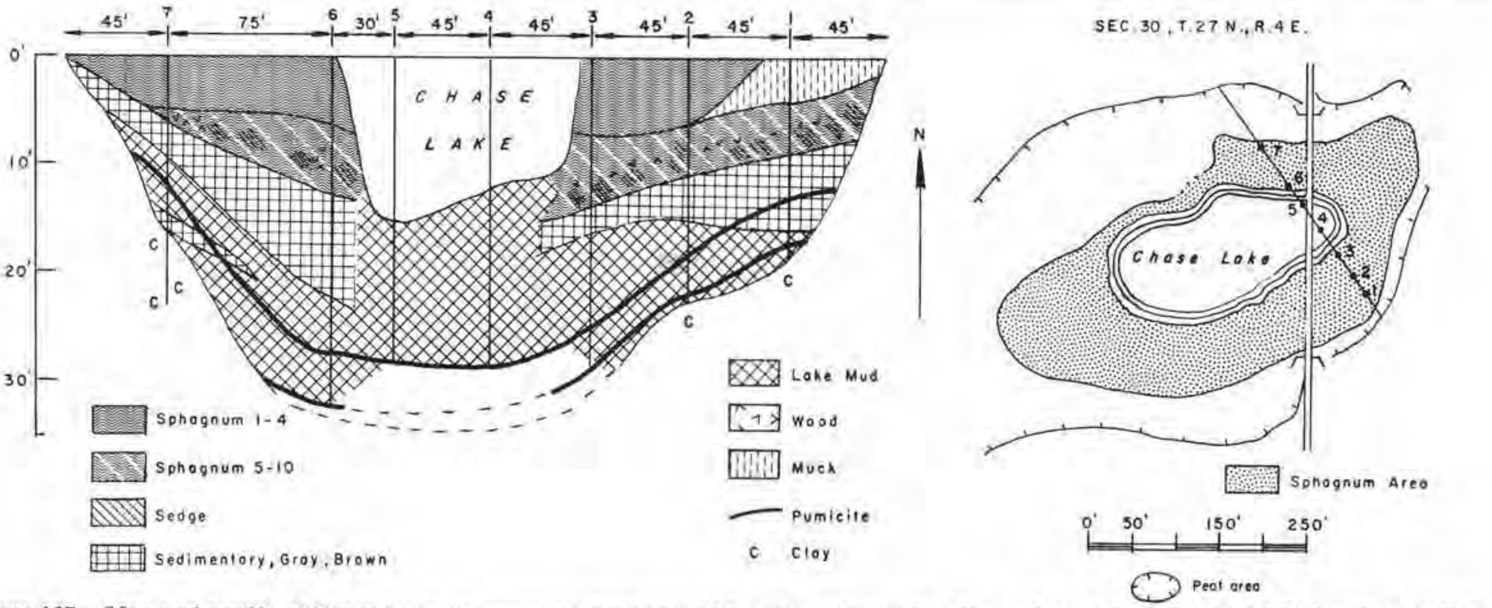


FIGURE 197.—Map and profile of Chase Lake (Esperance) peat area (10 acres, estimated). Map adapted from Rigg and Richardson (1938).

lake is slightly less than 400 feet above sea level. They lie in a depression in the glacial drift of the region. The elevation of the land around them, except on the east side, is 25 feet or more above the level of the peat. An old ditch, through which there has probably been some drainage, extends eastward from the east shore of the lake.

This is a sphagnum bog with a lake or pond in the center and a natural "marginal ditch" on its outer border. The "ditch" broadens into a swamp at the east. The vegetation on the bog comprises Labrador tea and other bog shrubs and cotton grass, sundew, and other herbs. The bog is very wet, and the mat of vegetation near the lake sinks under the weight of a man. Hemlock and white pine trees grow on the peat. Some have been cut.

Rigg and Richardson (1938) published a profile of this peat area. The profile shown in figure 197 is redrawn from it. The material called lake mud by Rigg and Richardson would probably be called sedimentary peat if the criteria now used had been applied then. The sphagnum is classified on the von Post scale mentioned in chapter II (p. 5).

During recent years peat from the northeastern part of the area has been removed and marketed in bulk. Several years ago an attempt was made to establish a muskrat farm on the lake. It was abandoned, as was also a similar attempt on the Woods Creek bog east of Monroe.

Dachnowski-Stokes (1930) has described this bog under the heading "The Esperance type profile." He calls attention to the presence of methane gas and "ooze-like diatomaceous sedimentary peat."

#### Winters Lake peat area

The Winters Lake peat area (9 acres) is in sec. 21, T. 28 N., R. 8 E., about 3 miles by road northeast of Sultan.

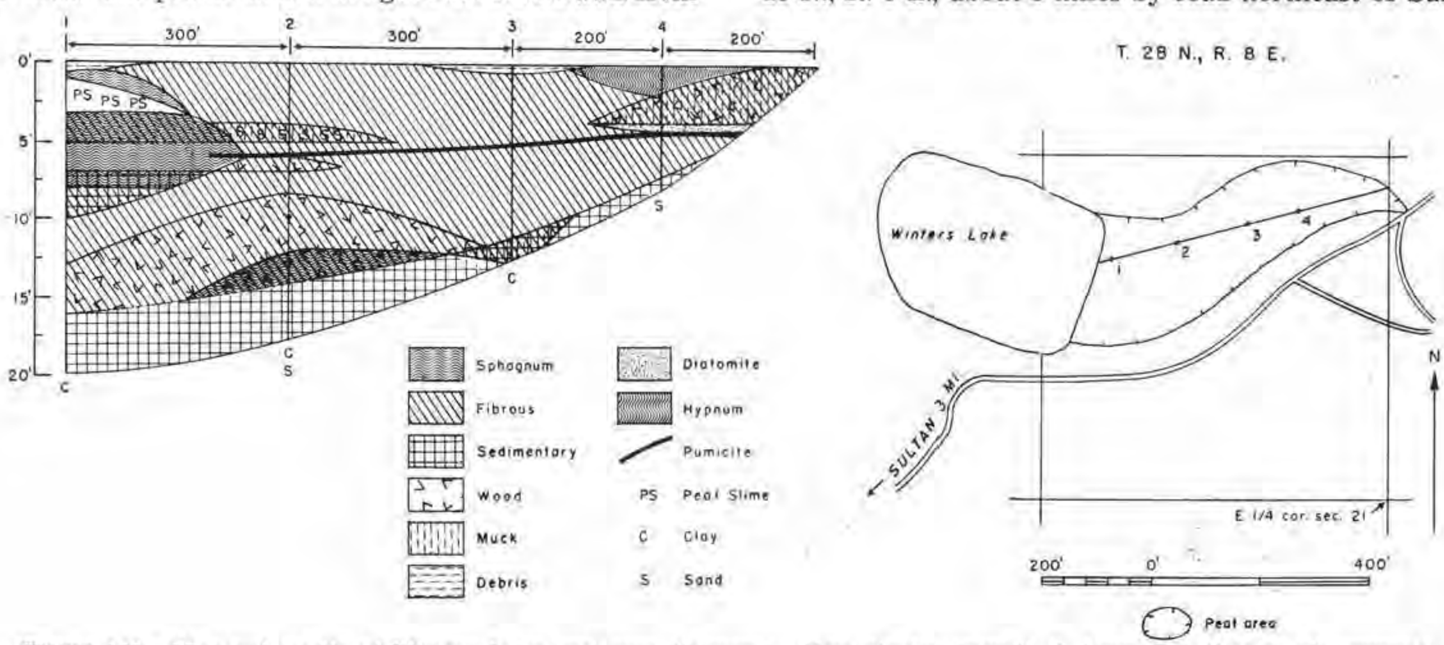


FIGURE 198.—Map and profile of Winters Lake peat area (9 acres). Map adapted from U. S. Army Map Service photomosaic.

The peat borders the east end of the lake, and the road passes close to the southern edge of the peat area (map, fig. 198). The lake and the topography of the surrounding region are shown on the Sultan quadrangle. The elevation of the lake is 628 feet above sea level. A stream flows eastward from Winters Lake to Kellogg Lake.

A sphagnum bog borders the lake and merges gradually into a swamp forest. The profile, 1,000 feet long, extends in an easterly direction from the lake shore. At hole 1 the shrubs are Labrador tea, salal, and sweet gale. The mosses are *Sphagnum* and *Hypnum* in about equal abundance. At hole 2 the trees are hemlock and cedar. Bracken fern is abundant, and *Hypnum* moss is abundant, but there is no *Sphagnum*. At hole 3 the shrubs are Labrador tea, bog laurel, and hardhack. The moss is *Hypnum*.

The profile (fig. 198) shows a complicated structure. Ten materials are present. Four different mixtures include two of these, and four other mixtures include three of them. Only four materials (hypnum peat, diatomite, pumicite, and peat slime) occur without forming a conspicuous part of one or more mixtures, and even these can be detected in the other layers with which they are in contact. Fibrous peat, sphagnum peat, and sedimentary peat form pure layers of considerable thickness and are also important constituents of one or more mixtures. Numerous changes in the conditions under which these materials were being deposited evidently occurred during the development of this deposit. The activities of water which came as precipitation and as melt water from retreating glaciers, and temperature changes which occurred as the ice retreated must have been among the factors in the changing conditions.

The sphagnum peat near the surface is raw, but in deeper layers it is more or less disintegrated. The fibrous peat is dark brown and decomposed. The sedimentary peat is olive. The pumicite is brown and forms a layer 2 inches thick. The deposit rests on blue clay which contains some sand.

#### Beverly Park peat area

The Beverly Park peat area (8 acres) is in secs. 7 and 8, T. 28 N., R. 5 E. (map, fig. 199), near Beverly Park, close to the south city limits of Everett. The new route of U. S. Highway 99 borders the east side of the bog, and the top of the grade is approximately 30 feet above the surface of the bog. The topography of the region is shown on the Everett quadrangle. The elevation of the bog is about 325 feet above sea level. The peat lies in a depression in the glacial drift of the region. On the soil map of Snohomish County (Anderson et al., 1947) it is mapped as Greenwood peat.

This is a wet sphagnum bog with a natural "marginal ditch" surrounding it. The vegetation on the bog consists of the usual bog shrubs and herbaceous species. The trees on it are small hemlocks, white pines, cedars, and a few Douglas firs. *Sphagnum* grows vigorously among the bases of the shrubs. In the marginal ditch the vegetation consists of willows and hardhack with swamp species of herbaceous plants.

One hole bored near the center of the bog shows 36 feet of peat, and the dark-olive sedimentary peat at that depth is too compact to be penetrated deeper with a peat borer. At the 20- to 30-foot depth the sedimentary peat is soft and wet, and bubbles of marsh gas arise from it as the peat borer penetrates it. The sphagnum peat extends to an unusual depth (18 feet) in this bog, interrupted only by peat slime and a small amount of fibrous peat mixed with the sphagnum. The sphagnum is wet and is raw at the surface but somewhat disintegrated at depths of 5 feet and below. At the surface and at the 10-foot depth it is strongly acidic (pH 3.5 to 4.0). The sedimentary peat at the 21-foot depth is also strongly acidic (pH 4.0). The gray pumicite forms a layer 3 inches thick.

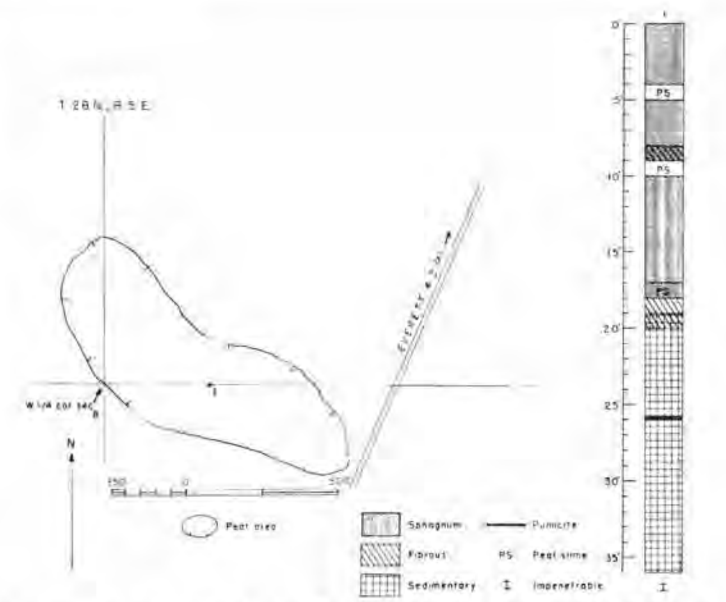

FIGURE 199.—Map and graphic log of a hole in Beverly Park peat area (8 acres). Map adapted from U. S. Army Map Service photomosaic.

The possibility of commercial use of the sphagnum in this bog merits investigation.

#### Woods Creek peat area

The Woods Creek peat area (7 acres) is in sec. 33, T. 28 N., R. 7 E., about 2.5 miles east of Monroe. It is reached by traveling 0.2 mile northeast on a county road from U. S. Highway 10A (State Highway 15). The topography of the region is shown on the Sultan quadrangle. The elevation of the peat is about 250 feet above sea level and is about 150 feet above Woods Creek. The peat surrounds a small lake or pond. On the soil map of Snohomish County (Anderson et al., 1947) it is mapped as Greenwood peat.

This is a sphagnum bog which has the usual flora of bog shrubs and herbaceous species with some small hemlock trees. The profile extends 525 feet in a southwesterly direction from the west shore of the lake. Hole 1 is at the margin of the lake in a mat of vegetation which sinks perceptibly under the weight of a man. The vegetation at hole 2 consists of Labrador tea, bog laurel, salal, and *Sphagnum*. At hole 3 it is comprised of Labrador tea and small hemlock trees. At hole 4 hardhack and other shrubs grow.

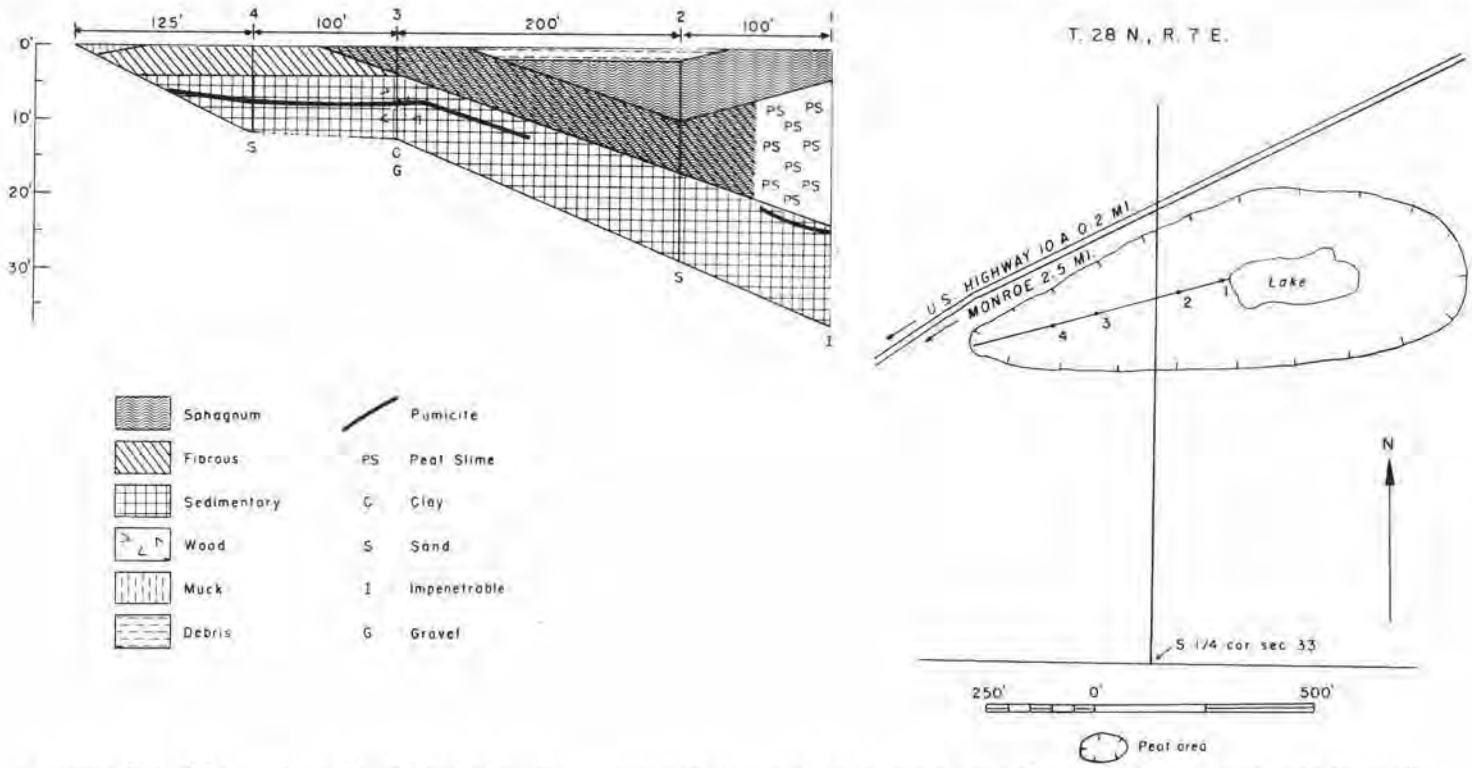


FIGURE 200.—Map and profile of Woods Creek peat area (7 acres). Map adapted from U. S. Army Map Service photomosaic.

The profile (fig. 200) shows 39 feet of sphagnum peat, peat slime, and sedimentary peat at the border of the lake. At the 39-foot depth the dark olive-green sedimentary peat is too compact to be bored deeper. At the 28-foot depth this peat is watery and feels greasy. At hole 4 the fibrous peat is brown, watery, and decomposed. The sphagnum near the surface in holes 1 and 2 is raw, but at the 2-foot depth it is disintegrated, and at the 3-foot depth it is decomposed. The pumicite in hole 4 forms a layer 2 inches thick, which is brown at the top and white at the bottom. In hole 3 the layer is 2 inches thick, and it is all brown. Pumicite was found at the 25-foot depth in hole 1, but no record of its color or of the thickness of the layer is available.

Several years ago the bog was fenced and used as a muskrat farm, but the project has been abandoned, as has also a similar project on another bog in Snohomish County and one in Pierce County.

### Old Homestead peat area

The Old Homestead peat area (3 acres) is near the northeast corner of sec. 17, T. 31 N., R. 4 E., about 4½ airline miles southeast of East Stanwood and about 2½ miles northeast of Warm Beach (Birmingham). It is about 2 miles south of the Stillaguamish River and is reached from Warm Beach by a county road and an abandoned road. The topography of the region is shown on the Stanwood quadrangle. The elevation of the area is about 400 feet above sea level.

This area is not shown on the soil map of Snohomish County (Anderson et al., 1947), but an area of about 40 acres just east of it in secs. 9 and 16 is mapped as Greenwood peat. This area was not seen in the field investigation upon which this bulletin is based.

The Old Homestead area is a dry brushy sedgy area with some aspen trees in the margin, surrounded by coniferous forest. The shrubs are Labrador tea and hardhack. There is some dead and some living *Sphagnum* on the surface among the shrubs and sedges.

Digging reveals 4 inches of sphagnum peat, 8 inches of muck, and 12 inches of hard fibrous brown peat somewhat mixed with muck, resting on sand. There are old collapsed buildings and old fences near the peat area.

### Cranberry Lake peat area

The Cranberry Lake peat area (2½ acres) is in sec. 35, T. 31 N., R. 4 E., about 9 miles northwest of Marysville. It borders the north shore of the lake (map, fig. 201). A county road passes near the deposit, and a road around the lake has been recently graded. The land around the lake shore has been surveyed into building lots.

The topography of the region is shown on the Stanwood and Marysville quadrangles. The elevation of the peat is about 550 feet above sea level. This deposit is mapped as Greenwood peat on the soil map of Snohomish County (Anderson et al., 1947).

The vegetation is composed of Labrador tea, salal, bracken fern, and small alder trees, with small herbaceous plants and *Sphagnum* moss and pigeon wheat moss growing among the woody plants. Evidently, several years ago the level of the lake was lowered about 2 feet by a ditch.

The deposit (fig. 201) consists mainly of dark-brown fibrous peat, some of which is decomposed. Near the lake shore there is some sphagnum peat at the surface, some woody peat at the 2- to 3-foot depth, and some sand near the bottom. The deposit is 5 feet deep at the center of the north shore of the lake and has sand under it. Farther north, 100 feet from the shore, it is 2 feet deep and has gravel under it.

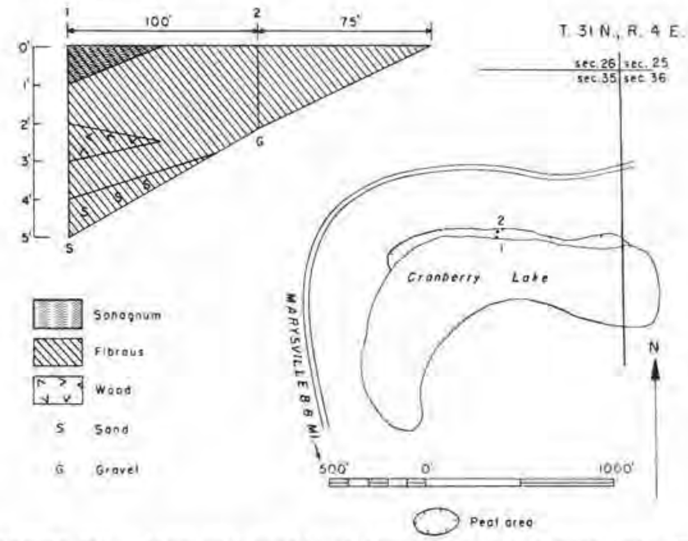


FIGURE 201.—Map and profile of Cranberry Lake peat area, Snohomish County (3 acres). Map adapted from U. S. Department of Agriculture soil map of Snohomish County and U. S. Army Map Service photomosaic.

**Mary Shelton Lake peat area**

The Mary Shelton Lake peat area (2½ acres) is in sec. 1, T. 30 N., R. 4 E., on the Tulalip Indian Reservation about 8 miles by road northwest of Marysville. A dirt road branching from a gravel road extends to the lake. The peat forms a narrow border around the entire lake shore. The topography of the region is shown on the Stanwood quadrangle. The elevation of the peat is about 370 feet above sea level, and the surrounding slopes are gentle. On the soil map of Snohomish County (Anderson et al., 1947) the peat is mapped as Greenwood peat, and the soil of a considerable area surrounding it is mapped as Alderwood gravelly sandy loam.

The lake appears to be about 2 or 3 feet lower than it

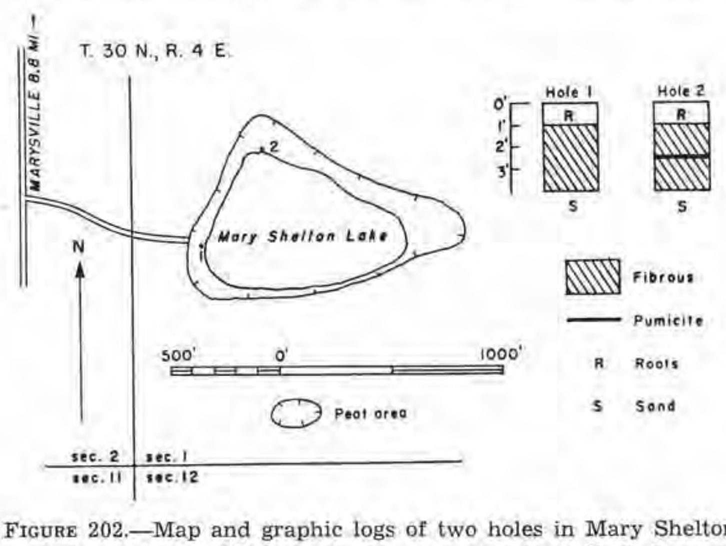


FIGURE 202.—Map and graphic logs of two holes in Mary Shelton Lake peat area (2½ acres). Map adapted from U. S. Department of Agriculture soil map of Snohomish County and U. S. Army Map Service photomosaic.

was at some time within the past 20 years. At the higher level the lake probably covered the peat area. The vegetation on the peat now is composed of willows, hardhack, cattails, *Dulichium*, mint, and *Sphagnum*.

Two holes (fig. 202) show 1 foot of a tangle of roots of herbaceous and woody plants, under which is a 3-foot layer of dark-brown decomposed fibrous peat resting on sand. Brown pumicite forms a layer 1 inch thick in hole 2.

**Tulalip peat area**

The Tulalip peat area (2½ acres) is in secs. 5 and 6, T. 30 N., R. 4 E., on the Tulalip Indian Reservation about 10 miles by road northwest of Marysville. A county road passes along the north side of the peat. The topography of the region is shown on the Stanwood quadrangle. The elevation of the peat is about 410 feet above sea level, though the area is only about ½ mile from the salt water of Port Susan. On the soil map of Snohomish County (Anderson et al., 1947) the deposit is mapped as Greenwood peat.

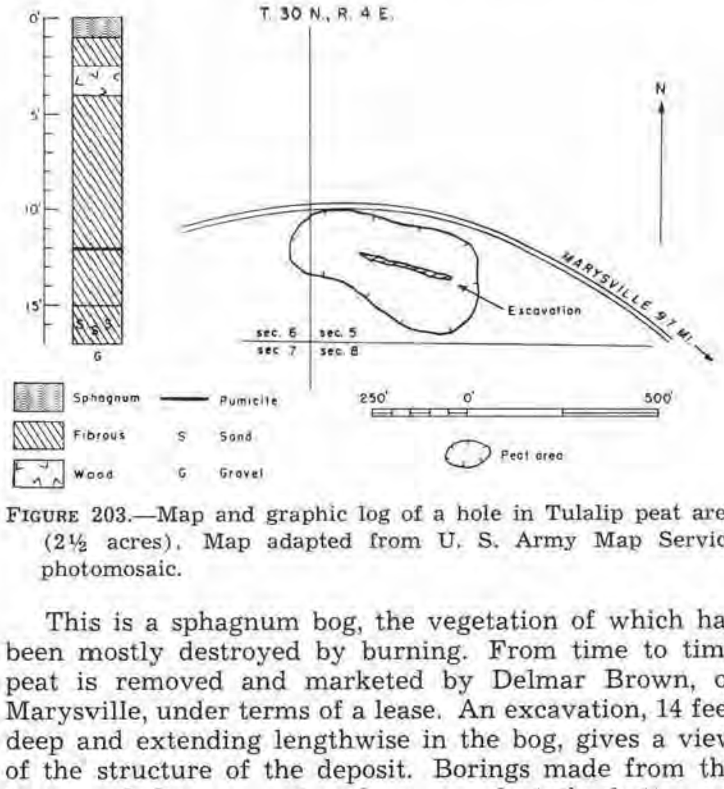


FIGURE 203.—Map and graphic log of a hole in Tulalip peat area (2½ acres). Map adapted from U. S. Army Map Service photomosaic.

This is a sphagnum bog, the vegetation of which has been mostly destroyed by burning. From time to time peat is removed and marketed by Delmar Brown, of Marysville, under terms of a lease. An excavation, 14 feet deep and extending lengthwise in the bog, gives a view of the structure of the deposit. Borings made from the bottom of the excavation show gravel at the bottom of the deposit at a depth of 17 feet (fig. 203). The sphagnum consists of whole stems with leaves attached. The fibrous peat is brown and is mostly decomposed, though some of it near the surface is raw, and at the 15- to 17-foot depth it is mixed with sand. The woody peat consists of hollow stems ¼ to ½ inch in diameter. The layer of pumicite exposed at about the 12-foot depth varies from 1 to 3 inches in thickness. Most of it is yellow, but some of it is white. The peat is strongly acidic. The pH of the sphagnum is 3.5 and of the woody peat is 3.8. The pH of the fibrous peat just above the pumicite is 4.0, and just below it is 4.5; at 15 feet it is also 4.5.

FIGURE 204.—Trench 17 feet deep cut in Tulalip peat deposit in removal of fibrous peat. Man's fingertips indicate layer of pumicite.

**Arcadia mucky diatomite area**

An area less than half a mile long and less than an eighth of a mile wide at its greatest width, in the W½ sec. 22, T. 30 N., R. 4 E., half a mile east of Arcadia on the Tulalip Indian Reservation, is mapped on the soil map of Snohomish County (Anderson et al., 1947) as Greenwood peat. A stream flows south through it. The area west of the stream, perhaps 15 acres, is in pasture and hayfield. Digging in the hayfield about 100 feet west of the stream revealed 3 inches of dry black muck; 12 inches of dry diatomite, relatively pure in some places but mixed with organic matter in other places; and 21 inches of muck mixed with sand.

### Other Peat Areas

Peat areas are numerous in Snohomish County. Besides the 32 areas described above, there are a considerable number shown on the soil map of Snohomish County (Anderson et al., 1947) which have not been investigated. The following list includes some of the larger of these.

GREENWOOD PEAT

1. NW¼ sec. 1, T. 28 N., R. 7 E., about 6 airline miles northwest of Sultan. Surrounds Lost Lake. Length approximately ½ mile. Estimated area 16 acres.
2. Two small areas in the SW¼ sec. 2, T. 28 N., R. 4 E., about 4 airline miles southwest of Everett. Length of the larger area approximately 1/10 mile. Estimated area of the two is 10 acres.
3. N½ sec. 9, T. 28 N., R. 8 E., about 4½ airline miles northeast of Sultan. Borders Bronson Lake. Length approximately ¼ mile. Estimated area 9 acres.
4. Sec. 8, T. 30 N., R. 8 E., about 1½ miles northeast of Robe. Length approximately 1 mile. Estimated area 160 acres.
5. Secs. 17, 18, 19, and 20, T. 30 N., R. 5 E., about 2 miles northwest of Marysville. On Tulalip Indian Reservation. Length approximately ¾ mile. Estimated area 70 acres.

GREENWOOD AND RIFLE PEAT

1. Secs. 12 and 13, T. 30 N., R. 4 E., and secs. 7 and 18, T. 30 N., R. 5 E., about 3½ airline miles northwest of Marysville. Surrounds an unnamed lake on Tulalip Indian Reservation. Length approximately ½ mile. Estimated area 20 acres.
2. Sec. 15 and 22, T. 30 N., R. 4 E., about 5 miles northwest of Marysville. On Tulalip Indian Reservation. Length approximately 1½ miles. Estimated area 480 acres.

GREENWOOD AND MUKILTEO PEAT

1. S½ sec. 26, T. 30 N., R. 6 E., about 3 airline miles northeast of Hartford. Length approximately ¼ mile. Estimated area 24 acres.

MUKILTEO PEAT

1. Sec. 13, T. 28 N., R. 8 E., about 5½ airline miles northeast of Sultan. Length approximately ¾ mile. Estimated area 170 acres.
2. Sec. 12, T. 28 N., R. 7 E., and sec. 7, T. 28 N., R. 8 E., about 4½ miles north of Sultan. Surrounds Woods Lake. Length approximately ¾ mile. Estimated area 90 acres.
3. W½ sec. 34, T. 27 N., R. 6 E., about 5 miles northwest of Duvall. Length approximately 1 mile. Estimated area 90 acres.
4. NW¼ sec. 22, T. 27 N., R. 4 E., about 1 mile southeast of Alderwood Manor. Length approximately ⅜ mile. Estimated area 14 acres.
5. Near center sec. 36, T. 28 N., R. 7 E., about 5½ miles northeast of Monroe. Length approximately ¼ mile. Estimated area 25 acres.
6. Secs. 3, 4, and 9, T. 28 N., R. 6 E., about 2½ miles northeast of Snohomish. Length approximately 1¼ miles. Estimated area 100 acres.
7. Secs. 16, 17, and 21, T. 28 N., R. 6 E., about 1½ airline miles southeast of Snohomish. Length approximately 1 mile. Estimated area 140 acres.
8. NW¼ sec. 20, T. 30 N., R. 7 E., about 1½ miles southeast of Granite Falls. Borders Swartz Lake. Length approximately ¼ mile. Estimated area 25 acres.
9. Secs. 5 and 6, T. 32 N., R. 5 E., about 7 airline miles northwest of Arlington. Length approximately ½ mile. Estimated area 80 acres. This peat area extends an unknown distance northward into Skagit County.

10. Secs. 28 and 29, T. 32 N., R. 6 E., about 4 airline miles northeast of Arlington. Length approximately ½ mile. Estimated area 135 acres.
11. NW¼ sec. 12, T. 32 N., R. 6 E., about 8½ miles northeast of Arlington. Length approximately ½ mile. Estimated area 80 acres.

RIFLE PEAT

1. Secs. 9 and 10, T. 28 N., R. 8 E., about 5 airline miles northeast of Sultan. Length 1¼ miles. Estimated area 260 acres.
2. Secs. 10, 11, 14, and 15, T. 27 N., R. 4 E., about 1½ miles northeast of Alderwood Manor. Length 1½ miles. Estimated area 380 acres.

## SPOKANE COUNTY DEPOSITS

### Saltese Marsh peat area

The Saltese Marsh peat area (1,200 acres) is in secs. 20, 28, 29, 32, and 33, T. 25 N., R. 45 E., and sec. 4, T. 24 N., R. 45 E., about 13 miles east of Spokane and about 2 miles south of Greenacres. County roads give access to the east and west sides, and an old road, now abandoned, crosses the area on the north line of secs. 32 and 33 (map, fig. 205).

The depression in which the peat lies is a valley which is dammed at its mouth by sand and gravel. The valley is a tributary to the Spokane Valley. Rapid aggrading by the Pleistocene Spokane River deposited the sand and gravel which blocks the mouth of the tributary valley.

The topography of the region is shown on the Spokane quadrangle and also on the Greenacres quadrangle, U. S. Geological Survey. The elevation of the peat is about 2,040 feet above sea level. The southern part of the area is somewhat higher than the northern part. The area is mapped on the soil map of Spokane County (Van Duyne et al., 1921) as muck and peat. These two soil types are grouped together in the mapping with the statement that, "In many instances one soil grades into the other so that separation is necessarily arbitrary, and on account of the close resemblance of the two soils and the slight agricultural difference between them in this county they are not shown separately on the map."

The peat area is a drained lake. Four ditches, put in by private land owners many years prior to 1910, extend across the peat—three in a northwesterly direction and one from east to west. The ditches unite near the northwest corner of the area, and the drainage goes to the Spokane River. Some of the ditches evidently followed the general course of Saltese Creek.

The ditches provide sufficient drainage in summer so that a large part of the area is utilized for oats, hay, and pasture, but there are considerable areas of waste land, some of which are swampy. In 1949 the crop of oats was poor, because the peat near the surface was too dry, but it was reported locally that in 1948 the peat was so wet that not all of the oatfields could be planted. It was also stated that water 1 foot deep stands on the peat in winter and that ducks and other waterfowl are numerous in the area then. Oats and native swamp and aquatic plants provide food for them.

The profile, 4,300 feet long, extends from west to east along the abandoned road on the north line of secs. 32 and 33, crossing three drainage ditches. Holes 1, 2, and 3 are in pasture or waste land. Holes 4, 5, 6, and 7 are in oatfields.

The materials found in this profile are shown in figure 205. The muck which forms a continuous layer at the surface is dark brown to black. The thick layer of fibrous peat which is also continuous through the profile is brown to yellow brown. Some of it is watery, and much of it is so completely decomposed that it is plastic. Hydrogen sulphide gas was found in hole 7. The layer of grayish pumicite is continuous and thick. Brown sedimentary peat lies under it in holes 2, 3, and 4, where it is 12 to 24 inches thick, but in holes 5, 6, and 7 the layer of pumicite is so compact that it cannot be penetrated more than 12 inches by the use of either the New American or the Hiller borer. It is not known how deep the deposit is at these three holes or whether sedimentary peat lies under the pumicite. Sand is present at the bottom of hole 2, and dark-brown mud and sand, at the bottom of hole 3. The layer of diatomite at the bottom of hole 4 is so compact that it could be penetrated only 6 inches. A layer of lake mud 12 inches thick lies over it.

One hole bored at the intersection of two ditches on the west line of sec. 28 shows 12 inches of organic soil; 1 inch of diatomite; 11 inches of brown decomposed fibrous peat; 24 inches of raw matted remains of tules, reeds, and sedges; 4 feet of moist decomposed fibrous peat, which varies from brown to greenish yellow; 15 inches of an olive-colored mixture of fibrous and sedimentary peat; and 9 inches of pumicite, which is white at the top and gray at the bottom. Beyond this depth the pumicite is so compact that it cannot be penetrated with the peat borer.

As stated below, Dachnowski-Stokes found salt on the surface of the peat in Saltese Marsh. In the investigations by the writer in 1949 no salt was found, and no other reports of salt in this marsh have been seen. Dachnowski-Stokes (1936) made borings ". . . on the east side of the marsh about 500 feet from the road" and found the following materials:

> 0 to 36 inches, sedge peat. In cultivated margins decomposed sedge muck which is strongly acidic in reaction (pH 4) and contains an excess of salts that appear as incrustations on the surface and are brought up largely through evaporation . . . . Below the plowed level is brown felty-fibered sedge peat containing a crystalline salt.
>
> 36 to 156 inches, brown or grayish-brown rhizomes and plant remains from aquatic vegetation.
>
> 156 to 180 inches, brown sedimentary peat, generally amorphous, plastic, and neutral in reaction. It contains a few fragments of light-brown rhizomes and in the lower part it assumes an abrasive character, owing to the presence of mineral matter similar to pumice and volcanic ash.

In regard to utilization he says, "The apparent benefit to agriculture from the development of Saltese Marsh does not seem to be significant. The improvement of such areas of peat land for cultivated crops is undesirable. A greater benefit to the general public is to be derived from the restoration of this area to its original water level and to its preservation as a wild life reserve."

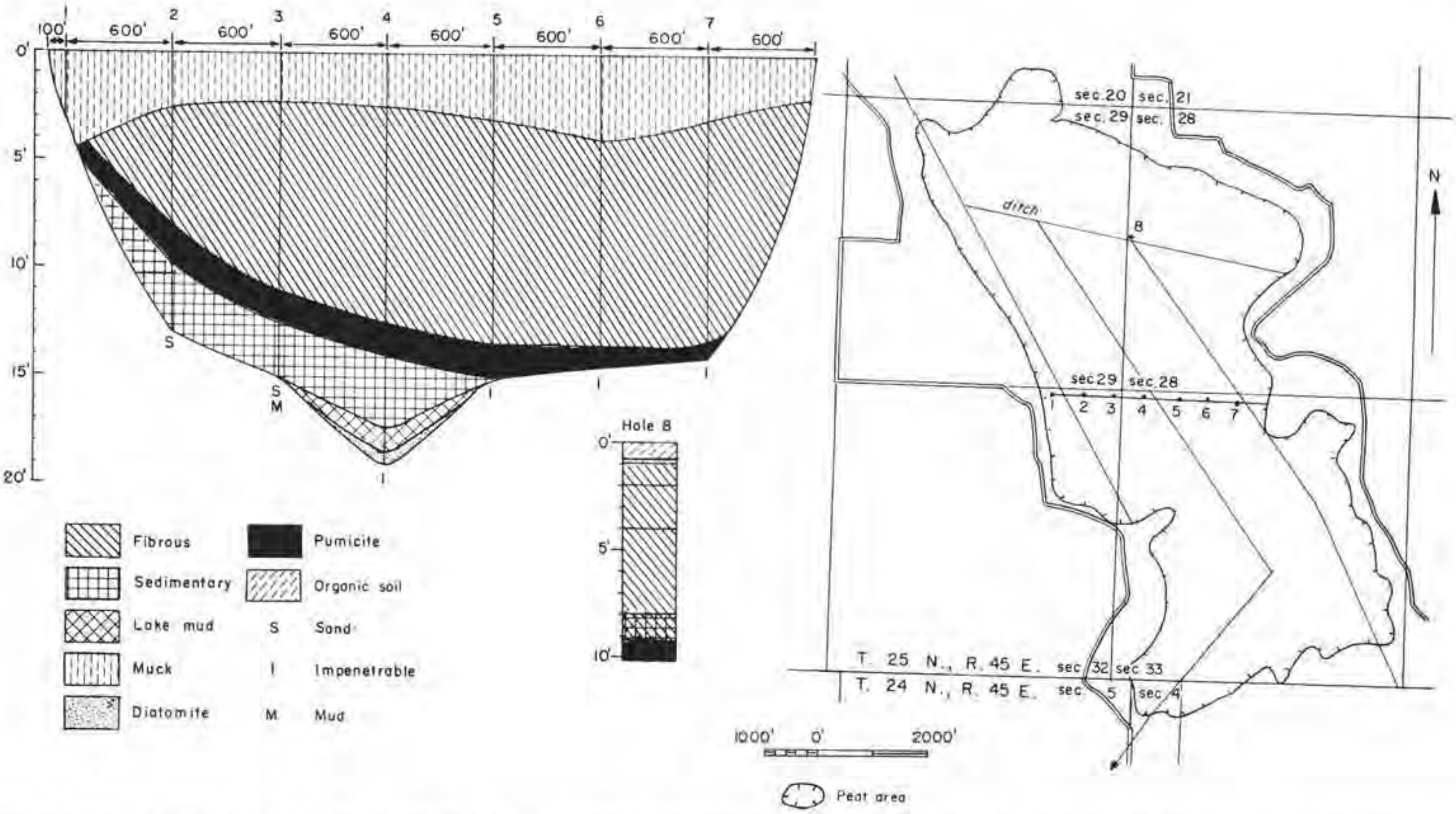


FIGURE 205.—Map, profile, and graphic log of a hole in Saltese Marsh peat area (1,200 acres). Map adapted from U. S. Department of Agriculture soil map of Spokane County.

The data on which this recommendation was made were obtained during his investigation of peat lands of the Pacific Coast states in relation to land and water resources. The present study indicates that a full investigation of all factors involved should be made before recommending any changes in the water level on this marsh.

#### Newman Lake peat area No. 1

Newman Lake peat area No. 1 (730 acres) is in secs. 10, 11, 12, 13, and 14, T. 26 N., R. 45 E., about 20 miles northeast of Spokane. It is reached by State Highway 2H and county roads, one of which crosses the peat. The peat borders the south end of the lake (map, fig. 206).

This region was covered with ice during the Spokane glaciation, which was approximately the same period during which the Puget Sound region was covered by the Vashon ice. The depression in which lie Newman Lake and the three peat areas bordering it was formed during and after the retreat of the Spokane ice. The depression is an old valley which formerly opened into the valley in which the Spokane River now flows. Rapid aggrading by the Pleistocene stream in the Spokane Valley filled the mouth of the tributary valley with sand and gravel and formed a basin similar in origin to that occupied by Saltese Marsh.

An irrigation ditch dug in the early 1900's extends in a southeasterly direction from an arm of the lake. The control gates in the ditch are primarily for the purpose of regulating the amount of water that flows in the ditch for irrigation purposes rather than of controlling the level of the lake. However, the ditch does remove water from the peat, and the lake has no other surface outlet.

The topography of the region is shown on the Spokane quadrangle and also on the Mount Spokane quadrangle. The elevation of the lake is 2,130 feet above sea level. On the soil map of Spokane County (Van Duyne et al., 1921) the peat area is mapped as muck and peat. (See p. 3 for statement in regard to this mapping.)

Much of the peat area is now utilized for the production of oats. In 1949 the crop appeared to be good on most of the area, but it was poor in some places. In the northern part of the area, near the lake shore, native vegetation still grows. A floating mat of vegetation borders the lake, and there are zones of cattails, tules, sedges, and rushes farther back from the shore. Thistles and other weeds have invaded the margins. Reed canary grass and other grasses have been introduced. Aquatic plants grow in the ditches, and hardhack and willows grow along the banks. Some yellow pine trees are still standing in the immediate vicinity.

The profile, 5,800 feet long, extends in a northwesterly direction from the southern border of the peat to an arm of the lake. Holes 1 to 4, inclusive, are along the ditch in pasture or waste land; holes 5 to 11 are along the road which is parallel to the ditch; and holes 12 and 13 are in the wet bog where the native vegetation has been somewhat disturbed.

The profile (fig. 206) shows mainly fibrous peat, but the amount of sedimentary peat in the deeper part toward the lake is considerable, and some muck is mixed with

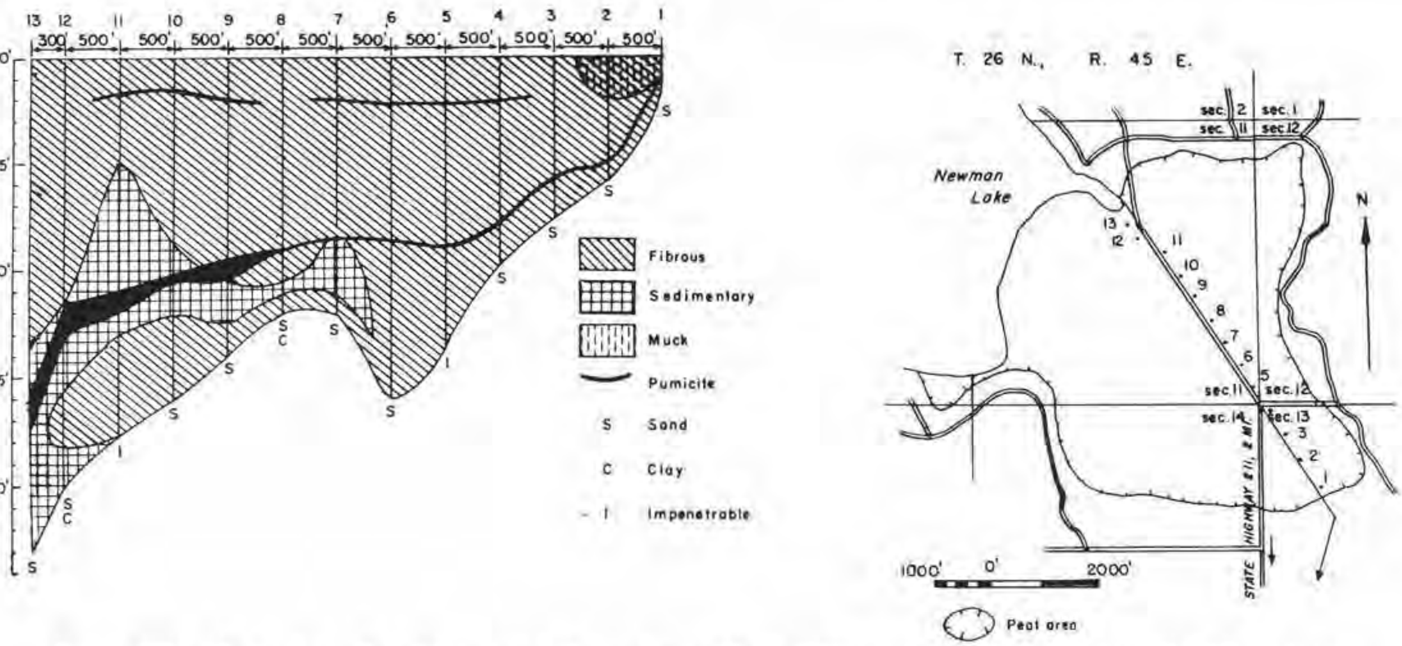


FIGURE 206.—Map and profile of Newman Lake peat area No. 1 (730 acres). Map adapted from U. S. Department of Agriculture soil map of Spokane County.

the fibrous peat in the shallow southern part near the border. There is a large amount of pumicite, which occurs in two layers.

The peat in the profile lies mostly on sand, but in holes 8 and 12 clay is mixed with the sand, and in holes 5 and 11 the peat is too compact to be penetrated to the bottom with the peat borer. The sand is mostly gray, but in hole 7 it is blue, and in holes 10 and 12 it is fine white quartz.

The fibrous peat is mostly brown, but some of it varies from light brown to dark brown and even black, and some has a distinctly red color. It has originated from various kinds of plants. Remains of cattails, sedges, and leaves of land plants are recognizable. It seems probable that the red peat originated from *Hypnum* moss. Much of the fibrous peat, however, is so decomposed that plant remains are difficult to recognize. Most of it is moist or wet, but some is rather dry. It is strongly acidic (pH 4.5). Some small wormlike masses of colloidal matter, each enclosed in a short case and having about the thickness of a lead pencil, are present in the deeper parts but have not been identified.

The mixture of muck and fibrous peat is dark brown. The sedimentary peat is mostly dark brown. Some of it is compact.

The upper layer of pumicite is about 1 inch thick, and it is at a fairly uniform depth of about 2 feet. Its color is yellowish brown. It was not found in holes 2, 3, 8, 12, and 13, but it may be so mixed with the fibrous peat in these holes that it was not recognized in the field examination. The deeper layer is all white except at holes 2 and 13. In hole 2 it is grayish, and in hole 13 it is gray at the top of the layer and white at the bottom. Probably the gray color is due to the mixture of dark-colored peat with the white pumicite. The thickness of this layer is much greater at the north end of the profile than at the south end but varies from hole to hole; at hole 9 it is 15 inches, and at hole 10 it is only 1 inch. There is some pumicite scattered in the peat in holes 2, 3, and 4.

Though some of this ash undoubtedly lies where it fell, probably much of it was washed in from the surrounding steep slopes. The tendency of recently deposited pumicite to slide down slopes when rains come is well known. In 1913 Rigg observed that the 12-inch layer of pumicite deposited on Kodiak Island in Alaska by the eruption of Mount Katmai in 1912 had slid down the mountain side to such an extent that it had moved a house from its foundation in Kodiak and had practically filled a lake at Kalsin Bay.

The irregularities in the thickness of the layer of pumicite in the peat deposit south of Newman Lake are consistent with the concept that it was washed in. A layer of pumicite several feet thick in the bank of a creek at the north end of the lake indicates that there has been considerable inwash there. The thickness (12 inches) of the layer of pumicite in the peat at the north end of the lake (fig. 207) may also indicate inwash. However, the layer of pumicite is thick in several peat deposits in Spokane County (Saltese Marsh, fig. 205; Lakeside Marsh, fig. 210; Meadow Lake, fig. 212; and Fish Lake, fig. 215). The available data are not sufficient to indicate positively whether all these can be accounted for by inwash or whether there was an eruption which deposited unusually large quantities of pumicite. It seems possible, however, that inwash has been a large factor in all these places.

Hansen (1939) made borings with a Hiller borer about 500 feet south of Newman Lake. He says, "The depth of the peat is 7.3 meters (23 feet 11 inches), and it is uniform in thickness over much of the area. A layer of volcanic ash (pumicite) occurs from the 4.7-meter (15 feet 5 inches) to the 4.4-meter (14 feet 5 inches) level, a thickness considerably greater than that usually found in the bogs of the Pacific Northwest. This may have been due to the heavy rains which generally follow volcanic eruptions, transporting the ash into the lake." He also says, "The lower meter of peat consists of a gray-brown sedimentary type overlaying sand. This grades upward into fibrous sedge peat, with the ash above separated by a sharp line of demarcation. Immediately above the ash again occurs sedimentary peat, which indicates inundation of the bog at this time, suggesting that abnormally heavy rains followed the volcanic eruption. The sedimentary peat grades into fibrous sedge peat toward the surface."

Dachnowski-Stokes (1936) made soundings in the SE¼ sec. 4, near the floodgate of the ditch, ". . . in an area sodded with bluegrass and used chiefly for pasture." He found 16 feet of peat lying on sand. The strata which he reports are: 0 to 24 inches, sedimentary peat; 24 to 120 inches, brown or yellow-brown fibrous peat; 120 to 192 inches, olive greenish-brown sedimentary peat. He found that the water at the floodgate is alkaline (pH 8), whereas in a dug hole, about 2 feet below the surface, it is acid (pH 5).

#### Newman Lake peat area No. 2

Newman Lake peat area No. 2 (332 acres) borders the north shore of the lake and lies in secs. 27, 28, 33, and 34, T. 27 N., R. 45 E. (map, fig. 207). The distance from Spokane and the origin of the depression are stated in the discussion of Newman Lake peat area No. 1. A county road extends near most of the northeastern border of peat area No. 2. Thompson Creek flows south across the peat and empties into the lake. A drainage ditch also carries water to the lake.

The topography of the region is shown on the Mount Spokane quadrangle. A benchmark just across the road which borders the northeast side of the peat shows an elevation of 2,145 feet above sea level, and another one at the eastern border shows 2,136 feet. The slopes surrounding most of the peat are steep.

The profile, 2,000 feet long, extends in a northerly direction from the north shore of the lake (map, fig. 207). Hole 1, close to the margin of the lake, is in a dense thicket of hardhack and willows and an abundant undergrowth of herbaceous plants. Water lilies grow in the margin of the lake. On July 8, 1949, the water was 1 inch deep at this hole. Hole 2 is in a meadowlike area of sedges and grasses where swamp shrubs apparently have been cleared away. Hole 4 is in the edge of a field, but no crop was growing there in 1949.

The materials found in the profile (fig. 207) are muck, diatomite, fibrous peat, peat slime, sedimentary peat, sand, and pumicite. A considerable amount of a mixture of fibrous peat and sedimentary peat is present. Mixtures of sand and sedimentary peat, muck and fibrous peat, and pumicite and sedimentary peat are also present.

The fibrous peat is brown, and it varies from wet to watery. Some of it is red and similar to the reddish peat found in Newman Lake peat area No. 1, south of the lake. Probably this is hypnum peat, but microscopic examination would be necessary to determine whether it is. The sedimentary peat is brown. The muck is dark brown to black.

The pumicite is mostly white where it is pure; at hole 4 it is soft at the top, but at a depth of 6 inches it is too compact to be penetrated farther. At hole 1 the gray

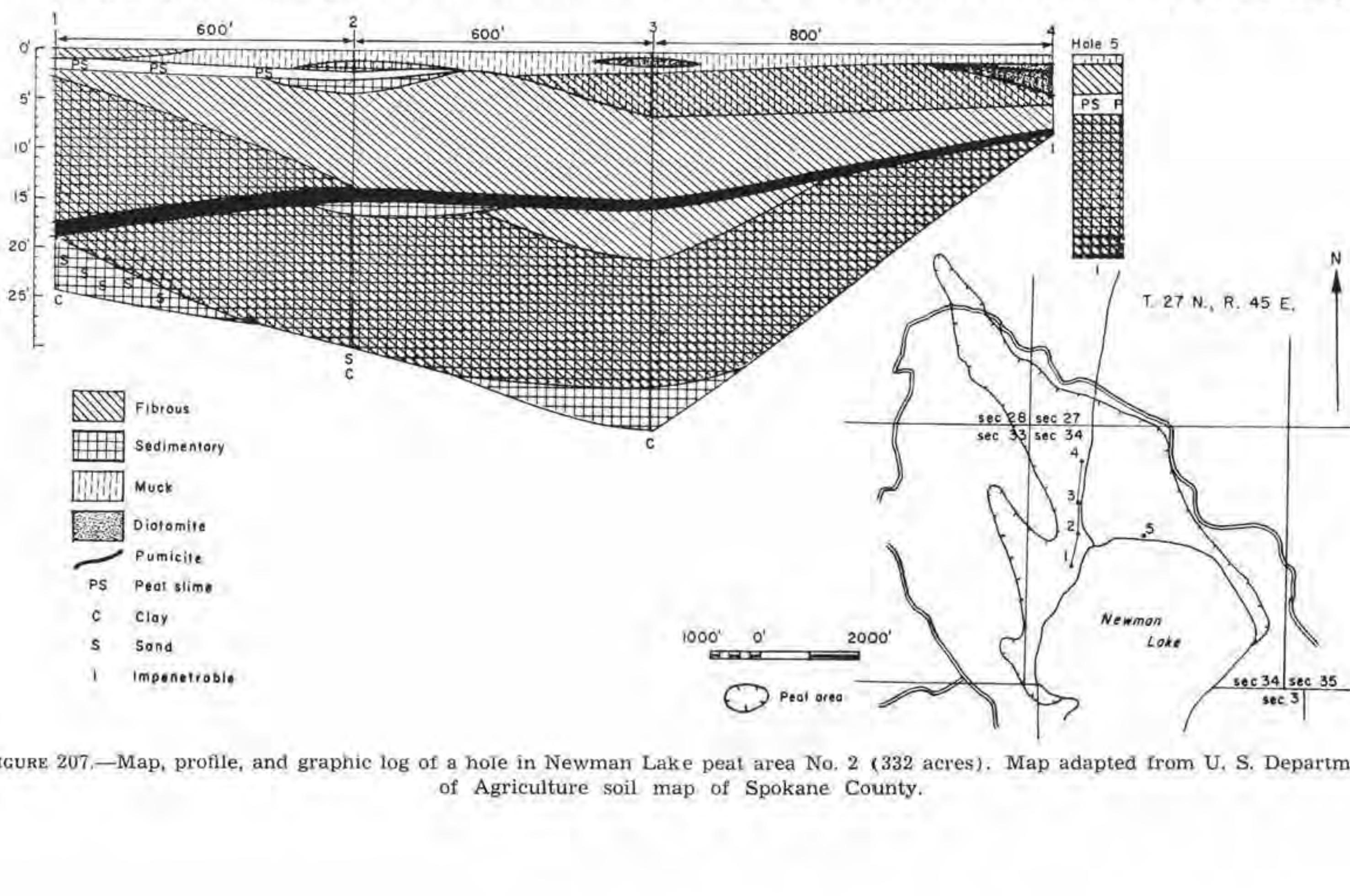


FIGURE 207.—Map, profile, and graphic log of a hole in Newman Lake peat area No. 2 (332 acres). Map adapted from U. S. Department of Agriculture soil map of Spokane County.

mixture of pumicite and sedimentary peat is 2 feet thick. At holes 2 and 3 the pumicite is pure and forms a layer about 1 foot thick. A deposit of white pumicite several feet thick is present in a bank of glacial drift near the north border of the peat.

At holes 1 and 3 the deposit rests on soft blue clay. At hole 2 it rests on blue clay and sand. At hole 4, as stated above, the pumicite is too compact to be penetrated with the peat borer.

### Newman Lake peat area No. 3

Newman Lake peat area No. 3 (150 acres) borders the northwest arm of the lake and lies in sec. 4, T. 26 N., R. 45 E., and sec. 33, T. 27 N., R. 45 E. (map, fig 208). A county road crosses the area. The distance and direction of the lake from Spokane and the origin of the depression are stated in the discussion of Newman Lake peat area No. 1. The topography of the region is shown on the Mount Spokane quadrangle. The elevation of the peat is approximately the same as that of Newman Lake peat area No. 2. The slopes around the deposit are steep. The area is mapped as peat and muck on the soil map of Spokane County (Van Duyne et al., 1921).

The profile, 1,500 feet long, extends in a southeasterly direction from the border of the area to the lake shore. No peat was found at the surface in this profile (fig. 208), but there is peat under the muck near the lake. At hole 1 there is only dark-gray clay. At hole 2 is the same clay with charred material and scattered pumicite at a depth of 2 feet. At hole 3 the clay is brown and mucky. The layer of pumicite at the 18-inch depth is ½ inch thick. Dark-brown muck is present at the 2- to 3-foot depth. At hole 4, which is near the lake shore, the upper 1 foot of material consists of roots of reed canary grass and other plants. Under this is a 2-foot layer of brown muck, the properties of which tend somewhat toward those of sedimentary peat. Under this is a brown wet mixture of fibrous and sedimentary peat. The material below this is brown decomposed fibrous peat. The white pumicite at the bottom of this hole was penetrated to a depth of 8 inches but is too compact to be penetrated beyond that depth.

### Liberty Lake peat area

The Liberty Lake peat area (87 acres) is in secs. 25 and 26, T. 25 N., R. 45 E., about 15 miles east of Spokane. The east side of the peat area is reached by a county road which passes east of the lake. The peat borders the south end of the lake (map, fig. 209). Liberty Creek, which is about 4 miles long and originates between Cable Peak and Round Mountain in Idaho, flows across the eastern part of the peat area and empties into the lake.

The origin of the depression in which the lake and the peat lie is similar to that of the depressions in which lie Saltese Marsh and Newman Lake. The topography of the region is shown on the Greenacres quadrangle, and the peat area is shown as marsh. The elevation of the peat is 2,055 feet above sea level. Steep slopes border the deposit on the east and west. The steepness of these slopes and the location of the peat are well shown in the aerial photograph in Hansen's publication (1947).

On the soil map of Spokane County (Van Duyne et al., 1921) the peat area is mapped as muck and peat, and the flat area bordering it on the south is mapped as Garrison fine sandy loam. As has been stated before, this soil survey (Spokane County) did not distinguish between muck and peat.

When this peat was examined (July 11, 1949), the water on it was so deep that boring within several hundred feet of the lake was impossible, but one member of the party, who wore hip boots, walked north on the peat to a point near the margin of the lake. The owner of the peat, A. T. Miller, Route 2, Greenacres, stated that several years before 1949 he had used a tractor to within a short distance from the lake.

The plants growing on the area in 1949 were cattails, bur reed, and other aquatic plants. The owner stated that several years before 1949 the area was a swamp forest in which pines and willows were dominant, and that he had cleared this forest. It was evident that in 1949 the water level was much higher than it had been when the forest was cleared.

In 1952 a court decision set the maximum level of the lake at 2,049.5 feet above sea level. In accordance with

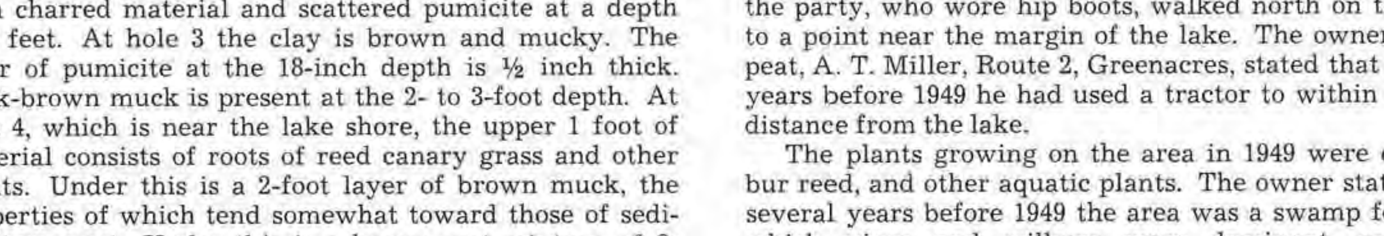


FIGURE 208.—Map and profile of Newman Lake peat area No. 3 (150 acres). Map adapted from U. S. Department of Agriculture soil map of Spokane County.

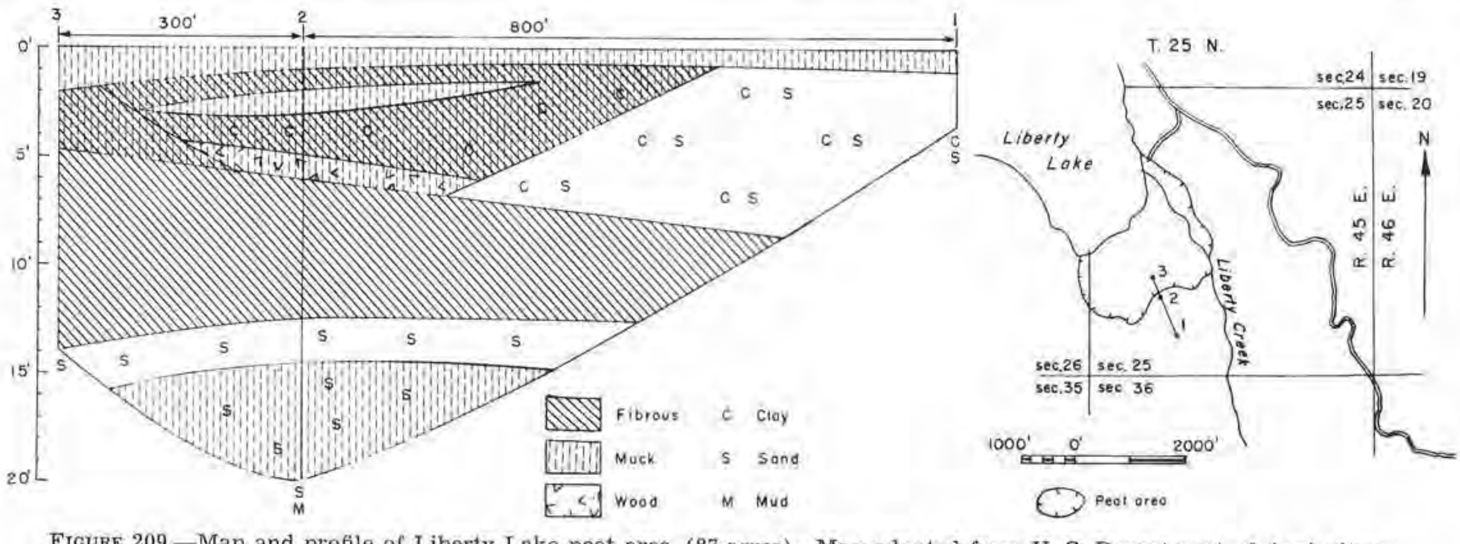


FIGURE 209.—Map and profile of Liberty Lake peat area (87 acres). Map adapted from U. S. Department of Agriculture soil map of Spokane County.

this decision it is the responsibility of the State to prevent rising of the water above that level. In the early 1900's an irrigation district group dug a canal to obtain water from the north end of the lake for irrigation, but some time later the canal was abandoned and a new canal was dug to obtain water from the Spokane River. This new canal is shown on the Greenacres quadrangle. However, the old canal was connected with the new one, and it continued to receive the overflow from the lake.

Hole 3 of the profile is about 1,000 feet from the south shore of the lake. When it was bored (July 11, 1949), a few inches of water stood on the peat at that place, and the surface of the muck was so soft that workers sank 12 inches into it while making the boring. The vegetation was composed of cattails, bur reed, and other aquatic plants characteristic of shallow lake margins. At hole 2, which is approximately 300 feet south of hole 3, the vegetation was the same but there was no standing water. Hole 1, which is 800 feet south of hole 2, was in an oatfield.

The profile (fig. 209) shows muck, fibrous peat, sand, and clay in hole 3. The brown fibrous peat forms a layer 9½ feet thick resting on sand. Above the fibrous peat is a dark-brown layer of mixed muck and fibrous peat 2½ feet thick. Above this is a soft layer of dark-brown muck. It is apparent that much mineral matter has been washed into this area from the surrounding steep slopes, and that the inwash has been greater at some periods than at others. This is evident from the general structure of the deposit and is emphasized by the fact that in the lower part of hole 2 there are alternating layers of sand and muck. No pumicite was found in the borings, but it may be scattered in other materials.

Hansen (1947) bored this peat for the purpose of obtaining fossil pollen for the study of postglacial forest succession, climate, and chronology. The date of his borings in the Liberty Lake peat is not stated, but it was probably a few years before 1947. It is evident that the lake level was lower when he made his borings than it was in 1949 and that his borings were nearer the lake than those made in 1949. He found 2 meters (6 feet 7 inches) of fibrous peat, 3.5 meters (11 feet 6 inches) of limnic (sedimentary) peat, 0.5 meter (1 foot 8 inches) of clay, and 1.0 meter (3 feet 3 inches) of silt. He found volcanic ash (pumicite) at a depth of 4.5 meters (14 feet 9 inches) below the surface.

#### Lakeside Marsh peat area

The Lakeside Marsh peat area (77 acres) is in secs. 25, 26, and 36, T. 24 N., R. 41 E. (map, fig. 210), just southeast of Lakeside and about 3 miles north of Cheney by U. S. Highway 395. The depression in which it lies is a scabland channel in which sand, gravel, and other materials have been irregularly deposited by glaciofluvial agencies. The topography of the region is shown on the Medical Lake quadrangle. The peat lies at an elevation of a little less than 2,375 feet above sea level. It is within the closed 2,375-foot contour. The rocky slope bordering the west side of the peat area is steep, but on the east side the slope is more gentle.

On the soil map of Spokane County (Van Duyne et al., 1921) the area is mapped as peat and muck. This is mainly a cattail-tule swamp in which cattails reach an extreme height of 8 feet. The area is used for pasture, but pasture grasses grow on only a small part of it. Water is made available by a shallow excavation about 15 by 40 feet.

The thick layers of sedimentary peat and fibrous peat which constitute the lower part of the deposit indicate relatively stable conditions during their deposition. Following the deposition of the pumicite several changes in the conditions of deposition occurred. These changes are indicated by the strata of marl, diatomite, and fibrous peat, and the mixtures of these materials.

The fibrous peat is brown to dark brown to black, and much of it is completely decomposed. The muck is black. The sedimentary peat is mostly olive colored, and much of it is compact. The marl has a grayish color, and small gastropod shells are present in it. The pumicite is grayish white and is compact at the bottom of the layer. It varies in thickness from 1 foot to 2½ feet. The deposit rests on gravel which is covered with a thin layer of green-blue clay.

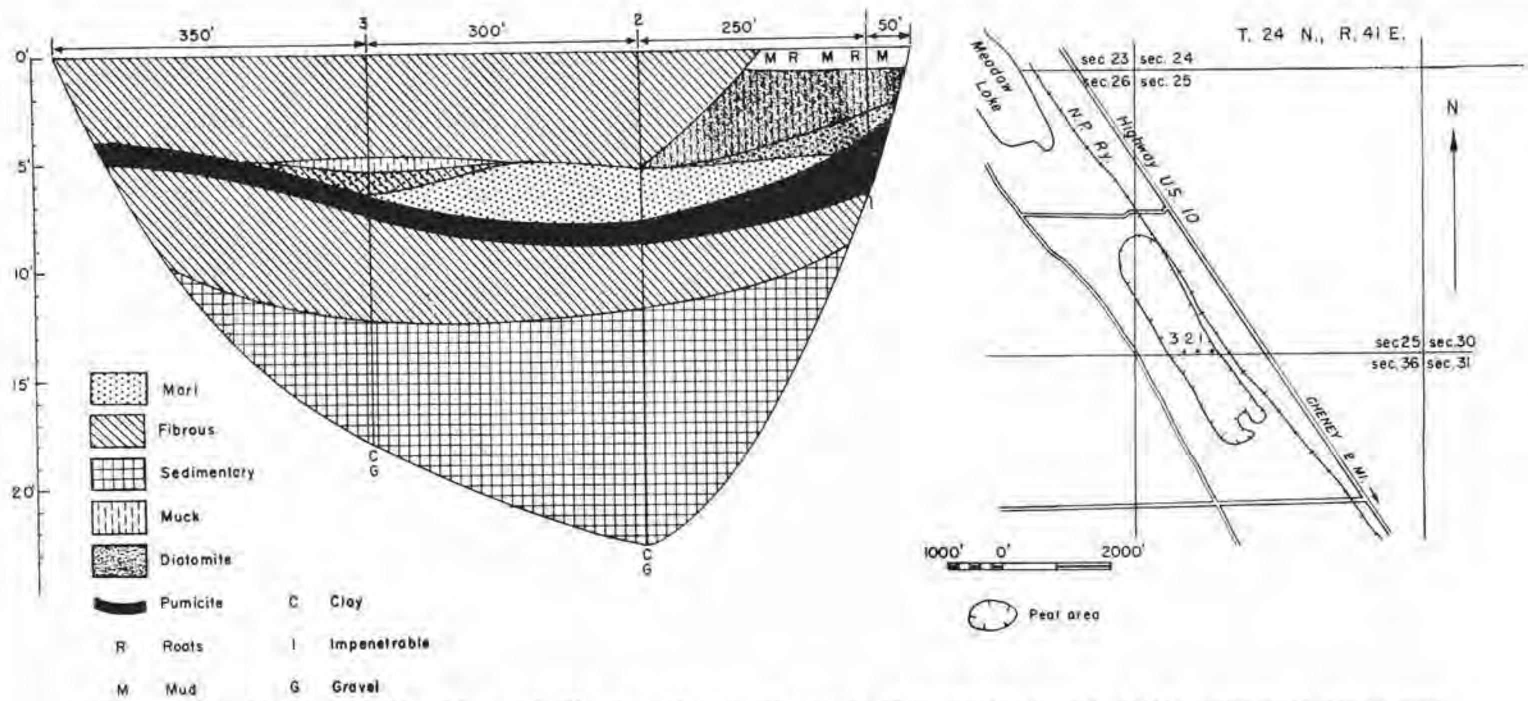


FIGURE 210.—Map and profile of Lakeside Marsh peat area (77 acres). Map adapted from U. S. Department of Agriculture soil map of Spokane County.

**Eloika Lake peat area No. 1**

Eloika Lake peat area No. 1 (37 acres) is in secs. 15 and 16, T. 29 N., R. 43 E., about 3½ airline miles northeast of Deer Park. It borders the south end of the lake (map, fig. 211). A county road passes near it; by this road the distance to Deer Park is considerably greater than the airline distance. The topography of the region is shown on the Newport quadrangle. The elevation of the peat is approximately 1,900 feet above sea level. The slopes bordering it are comparatively gentle. Westbranch Creek flows from the south end of the lake just east of the peat through a rather flat valley to the Little Spokane River. The lake and the peat lie in a depression in ground moraine left by Pleistocene continental ice.

On the soil map of Spokane County (Van Duyne et al., 1921) the area is mapped as muck and peat. The area comprises three zones—a floating map of vegetation, a brushy zone, and a hayfield. The mat of vegetation quakes when one walks on it. Water lilies grow in the margin of the lake. Willows grow in the brushy area.

The profile, 1,350 feet long, extends south from the shore of the lake. Hole 1 is in the brushy zone, and holes 2 and 3 are in the hayfield. The structure of the deposit (fig. 211) is comparatively simple at hole 1 but is more complicated at holes 2 and 3.

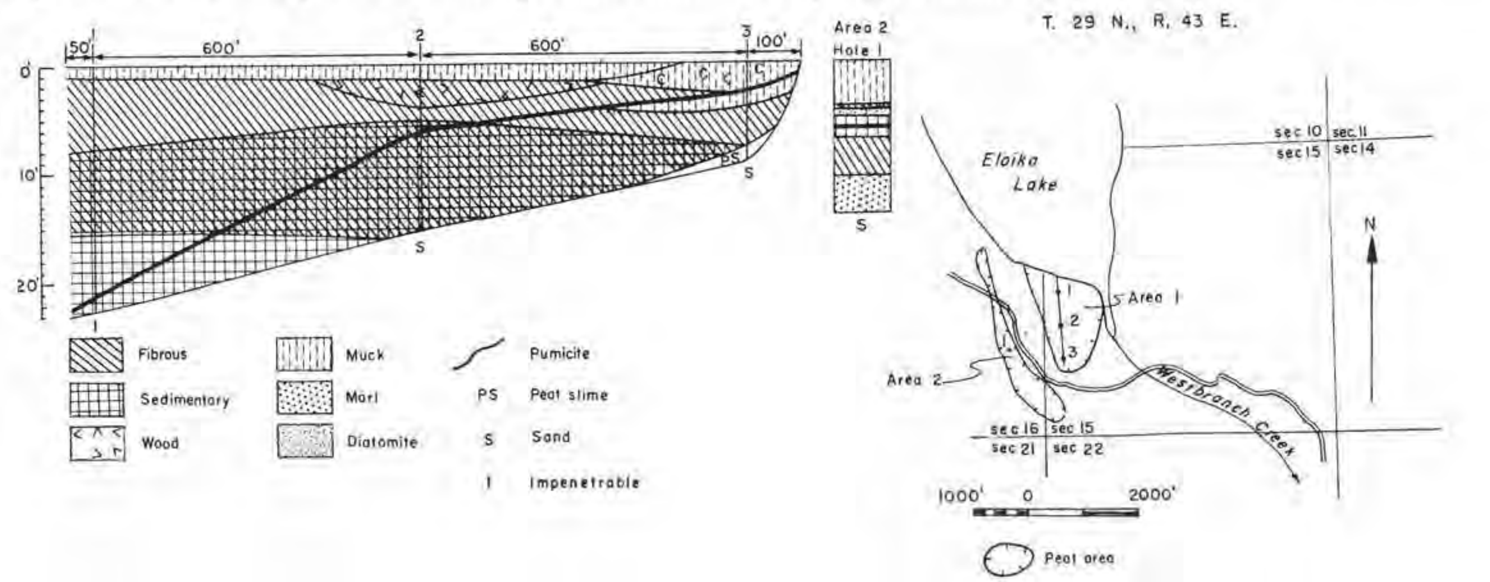


FIGURE 211.—Map, profile, and graphic log of a hole in Eloika Lake peat areas (37 acres and 24 acres). Map adapted from U. S. Department of Agriculture soil map of Spokane County.

The fibrous peat is mostly brown to light brown to yellow brown, but some of it is red. It is moderately decomposed. The muck is black. The sedimentary peat is yellow brown to olive brown. It is weakly acidic (pH 6.0). The pumicite is mostly white, but it is yellow at the bottom of the layer in hole 3. In hole 1 it is so compact that it can be penetrated only a few inches with the peat borer. In hole 2 the layer is 9 inches thick, and some pumicite is mixed with the peat for a few inches above the layer. In hole 3 the pumicite is 3 inches thick. The deposit rests on sand.

Dachnowski-Stokes (1936) visited this peat and made profile soundings. Evidently the lake level was higher then than it was in 1949. He reported the presence of aquatic plants on the central part of the peat area. He also noted the presence of partly decomposed stubbles of oats which were reported to have been sown about 2 years before. He found that water stood 1 foot below the surface in a dug hole. In his boring he found the following layers: 0 to 12 inches, sedge peat; 12 to 40 inches, grayish-brown or black diatomaceous sedimentary peat; 40 to 96 inches, more-or-less fibrous charred sedge peat and charred woody residue; 96 to 160 inches, greenish-brown sedimentary peat which is somewhat fibrous in the upper part and contains seeds from herbaceous marsh plants. He remarked, "The underlying mineral material consists of light-gray soft gritty clay over boulder drift." He concluded that "the facts brought out in the profile section indicate the advisability of abandoning its agricultural use."

Hansen (1947) found 5 meters (16 feet 5 inches) of peat in this deposit. He found volcanic ash (pumicite) at a depth of 1.6 meters (5 feet 3 inches). He found 2.0 meters (6 feet 7 inches) of limnic (sedimentary) peat and 0.25 meter (10 inches) of silt. The depths of peat reported by Dachnowski-Stokes and Hansen indicate that their borings were made in the central part of the peat area, probably in the vicinity of hole 2 of the profile shown in figure 211.

### Eloika Lake peat area No. 2

Eloika Lake peat area No. 2 (24 acres) is in secs. 15 and 16, T. 29 N., R. 43 E., about 650 feet west of area No. 1 (map, fig. 211). It does not border the lake. The two areas are shown on the Newport quadrangle, and both lie in the same depression.

One hole, bored near the center of the area in a natural sedge meadow, indicates that the structure of this deposit is somewhat different from that of area No. 1 (fig. 211). A layer of marl which contains small gastropod (snail) shells and pelecypod (mussel) shells occupies the lower 3½ feet of the deposit, and rests on coarse angular sand. Above this is a 3½-foot layer of brown to black, decomposed fibrous peat. Above the fibrous peat is a 2-foot layer of brown sedimentary peat having a 3-inch layer of white pumicite at its middle depth. The 12-inch layer of diatomite above the sedimentary peat is pure at the bottom but is mixed with muck at the top. The muck is black and some of it is watery. Some yellow-brown material, probably pumicite, is mixed with it at the 18-inch level.

The deposit is weakly acidic to neutral. At the 2-foot depth the muck is weakly acidic (pH 6.2), and at 4 feet the pH is 6.3. The pH of the mixture of muck and diatomite at 4½ feet is very weakly acidic (pH 6.5). The marl at 13 feet is neutral (pH 7.0).

### Meadow Lake peat area

The Meadow Lake peat area (31 acres) is in sec. 23, T. 24 N., R. 41 E., close to the town of Four Lakes and about 4 miles north of Cheney. It borders the north side of the lake (map, fig. 212). The road from Cheney to Four Lakes passes near the east side of the peat, another road passes close to the west side, and the Northern Pacific Railway passes the eastern border of the peat. The area is about 1 mile north of the Lakeside Marsh peat area, and the two deposits lie in the same scabland channel. The topography of the region is shown on the Medical Lake quadrangle. The elevation of the area above sea level is approximately the same (2,375 feet) as that of the Lakeside Marsh peat. On the soil map of Spokane County (Van Duyne et al., 1921) the deposit is mapped as peat and muck.

The part of the area adjacent to the lake is covered with a dense growth of cattails, and the boring was done in this area. Many water lilies grow in the margin of the lake.

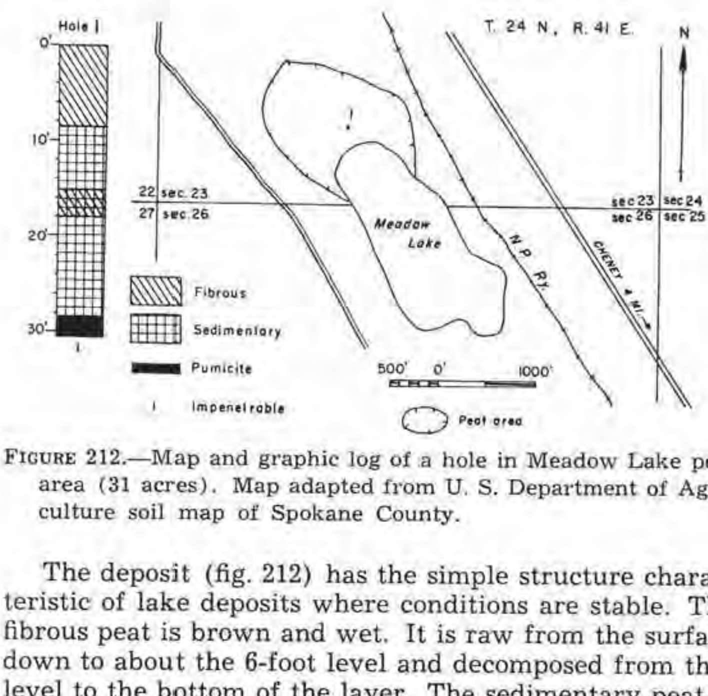


FIGURE 212.—Map and graphic log of a hole in Meadow Lake peat area (31 acres). Map adapted from U. S. Department of Agriculture soil map of Spokane County.

The deposit (fig. 212) has the simple structure characteristic of lake deposits where conditions are stable. The fibrous peat is brown and wet. It is raw from the surface down to about the 6-foot level and decomposed from that level to the bottom of the layer. The sedimentary peat is olive colored. The pumicite is white and is too compact to be penetrated with the peat borer more than 2 feet.

### Bailey Lake peat area

The Bailey Lake peat area (28 acres) is in sec. 28, T. 29 N., R. 43 E., about 2½ airline miles south of the south end of Eloika Lake, 2½ miles by road west of Milan, and 4½ airline miles northeast of Deer Park. It is accessible by road from U. S. Highway 195. It borders the south and west shores of the lake (map, fig. 213). Bear Creek flows south through the eastern part of the flat in which the peat lies, and the creek empties into the Little Spokane River. The Spokane quadrangle shows the topography of the region in which the lake lies, but the lake is not shown, presumably on account of its small size. It is a circular lake about 1,000 feet in diameter. Its elevation is approximately 1,900 feet above sea level. The lake and the peat are shown on the soil map of Spokane County (Van Duyne et al., 1921). The origin of the depression in which the lake and the peat lie is undoubtedly related to glacial activity, but the available data are not sufficient to indicate just what the conditions were.

The vegetation of the peat area is in four zones around part of the lake shore. On the line of the profile the cattail zone bordering the lake is 35 feet wide, the transition zone from the cattail zone to the sedge zone is 20 feet, the sedge zone is 25 feet, and the zone of pasture grasses is 325 feet. The cattail zone and the transition zone are on a mat of vegetation which quakes more or less when one walks on it. At the lake shore the mat sinks perceptibly under the weight of a man. Willows and hardhack grow near the lake

*Chara* (stonewort) grows in the lake, forming a layer about 1 foot thick. At the margin of the mat it is close to the surface, but at a distance of 50 feet from shore it is at a depth of 10 feet. How much of the sunken material is living was not determined, but at least it is not disintegrated. Hornwort grows on the bottom of the lake at greater depths.

In the profile, hole 1 is in the cattail zone, hole 2 is at the line between the transition zone and the sedge zone, and holes 3, 4, and 5 are in the zone of pasture grasses. The profile (fig. 213) shows a large amount of marl, as is characteristic of some other peat deposits of northeastern Washington. Examples of other peat deposits containing large amounts of marl are the Deep Creek deposit and the Cedar Lake deposit in Stevens County. In the peat deposits in western Washington, marl is present only rarely, and then in small amounts.

The marl in the Bailey Lake peat deposit is tan to yellow at the top of the layer, but it is mostly gray at deeper levels. It contains gastropod (snail) and pelecypod (mussel) shells a quarter of an inch or less in length. Marl is also present in the lake. This was investigated by thrusting the New American peat borer down from a boat to various levels. At a distance of about 100 feet from the border of the mat at the south shore of the lake, in line with the profile, a sample was obtained at a depth of 14 feet. It consisted of marl and sedimentary peat. The upper 1 inch of the sample was marl, and the lower 9 inches was dark olive-green gelatinous watery sedimentary peat. This sample probably does not represent definite layers present at exactly that level, but rather represents materials accumulated in the borer on its way down. The sample may be interpreted as having come from the level at which the sedimentary peat was solid enough to remain in the borer and hold the marl in the borer above it. At a distance of about 200 feet from shore a sample of the sedimentary peat without visible marl was obtained at a depth of 18 feet.

Near the mat the water of the lake a few feet under the surface is turbid. It seems probable that marl and organic materials in suspension cause this turbidity. The presence of a layer of *Chara* has already been mentioned, and the layer is shown in the profile (fig. 213). Under the *Chara* is watery marl which has a dirty tan color, probably due to the presence of organic matter.

Observation of the samples and the turbidity of the water near the shore considered in connection with general observations on the lake and the peat may lead to the following interpretations, which must be regarded to

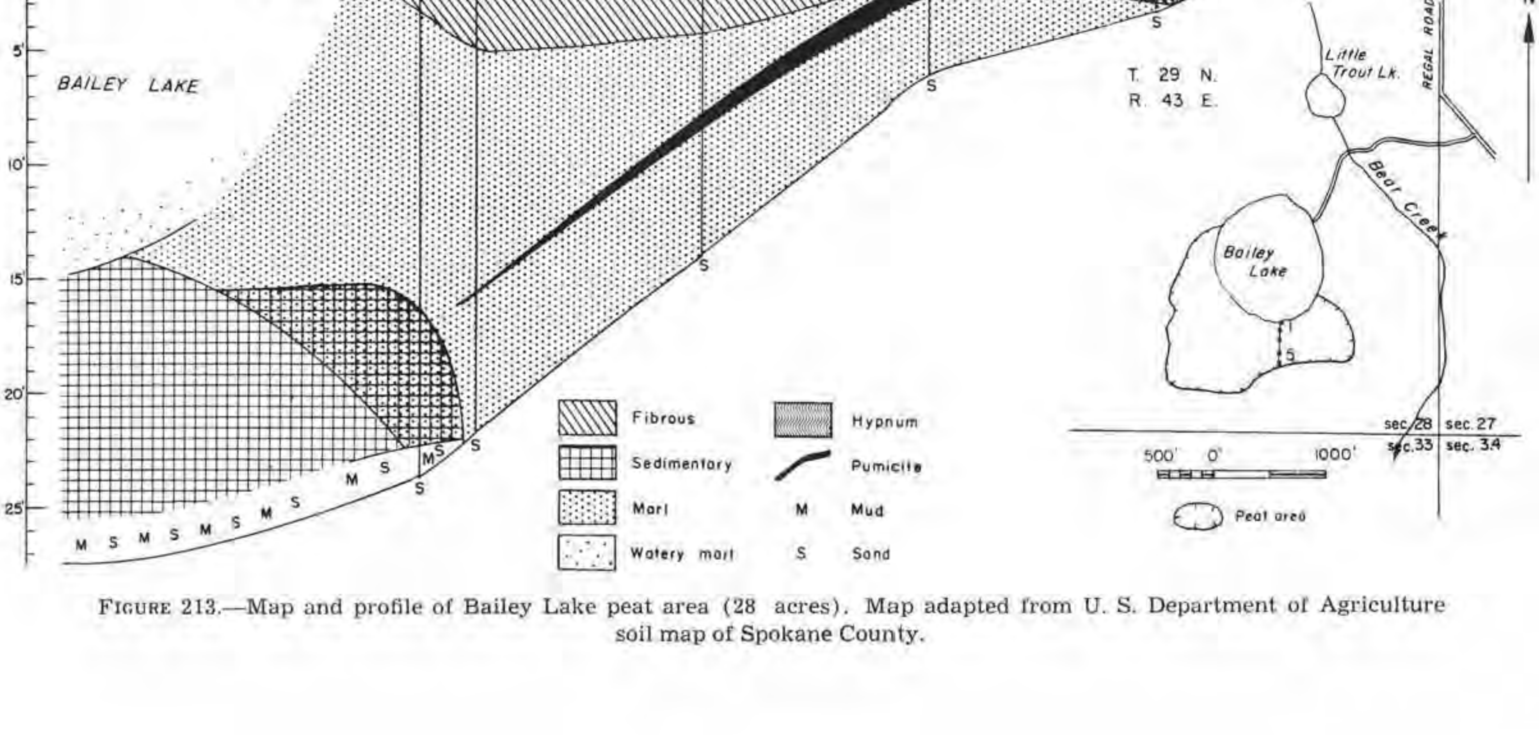


FIGURE 213.—Map and profile of Bailey Lake peat area (28 acres). Map adapted from U. S. Department of Agriculture soil map of Spokane County.

a certain extent as matters of opinion: (1) Marl is present in the lake only within about 200 feet from the border of the peat and does not form a general deposit on the bottom of the lake. (2) Marl is present in suspension at the border of the lake, and the transition from the suspension to the deposited layer is gradual. (3) The formation and deposition of marl are still going on. (4) The transition from the marl layer to the layer of sedimentary peat is gradual.

The profile shown in figure 213 differs from other profiles shown in this bulletin in that it shows the projection of some layers of the peat deposit into the lake. These projections are largely a matter of interpretation, as the available data are insufficient for exact placing of layers.

It should be noted that the plant, *Chara*, and the shells of mollusks, both of which are commonly associated with marl deposits, are present here. For a discussion of the probable conditions which result in the deposition of marl, see chapter II.

The fibrous peat is brown, and much of it is felty. It is watery near the lake and merely wet a little farther back from shore. In wet places near the bottom of the layer in holes 1, 2, and 3 it is decomposed. At the surface in the pasture it is dry. At hole 4 there is a 3-inch surface layer of brown soil.

The hypnum peat is red to reddish brown, and the transition from it to fibrous peat is gradual. The mixture of fibrous peat and sedimentary peat in hole 5 is brown. In hole 1 the mixtures of marl and sedimentary peat and of mud and sand are both gray.

The pumicite is white at hole 2, gray at hole 3, and brown at hole 4. At hole 5 it is gray, except around some small vertical stems, where it is brown. The layer is 3 to 12 inches thick.

The transition from weak acidity to alkalinity is gradual. In hole 2 the pH at successive depths is as follows: At 1 foot (fibrous peat) 5.3, at 4 feet (fibrous peat) 6.7, at 5 feet (decomposed fibrous peat) 7.0, at 6 feet (marl) 7.2, at 18 feet (marl) 7.0. The water of the lake is neutral (pH 7.0).

The deposit rests on sand which is gray at holes 2, 3, and 4, dark gray at hole 1, and black at hole 5.

#### Little Trout Lake peat area

The Little Trout Lake peat area (14 acres) is in sec. 28, T. 29 N., R. 43 E., about 1,000 feet north of the north shore of Bailey Lake. Both lakes lie in the same flat. Bear Creek flows into and out of Little Trout Lake (map, fig. 214). It seems probable that this deep depression is due to changes in the drainage pattern in the stream valley when a large volume of water was flowing from melting Pleistocene ice north of the area. The available data are not sufficient to indicate just what these changes were.

One hole was bored about 100 feet north of the lake in an old meadow. The boring was made August 1, 1950, at which time the hay crop had not yet been cut. The plants growing there were grasses, sedges, and dock. Peat-bog birch grew nearby, and cattails and purple marshlocks were abundant in wet places.

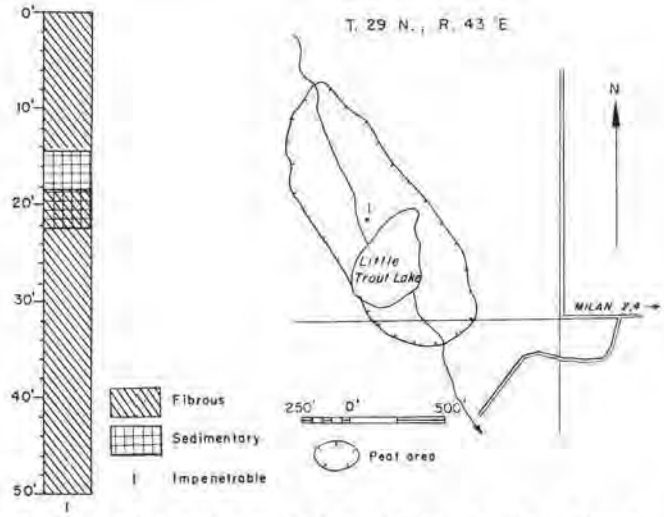


FIGURE 214.—Map and graphic log of a hole in Little Trout Lake peat area (14 acres). Map adapted from U. S. Department of Agriculture soil map of Spokane County and U. S. Geological Survey topographic map (Deer Park quadrangle).

This is a deep peat deposit (fig. 214). The fibrous peat at the 50-foot depth is soft. With the equipment available, deeper boring was not possible. Most of the peat found in this hole is fibrous. It is raw in the upper 2 feet, but below that level it is all either disintegrated or decomposed. The color varies from brown to dark brown except below the 35-foot level, where it is mostly black. Marsh gas bubbled up from the 14-foot and 18-foot levels during the boring. The sedimentary peat is olive colored. The deposit varies from weakly acidic (pH 6.0) at the 1-foot level to neutral (pH 7.0) at the 50-foot level.

#### Fish Lake peat area

The Fish Lake peat area (3 acres) is in sec. 32, T. 24 N., R. 42 E., and sec. 5, T. 23 N., R. 42 E., about 3 miles northeast of Cheney. It borders the north shore of the lake (map, fig. 215). A county road crosses the area. The lake and the peat are in a depression in a scabland channel. The topography of the region is shown on the Medical Lake quadrangle. The elevation of the lake is 2,173 feet above sea level. On the soil map of Spokane County (Van Duyne et al., 1921) Fish Lake is shown as Farrington Lake, and the peat is not mapped.

The peat forms a narrow strip about 1,000 feet long and mostly less than 100 feet wide along the north shore of the lake. The flora is composed of cattails, sedges, and bur reed. The flat valley floor extending about 1,000 feet north from the road was not investigated.

A hole bored near the shore of the lake (fig. 215) shows 38 feet of peat, the last few inches of which grade into gray clay and then into clay and sand. The fibrous peat is brown. Below the 20-foot depth it is decomposed. The sedimentary peat below the 26-foot depth is olive colored. The 10-inch layer between the 19- and 20-foot depths is brown. Pumicite is present in two layers, the upper layer being ½ inch thick, and the lower layer 16 inches thick. Both layers of pumicite are white.

The peat is slightly alkaline (pH 7.5) except at the 1-foot depth, where it is weakly acidic (pH 6.5). The mixture of clay and sand at the 38-foot depth is also

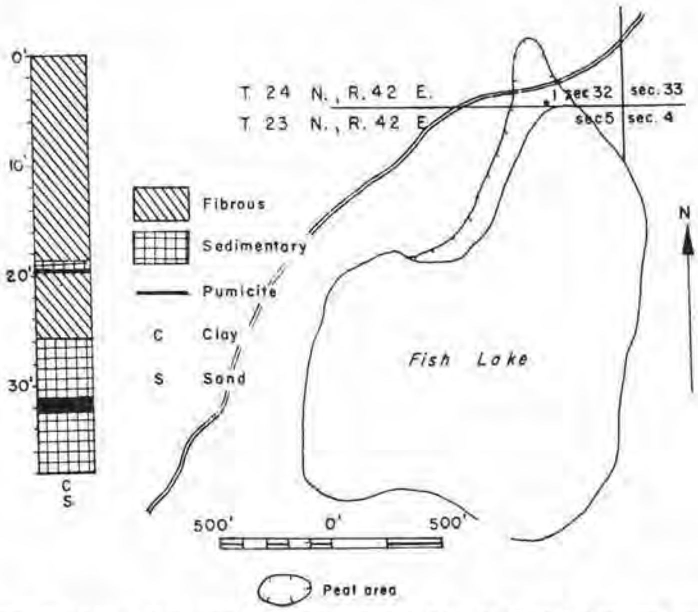


FIGURE 215.—Map and graphic log of a hole in Fish Lake peat area, Spokane County (3 acres). Map adapted from field sketch.

weakly acidic (pH 6.8). The water of the lake is neutral (pH 7.0). Since alkaline peat is rather uncommon, seven tests were made at depths ranging from 4 to 33 feet, and all showed pH 7.5.

Hansen (1947) shows a total of 8.8 meters (28 feet 10 inches) of materials in his sedimentary column in this peat deposit. He shows a layer of volcanic ash (pumicite) at a depth of 6.2 meters (20 feet 4 inches). Evidently this hole was a little farther from the lake than the hole reported in the present bulletin.

## STEVENS COUNTY DEPOSITS

### Cedar Creek peat area No. 1

Cedar Creek peat area No. 1 (248 acres) is in secs. 14 and 23, T. 40 N., R. 41 E., about 10 miles northeast of Northport. The north end of the area is about 2 miles from the Canadian border. It is about 1.7 miles long from north to south and varies from 500 to 1,700 feet in width (map, fig. 216). Cedar Creek, which is the outlet of Cedar Lake, flows north through the entire length of the area. Ditches also provide some drainage.

The depression in which the deposit lies owes it origin to the damming of Cedar Creek Valley by outwash from the retreating Pleistocene continental glacier. The outwash consists mainly of silt, sand, and gravel. On the soil map of Stevens County (Van Duyne and Ashton, 1915) the soil bordering the west side of the area is mapped as rough mountainous land, and the soil bordering the north and east sides is mapped as Springdale loam. Soils of the Springdale series are composed of glacial outwash or glacial stream or delta deposits. Springdale loam contains a large quantity of silt, fine gravel, and coarse sand. Gravel in varying quantities is present in the soil, and boulders occasionally occur on the surface. On the soil map this peat is shown to be continuous with the peat around Cedar Lake, but actually there is about 1,500 feet of hard land between the two.

The topography of the region is shown on the Colville quadrangle, U. S. Geological Survey. The elevation of the peat is about 2,150 feet above sea level.

The vegetation and utilization vary from place to place. There are oatfields, hayfields, pastures, wooded areas, and waste land. The oatfields are not extensive. In the hayfields sedges and tules grow with the low grasses. The trees in the wooded areas are spruce, birch, cedar, cottonwood, alder, and dogwood. Some of the waste land consists of sedge meadows in which the sedges are of a uniform height of about 2 feet. Tules are dominant in some places, and in others mosses, grasses, and mint form the principal vegetation. In part of the area the surface is moist, in part it is dry, and in part of it there is standing water a few inches deep.

The three profiles show the structure of the northern, central, and southern parts of the deposit. Profile A, 870 feet long, is in the northern part of the area and shows muck at the surface through its entire length. Profile B, 610 feet long, is in the narrowest part of the area and shows no muck at the surface. Profile C, 1,820 feet long, is in the widest part of the area and shows muck at the ends only. In profile A (fig. 216) the muck is dark brown to black. The fibrous peat is dark brown and is so completely decomposed that some of it approaches the character of muck. The marl is light tan colored where it is pure, and gray where it is mixed with clay. The pumicite in hole 1 is light tan in color and forms a layer 1 inch thick. In hole 3 soft gray pumicite forms a layer 3 inches thick, with a 4-inch layer of a light-gray mixture of pumicite and diatomite above it. The deposit, so far as shown by this profile, rests on clay, sand, and gravel. The rock under the clay and sand at the bottom of hole 1 may be a boulder, or it may be bed rock.

The peat in profile B (fig. 216) is all fibrous. It is dark brown and decomposed. Some of it is so completely decomposed that it approaches the character of muck. It contains much hydrogen sulphide gas. The cream-colored pumicite at the bottom of hole 2 forms a layer 4 inches thick and rests on gray clay. The layer of blue-gray clay at the bottom of hole 1 is only 2 inches thick, and it rests on rock which may be either a boulder or bed rock.

In profile C (fig. 216) the muck is black. The fibrous peat is brown to dark brown. Most of it is decomposed, and some of it is mucky. It contains hydrogen sulphide gas. In hole 2 it is compact at the bottom. The continuous layer of pumicite is 7 to 24 inches thick. It varies in color from white to cream to tan to gray. The color of the marl varies from cream to greenish gray. The clay on which the deposit rests is gray to bluish gray to greenish gray.

### Cedar Creek peat area No. 2

Cedar Creek peat area No. 2 (55 acres) is in sec. 26, T. 40 N., R. 41 E. Its northern border is about 1,500 feet south of the southern border of Cedar Creek area No. 1. It borders the north, west, and south shores of Cedar Lake (map, fig. 216). Cedar Creek originates in the lake and flows north across the peat. The topography of the region is shown on the Colville quadrangle. A benchmark about 700 feet northeast of the lake shows an elevation of 2,210 feet above sea level. The elevation of the hard land sepa-

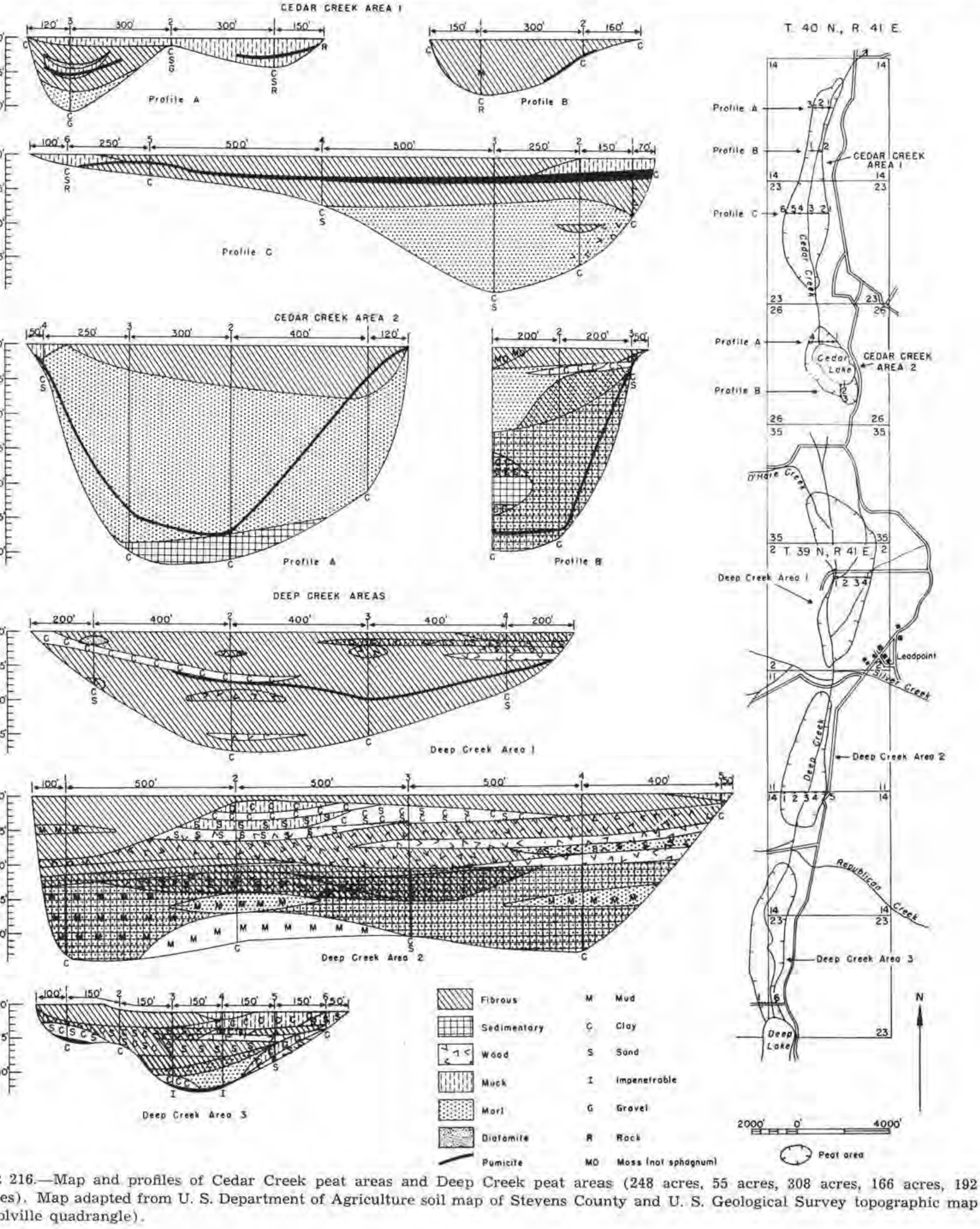


FIGURE 216.—Map and profiles of Cedar Creek peat areas and Deep Creek peat areas (248 acres, 55 acres, 308 acres, 166 acres, 192 acres). Map adapted from U. S. Department of Agriculture soil map of Stevens County and U. S. Geological Survey topographic map (Colville quadrangle).

rating the Cedar Creek drainage to the north from the Deep Creek drainage to the south is less than 100 feet above the general level of both drainage areas. On the soil map of Stevens County (Van Duyne and Ashton, 1915) the area is shown as muck and peat.

Much of the area is utilized for pasture, a hayfield, and a small field of mint, but there is some waste land. Some sedges grow with the pasture grasses. Sedges also cover most of the waste land, and some mosses grow with them south of the lake. Canadian thistles grow along the creek. *Chara* is abundant in the margin of the lake.

The deposit, so far as shown in profile A, consists mainly of marl and fibrous peat, the amount of muck and sedimentary peat being small (fig. 216). Hole 3 shows the thickest layer of marl so far found in any peat deposit in the state, though the solid deposit in the Riverside area in Okanogan County (see p. 10) is enormous by comparison. Much of the marl is soft, but it is compact at the top and bottom of the layer. Most of it has a cream color, but some of it is greenish gray. Near the bottom it contains small gastropod (snail) shells. Most of it is pure, but there is some organic matter mixed with the marl at the 3- to 4-foot depth and also at the 15- to 18-foot depth. Bubbles of methane (marsh gas) escaped from the hole during the boring at the 24-foot level. The muck is black. The fibrous peat is dark brown to black, and most of it is decomposed.

The fibrous peat is weakly acidic (pH 5.3 to 6.5). The marl is neutral (pH 7.0). The water of Cedar Creek, where it leaves the lake, is weakly acidic (pH 6.8).

In most places the deposit rests on clay, but there is some sand mixed with the clay in hole 4. The color of the clay varies from bluish gray to greenish gray and bluish black.

Profile B, 460 feet long, extends south from the border of the lake to hard land and shows a more complicated structure than profile A, which extends east and west just north of the lake. There has been considerable inwash of clay and some inwash of sand, and much of the marl is mixed with either sedimentary peat or fibrous peat. The clay is gray to dark gray. The characteristics of the marl, fibrous peat, sedimentary peat, and muck in this profile are not essentially different from those in profile A. The presence of moss (not sphagnum) in the upper 2½ feet of hole 1 correlates with the abundance of living moss on the surface in the vicinity of this hole. The clay at the bottom of holes 1 and 3 is dark gray. At hole 2 it is the same color but has a metallic appearance. The peat at the 1-foot depth is weakly acidic (pH 5.3). The sedimentary peat at the 21-foot depth is neutral (pH 7.0).

## Deep Creek Peat Areas

The valley in which the Deep Creek peat deposits lie is continuous to the north with the valley in which the Cedar Creek deposits occur (see the Colville quadrangle). The two groups of deposits are separated from each other by nearly flat land, mapped on the soil map of Stevens County (Van Duyne and Ashton, 1915) as Colville silt loam. The elevation of this low divide is less than 100 feet above the general level of the valley. The elevation of the peat areas is between 2,000 and 2,100 feet above sea level.

Deep Creek flows south through all three of the peat areas into Deep Lake (map, fig. 216). It flows out of the south end of the lake and eventually flows north into the Columbia River north of Northport. In the peat areas the creek is shallow. Its depth at the profile in area No. 1 is 1½ feet, and at the profile in area No. 3, about 600 feet north of the lake, it is 3 feet.

On the soil map of Stevens County the muck and peat along Deep Creek are mapped as one continuous area about 2 miles long, but actually there are three areas separated from one another by alluvial fans of material brought into the valley by two pairs of creeks from the mountainous regions east and west of the valley. Silver Creek, from the east, and an unnamed creek from the west have formed fans which separate area No. 1 from area No. 2. Republican Creek, from the east, and Sherlock Creek, from the west, have brought the material which separates area No. 2 from area No. 3. The origin of the barrier which has impounded Deep Lake has not been fully determined, but Current Creek flows into Deep Creek from the east just south of the lake, and Line Creek flows into Deep Creek from the west less than 1 mile to the south, and it seems probable that they have played a part in impounding the lake.

### Deep Creek peat area No. 1

Deep Creek peat area No. 1 (308 acres) is in sec. 35, T. 40 N., R. 41 E., and sec. 2, T. 39 N., R. 41 E. (map, fig. 216). It does not extend to the head of Deep Creek. O'Hare Creek comes in from the mountainous region on the west and flows south over the northern part of the peat area into Deep Creek. An unnamed creek comes in from the mountainous area on the east and flows over the peat area into Deep Creek near the south end of the area.

The profile, 1,600 feet long, extends from west to east along the south side of the Anderson mine road, which is a quarter of a mile south of the north line of sec. 2. The profile begins close to the Anderson zinc-lead mine. It crosses Deep Creek between holes 1 and 2 and ends in a cleared forest, where the vegetation is composed of grasses and scouring rushes.

Hole 1 is in a sedge meadow in which the sedge is uniformly about 3 feet tall. Some grass grows with the sedge. Hole 2 is in a sedge meadow where the sedge is about 1½ feet tall. Smartweed grows with the sedge. The vegetation at hole 3 consists of timothy and other grasses (mostly short) and smartweed with bunches of sedge nearby. Apparently this area was once a pasture. Hole 4 is in a hayfield. Thistles and dock flourish with the grasses and render the hay practically useless.

The profile shows mostly fibrous peat, but mixtures of it with muck and also with woody peat are present (fig. 216). Clay and sand have been washed in, and in several places gray clay is present in quantities so small that it is not shown in the profile. The layer of diatomite at the 2-foot depth in hole 1 is 1 inch thick. The layer of marl at the 8-inch depth in hole 2 is also 1 inch thick. Both of these layers were probably formed where they lie. The woody peat near the margins of the deposit may have been washed in or it may represent woody plants that grew on the peat. The woody peat in hole 2 probably represents woody plants that grew on the peat at different stages in the development of the deposit. Pumicite forms a layer 1 inch thick at hole 4 and 7 inches thick at hole 3.

The fibrous peat is mostly brown, but some of it has a reddish color which may indicate mixtures of hypnum peat. Some of the fibrous peat has a granular appearance that has not been accounted for. Remains of stems of scouring rushes are present in the fibrous peat at the 10- to 11-foot depth in hole 2. Most of the fibrous peat is decomposed. In some of it decomposition and decay have gone so far that it is practically muck. In hole 1 methane gas rose from the 7-foot level in such quantities that there were spurts of flame 3 inches high when burning matches were dropped on it. Hydrogen sulphide came up in considerable quantities from several depths in holes 2 and 3 during the boring and was detected by its characteristic odor. The reaction of the peat at various depths from 6 inches to 14 feet varies from weakly acidic (pH 6.3) to neutral (pH 7.0).

At hole 1 the deposit rests on a blue-gray mixture of sand and clay, at holes 2 and 3 it rests on gray clay, and at hole 4 on a gray mixture of sand and clay.

#### Deep Creek peat area No. 2

Deep Creek peat area No. 2 (166 acres) is in secs. 11 and 14, T. 39 N., R. 41 E. (map, fig. 216). A road extends northward close to the east side, and a dead-end branch of this road extends across the flat between area No. 1 and area No. 2. Another dead-end road extends across the flat between area No. 2 and area No. 3.

The profile, 2,050 feet long, extends along the south line of sec. 11 from the foot of the steep hill at the west side of the valley to a point about 75 feet west of the road on the east side of the valley. Hole 1 is in a pasture of sedges and grasses. Hole 2 is just east of a drainage ditch in a hayfield. Hole 3, 55 feet west of Deep Creek, is also in a hayfield. The hay at holes 2 and 3 had been cut and removed before the time at which the borings were made (July 18, 1949). Hole 4 is in a sedgy area in which red top and other grasses grow, and bunches of rushes are nearby.

The profile (fig. 216) shows a complicated structure. Fibrous peat forms the entire surface layer except for a small amount of muck at the east side. Woody peat forms a layer at about the 10-foot depth at the east side. Other than these, the entire deposit consists of layers of mixtures of two or three materials. These mixtures indicate many changes in the conditions under which various materials were being formed and deposited in the depression. Sand, clay, and mud were being washed in during the long time (several thousand years) that elapsed during the development of this deposit. There is a considerable amount of marl, but none of it is pure. Various mixtures of marl with sedimentary peat, fibrous peat, and mud occur. The large amount of woody peat throughout the profile probably indicates that woody plants grew on the peat at some stages of its development, though some may have been washed in. There may have been changes in the level of the water in the depression during the course of the development of the deposit. The fibrous peat is brown to dark brown, and most of it is decomposed.

#### Deep Creek peat area No. 3

Deep Creek peat area No. 3 (192 acres) is in sec. 14, T. 39 N., R. 41 E. (map, fig. 216). It borders the north shore of Deep Lake and extends about 1¼ miles north. Its northern border is about 1,000 feet from the southern border of area No. 2.

The profile, 900 feet long, extends from west to east along the north side of a dead-end road about 600 feet north of the north shore of Deep Lake. The surface of the peat at the west end of the profile is 5 feet higher than it is at the middle and the east end.

The structure of the deposit, so far as shown by the profile, is complicated. There are pure layers of fibrous peat, woody peat, marl, and muck, and various mixtures of these. Sand and clay have been washed in. Evidently, numerous changes occurred in this area during the retreat of the continental ice which covered the region. These changes have influenced the inwash of sand and clay from the surrounding slopes and the formation and deposition of organic materials in the lake which occupied the depression.

The fibrous peat is dark brown and decomposed. Most of it is wet, and some of it is watery. The clay is gray to gray green. The marl is yellow brown to bluish. The pumicite is gray. In holes 3 and 4 it is so compact that it cannot be penetrated more than 6 inches with the peat borer, and the thickness of the layer was not determined. At hole 1 it is 3 inches thick.

#### Haviland Meadows peat and muck area

The Haviland Meadows peat and muck area (740 acres) is in secs. 1 and 12, T. 30 N., R. 39 E., and secs. 6 and 7, T. 30 N., R. 40 E., about 6 airline miles northwest of Springdale and 12 airline miles southwest of Chewelah. County roads give access to the area.

Its elevation is about 2,130 feet above sea level, which is about 400 feet higher than the Colville River valley floor about 3 miles east. Deer Creek flows across the meadows from west to east and into the Colville River. The meadows appear to have been formed during glacial time as a lake bottom which filled behind an ice dam that occupied the Colville Valley and blocked the mouth of Deer Creek. Beaver dams at the lower (east) end of the meadows may have kept much of the surface of the meadow wet after the ice retreated, thus favoring the accumulation of organic matter. The topography of the region is shown on the Chewelah quadrangle. On the soil map of Stevens County (Van Duyne and Ashton, 1915) the meadow area is mapped as muck and peat.

Such information as is available indicates that the area was covered with a swamp forest when white men first came to the region. Much of it has been cleared and is now in cultivation, the principal crops being wheat, barley, and alfalfa. An area of 50 acres or more was being cleared in 1949. The trees were mostly cottonwood and aspen, some of which were 2 feet in diameter.

Ditches on this 50-acre area and nearby parts of the meadows show woody peat in various stages of decay.

Some of it is mucky. The maximum depth observed was 3 feet, but local information indicates that this peat is somewhat deeper (perhaps 5 feet) in other parts of the area. A layer of white pumicite 6 inches thick lies under the woody peat. Under the pumicite is greenish clay.

Mr. Fancher, who owns the entire area mapped as Haviland Meadows, states that the woody peat area is not more than 200 acres and that much of the remainder is gumbo soil. The term gumbo is applied in popular usage to a productive heavy silty soil, entirely free from sand, which is hard when dry but tends to become waxy when wet. During the peat investigation similar soil was found in the depression in which Deer Lake peat area No. 1 lies.

#### Narcisse Creek muck and peat area

The Narcisse Creek muck and peat area (240 acres) is in secs. 26, 27, 34, and 35, T. 35 N., R. 40 E., about 8 miles southeast of Colville. Narcisse Creek flows south through the area and then west to the Colville River. The topography of the region is shown on the Colville quadrangle. The elevation of the area is approximately 2,300 feet above sea level. The depression is shallow, and it is fairly well drained by the creek.

On the soil map of Stevens County (Van Duyne and Ashton, 1915) the area is mapped as muck and peat. The deposit contains a considerable area of shallow muck but very little peat. Some of the area is cattail swamp, some is waste land, and some is clay soil which is utilized for the production of barley.

The profile (fig. 217) shows muck, fibrous peat, woody peat, and pumicite. The muck is black. The mixture of fibrous peat and woody peat is brown and mucky. The pumicite at the bottom of hole 1 is so compact that it can be penetrated only a few inches with the peat borer. A hole dug in the cattail swamp east of hole 2 of the profile shows 1 foot of black muck, 1½ feet of dark brown muck and sand, then sand and gravel. At hole 2 the deposit rests on gray-green clay.

#### Coffin Lake peat area

The Coffin Lake peat area (196 acres) is in secs. 30 and 31, T. 36 N., R. 42 E., about 1 mile south of Middleport. It is about 15 airline miles east of Colville, but considerably farther by road. The roads in the vicinity of the peat area are poor. The Little Pend Oreille River (Creek) flows south through the peat area to Coffin Lake, then out of the lake south and west to the Colville River. The peat area borders the north end of the lake and extends northward about 1⅓ miles along the creek (map, fig. 218). The topography of the region is shown on the Colville quadrangle. Metsker's map of Stevens County gives the elevation of Coffin Lake as 3,118 feet above sea level. The

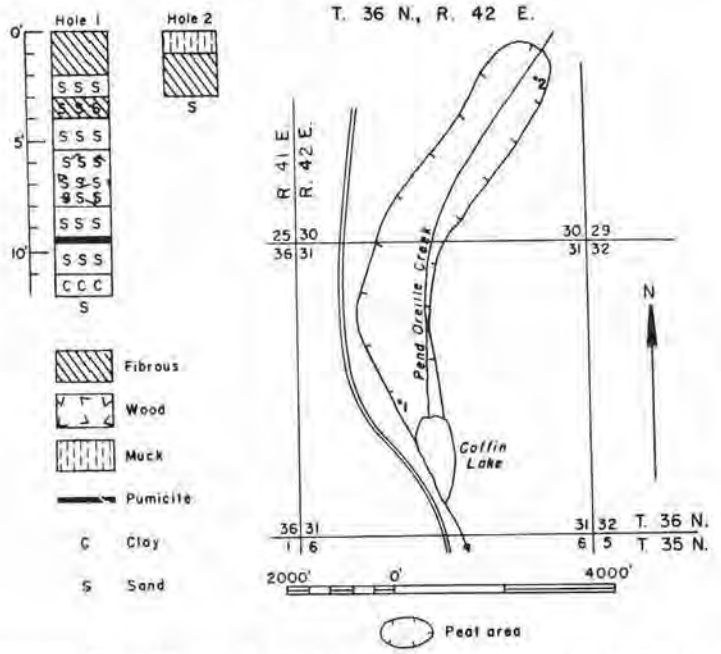


FIGURE 218.—Map and graphic logs of two holes in Coffin Lake peat area (196 acres). Map adapted from U. S. Department of Agriculture soil map of Stevens County.

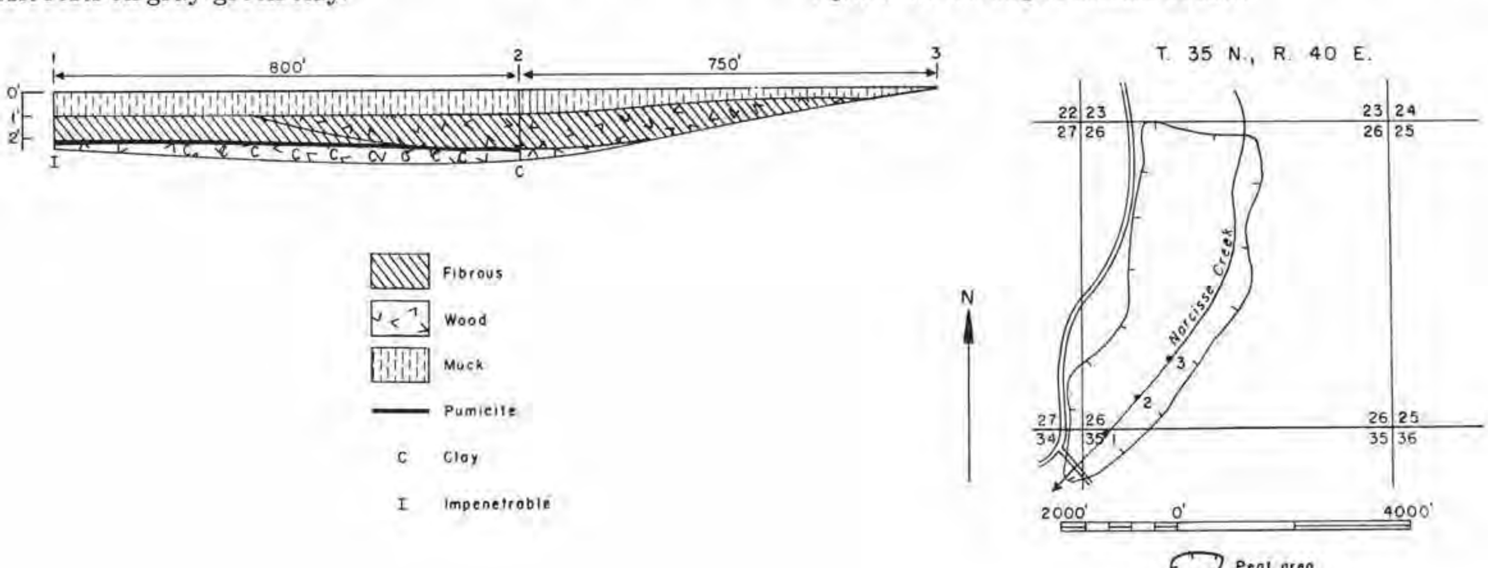


FIGURE 217.—Map and profile of Narcisse Creek muck and peat area (240 acres). Map adapted from U. S. Department of Agriculture soil map of Stevens County.

area is mapped as muck and peat on the soil map of Stevens County (Van Duyne and Ashton, 1915).

Most of the area is covered with willows. Water about 1 foot deep stood on the area when it was examined (July 15, 1949). Flooding of the creek has carried an abundance of sand into the area.

A hole near the south end of the area shows fibrous peat, woody peat, sand, and clay (fig. 218). A layer of white pumicite, 3 inches thick, has sand above and below it. Some sand is mixed with the fibrous peat and the woody peat. The fibrous peat is brown and decomposed. A hole near the north end shows 1 foot of brown muck and 2 feet of brown decomposed fibrous peat with which some sand is mixed.

#### Colville muck and peat area

The Colville muck and peat area (178 acres) is in secs. 7, 17, and 18, T. 35 N., R. 39 E., in the valley of the Colville River about 1 mile southwest of Colville. Its eastern border is a little more than ¼ mile west of the river (map, fig. 219). The topography of the region is shown on the Colville quadrangle. A benchmark just west of Colville at approximately the same level as the peat shows an elevation of 1,574 feet above sea level. The land rises abruptly near the western border of the peat. Near the north end of the peat an alluvial fan spreads out from a drainage system from the west. The owner of the land stated that water stood on the area when he bought it about 1939. The presence of gastropod (snail) and pelecypod (mussel) shells in the deposit indicates that a lake formerly occupied the depression. The area is now drained by a ditch. It comprises pasture, waste land, and a grove of alders and some birch.

The profile, 3,600 feet long, extends from south to north along the east line of sec. 18. There is muck at the surface in all holes, but at hole 2 it is mixed with clay (fig. 219). The fibrous peat in hole 4 is dark brown and mucky. The presence of mixed layers of diatomite, marl, and clay indicates changes in the condition of deposition and inwash in the lake. White pumicite forms a layer 6 inches thick.

#### Bliesner Farm peat area

The Bliesner Farm peat area (acreage undetermined) is in sec. 2, T. 31 N., R. 40 E., about 4 miles south of Chewelah. It is part of a large area which extends about 9 miles along the Colville River and which is mapped as muck and peat on the soil map of Stevens County (Van Duyne and Ashton, 1915). The area extends from a point about 5 miles north of Springdale to a point about 1 mile south of Chewelah, and its maximum width is about 1 mile.

The topography of the region is shown on the Chewelah quadrangle. The elevation of the muck and peat area is about 1,650 feet above sea level. The Colville River is

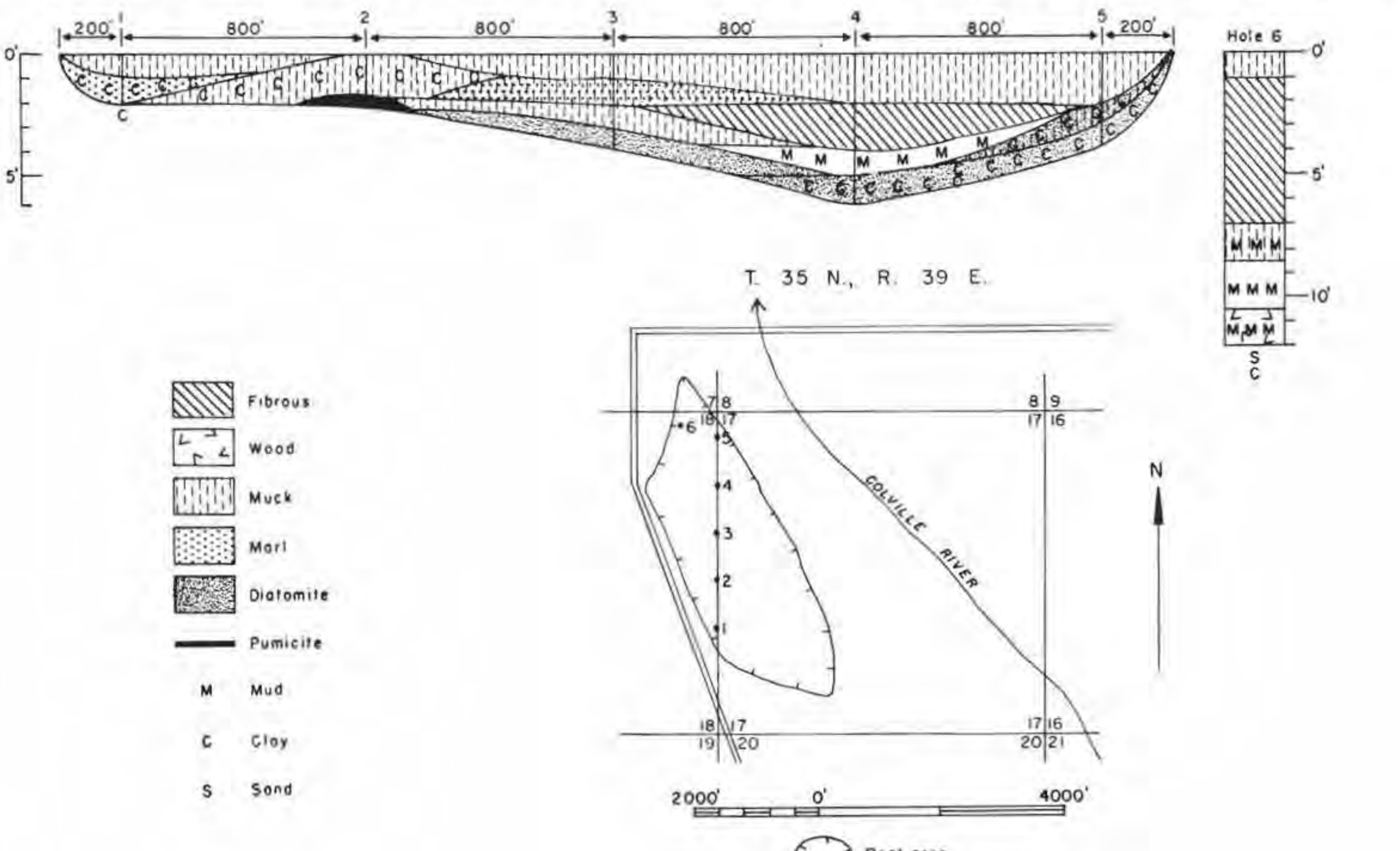


FIGURE 219.—Map, profile, and graphic log of a hole in Colville muck and peat area (178 acres). Map adapted from U. S. Department of Agriculture soil map of Stevens County.

a sluggish stream having a fall of about 6 feet per mile. The area mapped as muck and peat has been drained by dredging and straightening the river channel. The width of the valley varies from about 1 mile to more than 2 miles. The muck and peat deposit has developed in the poorly drained depression along the river in postglacial times. Glacial outwash evidently has been the main factor in determining local topography in the valley, but the deposition of alluvial fans formed by streams coming in from higher land to the east and west may also have been a factor. How much of the muck and peat has been formed in swampy areas and how much in local ponds or small lakes has not been determined. The presence of marl, diatomite, and small shells in the deposit indicates pond or lake origin of the peat.

The Soil Survey of Stevens County (Van Duyne and Ashton, 1915) reports, "The greater part of this area more closely resembles peat than muck," and "The practice of burning off land of this character is wrong." No information as to whether peat in the Colville Valley has been destroyed by burning is available. The deposit was bored at the Bliesner farm because local information indicated that peat occurs there, and no information as to its occurrence elsewhere in the area was obtained. This lack of reports or rumors, however, should not be considered as proof that peat may not be found elsewhere in the area. No detailed examination of the whole valley was made.

The locations of the four borings on the Bliesner farm are shown on the sketch map (fig. 220), and the materials in them are shown in the figure. The layers of material in the four holes show so little correlation that it seems best to discuss them separately rather than to attempt to combine them into a profile. Holes 1 and 2 are in a low mound of peat 300 to 400 feet in diameter. The top of the mound is about 5 feet higher than the general level of the valley floor in which holes 3 and 4 are located. The southern border of the mound is less than 200 feet north of Mr. Bliesner's barn.

Hole 1 is an exploratory hole at the highest point in the mound. It reveals that the organic matter is 17 feet deep at that point, that it rests on blue clay, and that a 2-inch layer of pumicite occurs at the 11-foot depth.

Hole 2 is near a small spring about 50 feet northwest of hole 1. It is on the mound, but the surface there is about 2 feet lower than the surface at hole 1. The level of the sand and water at the bottom of this hole is thus at approximately the same level as the clay at the bottom of hole 1. Hole 2 shows mainly fibrous peat, but small quantities of peat slime, mud, muck, and mineral matter are also present. The fibrous peat is brown to black. At the surface it is felty, but at a depth of 10 inches it consists of fibers of sedges or similar plants. Below the peat slime it is decomposed, and some of it is watery. At the 4- to 5-foot depth and the 11- to 12½-foot depth it contains unidentified mineral matter. The mixture of muck and fibrous peat at the 12½- to 15-foot depth is black.

It seems evident that the mound has been built up by the remains of plants which flourished in the wet area

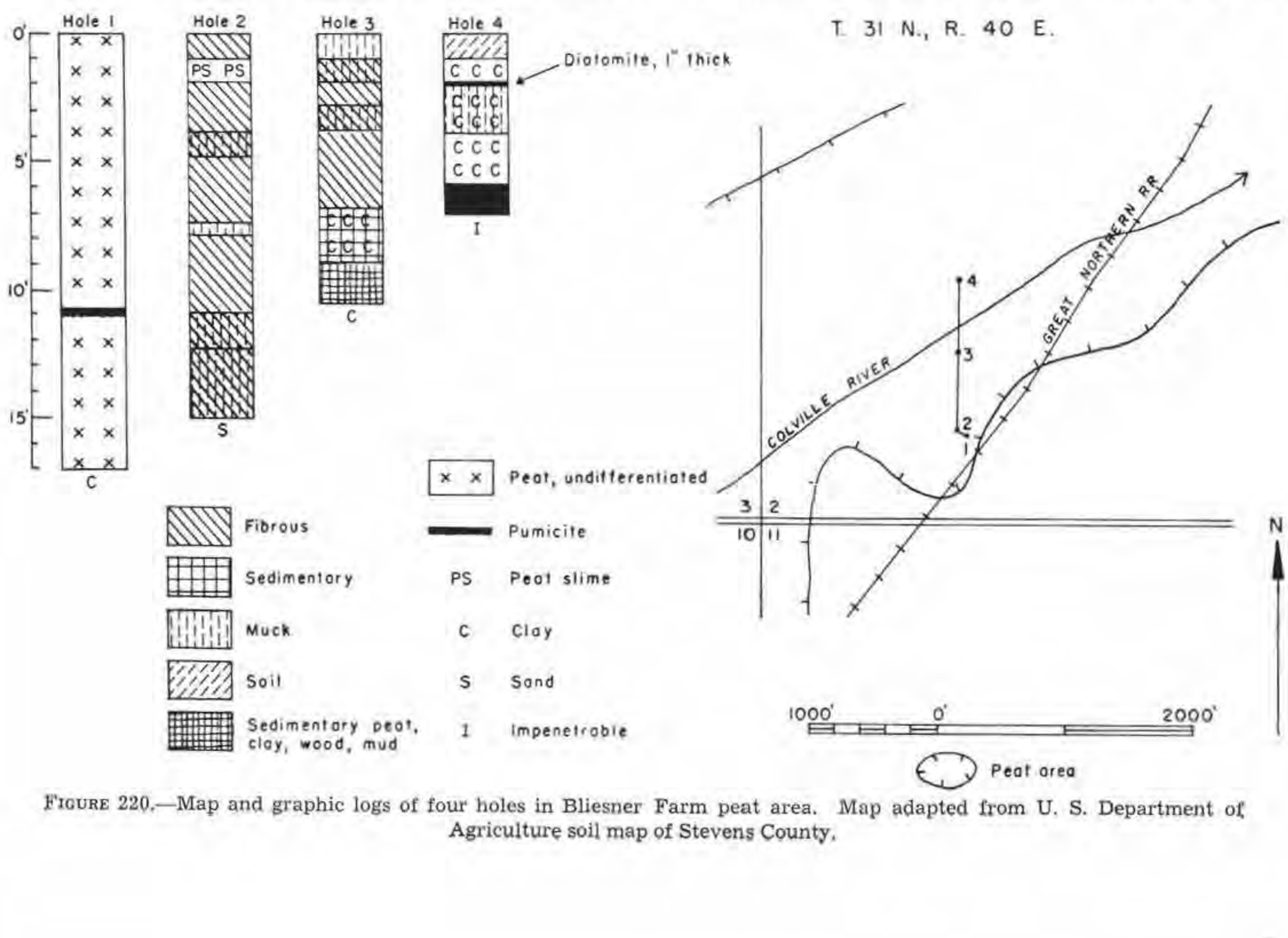


FIGURE 220.—Map and graphic logs of four holes in Bliesner Farm peat area. Map adapted from U. S. Department of Agriculture soil map of Stevens County.

around a spring. Mounds of plant remains in various stages of decay around springs in Ohio, Utah, and Yellowstone Park have been described (Rigg, 1942), and the peat in the Forest peat area in Lewis County, Washington, has a similar origin. In the mound on the Bliesner farm the water of the spring rises by artesian pressure.

The characteristics of the materials in hole 3, which is not in the mound area, are similar to those of the materials in hole 2. The peat in hole 3 rests on a 1-foot layer of blue-gray and green clay, under which is blue clay. The soil at the surface at hole 4 is brown. The layer of diatomite at the 2-foot level, under the clay layer, is 1 inch thick. The layer of pumicite at the bottom of this hole was penetrated to a depth of 16 inches, but beyond that it is too compact to be penetrated with the peat borer.

### Deer Lake peat area No. 1

Deer Lake peat area No. 1 (122 acres) is in sec. 1, T. 30 N., R. 41 E.; sec. 6, T. 30 N., R. 42 E.; and sec. 31, T. 31 N., R. 42 E., about 10 miles by road northeast of Springdale and about 12 airline miles southeast of Chewelah. It borders the northeast end of the lake and lies along a stream which flows into the lake (map, fig. 221). The topography of the region is shown on the Chewelah quadrangle. The elevation of the lake is 2,482 feet above sea level. To the northwest and southeast the land rises abruptly. The area is mapped as muck and peat on the soil map of Stevens County (Van Duyne and Ashton, 1915).

The available data indicate that peat in significant quantity occurs only in the area extending back about 1,500 feet from the lake shore. Digging in pastures and fields at several places in the central and northeast parts of the area revealed only soil or soil with some muck. Gumbo soil was found near the peat. This soil occurs also in Haviland Meadows, and its properties are discussed on page 210.

The profile, 1,200 feet long, is based on two holes (fig. 221). No hole was bored at the margin of the lake, but it is assumed that layers of material present 500 feet from the lake shore are continuous to the lake. This assumption seems justified by findings in other parts of the state.

The amount of diatomite in this deposit is large. The pure layer just above the pumicite is light gray, and its mixture with sedimentary peat is gray. The mixture of diatomite, muck, and wood is brown. Evidently the conditions of temperature and the abundance of mineral matter, especially silica, favored the abundant growth of diatoms at some periods, while at other periods the conditions favored the growth of the micro-organisms (plant and animal) that formed sedimentary peat. To what extent the muck in this deposit is due to the inwash of mineral matter and to what extent it is due to complete decay of fibrous peat was not determined. At a comparatively late period in the development of the deposit, conditions favored the growth of sedges and other plants which formed fibrous peat. It seems probable that the woody peat consists of the remains of small woody plants which grew on the surface of the peat. The pumicite is white. It forms a comparatively thick layer (1 foot), but not so thick as in Deer Lake area No. 2.

### Deer Lake peat area No. 2

Deer Lake peat area No. 2 (38 acres) is in secs. 2, 3, 10, and 11, T. 30 N., R. 41 E. It is about ½ mile long, and its maximum width is about 1,000 feet (map, fig. 222). Its narrow end is about 300 feet from the west shore of the lake. The topography of the region is shown on the Chewelah quadrangle. The elevation of the lake is 2,482 feet above sea level, and the peat is at practically the same level. The peat area is mapped as marsh on the quadrangle map. The land rises abruptly at the north side of the peat. At the south side it is relatively flat, but there is a

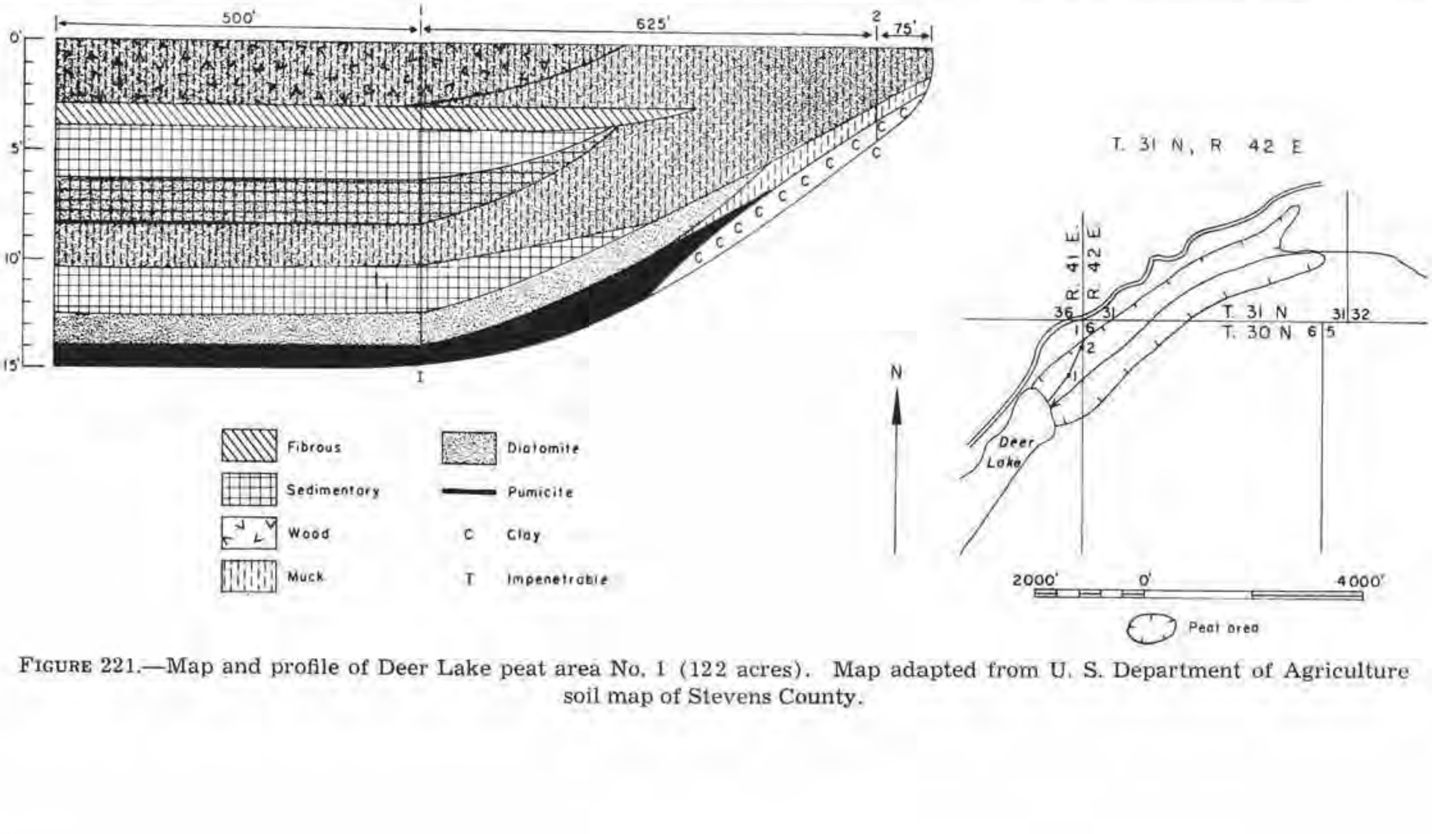


FIGURE 221.—Map and profile of Deer Lake peat area No. 1 (122 acres). Map adapted from U. S. Department of Agriculture soil map of Stevens County.

mountain 3,095 feet high at a distance of less than 1 mile. On the soil map of Stevens County (Van Duyne and Ashton, 1915) the peat area is mapped as muck and peat, and the flat land south of it is mapped as Springdale loam.

The profile, bored in 1950, is in an area that was plowed in 1947 and disked in 1950 in preparation for the removal of peat for marketing. A single hole 500 feet southeast of hole 3 of the profile is near the center of the area, where the vegetation consists of tules, cattails, knotweed, and water plantain.

The profile (fig. 222) shows an unusually large amount of hypnum peat, which is raw and is mostly light brown. The fibrous peat is brown to dark brown and is raw to disintegrated. The muck is black. The mixture of sedimentary peat and fibrous peat is olive colored.

White pumicite forms a continuous layer extending through the profile and having a maximum thickness of 3½ feet. In hole 2 a 1-inch layer is also present (at the 17-foot depth) above the thick layer and another 1-inch layer is present (at the 24-foot depth) below the thick layer. The particles in the lower 1-inch layer are larger than those in the main layer or the thin layer above it. In considering the probable way in which the pumicite came into this deposit, account must be taken of the layers revealed by the single hole near the center of the area. These are: a 1-inch layer, a 3-inch layer, and a 6-inch layer, but no extremely thick layer. A reasonable interpretation of the data is that the pumicite represents three separate ash falls, but that much of the pumicite in the thicker parts of the layers was washed in from higher land in the drainage area. The peat deposit, so far as shown by the profile and the single hole, rests on clay, sand, and gravel. The clay is blue.

The kinds of peat in the single hole are similar to those found in the profile. The upper layer of pumicite (1 inch thick) is white, the next (3 inches thick) is light gray, and the lowest (6 inches thick) is white.

The peat in this deposit varies from strongly acidic (pH 4.5) to weakly acidic (pH 5.5).

#### Waits Lake peat area

The Waits Lake peat area (98 acres) is in secs. 17 and 20, T. 31 N., R. 40 E., about 3 miles west of Valley and about 8 miles southwest of Chewelah. It extends in a narrow band more than 1½ miles along the north, west, and south shores of the lake (map, fig. 223). There is a drainage ditch from the north end of the lake, and the lake level appears to have been lowered about 3 feet. The topography of the region is shown on the Chewelah quadrangle. The elevation of the lake is 1,959 feet above sea level, and the 2,000-foot contour is not far from the border of the peat in some places. On the soil map of Stevens County (Van Duyne and Ashton, 1915) a muck and peat area is shown bordering the southwest shore of the lake, but not extending to the north shore.

The deposit (fig. 223) consists largely of marl, but there is some peat soil and some fibrous peat at the surface. The marl varies in color from white to cream. The peat soil is brown to black. The fibrous peat is brown to dark brown to black. The pumicite is white. In the hole north of the lake pumicite was penetrated 18 inches, but beyond that depth it was too compact to be penetrated with the peat borer. In hole 1 of the profile, 6 feet from the lake margin, there are three layers of pumicite—a 2-inch layer at a depth of 9 feet, a 1-inch layer at 20 feet 6 inches, and another 1-inch layer at 21 feet. The soil and the fibrous

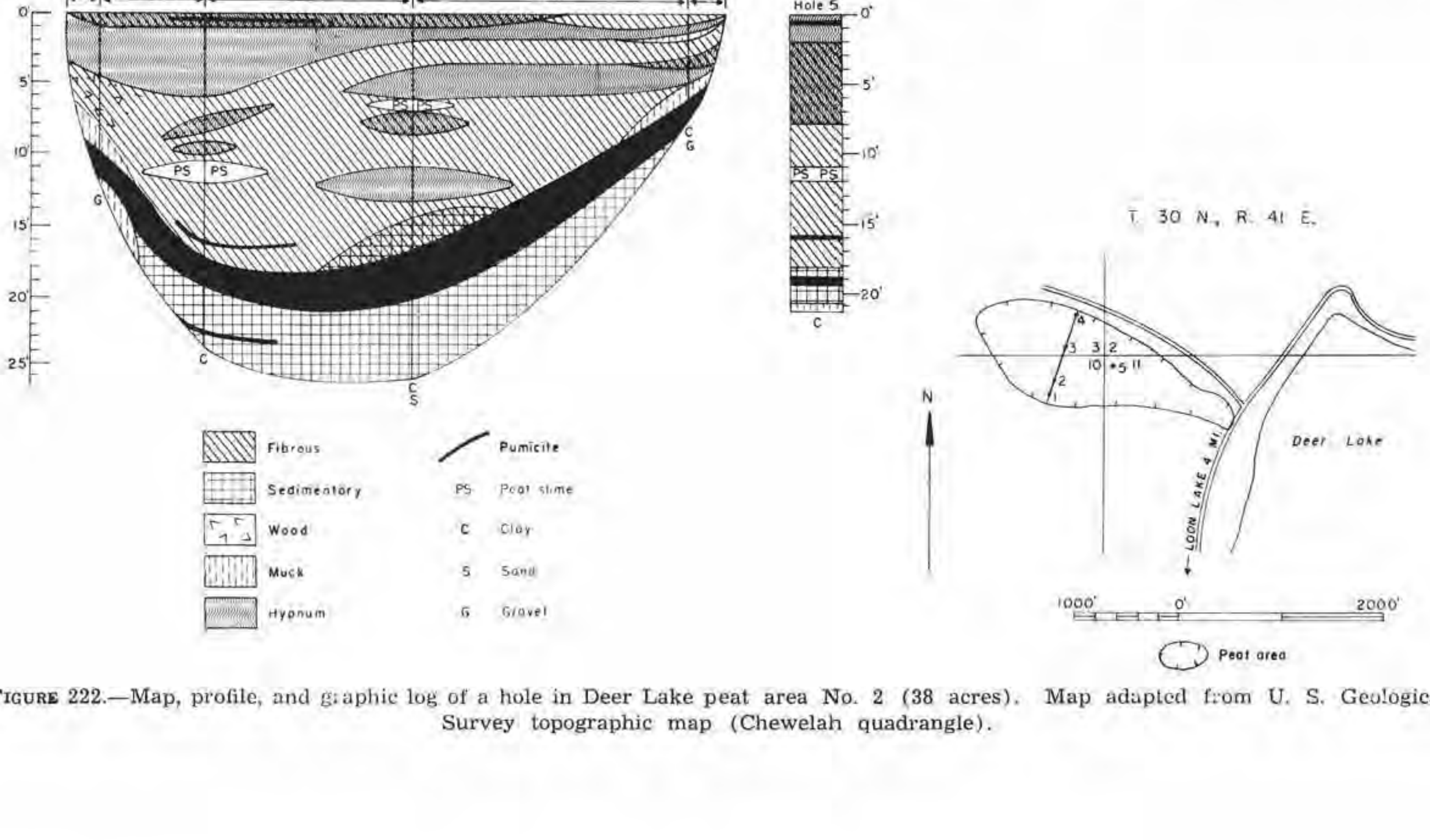


FIGURE 222.—Map, profile, and graphic log of a hole in Deer Lake peat area No. 2 (38 acres). Map adapted from U. S. Geological Survey topographic map (Chewelah quadrangle).

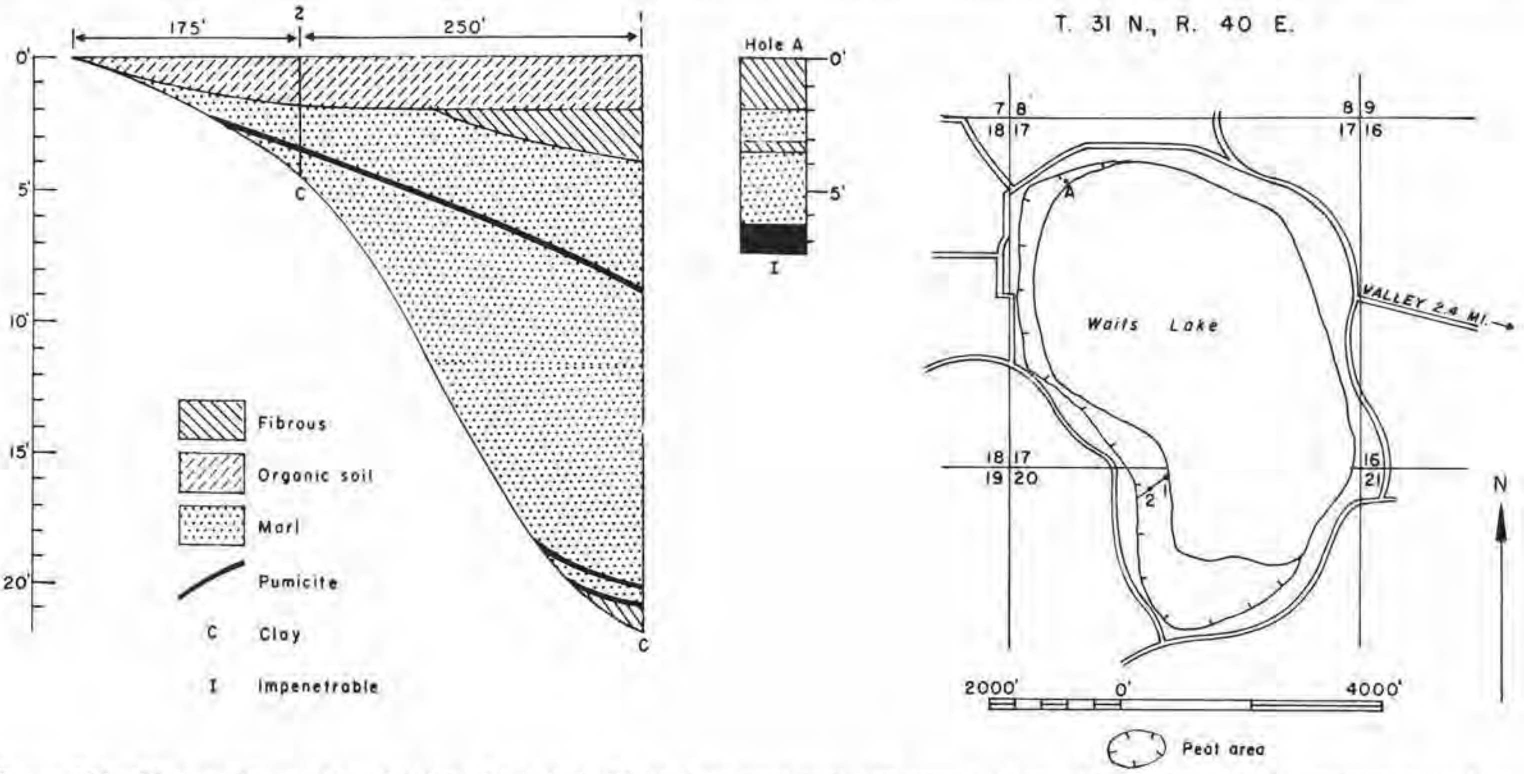


FIGURE 223.—Map, profile, and graphic log of a hole in Waits Lake peat area (98 acres). Map adapted from U. S. Department of Agriculture soil map of Stevens County and U. S. Geological Survey topographic map (Chewelah quadrangle).

peat are weakly acidic (pH 5.5 to 6.0). The marl is neutral (pH 7.0). The vegetation along the profile is composed of grasses, tules, sedges, knotweed, and silver weed. *Chara* grows in the lake margin near hole 1.

### Loon Lake peat area

The Loon Lake peat area (74 acres) is in sec. 33, T. 30 N., R. 41 E., about 5 miles east of Springdale. It borders the northwest shore of the lake (map, fig. 224), and a drainage ditch extends from the lake across the peat to Sheep Creek, which flows into the Colville River. The topography of the region is shown on the Chewelah quadrangle, which is based on a survey made in 1924 and 1927. The elevation of the lake is 2,380 feet above sea level. Local reports indicate that the level of the lake is now considerably lower than it was before the ditch was dug

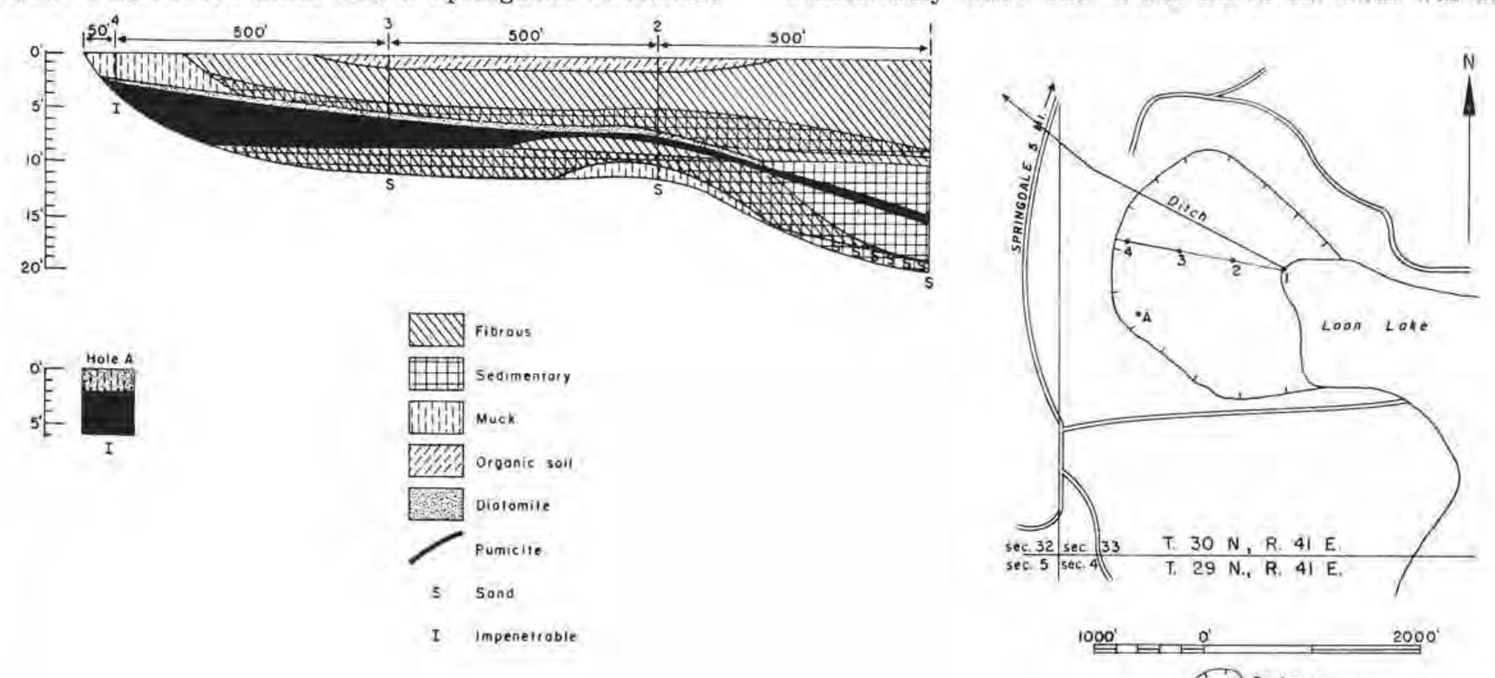


FIGURE 224.—Map, profile, and graphic log of a hole in Loon Lake peat area (74 acres). Map adapted from U. S. Department of Agriculture soil map of Stevens County and U. S. Geological Survey topographic map (Chewelah quadrangle).

and that the peat has settled since the lowering of the lake, so that it is now several feet lower than it was when first exposed. Information as to the date of the digging of the ditch is not available.

The profile, 1,550 feet long, extends in a northwesterly direction from the shore of the lake to hard land. Hole 1 is near the head of the ditch and is on the border line between the zone of sedges which grow on the peat and the zone of reeds extending about 300 feet into the lake. Hole 2 is in a grass-sedge pasture. Hole 3 is in a hayfield. Hole 4 is beside a ditch which separates a hayfield from an oatfield. Hole A, 6 feet deep, is 800 feet south of hole 4 of the profile.

The structure of the deposit (fig. 224) is characteristic of profiles extending between a lake and hard land from which inwash of mineral matter has caused the formation of muck. Sedimentary peat has formed in the lake, and sedges have formed a surface layer. The organic soil evidently consists of peat which has been modified by agricultural use. It and the muck are black. The fibrous peat is mostly decomposed and is black at the surface and brown at deeper levels. The sedimentary peat varies from olive colored to green. The layer of pumicite is thick near the hard land and becomes gradually thinner toward the lake; this variation in thickness indicates that most of it was washed in from the surrounding higher land. The pumicite is white in holes 1, 2, and 3 of the profile and light brown in hole 4. In hole A, 800 feet south of hole 4, it is cream colored. At hole 2 the pumicite is 3 inches thick, but at hole 3 it is 31 inches thick. The deposit rests on sand. The peat in hole 1 is weakly acidic, and the acidity decreases from pH 5.3 at the 2-foot level to pH 6.5 at the 19-foot level.

#### Lake Thomas peat area

The Lake Thomas peat area (41 acres) is in secs. 4 and 9, T. 36 N., R. 42 E., about 3 miles north of the Coffin Lake peat area and about 8 miles by road southwest of Tiger, which is in Pend Oreille County. The area borders the north end of Lake Thomas, and Pend Oreille Creek flows through it into the lake (map, fig. 225). The topography of the region is shown on the Colville quadrangle. The elevation of the lake is 3,162 feet above sea level. On the soil map of Stevens County (Van Duyne and Ashton, 1915) the area is mapped as muck and peat.

One hole 100 feet from the northwestern border of the area, in a sedge meadow on which water 1 foot deep stood on July 15, 1949, shows 17 feet of peat (fig. 225) resting on light-gray sand. Unlike the Coffin Lake peat area 3 miles south on the same stream, the Lake Thomas deposit shows no sand. The occurrence of nine layers of peat in this hole indicates changes in the conditions under which formation and deposition took place. The region was covered by the continental ice sheet, and local conditions changed from time to time during and after the melting of the ice. The fibrous peat is brown in the upper layers but is olive colored at the 15-foot depth. At the deeper levels it is decomposed. The woody peat is brown. Both the fibrous peat and the woody peat range from wet to watery. The mixture of pumicite and fibrous peat is brown. It forms a layer 6 inches thick.

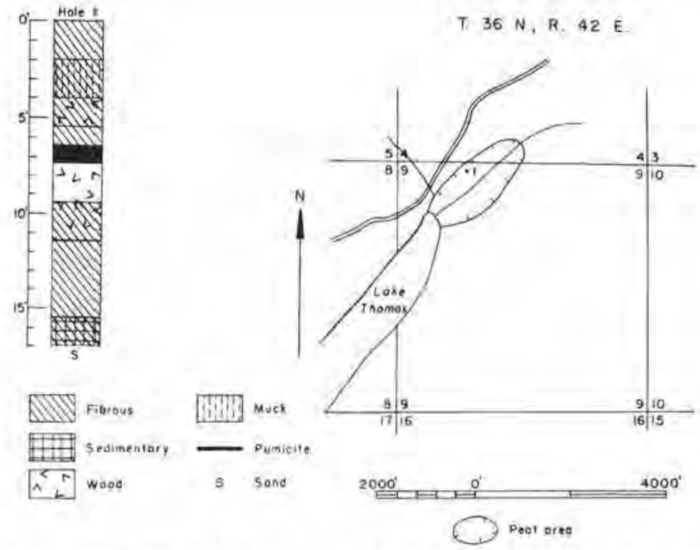


FIGURE 225.—Map and graphic log of a hole in Lake Thomas peat area (41 acres). Map adapted from U. S. Department of Agriculture soil map of Stevens County.

### THURSTON COUNTY DEPOSITS

#### Black River peat area

The Black River peat area (1,465 acres) is in secs. 7 and 18, T. 17 N., R. 2 W.; secs. 11, 12, 13, 14, 24, 25, 26, 35, and 36, T. 17 N., R. 3 W.; and sec. 2, T. 16 N., R. 3 W. It extends south from the south end of Black Lake to about ½ mile north of Little Rock. Its northern end is about 5 miles southwest of Olympia. Its length is about 4¾ miles, and its width, except for two arms which extend westward, varies from ¼ to ½ mile (map, fig. 226).

The topography of most of the region around the peat is shown on the Centralia quadrangle, U. S. Geological Survey, and in more detail on the Tenino quadrangle, which covers the northwest quarter of the Centralia quadrangle. Part of the area is also shown on the Gate quadrangle. The elevation of the peat is less than 100 feet above sea level, and the difference in elevation between the north end and the south end is small. The land bordering the peat is relatively flat. The river began flowing in its present channel after most of the peat deposit had been laid down.

At the present time the current in the channel of Black River flows north in the northern part of the peat area to Black Lake, and the current in the southern part of the area flows south to the Chehalis River. The dividing point between the two currents is a small pool in sec. 24. This anomalous condition is the result of changes in the drainage caused by ditching. The natural drainage from Black Lake was formerly through Black River, which flowed south from the lake to the Chehalis River. Percival Creek flowed into the north end of the lake. A ditch was dug from the head of Percival Creek to Budd Inlet, which is a part of Puget Sound, and the channel of the creek was deepened so that its current was reversed, and it now flows out of the lake. As there is considerable fall in this ditch, the level of the lake was lowered about 2 feet. As a result of this lowering, the current in the northern part of Black

River was reversed, so that it now flows into the lake. There are beaver dams in the river not far from where it enters the lake, but they do not prevent the northern flow.

On the unpublished soil map of Thurston County (Ness et al.) the peat area is mapped as Mukilteo peat.

Profile A (1,450 feet long) extends westward across the peat area near its northern end. Hole 1 is near the east bank of Black River and about 300 feet south of the south shore of Black Lake. It is in a heavy growth of willows averaging about 25 feet tall. The part of the peat area which lies east of the river is covered by a swamp forest. Hole 2 is 700 feet (estimated) west of hole 1. The bog in this vicinity has been burned and appears to be much drier than it has been in the past. The plants growing near hole 2 are alder, cattails, and swamp ferns.

Hole 3 is in a sphagnum bog. The vegetation comprises Labrador tea, bog laurel, salal, sedge, bracken fern, a few scattered patches of *Sphagnum*, and a few lodgepole pine trees. This vegetation extends eastward to within 50 feet of hole 2 and westward nearly to hole 4. The vegetation at hole 4 comprises bracken fern, salal, fireweed, grass, and a few alders. The plants growing at hole 5 are bracken fern, scouring rush, and a few willows and alders. Stumps and large logs are remnants of the coniferous forest that formerly covered the peat in this vicinity.

The large amount of woody peat shown in this profile (fig. 226) indicates that trees and shrubs have flourished on the area at different times and in varying abundance following the retreat of the continental ice that covered the region several thousand years ago. This peat area is within 5 miles of the southern limit of the Vashon glaciation as mapped by Bretz (1913). The fact that fibrous peat is mixed with much of the woody peat indicates that sedges and similar plants flourished with the trees and shrubs most of the time, but the thick layer of woody peat near the bottom of hole 1 and the thinner layer at the 10- to 12-foot depth in hole 3 indicate the absence of sedges and similar plants, or at least their relative scarcity.

The structure of the deposit shown in hole 1, which is near the present course of the river, indicates that the course of development there was somewhat different from that shown in holes 2, 3, 4, and 5, which are farther from the river and nearer to the western border of the deposit. The presence of diatomite indicates the abundance of silica, from which the walls of diatoms are formed, and also probably indicates the presence of phosphates which are favorable to their growth. Water temperatures must also have been favorable. At other times the conditions must have favored the growth of micro-organisms (plant and animal) which form sedimentary peat. The two layers of pure sedimentary peat in this hole are nearer the top than the bottom of the deposit, though in most peat areas such peat is at the bottom of the profile.

The sphagnum at hole 3—a 2-foot layer which thins out near holes 2 and 4—and the mixture of sphagnum with the fibrous peat in hole 4 were formed late in the development of the deposit. Most of the woody peat shown in this profile consists of the usual small particles of decayed wood, but some of it in holes 2 and 3 consists of twigs. These twigs may indicate origin from shrubs rather than trees.

The fibrous peat varies in color from light brown to dark brown. Most of it is merely moist, but some is wet and even watery. Partially disintegrated fibers are readily seen in most of it, but some of it is raw, and some is decomposed. The sedimentary peat in hole 3 is olive colored, but in hole 1 it is brown. The diatomite in hole 1 is tan colored. Pure diatomite is white, and the slightly darker color in this deposit is probably due to the percolation of water from the peat. The sphagnum is raw and wet. The muck in hole 5 is black. Sand is present at the bottom of all holes in this profile.

Profile B (3,100 feet long) is about 3¼ miles south of profile A and is close to the southern one of the western arms of the peat area. The profile extends from east to west. Holes 1 and 2 are in a swamp forest of willow, alder, and ash. The vegetation at hole 3 is composed of grass and skunk cabbage. Hole 4 is 2 feet from the west bank of the river. It is in a swampy place where the vegetation consists of cattails, sedges, and purple marshlocks. The vegetation at the remaining holes comprises the following: hole 5, sedges and marsh plants; hole 6, willow, hardhack, and sedge; hole 7, willow and hardhack; hole 8, Labrador tea, *Sphagnum* moss, reeds (*Juncus*), crab apple, and grass; hole 9, Labrador tea, bog laurel, hardhack, crab apple, and small spruce trees; hole 10, skunk cabbage, swamp fern, wild lily of the valley, and cascara, alder, and cedar trees.

The profile (fig. 226) shows mostly woody peat and fibrous peat, but sphagnum peat, muck, and diatomite are also present. The sphagnum at hole 9 correlates with the presence of bog shrubs at that hole. The diatomite does not form a pure layer. Its mixtures are shown in the profile. A considerable amount of inwashed sand is present in hole 3, and some in hole 1. Pumicite (white, ½ inch thick) was found in hole 4 only, and it was not found in any holes in profiles A and C, which absence probably indicates that conditions when the pumicite fell were such that it was scattered in the peat and did not form a definite layer. The characteristics of the various materials shown in the profile are not essentially different from those of the materials shown in profile A.

Profile C (480 feet long) extends from east to west at the extreme southern end of the peat area. The profile is close to the highway bridge which spans the river ½ mile north of Little Rock. It is on a dairy farm, and all holes are in pasture land. In comparison with profiles A and B this profile is short and shallow (fig. 226). The extreme depth is only 10½ feet as compared with 34½ feet in profile A and 26½ feet in profile B. What peat there is in profile C is mostly a mixture of fibrous peat and woody peat, the amount of pure fibrous peat being small. Diatomite is present in hole 2 only, and the layer there is only 1½ inches thick. The amount of muck is not large, and it occurs in three separate layers. The characteristics of the materials in this profile are not essentially different from those of the materials in profiles A and B.

Some comparisons of the three profiles may help in giving a general idea of the deposit as a whole, even though they are widely separated and the areas between

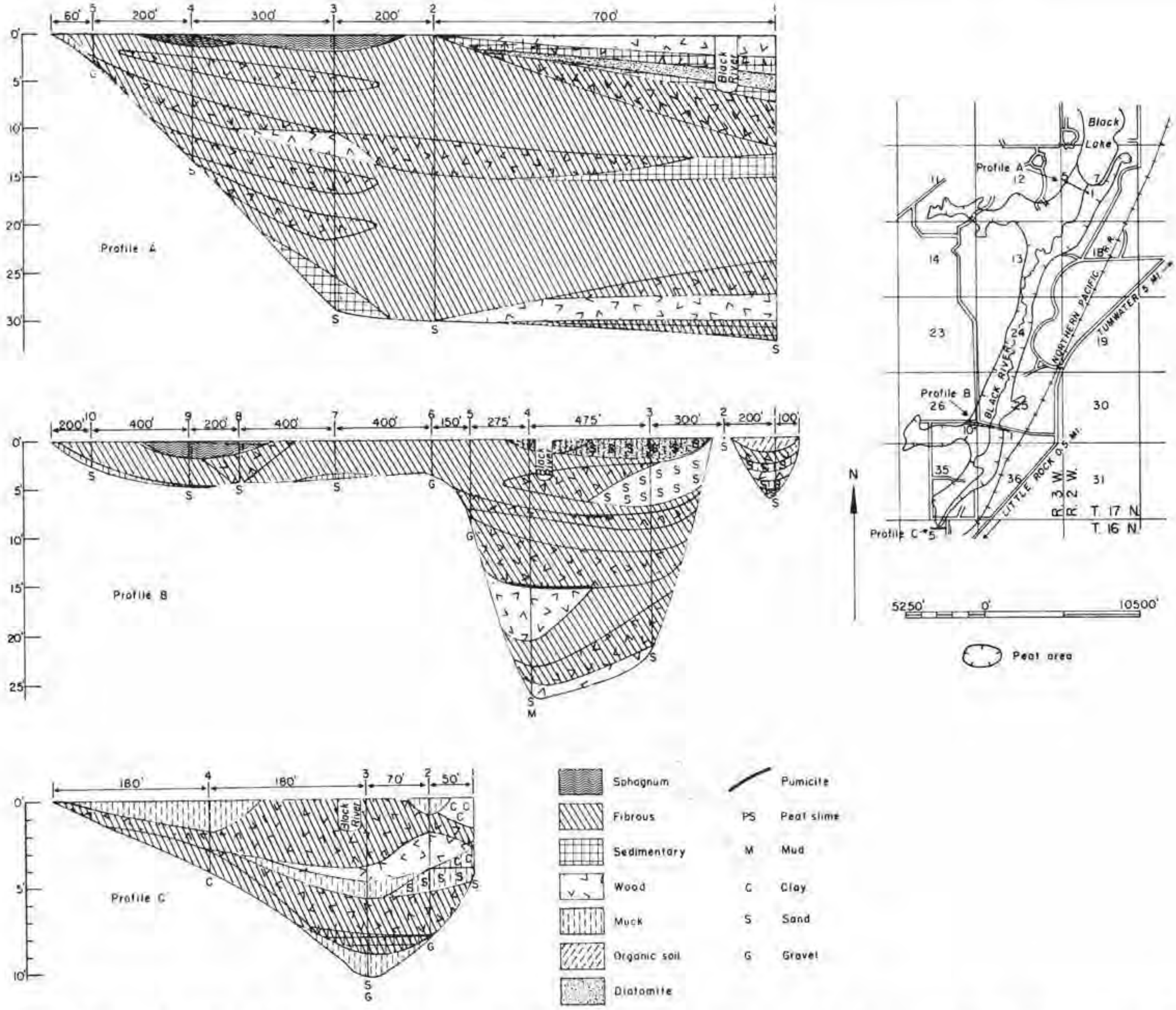


FIGURE 226.—Map and profiles of Black River peat area (1,465 acres, including 15 acres of sphagnum). Map adapted from U. S. Department of Agriculture unpublished soil map of Thurston County.

them have not been investigated. The following general statements may be verified by examining the profiles and reading the descriptions: (1) The quantity of peat decreases from north to south. (2) The river flows over the deepest part of the deposit. (3) Fibrous peat and woody peat form the major part of the deposit. (4) Diatomite is present near the surface in the vicinity of the river. (5) Swamp forest is present east of the river in profiles A and B. (6) Sphagnum occurs west of the river in profiles A and B.

#### Percival Creek peat area

The Percival Creek peat area (258 acres) is in secs. 20, 21, 28, 29, and 32, T. 18 N., R. 2 W. (map, fig. 227). It borders the north end of Black Lake and extends northeast about 1½ miles. The north end of the area is about 1¼ miles by road from Olympia. A drainage ditch which is in part the straightened and deepened channel of Percival Creek carries water through the entire length of the area from Black Lake to Budd Inlet. The reversal of the direction of flow in the creek has been discussed in the description of the Black River peat.

The Percival Creek area is largely covered by swamp forest, but several large open areas are covered by a dense growth of reed canary grass. The profile (1,125 feet long), extending from west to east, begins in a brushy area, crosses a meadow of reed canary grass at hole 2, and ends in a swamp forest at hole 5. The transition from the meadow through a brushy zone to the swamp forest is gradual. The trees in the swamp forest are cedar, spruce,

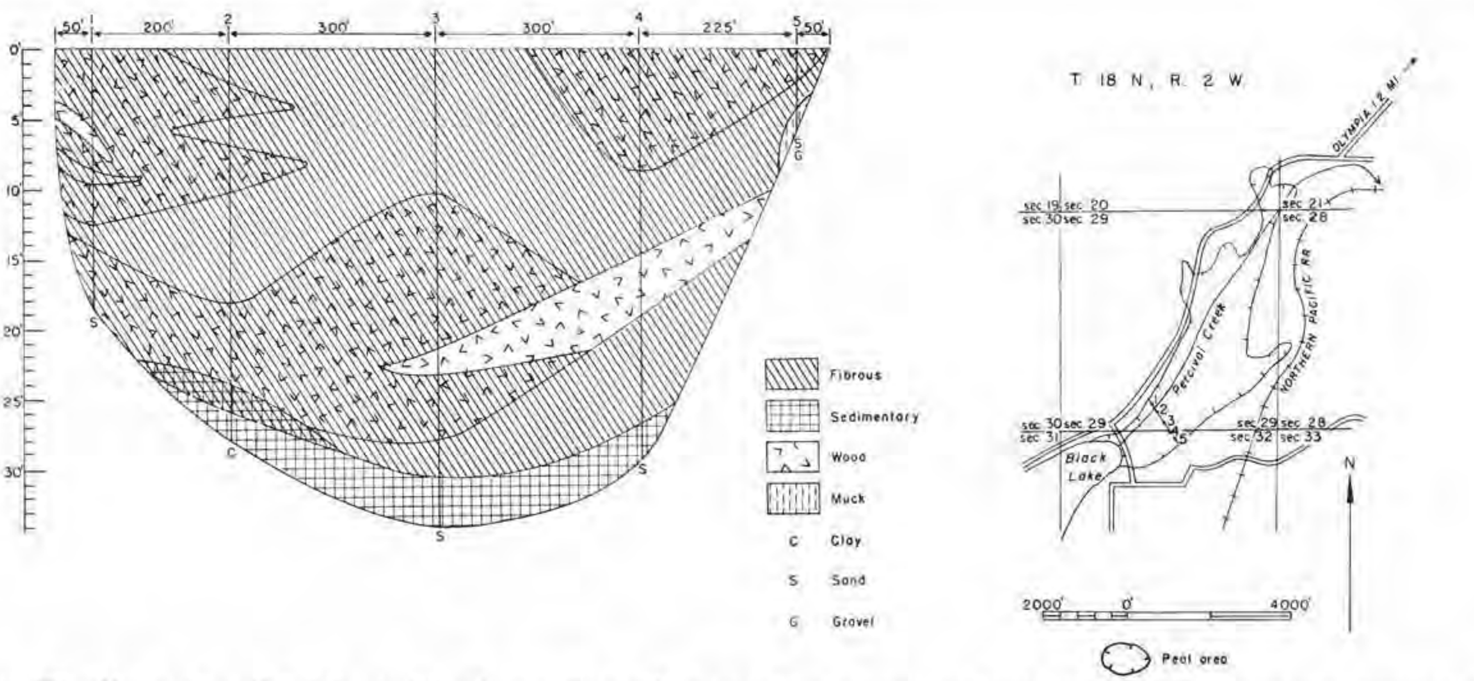


FIGURE 227.—Map and profile of Percival Creek peat area (258 acres). Map adapted from U. S. Department of Agriculture unpublished soil map of Thurston County and U. S. Army Map Service photomosaic.

ash, and alder. The older swamp forest in the vicinity of holes 4 and 5 has been logged, and logs and stumps of conifers up to 5 feet in diameter still remain.

The deposit (fig. 227) consists largely of fibrous peat and woody peat, but sedimentary peat is present at the bottom. The characteristics of the materials present in this deposit are not essentially different from those of the materials in the Black River deposit. The deposit rests on sand and gravel.

In 1950, peat for marketing was being removed from a pit near hole 1 by Hank Peterson of Olympia.

**Woodward Creek peat area**

The Woodward Creek peat area (170 acres) is in secs. 7, 18, and 19, T. 18 N., R. 1 W., about 1 mile east of Olympia (map, fig. 228). U. S. Highway 99 crosses the area, which begins at the head of Woodward Creek and extends about 2½ miles in a northerly direction on both sides of the creek. Its width in general is less than 800 feet. Woodward Creek (also called Pattison Creek) flows north into South Bay, which is a part of Puget Sound.

The topography of the region is shown on the Olympia quadrangle. The elevation of the peat is less than 100 feet above sea level. The deposit lies in a depression in the glacial drift of the region. The slopes bordering it vary from gentle to steep, but the land near it is nowhere more than 100 feet above the level of the peat. The depth and structure of the deposit indicate that it developed in a lake and that the creek formed its present channel at a very late time during the development. On the unpublished soil map of Thurston County (Ness et al.) the area is mapped as Mukilteo peat with two small areas of Greenwood peat.

Hole 1 is in the northern part of the peat area and is in a sphagnum bog which is reached from a dead-end road. A zone of peat-bog birch surrounds the bog, and willows grow beyond the birches. The deposit at this hole (fig. 228) is 30 feet deep, and it rests on gray sand. The sphagnum which forms the surface layer (3 feet thick) is pure and raw at the top of the layer, but toward the bottom it is somewhat disintegrated and some fibrous peat is mixed with it. The fibrous peat from the 3- to the 10-foot depth is dark brown and disintegrated. It includes some

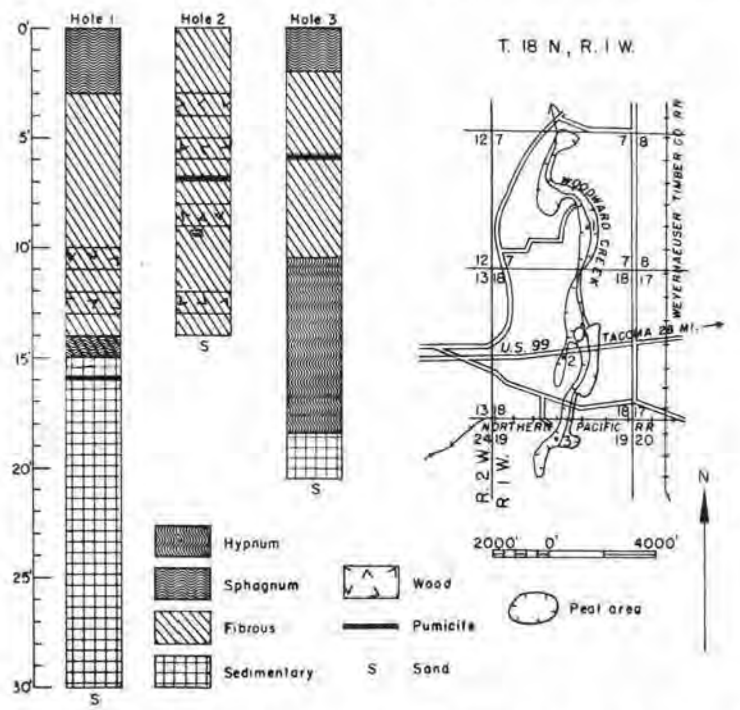


FIGURE 228.—Map and graphic logs of three holes in Woodward Creek peat area (170 acres). Map adapted from U. S. Department of Agriculture unpublished soil map of Thurston County and U. S. Army Map Service photomosaic.

charred material mixed with it at the 4- to 6-foot depth. Its mixtures with woody peat and twigs are also dark brown. Sphagnum is mixed with the fibrous peat at the 14- to 15-foot depth. The sedimentary peat is olive to dark green to dark brown. The olive-colored peat rapidly turns brown on drying. The ½-inch layer of pumicite is white.

Hole 2 is just north of U. S. Highway 99 near the center of the peat area and is in Mukilteo peat, where the vegetation consists of hardhack, willow, sword fern, and bracken fern. This is the shallowest of the three holes, and it does not show any sedimentary peat. The fibrous peat is brown to dark brown, and some of it is disintegrated. At four separate depths it is mixed with woody peat. The white pumicite forms a layer half an inch thick.

Hole 3 is in an area of about 7 acres on which commercial cranberries were planted about 1915 but have now entirely died out. This is near the southern end of the Woodward Creek peat area. The present vegetation is composed of hardhack, bracken fern, and fireweed. The upper 2-foot layer of the deposit consists of brown disintegrated dry sphagnum. The fibrous peat is light brown to brown and is mostly raw. The large amount of pure hypnum peat shown in this hole is rather unusual in the Puget Sound region. This peat is raw and brown. Brown pumicite forms a layer 1 inch thick at the 6-foot depth. The position of the layer of pumicite indicates that at the time at which it fell sedimentary peat was being formed at hole 1 but fibrous peat was being formed at holes 2 and 3.

#### Bucoda peat area

The Bucoda peat area (147 acres) is in secs. 3, 10, and 15, T. 15 N., R. 2 W., 2½ miles west of Bucoda. It may be reached by a narrow graveled county road that connects with a paved road (State Highway 1N) at a point 2½ miles southwest of Bucoda and 5 miles northeast of Centralia. The topography of the region is shown on the Tenino quadrangle, and the elevation of the peat is about 240 feet above sea level. The peat area is long and narrow (about 1½ miles long and averaging about 700 feet wide) and lies in the valley of a small unnamed tributary to the Skookumchuck River. The lower part of the valley is floored with sand and gravel, apparently a remnant of an extensive valley train which built up in the Skookumchuck Valley during recession of the Vashon continental ice in Pleistocene time. The Skookumchuck valley train accumulated so rapidly that sedimentation in the tributary valley was unable to keep pace. The tributary was blockaded at its mouth, and the resultant lake gradually filled with peat.

One hole bored near the center of the area (map, fig. 229) is a quarter of a mile north of the south line of sec. 10, T. 15 N., R. 2 W. Here, as elsewhere in the peat area, the vegetation is a swamp forest of willow, hardhack, and crab apple, with an undergrowth of sedges and skunk cabbage. At the depths indicated the hole shows: 0 to 1 foot, brown disintegrated fibrous peat (pH 4.7); 1 to 3 feet, fibrous peat and twigs; 3 to 4 feet, peat slime; 4 to 5 feet, mixed fibrous and sedimentary peat; 5 to 11½ feet, gray clay, with twigs at 7 to 10 feet; 11½ to 13 feet, fibrous peat and twigs; 13 to 14 feet, dark brown disintegrated fibrous peat; 14 to 17½ feet, olive sedimentary peat, compact at bottom. The deposit rests on 18 inches of soft gray clay, under which is gray sand.

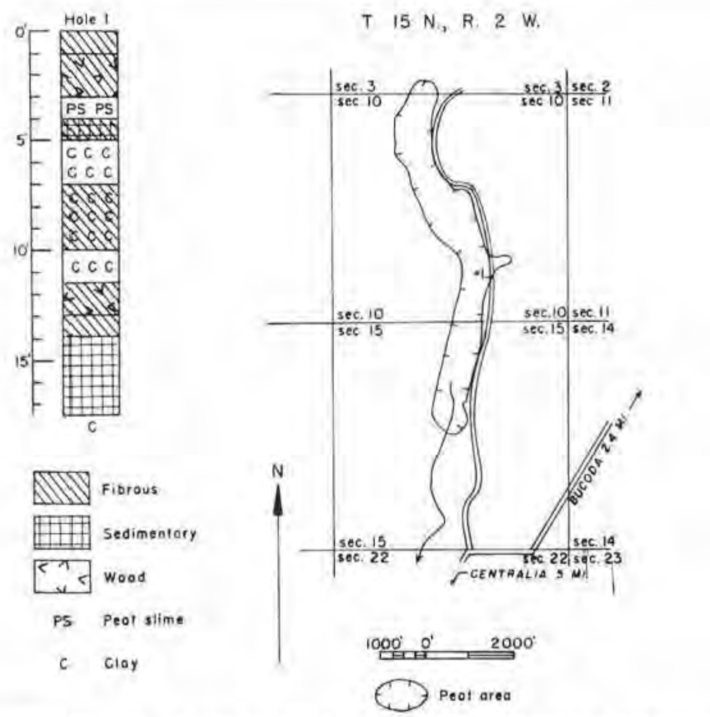

FIGURE 229.—Map and graphic log of a hole in Bucoda peat area (147 acres). Map adapted from U. S. Department of Agriculture unpublished soil map of Thurston County and U. S. Army Map Service photomosaic.

Because of the thick layer of clay in the fibrous peat, utilization of this peat might ordinarily be limited to clearing its surface and planting it to farm crops, but the fact that this is one of the most southern of the peat areas in the Puget Sound region suggests that this peat area may have value as a source of supply of fibrous peat in the Centralia-Chehalis area and to the south.

#### Hicks Lake peat area No. 1

Hicks Lake peat area No. 1 (142 acres) is in secs. 27, 28, and 34, T. 18 N., R. 1 W. (map, fig. 230), about 2½ miles southeast of Olympia. It borders the southeast shore of the lake and extends irregularly southward for almost a mile. The topography of the region is shown on the Olympia quadrangle, on which the peat is mapped as marsh. The elevation of the lake is 158 feet above sea level. The lake and the peat are in an undrained depression in the glacial drift of the region. In the vicinity of the lake and the peat the land is relatively flat. On the unpublished soil map of Thurston County (Ness, et al.) the area is mapped as Mukilteo peat.

The profile (2,350 feet long) crosses the widest part of the area from west to east. The vegetation along the line of the profile comprises brushy swamps with small trees (at holes 1, 2, and 8), a sphagnum bog (hole 4), an abandoned field with some bog vegetation (hole 5), a meadowlike swamp (hole 6), and a plowed field (hole

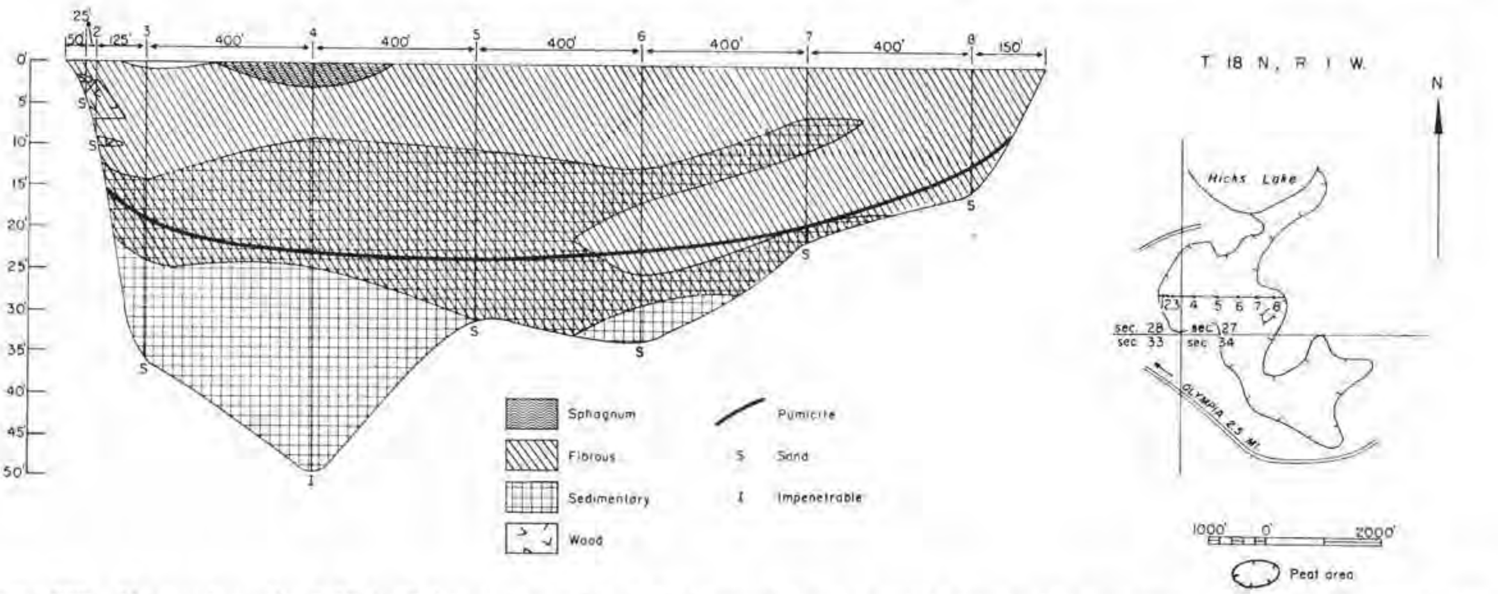


FIGURE 230.—Map and profile of Hicks Lake peat area No. 1 (142 acres). Map adapted from U. S. Department of Agriculture unpublished soil map of Thurston County and U. S. Army Map Service photomosaic.

7). The profile (fig. 230) shows mostly fibrous peat, sedimentary peat, and a mixture of the two, but a mixture of sphagnum peat and fibrous peat is present at the surface in hole 4, and some woody peat is mixed with the fibrous peat in hole 2. The fibrous peat is light brown to dark brown. Some of it is raw, some disintegrated, and some decomposed. It varies from moist to watery. The mixture of sphagnum peat and fibrous peat is reddish-brown, raw, and wet. The sedimentary peat varies from olive green to olive brown. The white pumicite forms a layer one-half to three-fourths of an inch thick, but in hole 5 only scattered grains were found. None was found in holes 4 and 6, but it seems probable that it is scattered there and that it could be found by microscopic examination. The deposit rests on gray sand. At the bottom of hole 4, however, the sedimentary peat is too compact to be penetrated with the peat borer.

**Hicks Lake peat area No. 2**

Hicks Lake peat area No. 2 (27 acres) is in secs. 27 and 28, T. 18 N., R. 1 W. (map, fig. 231). It borders the southwest shore of the lake and extends westward about 2,000 feet. The location and topography have been discussed in the account of Hicks Lake area No. 1.

The profile (925 feet long) extends in a southerly direction from the north border of the area near its widest part. The vegetation along the line of the profile is composed of coniferous and deciduous trees, swamp shrubs, herbaceous swamp species, and some sphagnum-bog species.

The profile (fig. 231) shows fibrous peat, sedimentary peat, mixtures of the two, and small amounts of woody peat and muck. The characteristics of these are not essentially different from those of the materials in area No. 1, but the layer of muck in hole 3 should be noted. The

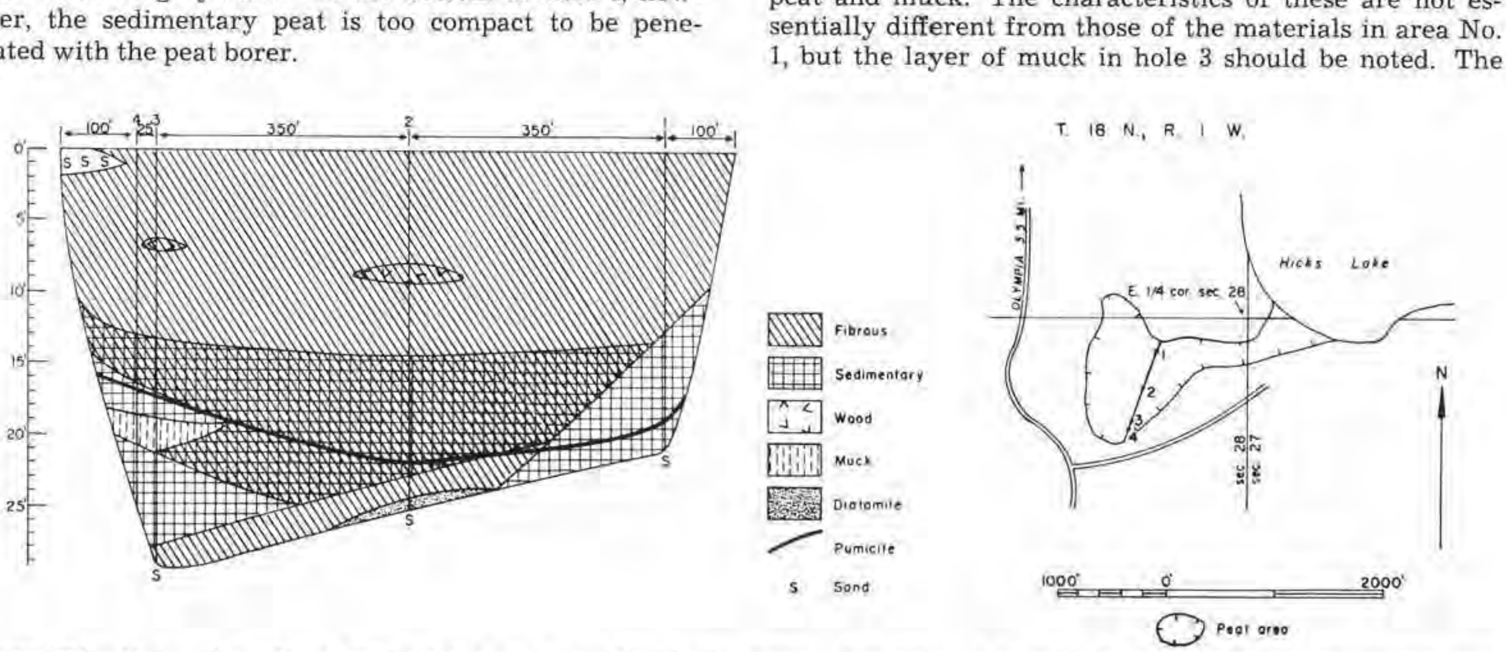


FIGURE 231.—Map and profile of Hicks Lake peat area No. 2 (27 acres). Map adapted from U. S. Army Map Service photomosaic.

muck is black. The sedimentary peat over it is olive green, and the sedimentary peat under it is olive brown. The layer of white pumicite is three-fourths of an inch thick. The deposit rests on gray sand. It seems probable that peat lies under the inwashed sand at the southern end of the profile, and this relationship is shown in figure 231.

### Johnson Road peat area

The Johnson Road peat area (135 acres) is in secs. 17, 18, 19, and 20, T. 17 N., R. 1 E. (map, fig. 232), about 11 miles by road southeast of Olympia. It lies in a depression in the glacial drift of the region. The topography of the region is shown on the Chehalis and Yelm quadrangles. The elevation of the peat is 230 feet above sea level. This deposit is mapped as Mukilteo peat on the unpublished soil map of Thurston County (Ness et al.).

The profile (1,050 feet long) extends into the northeast part of the area but not all the way across it. It is in swamp forest, some of which is overmature, as is indicated by the large number of down rotten logs. The trees are hemlock, spruce, vine maple, and alder. Skunk cabbage and swamp fern are characteristic of the forest undergrowth. The profile (fig. 232) shows fibrous peat and mixtures of fibrous and woody peat. In hole 1 a cross section of a rotten log was obtained with the peat borer. The fibrous peat is brown to dark brown and is mostly decomposed. A 1-inch layer of light-brown pumicite lies at the 3-foot depth in hole 1. The deposit rests on gray clay, sand, and gravel.

### Long Lake-Patterson Lake peat area

The Long Lake-Patterson Lake peat area (107 acres) is in sec. 35, T. 18 N., R. 1 W., and sec. 2, T. 17 N., R. 1 W. (map, fig. 233), about 6 miles southeast of Olympia. It is continuous from the north shore of Patterson Lake to the south shore of Long Lake, but there is an "island" of hard land bordering Long Lake, so that the peat there ends in two branches. A drainage ditch extends across the peat from Patterson Lake to Long Lake. The Northern Pacific-Union Pacific railroad extends diagonally across the area, and a highway crosses it in the narrowest part.

The profile (1,200 feet long), beginning on the bank of the drainage ditch 50 feet north of the place where the highway passes under the railway, extends north to the "island" of hard land. The vegetation along the profile includes willow and alder trees, hardhack shrubs, sedges, reeds, reed canary grass, fireweed, water celery, and *Sphagnum* moss. Hole 3 is in a hayfield. The profile (fig. 233) shows fibrous peat, sedimentary peat, a mixture of the two, and a mixture of fibrous peat and woody peat. The fibrous peat is brown to dark brown, raw to disintegrated, and moist to watery. Some charred wood is present in the woody peat. The sedimentary peat is olive green to olive brown. Some small stones were found in it in hole 1. The peat in hole 1 is strongly acidic (pH 4.5 to 4.8). The water in the creek is slightly less acidic (pH 5.0). White pumicite forms a layer half an inch thick at the bottom of hole 1 but was not found in the other holes. At hole 1 the deposit rests on sand and clay, at holes 2 and 3 on gray sand, and at hole 4 on gravel.

### Bigelow Lake peat area

The Bigelow Lake peat area (96 acres) is in secs. 12 and 13, T. 18 N., R. 2 W., and secs. 7 and 18, T. 18 N., R. 1 W., about 1 mile from the northeast city limits of Olympia. There are suburban residences on the higher flat land close to the east side of the peat area. The topography of the region is shown on the Olympia quadrangle. The elevation of the lake is 160 feet above sea level. On the unpublished map of Thurston County (Ness et al.) the area is mapped as Mukilteo peat.

A sphagnum bog borders the north shore of the lake. It has a deep carpet of living *Sphagnum*, and no evidence of burning was seen. The vegetation includes Labrador tea, bog laurel, cranberry, sundew, sedge, hardhack, cascara trees, and a few crab apple trees.

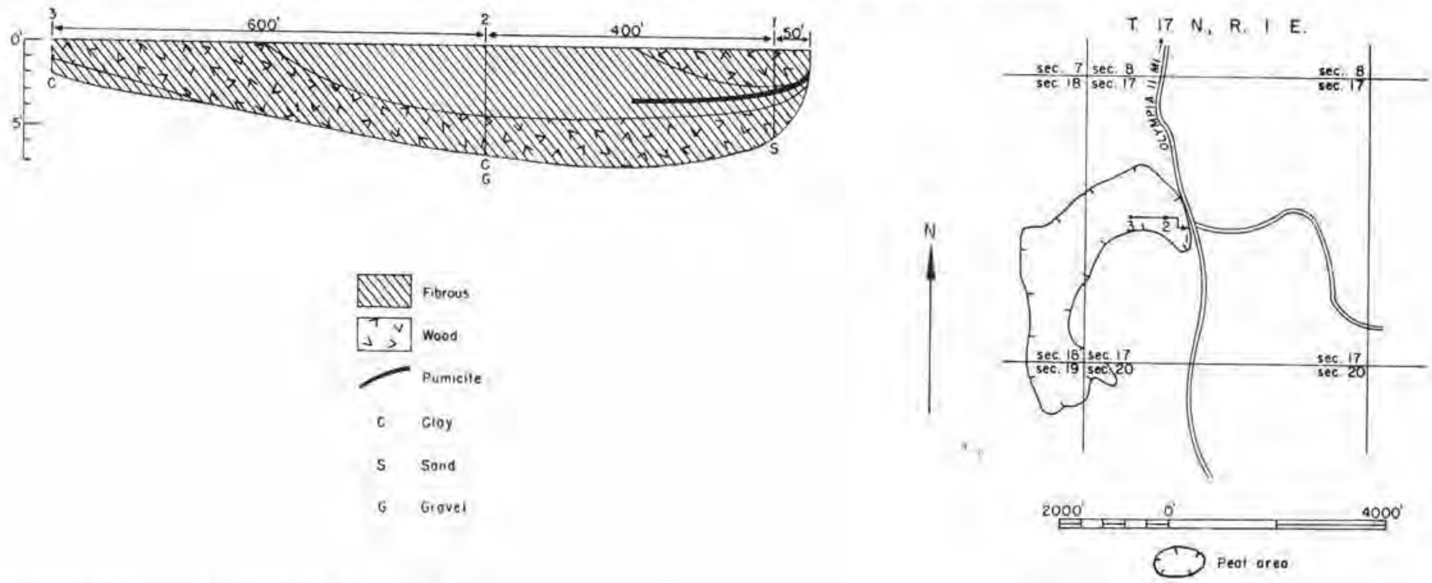


FIGURE 232.—Map and profile of Johnson Road peat area (135 acres). Map adapted from U. S. Department of Agriculture unpublished soil map of Thurston County.

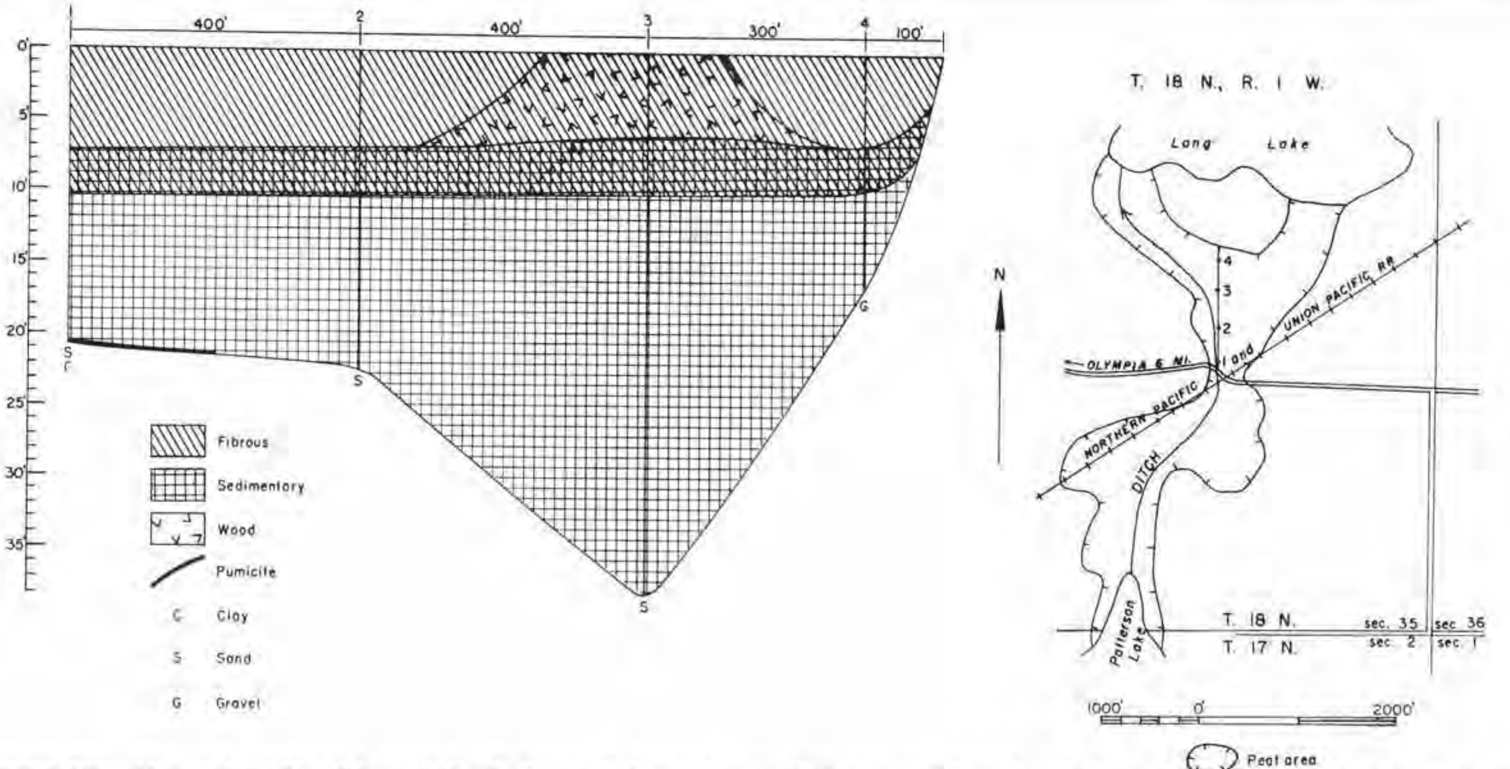


FIGURE 233.—Map and profile of Long Lake-Patterson Lake peat area (107 acres). Map adapted from U. S. Department of Agriculture unpublished soil map of Thurston County and U. S. Army Map Service photomosaic.

The peat deposit (fig. 234) is 27½ feet deep and rests on blue sand. The sphagnum, which forms a layer 3 feet thick at the surface of the deposit, is brown and disintegrated. A few fibers of sedges or similar plants are present in it. The peat slime which underlies the sphagnum layer and extends to the 6-foot depth contains some small fragments of wood. The fibrous peat is dark brown, disintegrated, and wet. Numerous seeds, probably of buckbean, are present at the 7- to 8-foot depth. The sedimentary peat is olive brown to dark brown. Brown pumicite forms a layer 1 inch thick.

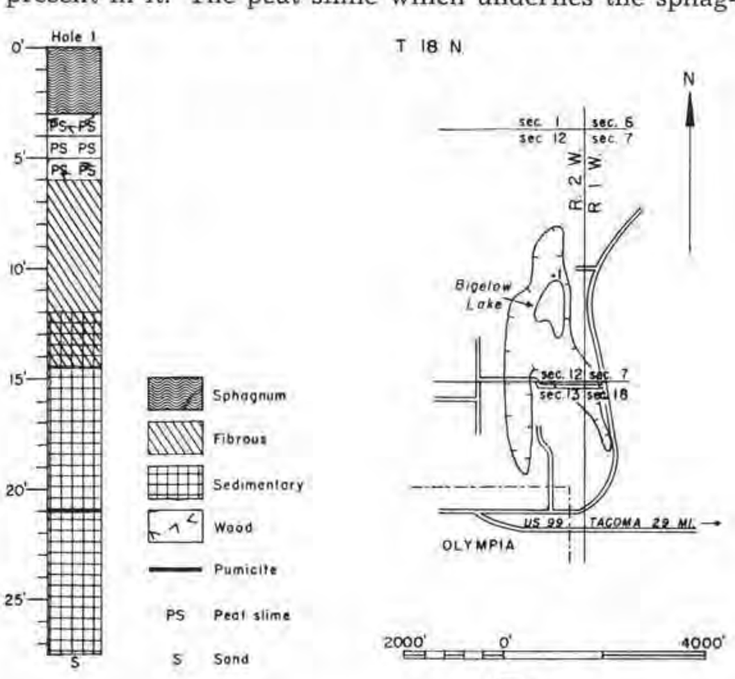


FIGURE 234.—Map and graphic log of a hole in Bigelow Lake peat area (96 acres). Map adapted from U. S. Department of Agriculture unpublished soil map of Thurston County and U. S. Army Map Service photomosaic.

**Kaiser Road peat area**

The Kaiser Road peat area (75 acres) is in secs. 5 and 8, T. 18 N., R. 2 W., about 2 miles northwest of Olympia. It is nearly 1 mile long, and its maximum width is about 400 feet. Kaiser Road passes close to its eastern border

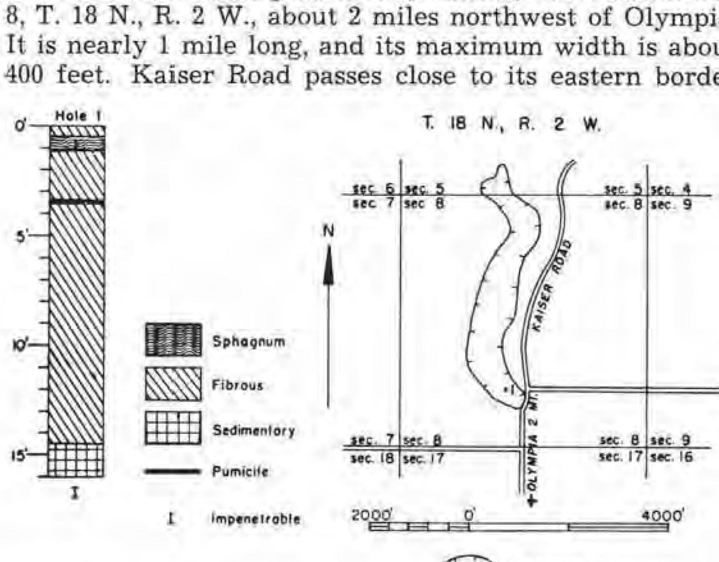


FIGURE 235.—Map and graphic log of a hole in Kaiser Road peat area (75 acres). Map adapted from U. S. Department of Agriculture unpublished soil map of Thurston County and U. S. Army Map Service photomosaic.

(map, fig. 235). The topography of the vicinity is shown on the Olympia quadrangle. The elevation of the peat is about 150 feet above sea level. The deposit lies in a depression in the glacial drift of the region. It is mapped as Mukilteo, Rifle, and Greenwood peat on the unpublished soil map of Thurston County (Ness et al.).

The vegetation in the vicinity of the one hole bored in the southern part of the area consists of a dense growth of hardhack, with some small willows, a few sedges, and some *Sphagnum*. The hole shows mostly fibrous peat, but there is a layer of brown disintegrated sphagnum near the surface, and at the bottom is a layer of olive-brown sedimentary peat which is so compact that it cannot be penetrated more than 18 inches with the peat borer. The fibrous peat is brown to dark brown and is disintegrated. The 1-inch layer of pumicite is brown.

### Gull Harbor peat area

The Gull Harbor peat area (56 acres) is on Clark's farm in secs. 25 and 36, T. 19 N., R. 2 W., about 3 miles north of Olympia and a little over 1 mile southeast of Gull Harbor. A dead-end road ends near the western border of the peat. On the Olympia quadrangle the peat area is shown as marsh, and the region surrounding it relatively flat. The peat lies in a depression in the glacial drift of the region and is about 150 feet above sea level. During the rainy season there is some drainage from the peat area through a small stream which flows to Gull Harbor. On the unpublished soil map of Thurston County (Ness et al.) the deposit is mapped as Mukilteo peat.

The vegetation in the vicinity of the one hole that was bored includes willow, hardhack, and some *Sphagnum* and other mosses. It is reported locally that this bog was completely cleared some years ago. The hole shows at the surface a 2-inch layer of raw mosses (not *Sphagnum*). Under this is a 10-inch layer of ashes of burned peat. Under the ashes is a 1½-foot layer of brown fibrous decomposed peat, which overlies gray clay.

### Boston Harbor peat area

The Boston Harbor peat area (43 acres) is in sec. 13, T. 19 N., R. 2 W. (map, fig. 236), about 1 mile east of Boston Harbor and about 6 miles north of Olympia. It is near the Boston Harbor school. Ditches in the peat provide some drainage, at least during the rainy season. The topography of the region is shown on the Olympia quadrangle. The elevation of the deposit is a little over 100 feet above sea level. The peat area lies in a depression in the glacial drift of the region and is part of a larger area mapped as marsh. On the unpublished soil map of Thurston County (Ness et al.) the deposit is mapped as Mukilteo peat.

The profile (825 feet long) crosses the southern part of the area. The vegetation in the vicinity of the profile is composed of hardhack, sedge, and *Sphagnum*. The bog was burned about 1947 or 1948 and probably had also been burned earlier. The fact that *Sphagnum* is growing so well now indicates that a layer of sphagnum was probably consumed in the burning. Some commercial blueberry plants are thriving near the south side of the area.

The profile (fig. 236) shows only fibrous peat, except for a 1-foot layer of brown muck at the bottom of hole 1 and 1 inch of brown pumicite in holes 2 and 4. The fibrous peat is brown to black and is disintegrated to decomposed. Gray clay is present at the bottom of all holes.

### Belmore peat area

The Belmore peat area (42 acres) is in sec. 4, T. 17 N., R. 2 W., about 3 miles southwest of Olympia. The southwest end of the deposit is accessible from a dead-end road, and a county road passes close to the northwest side (map, fig. 237). The peat lies in a depression in the glacial drift of the region. The surrounding soil is sandy. The topography of the region is shown on the Tenino quadrangle. The elevation of the peat is 155 feet above sea level. On the unpublished soil map of Thurston County (Ness et al.) the deposit is mapped as Greenwood and Mukilteo peat.

This is a very wet sphagnum bog having a natural "marginal ditch" which is rather broad in some places. All the surface of the bog is wet, and water stands on some of it. During the rainy season ditches in the bog provide some drainage to a creek which flows into Black Lake. The vegetation includes coniferous trees, deciduous trees, bog and swamp shrubs, and herbaceous bog and swamp species. The coniferous trees on the bog are mostly hemlock and lodgepole pine, but there are a few Douglas

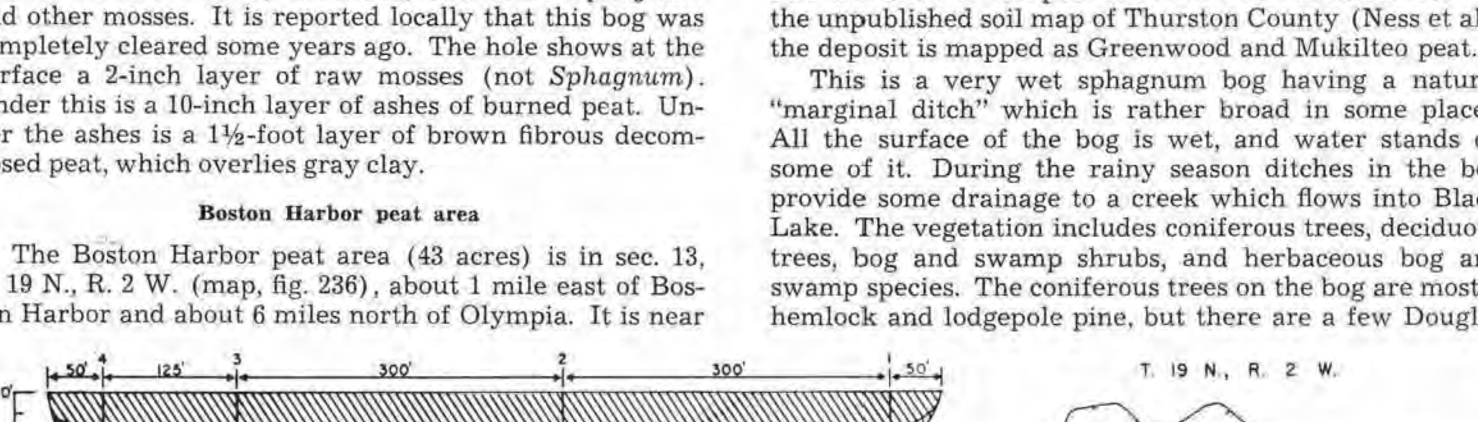


FIGURE 236.—Map and profile of Boston Harbor peat area (43 acres). Map adapted from U. S. Army Map Service photomosaic.

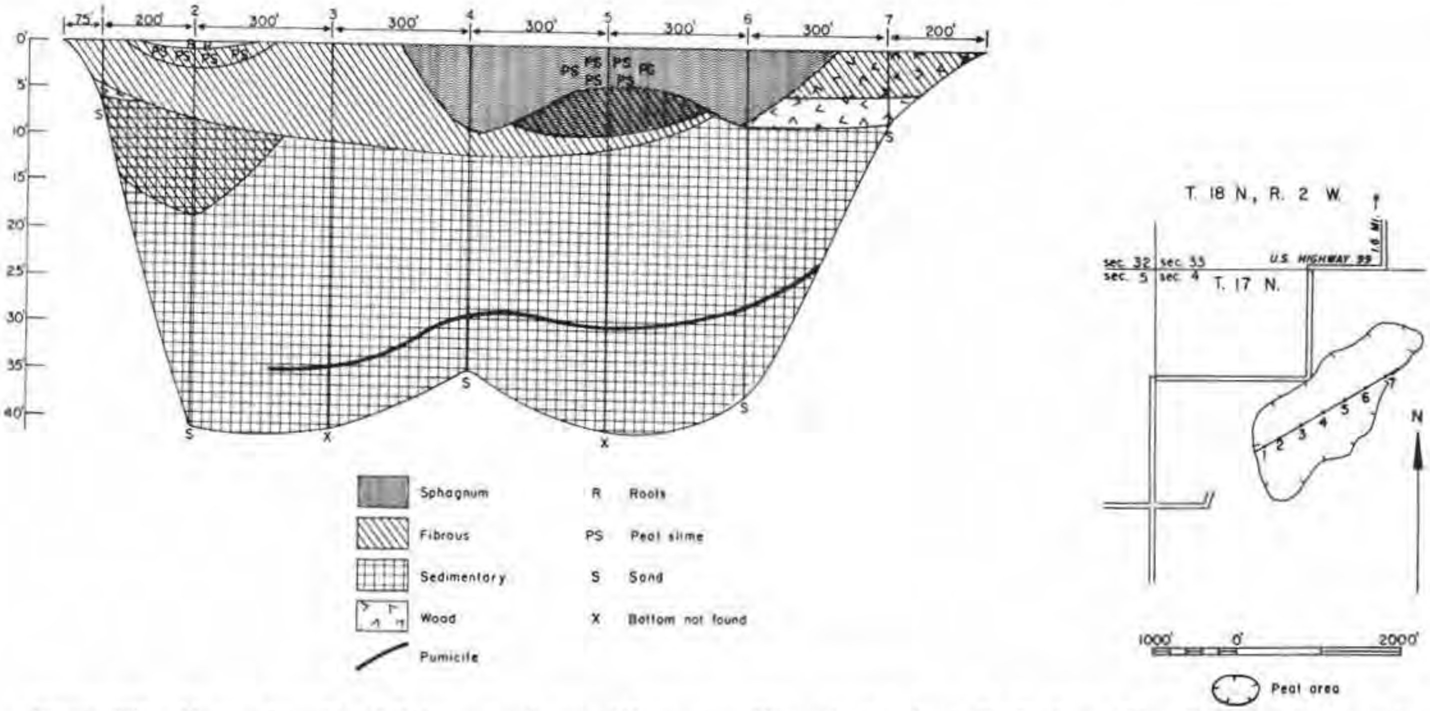


FIGURE 237.—Map and profile of Belmore peat area (42 acres). Map adapted from U. S. Army Map Service photomosaic.

firs. Seedlings and small trees of hemlock and lodgepole pine are numerous. On the margins of the bog Douglas fir trees are numerous, and some have reached such a size that they have been logged. The deciduous trees are alder, cascara, and willow. The shrubs are Labrador tea, bog laurel, hardhack, ninebark, salal, elderberry, huckleberry, and salmon berry. The small prostrate woody vines of the native cranberry are abundant. The herbaceous species are sundew, cotton grass, sedge, skunk cabbage, and water lily. Duckweed grows on the surface of the standing water. *Sphagnum* is abundant and is growing vigorously.

The profile (fig. 237) shows sphagnum peat, fibrous peat, sedimentary peat, woody peat, pumicite, and some peat slime. Some of the fibrous peat is mixed with sedimentary peat, some with sphagnum peat, and some with woody peat. Peat slime occurs in both fibrous peat and sphagnum peat. The sphagnum is raw at the surface and disintegrated at the bottom of the layer. The fibrous peat is brown to dark brown to black and is raw to disintegrated to decomposed. In some of the fibrous peat decomposition and inwash of mineral materials have progressed so far that it is practically muck. The fibers in some of it are so fine that the peat is felty. The fibrous peat varies from wet to watery. The color of the sedimentary peat varies from olive brown to dark brown, the darker color being toward the bottom of the layer. White pumicite forms a layer half an inch thick.

The deposit, so far as determined, rests on sand. Bottom was not reached in holes 3 and 5 because the equipment available at the time the borings were made was insufficient for boring deeper than 42 feet. The sedimentary peat at that depth is rather compact but not too compact to be penetrated with the peat borer.

This bog was inspected by Rigg in 1921, and records of the vegetation and physical conditions were made. The principal changes since that time are the great increase in the size of the trees and in the number of seedlings and small trees of hemlock and lodgepole pine and the great increase in the amount of living *Sphagnum*. If this bog is left undisturbed it will eventually be a forest of coniferous trees.

The removal of peat from this bog on a commercial scale would be possible, but the area is so wet that, except at the margins, floating equipment would probably be necessary. Sphagnum and fibrous peat are available. The amount of sedimentary peat is large, but its removal might be expensive, and its value has not been fully demonstrated.

### Ames-Huntley Road peat area No. 1

The Ames-Huntley Road peat area No. 1 (38 acres) is in sec. 36, T. 19 N., R. 2 W. (map, fig. 238), about 2 miles north of Olympia. The Ames-Huntley road, a paved highway, crosses the extreme southern part of the area. The peat lies in a depression in glacial drift and is drained from the south to Budd Inlet by way of Ellis Creek. The topography of the region is shown on the Olympia quadrangle. The elevation of the peat is 140 feet above sea level. On the unpublished soil map of Thurston County (Ness et al.) the deposit is mapped as Rifle peat.

Most of the area is covered by a dense growth of Labrador tea. The profile (850 feet long) crosses the widest part of the area. Hole A is 70 feet east and 450 feet south of hole 2 of the profile. The vegetation along the line of the profile and in the vicinity of hole A is composed of Labrador tea, bog laurel, cranberry, hardhack, bracken fern, *Dulichium*, sedge, rush, *Sphagnum*, pigeon wheat moss, and other mosses. Blackened trunks of dead conifers indicate a fire some time in the past. The *Sphagnum* at hole

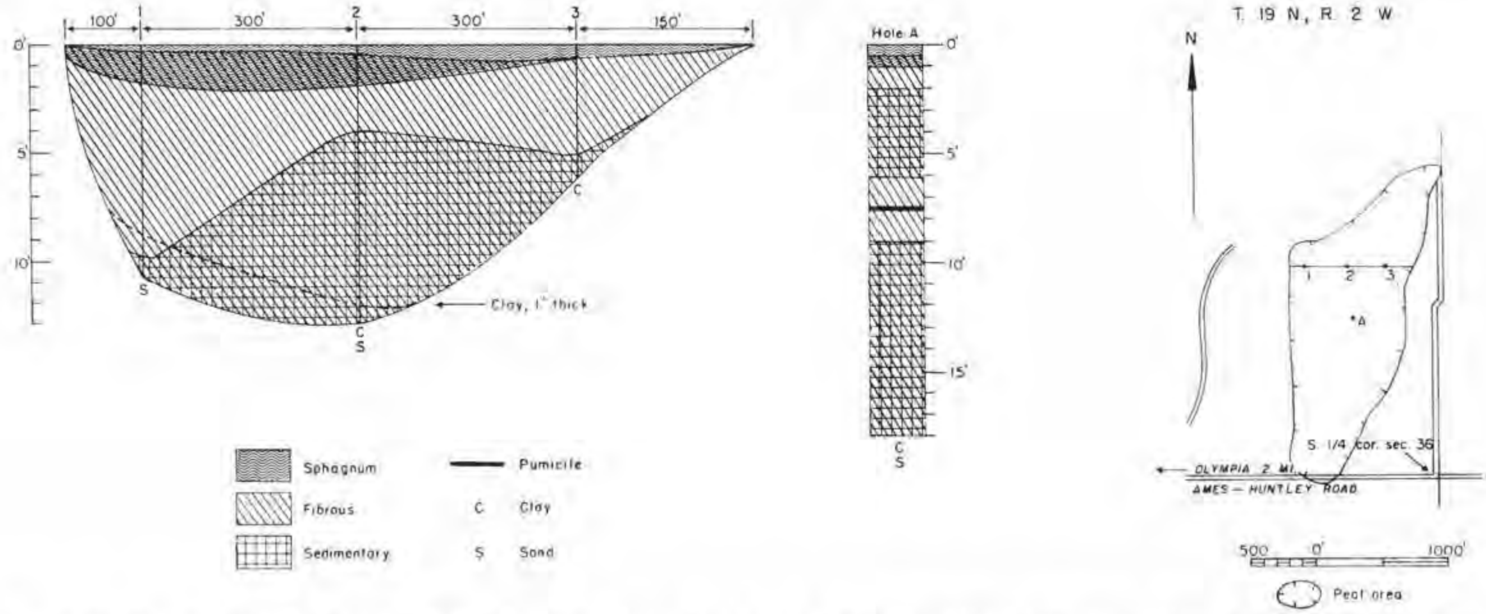


FIGURE 238.—Map, profile, and graphic log of a hole in Ames-Huntley Road peat area No. 1 (38 acres). Map adapted from U. S. Department of Agriculture unpublished soil map of Thurston County and U. S. Army Map Service photomosaic.

3 is dried up, but at all other holes it is growing. The presence of *Dulichium* indicates that at some time in the past the central part of the area, at least, must have been wetter than it is now (see p. 17).

The profile and the separate hole show sphagnum peat, fibrous peat, mixtures of the two, and mixtures of fibrous peat and sedimentary peat. The sphagnum at the surface is light brown, raw, and mostly dry. At the 1-foot depth in hole 3 it is disintegrated. The fibrous peat varies from fine to coarse. It is brown to dark brown and is disintegrated to decomposed. The layer shown as a mixture of fibrous peat and sedimentary peat consists mostly of fibrous peat at the top of the layer and mostly of sedimentary peat at the bottom of the layer. At the top it is brown, and at the bottom it is olive brown. The 1-inch layer of pumicite in hole A is brown. The layer of clay at the 8-foot depth in hole 1 is greenish-gray and 1 inch thick, and at the 12-foot depth in hole 2 it is blue and ½ inch thick. The deposit rests on gray and blue sand and clay.

#### Ames-Huntley Road peat area No. 2

The Ames-Huntley Road peat area No. 2 (65 acres) is in the SE¼ sec. 36, T. 19 N., R. 2 W., a few hundred feet east of area No. 1. The southern end of the area extends to within 200 feet of the Ames-Huntley road. The peat lies in a shallow depression in glacial drift, and it is drained northward by a tributary to Woodward Creek. The topography of the region is shown on the Olympia quadrangle, and the elevation of the peat is 140 feet above sea level. On the unpublished soil map of Thurston County (Ness et al.) the deposit is shown as Rifle peat.

About half of the area is waste land—swamp forest and brush—and the other half is planted to reed canary grass that is used for hay and pasture. One hole bored near the center of the area showed only 4 feet of dark-brown fibrous peat overlying a mixture of clay and sand. Most of the peat is decomposed, but that in the lower 1½ feet is raw, and the pH there is 5.0. There is a 1-inch layer of coarse brown pumicite at the 1-foot depth. Somewhat deeper peat is reported to be present in the cultivated field north of the hole, but it is unlikely that, even at its greatest depth, the peat would be more than 10 feet deep.

#### Maple Bowl peat area

The Maple Bowl peat area (31 acres) is in sec. 12, T. 17 N., R. 2 W., about 5 miles south of Olympia. A dead-end road gives access to the south side of the area. The peat lies in a kettle in glacial drift. The topography of the region is shown on the Tenino quadrangle, and the elevation of the peat is 150 feet above sea level. The deposit is mapped as Mukilteo and Greenwood peat on the unpublished soil map of Thurston County (Ness et al.).

The location of the profile (1,050 feet long) is shown on the map (fig. 239). The vegetation along the line of the profile consists mostly of trees and brush. Hardhack is present at all holes. The presence of Labrador tea at holes 1 and 2 correlates with the occurrence of sphagnum peat at the surface of the deposit in these holes (fig. 239). Salal, bracken fern, lodgepole pine, and cedar also occur along this part of the profile. At hole 3 the vegetation is composed of hardhack, bracken fern, and grass. At hole 4 it is composed of willow and hardhack.

The profile shows sphagnum peat, fibrous peat, woody peat, peat slime, sedimentary peat, and some mixtures. The sphagnum is light brown, disintegrated, and wet. The fibrous peat is light brown to reddish brown to dark brown and is disintegrated to decomposed. Some of the wood in hole 2 is charred, indicating a fire long ago. The sedimentary peat is olive green. Gray sand is present at the bottom of holes 1 and 3, and gray sand and clay at the bottom of hole 4. The sedimentary peat at the 44-foot depth in hole 2 is too compact to be penetrated with the peat borer.

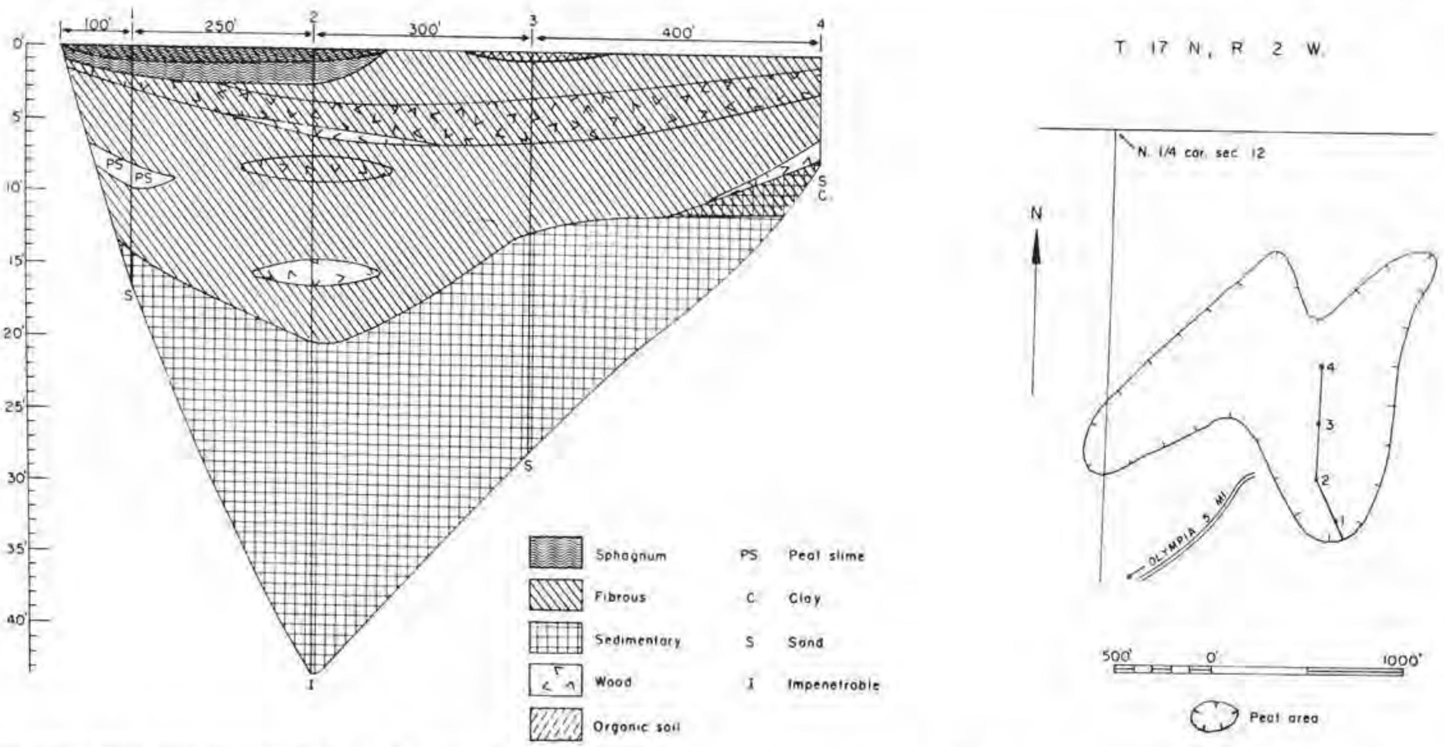


FIGURE 239.—Map and profile of Maple Bowl peat area (31 acres). Map adapted from U. S. Department of Agriculture unpublished soil map of Thurston County.

**Eberhardt peat area**

The Eberhardt peat area (26 acres) is in secs. 25 and 36, T. 19 N., R. 3 W., about 8 miles northwest of Olympia. It lies in a depression in glacial drift. The topography of the region is shown on the Shelton quadrangle, where the peat area is erroneously shown as a lake. The elevation of the peat is 100 feet above sea level. The deposit is mapped as Mukilteo peat on the unpublished soil map of Thurston County (Ness et al.).

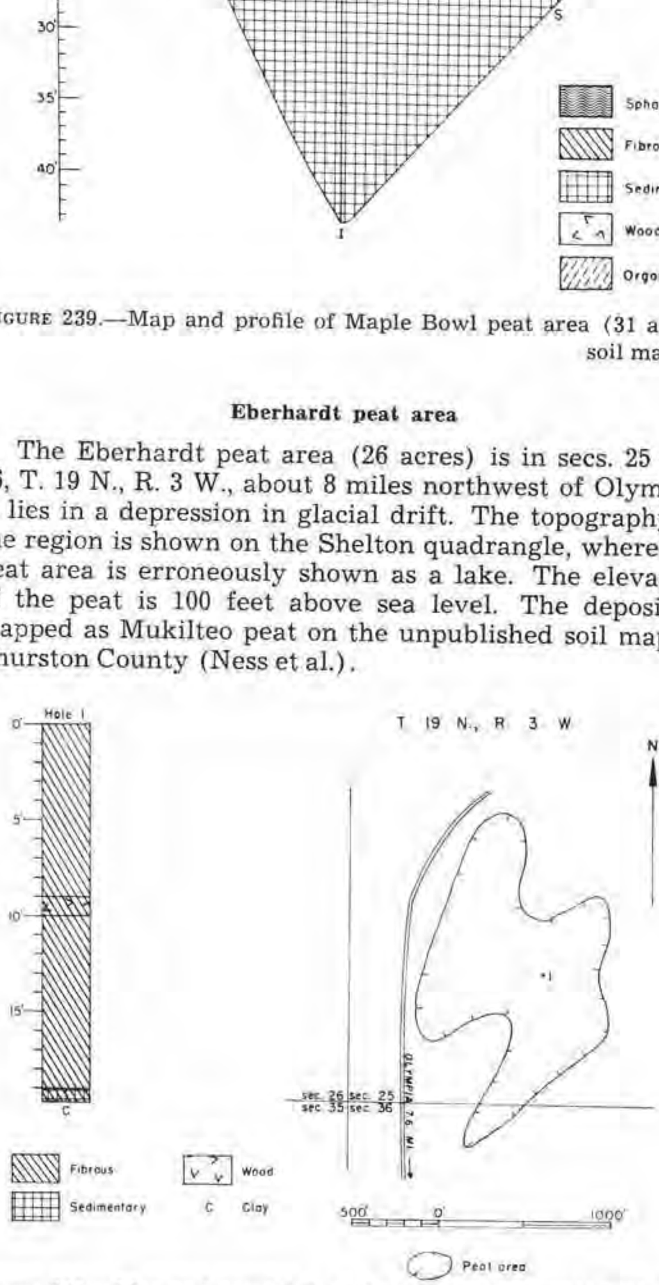


FIGURE 240.—Map and graphic log of a hole in Eberhardt peat area (26 acres). Map adapted from U. S. Army Map Service photomosaic.

More than half of this peat area is planted to blueberries. The uncultivated part is covered by a dense growth of hardhack. The owner, Joseph Eberhardt, states that the area now in blueberries was formerly covered by *Dulichium*, which is a low herbaceous plant belonging to the sedge family.

One hole (fig. 240) bored in the uncultivated part of the area (near the center of the peat area) shows 19 feet of brown fibrous peat, which is pure except at the 9- to 10-foot depth, where it is mixed with twigs. Below the fibrous peat is a 9-inch olive-brown mixture of fibrous and sedimentary peat. Below this is blue clay.

**Snyder Cove peat area**

The Snyder Cove peat area (14 acres) is in sec. 32, T. 19 N., R. 2 W., and sec. 5, T. 18 N., R. 2 W., about 3½ miles northwest of Olympia and ½ mile east of Snyder Cove. The Snyder Cove road extends along the south side of the area (map, fig. 241). The peat lies in a depression in glacial drift at an elevation of 135 feet above sea level. The topography of the region is shown on the Olympia quadrangle. On the unpublished soil map of Thurston County (Ness et al.) the deposit is mapped as Mukilteo peat.

The profile (625 feet long) crosses the area from west to east near the widest part. The vegetation along the line of the profile includes hardhack and *Sphagnum*, with willows near hole 1.

The material shown in the profile is mostly fibrous peat, but there is some sphagnum at the surface, and a small amount of sedimentary peat is at the bottom. At hole 1 there is 1 foot of water in which there is living *Sphagnum*, and at hole 2 there is 1 foot of light-brown

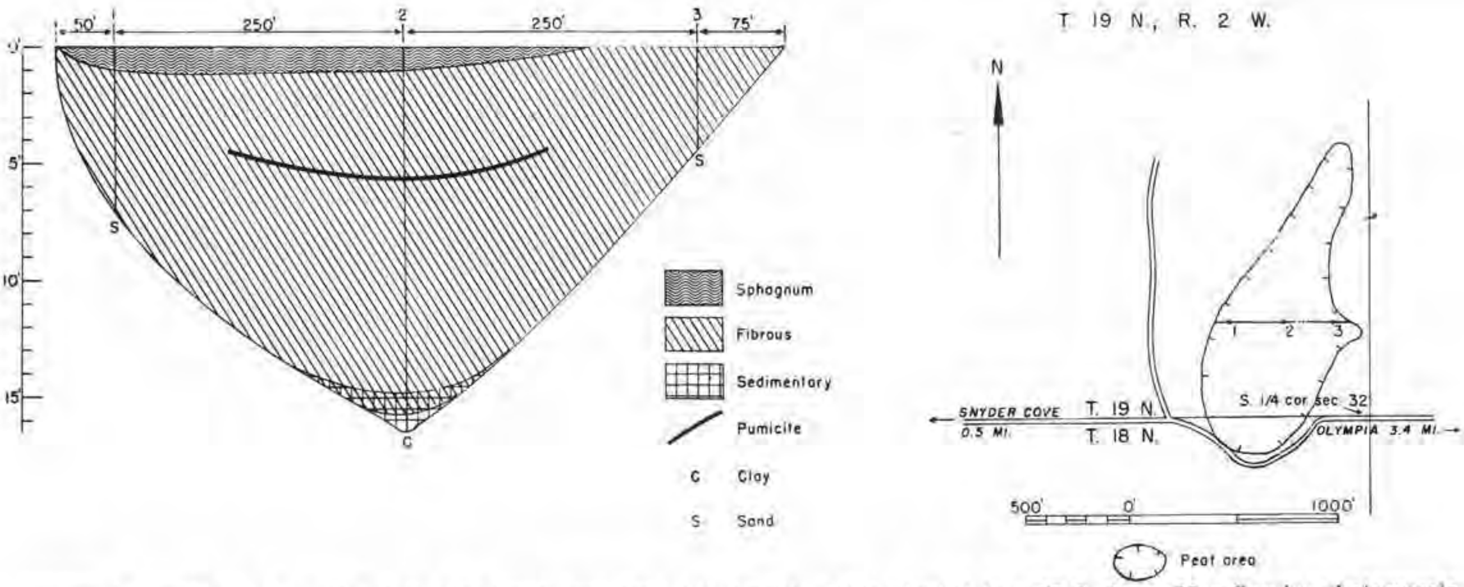


FIGURE 241.—Map and profile of Snyder Cove peat area (14 acres). Map adapted from U. S. Army Map Service photomosaic.

disintegrated sphagnum. The fibrous peat varies from light brown to dark brown and from disintegrated to decomposed. The sedimentary peat is dark green. In hole 2 there is 1 inch of brown pumicite. The deposit, so far as shown by the profile, rests on brown sand and gray clay.

### Eureka peat area

The Eureka peat area (12 acres) is in secs. 13, 23, and 24, T. 16 N., R. 1 E., about 3 miles southeast of Rainier. The road from Lawrence Lake to Rainier passes about ½ mile north of the area, and a dead-end road extends to the peat. The deposit lies in a depression in glacial drift, at an elevation of about 445 feet above sea level. The topography of the region is shown on the Yelm quadrangle. On the unpublished soil map of Thurston County (Ness et al.) the deposit is shown as Mukilteo peat.

The vegetation of the area is composed of hardhack and sedge with a dense surface cover of a robust species of *Sphagnum*, which is growing vigorously among their stems.

The deposit, so far as is shown by one hole, consists of 5½ feet of brown fibrous peat which is disintegrated in the upper 1 foot and decomposed from there to the bottom. The peat rests on blue clay and sand.

### Bush Prairie peat area

The Bush Prairie peat area (11 acres) is in sec. 2, T. 17 N., R. 2 W. (map, fig. 242), about 4 miles south of Olympia. It is accessible from U. S. Highway 99 by way of a dead-end road about ½ mile long. It lies in the extreme eastern part of the area known as Bush Prairie. The topography of the region is shown on the Chehalis and Tenino quadrangles, the latter quadrangle covering, on a larger scale, the northwest quarter of the former. The elevation of the peat is 140 feet above sea level. On the unpublished soil map of Thurston County (Ness et al.) the area is mapped as Greenwood peat.

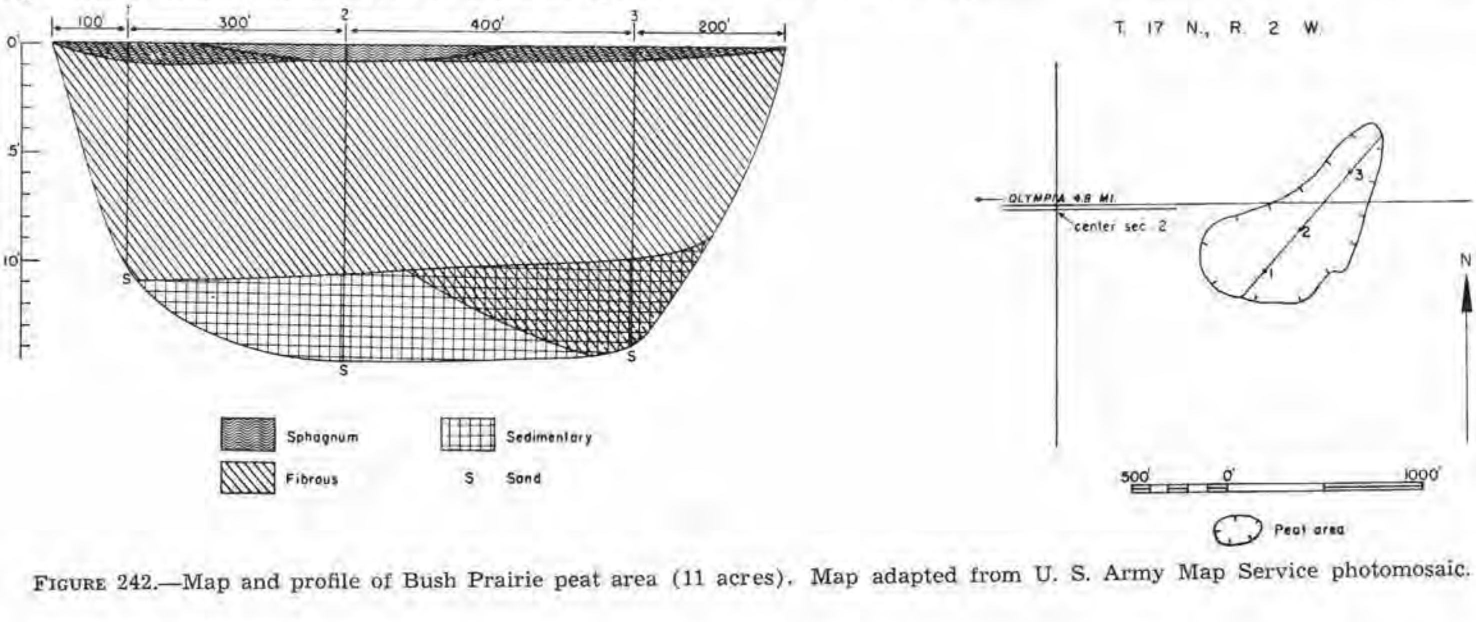


FIGURE 242.—Map and profile of Bush Prairie peat area (11 acres). Map adapted from U. S. Army Map Service photomosaic.

The vegetation along the line of the profile (1,000 feet long) comprises mainly Labrador tea, bog laurel, cranberry, and sedge, with *Sphagnum* growing among their stems. There are some hemlock and cedar trees as much as 1 foot in diameter and also a few Douglas firs.

The deposit consists mostly of fibrous peat, but there is some sphagnum at the surface and some sedimentary peat at the bottom. The fibrous peat is light brown to dark brown and is raw to decomposed. The sphagnum peat is light brown to dark brown and is mostly raw. The sedimentary peat is olive green and is compact at the bottom. The deposit rests on gray sand.

**Lake Susan peat area**

The Lake Susan peat area (10 acres) is in sec. 1, T. 17 N., R. 2 W. (map, fig. 243), about 4 miles south of Olympia. It surrounds Lake Susan and is near the north end of Munn Lake. A dead-end road extends to the west margin of the area. The peat lies in a depression in glacial drift at an elevation of 140 feet above sea level. The topography of the region is shown on the Chehalis quadrangle and also on the Tenino quadrangle, which covers the northwest quarter of the area covered by the Chehalis quadrangle. On the unpublished soil map of Thurston County (Ness et al.) the area is mapped as Greenwood peat.

The vegetation in the vicinity of the one hole bored in this peat consists of sedge and rush with some *Sphagnum*. There is a narrow border of hardhack around the area.

The hole shows pure fibrous peat except in the upper 2 feet and at the 6- to 7½-foot depth, where there is a mixture of fibrous peat and sedimentary peat. The fibrous peat is brown to dark brown, and most of it is disintegrated. Gray sand is present below the deposit.

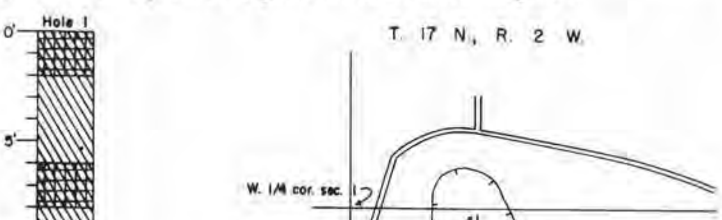


FIGURE 243.—Map and graphic log of a hole in Lake Susan peat area (10 acres). Map adapted from U. S. Army Map Service photomosaic.

**Kingslea Ranch peat area**

The Kingslea Rauch peat area (9 acres) is in sec. 35, T. 17 N., R. 1 E. (map, fig. 244), about 2 miles southwest of Yelm and near the Mountain View school. It lies in a depression in a terminal or recessional moraine (see Bretz, 1913). The topography of the region is shown on the Yelm quadrangle, and the elevation of the peat is about 375 feet above sea level. The deposit is mapped as Mukilteo peat on the unpublished soil map of Thurston County (Ness et al.). In 1950 the peat area was utilized as a hayfield.

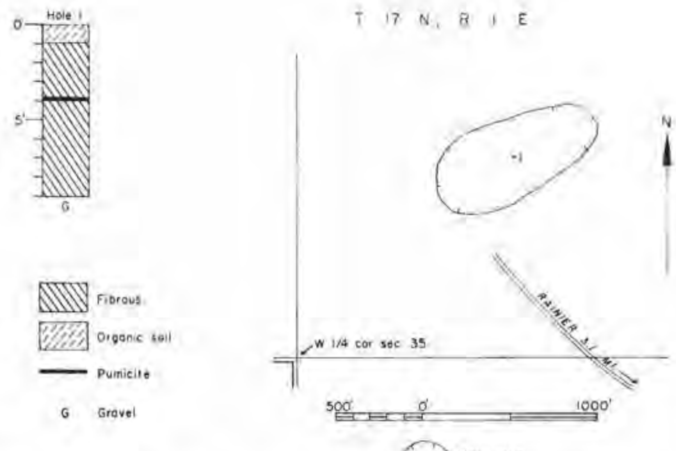


FIGURE 244.—Map and graphic log of a hole in Kingslea Ranch peat area (9 acres). Map adapted from U. S. Army Map Service photomosaic.

One hole near the center of the area (fig. 244) shows 1 foot of dark-brown peat soil and 8 feet of brown disintegrated fibrous peat that rests on gravel. A layer of brown pumicite at the 4-foot depth is ¾ inch thick.

**Grass Lake peat area**

The Grass Lake peat area (5 acres) is in secs. 8 and 17, T. 18 N., R. 2 W. (map, fig. 245), about 2 miles west of Olympia. It entirely surrounds the lake. The topography of the region is shown on the Olympia quadrangle, and

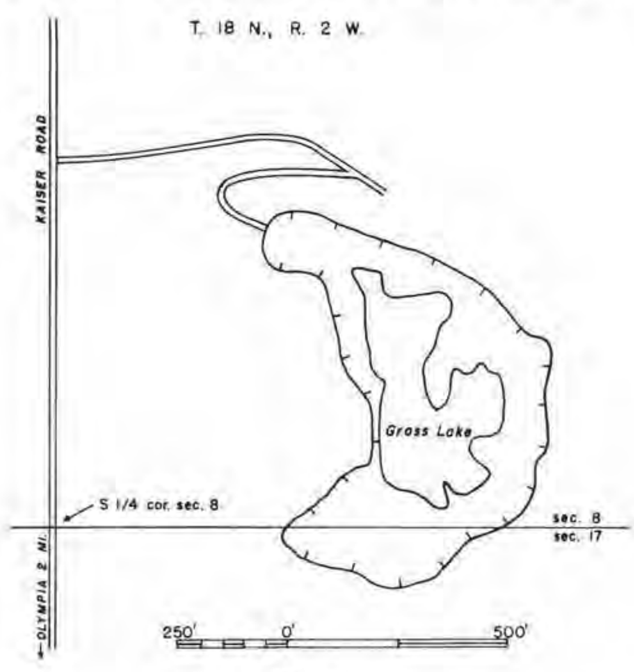


FIGURE 245.—Map of Grass Lake peat area (5 acres), adapted from field sketch by G. M. Valentine.

the elevation of the peat is 145 feet above sea level. On the unpublished soil map of Thurston County (Ness et al.) the deposit is mapped as Mukilteo peat.

The following information is from field notes recorded by G. M. Valentine, Division of Mines and Geology, in 1946. The vegetation consists of willows, sedges, reeds, water lilies, and mosses (not *Sphagnum*). The depth of the peat varies from 2 to 4 feet, the average being about 3 feet. The peat is composed of sedge, moss, leaves, and twigs. Its color is brown, and it is only moderately decomposed. Most of it rests on watery muck. The bottom of the lake is slimy muck. Some peat has been removed and used locally as a soil conditioner.

#### Chain Hill peat area

The Chain Hill peat area (4 acres) is in sec. 18, T. 16 N., R. 1 W., about 1½ miles north of Tenino. It is reached by a private road from U. S. Highway 99. It lies in a depression near the top of a low hill of glacial drift. A ditch in the eastern part of the area carries water to the south. On the unpublished soil map of Thurston County (Ness et al.) the area is mapped as Greenwood peat.

The vegetation includes Labrador tea, hardhack, salal, bracken fern, sedge, and *Sphagnum*. There are also some coniferous trees up to 20 feet or more in height. Sphagnum moss was removed and sold from 1939 through 1943 by L. B. Myers, who then owned the bog.

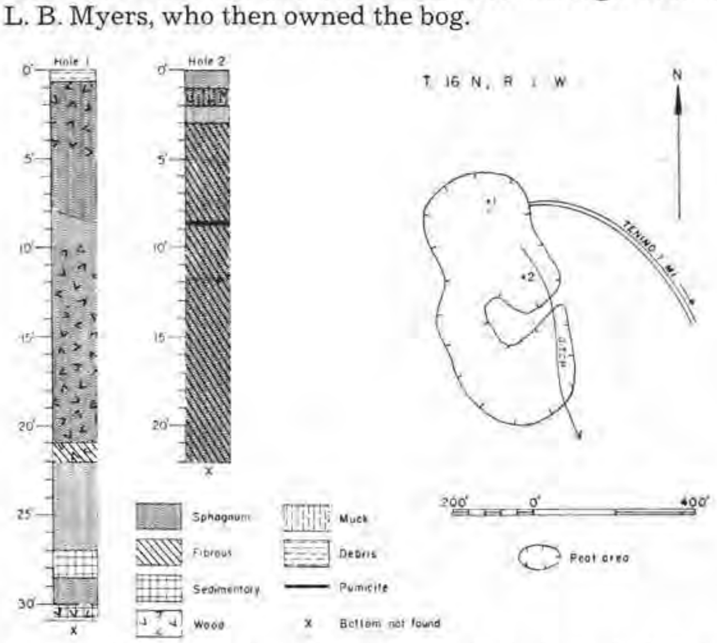


FIGURE 246.—Map and graphic logs of two holes in Chain Hill peat area (4 acres). Map adapted from field sketch by G. M. Valentine.

Two holes bored in this peat (fig. 246) failed to reach bottom, because the peat at the 31-foot depth in hole 1 is too compact to be penetrated with the peat borer, and the same condition exists at the 22-foot depth in hole 2. The large amount of sphagnum shown in hole 1 is remarkable. The upper 4 inches of the deposit is general debris, and the next 8 inches is pure sphagnum of good quality. From that depth to the 21-foot depth the sphagnum is somewhat disintegrated. At the 1- to 5-foot depth it is mixed with some wood, and the same is true from the 9- to the 21-foot depth. At the 5- to 9-foot depth it contains a few fibers of sedges or similar plants. Brown fibrous peat with some woody peat occurs at the 21- to 22-foot depth. The brown sphagnum at the 22- to 27-foot depth is disintegrated and somewhat watery. At the 29- to 30-foot depth it is dark brown and is disintegrated. The sedimentary peat is brown. Many logs are embedded in the peat at various depths.

Comparatively little pure sphagnum was found in hole 2, most of it being mixed with a considerable quantity of fibers of sedges or similar plants. White pumicite forms a layer 1 inch thick at the 8½-foot depth. Sand is mixed with the peat at the 21- to 22-foot depth.

Hansen (1947) made a boring in this peat for the purpose of getting fossil pollen for his work on postglacial forest succession, climate, and chronology in the Pacific Northwest. His sedimentary column is 13 meters (42 feet 7.6 inches) deep. He does not specify what kinds of peat or other materials were encountered except that volcanic ash (pumicite) was found at the 9½-meter (31-foot 2-inch) depth. He also bored a hole 38 feet deep in which he found blue clay at the bottom.

This bog could be utilized for the production of sphagnum, but much of this sphagnum contains some woody material and some fibrous peat. The area is small, however, and undoubtedly water would be encountered even at moderate depth.

### WHATCOM COUNTY DEPOSITS

#### Wiser Lake peat area

The Wiser Lake peat area (2,450 acres) is in sec. 36, T. 40 N., R. 2 E., secs. 1 and 2, T. 39 N., R. 2 E., secs. 29, 31, 32, 33, 34, 35, and 36, T. 40 N., R. 3 E., and secs. 2, 3, 4, 5, 6, 8, 9, 10, 11, 17, and 18, T. 39 N., R. 3 E. (map, fig. 247). The Guide Meridian Road (State Highway 1B), which extends due north from Bellingham, crosses Wiser Lake and the narrow strips of peat on its northern and southern shores about 10 miles north of Bellingham and 3½ miles southwest of Lynden.

The Wiser Lake peat comprises a large area in the shape of an irregular horseshoe opening toward the west, three smaller areas lying close to the northern boundary of the larger one, and one very small area lying between the two arms of the larger area. The northern arm of the main area begins about 1 mile southwest of Wiser Lake, extends irregularly east about 6 miles, then makes a sharp turn and extends about 5 miles in a southwesterly direction. The Wiser Lake peat area lies south of the Nooksack River, and the northwestern part of the main area is less than 1 mile from the river. Besides Wiser Lake, two other lakes (Fountain and Green) lie in the main area of the peat. A creek flows from the west end of Wiser Lake to the river. Tenmile Creek flows through part of the southern arm to the river, and Fourmile Creek flows from Green Lake through most of this arm to Tenmile Creek. Drainage ditches carry water from many parts of the area to these streams.

The peat area is in part on the flood plain of the Nooksack River but is mostly in glacial outwash and Recent alluvium left by shifting streams in latest glacial and postglacial times. The depressions in which the peat lies are very irregular in shape and depth. The topography of the region is shown on the Sumas 15-minute quadrangle, U. S. Geological Survey, and also on the Sumas and Lynden 7½-minute quadrangles, which cover the north half of the Sumas 15-minute quadrangle area. All of the peat lies at an elevation of less than 100 feet above sea level. The hard land surrounding the peat is relatively flat. On the soil map of Whatcom County (Poulson and Flannery 1953) the area is mapped as Rifle peat.

Ten profiles, all extending north and south, and three single holes were bored (map, fig. 247). Eight of the profiles and all the single holes are in the main area. One profile is in an area lying north of the main area and not connected with it (secs. 29, 32, and 33, T. 40 N., R. 3 E.) and one is in an isolated area lying northeast of the main area (secs. 35 and 36, T. 40 N., R. 3 E.). In all, 50 holes were bored in the Wiser Lake peat area, and the absence of peat in marginal areas previously mapped as peat was determined by digging.

Profile A (2,250 feet long) is on the line between secs. 1 and 2, T. 39 N., R. 2 E., a mile west of the Guide Meridian Road near the western end of the main peat area. Hole 1 is in an oatfield, hole 2 is in waste land, and the other holes are in swamp forest. A drainage ditch, in which water flows westward, crosses the profile 225 feet south of hole 1.

The profile (fig. 248) shows mostly muck and fibrous peat; but some sedimentary peat is present at the bottom of hole 2; a mixture of marl and sedimentary peat, at the bottom of hole 3; and some diatomite, at the bottom of hole 1. The muck is brown to black. At the bottom of hole 4 it is slimy. The fibrous peat is brown to dark brown and is decomposed. Some of it is moist and some is dry. The sedimentary peat is brown, and its mixture with marl

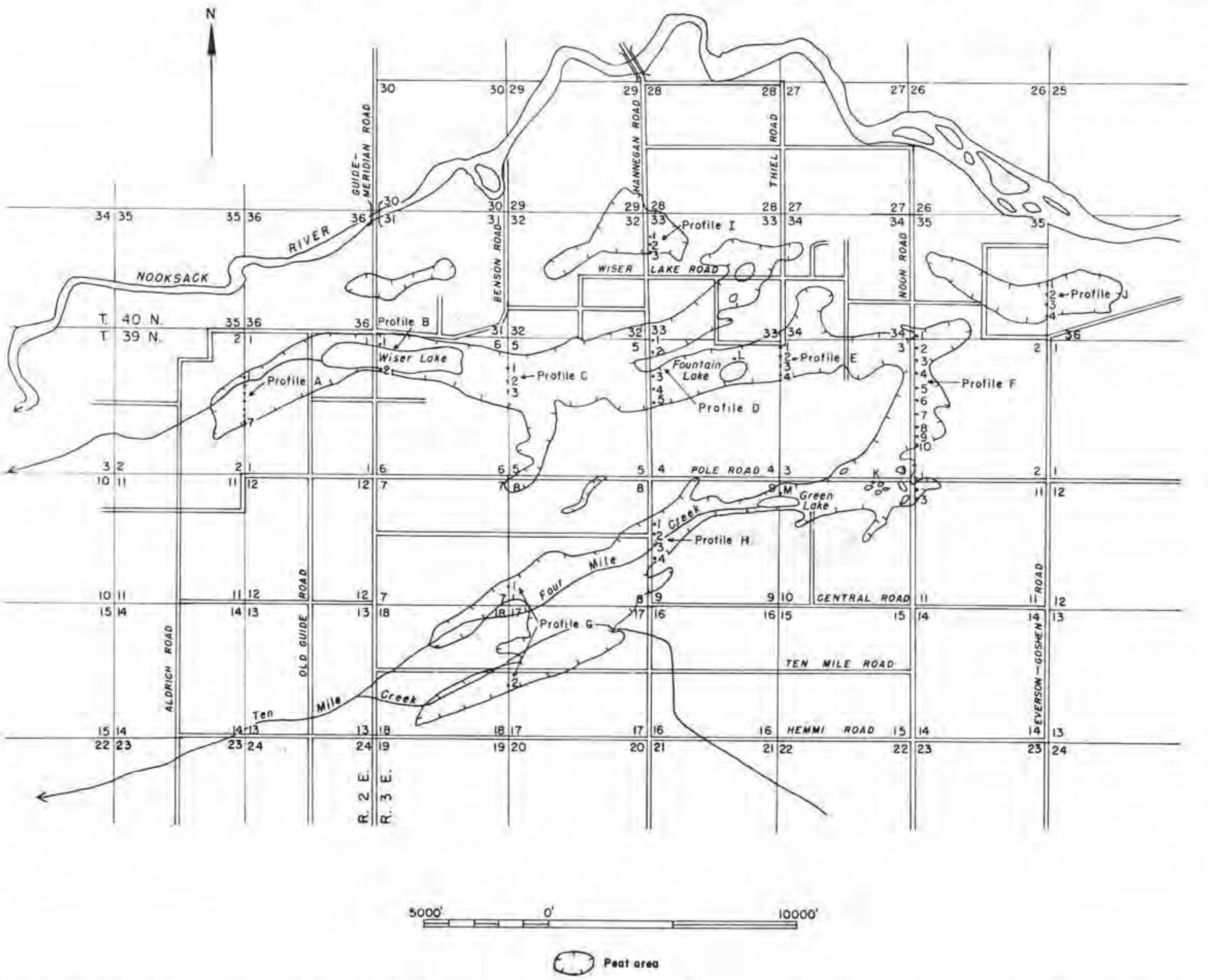


FIGURE 247.—Map of Wiser Lake peat area (2,450 acres), adapted from U. S. Department of Agriculture soil map of Whatcom County.

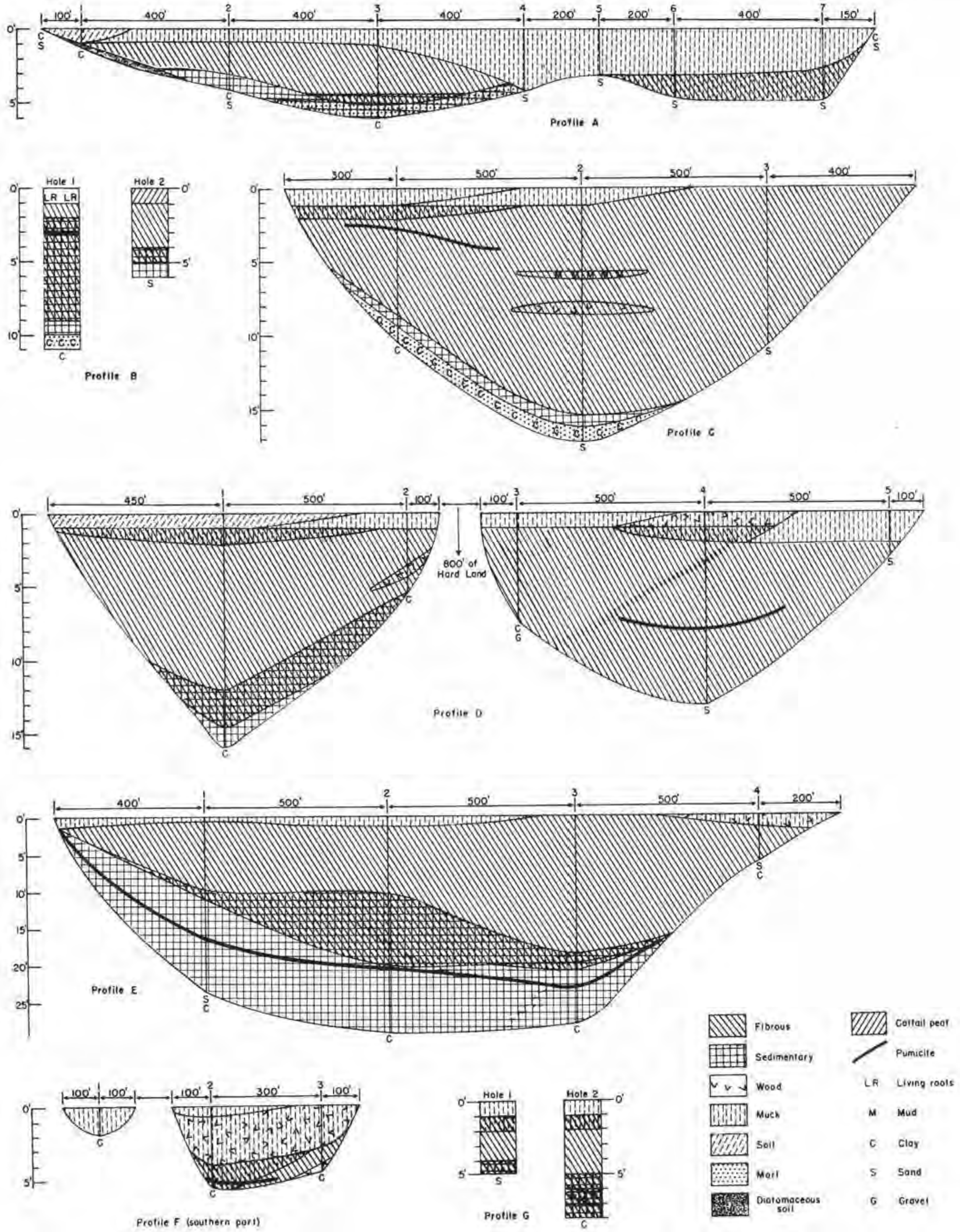


FIGURE 248.—Profiles A, B, C, D, E, F (southern part), and G, Wiser Lake peat area.

is light brown. The diatomite varies from white where it is pure to gray where it is mixed with organic matter.

Profile B consists of two holes that were bored just east of the Guide Meridian Road close to the west line of sec. 6, T. 39 N., R. 3 E. Hole 1 is on the north shore of Wiser Lake, and hole 2 is on the south shore. The peat extends 300 feet north from hole 1 and 100 feet south from hole 2. The lake is approximately 1,000 feet wide. Hole 1 (fig. 248) shows a mat of rhizomes and roots of cattails and tules at the surface. The 1-foot layer of brown fibrous peat under the mat is watery. Below this is a 7-foot layer of mixed fibrous and sedimentary peat. Below this mixture is a 1-foot layer of sedimentary peat, then a 1-foot layer of mixed marl and blue clay which rests on blue clay. Hole 2 shows a 1-foot layer of raw cattail peat under which is a 3-foot layer of dark olive-brown wet fibrous peat. Below this is a 1-foot layer of a mixture of fibrous and sedimentary peat. Below this mixture is a 1-foot layer of black muddy sedimentary peat which rests on dark-gray clay.

Profile C (1,700 feet long) is 1 mile east of the Guide Meridian Road. It is in line with the Benson Road and is between secs. 5 and 6, T. 39 N., R. 3 E. (map, fig. 247). Hole 1 is in a potato field, and holes 2 and 3 are in a swamp forest. The peat deposit ends in an oatfield 300 feet north of hole 1 and in a swamp forest 400 feet south of hole 3. There is a drainage ditch along the north side of the peat and another ditch 200 feet south of hole 1. Water flows westward in both ditches.

The profile (fig. 248) shows mostly dark-brown fibrous peat. There is some black muck and some black mucky soil at the surface, and a dark-brown mixture of fibrous peat and muck lies under the mucky soil in hole 1. The sedimentary peat near the bottom of holes 1 and 2 is olive brown. The mixture of marl and clay at the bottom of these holes is light gray. The clay at the bottom of hole 1 is blue, and the sand at the bottom of holes 2 and 3 is gray.

Profile D is 1 mile east of profile C. It extends along the east side of the Hannegan Road, which is between secs. 4 and 5, T. 39 N., R. 3 E. It consists of two parts. The northern part (1,050 feet long) is separated from the southern part (1,200 feet long) by 800 feet of hard land (fig. 248). The northern part shows mostly fibrous peat, but at the surface there is a 1-foot layer of soil in hole 1 and a 1-foot layer of muck in hole 2. A black mixture of muck and fibrous peat lies under the soil in hole 1. The fibrous peat is brown to olive brown and is disintegrated to decomposed. The sedimentary peat at the bottom of hole 1 is light brown. The underlying clay is nearly white.

The southern part of the profile shows mostly light-brown to brown fibrous peat, some of which is decomposed and some watery. The upper 1 foot in hole 3 is cultivated mucky soil, and in hole 4 the upper 1 foot is brown muck and wood with a black mixture of muck and fibrous peat under it. Yellow-brown pumicite forms a layer 1 inch thick in hole 4. The sand at the bottom of hole 4 is blue gray.

Profile E (2,100 feet long) is 1 mile east of profile D. It is in line with the Thiel Road and is on the line between secs. 3 and 4, T. 39 N., R. 3 E. (map, fig. 247). At a distance of 130 feet south of hole 1 the profile crosses a ditch in which water flows eastward. Hole 1 is in a pasture in an old swamp forest which is now completely cleared except for a few stumps. Holes 2 and 3 are in a swamp forest which has not been cleared. The trees are western birch, peat-bog birch, and willow, and there is a considerable amount of shrubby and herbaceous undergrowth.

The profile (fig. 248) shows mostly fibrous peat, sedimentary peat, and a mixture of the two. There is a 1-foot layer of muck at the surface in holes 1 and 2, and a 2-foot layer of a black mixture of muck and woody peat at hole 4. The fibrous peat is light brown to brown, and much of it is watery. It varies from disintegrated to decomposed. The sedimentary peat is brown. The white pumicite forms a layer ½ inch to 2 inches thick. The deposit rests on blue clay and sand.

Profile F is 1 mile east of profile E. It extends along the east side of the Noon Road, which is between secs. 2 and 3, T. 39 N., R. 3 E., close to the eastern end of the main peat area (map, fig. 247). The profile consists of two parts. The northern part (4,300 feet long, fig. 249) is separated from the southern part (800 feet long, fig. 248) by a ridge of hard land about 1,300 feet wide. The southern part is interrupted by 100 feet of hard land between holes 1 and 2. Most of the holes in both parts of the profile are in swamp forest or waste land, but hole 9 is in a hayfield.

Both parts of the profile show large amounts of woody peat. This indicates that swamp forest existed along the profile line during much of the long period of time which elapsed during the formation of the deposit. The marl at the bottom of hole 9 is light gray and is slightly alkaline (pH 7.5). The characteristics of the other materials in this profile do not differ essentially from those of the materials in profile E. The deposit, so far as shown by this profile, rests on clay, sand, and gravel.

Profile G (fig. 248) is near the western end of the south arm of the main area, in line with profile C and the Benson Road. It is between secs. 7 and 8, and 17 and 18, T. 39 N., R. 3 E. It consists of two holes. Hole 1 is about 1¼ miles south of the southern end of profile C, and hole 2 is about ½ mile south of hole 1. The peat extends 200 feet north and 150 feet south of hole 1, and extends 300 feet north and 300 feet south of hole 2. Hole 1 is in a hayfield, and there are fields of hay and oats near hole 2. Both holes are shallow, and the muck, fibrous peat, woody peat, and sedimentary peat in them do not differ essentially from the same kinds of material found in profile C. In hole 1 the peat rests on sand, and in hole 2 it rests on bluish-gray clay.

Profile H (1,750 feet long) is in the southern arm of the main area 1 mile east of profile G, along the east side of the Hannegan Road between secs. 8 and 9, T. 39 N., R. 3 E. It is in line with profiles D and I, and the north end of profile H is 4,880 feet south of the south end of profile D. The profile (fig. 249) shows muck, fibrous peat, woody peat, sedimentary peat, and marl. The muck is brown to dark brown to black. The fibrous peat is mostly watery. Its color is light brown to dark brown. The sedimentary peat is olive to dark green to brown. The color of the marl is gray to light green. The deposit rests on gray sand and blue clay.

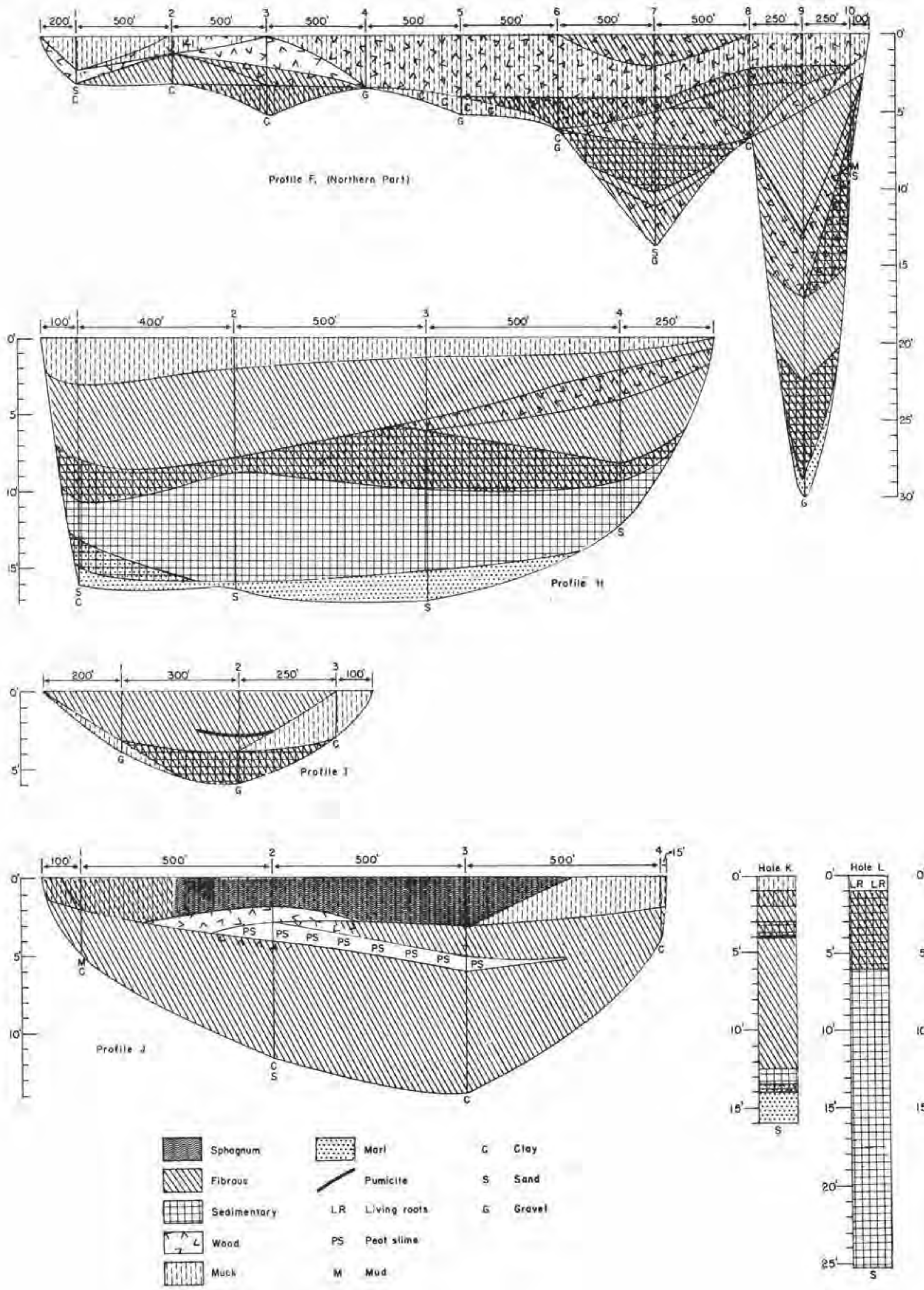


FIGURE 249.—Profiles F (northern part), H, I, and J, and holes K, L, and M, Wiser Lake peat area.

Profile I (850 feet long) is in an isolated area lying north of the main area. It extends along the Hannegan Road between secs. 32 and 33, T. 40 N., R. 3 E., in line with profiles D and H. It shows muck, fibrous peat, and mixed fibrous and sedimentary peat (fig. 249). The muck at the bottom of hole 1 is yellow and hard. The fibrous peat is brown, and some of it is very coarse. The deposit rests on clay and gravel.

Profile J (1,615 feet long) is in an isolated area lying close to but northeast of the main area. It is on the line between secs. 35 and 36, T. 40 N., R. 3 E., and is in line with the Everson-Goshen Road, 1 mile east of profile F. It is the easternmost profile in the Wiser Lake peat area and is 6 miles east of profile A.

The line of the profile extends across a pasture, a hayfield, and some waste land and is near a cornfield. The profile (fig. 249) shows muck, sphagnum peat, fibrous peat, woody peat, and peat slime. The muck is brown to black. The sphagnum peat is brown and disintegrated. The fibrous peat is brown, and some of it is decomposed. In spite of the presence of peat slime in the profile, some of the fibrous peat is dry. The deposit rests on clay and sand.

The single hole (hole K) on the south side of the Pole Road is on the bank of a drainage ditch at the north line of sec. 10, T. 39 N., R. 3 E., and is 0.4 mile west of hole 1 of the southern part of profile F (map, fig. 247). The single hole is much deeper than the hole in the profile and is more representative of the peat in that vicinity. It shows 14 feet of peat, under which is 2 feet of marl which rests on dark-gray sand (fig. 249). The marl is slightly acidic (pH 6.5), probably because of percolation of water from the peat above it. Marl is usually neutral or slightly alkaline, as is illustrated in hole 9 of profile F (pH 7.5). The layer of brown pumicite is ½ inch thick. The other materials are not essentially different from those in profile F.

The single hole (hole L) on the north shore of Fountain Lake is in sec. 4, T. 39 N., R. 3 E., a little less than half a mile west of hole 2 of profile E. It is in a quaking mat of vegetation, composed of living rhizomes and roots of cattails and other aquatic and semiaquatic plants, which extends 200 feet north from the lake shore. East of this mat is a sphagnum bog that is now less extensive than formerly because of clearing, burning, and draining. Efforts to bring the bog into use for crops or pasture have, however, been only partially successful. *Sphagnum* still grows vigorously in patches, but it has formed very little peat, the deepest found being 1 foot. Good sphagnum for making surgical dressings was obtained from this bog during World War I. Cotton grass is abundant. The shrubs are Labrador tea, bog laurel, and hardhack. The trees are lodgepole pine, peat-bog birch, and cascara.

This hole (fig. 249) shows a 5-foot layer of mixed fibrous and sedimentary peat under the mat of vegetation. Under this mixture is a 19-foot layer of sedimentary peat which rests on sand. The color of the sedimentary peat is olive to greenish to light brown. This hole is only 4½ feet shallower than hole 2 of profile E which is 0.4 mile east of it, and both holes have a thick layer of sedimentary peat at the bottom. It seems probable that peat 25 feet or more in depth is continuous between the two holes.

The single hole (hole M) on the north shore of Green Lake is in the south arm of the main area, on the line between secs. 9 and 10, T. 39 N., R. 3 E. It is in line with profile E and in line with the Thiel Road. The hole is in a mat consisting of the rhizomes and/or roots of cattails, purple marshlock (marsh fivefinger), tufted moneywort, and willow. Yellow water lily grows in the mat and also in the margin of the lake. The mat extends 400 feet north of this margin. The mat is now 4 feet lower than it has been, because the lake was lowered that much in 1947 by drainage through a ditch to Tenmile Creek.

The mat (fig. 249) is 1 foot thick, and under it is a 2-foot layer of watery fibrous peat. Under this is a 2-foot layer of dark-brown sedimentary peat, then a 1-foot layer of an olive-brown mixture of fibrous peat and sedimentary peat. Under this is a 7-foot layer of sedimentary peat, the color of which varies from olive to dark olive to brown to dark green, then there is a 2-foot layer of a mixture of sedimentary peat and marl which rests on blue-gray sand.

### Custer peat area

The Custer peat area (1,636 acres) is in secs. 25, 26, and 36, T. 40 N., R. 1 E., and secs. 27, 28, 29, 30, 31, 32, 33, and 34, T. 40 N., R. 2. E. It consists of two parts, both of which are north of the Nooksack River (map, fig. 250). The northern part is much the larger one. Its extreme western end is about ½ mile south of Custer, and it extends irregularly eastward about 5 miles. The smaller part lies ½ to 1 mile south of the eastern portion of the larger one. It is about 2 miles long, and at one point it is only about 500 feet from the Nooksack River. Both parts are in an area of sand, gravel, and clay recessional outwash of the Vashon glaciation, and the peat lies in irregular depressions left by melt-water streams.

The topography of the region is shown on the Blaine 15-minute quadrangle, and most of the peat is within the boundaries of the Bertrand Creek 7½-minute quadrangle, which covers the northeast quarter of the Blaine quadrangle. The peat is less than 75 feet in elevation above sea level, and the land around it is relatively flat. On the soil map of Whatcom County (Poulson and Flannery, 1953) the area is mapped as Rifle peat.

Profile A (4,700 feet long) extends from west to east along the south side of the Willeys Road. It is 40 feet south of the north line of sec. 36, T. 40 N., R. 1 E., and sec. 31, T. 40 N., R. 2 E. Holes 1 and 2 are in pasture land, hole 5 is in a hayfield, and holes 3, 4, and 6 are in wet brushy waste land.

The profile (fig. 250) shows fibrous peat, woody peat, and sedimentary peat, with some sphagnum in the upper part of hole 6 and some muck at the bottom of hole 7. The fibrous peat is brown to dark brown and is raw to disintegrated. Most of the woody peat consists of small particles of rotted wood, but twigs are present in some of it in hole 4, and some logs were encountered in that hole. The sedimentary peat has an olive color. Brown pumicite forms a layer 1 inch thick in holes 1, 4, and 6. It may be present in the other holes but so scattered in the peat that it escaped observation during the field work.

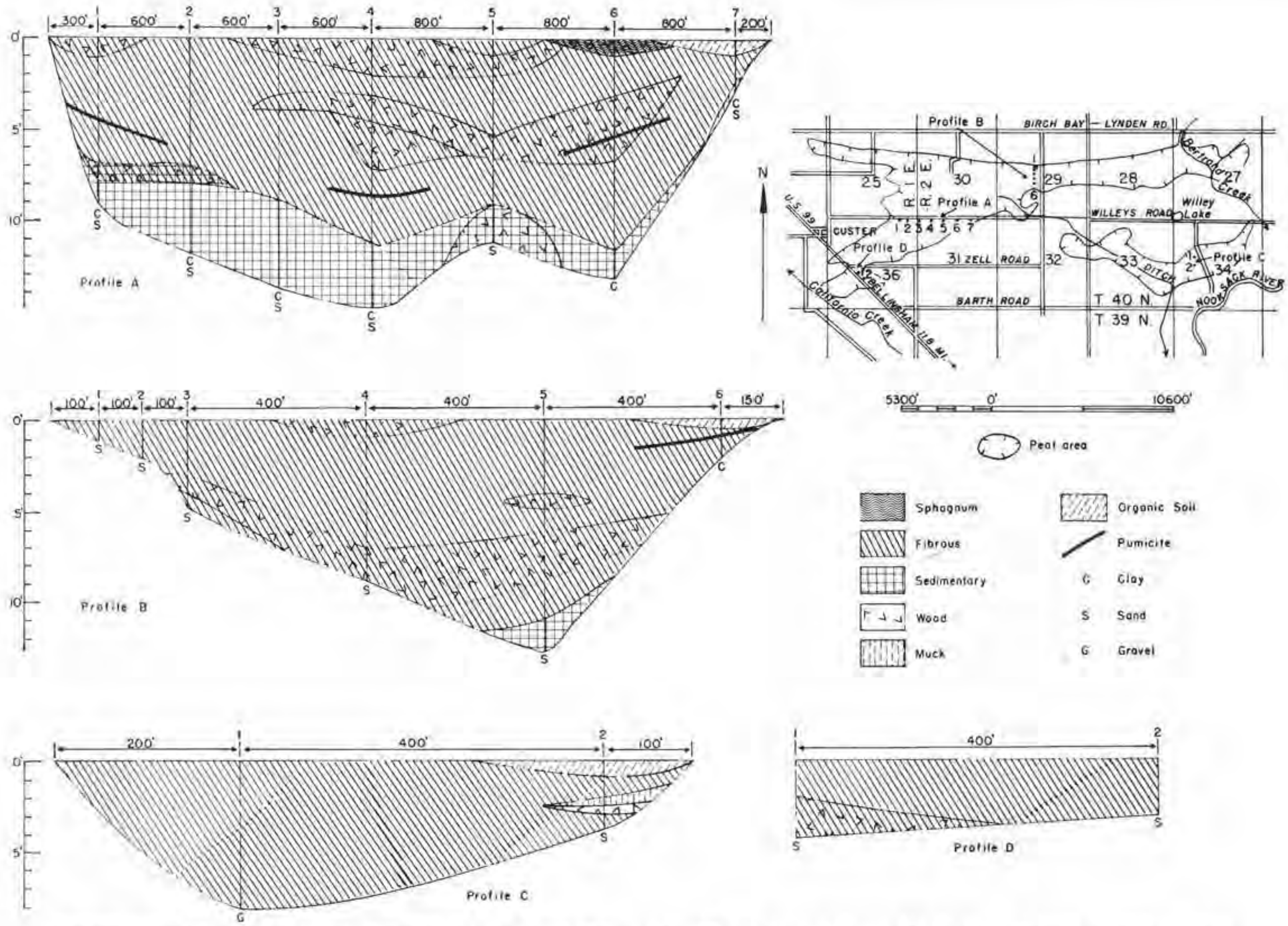


FIGURE 250.—Map and profiles of Custer peat area (1,636 acres). Map adapted from U. S. Department of Agriculture soil map of Whatcom County.

The peat at the 1-foot depth is strongly acidic (pH 4.2 to 4.8) except at hole 5, where it is weakly acidic (pH 6.0). At depths of 8 to 13 feet in holes 1 to 6, inclusive, it is weakly acidic (pH 6.0 to 6.5). The deposit rests on blue clay and gray sand except at hole 7, where the mixture of clay and sand under the muck is light brown.

Profile B (1,650 feet long) extends from north to south along the west side of the Woodland Road, which is on the center line of sec. 29, T. 40 N., R. 2 E. Holes 3 and 4 are in an oatfield, and holes 2, 5, and 6 are in waste land.

The profile (fig. 250) shows mostly fibrous peat, but there is some woody peat mixed with it, and at the bottom of hole 5 there is some sedimentary peat. The fibrous peat is brown to dark brown, and some of it is coarse. The sedimentary peat is olive brown. The deposit on the line of this profile rests mostly on gray sand, but gray clay occurs at the bottom of hole 6.

Profile C (700 feet long) is about ¼ mile east of the west line of sec. 34, T. 40 N., R. 2 E. (map, fig. 250). Hole 2 is about 2,500 feet north of the Nooksack River, and hole 1 is about the same distance southeast of Willey Lake. A dead-end road passes near the line of the profile.

The holes were bored in a pasture in which some sedges and reeds grow with the pasture grasses. The holes show fibrous peat, woody peat, sedimentary peat, and organic soil. The fibrous peat is brown to dark brown and is mostly disintegrated to decomposed. It is rather strongly acidic (pH 4.8). The deposit in the line of the profile rests on sand and gravel.

Profile D (400 feet long) is in sec. 36, T. 40 N., R. 1 E., along the east side of U. S. Highway 99 in the extreme southwestern part of the area .In August 1950, six inches of water stood at hole 1, the vegetation being composed of swamp and semiaquatic plants. The profile shows shallow brown to dark-brown fibrous peat, with which twigs are mixed in the lower part of hole 1 (fig. 250). The peat is rather weakly acidic (pH 5.2), and it rests on gray sand.

Great changes have occurred in the Custer peat area during the past 30 years. Old records indicate that in 1922 there was an extensive sphagnum bog about 1½ miles east of Custer and that east of this bog there were extensive swampy and brushy areas and swamp forest. Some areas of natural bog vegetation persisted until 1936.

Rigg investigated the region in 1922 and recorded field notes on natural vegetation, the encroachment of the bog on the swamp, evidences of burning, the digging of a drainage ditch, and the construction of roads. He made nine borings. Dachnowski-Stokes (1936) published notes on natural vegetation, the general course of the development of the bogs, the swamp and the swamp forest, and evidences of burning. He also made borings.

Rigg's records list the usual sphagnum-bog flora of herbaceous plants, shrubs, and trees. Some of the bog was in an early stage of development, characterized by a mixture of swamp and bog species such as skunk cabbage, purple marshlocks, herbaceous dogwood, buckbean, sundew, and orchids. Some of it was in later stages in which bog shrubs such as Labrador tea, bog laurel, and cranberry vines were abundant. Some of it had gone on to a fairly mature stage in which coniferous trees, including hemlock, cedar, lodgepole pine, and white pine, were abundant, and deciduous trees, including alder and western birch, were common. Living *Sphagnum* was abundant in the herb and shrub stages of the bog, and it was encroaching rapidly on the swamp. In some places it had formed peat 1 foot thick, and in others none at all. The brushy area was characterized by hardhack, black twinberry, and salal, and small crab apple trees were common in it.

Recent burning was indicated by ashes and charred remains of shrubs and herbaceous plants and the blackened trunks of dead trees still standing. The large drainage ditch was new and was carrying a considerable amount of water. Roads were few, and exploration had to be made mostly on foot. The borings showed 6 to 22 feet of peat resting on blue clay and sand.

Dachnowski-Stokes (1936) mentions that the Custer peat deposit occupies a broad depression in the boundary of the Nooksack River drainage basin and that plants have hindered drainage and thus probably have been the principal factor in the development of the peat area. His lists of plants are, in the main, in accord with Rigg's lists. He notes that fires have recurred frequently. In his borings he found 2 feet of sphagnum peat, 11 feet of fibrous peat, 2 feet of hypnum peat, and 2½ feet of sedimentary peat resting on blue clay.

The transformation of this peat area from the natural state described above to the stages in which much of it is utilized for crops and pasturage has been extensive but not complete. A considerable area of waste land still remains. Some peat has been removed for local use.

### Northwood peat area

The Northwood peat area (1,230 acres) is in secs. 32, 33, and 34, T. 41 N., R. 3 E., and secs. 3, 4, 5, 7, 8, and 9, T. 40 N., R. 3 E. (map, fig. 251). Its southern border is about 2 miles north of Lynden, and its extreme northern border is about ½ mile from the Canadian border. It is crossed by the Benson, Depot, Bender, Assink, and Pangborn Roads. Fishtrap Creek flows southwestward across the eastern part of the area. The deposit is in an area of sand, gravel, silt, and clay; these are recessional outwash sediments of the Vashon glaciation, and the peat lies in a large shallow depression left by a late-glacial stream.

The topography of the region is shown on the Sumas 15-minute quadrangle and also on the Lynden 7½-minute quadrangle, which covers the northwest quarter of the Sumas map. All of the peat lies at an elevation of less than 140 feet above sea level. The surface slopes gently from 140 feet in elevation at the north to 110 feet at the south, and the surrounding land has about the same slope. On the soil map of Whatcom County (Poulson and Flannery, 1953) the area is mapped as Rifle peat.

Profile A (6,050 feet long) crosses the area from south to north on the west side of the Bender Road, which is on the line between secs. 4 and 5, T. 40 N., R. 3 E., and secs. 32 and 33, T. 41 N., R. 3 E. Hole 1 is in a pasture, and there

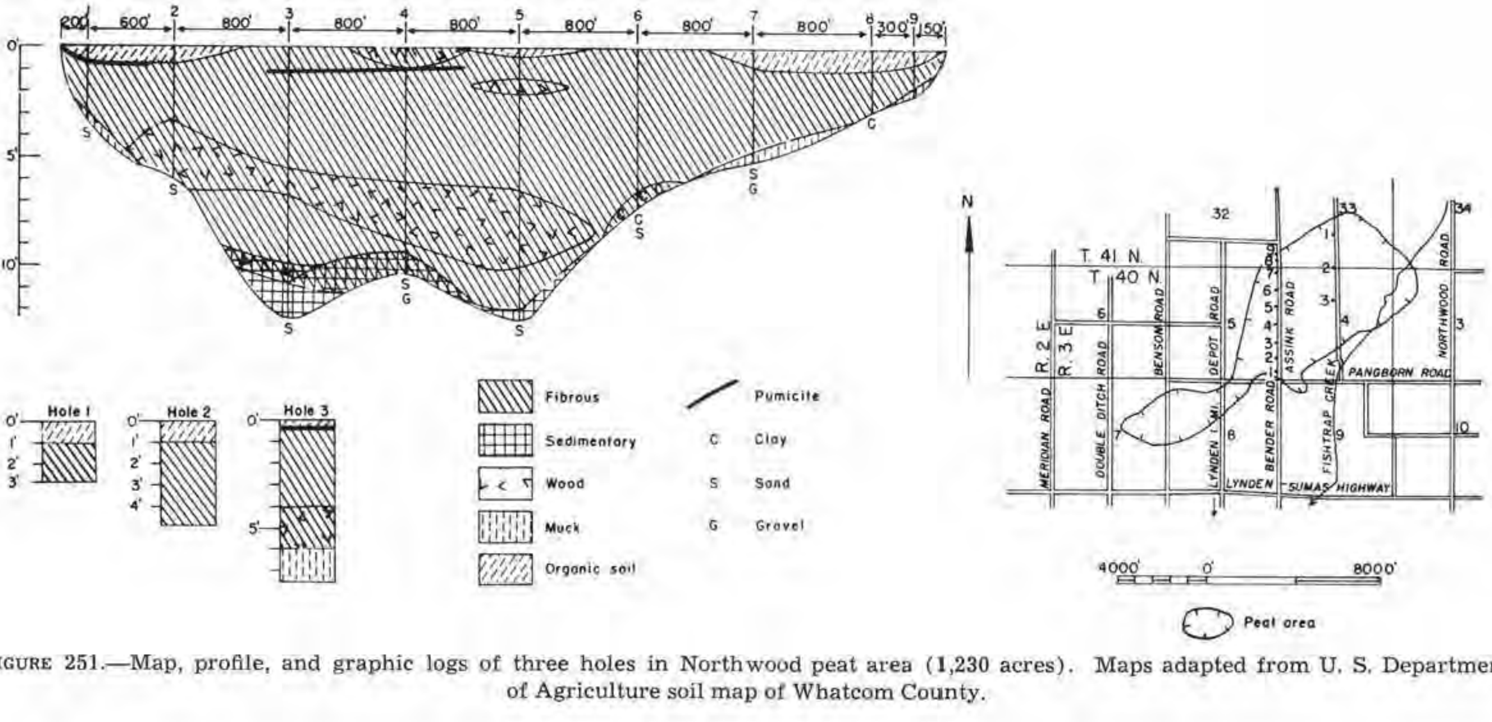


FIGURE 251.—Map, profile, and graphic logs of three holes in Northwood peat area (1,230 acres). Maps adapted from U. S. Department of Agriculture soil map of Whatcom County.

is waste land nearby. Hole 2 is in waste land covered by hardhack, willows, and grass. There is a pasture on the east side of the road opposite this hole. Hole 3 is in waste land covered by hardhack, willows, alder, and weeds. Hole 4 is in a pasture, and there is a hayfield and also an oatfield nearby. Hole 5 is in a potato field. Hole 6 is in a pasture, on the borders of which willows and hardhack grow. Holes 7, 8, and 9 are in hayfields.

The deposit (fig. 251) consists mostly of fibrous peat and its mixtures with woody peat. The amount of sedimentary peat and its mixtures with fibrous peat and woody peat is small. The layer of muck at the bottom of holes 1, 7, and 9 is thin. A mixture of fibrous peat and clay occurs at the bottom of hole 6. Organic soil forms a surface layer in holes 1, 2, 5, 7, 8, and 9. The fibrous peat is brown to dark brown and is raw to disintegrated. The color of the sedimentary peat is olive. The muck in hole 9 is gray. The pumicite in holes 1, 3, and 4 is brown. The peat from the surface to the 2-foot depth is strongly acidic (pH 4.3 to 4.5), but at greater depths it is weakly acidic (pH 5.8 to 6.5). The water in a ditch near hole 8 is weakly acidic (pH 5.8). The deposit rests on gray sand, gravel, and clay.

Profile B consists of three holes, 1,500 feet apart, on the north-south center line of sec. 33, T. 41 N., R. 3 E., and sec. 4, T. 40 N., R. 3 E. (map, fig. 251). Hole 1 is in a hayfield, and holes 2 and 3 are in potato fields. They show organic soil, fibrous peat, woody peat, and muck resting on gray clay and sand. These materials are not essentially different from those found in profile A.

It seems evident that a considerable amount of peat was burned in the more-or-less-successful efforts to bring the peat in this area into agricultural use and that the remaining peat has shrunk considerably as it dried, owing to clearing and drainage.

### Pangborn Lake peat area

The Pangborn Lake peat area (430 acres) is in secs. 1 and 2, T. 40 N., R. 3 E., and sec. 6, T. 40 N., R. 4 E., about 4 miles northeast of Lynden and about the same distance southwest of Sumas. Its northern boundary is less than 1 mile from the Canadian border. The topography of the region is shown on the Sumas quadrangle. The elevation of the peat is 130 feet above sea level, and the surrounding area is nearly flat but slopes very gently to the south. The peat and the lake lie in a depression in recessional outwash of the Vashon glaciation. On the soil map of Whatcom County (Poulson and Flannery, 1953) the area is mapped as Rifle peat.

The peat area is drained by a ditch dug in 1947 from the east end of the lake to Johnson Creek, a tributary to

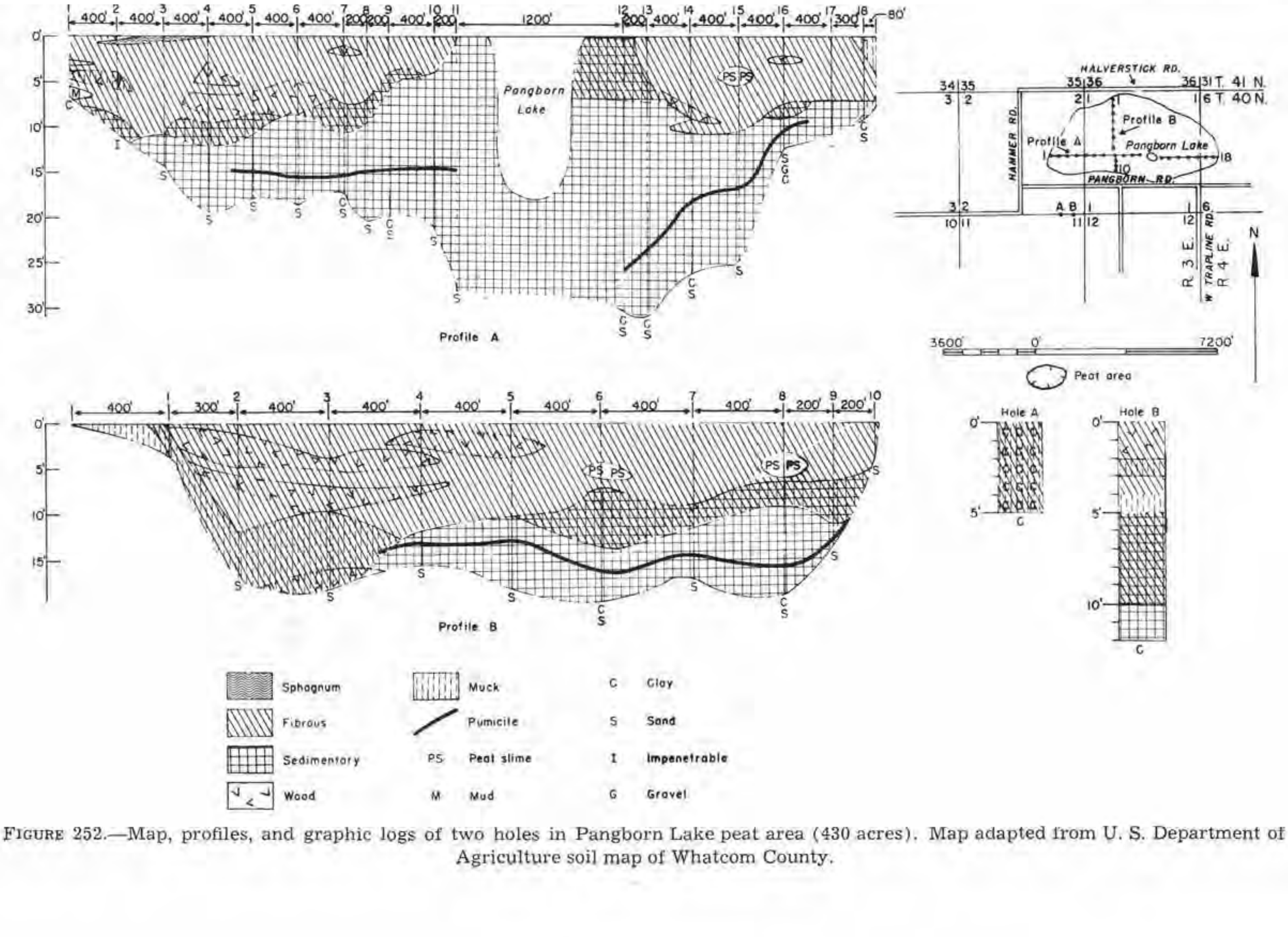


FIGURE 252.—Map, profiles, and graphic logs of two holes in Pangborn Lake peat area (430 acres). Map adapted from U. S. Department of Agriculture soil map of Whatcom County.

the Fraser River in Canada. The peat surrounds the lake, the level of which was lowered a few feet by the ditch. The engineering of the ditch and supervision of the work were done by the U. S. Soil Conservation Service. Half of the expense of the ditch was paid by the farmers who were benefited by the drainage, and half by the Washington State Department of Conservation and Development, Division of Flood Control. An earlier (1915 or 1916) attempt to drain the lake failed, and in 1918 the lake returned to its original level and remained so until 1947.

Profile A (6,800 feet long) extends from west to east and crosses the lake, which at present is much smaller than it was prior to the drainage (map, fig. 252); its present width is estimated at 500 or 600 feet. For a distance of perhaps 300 feet the peat on both sides of the lake on the line of the profile is covered by a quaking mat consisting of rhizomes and roots of swamp plants. The mat is not firm enough to support the weight of a man. The transition from the mat to a more firm surface toward the east and west is gradual.

Conditions at the east end of the lake were recorded by Rigg on September 22, 1922. A ditch extended from the east end of the lake to a creek which flowed eastward. No current could be detected in the ditch, but the plants growing in it were bent toward the east, indicating that water did flow when the level of the lake was higher.

The surface of the area inspected was a mat of vegetation on which were a sphagnum bog about 4 acres in area, a cattail swamp of about the same size, and a pasture which was much larger. In the bog and the swamp the mat was wet and soft but was firm enough to support the weight of a man. In the pasture it was dry and was firm enough to support the weight of grazing horses. Borings in the bog and the pasture showed soft fibrous peat down to a depth of 22 feet. Deeper boring was not possible with the equipment available.

The borings in profile A were made (June 1949) only two years after the lowering of the lake, and the work of clearing the waste land along the ditches and transforming it to agricultural land was still going on. There were pastures and oatfields near holes 2 and 3, and corn, potatoes, carrots, and beets were growing near holes 15 and 17. As indicated in figure 252, the profile is not complete at either end. Probably peat and muck extend a few hundred feet west of hole 1 and east of hole 18.

The profile shows mostly sedimentary peat in the deeper part near the lake and mostly fibrous peat in the shallower parts near the borders of the area. Some woody peat is mixed with fibrous peat, and there is also some peat slime. The sedimentary peat is mostly olive brown, but in some places it varies to light brown, dark brown, yellowish, and black. Some of it is watery. The fibrous peat is mostly brown, but some of it is dark brown to almost black. Some of it is coarse and raw, and very little of it is disintegrated. Much of it is watery. The half-inch layer of pumicite is white to grayish white. On the line of the profile the deposit rests on blue clay and sand, which in holes 16 and 17 is mixed with gravel.

Profile B (3,500 feet long) extends from north to south in the west half of sec. 1, T. 40 N., R. 4 E. All of the profile north of the point where it crosses profile A is along a


FIGURE 253.—Pangborn Lake. *(a)* West end of lake before drainage. *(b)* Same view after drainage. *(c)* East end of lake after drainage. U. S. Department of Agriculture Soil Conservation Service photos.

drainage ditch. The northern part of the profile is in a dense forest of cedar, western birch, alder, cascara, and hemlock, with an undergrowth of shrubs and herbaceous species. Farther south is a large new clearing in which crops have been planted. The soil is dry and powdery, and the crops (buckwheat and strawberries) are not doing well. South of this clearing is a thicket of willows and black twinberry. The south 400 feet of the profile is in an old sphagnum bog. The bog has been burned, but some patches of living *Sphagnum* still remain and are spreading. This *Sphagnum* is grayish white, as distinguished from reddish-brown and green colors which are more common in *Sphagnum* in the state of Washington. Labrador tea, bog laurel, cranberry, and sundew survive in places where the fire did not reach them, and hardhack is abundant.

The profile (fig. 252) shows fibrous peat, sedimentary peat, woody peat, muck, and pumicite. The characteristics of these are not essentially different from those of the materials in profile A. On the line of the profile the deposit rests on blue clay and sand.

The utilization of the peat in the Pangborn Lake area so far has been for pasturage and the growing of crops, but the removal of peat for marketing or for local use merits consideration. The large size of the area and the great depth of the peat are favorable factors. Peat could be removed easily from the shallower parts near the margin, but floating equipment probably would be necessary in removing peat from the deeper, wetter parts of the area. The white *Sphagnum* at the south side of the area has some commercial value, but the quantity available now is small, and the market for it is limited. Much of it has been destroyed by burning, but if it is left undisturbed the quantity will increase.

There are small areas of shallow peat and muck in secs. 1, 2, 11, and 12, T. 40 N., R. 3 E., about 1 mile south of the large area described above. Profile C (400 feet long) extends along a drainage ditch in waste land on the south line of the SE¼SE¼ sec. 2, T. 40 N., R. 3 E. Hole A (fig. 252) shows 5 feet of irregularly alternating layers of fibrous peat, muck, and clay. Hole B shows 12 feet of fibrous peat, woody peat, muck, and sedimentary peat. The fibrous peat is brown and coarse, the muck is black, and the sedimentary peat is olive brown. The deposit, at both holes, rests on blue clay.

This profile is in the northern part of the southern arm (secs. 11 and 12) of the large area of peat as shown on the soil map of Whatcom County (Poulson and Flannery, 1953), but the evidence revealed by digging in the area and inquiry among farmers indicates that the amount of peat in the area now is very small. How much peat was burned in preparing the land for agricultural use and how much the volume of the peat and muck may have decreased by shrinkage as the result of drainage are not known. Most of the area is now utilized for crops or pasturage.

#### Boundary-Meridian peat area

The Boundary-Meridian peat area (420 acres) is in secs. 35 and 36, T. 41 N., R. 2 E., and sec. 31, T. 41 N., R. 3 E. (map, fig. 254). It extends to the Canadian border and on into Canada. There are five "islands" of hard land in the American part of the area; its eastern end is about 4 miles north of Lynden. The topography of the

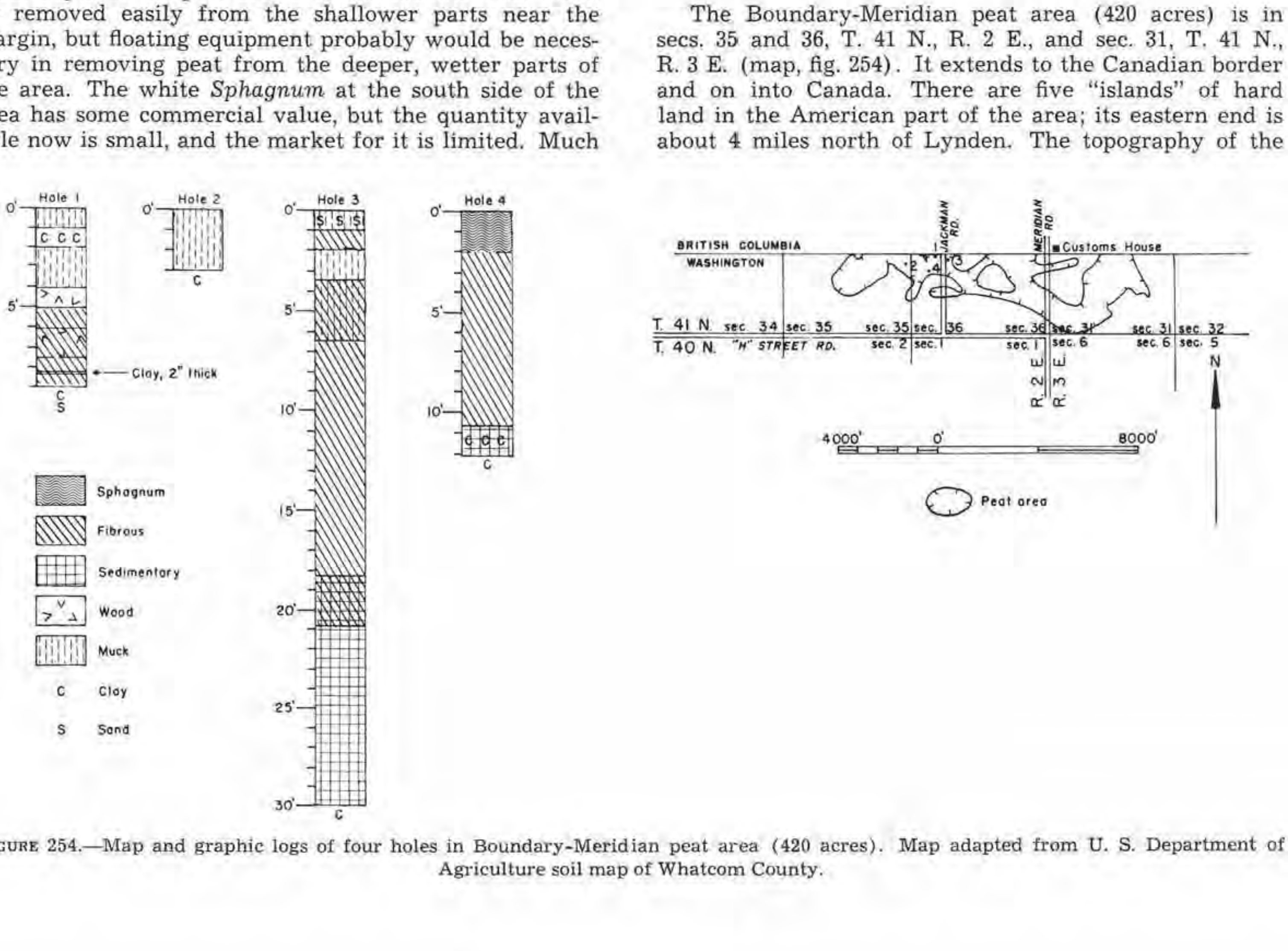


FIGURE 254.—Map and graphic logs of four holes in Boundary-Meridian peat area (420 acres). Map adapted from U. S. Department of Agriculture soil map of Whatcom County.

region is shown partly on the Sumas quadrangle and partly on the Blaine quadrangle. The elevation of the peat is 120 to 140 feet above sea level. The surrounding region is nearly flat but slopes very gently to the south. The peat lies in an area of glacial drift. On the soil map of Whatcom County (Poulson and Flannery, 1953) the peat area is mapped as Rifle peat.

Four separate holes were bored. Hole 1 is on the bank of an east-west drainage ditch, hole 2 is in a clearing in a swamp forest of birch and alder, hole 3 is on the east side of Jackman Road, and hole 4 is in an area of about 10 acres of sphagnum peat on the farm of Marius De Boer. In 1949 Mr. De Boer was selling sphagnum, which the purchasers removed from the bog. This is one of the few places in Whatcom County where living *Sphagnum* still remains. Others are Mosquito Lake, Pangborn Lake, Fountain Lake, and Lake Louise, and it is possible that there are other small remnants of sphagnum bogs.

The materials found in one or more of the four holes (fig. 254) are fibrous peat, sphagnum peat, muck, woody peat, sedimentary peat, and clay. The fibrous peat is mostly brown. Some of it is watery. The sphagnum peat is brown and is raw and pure. The muck is brown to black. The sedimentary peat is olive colored and compact. The clay at the bottom of the holes is blue.

It seems probable that considerable quantities of peat have been burned in preparing land in this area for agricultural use and that an appreciable amount of shrinkage occurred in what was left, due to drying when the area was drained.

#### Fazon Lake peat area

The Fazon Lake peat area (186 acres) is in sec. 13, T. 39 N., R. 3 E., about 9 miles northeast of Bellingham and about 6 miles southeast of Lynden. It surrounds the lake (map, fig. 255). The Hemmi Road crosses the southern part of the area, and the northern part is accessible from the Central Road. The Everson-Goshen Road passes about 800 feet west of the extreme western margin of the peat.

The topography of the region is shown on the Sumas and Lawrence quadrangles, the Lawrence covering the southeast quarter of the Sumas 15-minute quadrangle. The elevation of the lake is 128 feet above sea level. The lake and the peat lie in a depression in glacial drift, and the surrounding region is relatively flat. On the soil map of Whatcom County (Poulson and Flannery, 1953) the area is mapped as Rifle peat.

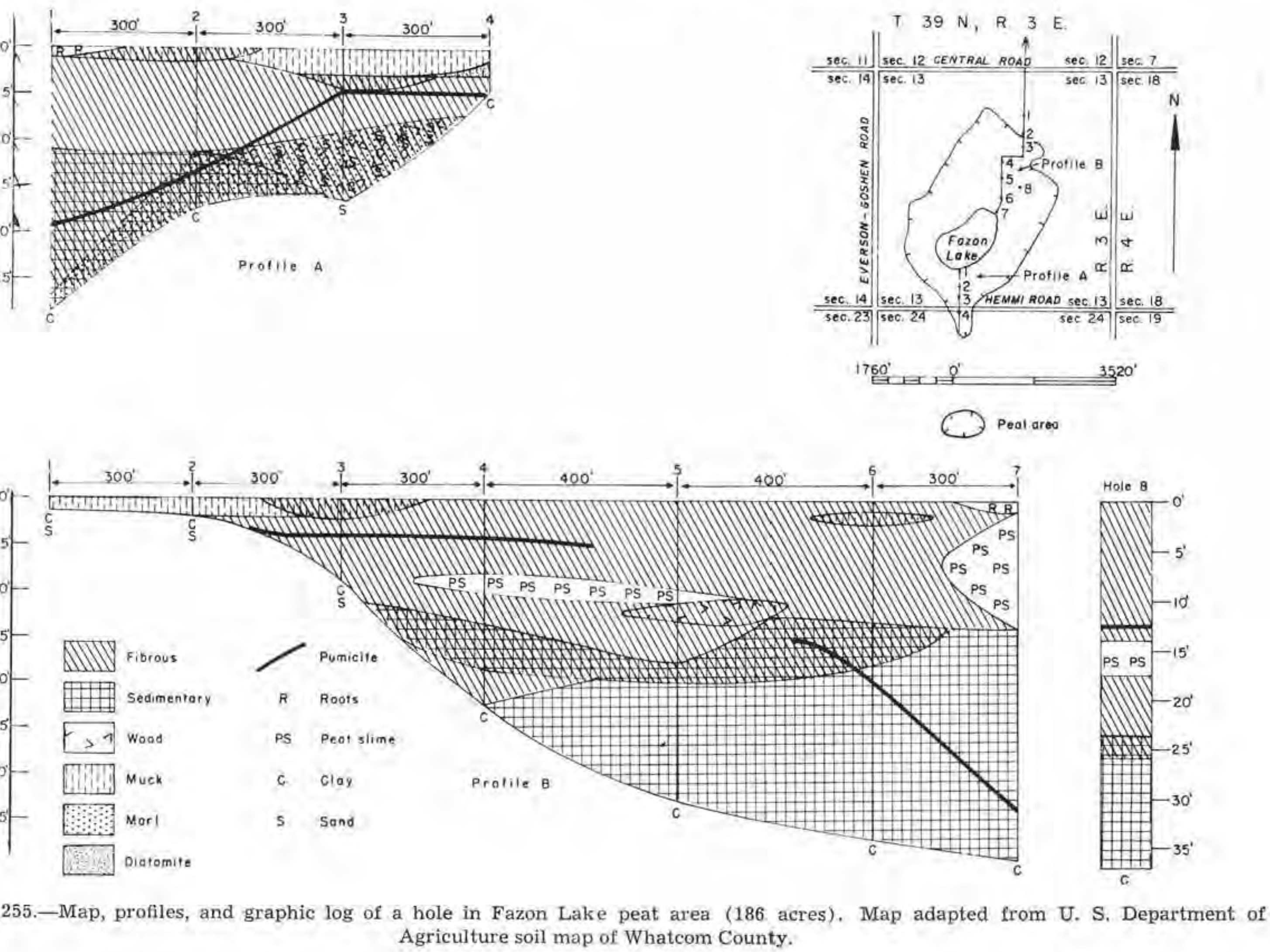


FIGURE 255.—Map, profiles, and graphic log of a hole in Fazon Lake peat area (186 acres). Map adapted from U. S. Department of Agriculture soil map of Whatcom County.

Profile A (900 feet long) extends south from the mat of rhizomes and roots at the south shore of the lake through waste land, pasture land, a hayfield near a blueberry field, and ends in a grainfield. The profile (fig. 255) shows fibrous peat, muck, sedimentary peat, sand, clay, marl, diatomite, and pumicite. The fibrous peat is brown to dark brown, and some of it consists of very fine fibers. In holes 1 and 2 it is watery. The muck is brown to black. In hole 2 muck and fibrous peat occur in alternating layers. The sedimentary peat occurs only in dark-brown mixtures with fibrous peat. Marsh gas (methane) is present at the bottom of hole 4. The color of the diatomite is whitish tan. The marl mixed with fibrous peat in holes 1 and 2 is white. Small gastropod (snail) and pelecypod (mussel) shells were found with the marl in hole 1. Pumicite is present in holes 1, 2, and 3. Soft blue clay lies under the peat in holes 1, 2, and 4, and dark-gray muddy sand in hole 3.

Profile B (2,000 feet long) extends from the mucky area at the north to the mat of living rhizomes and roots of swamp plants at the north shore of the lake. Holes 1, 2, and 3 are in line. Holes 4, 5, and 6 are in a line 490 feet west of the line of holes 1, 2, and 3. Hole 7 is S. 26° W. from hole 6. Hole 8 is not in the profile. It is 160 feet south and 400 feet east of hole 5. There is pasture land along the northern part of the profile and swamp forest farther south. Hole 8 is in a pasture in which some small trees and shrubs grow. Drainage ditches carry water from the lake.

The profile (fig. 255) shows fibrous peat, muck, woody peat, peat slime, sedimentary peat, and pumicite. The fibrous peat is mostly brown. Some of it is watery. The muck is brown. Woody peat occurs in hole 5 only, and there it is mixed with fibrous peat. Peat slime forms a thick layer in hole 7 at the margin of the lake, and a thinner layer in holes 4 and 5 at about the same level as the bottom of the thick layer in hole 7. The 1-inch layer of brown pumicite present in holes 3 and 4 is visible in the bank of the drainage ditch as a continuous layer uniform in depth and thickness, and is also visible in the bank of a drainage ditch 400 feet west of hole 3. On the line of the profile the deposit rests on soft blue clay, which is mixed with sand in holes 1, 2, and 3. At the bottom of hole 8 the blue clay is hard.

#### Lake Terrell peat area

The Lake Terrell peat area (98 acres) is in sec. 22, T. 39 N., R. 1 E., about 4 miles northwest of Ferndale. It borders the southeast shore of the lake (map, fig. 256). An unimproved road extends to the lake shore just west of the peat area. The topography of the region is shown on the Blaine quadrangle. The elevation of the lake is 208 feet above sea level, and the peat is at approximately the same level. The surrounding land is comparatively flat, but the surface is more irregular than it is in the vicinity of the previously described peat areas in this county. The lake and the peat lie in a depression in glacial till of Vashon age. On the soil map of Whatcom County (Poulson and Flannery, 1953) the area is mapped as Mukilteo peat, and bordering the southwest shore of Lake Terrell another area of about the same size is also mapped as Mukilteo peat.

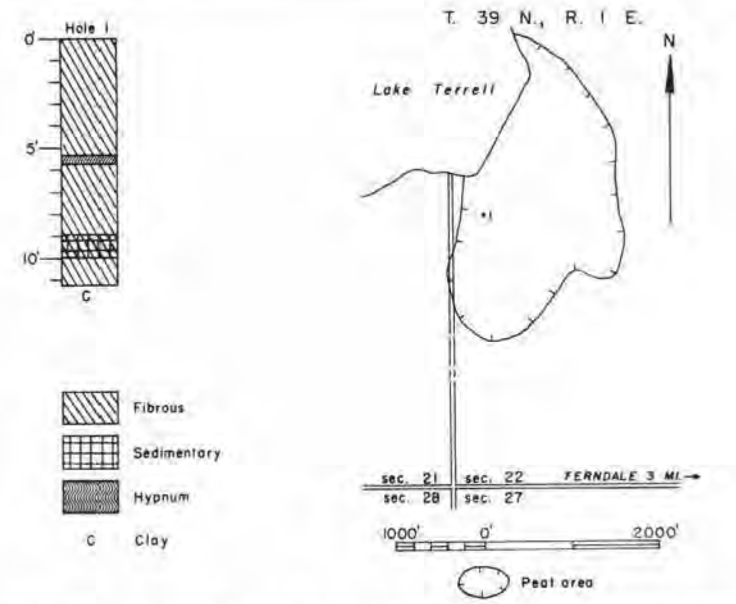


FIGURE 256.—Map and graphic log of a hole in Lake Terrell peat area (98 acres). Map adapted from U. S. Department of Agriculture soil map of Whatcom County.

One hole (fig. 256) was bored near the western border of the peat area in a place where the vegetation is composed of hardhack, reeds (*Juncus*), grass, and mint. Some peat has been removed from a pit near this hole. The hole shows mostly dark-brown disintegrated fibrous peat. Hypnum peat is present at the 6-foot level, and some olive-colored sedimentary peat is mixed with the fibrous peat at the 9- to 10-foot depth. The peat is strongly acidic (pH 4.3 to 4.7). It rests on blue clay.

#### Mountain View peat area

The Mountain View peat area (48 acres) is in secs. 22 and 27, T. 39 N., R. 1 E. (map, fig. 257), about 4 miles west of Ferndale. It is about ½ mile south of the Lake Terrell peat area. The northern edge of the area is crossed by the Mountain View Road, a paved highway. The topography of the region is shown on the Blaine quadrangle. The surrounding region is hilly, but the local relief is less than 100 feet. The peat lies at an elevation of 120 feet above sea level. It is in a depression in glacial till. On the soil map of Whatcom County (Poulson and Flannery, 1953) the peat is mapped as Mukilteo peat.

The profile (525 feet long) is in a pasture. Hole 1 is near a drainage ditch, along which wild rose and a species of mint grow. The profile (fig. 257) shows 1 foot of brown peat soil at the surface in all holes. Under this is a thick layer of brown fibrous peat which is mostly disintegrated. In the 6- to 7-foot depth, however, the fibers are only slightly disintegrated and they stand erect, evidently in the position in which they grew. Olive-colored sedimentary peat lies under the fibrous peat in holes 1 and 2. Blue clay underlies the peat in holes 1 and 2, and blue clay and sand in hole 3.

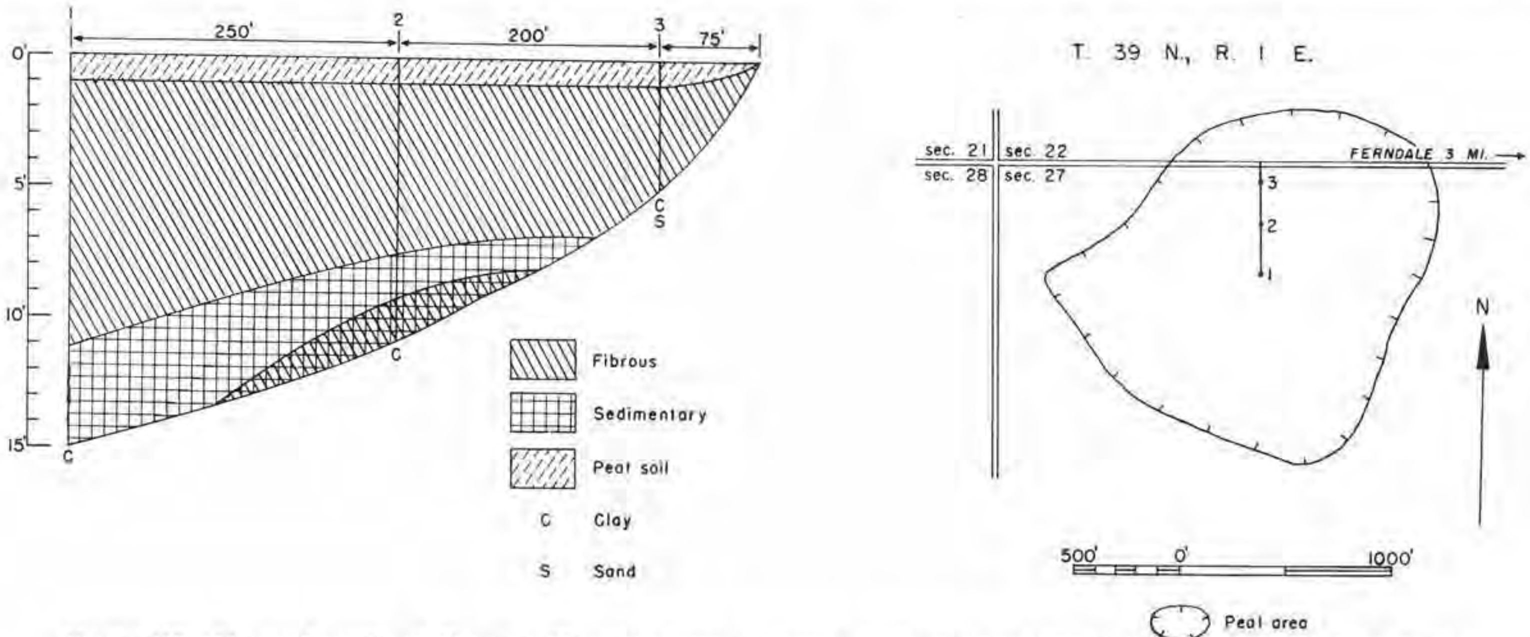


FIGURE 257.—Map and profile of Mountain View peat area (48 acres). Map adapted from U. S. Department of Agriculture soil map of Whatcom County.

### Monument 9 peat area

The Monument 9 peat area (38 acres) is in sec. 34, T. 41 N., R. 1 E., about 3½ miles east of Blaine (map, fig. 258). The boundary line between the United States and Canada is marked with a series of monuments, and monument number 9 is near this peat area. The peat can be reached by 0.6 mile of poor dirt road from the "H" Street Road. The topography of the region is shown on the Blaine quadrangle, where the peat area is mapped as swamp. The elevation of the peat is 410 feet above sea level. The deposit lies in an area of till and is surrounded on all sides except the northwest by hills which rise 50 feet or more above the level of the peat. Drainage from a pond in the peat area is by a natural stream which flows northwestward across the border into Canada. The peat area is mapped as peat or muck on the soil map of the eastern part of the Puget Sound Basin (Mangum, 1911).

The peat is covered almost entirely by an extremely dense growth of hardhack about 6 feet tall. In 1949 an old wire fence across the area was so completely covered by the hardhack that it could be found only by laboriously pulling away the stems of the plants.

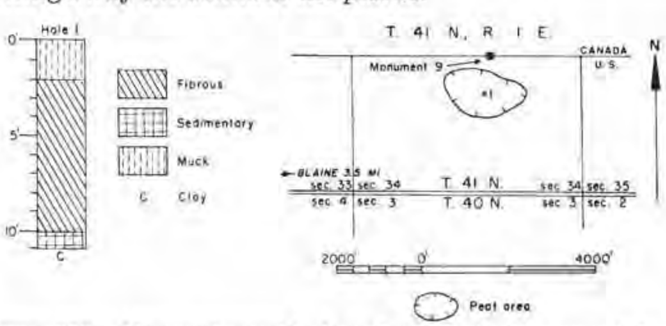


FIGURE 258.—Map and graphic log of a hole in Monument 9 peat area (38 acres). Map adapted from U. S. Department of Agriculture soil map of eastern part of Puget Sound Basin.

One hole in the central part of the area shows 9 feet of muck, fibrous peat, and sedimentary peat resting on soft blue clay (fig. 258). The muck is dark brown to black. The fibrous peat is brown, watery, and decomposed. The sedimentary peat is dark olive brown.

### Blaine peat area

The Blaine peat area (20 acres) is in sec. 35, T. 41 N., R. 1 E., about 4 miles east of Blaine and less than 1 mile southeast of the Monument 9 area. The southern part of the Blaine peat area is crossed by the "H" Street Road. The topography of the region is shown on the Blaine quadrangle. The elevation of the peat is 410 feet above sea level. The deposit lies in a depression in glacial till. On the soil map of Whatcom County (Poulson and Flannery, 1953) this area is mapped as Semiahmoo muck. Evidently it has originated from Mukilteo peat. One hole bored near the center of the area shows 18 inches of muck overlying 18 inches of brown fibrous peat resting on blue clay.

### Barnhart Road peat area

The Barnhart Road peat area (19 acres) is in sec. 3, T. 40 N., R. 2 E. (map, fig. 259), about 5 miles northwest of Lynden. A drainage ditch carrying water northward crosses the area. A dead-end road extends to a place near the peat. The topography of the region is shown on the Blaine quadrangle, on which the elevation of the peat is shown to be 210 feet above sea level. The peat lies in a depression in glacial till. On the soil map of Whatcom County (Poulson and Flannery, 1953) it is mapped as Semiahmoo muck.

The peat area is utilized as a pasture and a hayfield. One hole near the southern end of the area shows 19 feet of fibrous peat, sedimentary peat, and muck resting on blue clay. The fibrous peat is brown, and the sedimentary peat is dark olive. The muck is dark brown. The layer of pumicite at the 12-foot depth is thin.

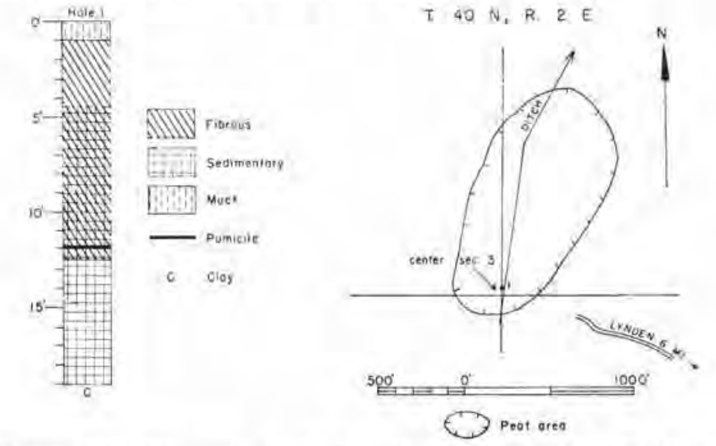


FIGURE 259.—Map and graphic log of a hole in Barnhart Road peat area (19 acres). Map adapted from U. S. Department of Agriculture soil map of eastern part of Puget Sound Basin and U. S. Army Map Service photomosaic.

### Carlson peat area

The Carlson peat area (18 acres) is in sec. 26, T. 38 N., R. 5 E. (map, fig. 260), about 5 miles northeast of Acme and less than 1 mile south of Mosquito Lake. The topography of the region is shown on the Van Zandt quadrangle, where the peat area is mapped as marsh. The elevation of the deposit above sea level is a little less than 700 feet. The peat lies in a short broad alluviated valley tributary to the Middle Fork of the Nooksack River in the western foothills of the mountainous region that extends eastward to Mount Baker and the Cascade Mountains. The hills on both sides of the valley rise to a height of from 2,000 to more than 4,000 feet. The valley floor has several lakes, much swampy area, and several peat areas, the southernmost of which is this, the Carlson peat area, which is mapped as Mukilteo peat on the soil map of Whatcom County (Poulson and Flannery, 1953). This map also shows three other peat areas in the valley, one surrounding Jorgensen Lake, one surrounding Mosquito Lake, and one a sphagnum bog north of Mosquito Lake. This last bog is the one described in this report under the name of Mosquito Lake peat area.

Judging by the size of the valley, it must have been occupied by a large stream, probably in Pleistocene time, but later drainage changes have left the valley unoccupied by any river now, leaving only a poorly drained, irregular valley floor on which several peat deposits have accumulated.

Some of the Carlson peat area is in pasture, but some of it is swampy. One hole bored east of the center of the area shows 8 feet of a brown mixture of fibrous peat and sedimentary peat resting on blue clay.

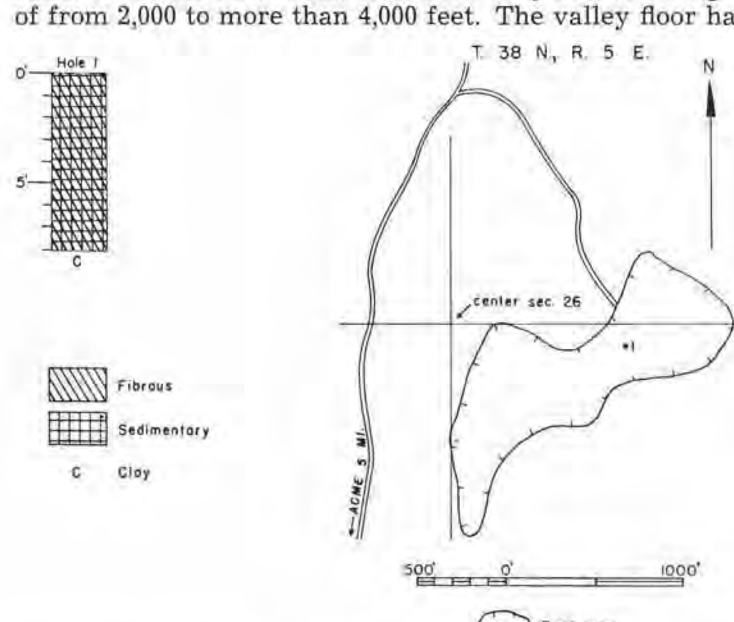


FIGURE 260.—Map and graphic log of a hole in Carlson peat area, Whatcom County (18 acres). Map adapted from U. S. Department of Agriculture soil map of eastern part of Puget Sound Basin and U. S. Army Map Service photomosaic.

### Mosquito Lake peat area

The Mosquito Lake peat area (16 acres) is in secs. 13 and 14, T. 38 N., R. 5 E. (map, fig. 261). It is about 6 airline miles southeast of Deming (considerably farther by road) and about 6 miles by road northeast of Acme. A county road passes near the eastern border, and from this road a private road extends to the northern border of the peat. The peat area is north of the lake and does not border it. The deposit lies less than ¼ mile southwest of the Middle Fork of the Nooksack River.

The topography of the region is shcwn on the Van Zandt quadrangle, and the elevation of the peat is about 670 feet above sea level. The land immediately surrounding the deposit is flat, but there are forested hills nearby. The land between the lake and the peat is flat. The physi-

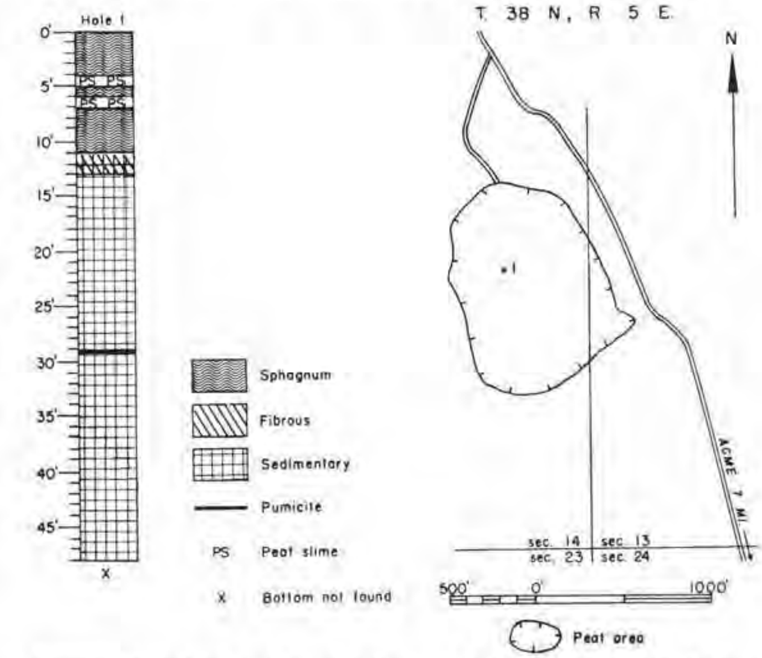


FIGURE 261.—Map and graphic log of a hole in Mosquito Lake peat area (16 acres). Map adapted from U. S. Army Map Service photomosaic.

ographic environment is described further on page 244 in the discussion of the Carlson peat area, which is in the same valley about 1½ miles south of the Mosquito Lake peat area. On the soil map of Whatcom County (Poulson and Flannery, 1953) the Mosquito Lake peat area is mapped as Greenwood peat.

This is a wet sphagnum bog which has the usual flora of bog shrubs and herbaceous species and some small coniferous trees. There is some swamp on the margins. Water flows into the bog from springs and flows out swiftly through ditches and a short stream to the Nooksack River.

One hole near the center of the sphagnum area shows 48 feet of peat (fig. 261), but bottom was not reached because deeper boring was not possible with the equipment available. The layer of sphagnum peat at the surface is 11 feet deep, but it is interrupted by two 1-foot layers of peat slime which contain fragments of sphagnum moss. The upper part of the layer is wet and raw. Below the 8-foot depth the moss is watery and is slightly disintegrated.

The sedimentary peat is soft and is mostly yellow, but at the 23- to 27-foot depth it varies to brown and even black, and at the 48-foot depth it is olive brown. At various depths it contains some sedge-like fibers and some small leaves of woody plants. Yellow sedimentary peat is found in a few other bogs in Washington (e. g., Cottage Lake peat area No. 2 in King County). A brown mixture of sedimentary peat and decomposed fibrous peat occurs at the 11- to 13-foot depth.

FIGURE 262.—Excavating sphagnum peat on Mosquito Lake peat area. Photo by W. R. Riley.

Several years prior to 1949 a considerable quantity of sphagnum moss was removed from this bog and marketed, but the operation was discontinued. The moss was cut into large blocks and dried in the sun during the summer. The dried blocks were shredded, and the shredded moss was baled. Buildings were erected, and electrically driven machinery for shredding and baling was installed. It would seem that further utilization of this bog would be justified if advantageous marketing could be arranged. Though the area is small, the moss is deep; and though the bog is wet, the drainage seems adequate to permit the removal of the moss.

Dachnowski-Stokes (1936) has described this peat and reported borings. He bored to a depth of 26 feet but does not report finding bottom. He reports 11 feet of strongly acid sphagnum peat, under which is 1 foot of organic sediments (pH 6) with a small admixture of fibrous plant remains and rhizomes of sedges. Below this he found 4 feet of yellow-brown hypnum peat, including species of *Drepanocladus*. At the bottom he found 10 feet of soft grayish-brown sedimentary peat, neutral in reaction (pH 7).

#### Sweet Road peat area

The Sweet Road peat area (6 acres) is in the NW¼ sec. 9, T. 40 N., R. 2 E., about 6 miles northwest of Lynden. Sweet Road is only a few hundred feet north of the northern boundary of the peat area. The topography of the region is shown on the Blaine quadrangle. The elevation of the peat is 230 feet above sea level in an area of glacial till. On the soil map of Whatcom County (Poulson and Flannery, 1953) it is mapped as Carbondale muck.

The area is a pasture surrounded by woods. One hole shows 1 foot of muck underlain by 2 feet of fibrous peat, then 1 foot of mixed fibrous and woody peat, then 1 foot of fibrous peat, and 1 foot of sedimentary peat resting on blue clay. Chunks of bog iron were found near the margin of the peat.

#### Lake Louise peat area

The Lake Louise peat area (1 acre) is in sec. 8, T. 37 N., R. 4 E., about 6 miles by road southeast of Bellingham. It borders the north shore of Lake Louise, which is about ½ mile from the southwest shore of Lake Whatcom. There is an outlet from the peat area to Austin Creek, which flows into Lake Whatcom. The topography of the region is shown on the Samish quadrangle, and the elevation of the peat is 324 feet above sea level. Except on the side which borders the lake, the peat is surrounded by rather steep slopes bearing second-growth forest.

This is a sphagnum bog which is still in its natural condition, with the usual flora of bog shrubs and herbs and a few small coniferous trees. No borings were made.

#### Salt marsh peat areas

Muenscher (1941) lists 14 salt marshes, varying from a few to 20 acres each, along the Whatcom County shores of Puget Sound. He says, "These are covered with a rather uniform vegetation frequently forming a dense meadow. Most of these meadows occur behind gravelly or sandy beaches or along the tidal or lower courses of small streams." He gives a list of 27 of the more common or interesting plants in these marshes. No information in regard to the peat in them is available.

# CHAPTER V

# CHEMICAL ANALYSES

## COLLECTION OF SAMPLES

Samples of peat for chemical analysis were taken in the field during the course of this investigation. Those taken in the upper 2 feet of a deposit were obtained by the use of a shovel, and the material was packed at once into glass jars by hand. The samples at depths below 2 feet were obtained by the use of a New American peat borer. All parts of the borer which came into contact with the sample are made of brass. As 2 quarts of material were required for an analysis, 15 or more borings were made for each sample. These were taken from different holes, all within a few feet of one another. The depths at which the samples were taken varied from the upper 1 foot to an extreme depth of 40 feet. The thickness of the layer from which any one sample was taken varied from 1 to 15 feet. The material obtained with the peat borer was ejected directly into the glass jars, but it was necessary to pack it in with the hands. Some of the jars had glass tops and some had metal tops. In the use of the latter a layer of commercial wax paper was placed inside the top to prevent contact of the sample with the metal. All samples were delivered to the laboratory within 10 days after they were taken. In the laboratory they were stored in a refrigerator until the analysis was begun.

The samples were analyzed in the laboratory of the Washington State Department of Agriculture at the College of Pharmacy, University of Washington. Numbers 1 to 45 were analyzed by John C. Hunt and Lyle J. Gordon. Numbers 46 to 50 were analyzed by William Roth, Assistant State Chemist. In the tables the samples are numbered from 1 to 50, but numbers 9, 10, 20, and 43 are omitted. These were special samples, and time for their analysis was not available. The source of each sample is shown in the table on page 253. Information in regard to the situation from which each sample was taken may be had by referring to the map and the profile of the deposit (chap. IV).

The 46 samples are from 28 different deposits in 14 counties. Effort was made to select samples which would be representative of the deposits in various parts of the state, but the sampling is insufficient to be taken as a basis for generalizations in regard to the peat of the whole state.

## METHODS OF ANALYSIS

References and notes on the procedures used by the chemists are as follows:

*Preparation of sample.*—The sample was air dried and screened through a U. S. standard sieve no. 16, with openings of 1.19 mm.

*Moisture.*—A. O. A. C.,[7] 6th ed. (1945), 1.3. The moisture was determined on the sample as received. All data are on an oven-dry basis.

*Ash.*—A. S. T. M.[8] Standards on Coal and Coke, P11, p. 20, Aug. 1947.

*pH.*—A. O. A. C., 6th ed. (1945), 1.50 (a). In most instances it was unnecessary to add any additional water to the sample.

*Chloride* (water soluble chloride).—"Soil and Plant Analysis," by C. S. Piper (1944), p. 45. Water (30 ml.) was added to samples weighing from 3 to 6 gm. These were mechanically shaken for an hour, the suspension was then filtered on No. 41 Whatman filter paper, and an aliquot was shaken and titrated.

*$P_2O_5$* (total organic and soluble).—A. O. A. C., 6th ed. (1945), 1.23. Special care was used in burning off the organic matter.

*Nitrogen* (total).—A. O. A. C., 6th ed. (1945), 1.10.

*Sulphide.*—Scott's Standard Methods of Chemical Analysis, 5th ed., p. 912. When hydrogen sulphide could be smelled, the sample was taken "as received"; it was found that when $H_2S$ could not be smelled the results were the same whether the sample was run "as received" or "air dried."

*Total replaceable bases.*—A. O. A. C., 5th ed. (1945), 1.34.

*Replaceable calcium.*—A. O. A. C., 5th ed. (1945), 1.35.

*Replaceable potash.*—A. O. A. C., 5th ed. (1945), 1.36. With the exception of samples 17, 19, and 32, the calcium oxalate precipitation was omitted in the $K_2O$ determination.

A sample of living *Sphagnum* moss collected by Rigg was analyzed (see p. 254) in 1944 by Paul A. Tornow, who was then a student in the College of Pharmacy, University of Washington. The procedures were as follows:

*Preparation of sample.*—The sample as received was placed in a drier at about 60° C. until dry. The sample was removed from the drier, screened to remove dirt and miscellaneous organic matter, and then ground to a number 20 powder. The sample was thoroughly mixed and allowed to stand at room temperature for about one week.

*Moisture.*—About 5 gm. of sample was weighed in a tared evaporating dish and placed in an oven at 105° C. until it reached constant weight.

*Ash.*—The total ash, water-insoluble ash, and acid-insoluble ash were determined on the sample by the A. O. A. C. method.

*Selective extraction.*—Using the selective extraction method, samples of the moss were extracted on a Soxhlet apparatus. The following solvents were used in the order named: petroleum ether, ether, chloroform, alcohol, and water. The percolates were evaporated spontaneously and dried to constant weight in a desiccator.

*Volatile oil.*—A 50-gm. sample was distilled in a Clavinger apparatus, using a trap for oil lighter than water.

Spectrographic examinations of three samples were made by G. M. Valentine, then on the staff of the Division of Mines and Geology.

## ANALYTICAL DATA

The analytical data are tabulated in such a way as to bring out the characteristics of each of the various kinds of peat. This plan cannot, however, be carried out fully because only 21 of the samples consist of a single kind of peat, while 25 consist of mixtures of two or more kinds. For this reason the data are tabulated under the following heads on pages 254 to 256: fibrous peat, sphagnum peat, sedimentary peat, mixtures of sphagnum and fibrous peat, mixtures of sedimentary and fibrous peat, and miscellaneous mixtures of two or more kinds of peat. The range and average for each item are shown in the tables.

[7] Association of Official Agricultural Chemists. (Official and tentative methods of analysis of the Association of Official Agricultural Chemists.)
[8] American Society for Testing Materials.

The essential facts in regard to field moisture content, ash, acidity, and chemical composition of each sample of peat are thus readily seen.

It seems desirable also to take an over-all view of the general character of the peats of the state so far as they can be characterized by the 46 samples. This is done by presenting summaries of the combined data from all the tables and following each item with such discussion as seems pertinent.

**Water.**—The most important factors which influence the field moisture content of Washington peat are: (1) the kind of peat, (2) the depth at which the sample was taken, (3) the time of year at which the sample was taken, (4) the rainfall of the region, (5) evaporation, (6) the inflow of water from the surrounding slopes or from streams originating some distance away, (7) drainage from the deposit, and (8) whether the deposit borders a lake.

*Field moisture content of 46 samples of peat*

| Water (percent) | Number of samples |
|---|---|
| 55 | 1 |
| 56 to 60 | 1 |
| 61 to 65 | 0 |
| 66 to 70 | 1 |
| 71 to 75 | 0 |
| 76 to 80 | 4 |
| 81 to 85 | 6 |
| 86 to 90 | 18 |
| 91 to 95 | 14 |
| 95.5 | 1 |

Maximum ............... 95.5 percent
Minimum ............... 55.0 percent

Several of these factors commonly operate in the same deposit; in some instances one factor is dominant and others are relatively unimportant. In discussing these factors it is impossible to separate any one of them completely from the others.

The kind of plant from which the peat is formed is an important factor. Where plenty of water is available, *Sphagnum* absorbs large quantities of it (see chap. II). Fibrous peat absorbs less water, but much water may be present between the fibers, and this peat varies from dry to wet. If humification is nearly complete and water is abundant, it may even form peat slime. The water relations of woody peat are much like those of fibrous peat, but it does not commonly form peat slime. Sedimentary peat is commonly just wet enough to make it plastic, but it may vary from extremely wet to extremely dry.

The relation between depth and water content is quite variable. In some deposits the water content is less at the surface than at greater depths. This is of course especially true where the deposit has been drained or where clearing has increased evaporation. The water content of the same kind of peat may differ with a difference of only a foot or even less in depth. Dry layers may be very close to wet layers, and peat slime may be close to a layer which is merely moist. Compact peat in which the water content is low is often present at the bottom of even a deep deposit. The causes of these variations are not evident in field work.

The water content of peat near the surface of a deposit may vary somewhat from one season of the year to another. Some deposits are flooded during the rainy season but are comparatively dry in late summer. The peat at greater depths is likely to have a constant water content throughout the entire year.

The water content of the same type of peat in many instances varies with the rainfall and the evaporation of the region. It is commonly higher in western Washington, where the rainfall is high and evaporation is low, than in the eastern part of the state where these factors are reversed; this is not always true, however, due to other factors such as drainage and clearing.

It is obvious that peat in deposits into which much water drains is wet, and that the extent to which this is true depends upon the drainage. The peat in deposits which border lakes commonly has a high water content.

**Ash.**—The table indicates a wide variation in the percentage of ash, the greater number of samples falling within the lower ranges. The range from 1.51 to 19.50 percent ash contains 47.8 percent of all samples, whereas the range from 61.51 to 79.50 percent ash contains only 19.6 percent of them. The distribution between these extreme ranges is fairly even.

*Ash content of 46 samples of peat*

| Ash (percent) | Number of samples |
|---|---|
| 1.51 to 7.50 | 11 |
| 7.51 to 13.50 | 5 |
| 13.51 to 19.50 | 6 |
| 19.51 to 25.50 | 1 |
| 25.51 to 31.50 | 2 |
| 31.51 to 37.50 | 2 |
| 37.51 to 43.50 | 3 |
| 43.51 to 49.50 | 2 |
| 49.51 to 55.50 | 3 |
| 55.51 to 61.50 | 2 |
| 61.51 to 67.50 | 2 |
| 67.51 to 73.50 | 3 |
| 73.51 to 79.50 | 4 |

Maximum ............... 75.9 percent
Minimum ............... 1.6 percent

Among the primary sources of mineral matter in the peat are: (1) mineral matter present within the tissues of the plant remains of which the peat is composed, (2) mineral matter in solution which is in water brought in by streams from the higher land or is dissolved from the bottom and sides of the depression, (3) clay, silt, and sand washed in, (4) pumicite deposited from volcanic eruptions, and (5) minerals present in sea water in the salt marshes. Among the secondary sources are: (1) the concentration of silica in some layers by diatoms and (2) the concentration of calcium carbonate and small amounts of other minerals as marl. It is impossible to determine definitely the source of the mineral matter in any one sample, although field examinations often provide indications. Of course all plant tissues leave some ash when burned, and some of the ash content of all the peat samples undoubtedly came from the plant remains from which the peat originated. The ash content of the sphagnum sample analyzed by Tornow was 3.89 percent. It seems probable that in the peat samples showing an ash content of 5 percent or less (numbers 1, 26, 28, 30, 35, 36, 37, and 39) practically all the ash came from the plant remains. It is possible that in all samples containing less than 10 percent of ash, plant remains were the main source.

It is evident that minerals in solution were brought into some deposits in Whatcom and Stevens Counties by streams from neighboring mountains. Of the 10 samples showing more than 60 percent of ash, 8 are from Whatcom County. Of these, 4 are from the Mosquito Lake deposit, 2 from the Wiser Lake deposit, and 2 from the Pangborn Lake deposit. The Mosquito Lake and Wiser Lake deposits are close to streams originating in the mountains, but the Pangborn Lake deposit is not.

It is evident that considerable quantities of mineral matter have been brought into the Deep Creek-Cedar Creek Valley in Stevens County by mountain streams. Considerable amounts of this material are now in the form of marl. The 1 sample (number 17) from this valley included some marl, sand, and clay.

Clay, silt, and sand are readily recognized in some peat deposits and are undoubtedly present in small amounts in others. To what extent they have contributed to ash content has not been determined. Pumicite has undoubtedly contributed to the ash content of certain peats. In western Washington, the layers of pumicite are thin (mostly 1 inch or less), but in some samples pumicite is dispersed in the peat and is not visible to the unaided eye. In some deposits in eastern Washington the layer is thick (up to 3 feet).

Mineral matter from sea water is evident in only 3 deposits (Hancock Lake, Crockett Lake, and Swantown), all of which are on the west shore of Whidbey Island in Island County. Sample number 46, taken from the upper 1 foot of the peat at a point about 500 feet southwest of the shore of Hancock Lake, showed a chlorine content of 5.3 percent. Sample number 47, taken from the same hole at the 5- to 6-foot depth showed a chlorine content of 13.5 percent. The salinity of Hancock Lake is 90 percent of that of normal sea water of the region. Sample number 50, taken close to the south shore of Crockett Lake, showed a chlorine content of 11.1 percent. No sample was taken from the Swantown deposit.

The chlorine content of the 3 samples just mentioned is much higher than that of any of the other 38 samples in which the chlorine was quantitatively determined (from 0.002 to 0.083 percent). The high chlorine content of these 3 samples is evidently due to the influence of sea water. Other evidences of this influence in all 3 of the deposits mentioned above are the presence of a plant community which is characteristic of salt marshes and also the very slight success which has been attained in efforts to bring the soil into use for the production of crops.

The concentration of mineral matter in the form of silica in some layers as a result of the growth of diatoms has evidently occurred in a number of deposits. The evidence for this is partly from field observations and partly from data obtained by quantitative determination of silica and ash content in the laboratory. Relatively pure layers of diatomite occur (e. g., the Shadow Lake deposit in King County), and mixtures of diatomite and peat or muck occur either near the diatomite layer (e. g., the Shadow Lake deposit) or elsewhere (e. g., the Lakeside deposit in Spokane County). In the Johns Lake deposit in Mason County the ash content is high (77.3 percent), and no other source of mineral matter is apparent. The evidence from quantitative determinations of silica and ash content is presented in the table on page 250 under the discussion on silica later in this chapter.

**Acidity.**⑨ — Laboratory determinations of hydrogen ion concentration by the use of a glass-electrode pH meter were made on 46 samples, and 378 field determinations were made by the use of test papers (see chap. I).

*Hydrogen ion concentration of 46 samples of peat*

| Hydrogen ion concentration (pH) | Number of samples |
|---|---|
| 3.1 to 3.5 | 2 |
| 3.6 to 4.0 | 8 |
| 4.1 to 4.5 | 5 |
| 4.6 to 5.0 | 10 |
| 5.1 to 5.5 | 3 |
| 5.6 to 6.0 | 8 |
| 6.1 to 6.5 | 5 |
| 6.6 to 7.0 | 2 |
| 7.1 to 7.5 | 1 |
| 7.6 | 2 |
| Maximum pH | 7.6 |
| Minimum pH | 3.1 |

The outstanding facts shown in this table are that the samples are mostly acidic, and that more of the samples have high acidity (low pH) than low acidity (high pH).

Low pH occurs in samples which consist wholly or mainly of sphagnum or were taken from layers lying under sphagnum. The data on which this statement is based are shown in the table above, the tables on pages 254 to 256 (chemical composition), the table on page 253 (source of samples), and the profiles. Of the 9 samples (numbers 1, 22, 24, 26, 28, 29, 36, 37, and 39) whose pH ranges from 3.1 to 3.9, there are 3 which consist of sphagnum only, 4 consist mainly of sphagnum, and 2 come from peat which lies a few feet below sphagnum. Corresponding comparisons indicate that the alkaline samples (numbers 5, 6, and 11) have relatively high ash content.

A summary of the 378 field determinations of pH is given in a table on page 249. As so few of the field determinations show neutral or alkaline peat (only 22 out of 378) the facts in regard to the occurrence of neutral and alkaline peat merit special attention. They are shown in tables on pages 256 and 257.

⑨ This heading is used because the term is commonly used in discussions of peat. It is not strictly correct, as alkaline peat is occasionally found. The terms "hydrogen ion concentration" (expressed as pH) and "reaction," of course, include both acidity and alkalinity.

*Summary of field determinations of hydrogen-ion concentration of 378 samples of peat*

| Kinds of peat | Number of determinations | Hydrogen-ion concentration (pH) | |
|---|---|---|---|
| | | Maximum | Minimum |
| Fibrous | 180 | 7.7 | 3.5 |
| Sphagnum | 45 | 4.8 | 3.0 |
| Sedimentary | 86 | 6.8 | 3.8 |
| Woody | 4 | 6.3 | 3.8 |
| Hypnum | 2 | 5.2 | 5.0 |
| Miscellaneous mixtures | 61 | 6.7 | 3.8 |

**Nitrogen.**—Total nitrogen was determined in all 46 samples represented in the tables on pages 254 to 256. Separate determinations of organic and inorganic nitrogen were not made. The maximum percent (3.80) is in the Winters Lake deposit in Snohomish County. The other samples containing more than 3.00 percent are from the Cedar Creek deposit in Stevens County (3.37), the North Bay deposit in Grays Harbor County (3.31), and the Tahuya Lake deposit in Kitsap County (3.20). The minimum nitrogen content (0.29 percent) was found in 2 deposits (Wiser Lake in Whatcom County and Newman Lake in Spokane County).

*Nitrogen content of 46 samples of peat*

| Nitrogen (percent) | Number of samples |
|---|---|
| 0.26 to 0.80 | 2 |
| 0.81 to 1.35 | 11 |
| 1.36 to 1.90 | 12 |
| 1.91 to 2.45 | 11 |
| 2.46 to 3.00 | 6 |
| 3.01 to 3.55 | 3 |
| 3.56 to 4.10 | 1 |

Of the 46 samples reported, 34 (74 percent) come within the range 0.81 to 2.45 percent nitrogen.

The data for the 46 samples suggest that there may be a relation between the nitrogen content and the nature of the plants of whose remains the peat is composed. The average percentages of nitrogen for samples consisting of only one kind of peat are: fibrous, 2.15 percent (table on p. 254); sphagnum, 1.47 percent (table on p. 254); and sedimentary, 1.63 percent (table on p. 255).

An inspection of the data on total nitrogen content and ash content suggests an inverse relation between the two. Dr. Carl B. Allendoerfer determined the coefficient of correlation between the two and found it to be -0.37. As the coefficient is negative, it indicates that whatever relation exists between the two is an inverse relation.

**Phosphorus.**—The percent of phosphorus in the 45 samples reported in the table ranges from 0.05 to 1.52.

The largest numbers of samples come within the lower ranges. Of the 45 samples, 32 (71 percent) come within the ranges from 0.05 to 0.35 percent. The 1 sample whose phosphorus content is so far above the others (1.52 percent) is from the Beehive Mountain deposit in Chelan County. This deposit was formed in a landslide lake, and it seems possible that inorganic phosphates may have been brought into the lake.

*Phosphorus content of 45 samples of peat*

| Phosphorus (percent) | Number of samples |
|---|---|
| 0.05 to 0.15 | 16 |
| 0.16 to 0.25 | 9 |
| 0.26 to 0.35 | 7 |
| 0.36 to 0.45 | 1 |
| 0.46 to 0.55 | 3 |
| 0.56 to 0.65 | 2 |
| 0.66 to 0.75 | 4 |
| 0.76 to 0.85 | 0 |
| 0.86 to 0.95 | 1 |
| 0.96 to 1.05 | 1 |
| 1.06 to 1.15 | 0 |
| 1.16 to 1.25 | 0 |
| 1.26 to 1.35 | 0 |
| 1.36 to 1.45 | 0 |
| 1.46 to 1.55 | 1 |

**Potassium.**—Replaceable potassium was tested for in 24 samples. Quantitative determinations were made on 5 of these, and in the other 19 only a trace was found. In the table on page 251 the data are shown as milliequivalents per 100 grams of oven-dry peat, and the data are discussed under the heading of replaceable bases.

The data were recalculated as percent of $K_2O$, and are shown thus in the tables on pages 254 to 256. The percentages range from 0.12 to 0.28. Wilson and Staker (1935) found that the percentages of potassium in 12 virgin woody peat soils in New York ranged from 0.10 to 0.57.

**Calcium.**—Replaceable calcium was determined in 3 samples. The data are shown in the table on page 251 and are discussed under the heading of replaceable bases. The data were recalculated to show percentages of CaO and are shown thus in two tables on pages 255 and 256. The highest percentage (2.84) was in a sample from the Deep Creek deposit in Stevens County, in which marl occurs. The lowest (0.43) was from the jellylike layer of sedimentary peat in the Cottage Lake deposit in King County. This low percentage of calcium seems to correlate with the nature of the deposit and the lack of limestone in the region. In 12 woody peat soils in New York, Wilson and Stacker (1935) found that the percentage of CaO ranged from 0.6 to 9.4.

**Silica.**—Silica was determined in only 5 samples. The data are presented as $SiO_2$ in the table below and in three tables on pages 254, 255, and 256. All the silica present would be in the ash, and a consideration of the possible sources of the silica may be based on the following table.

It seems reasonable to suppose that the high silica content in samples 7 and 19 is due mainly to the remains of diatoms, as the situation of the deposits from which these samples came is not such as to indicate any considerable inwash of mineral matter. In samples 15 and 16 the high silica content is evidently due to the presence of pumicite. the low silica content in the ash of sample 11 is consistent with the presence of much calcium in the form of marl.

*Ash and silica content of 5 peat samples*

| Sample number | Deposit | Ash in peat (percent) | Silica in peat (percent) | Silica in ash (percent) | Kind of peat and its situation with reference to mineral matter |
|---|---|---|---|---|---|
| 7 | Pangborn Lake | 63.2 | 58.6 | 92.7 | Fibrous. Upper 3 feet |
| 11 | Wiser Lake | 66.3 | 23.5 | 35.4 | Sedimentary with marl. Depth 14 to 16 feet |
| 15 | Newman Lake | 51.3 | 47.3 | 92.2 | Sedimentary and fibrous just below a thick layer of pumicite. Depth 13½ to 19 feet |
| 16 | Eloika Lake | 69.6 | 56.5 | 81.1 | Sedimentary and fibrous with pumicite. Depths 5 to 6 and 7 to 15 feet |
| 19 | Beehive Mountain | 48.9 | 44.7 | 91.4 | Fibrous and muck with some woody peat. Upper 3 feet |

**Chlorine.**—Quantitative determinations of chlorine as chloride were made on 41 samples, and qualitative tests on the other 5 samples indicated the presence of chlorine. Quantitative determinations were not made on the latter because the samples were not large enough; this does not necessarily mean that the chlorine content was small in these samples. Of the 41 samples on which quantitative determinations were made, 32 (78 percent) come within the range from 0.001 to 0.025 percent (see table below). The 3 samples (numbers 46, 47, and 50) in which the percentage of chlorine (above 5 percent) is far greater than in the others are all from salt marshes on the west coast of Whidbey Island, in Island County, where sea water is evidently the source of the chlorine.

*Chlorine content of 46 samples of peat*

| Chlorine (percent) | Number of samples |
|---|---|
| Trace (qualitative) | 5 |
| 0.001 to 0.005 | 6 |
| 0.006 to 0.010 | 9 |
| 0.011 to 0.015 | 10 |
| 0.016 to 0.020 | 3 |
| 0.021 to 0.025 | 4 |
| 0.026 to 0.030 | 1 |
| 0.031 to 0.035 | 1 |
| 0.036 to 0.040 | 1 |
| 0.041 to 0.045 | 1 |
| 0.046 to 0.050 | 1 |
| 0.081 to 0.085 | 1 |
| 5.1 to 5.5 | 1 |
| 10.1 to 10.5 | 1 |
| 13.1 to 13.5 | 1 |

**Sulphur.**—Sulphur (as sulphide) was determined in 46 samples. The data are shown in the tables on pages 254 to 256 and are summarized in the table below. Of these samples, 34 (74 percent) come within the range from 0.006 to 0.020 percent. The 1 sample (number 45) whose sulphur content (0.071 percent) is much higher than the others is from the Cedar Creek deposit in Stevens County. Minerals are evidently carried into this deposit by streams from neighboring mountains. Possibly the sulphur is derived from nearby sulphide-ore mineralization. It should be noted, however, that a sample (number 17) from the nearby Deep Creek deposit shows only 0.026 percent of sulphur. Four other samples (numbers 1, 2, 3, and 47) show relatively high sulphur content (0.031 to 0.049 percent). Three of these are from the Mosquito Lake deposit, in Whatcom County, into which minerals are probably brought by streams from the mountains. The fourth is from the Hancock Lake deposit, on the west shore of Whidbey Island, in Island County, in which sea water is probably the source of the sulphur. The occurrence of hydrogen sulphide gas in Washington peat deposits has been discussed in chapter II.

*Sulphur (as sulphide) content of 46 samples of peat*

| Sulphur (percent) | Number of samples |
|---|---|
| 0.001 to 0.005 | 4 |
| 0.006 to 0.010 | 15 |
| 0.011 to 0.015 | 11 |
| 0.016 to 0.020 | 8 |
| 0.021 to 0.025 | 2 |
| 0.026 to 0.030 | 1 |
| 0.031 to 0.035 | 1 |
| 0.036 to 0.040 | 2 |
| 0.041 to 0.045 | 0 |
| 0.046 to 0.050 | 1 |
| 0.071 to 0.075 | 1 |

**Replaceable bases.**—Determinations were made of total replaceable bases expressed as milliequivalents per 100 grams of oven-dry peat in 24 samples of Washington peat. Replaceable calcium was determined on 3 of these. Quantitative determinations of replaceable potassium were made on 5 of the samples, and the presence of traces of replaceable potassium was demonstrated in the other 19. The data are shown in the table on page 251. It should be noted that the data on calcium and potassium are not the same as those in the tables on pages 254 to 256, because in those tables the data were recalculated as CaO and $K_2O$ in order to make them comparable with other data shown.

Before discussing the data presented in this table it seems desirable to define some terms and make some explanation. These terms are, of course, well known to soil technologists and plant physiologists, but they may be less familiar to others. The facts about replaceable bases in soils have been learned mostly during the past 30 years, and interpretations of these facts in terms of the various phenomena which occur in soils and the influence of these phenomena on the growth of plants have been made from time to time.

*Replaceable bases*
(milliequivalents per 100 grams oven-dry peat)

| Sample number | Total* | Calcium | Potassium |
|---|---|---|---|
| 19 | 116 | 94 | 0.47 |
| 17 | 111 | 101 | tr.† |
| 32 | 18.1 | 15.4 | tr. |
| 26 | 18.0 | | 0.30 |
| 27 | 27.6 | | 0.59 |
| 29 | 14.5 | | 0.25 |
| 31 | 21.5 | | 0.28 |
| 45 | 113 | | tr. |
| 34 | 44.4 | | tr. |
| 30 | 41.1 | | tr. |
| 44 | 40.7 | | tr. |
| 33 | 39.2 | | tr. |
| 25 | 34.5 | | tr. |
| 28 | 25.4 | | tr. |
| 24 | 23.4 | | tr. |
| 42 | 22.9 | | tr. |
| 41 | 20.5 | | tr. |
| 39 | 16.0 | | tr. |
| 40 | 11.7 | | tr. |
| 22 | 8.9 | | tr. |
| 35 | 6.3 | | tr. |
| 36 | 2.3 | | tr. |
| 37 | 2.0 | | tr. |
| 38 | 1.5 | | tr. |

* Replaceable hydrogen is not included in this total.
† tr. = Trace, or less than 0.21 m.eqv. per 100 grams.

Replaceable bases in soils are bases which when adsorbed[⑩] on colloidal particles can be replaced by other bases which are present in the soil or the soil solution. The bases most commonly involved are calcium, potassium, and magnesium, but sodium is also involved in some instances.

Any ion can replace another ion according to the law of mass action, although some are more efficient than others. Examples of replacements which occur in cation exchange in soils are: (1) potassium ions can replace calcium, magnesium, or sodium ions, (2) sodium ions can replace hydrogen ions,[⑪] and (3) hydrogen ions can replace calcium, potassium, and magnesium ions. Potassium can be held on colloidal particles in either the replaceable or the nonreplaceable form. It is probable that this distinction is not absolute and that there are merely degrees of replaceability, but the terms "replaceable potassium" and "nonreplaceable potassium" are in common use.

The colloidal particles of soils bear negative charges, and the ions adsorbed on them bear positive charges. The replacing of one cation adsorbed on a colloidal particle by a different cation is called base exchange (cation exchange). The total of such exchanges possible in a soil is called its exchange capacity. The extent to which this exchange capacity is satisfied by cations other than hydrogen is the base saturation, and it is expressed as a percentage.

The available data on base exchange in soils are largely the product of work on mineral soils, especially clays, but some work has been done on organic soils including peat (e. g., Wilson and Staker, 1935).

The writer has consulted the following books: Hoagland (1944), Robinson (1949), Lyon, Buckman, and Brady (1952), and Knight and others (1935). If the reader desires further information he will find a wealth of it in these works.

The discussion of the data in the table on this page centers around (1) the great variation in the total amount of replaceable bases, (2) the relation of the amount of replaceable calcium and potassium to the total replaceable bases, and (3) the relation between the pH of the samples and the total of replaceable bases in them.

The total amount of replaceable bases in the 24 samples (table on this page) varies from a maximum of 116 to a minimum of 1.5 milliequivalents of base per 100 grams of bone-dry peat. In 18 of the samples the amount ranges from 44.4 to 6.3. The 3 in which the amount is below this range and the 3 in which it is far above this range merit attention.

The 3 showing low amounts are all from the Tulalip deposit in Snohomish County. This deposit has at the surface 1 foot of sphagnum whose pH (field determination) was 3.5. The composition of the 3 samples was: number 36, woody; number 37, fibrous; number 38, fibrous and sand.

None of the 3 samples (numbers 17, 19, and 45) which contain comparatively large amounts of replaceable bases consists of pure peat. All contain some of one or more of the following materials: marl, sand, clay, and muck. These materials may be the source of some replaceable bases.

Replaceable calcium was determined on only 3 of the 24 samples. Of these samples, 2 had a high content of total replaceable bases (116.4 and 110.5) and 1 had a relatively low content (18.1). The replaceable calcium constituted 81 and 91 percent, respectively, of the total replaceable bases in the 2 samples with a high content and 82 percent of the sample with a relatively low content.

Replaceable potassium constituted only a very small percentage of the total replaceable bases in the 5 samples in which it was determined. The maximum was 2.1 percent, and the minimum was 0.4 percent.

These data are comparable to those found by Wilson and Staker (1935), who determined total replaceable bases in 12 virgin woody peat soils in New York. Their samples were taken from the upper 1 foot of the deposits. The maximum was 274.4 and the minimum was 28.7 milliequivalents of base per 100 grams of peat. They found that calcium was the predominant replaceable cation in the 2 of the New York virgin woody peat soils on which they made their determinations, and that the amount of replaceable potassium was very small. Other replaceable cations in the order of the decreasing quantities found in these soils were iron, magnesium, silicon, aluminum, manganese, and sodium. All of these except sodium were present in larger amount than potassium.

⑩Adsorption is a surface phenomenon and is especially important in soils containing large amounts of colloidal materials. The essential nature of colloids is that their particles are extremely small, and colloidal materials therefore expose large amounts of surface.

⑪ The hydrogen ion bears a positive electrical charge, and it is convenient to include it here. All ions bearing positive charges are called cations, and the term *replaceable cations* includes the hydrogen ion and the other positive ions here mentioned. The term *replaceable bases* does not include the hydrogen ion.

Inspection of the data on total replaceable bases (table, p. 251) and on pH of the 24 samples suggests that there is a relation between the two, and the coefficient of correlation also indicates that there is a relation. The coefficient is 0.66.[®] Wilson and Staker (1935) report that the coefficient of correlation between total replaceable cations (not including hydrogen) and pH in their 12 New York virgin woody peat soils was 0.8951 ± 0.0387. As hydrogen can replace calcium, potassium, and magnesium, and as peat soils are acidic, it would seem natural that there should be a relation between total replaceable bases and pH.

Exchange capacity is an important property of peat soils. It necessarily involves the presence of colloidal materials, and peat soils are characteristically colloidal. Waksman (1942, p. 83) has discussed peat as a colloidal system. Rigg and Thompson (1919) demonstrated the presence of colloidal material in the waters of sphagnum bogs in western Washington and in Alaska. Further investigation of exchangeable bases in peat in the state of Washington seems desirable.

Wilson and Staker (1935) have compared the amount of replaceable bases in their 12 New York virgin woody peat soils with the amounts usually present in mineral soils. They say, "All of the [peat] soils were found to possess a high absorptive capacity for cations, and to contain a large amount of replaceable cations in comparison with the amount usually accredited to mineral soils."

**Spectrographic determinations.**—Spectrographic determinations on 3 samples of peat from the Fazon Lake deposit in Whatcom County were made by G. M. Valentine in 1949. All samples are from hole 3, profile A, at depths varying from 2 to 30 feet. The elements found in major quantities are silicon, magnesium, sodium, potassium, and iron. Those found in minor quantities are titanium, zirconium, nickel, calcium, boron, manganese, lithium, vanadium, zinc, copper, and chromium. This list includes most of the minor, or so-called trace elements, which in recent years have been shown to be important for the growth of crop plants. Possibly their presence constitutes an important part of the benefit shown from the use of peat as a soil amendment.

**General considerations.**—The chemical analyses indicate that most Washington peats, like those from other parts of the United States, cannot be expected to supply the ordinary fertilizer elements in the amounts necessary for satisfactory growth of crop plants. The use of peat areas for the growth of crops commonly requires the addition of fertilizer elements, especially phosphorus and potash, if satisfactory yields are to be expected. The addition of manure to promote the action of micro-organisms on the nitrogen compounds in peat is also desirable. The benefits from the addition of peat as a soil amendment are mostly in improved physical condition of the soil, increased water-holding capacity, the addition of trace elements which may cause increased growth in crop plants, and possibly the presence of organic growth-promoting compounds.

Information in regard to the chemical constituents of peat in other states and also in Canada and some European countries is available in a number of publications. Much of this information relates to inorganic constituents, but some of the analyses reported include organic constituents also. Some of the data reported are directly comparable to the data reported in the present bulletin, but some are not comparable because the workers have approached the investigation from a different viewpoint. In general, the quantities of the various constituents reported in the present bulletin are similar to the quantities reported from other states and countries, but in some instances they are different. These may be explained, at least in part, on the basis of variations in climatic environment and the nature of the geology of the areas involved.

Among the important reports from other states are Minnesota (Alway, 1920), New Jersey (Waksman, 1942 and 1943), and Florida (Davis, 1946). Some of these also give data from foreign countries. Haanel (1925) includes data from Canada and also some European countries. The articles by Feustel (1939) and Feustel and Byers (1930) give data from various parts of the United States. The textbook by Lyon, Buckman, and Brady (1952) gives data from several states of the United States and also from Canada and some European countries.

[®] If, for instance, the confidence interval at the 0.05 level is used, this may be construed as meaning statistically that if an infinite number of determinations had been made instead of only 24, the coefficient of correlation in 95 percent of the determinations would have been between 0.35 and 0.84.

*Source of samples*

| Sample number | Name of deposit | Kind of Peat | County | Profile | Hole | Depth at which sample was taken (feet) |
|---|---|---|---|---|---|---|
| 1 | Mosquito Lake | Sphagnum | Whatcom | | 1 | 0 to 4 |
| 2 | Mosquito Lake | Sphagnum, fibrous, sedimentary | Whatcom | | 1 | 7 to 13 |
| 3 | Mosquito Lake | Sedimentary | Whatcom | | 1 | 13 to 15 |
| 4 | Mosquito Lake | Sedimentary | Whatcom | | 1 | 15 to 18 |
| 5 | Mosquito Lake | Sedimentary | Whatcom | | 1 | 18 to 29 |
| 6 | Mosquito Lake | Sedimentary | Whatcom | | 1 | 31 to 40 |
| 7 | Pangborn Lake | Fibrous | Whatcom | A | 6 | 0 to 3 |
| 8 | Pangborn Lake | Fibrous, sedimentary | Whatcom | A | 6 | 4 to 14 |
| 11 | Wiser Lake | Sedimentary, marl | Whatcom | H | 1 | 14 to 16 |
| 12 | Wiser Lake | Sedimentary | Whatcom | H | 3 | 10 to 14½ |
| 13 | Newman Lake No. 1 | Cultivated peat soil | Spokane | | 12 | 0 to 1 |
| 14 | Newman Lake No. 1 | Fibrous | Spokane | | 12 | 2 to 11½ |
| 15 | Newman Lake No. 1 | Sedimentary, fibrous | Spokane | | 12 | 13 to 18 |
| 16 | Eloika Lake | Fibrous, sedimentary | Spokane | | 2 | 5 to 6, 8 to 15 |
| 17 | Deep Creek No. 1<br>Deep Creek No. 2<br>Deep Creek No. 3 | Fibrous, woody, sedimentary, marl, sand, clay | Stevens | | 2, 3, 4<br>1, 2, 3, 4<br>3 | 2 to 15<br>0 to 12<br>0 to 3 |
| 18 | Bonaparte Meadows | Fibrous, woody, sedimentary | Okanogan | A | 1 | 2 to 11 |
| 19 | Beehive Mountain | Fibrous, muck | Chelan | | 2 | 0 to 3 |
| 21 | Fish Lake | Sedimentary (colloidal) | Chelan | | 2 | 8 to 10 |
| 22 | Spencer Lake | Sphagnum, woody | Mason | | 2 | 1 to 10 |
| 23 | Spencer Lake | Sphagnum, fibrous | Mason | | 2 | 11 to 21 |
| 24 | North Bay No. 2 | Sphagnum | Grays Harbor | | 1 | 0 to 1 |
| 25 | North Bay No. 2 | Fibrous, woody, muck | Grays Harbor | | 1 | 1 to 6 |
| 26 | North Bay No. 1 | Sphagnum, fibrous | Grays Harbor | | 2 | 0 to 1 |
| 27 | North Bay No. 1 | Fibrous, woody | Grays Harbor | | 2 | 1 to 5 |
| 28 | Carlisle Lakes | Sphagnum | Grays Harbor | | 7 | ¼ to 1¼ |
| 29 | Carlisle Lakes | Fibrous, sphagnum | Grays Harbor | | 7 | 1¼ to 4 |
| 30 | Rockett (upper area) | Sphagnum, fibrous | Cowlitz | | 1 | 0 to 4 |
| 31 | Peninsula | Sphagnum, fibrous | Pacific | State Highway 12A | 1 | 0 to 9 |
| 32 | Cottage Lake No. 2 | Sedimentary (colloidal) | King | | 5 | 8 to 14 |
| 33 | Winters Lake | Fibrous, woody, sedimentary, sphagnum | Snohomish | | 2 | 14 to 17 |
| 34 | Frye Marsh | Fibrous, woody, peat soil | Snohomish | | 11 | 1 to 2 |
| 35 | Thomas Lake | Fibrous, sphagnum | Snohomish | | 3 | 4 to 7 |
| 36 | Tulalip | Fibrous, woody | Snohomish | | 1 | 2½ to 4 |
| 37 | Tulalip | Fibrous | Snohomish | | 1 | 4 to 12 |
| 38 | Tulalip | Fibrous, sand | Snohomish | | 1 | 12½ to 16 |
| 39 | Granite Falls | Sphagnum, sedimentary | Snohomish | | 1 | 0 to 8 |
| 40 | Granite Falls | Sedimentary | Snohomish | | 1 | 10 to 18 |
| 41 | Granite Falls | Sedimentary | Snohomish | | 1 | 21 to 26 |
| 42 | Kirk Lake | Fibrous, sedimentary | Snohomish | | 7 | 2 to 8 |
| 44 | Loon Lake | Fibrous | Stevens | | 1 | 1 to 8 |
| 45 | Cedar Creek No. 2 | Fibrous, marl | Stevens | A | 3 | 1 to 6 |
| 46 | Hancock Lake | Fibrous | Island | B | 3 | 0 to 1 |
| 47 | Hancock Lake | Fibrous | Island | B | 3 | 5 to 6 |
| 48 | Lake Tahuya | Sphagnum, fibrous | Kitsap | | 2 | 9 to 10 |
| 49 | Johns Creek | Sedimentary (colloidal) | Mason | | 1 | 3 to 5 |
| 50 | Crockett Lake | Fibrous | Island | A | 1, 2 | 1 to 2 |

NOTE: The profile is designated only where there was more than one profile in the deposit.

*Fibrous peat—Soil reaction, moisture content, chemical composition, and total replaceable bases*

| Sample number | pH | Moisture as received (percent) | Composition of moisture-free material (percent) | | | | | | | Total replaceable bases* |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Ash | Total N | $P_2O_5$ | $K_2O$ | $SiO_2$ | Cl | S | |
| 7 | 5.4 | 90.1 | 63.2 | 2.02 | 0.09 | | 58.6 | 0.013 | 0.017 | |
| 14 | 4.9 | 87.7 | 44.5 | 2.00 | 0.69 | | | 0.014 | 0.012 | |
| 29 | 3.6 | 90.9 | 11.2 | 2.38 | 0.29 | 0.012 | | 0.011 | 0.008 | 14.5 |
| 37 | 3.8 | 87.5 | 1.89 | 2.69 | 0.32 | tr. | | 0.014 | 0.008 | 2.0 |
| 44 | 5.8 | 87.0 | 41.9 | 2.12 | 0.18 | tr. | | 0.041 | 0.016 | 40.7 |
| 46 | 5.4 | 86.0 | 14.9 | 1.8 | 0.06 | | | 5.3 | 0.002 | |
| 47 | 4.75 | 92.0 | 20.8 | 2.1 | 0.05 | | | 13.5 | 0.04 | |
| 50 | 5.9 | 85.8 | 27.8 | 2.1 | 0.09 | | | 11.1 | 0.017 | |
| Range | 3.6<br>5.9 | 85.8<br>92.0 | 1.89<br>63.2 | 1.8<br>2.69 | 0.05<br>0.69 | | | 0.011<br>13.5 | 0.002<br>0.04 | 2.0<br>40.7 |
| Average | 4.94 | 88.4 | 28.27 | 2.15 | 0.22 | | | 3.83 | 0.015 | 19.1 |

* Milliequivalents per 100 grams oven-dry peat.

*Sphagnum peat—Soil reaction, moisture content, chemical composition, and total replaceable bases*

| Sample number | pH | Moisture as received (percent) | Composition of moisture-free material (percent) | | | | | | Total replaceable bases* |
|---|---|---|---|---|---|---|---|---|---|
| | | | Ash | Total N | $P_2O_5$ | $K_2O$ | Cl | S | |
| 1 | 3.7 | 93.4 | 1.63 | 1.18 | 0.09 | | tr. | 0.049 | |
| 24 | 3.9 | 86.8 | 7.13 | 2.22 | 0.17 | tr. | 0.030 | 0.015 | 23.4 |
| 28 | 3.1 | 94.0 | 1.60 | 1.02 | 0.91 | tr. | 0.024 | 0.016 | 25.4 |
| Range | 3.1<br>3.9 | 86.8<br>94.0 | 1.60<br>7.13 | 1.02<br>2.22 | 0.09<br>0.91 | | 0.024<br>0.030 | 0.015<br>0.049 | 23.4<br>25.4 |
| Average | 3.6 | 91.4 | 3.45 | 1.47 | 0.39 | | 0.018 | 0.027 | 24.4 |

* Milliequivalents per 100 grams oven-dry peat.

*Sphagnum—Proximate analysis* of air-dry material*

| | Percent |
|---|---|
| Total ash | 3.89 |
| Water-insoluble ash | 3.79 |
| Acid-insoluble ash | 2.66 |
| Petroleum ether extract | 1.00 |
| Ether extract | 2.01 |
| Chloroform extract | 2.20 |
| Alcohol extract | 6.15 |
| Water extract | 5.58 |
| Volatile oil | slight trace |

* Analysis by Paul A. Tornow (see p. 246).

*Sedimentary peat—Soil reaction, moisture content, chemical composition, and total replaceable bases*

| Sample number | pH | Moisture as received (percent) | Composition of moisture-free material (percent) | | | | | | | Total replaceable bases* |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Ash | Total N | $P_2O_5$ | $K_2O$ | CaO | Cl | S | |
| 3 | 6.5 | 90.0 | 68.6 | 1.65 | 0.11 | | | 0.006 | 0.040 | |
| 4 | 6.2 | 85.3 | 69.2 | 1.12 | 0.10 | | | tr. | 0.010 | |
| 5 | 7.2 | 86.5 | 77.2 | 1.06 | 0.15 | | | tr. | 0.010 | |
| 6 | 7.6 | 88.6 | 75.9 | 0.83 | 0.07 | | | 0.015 | 0.010 | |
| 12 | 5.6 | 79.2 | 74.7 | 1.04 | 0.74 | | | 0.011 | 0.003 | |
| 21 | 6.3 | 95.5 | 33.1 | 2.97 | 0.51 | tr. | | 0.007 | 0.010 | |
| 32 | 6.7 | 90.1 | 59.9 | 1.76 | 0.11 | tr. | 0.43 | 0.009 | 0.022 | 18.1 |
| 40 | 5.6 | 93.0 | 51.1 | 2.37 | 0.22 | tr. | | 0.008 | 0.025 | 11.7 |
| 41 | 5.7 | 87.9 | 50.9 | 1.48 | 0.14 | tr. | | 0.004 | 0.014 | 20.5 |
| 49 | 4.9 | 83.6 | 77.3 | 2.00 | 0.06 | | | 0.014 | 0.006 | |
| Range | 4.9<br>7.6 | 79.2<br>95.5 | 33.1<br>77.3 | 0.83<br>2.97 | 0.06<br>0.74 | | | 0.004<br>0.015 | 0.003<br>0.040 | 11.7<br>20.5 |
| Average | 6.2 | 88.0 | 63.8 | 1.63 | 0.22 | | | 0.007 | 0.015 | 16.8 |

* Milliequivalents per 100 grams oven-dry peat.

*Mixed sphagnum and fibrous peat—Soil reaction, moisture content, chemical composition, and total replaceable bases*

| Sample number | pH | Moisture as received (percent) | Composition of moisture-free material (percent) | | | | | | Total replaceable bases* |
|---|---|---|---|---|---|---|---|---|---|
| | | | Ash | Total N | $P_2O_5$ | $K_2O$ | Cl | S | |
| 23 | 4.8 | 91.9 | 19.5 | 1.75 | 0.97 | tr. | 0.018 | 0.011 | |
| 26 | 3.9 | 85.6 | 4.56 | 3.31 | 0.35 | 0.014 | 0.048 | 0.012 | 18.0 |
| 30 | 4.8 | 92.3 | 3.14 | 1.35 | 0.26 | tr. | 0.005 | 0.007 | 41.1 |
| 31 | 4.1 | 80.4 | 27.2 | 1.03 | 0.10 | 0.013 | 0.034 | 0.010 | 21.5 |
| 35 | 4.5 | 92.5 | 4.12 | 1.76 | 0.69 | tr. | 0.020 | 0.004 | 6.3 |
| 48 | 4.1 | 77.5 | 18.9 | 3.2 | 0.11 | | 0.009 | 0.01 | |
| Range | 3.9<br>4.8 | 77.5<br>92.5 | 3.14<br>27.2 | 1.03<br>3.31 | 0.10<br>0.97 | 0.013<br>0.014 | 0.005<br>0.048 | 0.004<br>0.012 | 6.3<br>41.1 |
| Average | 4.4 | 85.9 | 12.90 | 2.07 | 0.43 | 0.005 | 0.022 | 0.009 | 21.7 |

* Milliequivalents per 100 grams oven-dry peat.

*Mixed sedimentary and fibrous peat—Soil reaction, moisture content, chemical composition, and total replaceable bases*

| Sample number | pH | Moisture as received (percent) | Composition of moisture-free material (percent) | | | | | | | Total replaceable bases* |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Ash | Total N | $P_2O_5$ | $K_2O$ | $SiO_2$ | Cl | S | |
| 8 | 4.9 | 88.8 | 61.1 | 0.91 | | | | 0.083 | 0.014 | |
| 15 | 5.0 | 80.8 | 51.3 | 0.29 | 0.42 | | 47.3 | tr. | 0.005 | |
| 16 | 5.9 | 84.2 | 69.6 | 1.42 | 0.57 | | 56.5 | 0.004 | 0.009 | |
| 42 | 4.8 | 91.3 | 11.5 | 2.78 | 0.15 | tr. | | 0.002 | 0.017 | 22.9 |
| Range | 4.8<br>5.9 | 80.8<br>91.3 | 11.5<br>69.6 | 0.29<br>2.78 | 0.15<br>0.57 | | 47.3<br>56.5 | 0.002<br>0.083 | 0.005<br>0.017 | |
| Average | 5.2 | 86.3 | 48.4 | 1.35 | 0.29 | | 51.9 | 0.022 | 0.011 | |

* Milliequivalents per 100 grams oven-dry peat.

*Miscellaneous mixtures of peat and associated materials—Soil reaction, moisture content, chemical composition, and total replaceable bases*

| Sample number | Materials | pH | Moisture as received (percent) | Composition of moisture-free material (percent) | | | | | | | | Total replaceable bases* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Ash | Total N | $P_2O_5$ | $K_2O$ | CaO | $SiO_2$ | Cl | S | |
| 27 | Fibrous, woody.. | 4.8 | 91.5 | 13.3 | 2.78 | 0.19 | 0.028 | | | 0.024 | 0.015 | 27.6 |
| 36 | Fibrous, woody.. | 3.2 | 83.2 | 1.96 | 2.71 | 0.29 | tr. | | | 0.004 | 0.009 | 2.3 |
| 18 | Fibrous, woody, sedimentary .. | 5.6 | 91.9 | 14.2 | 1.97 | 0.73 | tr. | | | 0.005 | 0.018 | |
| 33 | Fibrous, woody, sedimentary, sphagnum .... | 5.4 | 89.5 | 39.4 | 3.80 | 0.23 | tr. | | | 0.014 | 0.018 | 39.2 |
| 22 | Sphagnum, woody | 3.8 | 68.6 | 13.8 | 1.50 | 0.64 | tr. | | | 0.010 | 0.013 | 8.9 |
| 39 | Sphagnum, sedimentary .. | 3.7 | 94.9 | 1.65 | 1.06 | 0.24 | tr. | | | 0.009 | 0.013 | 16.0 |
| 2 | Sphagnum, fibrous, sedimentary .. | 5.8 | 93.5 | 7.20 | 1.40 | 0.05 | | | | tr. | 0.031 | |
| 19 | Fibrous, muck .. | 6.5 | 78.8 | 48.9 | 1.58 | 1.52 | 0.022 | 2.62 | 44.7 | 0.038 | 0.008 | 116.4 |
| 25 | Fibrous, woody, muck ......... | 4.3 | 89.5 | 9.58 | 1.70 | 0.22 | tr. | | | 0.022 | 0.018 | 34.5 |
| 34 | Fibrous, woody, peat soil ...... | 4.6 | 86.8 | 11.6 | 1.80 | 0.19 | tr. | | | 0.013 | 0.015 | 44.4 |
| 13 | Peat soil ........ | 4.0 | 58.5 | 39.1 | 2.44 | 0.54 | | | | 0.024 | 0.011 | |
| 11 | Sedimentary, marl ......... | 7.6 | 55.0 | 66.3 | 0.29 | 0.52 | | | 23.5 | 0.009 | 0.010 | |
| 45 | Fibrous, marl ... | 6.7 | 90.6 | 14.1 | 3.37 | 0.26 | tr. | | | 0.015 | 0.071 | 113.3 |
| 38 | Fibrous, sand ... | 4.3 | 88.2 | 5.53 | 2.84 | 0.24 | tr. | | | 0.020 | 0.006 | 1.5 |
| 17 | Fibrous, woody, sedimentary, marl, clay, sand ......... | 6.1 | 84.4 | 32.6 | 1.07 | 0.30 | tr. | 2.84 | | 0.007 | 0.026 | 110.5 |
| Range ................ | | 3.2<br>7.6 | 55.0<br>94.9 | 1.65<br>66.3 | 0.29<br>3.80 | 0.05<br>1.52 | 0.022<br>0.028 | 2.62<br>2.84 | 23.5<br>44.7 | 0.004<br>0.038 | 0.006<br>0.071 | 1.5<br>116.4 |
| Average .............. | | 5.1 | 83.0 | 21.28 | 2.02 | 0.41 | 0.004 | 2.73 | 34.1 | 0.014 | 0.019 | 46.78 |

* Milliequivalents per 100 grams oven-dry peat.

*Neutral peat (pH 7.0). Field determinations*

| Deposit | County | Kind of peat | Depth of sample (feet) | Special conditions |
|---|---|---|---|---|
| Bailey Lake .................... | Spokane | Fibrous | 4–5 | Deep marl under the fibrous peat |
| Little Trout Lake............... | Spokane | Fibrous | 49–50 | About 1,000 feet from Bailey Lake, in same flat |
| Lakeside Marsh ................ | Spokane | Sedimentary | 13–14 | Marl present in the deposit |
| Lakeside Marsh ................ | Spokane | Sedimentary | 17–18 | Marl present in the deposit |
| Lakeside Marsh ................ | Spokane | Sedimentary | 21–22 | Marl present in the deposit |
| Deep Creek .................... | Stevens | Fibrous | 3–4 | Marl present in the deposit |
| Deep Creek .................... | Stevens | Fibrous | 6–7 | Marl present in the deposit |
| Deep Creek .................... | Stevens | Fibrous, woody | 13–14 | Marl present in the deposit |
| Cedar Creek ................... | Stevens | Fibrous | 17–18 | Marl present in the deposit |
| Cedar Creek ................... | Stevens | Sedimentary | 21–22 | Marl present in the deposit |
| Crab Lake ..................... | Grant | Fibrous | 5–6 | Deposit in scabland channel. Long stream from scablands flows into deposit |
| Crab Lake ..................... | Grant | Fibrous | 13–14 | Deposit in scabland channel. Long stream from scablands flows into deposit |
| Crockett Lake .................. | Island | Fibrous | 8–9 | Sea water reaches deposit at high tide |
| Beaverton ..................... | San Juan | Sedimentary, woody | 17–18 | No special conditions apparent |

*Alkaline peat. Field determinations*

| Deposit | County | Kind of peat | pH | Depth of sample (feet) | Special conditions |
|---|---|---|---|---|---|
| Fish Lake | Spokane | Fibrous | 7.5 | 4–5 | Deposit in scabland channel. pH of bordering lake, 7.0 |
| Fish Lake | Spokane | Fibrous | 7.5 | 9–10 | Deposit in scabland channel. pH of bordering lake, 7.0 |
| Fish Lake | Spokane | Fibrous | 7.5 | 14–15 | Deposit in scabland channel. pH of bordering lake, 7.0 |
| Fish Lake | Spokane | Fibrous | 7.5 | 19–20 | Deposit in scabland channel. pH of bordering lake, 7.0 |
| Fish Lake | Spokane | Sedimentary | 7.5 | 29–30 | Deposit in scabland channel. pH of bordering lake, 7.0 |
| Fish Lake | Spokane | Sedimentary | 7.5 | 33–34 | Deposit in scabland channel. pH of bordering lake, 7.0 |
| Curlew Lake | Ferry | Fibrous | 7.7 | 0–1 | Marl below the peat |
| Copper Lakes | Ferry | Fibrous | 7.7 | 0–1 | Marl below the peat. Limestone in vicinity |

# CHAPTER VI

# UTILIZATION

## METHODS OF IMPROVING PEAT LANDS

Large areas of peat lands in the state are utilized for pasturage and the growth of crops, considerable amounts of fibrous peat are removed from the deposits and used as soil conditioners, and some peat moss is removed and used as a soil conditioner and for other purposes.

The utilization of peat lands for agricultural purposes usually involves considerable labor and expense, and often 2 years or more must elapse before satisfactory production is attained. Information on agricultural use and management of peat and muck lands is contained in the soil survey reports for King, Kitsap, Snohomish, Whatcom, Clallam, Spokane, Stevens, and other counties. Persons planning to utilize such lands will find it advantageous to consult the departments of Agronomy and Agricultural Engineering at the State College of Washington, the various County Extension Agents, or representatives of the U. S. Soil Conservation Service.

The utilization of peat and muck lands commonly involves drainage, clearing, and mechanical loosening of the surface to permit access of air and sunlight to the soil particles. Drainage may be expensive. In small areas ditches are dug by the owner or by neighborly cooperation, but in larger areas drainage districts have been organized and county, state, or national agencies have cooperated. Clearing of trees and brush is necessary in many areas. Larger trees are logged, and smaller ones are used for fuel or for general use on the farm. The removal of brush by hand is laborious, and machines are now available for reducing brush to small bits which may later be worked into the soil or piled in a safe place and burned. These machines have been used in clearing brushy lands for agricultural use, along brushy highways, and in connection with the pruning of orchards.

Burning as a means of destroying brush and killing trees has been common. If it can be done without setting fire to the peat it is a satisfactory means. If the peat is wet it will not take fire, but if it is even fairly dry it will burn. Peat fires are difficult to extinguish, and much valuable peat has been destroyed where the intent was to destroy the surface vegetation only. Peat fires may persist for a year or more, dying down to a smouldering condition during the winter and blazing up again when summer comes. Fire as a means of clearing peat areas should be used only in areas where careful investigation has shown that valuable peat and other organic matter will not be sacrificed. In case of doubt it is well to consult with Soil Conservation officials, the County Extension Agent, or other agricultural experts.

Some peat areas are cleared by mowing, where the vegetation is composed mostly of herbaceous plants such as reeds, sedges, and grasses. Whatever means of clearing is used, the surface of the deposit is commonly stirred up by some mechanical means to loosen it and thus allow air to come into contact with the particles of organic matter. Probably sunlight also promotes some desirable chemical processes. Various types of agricultural implements, mostly discs, are used for this purpose.

## AGRICULTURAL UTILIZATION OF PEAT LANDS

The use of peat lands for pastures, either improved or unimproved, is common, and some good pastures have been established. Several pasture grasses do at least fairly well on peat soils. Clover is often planted, as are mixtures of clover and timothy. These desirable forage plants must, however, compete with undesirable native plants and with farm weeds. The native sedges and reeds and also some shrubs are persistent and difficult to eradicate. One rush (*Juncus effusus*), which grows in tussocks often a foot or more in diameter, is one of the worst. Hardhack (often called buckbrush) is also troublesome. Some herbaceous marsh plants also survive in these pastures. Skunk cabbage is among the most troublesome ones. Farm weeds invade these pastures and are very detrimental. Thistles, including the Canadian thistle, are among the most troublesome weeds, and field horsetail (scouring rush) and field plantain are common invaders. Many other weeds also contribute to the deterioration of these pastures. Some peat-land pastures are so poor that they are little more than places for domestic animals to roam. On some farms peat areas are fenced in together with good pastures which are on higher land.

Good crops of hay are produced on many peat areas. Several grasses suitable for hay flourish on peat soils. Oats are commonly raised for hay. Clover is also frequently used, and alfalfa occasionally, but these legumes require that peat soil be well limed to counteract natural acidity. Some of the hay fields are weedy or even brushy, and there are all gradations from good to very poor. Some are so poor that they have been abandoned. An interesting example of the successful use of peat land for the production of hay is seen in Island County, on the Miller Lake peat deposit, where the peat (fibrous and sedimentary) is 39 feet deep. The crop was good in 1950, and at that time the surface was firm enough for the use of tractor-drawn equipment.

The most common agricultural crop on peat soils in both eastern and western Washington is oats. Wheat, barley, and peas are grown on some peat soils, but information on the quality of the crops is not at hand. Mustard was being grown on one peat area in eastern Washington in 1949.

Good crops of oats for threshing are produced in peat areas where the amount of water, at the depth to which the roots of the plants extend, is suitable—not too much, and not too little. An example was seen in 1949 on the peat area at the south end of Newman Lake in Spokane County. The crop in general was good, though it was poor in a few small patches. In some other areas in the same county the peat near the surface was so dry that the plants were short, and very few seeds matured.

FIGURE 263.—Truck garden on peat soil, Seattle.

Truck gardens and farms on peat soil are common in western Washington, and there are a considerable number of them in the eastern part of the state. Among the crops grown are cabbage, lettuce, cauliflower, spinach, broccoli, celery, rhubarb, beets, carrots, beans, peas, corn, potatoes, and strawberries. These crops do well, but mineral fertilizers are usually necessary. Some peat areas are utilized for the production of nursery stock. Rhododendrons are commonly grown. Perennial flowers, bulbs, and rock-garden plants are also grown.

Cranberries are extensively grown on peat and muck soils where climatic conditions are favorable and plenty of water is available. In Washington, these conditions are found mainly in the sandy regions along the shore of the Pacific Ocean. The three principal areas of production are the Long Beach peninsula area in Pacific County, the North Beach area in Grays Harbor County, and the Grayland area in Pacific and Grays Harbor Counties. Though many of the individual commercial cranberry bogs are small, the total runs to about a thousand acres. Some are 2 acres or even less in area, others are 20 acres or more, and larger ones are in preparation. Some native sphagnum bogs have been utilized for commercial cranberry bogs, but most of the utilization has been of areas of fibrous peat, mucky peat, or muck.

A few small commercial cranberry bogs are farther from the ocean and are not in sandy regions. The Wessler bog in Clallam County (about 4 acres) is in a peat area of 23 acres, about 7 miles from the ocean. Two small commercial bogs (Granite Falls peat area in Snohomish County and Bingaman Lake peat area in King County) are many miles from the ocean. Other places where cranberries have been produced (but the bogs are now abandoned) are the Gurley Creek peat area in Kitsap County, Milton peat area No. 2 in Pierce County, the Misner farm area in King County, and the Woodward Creek area in Thurston County. Several local reports of abandoned commercial cranberry bogs and of preparations for the establishment of bogs at a distance from the ocean have not been verified.

The plants used for commercial production in Washington are varieties of the large cranberry (*Vaccinium macrocarpon*) of eastern United States. The small cranberry (*V. oxycoccus*) which is abundant in native sphagnum bogs in Washington is suitable for domestic use for jams and jellies but not for commercial production.

The problem of marketing cranberries has been solved by cooperation and the fixing of standards among the growers in the areas near the Pacific Ocean. Growers at a distance from these main areas have sold most of their berries locally or have been able to meet the standards set by the cooperatives.

Blueberries are extensively produced on peat and muck soils in Washington, and there is also some production on other types of soil. Some of the production is near the shore of the Pacific Ocean, and some in the western part of the state is rather far removed from the ocean. The size of the production areas ranges from an acre or 2 up to 25 acres or more. Production is fairly extensive in Pacific, King, and Thurston Counties, and there is considerable production in other counties. New areas are being planted, and production is increasing. Marketing has been facilitated by cooperation among the producers. The

Cranberry-Blueberry Experiment Station of the State College of Washington near Long Beach in Pacific County, under the supervision of Professor D. J. Crowley, has been an important factor in the production of both cranberries and blueberries in the state.

Mint is grown in both eastern and western Washington, but less of it is grown on peat and muck soils than on other soil types. The acreage on peat and muck soils in western Washington is considerable, but in the eastern part of the state it is small. The largest area (250 acres) on peat is on the Fargher Lake deposit in Clark County. This peat was formerly used for the production of oats and truck crops, but the change to mint is now practically complete. The oil is distilled locally and sold to buyers in the state or elsewhere. Some mint is grown on the Orchards peat area in the same county, and a small amount of dill is also grown there. The dill is handled and marketed in the same way as the mint.

## OTHER IN SITU USES FOR PEAT LANDS

Some peat areas which are flooded during at least part of the year are natural feeding and nesting areas for ducks and other waterfowl, and in some areas fees for shooting privileges are a source of income to the owners. In some areas oats or other crops are grown in summer when the peat surface is free from water, and waterfowl hunting is done in other seasons when the areas are flooded.

There have been some attempts at using bog lakes for muskrat farms, but, so far as information is available, all these farms have been abandoned. In some instances considerable sums of money have been spent in surrounding the areas with fences which it was hoped would be muskrat proof.

The utilization of sphagnum bogs for the production of crops and as places for the construction of buildings merits special discussion. The sphagnum bogs are mapped as Greenwood peat on the soil maps. The distinctive structural, physical, and chemical properties of sphagnum moss, which are discussed in chapter II, impart distinctive characters to the soils which result when sphagnum areas are cleared and drained. Pure raw sphagnum is a very loose acidic material which is unsuitable for the growth of crop plants. It is more suitable if disintegration and decomposition have gone on to such an extent that the material is almost completely humified. If sedges or other fibrous plants have grown with the sphagnum, the resulting peat is somewhat better than pure sphagnum for crop production.

Mechanical equipment is now commonly used in converting these bogs into farms or gardens, but in pioneer days hand labor was usual. Much of this labor was done by Orientals. The procedure used long ago in transforming a wet sphagnum bog into a successful truck garden may be illustrated by describing what was done by Japanese on such an area along Meridian Avenue in the northern part of Seattle. Drainage ditches were dug, trees and brush were removed, the surface material to a depth of a foot or more was scalped off, mainly by the use of large hoes, and this material was removed by the use of wheelbarrows operated on planks and was piled at the margin of the bog. The surface of the scalped bog was then spaded and allowed to lie exposed to the air and the sun of summer and the rains of winter for a year or two. Lettuce, cabbage, carrots, onions, and other truck crops were then planted. A flourishing truck garden was thus established, but as the city grew the ownership changed and the area was platted. Streets were made passable by the use of fill dirt, and some fill dirt was used on lots. Houses were built and occupied, and now the Japanese are gone and garden truck is raised only in back yards.

A few small sphagnum bogs in Seattle passed directly from their natural condition to sites for small homes. The construction of houses was begun without adequate investigation of the material on which they were to rest, and difficulties were encountered. Some concrete foundations sank into the bog before the houses were finished. Some occupied houses sank irregularly 2 feet or more. Some concrete sidewalks sank a few feet, and some of them on the margins of the areas moved sidewise as much as 4 feet. One bulldozer plunged into the soft peat and was recovered only with difficulty. Water stood in basements. The use of fill dirt finally was resorted to in some areas. Although occupied houses now stand on most of the lots, many of them are without basements. Adequate investigation is now commonly made, and construction methods suitable to the terrane are employed. One building several stories high now stands on an old sphagnum bog. It rests on groups of 4 or 6 piling capped with concrete; the piling are driven down to hard soil (16 feet).

## PEAT REMOVAL AND UTILIZATION

Though the total acreage of peat deposits in the state utilized for crop production is greater than that utilized for any other purpose, the removal of peat and its use as soil conditioners and for other purposes is economically important. Much peat, especially in the northern part of the Puget Sound province, is removed and used in various ways. The two kinds most commonly removed are fibrous peat and moss peat. Though the methods of removal of these two kinds of peat and the uses to which they are put have much in common, they differ enough to make it convenient to discuss them separately.

Fibrous peat is removed by the use of draglines, scoops running on endless cables, power shovels, or clamshell dredges. Most of the machinery is supported and moved about on the surface of the peat or on planks or larger wooden supports, but some of it is on scows floating on a lake or pond. The peat is dumped directly into trucks or into loading bins. Some of it is sold in bulk in the wet condition, but some is dried and ground in mills and stored for retail sale in gunny sacks or in plastic bags or paper cartons of various sizes. The tendency now is toward the use of smaller packages. These sell well, and the price realized per pound is higher. In deeper excavations some sedimentary peat is removed with the fibrous peat, and near the margins of the deposits some muck may be included. Small amounts of woody peat are sometimes included also. Pure fibrous peat and its mixtures with muck and sedimentary peat are often sold under the name of humus, or sometimes leaf mold.

Wet peat is used extensively on large areas that are being landscaped, but it is also used on small gardens and in preparing new lawns. Smaller bags or packages of dried ground peat are purchased mostly by persons who grow potted plants in the home or flowers around the home. Commercial growers purchase it in form and quantity best suited to their needs.

Sphagnum moss is sold in garden stores, hardware stores, and also in markets in which food is sold. The demand is so great that almost any kind of store may find it advantageous to handle it. Most of it comes at present from British Columbia, Canada, and comparatively little comes from deposits in the state of Washington. In the past it has been sold mostly in bales, and much of it still comes in that form, but the tendency now is to put it into plastic bags or paper cartons. Many of the bags and cartons are small and easily handled.

In past years, excavation of peat moss from the bogs was mostly by hand by the use of special spades, and the material was dried in the sun and then shredded and baled. The tendency now is toward removal by power machinery, artificial drying, and small packaging. Large quantities of moss are, however, still handled by the old standard methods.

The sphagnum moss which is removed from the bogs in Washington or imported from Canada and used for various purposes is mostly moss which grew many years ago and is now so thoroughly compacted that it can be removed in the form of blocks. In Wisconsin and perhaps in other states, moss which grew only 5 years or less ago and is only slightly, if at all, compacted is being harvested and used. Methods of tending the moss areas in order to improve the quality and quantity of the yield have been devised, and methods of harvesting the loose moss and baling it for the market have been developed. Some success has been attained in the management of mossing areas on the basis of a sustained yield with a 3- to 5-year rotation. The demand and the price have been sufficient to induce a considerable number of persons to invest time and money in the moss industry.

The more important facts in regard to the moss industry in Wisconsin® can be briefly stated.

Moss has been harvested on sandy marshy lands in central Wisconsin since about 1885. In some of the townships within the 1,200-square-mile commercial mossing area, more than 75 percent of the total land area is marsh land. The native vegetation on these marsh lands includes sedges, grasses, 3 species of *Sphagnum* moss, scrub willows, hardhack, and other shrubs, and some small coniferous trees, mostly spruce.

Moss harvesting starts as soon as the moss marshes are ice free after the spring runoff. Moss is gathered with special 4- or 5-tined short-handled rakes comparable to potato hooks. The moss is air dried in the field and is then compressed into bales measuring 14 by 14 by 45 inches and weighing 18 to 22 pounds.

® Written communication from L. P. Voight, Director, Conservation Department of the State of Wisconsin.

Until 1951 the natural supply of this Wisconsin peat far exceeded the demand. Since that date special efforts have been made to increase the quality and quantity of the moss available for harvest on some areas. Quadrants have been established to test the effectiveness of (1) moderate compaction of the sedge and moss vegetation, (2) "seeding" by the use of rakings from the drying beds, (3) the use of chemical herbicides, and (4) controlled burning to get rid of trees, shrubs, and other undesirable vegetation. Final results are expected at the close of the 1956 growing season, but it is already determined that "the use of fire; i. e., prescribed burning, is of little benefit in moss management. On the lands under the jurisdiction of the Department of Conservation it is carried on only when the marshes are frozen and when they are sufficiently wet to protect the moss, or within a few days prior to harvest. The chief value of the fire is to eliminate the over-story of sedges and grasses to enable the crop to be more efficiently harvested. Prescribed burning is, therefore, limited to a single burn per rotation."

Some marshes have been under the management of the Department of Conservation of the State of Wisconsin since 1940, and it is the opinion of the field men that those areas which were intensively worked during this period have improved in both quality and quantity of yield.

The average production on these well-tended state-administered marshes is 50 to 60 bales per acre per year. Some good, well-tended marshes have produced twice that much. In 1955 wholesalers were paying $1.00 per bale for stave and wire bales and $1.25 per bale for burlap-wrapped bales.

The uses of sphagnum moss in Wisconsin at present are for packing tree, shrub, and flower stock, the rooting of various plants, as a medium to start new plants, as base materials for floral wreaths, anglers' bait-box filler, and a mulch material for new seedlings and plantings.

Approximately 50 percent of the crop is harvested on public lands. On these lands it is sold on a "stumpage" basis. Small operators have as little as $200 invested in mossing equipment and produce as little as 300 to 2,000 bales per year. A few of the larger producers have as much as $10,000 invested in such mossing equipment as crawler tractors, trucks, canvas, wagons, mechanical spreaders, rakes, and wheel tractors. Such operators produce 10,000 to 20,000 bales per year.

When heavy market demands caused prices to soar, moss users looked for and found substitute materials. Included in these materials are vermiculite, spun glass, shingle tow, and polyethylene wrappings.

These facts about moss production in Wisconsin naturally suggest the utilization of swampy areas of waste land in Washington for commercial production of moss. Among the questions which would have to be answered in deciding whether a moss industry is possible in this state are these: (1) Are suitable areas of sufficient size on either publicly or privately owned land available? (2) Can methods of tending and harvesting which are suitable to the climate of either eastern or western Washington, or both, be developed? (3) Could moss produced in this way compete with moss now available and with substitute materials now available?

Definite answers cannot be given to these questions without special investigations, but some comments may be made.

There are considerable areas of marshy or swampy land in both western and eastern Washington. These areas vary from swamp forest to sedge meadows. As recently as 1920 there were still bogs in western Washington on which sphagnum loose enough to be handled by the use of pitchforks was growing in abundance. Clearing, drainage, and burning have so modified these bogs that very little moss now remains in them. No insurmountable difficulties in the development of methods of tending and harvesting are foreseen. Moss produced in Washington on the Wisconsin plan would have to compete with the baled or packaged moss produced in Washington or imported from Canada, and possibly with one or more of the substitute materials listed above.

The largest uses of peat moss in Washington are for soil conditioners and chicken litter. Some moss which has been used as chicken litter and has thus absorbed manure is later used as combined fertilizer and soil conditioner. Products having these combined properties are also prepared by adding organic or mineral fertilizer to the moss as it comes from the grinding and dehydrating plant. The organic materials commonly added are byproducts from the processing of fish or whales. The minerals added are preparations containing suitable amounts of phosphates, potash, and nitrogen. Several products of these two kinds have appeared on the market during recent years, and there is now an established demand for them. Fibrous peat as well as moss peat is sometimes treated in this way.

During recent years much peat moss has been used in the packing of asparagus for the market. A thin moist sphagnum mat is placed in the bottom of the crate, and the cut ends of the asparagus stems are placed directly on it. This keeps the stems moist without promoting decay, and the practice is advantageous to both producer and dealer. Sphagnum is also used in the germination of seeds and for various purposes in scientific laboratories. It is also extensively used in greenhouses and by florists. To some extent, it has also been used for insulation in small buildings.

Peat has had small use for fuel in some parts of the United States in the past and is still an important fuel in some countries, but it has never been used for this purpose in Washington, and it is unlikely that it ever will be. Living *Sphagnum* was harvested in this state during World War I for use in surgical compresses, but it has been supplanted for this use by other materials. Peat has been used temporarily or experimentally for other purposes in the past, and it is likely that totally new uses may be discovered in the future. Special opportunity exists for the development of a use for sedimentary peat, which occurs in large quantities in the state, but for which no use has as yet been found.

## PEAT INDUSTRY IN THE UNITED STATES

Information in regard to the production and use of peat in the United States during the past few years has recently been published by the United States Bureau of Mines (Sheridan and DeCarlo, 1957).

During recent years Florida and Washington have been the principal peat-producing states. In 1955 Florida produced 61,098 net tons of peat valued at $231,829, and Washington produced 37,640 net tons valued at $113,254. In that year these two states together produced 36 percent of the total for the United States. From 1951 through 1954 Washington's production was greater than that of any other state.

Other states or groups of states producing 20,000 net tons or more in 1955 were New Jersey and New York, 31,980 net tons; Illinois, Indiana, and Iowa, 31,520 net tons; Michigan, Minnesota, and Wisconsin, 29,793 net tons; Pennsylvania, 23,277 net tons; Ohio, 22,484 net tons; and California, Colorado, and Idaho, 20,207 net tons. Smaller amounts were produced in the New England States and in Georgia and Texas.

For the purposes of collecting and compiling economic and statistical data on the peat industry the Bureau of Mines has classified peat into three general types—moss peat, reed-sedge peat, and peat humus.

Moss peat consists chiefly of the poorly or moderately decomposed stems and leaves of several species of *Sphagnum*, *Hypnum*, and other mosses.

Reed-sedge peat consists chiefly of the poorly or moderately decomposed remains of reeds, canes, and reed-like grasses and sedges such as wire grass, saw grass, rushes and cattails.

Peat humus is peat which is so decomposed that its biological identity has been lost.

In 1955 the production and value of these types was: moss peat, 32,449 tons, valued at $424,143; reed-sedge peat, 83,694 tons, valued at $976,236; peat humus, 127,085 tons, valued at $804,921; and other materials of plant origin (mainly muck), 30,441 tons, valued at $77,565. In that year 82 producers in 18 states reported the production of peat.

The apparent consumption of peat in the United States may be considered equal to domestic production plus imports, as little, if any, peat is exported, and normally, none is stocked. In 1955 the apparent consumption was 502,979 net tons. Of this, 273,669 net tons was produced in the United States and 229,310 net tons was imported. The average value per ton of the domestic peat was $8.34 and of the imported peat was $40.39 per ton.

In 1955, 51 percent of the imported peat came from West Germany, 45 percent from Canada, and the remaining 4 percent from Netherlands, Denmark, Ireland, Finland, United Kingdom, and Sweden. Nearly all imported peat is sphagnum-moss peat.

In the United States peat is used chiefly for soil-improvement purposes—for constructing and improving lawns and golf-course greens, improving garden soils, and growing plant life in general.

Peat is found in 30 states in the United States, the principal deposits occurring in Minnesota, Wisconsin, Florida, Michigan, New York, Virginia, and North Carolina. The 16 states in the northern region of the United States—the New England states, the states bordering the Great Lakes, and Iowa—contain 80 percent of the total deposits of the country. The 7 states in the Atlantic Coast region, including Florida, contain 19 percent of the total. The remaining 1 percent is in the Pacific Coast states and the Gulf states.

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# APPENDIX

**List of plant names—common and botanical**

- alder ........ *Alnus* sp.
  - late ........ *Alnus sinuata* (Regel) Rydb.
  - mountain ........ *Alnus sinuata* (Regel) Rydb.
  - red ........ *Alnus rubra* Bong.
- apple ........ *Malus* sp.
  - wild crab ........ *Malus fusca* (Raf.) Schneid.
- ash ........ *Fraxinus oregana* Nutt.
- aspen ........ *Populus* sp.
  - trembling ........ *Populus tremuloides* Michx.
  - quaking ........ *Populus tremuloides* Michx.
- aster ........ *Aster* sp.
- bedstraw ........ *Galium* sp.
- bilberry (blueberry) ... *Vaccinium* sp.
  - bog ........ *Vaccinium uliginosum* L.
  - dwarf ........ *Vaccinium caespitosum* Michx.
- birch ........ *Betula* sp.
  - peat-bog ........ *Betula glandulosa* Michx.
  - western ........ *Betula papyrifera* var. *occidentalis* (Hook.) Sarg.
- blackberry ........ *Rubus* sp.
  - evergreen ........ *Rubus laciniatus* Willd.
- buckbean ........ *Menyanthes trifoliata* L.
- bunchberry ........ *Cornus canadensis* L.
- bur reed ........ *Sparganium* sp.
- buttercup ........ *Ranunculus* sp.
- cascara ........ *Rhamnus Purshiana* DC.
- cattail ........ *Typha latifolia* L.
- cedar ........ *Thuja plicata* D. Don.
- chickweed ........ *Cerastium* sp. and *Stellaria* sp.
- clover
  - alsike ........ *Trifolium hybridum*
- cottonwood ........ *Populus trichocarpa* T. and G.
- cranberry ........ *Vaccinium* sp.
  - commercial ........ *Vaccinium macrocarpon* Ait.
  - large ........ *Vaccinium macrocarpon* Ait.
  - native ........ *Vaccinium oxycoccus* L. var. *ovalifolium* Michx.
  - small ........ *Vaccinium oxycoccus* L. var. *ovalifolium* Michx.
  - wild ........ *Vaccinium oxycoccus* L. var. *ovalifolium* Michx.
- cress, water ........ *Roripa nasturtium aquaticum* (L.) S. and T.
- crowberry ........ *Empetrum nigrum* L.
- devilsclub ........ *Echinopanax horridum* (Smith) Miq.
- dock ........ *Rumex* sp.
- dogwood ........ *Cornus* sp.
  - herbaceous ........ *Cornus canadensis* L.
  - swamp ........ *Cornus stolonifera* Michx.
  - tree ........ *Cornus nuttallii* Audubon
- Douglas fir ........ *Pseudotsuga taxifolia* Britt.
- duckweed ........ *Lemna minor* L.
- elderberry ........ *Sambucus* sp.
  - blue ........ *Sambucus caerulea* Raf.
  - red ........ *Sambucus (leiosperma* Geid.) *callicarpa* Greene
- fennel, dog ........ *Anthemis Cotula* L.
- fern
  - bracken ........ *Pteridium aquilinum pubescens* Underw.
  - deer ........ *Blechnum spicant* (Linne) Weiss
  - swamp ........ *Athyrium filixfemina* (Linne) Roth
  - sword ........ *Polystichum munitum* (Kaulfuss) Presl.
- fireweed ........ *Epilobium angustifolium* L.
- fivefinger
  - marsh ........ *Potentilla palustris* (L.) Scop.
- forget-me-not ........ *Myosotus laxa* Lehm.
- gentian ........ *Gentiana* sp.
  - blue ........ *Gentiana sceptrum* Griseb.
  - white ........ *Gentiana Douglasiana* Bong.
- glasswort (samphire or salthorn) ........ *Silicornia pacifica* (Mill) Standl
- goldenrod ........ *Solidago* sp.
- grass
  - arrow ........ *Triglochin maritima* L.
  - cotton ........ *Eriophorum chamissonis* C. A. Meyer
  - quack ........ *Agropyron repens* (L.) Beauv.
  - reed canary ........ *Phalaris arundinacea* L.
  - salt ........ *Distichlis spicata* (L.) Greene
  - velvet ........ *Holcus lanatus* L.
- hardhack ........ *Spiraea Douglasii* Hook.
- heath shrub ........ any shrub of the family Ericaceae; e. g., Labrador tea and bog laurel
- hellebore, false ........ *Veratrum*
- hemlock ........ *Tsuga heterophylla* (Raf.) Sarg.
  - mountain ........ *Tsuga mertensiana* (Bong.) Sarg.
- hornwort ........ *Ceratophyllum demersum* L.
- huckleberry ........ *Vaccinium* spp.
  - evergreen ........ *Vaccinium ovatum* Pursh
  - fool's ........ *Menziesia ferruginea* Smith
  - red ........ *Vaccinium parvifolium* Smith
- knotweed ........ *Polygonum* spp.
- Labrador tea ........ *Ledum groenlandicum* Oeder and *L. columbianum*
- laurel ........ *Kalmia* sp.
  - bog ........ *Kalmia polifolia* Wang and *K. microphylla* (Hook.) Heller
- lily
  - of the valley (wild) . *Unifolium bifolium Kamtschaticum* (Gmel.) Piper
  - prairie ........ *Lilium* sp.
  - tiger (wild) ........ *Lilium columbianum* Hanson
  - water ........ *Nuphar polysepalum* Engelm. and *Castalia* sp.
- liverwort ........ *Marchantia*
- lousewort ........ *Pedicularis* sp.
- maple ........ *Acer* sp.
  - big-leaf ........ *Acer macrophyllum* Pursh
  - vine ........ *Acer circinatum* Pursh

marestail .............. *Hippuris vulgaris* L.
marshlock
  purple .............. *Comarum palustre* L.
milfoil
  water ............... *Myriophyllum* sp.
mint .................... *Mentha* spp.
moss
  feather ............. *Hylocomnium splendens* (Hedw.) B. S. G.
  Hypnum .......... *Hypnum* spp.
  peat ................ *Sphagnum* spp.
  pigeon wheat ...... *Polytrichum* sp.
  Sphagnum .......... *Sphagnum* spp.
monkey flower ......... *Mimulus* spp.
moneywort ............ *Lysimachia thyrsiflora* L.
nettle ................. *Urtica Lyallii* Wats.
ninebark .............. *Physocarpus capitatus* (Pursh) Tientze
orchid .................. any species of the family Orchidaceae
  white .............. *Habenaria leucostachys* (Lindl.) Wats.
pine .................... *Pinus* sp.
  lodgepole ........... *Pinus contorta* Dougl.
  white .............. *Pinus monticola* Dougl.
plaintain .............. *Plantago major* L.
  water ............... *Alisma Plantago-aquatica* L.
pondweed ............. *Potamogeton* sp. and *Zannichellia palustris* L.
reed .................... *Phragmites communis* Trin.
rhododendron .......... *Rhododendron macrophyllum* G. Don
rose .................... *Rosa* spp.
  wild ................ *Rosa* spp.
rush .................... *Juncus* spp.
  beak ............... *Rynchospora alba* (L.) Vahl.
  scouring ............ *Equisetum* spp.
  spike ............... *Eleocharis* spp.
St. John's wort......... *Hypericum anagalloides* C. and S.
salal ................... *Gaultheria shallon* Pursh
salthorn ............... (see glasswort)
salmon berry ........... *Rubus spectabilis* Pursh
samphire .............. (see glasswort)
sedge ................. *Carex* spp.
silver weed ........... *Potentilla anserina* L.
skunk cabbage ......... *Lysichitum americanum* Hulten and St. John
smartweed ............. *Polygonum* sp.
spiraea (spirea) ....... *Spiraea Douglasii* Hook.
spruce ................. *Picea sitchensis* (Bong.) Carr.
stonewort ............. *Chara* sp.
star flower ............ *Trientalis* sp.
  arctic ............... *Trientalis arctica* Fisch.
  bog ................. *Trientalis latifolia* Hook.
strawberry ............ *Fragaria* sp.
sundew ............... *Drosera* sp.
  long-leaf ........... *Drosera anglica* Huds.
  round-leaf .......... *Drosera rotundifolia* L.
sweet gale ............. *Myrica gale* L.
tansy
  goose (silver weed) . *Potentilla anserina* L.
thistle ................. *Cirsium* spp.
  Canadian ........... *Cirsium arvense* (L.) Scop.
tufted moneywort ..... *Lysimachia thyrsiflora* L.
tule ..................... *Scirpus acutus* Muhl.
twinberry
  black ............... *Lonicera involucrata* Banks
twinflower ............ *Linnaea borealis* L. var. *americana* (Forbes) Rehd.
violet .................. *Viola* spp.
  blue ................ *Viola* sp.
  white ............... *Viola* sp.
  yellow .............. *Viola* sp.
water celery ........... *Oenanthe sarmentosa* Presl.
water shield ........... *Brasenia Schreberi* Gmel.
water weed ............ *Elodea*
wax myrtle ............ *Myrica californica* Cham.
willow ................. *Salix* spp.
  bog ................. *Salix* sp.
wintergreen ........... *Pyrola* sp.
yarrow ................ *Achillea millefolium* L.

## INDEX

### A



### B



### C

**N**



**O**



**P**

**T**



**U**



**V**



**W**