DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGY AND EARTH RESOURCES

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SURFICIAL GEOLOGY OF THE SPRINGDALE AND FOREST CENTER QUADRANGLES, STEVENS COUNTY, WASHINGTON

by

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PURPOSE OF INVESTIGATION

The purpose of the mapping project was to provide a large-scale (1:24,000) reconnaissance surficial geologic map of the 7½-minute Springdale and Forest Center quadrangles in Stevens County, Washington. The product is to be used to enhance land-use planning and ground-water investigations in the study area, to provide a better understanding of local Quaternary glacial history, and as a compilation base for part of the U.S. Geological Survey's proposed Quaternary Map of the United States Series.

Existing geologic maps of the two quadrangles are small-scale, emphasize bedrock geology, and do not subdivide Quaternary deposits. The present mapping project resulted in the differentiation of Quaternary glaciofluvial, glaciolacustrine, alluvial, and talus deposits.

PREVIOUS INVESTIGATIONS

Previous, unpublished geologic mapping of the study area was done as part of the Chewelah 30-minute quadrangle by R. H. B. Jones (1928). The Springdale quadrangle was included in the published geologic map of the Loon Lake 15-minute quadrangle by F. K. Miller (1969). Both maps emphasize bedrock geology and present Quaternary sediments as a single undifferentiated unit. R. F. Flint (1936) discussed the deglaciation of eastern Washington, including the Colville Valley. Van Duyne and Ashton (1915) prepared a comprehensive soils map of Stevens County. Although detailed reports of surrounding areas are available, many of the investigations dealing with the study area proper are regional in nature, with little specific information. Pertinent investigations in the general region of the study area are listed in the reference section.

FIELD METHODS

Field investigations of the Springdale and Forest Center quadrangles surficial reconnaissance mapping project was completed throughout the month of August, 1979. Aerial photography, at a scale of 1:62,500, was employed in the mapping project. Field mapping was completed equally on foot and by field vehicle. Contacts of geologic units were delineated on aerial photographs, then verified in the field. An altimeter was employed to establish several contacts. Information was recorded directly on 7½-minute quadrangle base maps and in field notes, now on file in the Division's Stevens County field-notes file.

Determination of mappable units was based on the fact that previous geologic mapping emphasized bedrock and combined all surficial deposits under a single undifferentiated unit. Sedimentary units were differentiated on the basis of thickness, areal extent, geomorphologic expression, depositional sequence, and compositional and textural variations. Glacial drift was subdivided into outwash and till because of the value of differentiation to ground water investigations.

Bedrock contacts in the Springdale quadrangle were copied directly from F. K. Miller's map of the Loon Lake quadrangle. R. H. B. Jones' unpublished map of the Forest Center quadrangle was used as a guide to mapping; however, all bedrock contacts were reestablished by the author.

LOCATION AND DRAINAGE

The Springdale and Forest Center 7½-minute quadrangles are located in the southern part of Stevens County, northeastern Washington, about 25 miles northeast of Spokane. They are bounded by latitudes 48°00' and 48°07'30" and longitudes 117°37'30" and 117°52'30". The study area is part of the Okanogan Highlands physiographic province and has a mature topography, modified by glacial deposits. Elevations range from 1,700 feet, along the valley of the Colville River in the northeastern corner of the Forest Center quadrangle, to 3,336 feet, in the highlands of the southern portion of the Springdale quadrangle.

The study area is drained by Chamokane Creek which flows southward into the Spokane River and Colville River which flows northward into the Columbia River, the ultimate drainage of the entire county. Most of the streams in the Colville-Chamokane drainage are shallow, underfit, sluggish, and swampy; many are intermittent.

The Colville River originates from springs that emerge from glacial outwash east of Springdale. From the springs west to the floor of the Colville-Chamokane Valley, the stream is called Sheep Creek. From that point it turns abruptly north and becomes the Colville River. The river's main tributaries in the study area, Deer and Hesseltine Creeks, have incised moderately deep, narrow valleys down the steep faces of the basalt highlands but become shallow and sluggish where they cross meadows along their courses.

Chamokane Creek originates in the Huckleberry Mountains to the west of the study area, and flows in an easterly direction across Camas Valley to the floor of the Colville-Chamokane Valley at Springdale. There, it turns abruptly south and is slightly entrenched in a complex system of gravel outwash terraces. With few tributaries, it drains about 200 square miles of the south-central part of Stevens County.

The Colville River and Chamokane Creek flow within 1 mile of each other at Springdale before they turn respectively to the north and south. No perceptible drainage divide separates the two streams. The divide is probably in the outwash fill rather than the buried bedrock of the Valley floor (Flint, 1936).

Throughout the bedrock upland of the study area, several glacial tarns occupy small basins. Numerous kettle ponds occur throughout the study area, with the greatest concentration in the Pinedale end moraine of the Colville ice lobe west of Springdale. Loon Lake, in the southeastern corner of the Springdale quadrangle, was impounded by glacial outwash deposits.

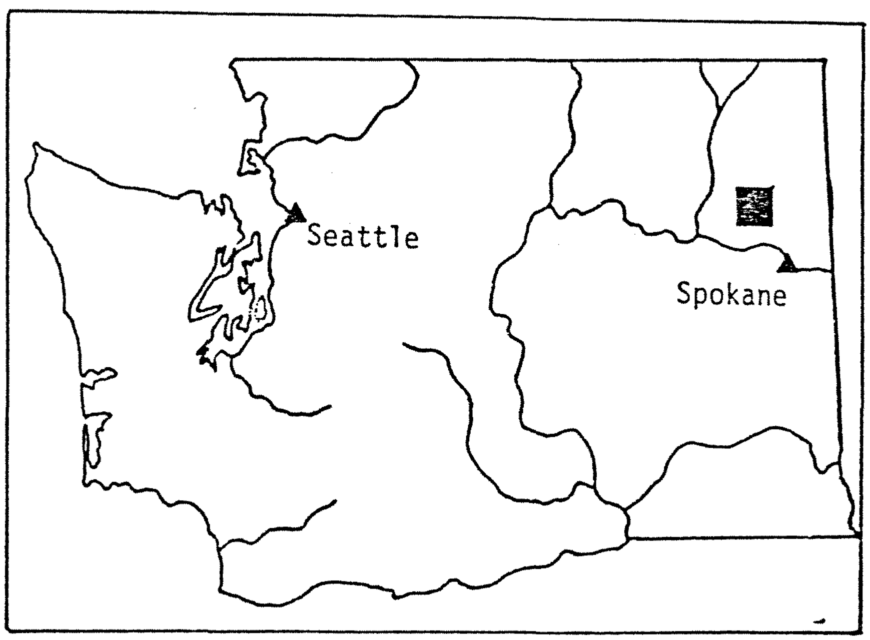

Figure 1. Index map showing location of Springdale and Forest Center quadrangles.

GEOLOGIC SETTING

A basement complex of pre-Tertiary plutonic and metasedimentary rocks represent the oldest bedrock in the study area. Basaltic lava of the Columbia River Basalt Group flowed into the area from the Columbia Plateau to the south and mantled much of the basement rock during the Miocene.

In Pleistocene time, the Colville lobe of the Cordilleran Ice Sheet moved into the area from the north at least twice and covered most of the area with several hundred feet of ice. Glacial scouring removed most of the basalt bedrock, leaving basalt mesas in the southwestern portion of the study area and erosional remnants throughout the northeastern portion. Tremendous quantities of glacial debris were carried into the area by the ice and deposited by melt water in glacial lakes, on outwash plains, in kame terraces, and directly by the ice as moraines.

In Recent time, following retreat of the glaciers, silty alluvium veneered high meadows and developed along modern streams, abandoned outwash channels and in kettle ponds. Peat and muck deposits occupy the same environments.

BASEMENT ROCKS

Precambrian to pre-Tertiary metasedimentary and Cretaceous plutonic rocks (pTu) underlie the study area, forming the basement complex upon which younger rock units rest (Becraft and Weis, 1963; Miller, 1969). The metasediments are predominantly quartzite, siltite, argillite, crystalline limestone, and dolomite. They crop out predominantly in the Springdale quadrangle and the extreme northwestern corner of the Forest Center quadrangle. The highlands have a surface of considerable relief because folding and tilting of the metasediments exposed less-resistant strata to selective removal by erosional agents, predominantly glacial ice. Plutonic rocks, the most widespread bedrock in the study area, crop out mostly in the southern half of the Springdale quadrangle. Granitic rocks of the Loon Lake batholith predominate, composed chiefly of granodiorite and quartz monzonite (Miller, 1969).

In late Tertiary time, a tongue of the extensive tholeiitic basaltic lava (Tb) that created the Columbia Plateau in southeastern Washington flowed about 20 miles north of the Spokane River into the study area. This basalt (Camas Basalt of Weaver, 1920) is tentatively correlated with the Grande Ronde Basalt of the Columbia River Basalt Group (Swanson and others, 1979a, 1979b). It covers much of the southwestern third of the Forest Center quadrangle, with a few isolated occurrences throughout the northwestern quarter of the Springdale quadrangle. These isolated outcrops, or erosional remnants, indicate that basalt flows previously covered a larger portion of the study area, much of which was removed by glacial scouring. The basalt is expressed as mesas with upper surfaces at approximately 2,500-feet elevation. On Jumpoff Joe Mountain, the upper surface of the basalt is at 2,900 feet.

GLACIATION OF AREA

Twice during Pleistocene time, the Cordilleran Ice Sheet moved into the study area from the north and blanketed the terrain with several hundred feet of ice. The Colville lobe of the continental glacier occupied the Colville-Chamokane Valley and, at its maximum extent (Bull Lake Glaciation), reached the northern border of the Columbia Plateau 2½ miles south of Long Lake, Washington. It blocked the Spokane River and impounded Glacial Lake Spokane to the east (Flint, 1936; Richmond and others, 1965). All of the study area was covered by ice except the highlands of the Loon Lake Granite in the southern half of the Springdale quadrangle. Sharp crests in the deeply-weathered granite suggest a lack of glacial cover in this area (Richmond and others, 1965). See figure 2 for drift borders proposed by Richmond and others. In its advances, the Colville lobe brought in a large amount of glacial debris that was deposited upon retreat of the melting ice either directly by the ice in morainal deposits, by streams of glacial melt water as outwash plains or kame terraces, and in glacial lakes as lacustrine deposits.

Glacial ice scoured out large quantities of basalt bedrock, leaving isolated outcrops in the northern half of the Springdale quadrangle and flat-topped mesas in the southern half of the Forest Center quadrangle. Glacial scouring created surfaces of considerable relief in the metasediments. The original floodplain of the Colville-Chamokane Valley was widened and deepened by glacial ice as evidenced by hanging tributary valleys discordant with present drainage. The valley floor is flat, 1 to 3 miles wide, and underlain by thick glacial fill.

At its maxium extent, the Colville ice lobe filled the Colville-Chamokane Valley and tributary valleys (Camas Valley and Haviland Meadows) to at least 2,500 feet. This led to the impoundment of several small bodies of water throughout the area that became sediment traps as valley mouths were dammed by ice. This elevation is suggested by a lacustrine clayey silt veener over Lyons Hill, a 2,500-foot basalt mesa to the west of Springdale. The silt was deposited in Glacial Lake Wellpinit (Flint, 1936), impounded behind ice in Camas and Colville-Chamokane Valleys and by higher land to the west. It is represented by a broad, gently undulating surface drained to the south into Spokane Canyon by small creeks. Flint proposed that the lake was continuous with standing water in the Spokane Canyon which spilled south onto the Columbia Plateau.

Ice also filled Haviland Meadows, a tributary valley in the northwestern part of the Forest Center quadrangle, to 2,500 feet. Ice and morainal deposits diverted the drainage of Deer Creek which then flowed southeasterly along the front of the ice and across the basalt mesa, scouring out narrow, deep outwash channels and rock basins in the basalt bedrock (secs. 13, 14, and 24, T. 30 N., R. 39 E.). These outwash channels occur at three successively lower elevations, each dissecting the one immediately above, and represent changes in drainage in response to retreat of the ice lobe. After ice had withdrawn from Deer Meadow (secs. 14, T. 30 N., R. 39 E.), the stream breached the moraine and established a course along the meadow's southern edge.

Melt water from the diverted Deer Creek drainage contributed to the construction of a kame terrace on the north wall of Camas Valley in sec. 25, T. 30 N., R. 39 E., and sec. 30, T. 30 N., R. 40 E. Concurrently, three kame terraces developed along the margins of the main ice lobe in the Colville-Chamokane Valley, by sediment-laden melt water from Sheep Creek, Hesseltine Creek, and an unnamed creek in the northwestern quarter of the Springdale quadrangle.

A large moraine was deposited by the ice lobe on the western side of

Haviland Meadows. An outwash fill developed around the western margin of the moraine due to ponding of the Deer Creek drainage. As ice retreated from the meadow and Deer Creek resumed its original course, both the outwash fill and the moraine were deeply dissected.

Ice to the 2,500-foot level filled the valley of Grouse Creek and deposited a moraine at the eastern foot of Jumpoff Joe Mountain in the northeastern corner of the Springdale quadrangle. A large outwash plain developed on the south side of the moraine when preexisting stream valleys were filled with outwash sands and gravels. Deer and Loon Lakes were impounded by this fill. The outwash plain is extensive, measuring about 4 miles in length, to 2 miles in width, and over 100 feet in depth at Loon Lake, its southern limit. Several shallow melt water terraces developed at various elevations on the surface of the plain. Melt water escaped via Sheep Creek, through a narrow breach in a linear outcrop of Loon Lake granite. Because of the constricted drainage, melt water ponded and washed out an 80-foot gully in secs. 28 and 29, T. 29 N., R. 41 E. A mile farther west on Sheep Creek, melt water was ponded again due to a bedrock constriction and the addition of melt water by two tributary streams. Sheep Creek has dissected six terraces in the thick deposit of outwash sand and gravel that settled out in the pond.

As the ice retreated to about the 2,200-foot level, glacial lakes were impounded in Camas Valley and Haviland Meadows behind barriers of till and outwash at their entrances to the Colville-Chamokane Valley. As a result, these entrant valleys contain a thick fill of outwash and lacustrine clay, silt, sand and gravel.

The outermost moraine of early-stade Pinedale Glaciation was deposited at Springdale across the entire width of the Colville-Chamokane Valley and into the entrant mouth of Camas Valley. From its highest elevation (2,200 feet) at Springdale, it slopes northward for 2 miles until it passes under a thick wedge of lacustrine sediments and alluvium. The morainal-lacustrine sequence marks the initial position in the northward retreat of the wasting ice lobe. The ice was partially buried in its own outwash so that as it wasted the outwash was let down, or collapsed, to form the northerly-sloping moraine. This created a lake between the wasting ice and the moraine in which laminated silt and clay was deposited (Flint, 1936).

During the middle stade of Pinedale Glaciation, Glacial Lake Missoula burst its ice dam in the Clark Fork Valley near the Idaho-Montana border and poured across much of the Columbia Plateau. The floodwaters surged across the Deer Park Basin to the southeast of the study area. Some of the floodwater poured through the valley at the northern base of Loon Lake Mountain, immediately east of Loon Lake, and created giant current ripples throughout a section of land north of the lake. Richmond and others (1965) place a Missoula Flood boundary across the middle of the Forest Center quadrangle, mainly involving the Colville-Chamokane Valley (see figure 2 for flood border of Richmond). Nothing was found in the present investigation to substantiate this boundary beyond the giant current ripples.

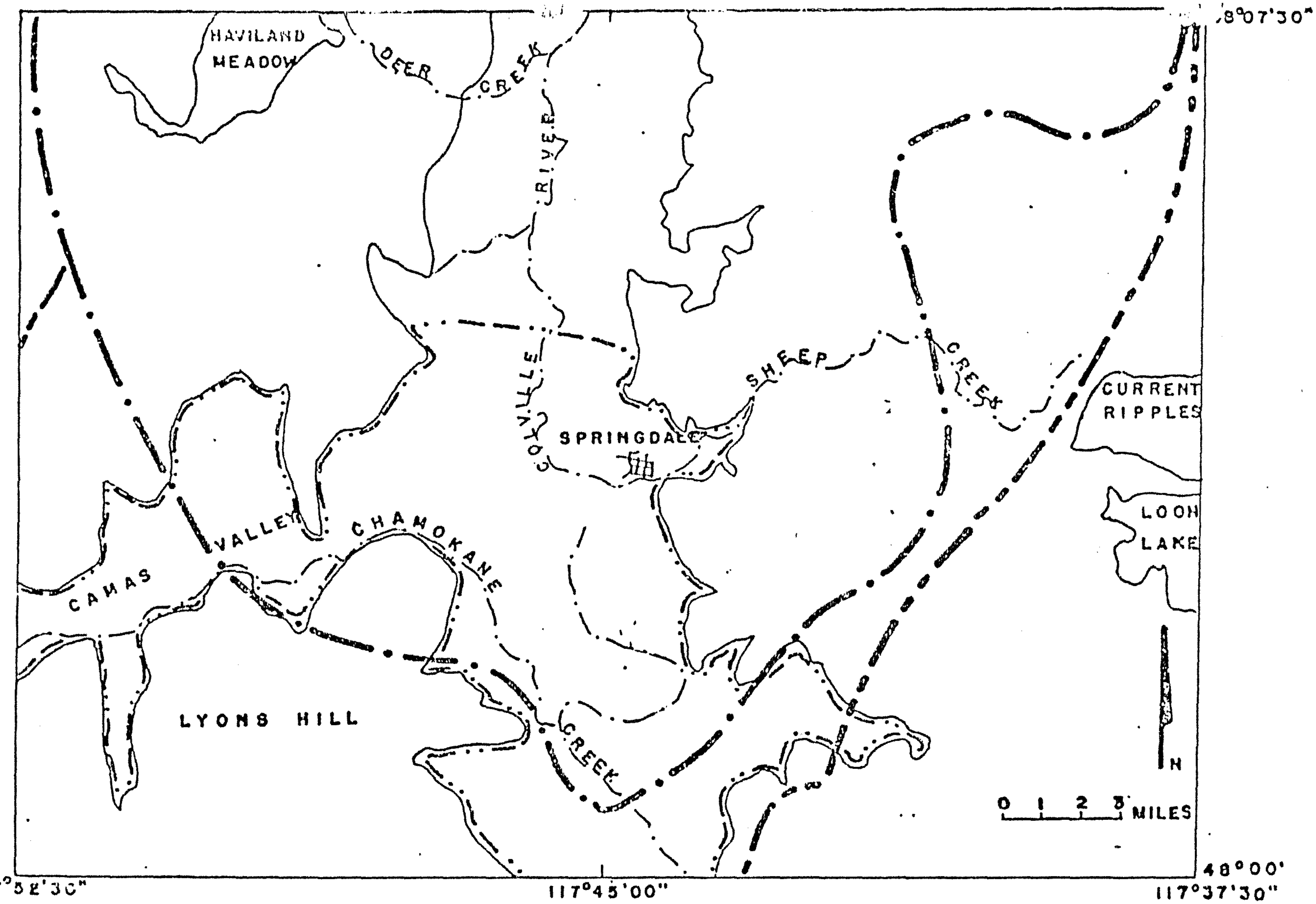

Figure 2. Sketch map showing Missoula Flood boundary and Pinedale and Bull Lake glacial boundaries in study area, after Richmond and others, 1965.

LEGEND:

PINEDALE GLACIAL BOUNDARY

BULL LAKE GLACIAL BOUNDARY

MISSOULA FLOOD BOUNDARY

SURFICIAL DEPOSITS

Glacial Deposits

Glaciolacustrine Silt Deposits (Qgs)

Two lacustrine silt deposits occur in the study area due to impoundment of glacial melt water by ice dams (Flint, 1936; Van Duyne and Ashton, 1915; Becraft and Weis, 1963). The older of the two (Qgs_1) covers about 5 square miles in the southwestern half of the Forest Center quadrangle as a veneer on the basalt mesas south of Camas Valley. The deposit accumulated in Glacial Lake Wellpinit, when glacial ice in the Colville-Chamokane and Camas Valleys butted against the mesa walls to the 2,500-foot level (Flint, 1936).

The glaciolacustrine sediment is a very light brown, finely laminated, compact, unconsolidated clayey silt with some fine sand. Granitic and metamorphic erratic boulders are widely scattered over the surface. The unit is composed of 10 percent smectite, 45 percent chlorite and kaolinite, and 45 percent illite as determined by X-ray analysis of a sample from sec. 13, T. 29 N., R. 39 E. The unit is uniformly exposed to 3 feet along the road that traverses the mesa.

In secs. 5 and 8, T. 29 N., R. 40 E., a layer of dark reddish-brown shale, 2 to 3 feet below the surface and 2 to 3 feet thick underlies the Wellpinit lake fill. It probably developed as the result of in-situ weathering of the underlying basalt.

The contact between the silt deposits and the basalt mesa is at 2,500-feet elevation. The lake fill reaches an upper limit of 2,600 feet in sec. 13, T. 29 N., R. 39 E., at the base of Marshall Hill, a quartzite outcrop. Flint (1936) assigns an upper limit of 2,500 feet for the lake fill while Becraft and Weis (1963) suggest 2,600 feet as the upper limit. Either the lake sediment was originally deposited below 2,600 feet and was reworked and redeposited by the wind to the 2,600-foot level, or was originally deposited at 2,600 feet and upon rapid draining of the lake, only a thin veneer of silt was left above that elevation (Becraft and Weis, 1963).

On the north side of Camas Valley, another basalt mesa is mantled with a silt veneer that has been included with the Wellpinit silt unit. It undoubtedly formed at the same time and in a similar lacustrine environment on the opposite side of the ice-filled Camas Valley from Glacial Lake Wellpinit. The unit is lithologically similar to the Wellpinit silt but is not as well-defined or as thick. It grades upward at about 2,600 feet into a dusky red, compact, unconsolidated silt called Empey silt loam by Van Duyne and Ashton (1915). This unit, which has been included with the Wellpinit silt, occurs throughout secs. 22, 23, 26, and 27, T. 30 N., R. 39 E., to 2,700 feet at the southern base of Empey Mountain. It may be due to the development of a residual soil on the maroon argillite of the Precambrian Stensgar Dolomite (Jones, 1928), which would account for its distinctive dark red color. It is apparently free of glacially-derived gravel, although quartzite and siltite float from the adjoining steep slopes is abundant on its surface. According to Van Duyne and Ashton (1915), the character and structure of the subsoil indicates that it is derived from lake-lain sediments. A well record in the area indicated 100 feet of the deposit before bedrock was encountered. It may represent a high stand of ponded melt water when glacial ice was at its maximum thickness and Deer Creek to the north was diverted into the area.

The younger of the two glaciolacustrine silt deposits (Qgs_2) occupies about 2½ square miles along the Colville River in the extreme northeastern corner of the Forest Center quadrangle. The unit (Mission clay of Van Duyne, 1915) represents over 100 feet of light brownish gray, compact, laminated clayey silt. Small erratic boulders occur throughout the deposits along with gravel washed into the lake by tributary streams. Compositionally and texturally this silt is identical to the Glacial Lake Wellpinit silt deposit as determined by X-ray analysis of samples from sec. 16, T. 30 N., R. 40 E. On the western side of the deposit, the unit grades upward into outwash and colluvium from the adjacent basalt highlands.

The silt accumulated in a glacial lake impounded between the Pinedale end moraine at Springdale and the retreating Colville ice lobe. The unit occurs almost continuously on both sides of the valley from Springdale to Colville and is interbedded with till, boulder beds, and gravel progressively northward. It forms narrow constructional terraces with undulating surfaces along the eastern margin of the valley. These dune-like undulations, with heights of 15-20 feet, are partly a reflection of the irregularities of underlying collapsed gravels and of post-glacial erosion by streams and wind. Good exposures occur in roadcuts that dissect these rolling hills. This unit slopes northward in the study area; north of there, it flattens into a smooth-surfaced silt lake fill whose surface has been reworked by modern streams and veneered with Recent alluvium (Flint, 1936).

GLACIAL MORAINES (Qgt)

Four large moraines occur in the study area. Moraines in secs. 4, 5, and 9, T. 30 N., R. 41 E., and secs. 1, 2, 11, 12, 14, T. 30 N., R. 39 E., were deposited by lobes that filled, respectively, Grouse Creek and Haviland Meadows valleys when the Colville lobe was at its maximum depth. Till in these moraines, deposited directly by the ice against basalt bedrock obstructions, is unsorted, unstratified, and unconsolidated mixtures of clay, sand, gravel, and boulders. Clasts are predominantly rounded to subangular quartzite, with some granite and basalt. Morainal surfaces are undulatory, with reliefs of 100 to 200 feet from base to top, and the Grouse Creek moraine contains several small kettle ponds. The Grouse Creek moraine is well-exposed in roadcuts along I395 and the Haviland Meadows moraine is well-exposed along the upper Deer Creek drainage and logging road cuts.

In secs. 5, 6, 7, and 8, T. 30 N., R. 40 E., a moraine fills the valley mouth of Haviland Meadows from its base at 1,800 feet in the Colville Valley to its top at 2,000 feet. In the high-elevation and near-surface portions of this moraine, the till is lithologically similar to the two moraines above. In the basal portions of the moraine, however, along the Deer Creek canyon in sec. 8, T. 30 N., R. 40 E., lodgment till is exposed in the roadcut. This till has a compact, consolidated, fissile texture and the gravel to pebble fraction is oriented east-west in the direction of ice movement. The moraine appears to have diverted Deer Creek to the south of its original stream course.

The greatest thickness of glacial till occurs at Springdale in the Pinedale end moraine. The moraine's surface, which drops 200 feet in 2 miles, is riddled with kettle ponds, large, shallow, irregular closed basins, and the constructional undulations common to end moraines.

ified silt, sand, and large quartzite boulders. Exposure is poor, limited to a small gravel pit in sec. 4, T. 29 N., R. 40 E., and a pit in sec. 4, T. 29 N., R. 40 E., at the southern extreme of the moraine where outwash sand and gravel predominate. The moraine butts up against basalt outcrops at its southern extreme and in the mouth of the Camas Valley, which is filled by the moraine to 2,200 feet. The top of the moraine contains several kettle ponds. Chamokane Creek was apparently diverted by the moraine so that it incised a narrow channel through a northern limb of the basalt mesa in sec. 32, T. 30 N., R. 40 E. The mouth of Hesseltine Creek valley is filled with till of the Pinedale end moraine overlain by outwash sand and gravel. Hesseltine Creek appears to have been diverted south by the morainal deposit.

Flint (1936) states that along the eastern and northern margins of Lyons Hill, the Glacial Lake Wellpinit fill is interbedded with a thick wedge of till. He used this occurrence to demonstrate that the ice was in contact with the cliff faces of the basalt mesa whose surface carried the lake while the sediment was accumulating. According to Flint, this relationship is clearly exposed in roadcuts in SE¼ sec. 20 and SW¼ sec. 21, T. 29 N., R. 40 E., south of the study area. Field examination failed to show any evidence of till at this locality or along roadcuts dissecting the eastern contact of the Wellpinit fill in the study area.

Glaciofluvial Deposits (Qgo)

Outwash Plains — Outwash sands and gravels mantle the entire study area except for the Loon Lake granite highlands. The largest deposits occur in outwash plains north of Loon Lake, in Camas Valley, and in the Chamokane Creek valley south of Springdale.

The unit is composed of clay, silt, sand, gravel and boulders, with quartzite the predominant clast lithology. Outwash deposits are well sorted and stratified, uncemented, and so compact that they hold a vertical slope. They usually include layers of clay or very compact fine to medium sand up to 1 foot in thickness and are capped with, on the average, 6 inches of pale brown silt. One sample of outwash, procured from the C. and G. Excavating Company's sand and gravel operation in sec. 28, T. 30 N., R. 41 E., gave the author the following grain size percentages:

Sieve diameter (mm)	Sediment size	Percent retained
4.0	Pebbles	61.9
1.981	Granules	15.2
.991	Very coarse sand	7.8
.495	Coarse sand	7.4
.246	Medium sand	3.5
.124	Fine sand	1.3
.061	Very fine sand	1.5
—	Silt	1.4

The outwash plain north of Loon Lake occupies about 4 square miles in secs. 9, 10, 15, 16, 21, 22, 27, and 28, T. 30 N., R. 41 E. The outwash was deposited by melt water from the ice lobe in Grouse Creek valley and from Deer Lake drainage. Loon Lake and Deer Lake (east of the study area) were impounded by the outwash deposits. The surface of the plain is dissected by several shallow outwash terraces and a deep gully created by turbulent melt water ponded behind a narrow gap in the Loon Lake granite. Downstream and west of this gully 1-square mile of outwash fill developed along Sheep Creek as a result of another bedrock restriction and the addition of melt water from tributary streams. Sheep Creek incised six step-like terraces in the western side of the fill.

During maximum glaciation when Haviland Meadows was filled with ice and Deer Creek was diverted southward over the basalt mesa, large quantities of outwash sand and gravel were distributed over the mesa to the 2,500-foot level where they grade upward into lacustrine silt.

Upon retreat of ice from Haviland Meadows and Camas Valley, thick deposits of outwash were left behind on the valley floors. In Haviland Meadows the outwash was completely mantled by Recent alluvium; in Camas Valley only the lower elevations along Chamokane Creek were mantled by alluvium so that much of the outwash plain is exposed.

The Chamokane Creek fill represents the greatest accumulation of outwash in the study area. It originates at Springdale at 2,050 to 2,100 feet elevation where it reaches its maximum thickness at the base of the Pinedale end moraine. It is a wedge of outwash silt, sand, and predominantly coarse gravel, with a slope of 35 feet per mile, a record of the final gradient of the outwash stream, minus allowances for isostatic rebound from glacial unloading. The outwash shows fairly uniform gradation downstream. An abandoned outwash channel about 1,000 feet wide and 60 feet deep incises the outwash fill at Springdale, then leads into a complex system of partially abandoned outwash terraces that have been further complicated by the post-glacial Chamokane Creek (Flint, 1936). Slipoff slopes occur along the east bank of Chamokane Creek in secs. 10 and 15, T. 29 N., R. 40 E.

Kame terraces (ice-contact stratified drift) — Four kame terraces occur in the study area, three along the Colville-Chamokane Valley and one in Camas Valley. The southernmost terrace occurs in sec. 35, T. 30 N., R. 40 E., immediately south of Springdale at May Hill, where it rises from 2,120 feet at its base in the Colville-Chamokane Valley to 2,425 feet at its top. It developed in response to damming of sediment-laden Sheep Creek by ice in the Colville-Chamokane Valley. A total lack of exposure prevented examination of depositional features. The 2,400-foot elevation of the kame terrace conforms to a general 2,400-foot table of outwash between Sheep Creek and the base of the Loon Lake granite highlands and the outwash plain north of Loon Lake.

A second kame terrace occurs in sec. 15, T. 30 N., R. 40 E., as a result of ice-damming of an unnamed creek that flows from the east into the Colville-Chamokane Valley. Examination of the outwash exposed along the creek banks indicated a 15^{o} westerly dip to the deltaic bedding.

A third kame terrace occurs in sec. 17, T. 30 N., R. 40 E., at the mouth of Hesseltine Creek. The terrace outwash deposits overlie and interfinger with till from the Pinedale end moraine. A large alluvium-veneered depression caps the terrace.

A fourth kame terrace was constructed on the north side of Camas Valley in response to diversion of Deer Creek across the basalt mesa to the north. The terrace occupies about one square mile in secs. 30 and 31, T. 30 N., R. 40 E., and sec. 25, T. 30 N., R. 39 E., at the base of Craney Hill. The basalt bedrock that composes Craney Hill extends under the terrace and controls its topography and bedding. A gravel pit at the toe of the terrace in sec. 31. T. 30 N., R. 40 E., exposes deltaic bedding dipping 15^{o} to the south. The outwash is composed predominantly of medium to coarse sand and gravel as can be seen in the following table of grain size percentages. Clasts are rounded to subangular and clast lithology is 50 percent quartzite, 30 percent other metasediments and 20 percent basalt. The outwash deposits are well-sorted and stratified, uncemented, and compact to the extent that they hold a vertical slope. Many thin (1 to 2 inch) layers of compact medium to coarse sand occur throughout the exposure and the uppermost 10 feet of the exposure is composed of thin beds of fine to medium sand.

Sieve diameter (mm)	Sediment size	Percent retained
4.0	Pebbles	48.9
1.981	Granules	11.0
.991	Very coarse sand	9.3
.495	Coarse sand	12.1
.246	Medium sand	14.4
.124	Fine sand	3.7
.061	Very fine sand	0.4
---	Silt	0.2

In a gravel pit on the western limb of the kame terrace in sec. 25, T. 30 N., R. 39 E., the deltaic bedding dips at a variety of angles to the west, the angles increasing toward the top of the exposure, except the uppermost 3 feet which has nearly horizontal bedding. Compositionally, the deposit is identical to the one above.

Missoula Flood Deposits (Qf)

Immediately north of Loon Lake, in secs. 27 and 28, T. 30 N., R. 41 E., 1 square mile of giant current ripples were developed in the glacial outwash by the Glacial Lake Missoula outburst flood. The floodwater flowed through an entrant valley in the highlands to the east and deposited flood sediments in a series of north-south trending arcuate ripple marks that are 2 to 3 feet high and 125 to 150 feet wide from crest-to-crest. They are composed of poorly sorted or stratified, uncemented clay, silt, sand and gravel; the sand and gravel clasts are predominantly subrounded quartzite. The grain size percentages as determined by the author are as follows:

Sieve diameter (mm)	Sediment size	Percent retained
4.0	Pebbles	53.6
1.981	Granules	12.8
.991	Very coarse sand	6.8
.495	Coarse sand	4.6
.246	Medium sand	4.1
.124	Fine sand	4.1
.061	Very fine sand	9.5
---	Silt	4.5

Mineralogically, the flood sediments are indistinguishable from the underlying glacial outwash; however, the flood sediments contain a larger percentage of silt to very fine sand and lack the coherence of the outwash deposits. A small deposit of Touchet-like slackwater silt and sand was noted in association with the current ripples in a gravel pit in sec. 27, T. 30 N., R. 41 E.

The entrant valley for the floodwater opens eastward onto the very broad Deer Park basin, drained by the Little Spokane River. Glacial Lake Spokane extended into the Deer Park basin during Bull Lake glaciation when it was impounded by the eastern edge of the Colville ice lobe as it dammed the Spokane River (Cline, 1969). Glaciolacustrine silts and clays were deposited in the lake. During Pinedale Glaciation, Missoula floodwater surged into the area, mantling the lake deposits with flood gravels. The higher amount of sediments in the silt to medium-sand range in the Loon Lake current ripples, relative to the underlying glacial outwash, may be due to transportation of Glacial Lake Spokane silts and clays into the study area by the floodwater.

Landslide (Qls)

A possible landslide occurs in secs. 8 and 17, T. 29 N., R. 40 E. The slide occurs at the head of a shallow, glacially scoured valley in a basalt mesa (Lyons Hill) along the Colville-Chamokane Valley south of Springdale.

It appears that the ice undercut or sheared off large blocks of bedrock from the basalt cliffs. These blocks slumped and were mantled and stabilized by buttresses of glacial debris. Field inspection failed to demonstrate any rotation of the slump blocks; determination of whether they are in place was complicated by a thick cover of basalt colluvium.

Post-Glacial Deposits

Alluvium (Qal) — Alluvium occurs throughout the study area along modern streams, in large meadows that were glacial lake beds, kettle ponds, and abandoned glacial outwash channels. The most extensive deposits, in Haviland Meadows, Camas Valley, Ahrens Meadow, and along the Colville River valley are the results of restricted drainage brought about by the damming of valleys with morainal material. Most alluvium is very dark grayish brown, organic-rich, clay, silt, and sand. It is blocky and hard when dry, waxy when wet, and contains several thin lenses of light grayish brown clay. The surfaces of the extensive alluvial deposits have a very gentle slope and are traversed by shallow, sluggish, underfit streams.

Volcanic ash probably Mount Mazama (Rigg, 1958) occurs in lenses of variable thickness in most of the meadow deposits. This is due to the secondary origin of the pumicite, it having been washed into the sedimentary traps from surrounding uplands.

Peat and Muck — Peat and muck deposits are widely distributed throughout the study area as a result of restricted drainage in small upland basins, closed meadows, kettle ponds, and along abandoned glacial outwash channels. It is usually in association with thin secondary layers of pumicite and underlain by thin lenses of blue clay.

Two major peat and muck occurrences in the study area have been documented by G. B. Rigg (1958). According to Rigg, the Haviland Meadows peat and muck deposit is 740 acres in secs. 1 and 12, T. 30 N., R. 39 E., and secs. 6 and 7, T. 30 N., R. 40 E. No mention was made of test holes and no profile was constructed for this deposit. The owner of the meadow believes the deposit to be much less extensive than 740 acres and that it occurs in one small area at the extreme southern end of the meadow and two larger areas at the northern and northeastern ends. An examination by the author of the banks of Deer Creek, which has incised an 8-foot channel through the meadow from west to east, failed to show any peat along its banks, although thin lenses of clay and pumicite were visible. Local information indicates that the deposit is as much as 5 feet thick and is underlain by greenish clay.

The Loon Lake peat and muck deposit occupies 74 acres in sec. 33, T. 30 N., R. 41 E., on the northwest shore of the lake. Rigg constructed a profile of this deposit based on 6 test-hole sites. Sedimentary peat was formed in the lake, and sedges have formed a surface layer. The black organic soil consists of peat which has been modified by agricultural use. The fibrous peat is mostly decomposed and is black at the surface and brown at deeper levels. The sedimentary peat varies in color from olive to green. A layer of pumicite washed in from adjacent highlands thins from 31 to 3 inches toward the lake. The deposit rests on sand (Rigg, 1958).

Talus Deposits — Talus deposits composed entirely of angular basalt fragments, occur in the Forest Center quadrangle at the bottom of cliff faces in the basalt mesas surrounding Camas Prairie. A small talus slope also occurs at the base of the contact between Loon Lake granite and Addy Quartzite in secs. 2 and 11, T. 29 N., R. 40 E.

POST-GLACIAL DEVELOPMENT OF PRESENT TERRAIN

Post-glacial modification of the study area's terrain has been predominantly the result of modern stream action. Where the streams are shallow and sluggish, as in the upland meadows and the Colville River valley, they have veneered and smoothed their valleys with several feet of organic-rich clay, silt, and fine sand. Where they follow glacial meltwater channels, as in the Chamokane and Sheep Creek valleys, they have modified outwash terraces with modern stream terraces. Modern stream and wind action has created an undulatory surface on the glacial lake beds atop Lyons Hill and surrounding the Colville River valley.

	AGE	FORMATION	MAP SYMBOL	CHARACTER
QUATERNARY	Holocene	Peat and muck	Qp	Accumulations of organic material in ponds and meadows; small amounts of silt and sand, thin layers of volcanic ash, and blue clay present.
QUATERNARY	Holocene	Talus	Qtal	Collections of angular basalt fragments formed at foot of steep slopes.
QUATERNARY	Holocene	Alluvium	Qal	Primarily a veneer of dark grayish brown, organic, clayey silt and sand along stream channels and meadows; contains thin layers of clay and volcanic ash. Includes lacustrine silt and clay in ponds and abandoned outwash channels.
QUATERNARY	Pleistocene: Middle stade Pinedale Glaciation	Missoula Flood deposits	Qf	Reworked glacial outwash containing current ripples composed of poorly sorted or stratified, uncemented, uncompacted silt, and subrounded, quartzitic sand and gravel. Contains local pockets of light brown, unconsolidated slackwater silt and sand.
QUATERNARY	Pleistocene: Middle stade Pinedale Glaciation	Glaciolacustrine silt (younger)	Qgs_2	Light brownish gray, finely-laminated, unconsolidated, clayey silt with some sand and gravel. Unit occurs as valley fill confined to Colville Valley; along eastern margin occurs as terraces with distinctively undulatory surfaces; grades upward into outwash and basalt colluvium on western margin.
QUATERNARY	Pleistocene: Middle stade Pinedale Glaciation	Glaciofluvial deposits	Qgo	Outwash clay, silt, and quartzitic sand and gravel. Deposits well-sorted and stratified, uncemented, and compact so that they maintain a vertical slope. Deposits capped with 6 inches of pale brown silt and include compact layers to 1 foot in thickness of clay to medium sand. Includes ice-contact stratified drift in kame terraces.
QUATERNARY	Pleistocene: Early stade Pinedale Glaciation	Glacial till	Qgt	Unsorted, unstratified, unconsolidated mixtures of clay, silt, and subrounded quartzitic sand and gravel deposited directly by ice in moraines. Includes extremely compact, consolidated, fissile lodgement till at base of Deer Creek canyon.
QUATERNARY	Pleistocene: Bull Lake Glaciation	Landslide deposit	Qls?	Slump blocks of basalt at eastern base of Lyons Hill; mantled and buttressed by glacial debris and basalt colluvium.

	AGE	FORMATION	MAP SYMBOL	CHARACTER
QUATERNARY	Bull Lake Glaciation	Glaciolacustrine silt (older)	Qgs_1	Very light brown, finely-laminated, unconsolidated clayey silt with some fine sand, confined to surface of basalt mesas. Basalt and metamorphic boulders scattered over surface. Underlain by thin layer of dark red shale. Includes dusky red, unconsolidated silt confined to base of Empey Mountain.
TERT.	Pliocene-Miocene	Yakima Basalt	Tb	Lava flows of the Grande Ronde Basalt Formation.
	Cretaceous through Precambrian	Pre-Tertiary rocks, undifferentiated	pTu	Precambrian through Mesozoic metamorphic and plutonic rocks.

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OPEN FILE REPORT NO. 80-3
PLATE I

Base from USGS 1:24000
Springdale, Wash., 1965

LEGEND

Qp	Peat and muck
Qtal	Talus
Qal	Alluvium
Qf	Missoula Flood deposits
Qgs_2	Glaciolacustrine silt (younger)
Qgo	Glacial outwash deposits
Qgt	Glacial till deposits
Tb	Yakima Basalt
pTu	Pre-Tertiary rocks, undifferentiated

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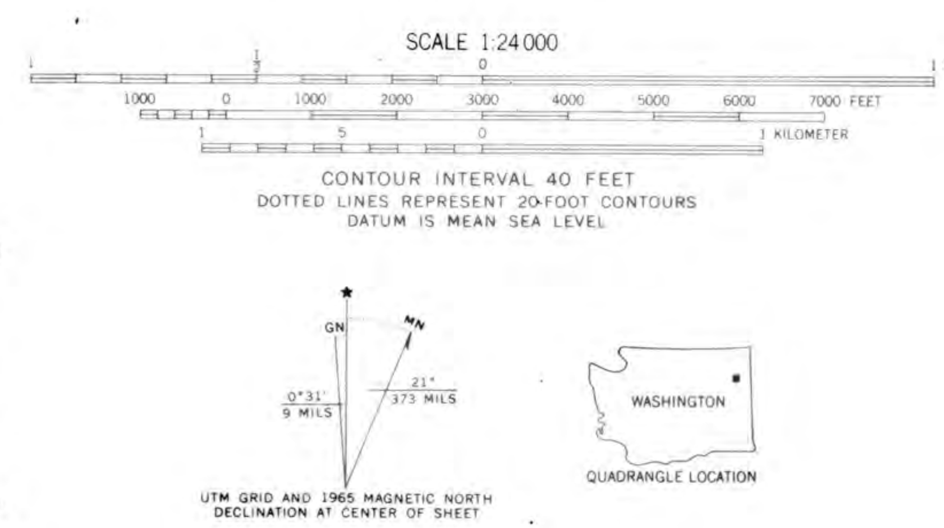

SURFICIAL GEOLOGIC MAP OF THE SPRINGDALE QUADRANGLE, STEVENS COUNTY, WASHINGTON

by Glennda B. McLucas

1980

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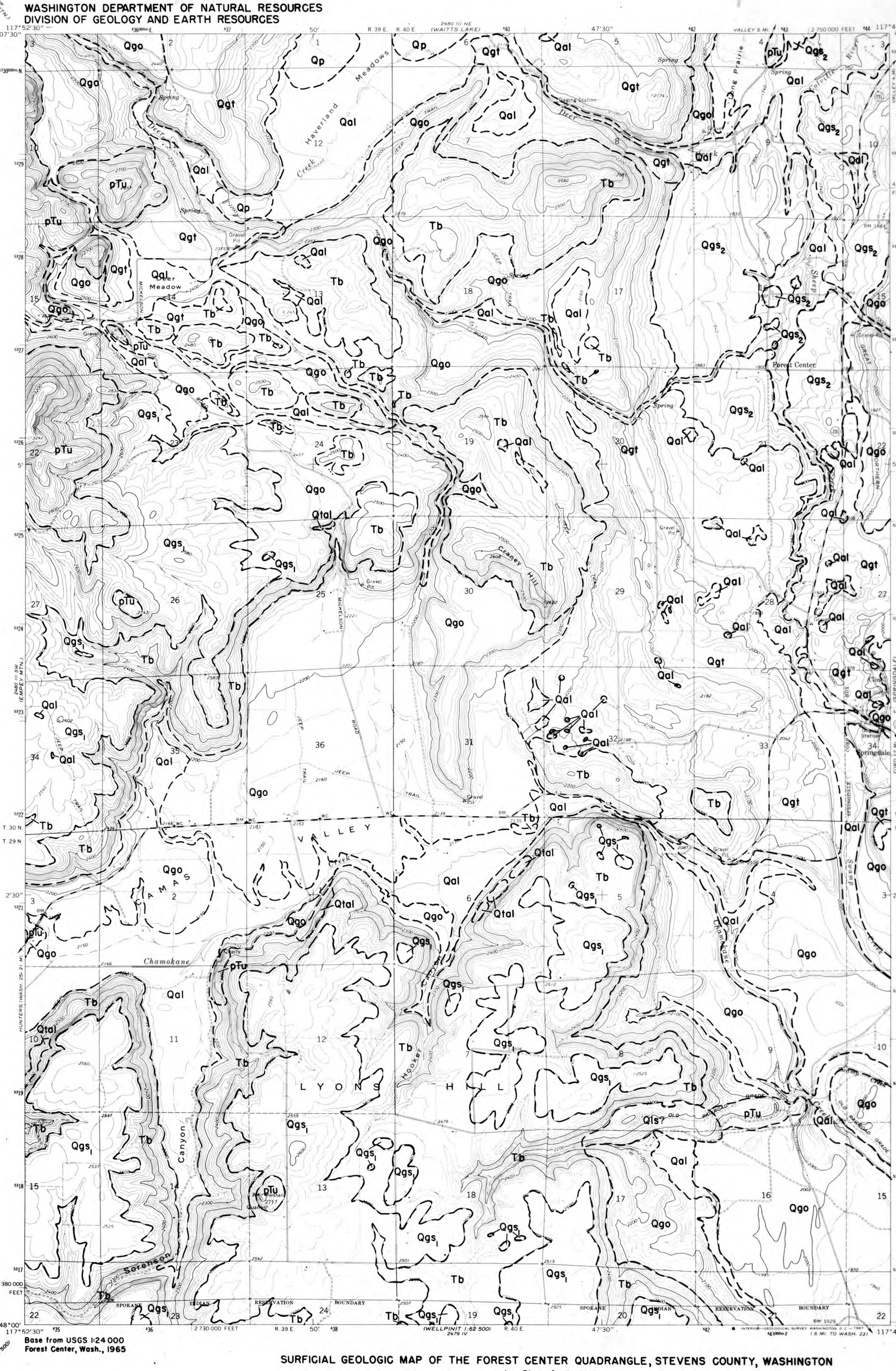
80-3
Plate 1

WASHINGTON DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGY AND EARTH RESOURCES

OPEN FILE REPORT NO. 80-3
PLATE 2



LEGEND

Qp	Peat and muck
Qtal	Talus
Qal	Alluvium
Qls?	Landslide deposit
Qgs_2	Glaciolacustrine silt (younger)
Qgs_1	Glaciolacustrine silt (older)
Qgo	Glacial outwash deposits
Qgt	Glacial till deposits
Tb	Yakima Basalt
pTu	Pre-Tertiary rocks, undifferentiated
— — —	approximate contact

SCALE 1:24 000

CONTOUR INTERVAL 20 FEET
DOTTED LINES REPRESENT 10-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL

UTM GRID AND 1965 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

QUADRANGLE LOCATION

Base from USGS 1:24 000
Forest Center, Wash., 1965

SURFICIAL GEOLOGIC MAP OF THE FOREST CENTER QUADRANGLE, STEVENS COUNTY, WASHINGTON
by Glennda B. McLucas
1980