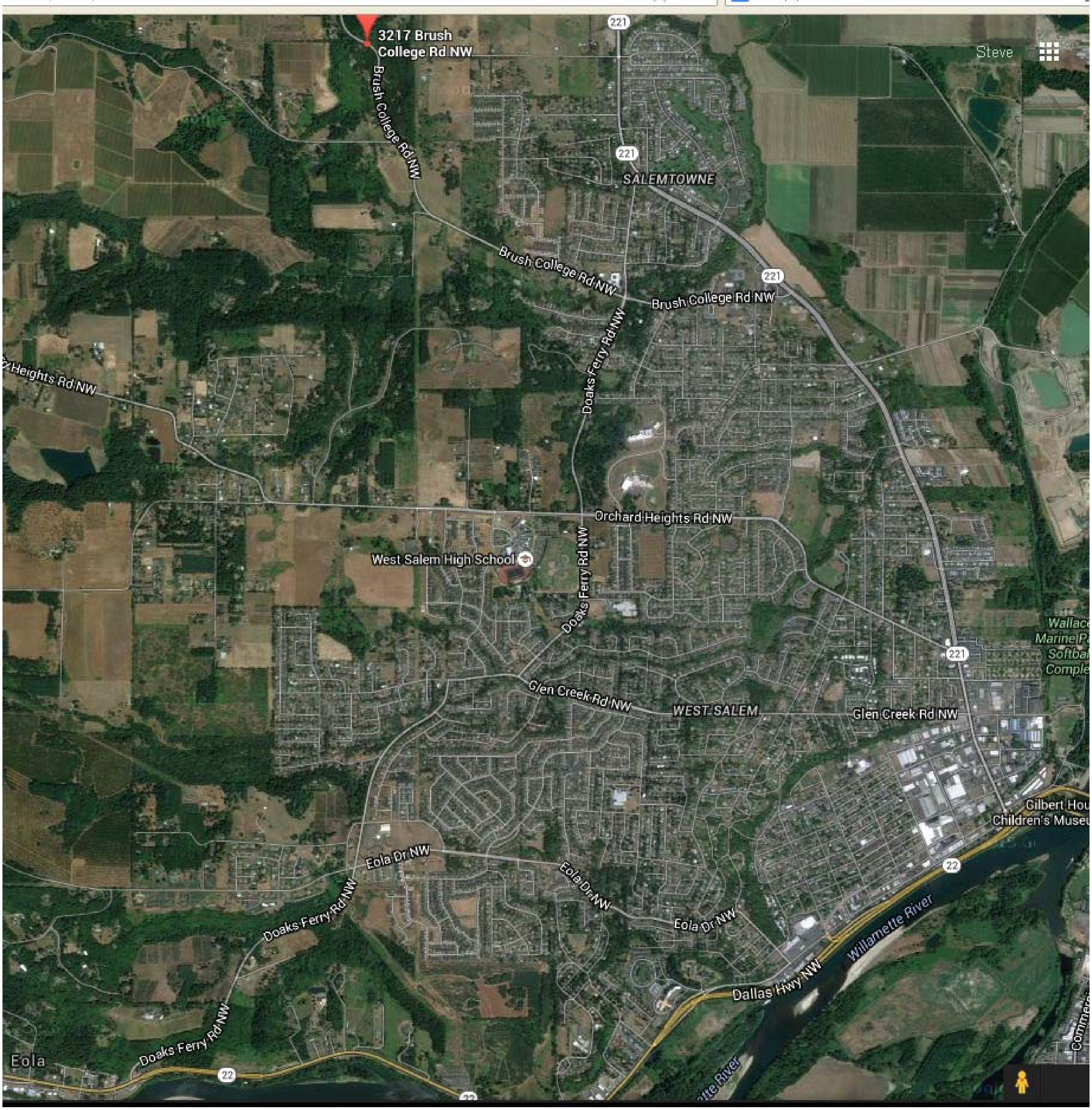
ES476 Hydrology Field Trip Guide
Water Well Drilling Demonstration

Robinson Well Drilling Salem, Oregon

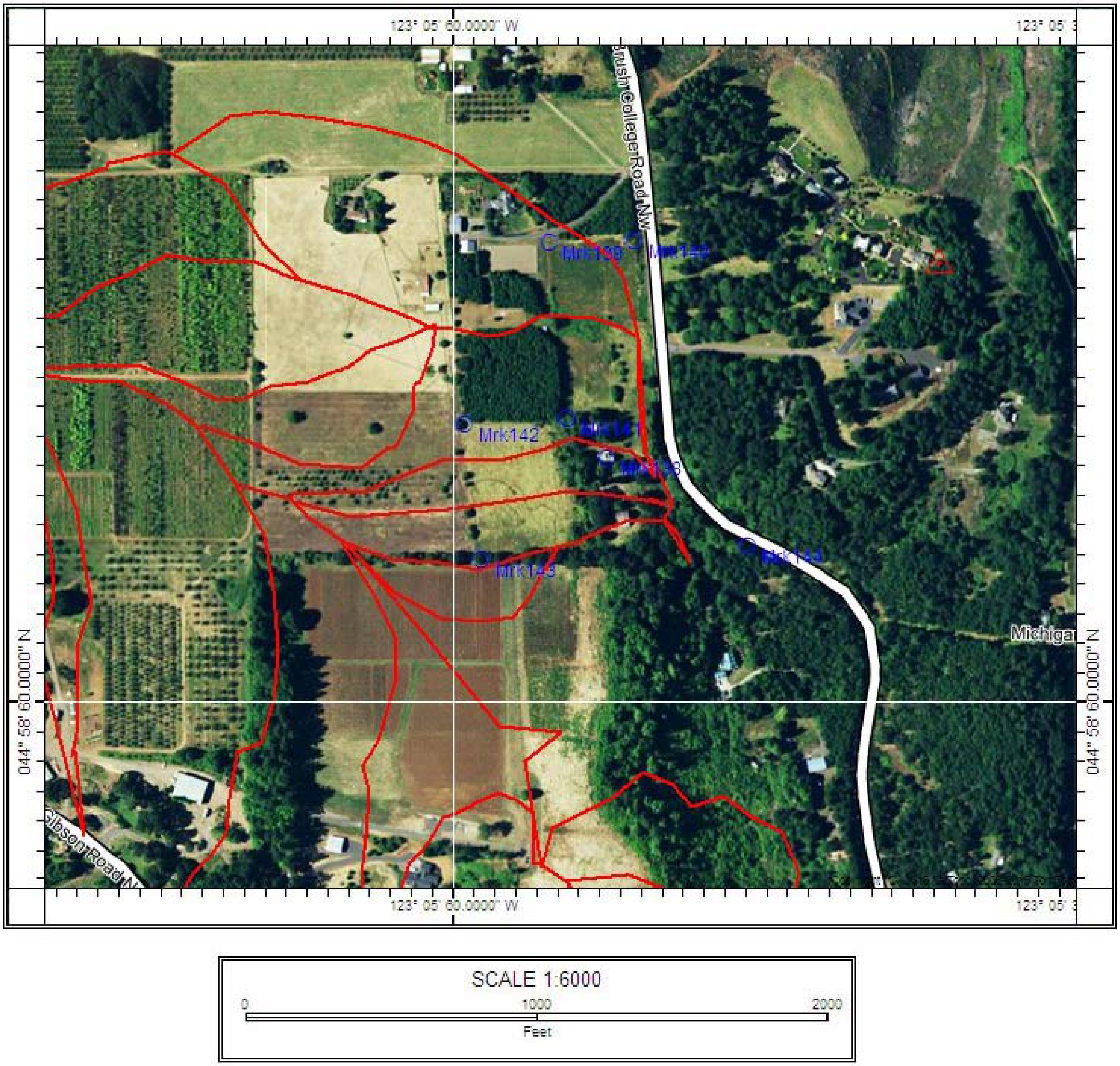
Brush College Road Project
February 25, 2016

Compiled by Dr. Steve Taylor

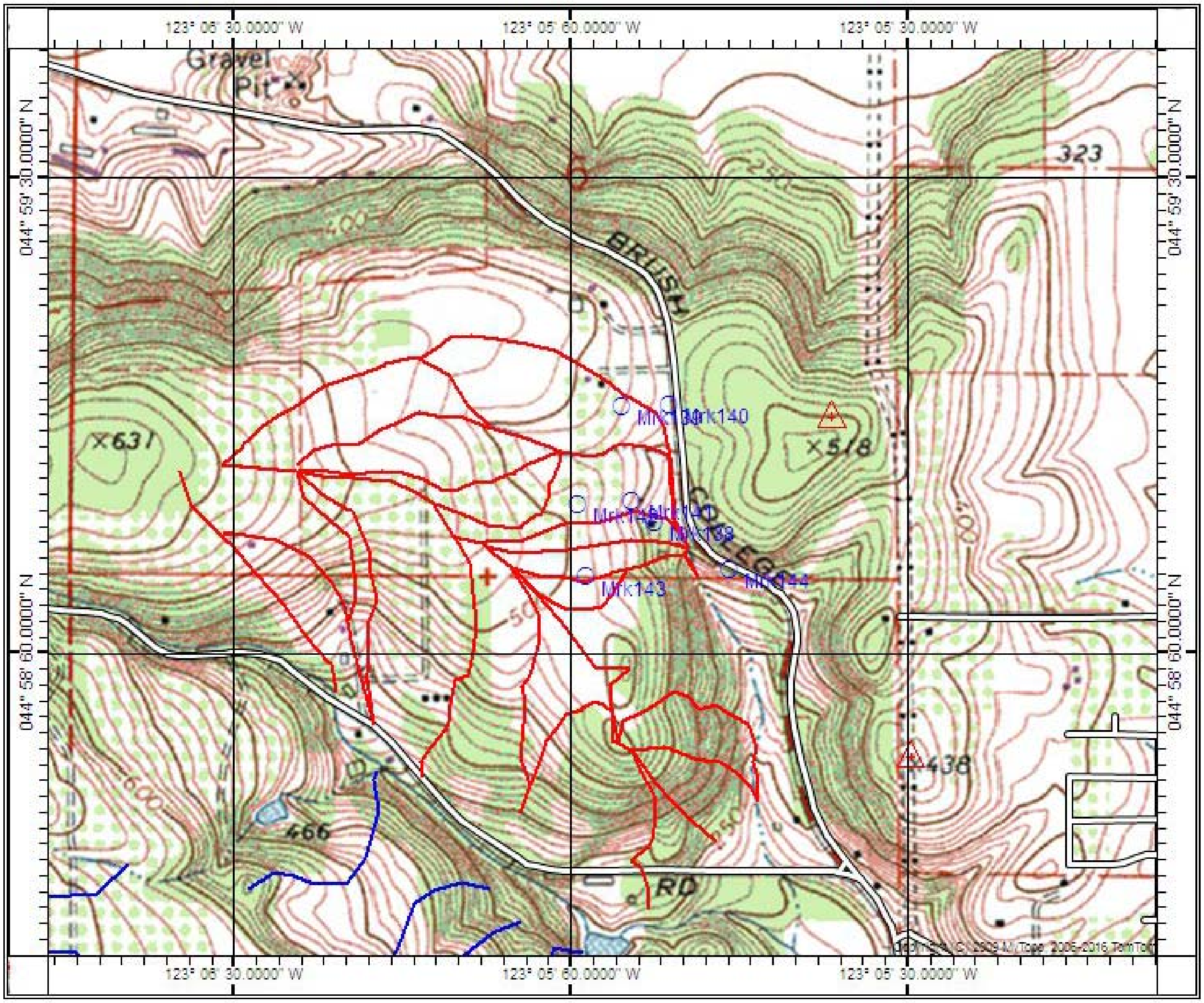
Brush College Road Project Site

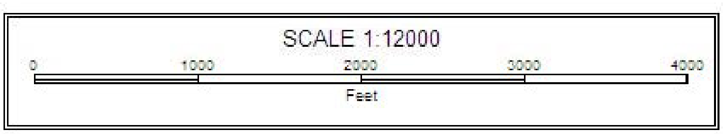


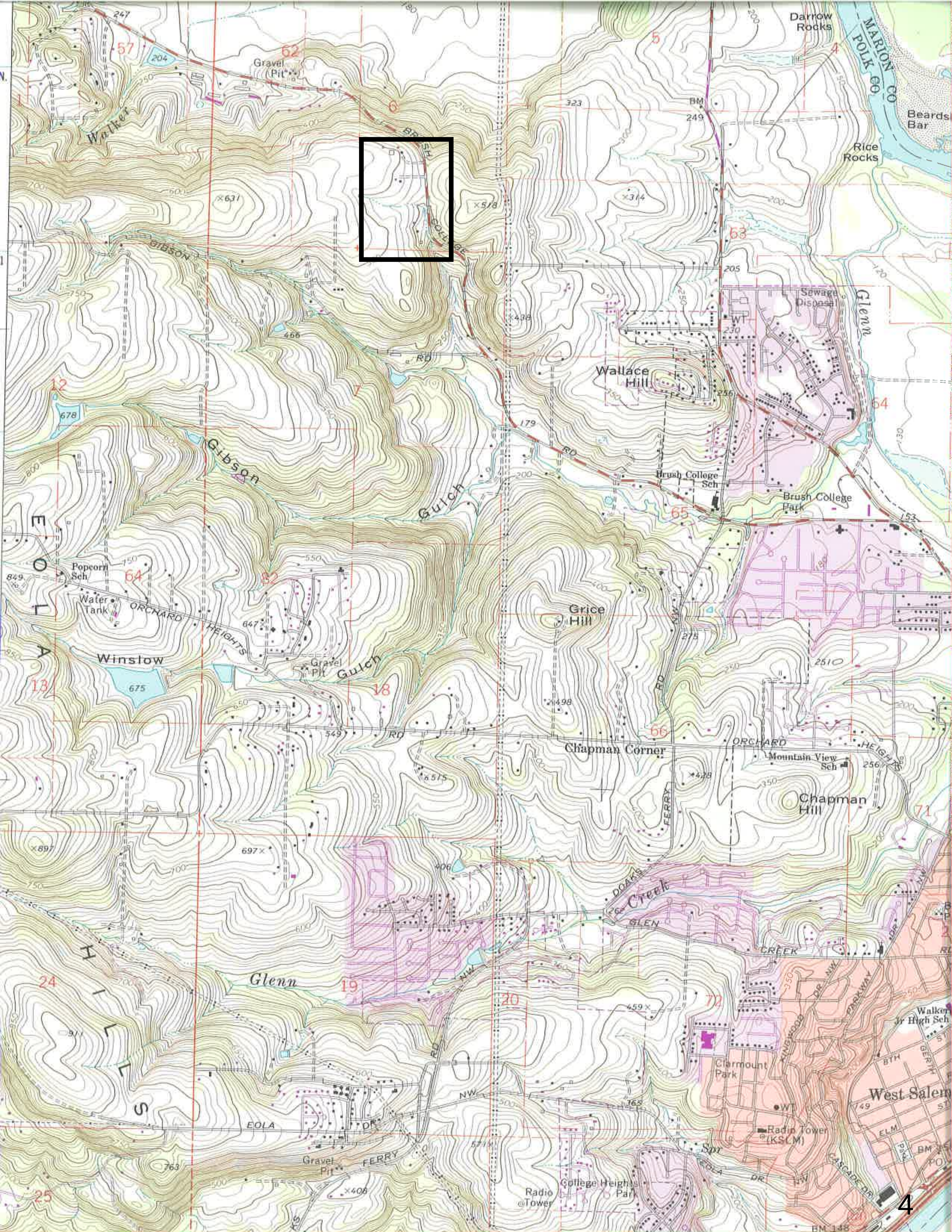
Brush College Road Project Site



Brush College Road Project Site



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Gulch
Popcorn Sch
Water Tank
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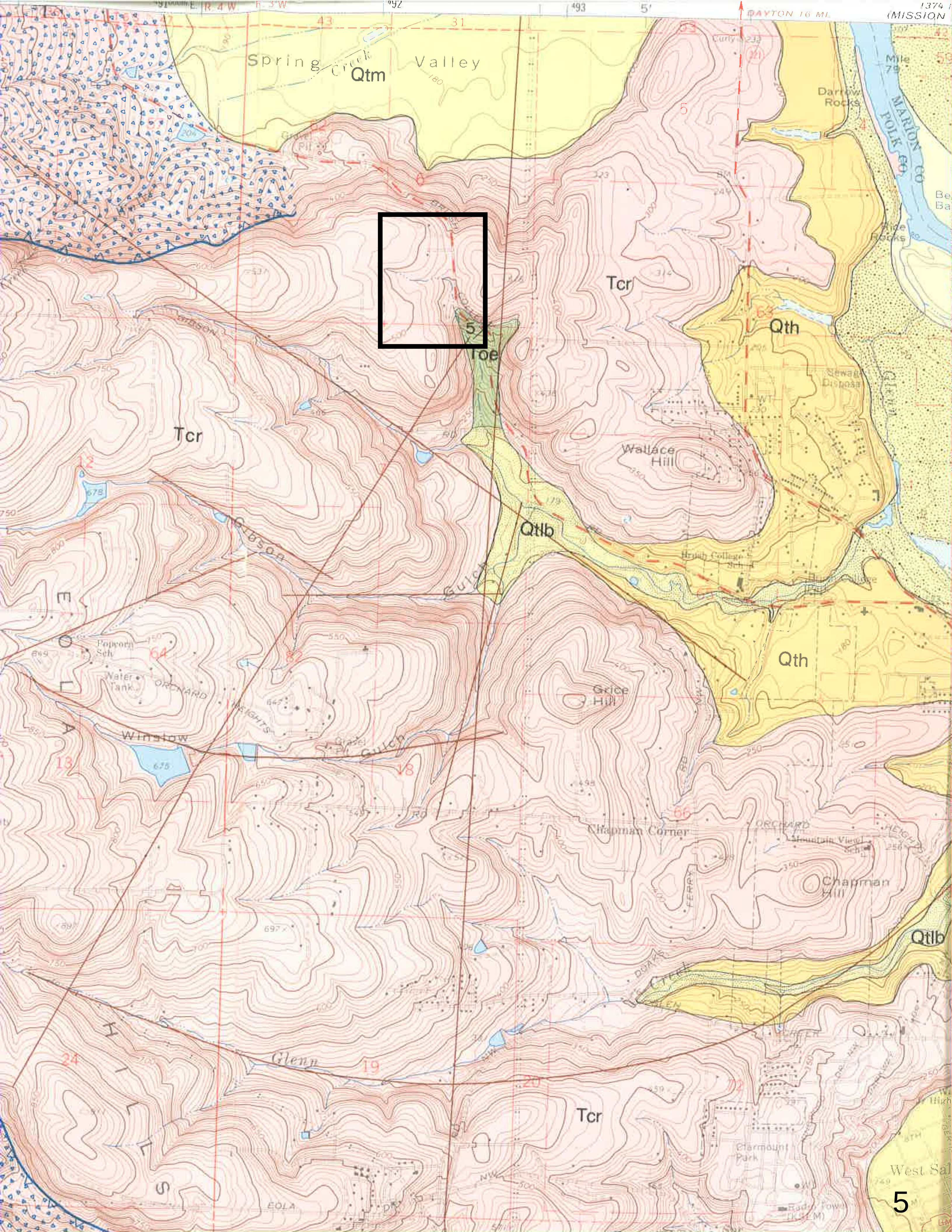
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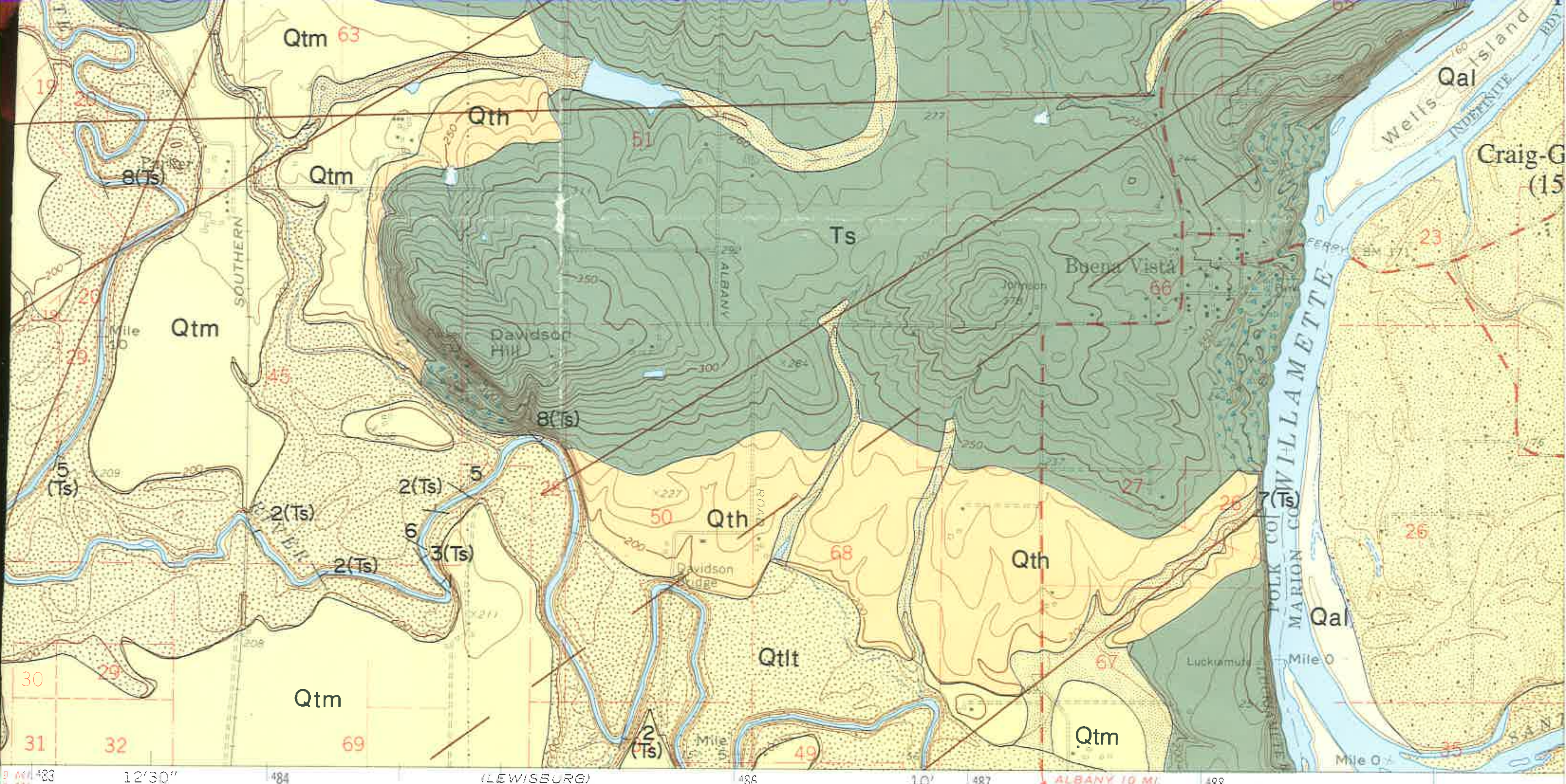
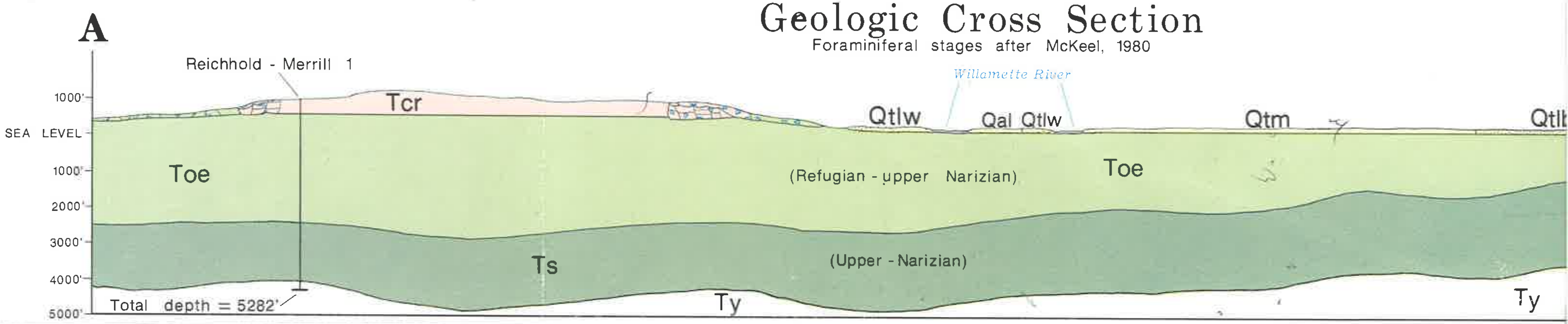
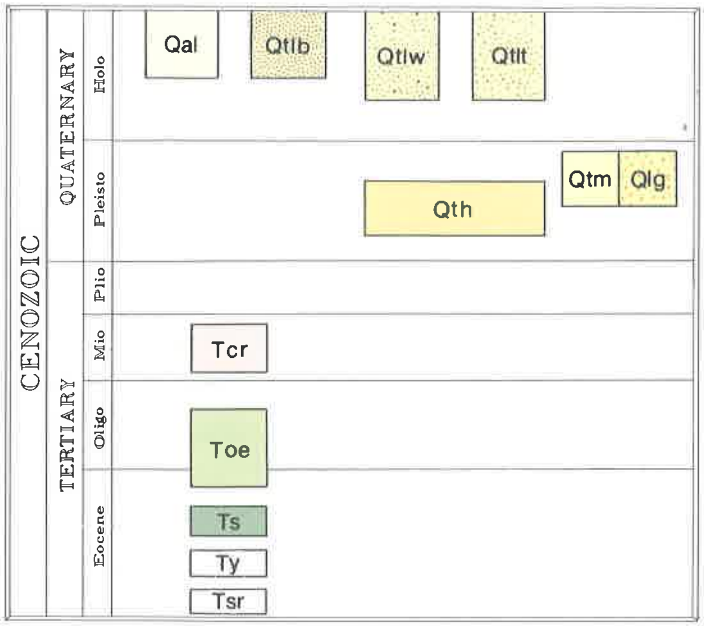


Geologic Cross Section

Foraminiferal stages after McKeel, 1980



TIME ROCK CHART



Reflects traditional usage in Western Oregon, after: Gonthier, 1980; Bela, 1979; Helm and Leonard, 1977; Beaulieu, 1974; Hickman, 1969; Baldwin and others, 1955; Vokes and others, 1954.

EXPLANATION

SURFICIAL GEOLOGIC UNITS

Qal — **Recent river alluvium:** *Unconsolidated cobbles, coarse gravel, sand, and some silt and clay within active channels of Willamette River. Generally 15-45 ft thick, consisting of stratified sands and well-rounded pebbles, gravels, and cobbles of primarily basaltic and andesitic composition; often overlain by 3-15 ft of light-brown sand and silt overburden. Characterized by low relief, point-bar and channel-bar deposits; many areas unvegetated, others support dense stands of brush and phreatophytes, such as willows and cottonwoods. Subject to major flooding, critical stream-bank erosion, and lateral channel migration; includes many areas located between 1852 meander line and present channel that illustrate possible extent of future changes*

Qtlw — **Lower terrace deposits of the Willamette River (Quaternary):** *Unconsolidated to semiconsolidated cobbles, gravel, sand, silt, clay, muck, and organic matter of variable thickness (30-50 ft) on the flood plain and lowland terraces immediately above the Recent river alluvium* (Qal)*; typically 5-20 ft of light-brown silt and clay or very fine sand overlying 10-45 ft of moderately well-sorted sand and locally cemented gravel. Surface topography characterized by a low, undulating, fluvial surface with abandoned channels, meander scrolls, oxbow lakes, and sloughs; subject to major and local flooding, some catastrophic channel migration of major scale, ponding, and high ground water. Flood-plain soils are predominantly well drained and somewhat excessively drained silty clay loams, silt loams, and sandy loams; good ground-water yields generally of 100-500 gallons per minute*

Qtlt — **Lower terrace deposits of tributary rivers and streams (Quaternary):** *Unconsolidated to semiconsolidated gravel, sand, silt, clay, and organic matter generally 15-30 ft thick on lowland terraces and flood plains immediately above major tributary rivers of the Willamette River. Gravel deposits are very thin to variable in thickness, according to tributary drainage source, generally limited to active stream beds or former meander channels, and located at or near bed rock beneath 20-30 ft of sand, silt, and clay. Somewhat tortuous meandering streams entrenched 15-45 ft, often flowing on Tertiary sedimentary bed rock or semiconsolidated older valley-fill alluvium. Surface topography characterized by a low, undulating fluvial surface of swell and swale relief, abandoned meander loops, and oxbow lakes; subject to high ground water and ponding and major and local flooding; flood-plain soils are predominantly well drained and somewhat excessively drained silty clay loams, silt loams, and sandy loams. Some soft, compressible organic soils of low shear strength may occur locally, particularly within abandoned channels and oxbows. Major stream-bank erosion commonly occurs at outer bends of meander loops by shallow earthflow and slump due to undercutting. Ground-water yields generally small*

Qtlb — **Lower terrace deposits of alluvial bottomlands (Quaternary):** *Flat, moderately to poorly drained areas with soft, organic compressible soils of low shear strength locally; characterized by low relief, ponding, and high ground water. Deposits typically consist of somewhat stratified very fine sands, silty sandy clays, silty clays, and silty clay loams, with slight to moderate plasticity (ML-CL); 4-12 ft thick along bottomlands of interior drainages of low, rolling sedimentary bedrock units. Deposits locally may represent somewhat thicker accumulations of silt and silty clay materials of fluviatile and/or loessal origin derived in part from Willamette Silts. Similar deposits along creeks are associated with deposits of units* **Qtm** *and* **Qth** *and are often modified by ditching and field drainage for agriculture; typical examples are deep (more than 60 in.) clay (CH), silty clay (CH), and silty clay loam (CL or ML) black Bashaw clay soils of Baskett Slough (Rickreall quadrangle). Similar thicknesses of reddish-brown sandy silty material (ML-CH) in basaltic terrain* (Tcr)

Qtm — **Middle terrace deposits (Quaternary):** *Semiconsolidated gravel, sand, silt, and clay forming very flat terraces of major extent along the Willamette River. Generally 10-30 ft of light-brown silty clay and interbedded very fine sand and silt (ML or CL-CH) surficial material; believed primarily related to Willamette Silts, including associated glacial erratics consisting of tiny fragments and pebbles up to boulders greater than 4 ft in diameter. Soils somewhat poorly drained and poorly drained silt loams and silty clay loams to moderately well-drained and well-drained silt loams subject to seasonal high ground water and ponding. Sand and gravel (GP, SM), where present, usually occur below 30 ft depth; locally more abundant near Monmouth-Independence and in the lower part of Ash Creek. Total thickness 0-85 ft, but often only 40-50 ft; within Rickreall 7½-minute quadrangle, 15-35 ft of brown clay or silt generally occurs above several to 30 ft of gravelly clay, black sands, and gravels.*

Qlg

fan in the Stayton-Turner-Salem areas during an early stage of the Santiam River; of limited extent within the map area; uppermost few feet of gravels extensively oxidized and weathered, often chalky; thickness ranges from 30-40 ft to possibly as much as 300 ft. Regionally, the upper foot or so of gravel is cemented by an impermeable clay pan locally, which restricts drainage. Composition of gravels (mostly basalt, but also andesite, dacite, rhyolite, quartz, and diorite) essentially uniform. Within map area near Salem, soils are well drained and somewhat poorly drained gravelly silt loam and gravelly loam. Extensively utilized as source of sand and gravel. Good ground-water yields greater than 100 gallons per minute

Qth

Higher terrace deposits (Quaternary-middle Pleistocene): *Generally semiconsolidated light-brown sand, silt, and clay of variable thickness (3-15 ft) on higher terraces and remnants of old higher terraces adjacent to sedimentary bedrock foothills; mantled by moderately well-drained and well-drained silt loam soils. Includes colluvium, slope wash, and alluvial fan deposits near sedimentary bedrock foothills; deposits thin where transitional with pediments. Material generally similar to unit* **Qtm**, *particularly in West Salem, containing glacial erratics related to Willamette Silt but also some gravelly alluvium. Some higher terrace deposits on west side of Salem Hills between Salem and Illahe Hill not shown due to scale. Also includes weathered (decomposed) cobbles and gravels which extend beyond the study area west of Rickreall (8-10 ft thick) and at southeastern margin of Sidney quadrangle (10-50? ft thick), where they are equivalent to the Leffler gravels of Allison (1953). These deposits also mantled by 3-15 ft of light-brown, silt loam and silty clay loam soils. Generally little or no ground-water yield*

BEDROCK GEOLOGIC UNITS

Tcr

Columbia River Basalt Group (Miocene): *Medium-gray to black, fine-grained, even-textured to slightly porphyritic basalt; unweathered flows generally dense, fairly crystalline, exhibiting massive columnar jointing near base to diced or hackly jointing in entablature. Unit consists of weathered and unweathered basaltic lava flows with interflow zones characterized by vesicular flow-top breccia, ash, and baked soils. Maximum thickness generally ranges 400-600 ft, with thickness greatly modified by erosion and weathering in many places; individual flows range from 40 ft to more than 100 ft in thickness.*

Formations recognized within the Yakima Basalt Subgroup (Beeson, 1980, personal communication) include (1) Grande Ronde Basalt: two to four "low Mg" N_2 flows, including one to two "Winter Water" flow(s) at top (typical exposure at Dairy Queen, West Salem); one to two thick "low Mg" flow(s), 100-150 ft thick, extensively quarried throughout map area; one to two flow(s) of "high Mg" N_2 basalt, generally deeply weathered, occurring above the "Winter Water" flow(s); and (2) a thinner layer of younger Wanapum Basalt, represented by one to three flow(s) of the Frenchman Springs Member, observed only in South Salem within the study area, although it also occurs outside the map area in the vicinity of Turner.

Weathered flows consist of reddish-brown to grayish-brown, crumbly to medium-dense basalt. Weathering is variable and believed related to individual basalt flows; some exposures are altered to red clay (laterite) to depths of 30 ft, and occasionally as deep as 60-175 ft, while others are only slightly weathered at surface. Some locations in Salem Hills (generally between 500-900 ft elevation within area bounded by Pringle School-Prospect Hill-Jackson Hill) show extensive laterization which has resulted in deposits of bauxite (Corcoran and Libbey, 1956). Soils are reddish-brown, well-drained silty clay loams and gravelly silty clay loams. Unit yields small to large quantities of ground water from permeable rubbly zones between flows

Toe

Eocene-Oligocene sedimentary rock (middle and lower Oligocene and upper Eocene): *Equivalent to tuffaceous marine sedimentary rocks (Tts) of Baldwin and others (1955), Illahe tuffs (Tit) of Mundorff (1939), Illahe Formation (Ti) of Thayer (1939), Eocene-Oligocene marine sedimentary rocks (Tm) of Price (1967), and undifferentiated Tertiary rocks (Tu) of Gonthier (in press). Consists of two lithologic and faunal units west of Willamette River (Baldwin and others, 1955) but undifferentiated in this map due to poor exposures. Older unit light-gray to tan sandy tuffaceous siltstone equivalent in age to early Oligocene Keasey Formation; thickest section near border of Amity-Rickreall 7½-minute quadrangles, where approximately 1,000 ft thick; other lower Oligocene strata well exposed in Yamhill River near Yamhill locks, where steeply dipping and complexly faulted. Younger unit is fine- to coarse-grained tuffaceous sandstone equivalent in age to middle Oligocene Pittsburg Bluff Formation; basal stratum approximately 150 ft of dark-gray, coarse-grained, calcareous cemented lithic sandstone, chiefly composed of detrital igneous rock fragments. White, fine-grained, massively bedded phase of pumiceous volcanic glass approximately 250 ft thick exposed for 3 mi along hillside south of Finzer (Salem West quadrangle); good exposures of pebbly tuff, tuffaceous conglomerate, and fine-grained platy tuff along Bunker Hill Road in Sidney 7½-minute quadrangle.*

Tuffaceous marine sandstone and siltstone of Oligocene sedimentary rock correspond to Oligocene Eugene Formation described by Hickman (1969), which contains early to middle Oligocene molluscan faunas. Recent foraminiferal analyses (McKeel, 1980) of oil and gas wells within the study area indicate unit contains almost 2,000 ft of upper Refugian and Refugian strata (Reichhold-Merrill #1, Sidney quadrangle) and 200-1,000 ft of basal siltstone, claystone, and shale of late Narizian (provincial West Coast late Eocene) age (Reserve-Bruer #1 and Reichhold-Merrill #1)

Ts

Upper Eocene sandstone: *Equivalent to Helmick beds (Thb) of Mundorff (1939) and Spencer (Ts) of Gonthier (in press); very fine- to medium-grained, thinly laminated (fissile) to thin-bedded, as well as prominently more massive, light-gray to yellowish-brown moderately well-sorted micaceous, calcareous, lithic arkosic marine (tuffaceous) sandstones; frequently interbedded with fine-grained marine tuffaceous siltstone, thinly laminated clay shale, and claystone; comprised of almost equal proportions of quartz, feldspar, and rock fragments cemented with calcite (in concretions); minor constituents include approximately 2% glauconite, 4% mica (biotite, muscovite, and chlorite), and less than 1% authigenic pyrite; well compacted; carbonaceous material consisting of plant stems, leaves, and other organic fragments common; calcareous concretions, fossiliferous or containing carbonaceous material, prominent along Willamette River south of Buena Vista (Monmouth quadrangle); pebbly lenses, abundant organic matter, and paleoecology indicate strandline environment; provenance from chiefly volcanic terrain. Weathered outcrops of massive, very fine- to medium-grained sands, generally friable, ranging in color from white to yellowish-brown, pale-brown, or yellowish-orange.*

According to McKeel (1980), this unit is bracketed by upper Narizian strata in the Reichhold-Finn #1 well (Amity quadrangle), by upper Narizian and Narizian strata in the Reserve-Bruer #1 well (Amity quadrangle), and by upper Narizian strata in the Reichhold-Merrill #1 well (Salem West quadrangle). Average thickness about 800 ft

Ty

Yamhill Formation (middle and upper Eocene): *Medium- to dark-gray, massive to faintly bedded, micaceous, tuffaceous shale and siltstone. Occasional beds of medium-gray to greenish-gray, fossiliferous, calcareous sandstone; minor limestone concretions.*

According to McKeel (1980), this unit contains 2,000-3,000 ft of Narizian and lower Narizian strata in the Reichhold-Finn #1 and Reserve-Bruer #1 wells, located in the Amity quadrangle. Shown only in the cross section

Tsr

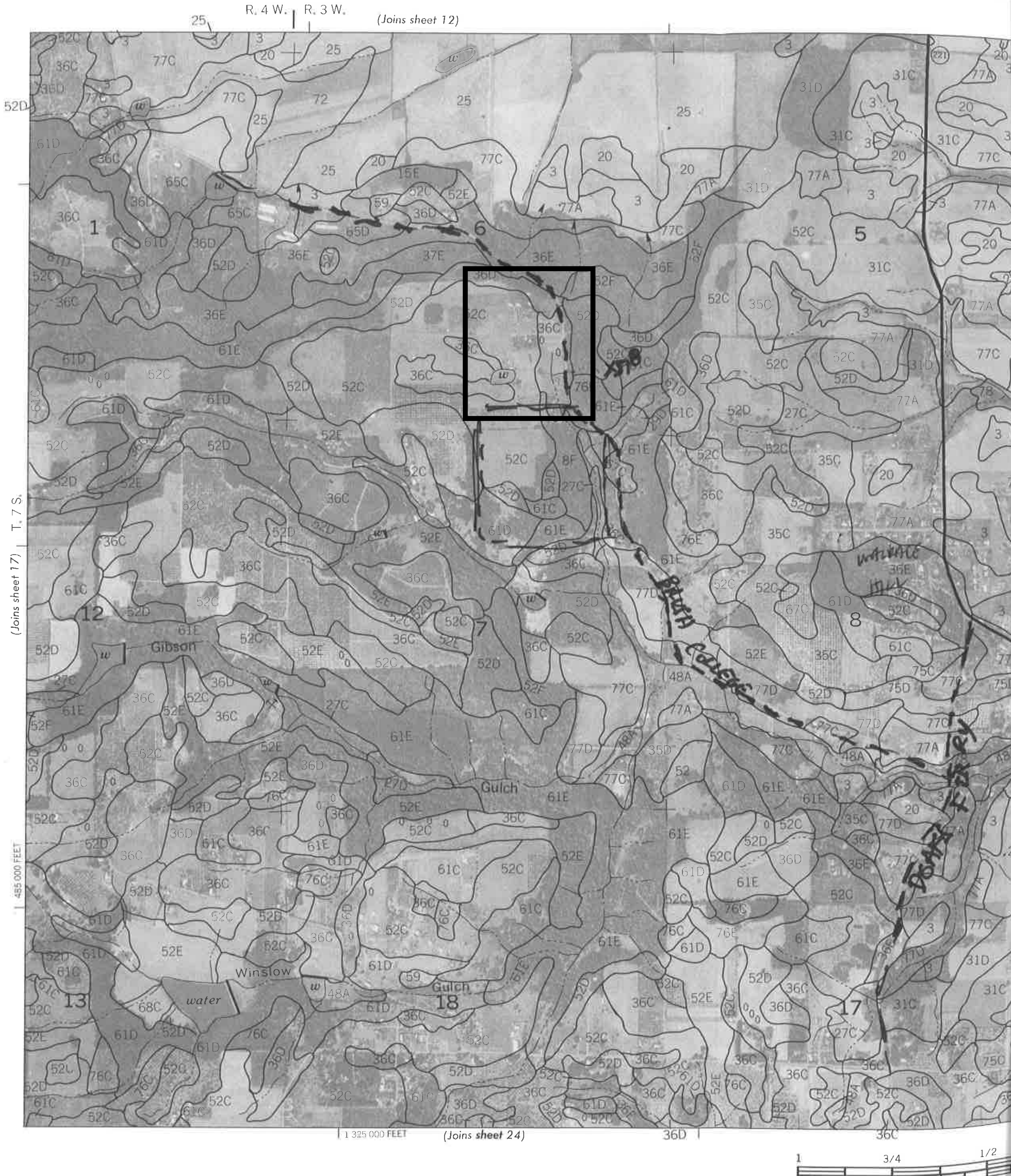
Siletz River Volcanics (lower and middle Eocene): *Dark-greenish-gray, aphanitic to porphyritic, vesicular basalt and pillow basalt; flow breccia; tuff breccia; red to green, calcareous sandy tuff; medium- to dark-gray, calcareous, tuffaceous shale, siltstone, and sandstone.*

According to McKeel (1980), this unit contains 300-1,700 ft of lower Narizian-Ulatisian strata in the Reserve Bruer #1 and Reichhold-Finn #1 wells, located in the Amity quadrangle. Additionally these wells contain 700-2,000 ft of underlying Siletz River Volcanics of indeterminate age. Shown only in the cross section

OTHER SYMBOLS

Lineament: *Selected major lineaments identified from 1:76,000 false-color infrared aerial photographs (U.S. Army Corps of Engineers, 1978), orthophotoquads, and topographic maps. Features include aligned ridges, major escarpments, concentric curvilinear drainages, aligned drainages across saddles, and parallelism; omitted are short linear segments along drainages of less than 1 mi length; general trends NE and NW, typical of lineament features observed in western Oregon*

Landslide topography: *Large areas of deep bedrock failure characterized by irregular topography, disrupted stratigraphy, overall anomalous moderate to shallow slope, prominent arcuate headscarps, backward-tilted blocks, springs, sag ponds, and disrupted drainage patterns. Most prominent along west side of Salem Hills and south and west side of Eola Hills, where undercutting of soft marine sediments (Eocene to Oligocene sedimentary*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1

This soil is well suited to the production of Douglas-fir. It is not well suited to Christmas tree production because the slope causes difficulty in management and harvesting. Mixed stands of Douglas-fir, Oregon white oak, and grand fir are on the soil. The older, even-aged stands are dominantly Douglas-fir. The site index for Douglas-fir on this soil is about 148. Based on this average site index, the soil is capable of producing about 11,700 cubic feet, or 59,700 board feet (International rule, one-fourth inch kerf), of merchantable timber from a fully stocked, even-aged stand of 80-year-old trees.

Roads and landings need water bars and grass seeding to prevent erosion. Roads need a maximum of base rock for all-season use.

The crops produced on this soil help to provide food and cover for ring-necked pheasant, California quail, and bobwhite quail. Ruffed grouse, mountain quail and band-tailed pigeons are common in wooded areas of Oregon white oak, Douglas-fir, western hazel, bigleaf maple, and other trees, shrubs, and grasses. These birds feed on the fruit and seeds of trees and shrubs. Black-tailed deer are common in both cultivated and uncultivated areas of the soil. Planting Douglas-fir, using grassed waterways, planting along roadsides, and maintaining fence rows and brushy areas improve the cover and food supply for wildlife.

Increased population growth in the county has resulted in increased home construction. The main limitations to homesites and septic tank filter fields are the slow permeability and slope. Most areas of this soil are not on community sewage systems.

This soil is in capability subclass IVe.

8F—Bellpine silty clay loam, 30 to 50 percent slopes. This well drained soil is on low foothills and higher, rolling uplands. The soil formed in colluvium weathered from sedimentary rock. It is underlain by siltstone at a depth of 20 to 40 inches. Slopes average about 40 percent. Elevation is 300 to 800 feet. The average annual precipitation is 40 to 60 inches, the average annual air temperature is 52 to 54 degrees F, and the frost-free period is 165 to 200 days.

In a representative profile, the surface layer is dark reddish brown silty clay loam about 9 inches thick. The subsoil is dark reddish brown silty clay and clay about 23 inches thick. Partly weathered siltstone is at a depth of 32 inches.

Included with this soil in mapping are areas of Jory and Rickreall soils, which make up about 10 percent of this map unit, and Dupee and Suver soils which make up 5 percent.

Permeability is slow. Effective rooting depth is 20 to 40 inches. Available water capacity is 3.5 to 6 inches, and the water-supplying capacity is 17 to 24 inches. Runoff is rapid, and the hazard of erosion is high.

This soil is used for timber production and pasture. Oregon white oak and grass are in some areas. The slope makes this soil unsuitable for cultivation. The soil is suited to limited tillage for pasture management. It is well suited to the production of Douglas-fir. The soil is not well suited to Christmas tree production, because the slope causes difficulty in management and harvesting. Mixed stands of Douglas-fir, Oregon white oak, and grand fir are on this soil. The older, even-aged stands are dominantly Douglas-fir. The average site index for Douglas-fir on this soil is about 148. Based on this average site index, the soil is capable of producing about 11,700 cubic feet, or 59,700 board feet (International rule, one-fourth inch kerf), of merchantable timber from a fully stocked, even-aged stand of 80-year-old trees.

Roads and landings need water bars and grass seeding to prevent erosion. Roads need a maximum of base rock for all-season use.

Areas of soil that are adjacent to cultivated soils provide habitat for ring-necked pheasant, California quail, and bobwhite quail. Ruffed grouse, mountain quail, and band-tailed pigeons are common in wooded areas of Oregon white oak, Douglas-fir, western hazel, bigleaf maple and other trees, shrubs, and grasses. These birds feed on the fruit and seeds of trees and shrubs. Black-tailed deer are common in both cultivated and uncultivated areas of the soil. Planting Douglas-fir, using grassed waterways, planting along roadsides, and maintaining fence rows and brushy areas improve the cover and food supply for wildlife.

Increased population growth in the county has resulted in increased home construction. This soil has major limitations for dwellings and roads because of the slope. Most areas are not on community sewage systems.

This soil is in capability subclass VIe.

8G—Bellpine silty clay loam, 50 to 75 percent slopes. This well drained soil is on low foothills and higher, rolling uplands. This soil formed in colluvium weathered from sedimentary rock. It is underlain by siltstone at a depth of 20 to 40 inches. Slopes average about 60 percent. Elevation is 300 to 800 feet. The average annual precipitation is 40 to 60 inches, the average annual air temperature is 52 to 54 degrees F, and the frost-free period is 165 to 200 days.

In a representative profile, the surface layer is dark reddish brown silty clay loam about 9 inches thick. The subsoil is dark reddish brown silty clay and clay about 23 inches thick. Partly weathered siltstone is at a depth of 32 inches.

Included with this soil in mapping are areas of Jory and Rickreall soils, which make up about 10 percent of the map unit, and Dupee and Suver soils, which make up 5 percent.

Permeability is slow. Effective rooting depth is 20 to 40 inches. Available water capacity is 3.5 to 6 inches, and the water-supplying capacity is 17 to 24 inches. Runoff is rapid, and the hazard of erosion is high.

ging. Roads and landings may need protection from erosion by constructing water bars and seeding road cuts and fills. Roads on this soil require a maximum of base rock for all-season use. Construction and maintenance of roads is difficult because of steep slopes and the hazard of slides.

Plant competition is slight. Grass, brush, and fern competition is especially difficult to control in nonstocked, cutover areas. Seedling mortality generally is not a concern. Natural regeneration generally is adequate, but supplemental site preparation and seeding or planting may be needed. There is little hazard of windthrow.

Douglas-fir, hazel, bigleaf maple, alder, and other trees and shrubs are important food and cover plants for ruffed grouse, mountain quail, and band-tailed pigeons. These game birds feed on the leaves, buds, nuts, fruit, and seed from the Pacific dogwood, madrone, elderberry, cascara, and other plants for food. Black-tailed deer use this area for food and cover.

Numerous drainageways are available for small ponds. Except for a few major creeks and springs, the drainageways are dry late in summer.

The slope is the major limitation to homesites. Roads and streets are subject to slips and slides.

This soil is in capability subclass VIIe.

51D—Mulkey loam, 5 to 25 percent slopes. This well drained soil is in mountainous topography in the Coast Range. The soil formed in residuum and colluvium weathered from basic igneous rock. Bedrock is at a depth of 20 to 40 inches. Slopes average about 15 percent. Elevation is 3,000 to 3,400 feet. The average annual precipitation is 80 to 120 inches, the average annual air temperature is 43 to 45 degrees F, and the frost-free period is about 80 to 100 days.

In a representative profile, the surface layer is very dark brown and very dark grayish brown loam about 23 inches thick. The subsoil is dark brown gravelly loam about 7 inches thick. The upper 5 inches of the substratum is dark yellowish brown very gravelly loam, and the lower part is fractured gabbro.

Included with this soil in mapping are areas of Kilchis soils, which make up 10 percent of this map unit, and Klickitat soils, which make up about 5 percent.

Permeability is moderately rapid. Effective rooting depth is 20 to 40 inches. Available water capacity is 3 to 6.5 inches, and the water-supplying capacity is 15 to 20 inches. Runoff is medium, and the hazard of erosion is moderate.

This soil has only fair suitability for timber production. It is on peaks in open park areas of grass, fern, and intermittent, mixed stands of Douglas-fir, noble fir, and hemlock. The site index for Douglas-fir on this soil is about 90. Based on this site index, the soil is capable of producing about 5,200 cubic feet, or 10,200 board feet (International rule, one-fourth inch kerf), of merchantable timber from a fully stocked, even-aged stand of 80-year-old trees. The site index for noble fir is about 90.

Limitations to the use of equipment are slight. Trafficability is good, except during very wet periods. Roads, skid trails, and landings need water bars and grass seeding to help control erosion.

Plant competition causes some concerns. Grass and brackenfern are aggressive and often prevent the establishment of conifers. There is some hazard of seedling mortality. This soil generally is covered with snow for long periods in winter. Natural regeneration is slow and site preparation, stocking, and planting are necessary. There is some hazard of windthrow. High winds are common throughout the year.

Blue grouse, ruffed grouse, and black-tailed deer are numerous on this soil. Small herds of Roosevelt elk are in the extreme western part of the county. Areas of the soil are often closed to entry in summer and early in fall months because of low humidity and high danger of fire. Except for a few major creeks and springs, the drainageways are dry in July, August, and September. Cool sea breezes and fog often add moisture during this period. There are numerous draws and drainageways where small ponds could be built.

The slope is the major limitation to homesites.

This soil is in capability subclass VIe.

52C—Nekia silty clay loam, 2 to 12 percent slopes. This well drained soil is in the foothills and on the higher, rolling uplands that border the mountainous area. The soil formed in colluvium and residuum weathered from basic rock. Basalt is at a depth of 20 to 40 inches. Slopes average about 8 percent. Elevation is 300 to 1,200 feet. The average annual precipitation is 40 to 60 inches, the average annual air temperature is 52 to 54 degrees F, and the frost-free period is 165 to 200 days.

In a representative profile, the surface layer is dark reddish brown silty clay loam about 9 inches thick. The subsoil is dark reddish brown silty clay and clay about 16 inches thick. Partly weathered and fractured basalt is at a depth of 25 inches.

Included with this soil in mapping are areas of Jory and Ritner soils, which make up about 10 percent of this map unit, and Witzel soils, which make up 5 percent.

Permeability is moderately slow. Effective rooting depth is 20 to 40 inches. Available water capacity is 4 to 7 inches, and the water-supplying capacity is 17 to 24 inches. Runoff is slow, and the hazard of erosion is slight.

Most of this acreage is cultivated. Cereal grain, orchards, forage, and grass seed are the main crops. The soil is moderately productive for these crops. It is not so productive or easily tilled as other soils on terraces or bottom lands.

This soil responds well to fertilizers and amendments. If residues are used, additional nitrogen is generally needed to prevent a decrease in yield. Properly managing crop residue and using a cropping system in which grasses and legumes or a grass and legume mixture are grown at least 25 percent of the time help to reduce runoff and erosion and help to maintain fertility and workability.

This soil generally is not irrigated. Irrigation water generally must be stored in ponds or reservoirs, and suitable reservoir sites are limited.

This soil produces good stands of Douglas-fir trees. It is well suited to the production of Christmas trees. Mixed stands of Douglas-fir, Oregon white oak, and grand fir grow on this soil. The site index for Douglas-fir on this soil ranges from 141 to 161, and the average site index is 151. Based on the average site index, the soil is capable of producing about 12,200 cubic feet, or 62,500 board feet (International rule, one-fourth inch kerf), of merchantable timber from a fully stocked, even-aged stand of 80-year-old trees.

Limitation to the use of equipment are few. This soil is plastic and sticky when wet; this restricts trafficability. Roads and landings need protection against erosion by constructing water bars and seeding cuts and fills to permanent grass cover.

The crops and natural vegetation on this soil provide food and cover for ring-necked pheasant, California quail, and bobwhite quail. In wooded areas of Oregon white oak, Douglas-fir, hazel, bigleaf maple, and other trees, shrubs, and grass, common birds include ruffed grouse, mountain quail, and band-tailed pigeons. These birds feed on the fruit and seeds of trees and shrubs. Black-tailed deer are common on this unit in both cultivated and uncultivated areas. Planting Douglas-fir, using grassed waterways, planting along roadsides, and maintaining fence rows and brushy areas improve the cover and food supply for wildlife.

Increased population growth in the county has resulted in increased home construction on this soil. The main limitation to homesites is the moderately slow permeability that restricts septic tank filter fields. Most areas of the soil are not on community sewage systems.

This soil is in capability subclass IIe.

52D—Nekia silty clay loam, 12 to 20 percent slopes. This well drained soil is in the foothills and on the higher, rolling uplands that border the mountainous area. The soil formed in colluvium and residuum weathered from basic rock. Basalt bedrock is at a depth of 20 to 40 inches. Slopes average about 18 percent. Elevation is 300 to 1,200 feet. The average annual precipitation is 40 to 60 inches, the average annual air temperature is 52 to 54 degrees F, and the frost-free period is 165 to 200 days.

In a representative profile, the surface layer is dark reddish brown silty clay loam about 9 inches thick. The subsoil is dark reddish brown silty clay and clay about 16 inches thick. Partly weathered and fractured basalt is at a depth of 25 inches.

Included with this soil in mapping are areas of Jory and Ritner soils, which make up 10 percent of this map unit, and Witzel soils, which make up 5 percent.

Permeability is moderately slow. Effective rooting depth is 20 to 40 inches. Available water capacity is 4 to 7 inches, and the water-supplying capacity is 17 to 24 inches. Runoff is medium, and the hazard of erosion is moderate.

Most of the acreage of this soil is cultivated. Cereal grain, orchards, forage, and grass seed are the main crops, and the soil is moderately productive for these crops. The soil is not so productive or easily tilled as other soils on terraces or bottom lands.

This soil responds well to fertilizers and amendments. If residues are used, additional nitrogen is generally needed to prevent a decrease in yield. Properly managing crop residue and using a cropping system in which grasses and legumes or a grass and legume mixture are grown at least 50 percent of the time help to reduce runoff and erosion and help to maintain fertility and workability.

This soil generally is not irrigated. Irrigation water generally must be stored in ponds or reservoirs, and suitable reservoir sites are limited.

This soil produces good stands of Douglas-fir. It is moderately suited to Christmas tree production. Mixed stands of Douglas-fir, Oregon white oak, and grand fir grow on the soil. The site index for Douglas-fir ranges from 135 to 159, and the average site index is 144. Based on the average site index, this soil is capable of producing about 11,200 cubic feet, or 56,000 board feet (International rule, on-fourth inch kerf), of merchantable timber from a fully stocked, even-aged stand of 80-year-old trees.

Limitations to the use of equipment are slight. Roads and landings need protection against erosion by constructing water bars and seeding cuts and fills to permanent grass cover. The slope may interfere with management and harvesting.

The crops and natural vegetation on this soil provide food and cover for ring-necked pheasant, California quail, and bobwhite quail. In wooded areas of Oregon white oak, Douglas-fir, hazel, bigleaf maple, and other trees, shrubs, and grasses, common birds include ruffed grouse, mountain quail, and band-tailed pigeon. These birds feed on the fruit and seeds of trees and shrubs. Black-tailed deer are common in both cultivated and uncultivated areas. Planting Douglas-fir, using grassed waterways, planting along roadsides, and maintaining fence rows and brushy areas improve the cover and food supply for wildlife.

Increased population growth in the county has resulted in increased home construction on this soil. The main limitation for homesites is that they cannot be used for septic tank filter fields because of the moderately slow permeability and moderately steep slopes. Most areas of the soil are not on community sewage systems.

This soil is in capability subclass IIIe.

52E—Nekia silty clay loam, 20 to 30 percent slopes. This well drained soil is in the foothills and on the higher, rolling uplands that border the mountainous area. The soil formed in colluvium and residuum weathered from basic rock. Basalt is at a depth of 20 to 40 inches. Slopes average about 25 percent. Elevation is 300 to 1,200 feet. The average annual precipitation is 40 to 60 inches, the average annual air temperature is 52 to 54 degrees F, and the frost-free period is 165 to 200 days.

In a representative profile, the surface layer is dark reddish brown silty clay loam about 9 inches thick. The subsoil is dark reddish brown silty clay and clay about 16 inches thick. Partly weathered and fractured basalt bedrock is at a depth of 25 inches.

Included with this soil in mapping are areas of Jory and Ritner soils, which make up 10 percent of this map unit, and Witzel soils, which make up 5 percent.

Permeability is moderately slow. Effective rooting depth is 20 to 40 inches. Available water capacity is 4 to 7 inches, and the water-supplying capacity is 17 to 24 inches. Runoff is rapid, and the hazard of erosion is high.

This soil is used principally for forage crops, forestry, cereal grain, orchards, and grass seed. The slope makes this soil poorly suited to cultivation. If cultivated, this soil requires such intensive practices as contour cropping, returning crop residue to the soil, rough tillage, and winter cover crops to control erosion. Properly managing crop residue and using a cropping system in which grasses and legumes or a grass and legume mixture are grown at least 75 percent of the time help to reduce runoff and erosion and help to maintain fertility and workability.

This soil produces good stands of Douglas-fir trees. It is not well suited to Christmas tree production because the slope causes difficulty in management and harvesting. Mixed stands of Douglas-fir, Oregon white oak, and grand fir grow on the soil. The average site index for Douglas-fir on this soil is about 144. Based on the average site index, this soil is capable of producing about 11,200 cubic feet, or 56,000 board feet (International rule, one-fourth inch kerf) of merchantable timber from a fully stocked, even-aged stand of 80-year-old trees.

Limitations to the use of equipment are slight. This soil is plastic and sticky when wet; this restricts trafficability. Roads and landings need protection against erosion by constructing water bars and seeding cuts and fills to permanent grass cover.

The crops and natural vegetation on this soil provide food and cover for ring-necked pheasant, California quail, and bobwhite quail. In wooded areas of Oregon white oak, Douglas-fir, hazel, bigleaf maple, and other trees, shrubs, and grass, common birds include ruffed grouse, mountain quail, and band-tailed pigeon. These birds feed on the fruit and seeds of trees and shrubs. Black-tailed deer are common in both cultivated and uncultivated areas. Planting Douglas-fir, using grassed waterways, planting along roadsides, and maintaining fence rows and brushy areas improve the cover and food supply for wildlife.

Increased population growth in the county has resulted in increased home construction on this soil. The main limitations for homesites are the major restrictions for septic tank filter fields, dwellings, and roads because of the slope and the moderately slow permeability. Most areas of the soil are not on community sewage systems.

This soil is in capability subclass IVe.

52F—Nekia silty clay loam, 30 to 50 percent slopes. This well drained soil is in the foothills and on the higher, rolling uplands that border the mountainous area. The soil formed in colluvium and residuum weathered from basic rock. Basalt bedrock is at a depth of 20 to 40 inches. Slopes average about 40 percent. Elevation is 300 to 1,200 feet. The average annual precipitation is 40 to 60 inches, the average annual air temperature is 52 to 54 degrees F, and the frost-free period is 165 to 200 days.

In a representative profile, the surface layer is dark reddish brown silty clay loam about 9 inches thick. The subsoil is dark reddish brown silty clay and clay about 16 inches thick. Partly weathered and fractured basalt bedrock is at a depth of 25 inches.

Included with this soil in mapping are areas of Jory and Ritner soils, which make up about 10 percent of this map unit, and Witzel soils, which make up 5 percent.

Permeability is moderately slow. Effective rooting depth is 20 to 40 inches. Available water capacity is 4 to 7 inches, and the water-supplying capacity is 17 to 24 inches. Runoff is rapid, and the hazard of erosion is high.

This soil is used for timber production. Some areas of the soil are in stands of Oregon white oak and grass. Because of slope, cultivation is unsuitable for this soil; however, some limited tilling for pasture is performed.

This soil is well suited to the production of commercial stands of Douglas-fir. It is not well suited to Christmas tree production because the slope causes difficulty in management and harvesting. Mixed stands of Douglas-fir, Oregon white oak, and grand fir grow on the soil. The average site index for Douglas-fir on this soil is about 144. Based on the average site index, this soil is capable of producing about 11,200 cubic feet, or 56,000 board feet (International rule, one-fourth inch kerf), of merchantable timber from a fully stock, even-aged stand of 80-year-old trees.

Limitations to the use of equipment are slight. Roads and landings need protection from erosion by constructing water bars and seeding cuts and fills and skid roads. Roads on this soil need a maximum of base rock for all-season use.

The crops and natural vegetation on this soil and on adjacent cultivated areas provide food and cover for

No commercial stands of timber grow on this soil. The soil is poorly suited to growing Christmas trees because of droughtiness.

Ring-necked pheasant, California quail, and bobwhite quail may be present in areas of the soil that are intermingled with cultivated soils. Native grass, Oregon white oak, poison-oak, and wild rose provide important food and cover for black-tailed deer and other wildlife.

The soil has major limitations for homesites, commercial buildings, roads and streets, and other community uses because of the shallow depth to bedrock.

This soil is in capability subclass VIe.

60E—Rickreall silty clay loam, 20 to 50 percent slopes. This well drained soil is on foot slopes and low, rolling foothills. The soil formed in material weathered from sedimentary bedrock. Siltstone is at a depth of 12 to 20 inches. Slopes average about 35 percent. Elevation is 300 to 800 feet. The average annual precipitation is 40 to 60 inches, the average annual air temperature is 52 to 54 degrees F, and the frost-free period is 165 to 210 days.

In a representative profile, the surface layer is dark reddish brown silty clay loam about 5 inches thick. The subsoil is dark reddish brown, reddish brown, and yellowish red silty clay and clay about 12 inches thick. Weathered siltstone is at a depth of 17 inches.

Included with this soil in mapping are areas of Bellpine, Hazelair, and Steiwer soils, which make up 15 percent of this map unit.

Permeability is slow. Effective rooting depth is restricted by sedimentary bedrock at a depth of about 12 to 20 inches. Available water capacity is 2 to 3 inches, and the water-supplying capacity is 8 to 14 inches. Runoff is rapid, and the hazard of erosion is high.

This soil is used for pasture, which is mainly in natural stands of grass and Oregon white oak. Erosion can be controlled by maintaining a ground cover of native vegetation.

No commercial stands of timber grow on this soil. The soil is poorly suited to Christmas trees because of droughtiness and steep slopes.

Ring-necked pheasant, California quail, and bobwhite quail may be present in areas of the soil that are intermingled with cultivated soils. Oregon white oak, grass, poison-oak, and wild rose provide important food and cover for black-tailed deer and other wildlife.

This soil has major limitations for homesites, commercial buildings, roads and streets, and other community uses because of shallow depth to rock and the slope.

This soil is in capability subclass VIIe.

60F—Rickreall silty clay loam, 50 to 75 percent slopes. This well drained soil is on foot slopes and low, rolling foothills. The soil formed in material weathered from sedimentary bedrock. Siltstone is at a depth of 12 to 20 inches. Slopes average about 60 percent. Elevation is 300 to 800 feet. The average annual precipitation is 40 to 60 inches, the average annual air temperature is 52 to 54 degrees F, and the frost-free period is 165 to 210 days.

In a representative profile, the surface layer is dark reddish brown silty clay loam about 5 inches thick. The subsoil is dark reddish brown, reddish brown, and yellowish red silty clay and clay about 12 inches thick. Weathered siltstone is at a depth of 17 inches.

Included with this soil in mapping are areas of Bellpine, Hazelair, and Steiwer soils, which make up 15 percent of this map unit.

Permeability is slow. Effective rooting depth is restricted by sedimentary bedrock at a depth of about 12 to 20 inches. Available water capacity is 2 to 3 inches, and the water-supplying capacity is 8 to 14 inches. Runoff is rapid, and the hazard of erosion is high.

This soil is used for pasture, which is mainly in natural stands of grass and Oregon white oak. Erosion can be controlled by maintaining a ground cover of native vegetation.

No commercial stands of timber grow on this soil. The soil is poorly suited to growing Christmas trees because of droughtiness and the steep slopes.

Ring-necked pheasant, California quail, and bobwhite quail may be present in areas of this soil that are intermingled with cultivated soils. Oregon white oak, grass, poison-oak, and wild rose provide important food and cover for black-tailed deer and other wildlife.

This soil has major limitations for homesites, commercial buildings, roads and streets, and other community uses because of shallow depth to rock and the slope.

This soil is in capability subclass VIIe.

61C—Ritner gravelly silty clay loam, 3 to 12 percent slopes. This well drained soil is on foothills. The soil formed in cobbly colluvium weathered from basic igneous rock. Basalt is at a depth of 20 to 40 inches. Slopes average about 8 percent. Elevation is 400 to 1,200 feet. The average annual precipitation is 40 to 60 inches, the average annual air temperature is 52 to 54 degrees F, and the frost-free period is 165 to 210 days.

In a representative profile, the surface layer is dark reddish brown gravelly silty clay loam about 6 inches thick. The upper 20 inches of the subsoil is dark reddish brown gravelly silty clay loam and silty clay, and the lower 12 inches is dark reddish brown very cobbly silty clay. Fractured basalt is at a depth of 38 inches.

Included with this soil in mapping are areas of Witzel and Nekia soils, which make up 10 percent of this map unit.

Permeability is moderately slow. Effective rooting depth is restricted by basalt at a depth of 20 to 40 inches. Available water capacity is 3 to 6 inches, and the water-supplying capacity is 16 to 23 inches. Runoff is slow, and the hazard of erosion is slight.

This soil is used mainly for cereal grain, orchards, pasture, and woodland. It is not so productive or easily tilled as other soils on terraces or bottom lands.

Erosion can be controlled with cross-slope farming, grassed waterways, winter cover crops, and returning crop residue to the soil. Properly managing crop residue and using a cropping system in which grasses and legumes or a grass and legume mixture are grown at least 25 percent of the time improve tilth and crop yields.

Grain and grass crops respond to nitrogen, and legumes respond to phosphorus, sulfur, boron, and, in many places, lime. If crop residues are used, additional nitrogen is needed to prevent a decrease in yields.

This soil generally is not irrigated. Irrigation water generally must be stored in reservoirs, and suitable reservoir sites are limited.

This soil is moderately well suited to Douglas-fir production and is well suited to Christmas tree production. Mixed stands of Oregon white oak, Douglas-fir, and grand fir grow on the soil. The site index for Douglas-fir on the soil ranges from 128 to 142, and the average site index is 135. Based on this site index for Douglas-fir, the soil is capable of producing about 10,300 cubic feet, or 47,400 board feet (International rule, one-fourth inch kerf), of merchantable timber from a fully stocked even-aged stand of 80-year-old trees.

Limitations to the use of equipment are slight. This soil is plastic and sticky when wet; this restricts trafficability. Roads and landings need protection against erosion by constructing water bars and seeding cuts and fills.

Seedling mortality and plant competition present some concerns.

The crops grown on this soil provide food and cover for ring-necked pheasant, California quail, and bobwhite quail. In wooded areas of Oregon white oak, Douglas-fir, grand fir, bigleaf maple, and other trees, shrubs, and grasses, common birds include ruffed grouse, mountain quail, and band-tailed pigeons. These birds feed on the fruit and seeds of trees and shrubs. Black-tailed deer are common. Planting Douglas-fir, using grassed waterways, planting along roadsides, and maintaining fence rows and brushy areas improve the cover and food supply for wildlife.

Increased population growth in the county has resulted in increased home construction on this soil. There are some limitations for homesites, commercial buildings, and local roads and streets because of depth to rock and low strength. The soil has major limitations for septic tank absorption fields because of the depth to rock and moderately slow permeability.

This soil is in capability subclass IVs.

61D—Ritner gravelly silty clay loam, 12 to 30 percent slopes. This well drained soil is on foothills. The soil formed in colluvium weathered from basic igneous rocks. Basalt is at a depth of 20 to 40 inches. Slopes average about 20 percent. Elevation is 400 to 1,200 feet. The average annual precipitation is 40 to 60 inches, the average annual air temperature is 52 to 54 degrees F, and the frost-free period is 165 to 210 days.

In a representative profile, the surface layer is dark reddish brown gravelly silty clay loam about 6 inches thick. The upper 20 inches of the subsoil is dark reddish brown gravelly silty clay loam and silty clay, and the lower 12 inches is dark reddish brown very cobbly silty clay. Highly fractured basalt is at a depth of 38 inches.

Included with this soil in mapping are areas of Witzel and Nekia soils, which make up 10 percent of this map unit.

Permeability is moderately slow. Effective rooting depth is restricted by basalt at a depth of 20 to 40 inches. Available water capacity is 3 to 6 inches, and the water-supplying capacity is 16 to 23 inches. Runoff is medium, and the hazard of erosion is moderate.

This soil is used mainly for pasture and woodland. The slope makes this soil unsuitable for cultivation. Improved varieties of grasses are desirable for cover if they can be established. Planting improved varieties of grasses early in spring insures a better cover than if planted later and helps to protect the soil from erosion the following winter.

This soil is moderately well suited to Douglas-fir production. It is not well suited to Christmas tree production because the slope restricts harvesting and management. Mixed stands of Oregon white oak, Douglas-fir and grand fir grow on the soil. The site index for Douglas-fir ranges from 128 to 142, and the average site index is 135. Based on this site index for Douglas-fir, the soil is capable of producing about 10,300 cubic feet, or 47,400 board feet (International rule, one-fourth inch kerf), of merchantable timber from a fully stocked even-aged stand of 80-year-old trees.

Limitations to the use of equipment are slight. This soil is plastic and sticky when wet; this restricts trafficability. Roads and landings need protection against erosion by constructing water bars and seeding cuts an fills.

Seedling mortality and plant competition present some concerns.

The crops produced on this soil provide food and cover for ring-necked pheasant, California quail, and bobwhite quail. In wooded areas of Oregon white oak, Douglas-fir, grand fir, bigleaf maple, and other trees, shrubs and grasses, common birds include ruffed grouse, mountain quail, and band-tailed pigeons. These birds feed on the fruit and seeds of trees and shrubs. Black-tailed deer are common. Planting Douglas-fir, using grassed waterways, planting along roadsides, and maintaining fence rows and brushy areas improve the cover and food supply for wildlife.

This soil has major limitations for homesites, commercial buildings, local roads and streets, and septic tank absorption fields because of the slope.

This soil is in capability subclass VIs.

61E—Ritner gravelly silty clay loam, 30 to 60 percent slopes. This well drained soil is on foothills. The soil formed in colluvium weathered from basic igneous rock. Basalt is at a depth of 20 to 40 inches. Slopes average about 45 percent. Elevation is 400 to 1,200 feet. The average annual precipitation is 40 to 60 inches, the average annual air temperature is 52 to 54 degrees F, and the frost-free period is 165 to 210 days.

In a representative profile, the surface layer is dark reddish brown gravelly silty clay loam about 6 inches thick. The upper 20 inches of the subsoil is dark reddish brown gravelly silty clay loam and silty clay, and the lower 12 inches is dark reddish brown very cobbly silty clay. Highly fractured basalt is at a depth of 38 inches.

Included with this soil in mapping are areas of Witzel and Nekia soils, which make up 10 percent of this map unit.

Permeability is moderately slow. Effective rooting depth is restricted by basalt at a depth of 20 to 40 inches. Available water capacity is 3 to 6 inches, and the water-supplying capacity is 16 to 23 inches. Runoff is rapid, and the hazard of erosion is high.

This soil is used mainly for pasture and timber production. The slope makes the soil unsuitable for cultivation. Improved varieties of grasses are desirable for cover if they can be established. Planting these grasses early in spring insures a better cover than if they are planted later and helps to protect the soil from erosion the following winter.

This soil is moderately well suited to Douglas-fir production. It is poorly suited to Christmas tree production because the slope restricts management and harvesting. Mixed stands of Oregon white oak, Douglas-fir, and grand fir grow on the soil. The site index for Douglas-fir on the soil is about 148. Based on this average site index, the soil is capable of producing about 11,700 cubic feet, or 59,700 board feet (International rule, one-fourth inch kerf) of merchantable timber from a fully stocked, even-aged stand of 80-year-old trees.

Limitations to the use of equipment are slight. This soil is plastic and sticky when wet; this restricts trafficability. Roads and landings need protection against erosion by constructing water bars and seeding cuts, fills, and skid roads.

Seedling mortality and plant competition are concerns.

Ring-necked pheasant, California quail, and bobwhite quail may be present in areas of this soil that are intermingled with cultivated soil. In wooded areas of Oregon white oak, Douglas-fir, grand fir, bigleaf maple, and other trees, shrubs, and grass, common birds include ruffed grouse, mountain quail, and band-tailed pigeons. These birds feed on the fruit and seeds of trees and shrubs. Black-tailed deer are common. Planting Douglas-fir, using grassed waterways, planting along roadsides, and maintaining fence rows and brushy areas improve the cover and food supply for wildlife.

This soil has major limitations for all coummunity uses because of the slope.

This soil is in capability subclass VIIs.

62—Riverwash. This excessively drained miscellaneous area is in narrow bands along major river and stream channels. This material is too variable to be classified as soil. It is made up of gravel and cobblestones in a sandy matrix. It is recent alluvium. Riverwash is exposed during periods of low water and is subject to shifting during normal high water and at flood stage. It ranges in depth from 40 to more than 60 inches. Slopes are 0 to 5 percent but average about 2 percent. Elevation is 125 to 700 feet. The average annual precipitation is 40 to 80 inches, the average annual air temperature is 50 to 54 degrees F, and the frost-free period is 140 to 210 days.

Permeability is rapid to very rapid. Available water capacity and the water-supplying capacity are too variable to rate. Runoff is slow, and the hazard of erosion is high.

None of this miscellaneous area is cultivated or used for timber production. Most is void of vegetation except for occasional bunches of grass and scattered shrubs, which provide very little food and cover for wildlife.

The hazard of frequent flooding from overflow is the major limitation to homesites. Riverwash has some limited recreational use.

Riverwash is in capability subclass VIIIw.

63—Rock outcrop. This miscellaneous area is on steep side slopes and escarpments in the mountains of the Coast Range. It is areas of hard igneous rock. Slopes range from 30 to 90 percent. Elevation is 1,100 to 3,500 feet. The average annual precipitation is 60 to 150 inches, the average annual air temperature is 42 to 53 degrees F, and the frost-free period is 90 to 200 days.

Runoff is very rapid and the hazard of erosion is high.

This miscellaneous area is nearly void of vegetation. It has no commercial stands of timber. Because of the lack of vegetation, this miscellaneous area has little or no value as wildlife habitat.

The slope and outcroppings of rock are the major limitations to community use.

Rock outcrop is in capability subclass VIIIs.

64B—Salkum silty clay loam, 2 to 6 percent slopes. This well drained soil is on high, gravelly terraces that have broad, gently sloping tops and steeper side slopes. The soil formed in old, clayey, weathered, gravelly alluvial deposits. Weathered gravel is at a depth of 40 to 60 inches. Slopes average about 4 percent. Elevation is 325 to 375 feet. The average annual precipitation is 40 to 60 inches, the average annual air temperature is 52 to 54 degrees F, and the frost-free period is 165 to 200 days.

In a representative profile, the surface layer is dark reddish brown silty clay loam about 12 inches thick. The

POLK 50738

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WATER RESOURCES DEPT. SALEM, OREGON

STATE OF OREGON
WATER SUPPLY WELL REPORT
(as required by ORS 537.765)

WELL I.D. # L 0
START CARD # 110141

Instructions for completing this report are on the last page of this form.

(1) OWNER: Well Number 1
Name Joe DeCamp
Address 2033 Tanager Ave
City Salem State OR Zip 97304

(2) TYPE OF WORK
☒ New Well ☐ Deepening ☐ Alteration (repair/recondition) ☒ Abandonment

(3) DRILL METHOD:
☒ Rotary Air ☐ Rotary Mud ☐ Cable ☐ Auger
☐ Other

(4) PROPOSED USE:
☒ Domestic ☐ Community ☐ Industrial ☐ Irrigation
☐ Thermal ☐ Injection ☐ Livestock ☐ Other

(5) BORE HOLE CONSTRUCTION:
Special Construction approval ☐ Yes ☒ No Depth of Completed Well 0 ft.
Explosives used ☐ Yes ☒ No Type Amount

HOLE Diameter	From	To	SEAL Material	From	To	Sacks or pounds
6	0	663	Cement	0	663	62 + bent.

How was seal placed: Method ☐ A ☐ B ☒ C ☐ D ☐ E
☐ Other
Backfill placed from ft. to ft. Material
Gravel placed from ft. to ft. Size of gravel

(6) CASING/LINER:

	Diameter	From	To	Gauge	Steel	Plastic	Welded	Threaded
Casing:	None				☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
Liner:					☐	☐	☐	☐
					☐	☐	☐	☐

Final location of shoe(s)

(7) PERFORATIONS/SCREENS:
☐ Perforations Method
☐ Screens Type Material

From	To	Slot size	Number	Diameter	Tele/pipe size	Casing	Liner
						☐	☐
		None				☐	☐
						☐	☐
						☐	☐
						☐	☐

(8) WELL TESTS: Minimum testing time is 1 hour
☐ Pump ☐ Bailer ☒ Air ☐ Flowing Artesian

Yield gal/min	Drawdown	Drill stem at	Time
7 1/2			1 hr.

Temperature of water 56 Depth Artesian Flow Found
Was a water analysis done? ☐ Yes By whom
Did any strata contain water not suitable for intended use? ☐ Too little
☐ Salty ☐ Muddy ☐ Odor ☐ Colored ☐ Other
Depth of strata:

(9) LOCATION OF WELL by legal description:
County Polk Latitude Longitude
Township 7-S N or S Range 3-W E or W. WM.
Section 6 NE 1/4 NE 1/4
Tax Lot 905 Lot Block Subdivision
Street Address of Well (or nearest address) None Next to 3205 Brush College Rd

(10) STATIC WATER LEVEL:
— ft. below land surface. Date 8-25-98
Artesian pressure lb. per square inch. Date

(11) WATER BEARING ZONES:
Depth at which water was first found 179

From	To	Estimated Flow Rate	SWL
179	184	7 1/2	

(12) WELL LOG:
Ground Elevation

Material	From	To	SWL
Sandstone broken	0	4	
Brownish Tan Claystone	4	12	
Light brown Claystone	12	38	
Soft brown Claystone	38	62	
Gray claystone with Sandstone Seams	62	136	
Green & gray Claystone	136	179	
Dark gray & brown Claystone	179	184	
Gray claystone	184	663	
No Static Water level			
No Water after we finished Drilling			

Date started 8-20-98 Completed 8-25-98

(unbonded) Water Well Constructor Certification:
I certify that the work I performed on the construction, alteration, or abandonment of this well is in compliance with Oregon water supply well construction standards. Materials used and information reported above are true to the best of my knowledge and belief.
WWC Number 1629
Signed [signature] Date 8-27-98

(bonded) Water Well Constructor Certification:
I accept responsibility for the construction, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon water supply well construction standards. This report is true to the best of my knowledge and belief.
WWC Number 1273
Signed Floyd G. [signature] Date 8-27-98

ORIGINAL & FIRST COPY-WATER RESOURCES DEPARTMENT SECOND COPY-CONSTRUCTOR THIRD COPY-CUSTOMER

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WATER RESOURCES DEPT. SALEM, OREGON
POLK 50739

STATE OF OREGON
WATER SUPPLY WELL REPORT
(as required by ORS 537.765)
Instructions for completing this report are on the last page of this form.

WELL I.D. # L# L20460
START CARD # 099293

(1) OWNER: Well Number 2
Name Joe DeCamp
Address 2033 Tanager Ave NW
City Salem State OR Zip 97304

(2) TYPE OF WORK
☒ New Well ☐ Deepening ☐ Alteration (repair/recondition) ☐ Abandonment

(3) DRILL METHOD:
☒ Rotary Air ☐ Rotary Mud ☐ Cable ☐ Auger
☐ Other

(4) PROPOSED USE:
☒ Domestic ☐ Community ☐ Industrial ☐ Irrigation
☐ Thermal ☐ Injection ☐ Livestock ☐ Other

(5) BORE HOLE CONSTRUCTION:
Special Construction approval ☐ Yes ☒ No Depth of Completed Well 740 ft.
Explosives used ☐ Yes ☒ No Type Amount

HOLE Diameter	From	To	SEAL Material	From	To	Sacks or pounds
10	0	78	Cement	0	78	13+bent
6	78	740				

How was seal placed: Method ☐ A ☐ B ☒ C ☐ D ☐ E
☐ Other
Backfill placed from ft. to ft. Material
Gravel placed from ft. to ft. Size of gravel

(6) CASING/LINER:

	Diameter	From	To	Gauge	Steel	Plastic	Welded	Threaded
Casing:	6 in	+1	794	.250	☒	☐	☒	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
Liner:	4½ in	+L	730	#160	☐	☒	☐	☐
					☐	☐	☐	☐

Final location of shoe(s) 79 ft 4 in

(7) PERFORATIONS/SCREENS:
☒ Perforations Method Saw
☐ Screens Type Material

From	To	Slot size	Number	Diameter	Tele/pipe size	Casing	Liner
331	631	⅛x6	180			☐	☒
						☐	☐
671	691	⅛x6	12			☐	☒
						☐	☐
						☐	☐

(8) WELL TESTS: Minimum testing time is 1 hour
☐ Pump ☐ Bailer ☒ Air ☐ Flowing Artesian

Yield gal/min	Drawdown	Drill stem at	Time
1		740	1 hr.

Temperature of water 55 Depth Artesian Flow Found
Was a water analysis done? ☐ Yes By whom
Did any strata contain water not suitable for intended use? ☐ Too little
☐ Salty ☐ Muddy ☐ Odor ☐ Colored ☐ Other
Depth of strata:

(9) LOCATION OF WELL by legal description:
County Polk Latitude Longitude
Township 7-S N or S Range 3-W E or W. WM.
Section 6 NE 1/4 NE 1/4
Tax Lot 905 Lot Block Subdivision
Street Address of Well (or nearest address) Next to 3205 Brush College Rd.

(10) STATIC WATER LEVEL:
208 ft. below land surface. Date 9-3-98
Artesian pressure lb. per square inch. Date

(11) WATER BEARING ZONES:
Depth at which water was first found 362

From	To	Estimated Flow Rate	SWL
362	511	1	300

(12) WELL LOG:
Ground Elevation

Material	From	To	SWL
Top Soil	0	1	
Tan Claystone	1	17	
Brown Claystone	17	22	
Tan Claystone	22	56	
Tan & brown claystone slightly weathered	56	61	
Gray Claystone	61	166	
Soft Gray Claystone	166	188	
Gray Claystone	188	401	
Light Gray Sandstone	401	402	
Gray Claystone	402	448	
Light Gray Sandstone	448	450	
Gray Claystone	450	506	
Hard Gray Sandstone	506	511	
Hard Gray Claystone with Sand Stone Seams	511	740	

Date started 8-25-98 Completed 9-3-98

(unbonded) Water Well Constructor Certification:
I certify that the work I performed on the construction, alteration, or abandonment of this well is in compliance with Oregon water supply well construction standards. Materials used and information reported above are true to the best of my knowledge and belief.
WWC Number 1629
Signed [signature] Date 9-3-98

(bonded) Water Well Constructor Certification:
I accept responsibility for the construction, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon water supply well construction standards. This report is true to the best of my knowledge and belief.
WWC Number 1273
Signed Floyd G. Sipp Date 9-3-98

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MAY 06 1999

WATER RESOURCES DEPT.
SALEM, OREGON

POLK 50898

STATE OF OREGON
WATER SUPPLY WELL REPORT
(as required by ORS 537.765)
Instructions for completing this report are on the last page of this form.

WELL I.D. # L 27173
START CARD # 119213

(1) OWNER: Well Number
Name PORTER SILER
Address 3275 BRUSH COLLEGE RD. NW
City SALEM. State OR Zip 97304

(2) TYPE OF WORK
[X] New Well [ ] Deepening [ ] Alteration (repair/recondition) [ ] Abandonment

(3) DRILL METHOD:
[X] Rotary Air [ ] Rotary Mud [ ] Cable [ ] Auger
[ ] Other

(4) PROPOSED USE:
[X] Domestic [ ] Community [ ] Industrial [ ] Irrigation
[ ] Thermal [ ] Injection [ ] Livestock [ ] Other

(5) BORE HOLE CONSTRUCTION:
Special Construction approval [ ] Yes [X] No Depth of Completed Well 460 ft.
Explosives used [ ] Yes [X] No Type Amount

HOLE Diameter	From	To	SEAL Material	From	To	Sacks or pounds
10	0	219	CEMENT	3	219	86 SACKS
6	219	460	BENT.	0	3	3 SACKS

How was seal placed: Method [ ] A [ ] B [X] C [ ] D [ ] E
[X] Other BENTONITE PLACED DRY
Backfill placed from ft. to ft. Material
Gravel placed from ft. to ft. Size of gravel

(6) CASING/LINER:

	Diameter	From	To	Gauge	Steel	Plastic	Welded	Threaded
Casing:	6	+1.5	219	.250	[X]	[ ]	[X]	[ ]
Liner:	5 9/16	198	460	.188	[X]	[ ]	[X]	[ ]

Final location of shoe(s) 6" @ 219' 5" @ 460'

(7) PERFORATIONS/SCREENS:
[X] Perforations Method GRINDING WHEEL
[ ] Screens Type Material

From	To	Slot size	Number	Diameter	Tele/pipe size	Casing	Liner
400	450	3/16x2½	300			[ ]	[X]

(8) WELL TESTS: Minimum testing time is 1 hour
[ ] Pump [X] Bailer [X] Air [ ] Flowing Artesian

Yield gal/min	Drawdown	Drill stem at	Time
20		455	1 hr.
15	105		2 HR

Temperature of water 55 Depth Artesian Flow Found
Was a water analysis done? [ ] Yes By whom
Did any strata contain water not suitable for intended use? [X] Too little
[ ] Salty [ ] Muddy [ ] Odor [ ] Colored [ ] Other
Depth of strata: APPROX. 180'

(9) LOCATION OF WELL by legal description:
County POLK Latitude Longitude
Township 7S N or S Range 3W E or W. WM.
Section 6 NW 1/4 SE 1/4
Tax Lot 900 Lot Block Subdivision
Street Address of Well (or nearest address) SAME

(10) STATIC WATER LEVEL:
239 ft. below land surface. Date 4-30-99
Artesian pressure lb. per square inch. Date

(11) WATER BEARING ZONES:
Depth at which water was first found 180' + or-

From	To	Estimated Flow Rate	SWL
180	APPROX.	<1 GPM	85
410	430	20 GPM	239

(12) WELL LOG:
Ground Elevation

Material	From	To	SWL
TOPSOIL	0	1	
CLAY RED	1	16	
CLAY & DECOMPOSED ROCK	16	32	
BASALT GREY HARD	32	41	
DECOMPOSED RED ROCK VERY WEATHERED	41	47	
BASALT GREY WEATHERED & FRACTURED	47	80	
CLAY WHITE W/ROCK	80	85	
WEATHERED ROCK BRN	85	103	
BASALT GREY HARDER	103	265	
CLAYSTONE BLUE,GRN,GREY	265	315	
TUFFSTONE GRN HARD	315	365	
TUFFSTONE GREY HARD	365	460	

Westerberg Drilling, Inc.
36728 S. Kropf Rd.
Molalla, OR 97038

Date started 4-21-99 Completed 4-30-99

(unbonded) Water Well Constructor Certification:
I certify that the work I performed on the construction, alteration, or abandonment of this well is in compliance with Oregon water supply well construction standards. Materials used and information reported above are true to the best of my knowledge and belief.
WWC Number 1358
Signed [signature] Date 5-3-99

(bonded) Water Well Constructor Certification:
I accept responsibility for the construction, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon water supply well construction standards. This report is true to the best of my knowledge and belief.
WWC Number 688
Signed Steven N. Stadeli Date 5-3-99

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POLK 51535

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Polk 51535

STATE OF OREGON
WATER SUPPLY WELL REPORT
(as required by ORS 537.765)
Instructions for completing this report are on the last page of this form.

WELL I.D. # L 55054
START CARD # 147698

(1) LAND OWNER Well Number
Name Don Forbes
Address 420 Flying Squirrel Way NW #107
City Salem State OR Zip 97304

(2) TYPE OF WORK
☒ New Well ☐ Deepening ☐ Alteration (repair/recondition) ☐ Abandonment

(3) DRILL METHOD:
☒ Rotary Air ☐ Rotary Mud ☐ Cable ☐ Auger
☐ Other

(4) PROPOSED USE:
☒ Domestic ☐ Community ☐ Industrial ☐ Irrigation
☐ Thermal ☐ Injection ☐ Livestock ☐ Other

(5) BORE HOLE CONSTRUCTION:
Special Construction approval ☐ Yes ☒ No Depth of Completed Well 601 ft.
Explosives used ☐ Yes ☒ No Type ______ Amount ______

HOLE Diameter	From	To	SEAL Material	From	To	Sacks or pounds
10	0	75	Bentonite	0	22	14
8	75	126	Cement	22	126	21
6.5	126	364				
5 7/8	364	601				

How was seal placed: Method ☐ A ☐ B ☒ C ☒ D ☐ E
☒ Other Bentonite placed dry
Backfill placed from ______ ft. to ______ ft. Material ______
Gravel placed from ______ ft. to ______ ft. Size of gravel ______

(6) CASING/LINER:

	Diameter	From	To	Gauge	Steel	Plastic	Welded	Threaded
Casing:	6-in	+1	126	.25	☒	☐	☒	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
Liner:	4-in	+8-in	601	#160	☐	☒	☐	☐
					☐	☐	☐	☐

Drive Shoe used ☐ Inside ☐ Outside ☒ None
Final location of shoe(s)

(7) PERFORATIONS/SCREENS:
☒ Perforations Method Saw
☐ Screens Type ______ Material ______

From	To	Slot size	Number	Diameter	Tele/pipe size	Casing	Liner
381	591	8x6				☐	☐
						☐	☐
						☐	☐
						☐	☐

(8) WELL TESTS: Minimum testing time is 1 hour
☐ Pump ☐ Bailer ☒ Air ☐ Flowing Artesian

Yield gal/min	Drawdown	Drill stem at	Time
2.5		600	2 hr.

Temperature of water 56 Depth Artesian Flow Found
Was a water analysis done? ☐ Yes By whom
Did any strata contain water not suitable for intended use? ☐ Too little
☐ Salty ☐ Muddy ☐ Odor ☐ Colored ☐ Other
Depth of strata:

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(9) LOCATION OF WELL by legal description:
County Polk Latitude ______ Longitude ______
Township 7-S N or S Range 3-W E or W. WM.
Section 6 SE 1/4 SE 1/4
Tax Lot ______ Lot ______ Block ______ Subdivision ______
Street Address of Well (or nearest address) 3200 Brush College Rd NW Salem OR 97304

(10) STATIC WATER LEVEL:
257 ft. below land surface. Date 5-7-02
Artesian pressure ______ lb. per square inch Date ______

(11) WATER BEARING ZONES:
Depth at which water was first found 68

From	To	Estimated Flow Rate	SWL
68	90	3	55
570	601	2.5-3gpm	257

(12) WELL LOG:
Ground Elevation ______

Material	From	To	SWL
Top Soil & boulders	0	9	
Gray basalt with			
weathered seams	9	45	
Med broken basalt	45	68	
light gray clay-caving	68	90	
Med gray claystone	90	115	
light blue & gray			
claystone Med Hard	115	145	
Hard dark gray			
Sandstone with clay.			
Stone seams	145	503	
Very hard light			
gray claystone	503	512	
Med-hard claystone			
gray	512	570	
Gray Sandstone			
with hard claystone			
Seams & sea shells	570	601	

Date started 4-23-02 Completed 5-7-02

(unbonded) Water Well Constructor Certification:
I certify that the work I performed on the construction, alteration, or abandonment of this well is in compliance with Oregon water supply well construction standards. Materials used and information reported above are true to the best of my knowledge and belief.
WWC Number 1629
Signed [signature] Date 5-10-02

(bonded) Water Well Constructor Certification:
I accept responsibility for the construction, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon water supply well construction standards. This report is true to the best of my knowledge and belief.
WWC Number 1273
Signed Floyd Supp Date 5-10-02

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POLK 52055

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STATE OF OREGON
WATER SUPPLY WELL REPORT
(as required by ORS 537.765)
Instructions for completing this report are on the last page of this form.

(WELL I.D.)# L
(START CARD) # 166056

(1) OWNER: Well Number 1
Name Matt F Sells
Address 3205 Brush College Rd. NW
City Salem State OR Zip 97304

(2) TYPE OF WORK
☑ New Well ☐ Deepening ☐ Alteration (repair/recondition) ☑ Abandonment

(3) DRILL METHOD:
☑ Rotary Air ☐ Rotary Mud ☐ Cable ☐ Auger
☐ Other

(4) PROPOSED USE:
☑ Domestic ☐ Community ☐ Industrial ☐ Irrigation
☐ Thermal ☐ Injection ☐ Livestock ☐ Other

(5) BORE HOLE CONSTRUCTION:
Special Construction approval ☐ Yes ☑ No Depth of Completed Well 200' ft.
Explosives used ☐ Yes ☑ No Type ____ Amount ____

HOLE Diameter	From	To	SEAL Material	From	To	Sacks or pounds
10"	0	4	Cement	35	200	1.4 Yards
6"	4	200	Bentonite	0	30	8 Bags

How was seal placed: Method ☐A ☐B ☑C ☐D ☐E
☐ Other Filled to top with dry bentonite
Backfill placed from ____ ft. to ____ ft. Material ____
Gravel placed from 30 ft. to 35 ft. Size of gravel 3/8 pea

(6) CASING/LINER:

	Diameter	From	To	Gauge	Steel	Plastic	Welded	Threaded
Casing:					☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
Liner:					☐	☐	☐	☐
					☐	☐	☐	☐

Final location of shoe(s)

(7) PERFORATIONS/SCREENS:
☐ Perforations Method ____
☐ Screens Type ____ Material ____

From	To	Slot size	Number	Diameter	Tele/pipe size	Casing	Liner
						☐	☐
						☐	☐
						☐	☐
						☐	☐
						☐	☐

(8) WELL TESTS: Minimum testing time is 1 hour
☐ Pump ☐ Bailer ☑ Air ☐ Flowing Artesian

Yield gal/min	Drawdown	Drill stem at	Time
.2 GPM		32'	1 hr.

Temperature of water 55° Depth Artesian Flow Found ____
Was a water analysis done? ☐ Yes By whom ____
Did any strata contain water not suitable for intended use? ☑ Too little
☐ Salty ☐ Muddy ☐ Odor ☐ Colored ☐ Other ____
Depth of strata:

(9) LOCATION OF WELL by legal description:
County Polk Latitude ____ Longitude ____
Township 7 S Range 3 W WM.
Section 6 SW 1/4 NE 1/4
Tax Lot 3220 Lot ____ Block ____ Subdivision ____
Street Address of Well (or nearest address) 3205 Brush College Rd. NW
Salem, OR 97304

(10) STATIC WATER LEVEL:
160 ft. below land surface. Date 9/29/2004
Artesian pressure ____ lb. per square inch. Date ____

(11) WATER BEARING ZONES:
Depth at which water was first found 30-35'

From	To	Estimated Flow Rate	SWL
30	35	.2 GPM	160

(12) WELL LOG:
Ground Elevation ____

Material	From	To	SWL
Brown clay broken rock	0	4	
Brown clay with boulders	4	158	160
Claystone gray brown	158	200	

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SALEM, OREGON

Ron Robinson Well Drilling
4620 Salem Dallas Hwy NW
Salem, OR 97304
503.371.1844 office
503.371.4829 fax

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OCT 04 2004
WATER RESOURCES DEPT
SALEM, OREGON

Date started 9/24/2004 Completed 9/29/2004

(unbonded) Water Well Constructor Certification:
I certify that the work I performed on the construction, alteration, or abandonment of this well is in compliance with Oregon water supply well construction standards. Materials used and information reported above are true to the best of my knowledge and belief.
WWC Number ____
Signed ____ Date ____

(bonded) Water Well Constructor Certification:
I accept responsibility for the construction, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon water supply well construction standards. This report is true to the best of my knowledge and belief.
WWC Number 1585
Signed [signature] Date 9/30/2004

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POLK 52055

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STATE OF OREGON
WATER SUPPLY WELL REPORT
(as required by ORS 537.765)
Instructions for completing this report are on the last page of this form.

(WELL I.D.)# L
(START CARD) # 166056

(1) OWNER: Well Number 1
Name Matt F Seils
Address 3205 Brush College Rd. NW
City Salem State OR Zip 97304

(2) TYPE OF WORK
☐ New Well ☐ Deepening ☐ Alteration (repair/recondition) ☑ Abandonment

(3) DRILL METHOD:
☑ Rotary Air ☐ Rotary Mud ☐ Cable ☐ Auger
☐ Other

(4) PROPOSED USE:
☑ Domestic ☐ Community ☐ Industrial ☐ Irrigation
☐ Thermal ☐ Injection ☐ Livestock ☐ Other

(5) BORE HOLE CONSTRUCTION:
Special Construction approval ☐ Yes ☑ No Depth of Completed Well 200' ft.
Explosives used ☐ Yes ☑ No Type Amount

HOLE Diameter	From	To	SEAL Material	From	To	Sacks or pounds
10"	0	4	Cement	35	200	1.4 Yards
6"	4	200	Bentonite	0	30	8 Bags

How was seal placed: Method ☐ A ☐ B ☑ C ☐ D ☐ E
☐ Other Filled to top with dry bentonite
Backfill placed from ft. to ft. Material
Gravel placed from 30 ft. to 35 ft. Size of gravel 3/8 pea

(6) CASING/LINER:

	Diameter	From	To	Gauge	Steel	Plastic	Welded	Threaded
Casing:					☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
Liner:					☐	☐	☐	☐
					☐	☐	☐	☐

Final location of shoe(s)

(7) PERFORATIONS/SCREENS:
☐ Perforations Method
☐ Screens Type Material

From	To	Slot size	Number	Diameter	Tele/pipe size	Casing	Liner
						☐	☐
						☐	☐
						☐	☐
						☐	☐
						☐	☐

(8) WELL TESTS: Minimum testing time is 1 hour
☐ Pump ☐ Bailer ☑ Air ☐ Flowing Artesian

Yield gal/min	Drawdown	Drill stem at	Time
.2 GPM		32'	1 hr.

Temperature of water 55° Depth Artesian Flow Found
Was a water analysis done? ☐ Yes By whom
Did any strata contain water not suitable for intended use? ☑ Too little
☐ Salty ☐ Muddy ☐ Odor ☐ Colored ☐ Other
Depth of strata:

(9) LOCATION OF WELL by legal description:
County Polk Latitude Longitude
Township 7 S Range 3 W WM.
Section 6 SW 1/4 NE 1/4
Tax Lot 3220 Lot Block Subdivision
Street Address of Well (or nearest address) 3205 Brush College Rd. NW Salem, OR 97304

(10) STATIC WATER LEVEL:
160 ft. below land surface. Date 9/29/2004
Artesian pressure lb. per square inch. Date

(11) WATER BEARING ZONES:
Depth at which water was first found 30-35'

From	To	Estimated Flow Rate	SWL
30	35	.2 GPM	160

(12) WELL LOG:
Ground Elevation

Material	From	To	SWL
Brown clay broken rock	0	4	
Brown clay with boulders	4	158	160
Claystone gray brown	158	200	
Ron Robinson Well Drilling			
4520 Salem Dallas Hwy NW			
Salem, OR 97304			
503.371.1844 office			
503.371.4829 fax			

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SALEM, OREGON

Date started 9/24/2004 Completed 9/29/2004

(unbonded) Water Well Constructor Certification:
I certify that the work I performed on the construction, alteration, or abandonment of this well is in compliance with Oregon water supply well construction standards. Materials used and information reported above are true to the best of my knowledge and belief.
WWC Number
Signed Date

(bonded) Water Well Constructor Certification:
I accept responsibility for the construction, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon water supply well construction standards. This report is true to the best of my knowledge and belief.
WWC Number 1585
Signed Date 9/30/2004

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POLK 52701

STATE OF OREGON
WATER SUPPLY WELL REPORT
(as required by ORS 537.765 & OAR 690-205-0210)

WELL LABEL # L 87478

START CARD # 194907

(1) LAND OWNER

Owner Well I.D.
First Name PAUL Last Name SHAFFER
Company
Address 3225 BRUSH COLLEGE RD. N.W.
City SALEM State OR Zip 97304

(2) TYPE OF WORK

[X] New Well [ ] Deepening [ ] Conversion
[ ] Alteration (repair/recondition) [ ] Abandonment

(3) DRILL METHOD

[X] Rotary Air [ ] Rotary Mud [ ] Cable [ ] Auger [ ] Cable Mud
[ ] Reverse Rotary [ ] Other

(4) PROPOSED USE

[X] Domestic [ ] Irrigation [ ] Community
[ ] Industrial/ Commercial [ ] Livestock [ ] Dewatering
[ ] Thermal [ ] Injection [ ] Other

(5) BORE HOLE CONSTRUCTION

Special Standard [ ] (Attach copy)
Depth of Completed Well 481 ft.

BORE HOLE Dia	From	To	SEAL Material	From	To	Amt	sacks/ lbs
10	0	123	Bentonite	0	12	7	S
8	123	325	Cement	12	123	24	S
6	325	481	Cement	280	325	6	S

How was seal placed: Method [ ] A [ ] B [X] C [X] D [ ] E
[X] Other Bentonite dry
Backfill placed from 123 ft. to 280 ft. Material Cement
Filter pack from ft. to ft. Material Size
Explosives used: [ ] Yes Type Amount

(6) CASING/LINER

Casing	Liner	Dia	+	From	To	Gauge	Stl	Plstc	Wld	Thrd
(●)	( )	6	[X]	1	325	.250	(●)	( )	[X]	[ ]
( )	(●)	4.5	[X]	1	481	#200	( )	(●)	[ ]	[ ]
( )	( )		[ ]				( )	( )	[ ]	[ ]
( )	( )		[ ]				( )	( )	[ ]	[ ]
( )	( )		[ ]				( )	( )	[ ]	[ ]

Shoe [ ] Inside [ ] Outside [ ] Other Location of shoe(s)
Temp casing [ ] Yes Dia From To

(7) PERFORATIONS/SCREENS

Perforations Method Drill
Screens Type Material

Perf/S creen	Casing/ Liner	Screen Dia	From	To	Scrn/slot width	Slot length	# of slots	Tele/ pipe size
Perf	Liner	4.5	421	476	.625	.625	103	

(8) WELL TESTS: Minimum testing time is 1 hour

( ) Pump ( ) Bailer (●) Air ( ) Flowing Artesian

Yield gal/min	Drawdown	Drill stem/Pump depth	Duration (hr)
20		480	1

Temperature 54 °F Lab analysis [ ] Yes By
Water quality concerns? [ ] Yes (describe below)

From	To	Description	Amount	Units

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WATER RESOURCES DEPT
SALEM, OREGON

(9) LOCATION OF WELL (legal description)

County POLK Twp 7 S N/S Range 3 W E/W WM
Sec 6 SE 1/4 of the SE 1/4 Tax Lot 902
Tax Map Number Lot
Lat ° 0 ' " or DMS or DD
Long ° 0 ' " or DMS or DD
(●) Street address of well ( ) Nearest address

3225 BRUSH COLLEGE RD N.W. SALEM OR 97304

(10) STATIC WATER LEVEL

	Date	SWL(psi)	+	SWL(ft)
Existing Well / Predeepening			[ ]	
Completed Well	10-08-2007		[ ]	318

Flowing Artesian? [ ] Dry Hole? [ ]

WATER BEARING ZONES Depth water was first found 125

SWL Date	From	To	Est Flow	SWL(psi)	+	SWL(ft)
10-02-2007	125	161	1		[ ]	101
10-08-2007	425	481	20		[ ]	318
					[ ]	
					[ ]	
					[ ]	

(11) WELL LOG

Ground Elevation

Material	From	To
Top soil and boulders	0	3
Medium to firm brown clay and some small boulders	3	25
Semi-decomposed basalt	25	30
Firm light gray basalt	30	125
Dark basalt with gray claystone layers	125	161
Gray claystone	161	184
Light blue gray claystone	184	190
Gray claystone	190	195
Semi-soft gray and green claystone	195	209
Firm dark gray claystone semi-gritty	209	425
Gray claystone with fractured saems	425	481

Date Started 10-01-2007 Completed 10-08-2007

(unbonded) Water Well Constructor Certification

I certify that the work I performed on the construction, deepening, alteration, or abandonment of this well is in compliance with Oregon water supply well construction standards. Materials used and information reported above are true to the best of my knowledge and belief.

License Number 1629 Date 10-09-2007
Password : (if filing electronically)
Signed

(bonded) Water Well Constructor Certification

I accept responsibility for the construction, deepening, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon water supply well construction standards. This report is true to the best of my knowledge and belief.

License Number 1273 Date 10-09-2007
Password : (if filing electronically)
Signed Floyd Sipp
Contact Info (optional)

ORIGINAL - WATER RESOURCES DEPARTMENT

THIS REPORT MUST BE SUBMITTED TO THE WATER RESOURCES DEPARTMENT WITHIN 30 DAYS OF COMPLETION OF WORK

Form Version: 0.89

POLK 52748 Revised
52748

STATE OF OREGON
WATER SUPPLY WELL REPORT
(as required by ORS 537.765 & OAR 690-205-0210)

WELL LABEL # L 92829

START CARD # 1002720

(1) LAND OWNER

Owner Well I.D.

First Name Matt Last Name Seils
Company
Address 3205 Brush College RD NW
City Salem State OR Zip 97304

(2) TYPE OF WORK

[X] New Well [ ] Deepening [ ] Conversion
[ ] Alteration (repair/recondition) [ ] Abandonment

(3) DRILL METHOD

[X] Rotary Air [ ] Rotary Mud [ ] Cable [ ] Auger [ ] Cable Mud
[ ] Reverse Rotary [ ] Other

(4) PROPOSED USE

[X] Domestic [ ] Irrigation [ ] Community
[ ] Industrial/ Commercial [ ] Livestock [ ] Dewatering
[ ] Thermal [ ] Injection [ ] Other

(5) BORE HOLE CONSTRUCTION

Special Standard [X] (Attach copy)

Depth of Completed Well 400 ft.

BORE HOLE Dia	From	To	SEAL Material	From	To	Amt	sacks/ lbs
14	0	20	Cement	0	20	15	S
12	20	28	Cement	20	28	6	S
10	0	35	Bentonite Chips	0	35	16	S
~~10~~	~~35~~	~~140~~	~~Cement~~	~~0~~	~~140~~	~~35~~	~~S~~
~~6~~	~~140~~	~~400~~					

How was seal placed: Method [ ] A [X] B [X] C [ ] D [ ] E
[X] Other Poured and Probed

Backfill placed from ft. to ft. Material
Filter pack from ft. to ft. Material Size
Explosives used: [ ] Yes Type Amount

(6) CASING/LINER

Casing	Liner	Dia	+	From	To	Gauge	Stl	Plstc	Wld	Thrd
(•)	( )	10	[ ]	0	28	250	(•)	( )	[X]	[ ]
(•)	( )	6	[X]	2	140	250	(•)	( )	[X]	[ ]
( )	(•)	4	[ ]	0	400	160	( )	(•)	[X]	[ ]
( )	( )		[ ]				( )	( )	[ ]	[ ]
( )	( )		[ ]				( )	( )	[ ]	[ ]

Shoe [X] Inside [ ] Outside [ ] Other Location of shoe(s) 140
Temp casing [ ] Yes Dia From To

(7) PERFORATIONS/SCREENS

Perforations Method SAW CUT
Screens Type Material

Perf/Screen	Casing/ Liner	Dia	From	To	Scrn/slot width	Slot length	# of slots	Tele/ pipe size
Perf	Liner	4	280	380	.125	6.5	75	

(8) WELL TESTS: Minimum testing time is 1 hour

( ) Pump ( ) Bailer (•) Air ( ) Flowing Artesian

Yield gal/min	Drawdown	Drill stem/Pump depth	Duration (hr)
5		395	1

Temperature 57 °F Lab analysis [ ] Yes By
Water quality concerns? [ ] Yes (describe below)

From	To	Description	Amount	Units

(9) LOCATION OF WELL (legal description)

County POLK Twp 7 S N/S Range 3 W E/W WM
Sec 6 1/4 of the 1/4 Tax Lot 910
Tax Map Number Lot
Lat ° 0 ' " or 44.987 DMS or DD
Long ° 0 ' " or -123.09421 DMS or DD
(•) Street address of well ( ) Nearest address

3205 Brush College RD NW Salem OR, 97304

(10) STATIC WATER LEVEL

	Date	SWL(psi)	+	SWL(ft)
Existing Well / Predeepening			[ ]	
Completed Well	12-19-2007		[ ]	289

Flowing Artesian? [ ] Dry Hole? [ ]

WATER BEARING ZONES Depth water was first found 360

SWL Date	From	To	Est Flow	SWL(psi)	+	SWL(ft)
12-18-2007	360	380	5		[ ]	289
					[ ]	
					[ ]	
					[ ]	

(11) WELL LOG

Ground Elevation

Material	From	To
Top Soil	0	2
Clay brown firm W/cobbels	2	19
boulders and fill	19	22
Sandstone grey firm	22	30
Clay grey and brown sticky W/rocks	30	43
Claystone grey firm	43	115
Sandstone grey firm	115	250
Sandstone grey fractured W/firm and broken seams	250	400
Note: Special Standards Attached		
for Bentonite Seal on Inner Casing!		

RECEIVED
JAN 14 2008
WATER RESOURCES DEPT
SALEM, OREGON

RECEIVED
MAR 18 2008
WATER RESOURCES DEPT
SALEM, OREGON

Date Started 12-04-2007 Completed 12-19-2007

(unbonded) Water Well Constructor Certification

I certify that the work I performed on the construction, deepening, alteration, or abandonment of this well is in compliance with Oregon water supply well construction standards. Materials used and information reported above are true to the best of my knowledge and belief.

License Number 1725 Date 12-23-2007
Password : (if filing electronically)
Signed [signature]

(bonded) Water Well Constructor Certification

I accept responsibility for the construction, deepening, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon water supply well construction standards. This report is true to the best of my knowledge and belief.

License Number 1725 Date 12-23-2007
Password : (if filing electronically)
Signed [signature]
Contact Info (optional)

ORIGINAL - WATER RESOURCES DEPARTMENT
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Form Version: 0.89

POLK 52748

STATE OF OREGON
WATER SUPPLY WELL REPORT
(as required by ORS 537.765 & OAR 690-205-0210)

WELL LABEL # L 92829

START CARD # 1002720

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Owner Well I.D.

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Company
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City Salem State OR Zip 97304

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Special Standard [ ] Attach copy

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10	0	35	Bentonite Chips	0	35	16	S
10	35	140	Cement	35	140	30	S
6	140	400					

How was seal placed: Method [ ] A [X] B [X] C [ ] D [ ] E

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Backfill placed from ft. to ft. Material
Filter pack from ft. to ft. Material Size
Explosives used: [ ] Yes Type Amount

(6) CASING/LINER

Casing	Liner	Dia	+	From	To	Gauge	Stl	Plstc	Wld	Thrd
(●)	( )	10	[ ]	0	28	250	(●)	( )	[X]	[ ]
(●)	( )	6	[X]	2	140	250	(●)	( )	[X]	[ ]
( )	(●)	4	[ ]	0	400	160	( )	(●)	[X]	[ ]
( )	( )						( )	( )		
( )	( )						( )	( )		

Shoe [X] Inside [ ] Outside [ ] Other Location of shoe(s) 140

Temp casing [ ] Yes Dia From To

(7) PERFORATIONS/SCREENS

Perforations Method SAW CUT
Screens Type Material

Perf/Screen	Casing/ Liner	Screen Dia	From	To	Scrn/slot width	Slot length	# of slots	Tele/ pipe size
Perf	Liner	4	280	380	.125	6.5	75	

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	Date	SWL(psi)	+	SWL(ft)
Existing Well / Predeepening			[ ]	
Completed Well	12-19-2007		[ ]	289

Flowing Artesian? [ ] Dry Hole? [ ]

WATER BEARING ZONES Depth water was first found 360

SWL Date	From	To	Est Flow	SWL(psi)	+	SWL(ft)
12-18-2007	360	380	5		[ ]	289
					[ ]	
					[ ]	
					[ ]	

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Clay grey and brown sticky W/rocks	30	43
Claystone grey firm	43	115
Sandstone grey firm	115	250
Sandstone grey fractured W/firm and broken seams	250	400

RECEIVED
JAN 14 2008
WATER RESOURCES DEPT
SALEM, OREGON

Date Started 12-04-2007 Completed 12-19-2007

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License Number 1725 Date 12-23-2007

Password : (if filing electronically)
Signed

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License Number 1725 Date 12-23-2007

Password : (if filing electronically)
Signed
Contact Info (optional)

ORIGINAL - WATER RESOURCES DEPARTMENT
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Form Version: 0.89

installed by the pull-back method. The hydraulic jacks that pull down the casing in the stovepipe method can then be reversed to pull back the casing.

DIRECT ROTARY DRILLING

The direct rotary drilling method was developed to increase drilling speeds and to reach greater depths in most formations (Figure 10.11). The borehole is drilled by rotating a bit, and cuttings are removed by continuous circulation of a drilling fluid as the bit penetrates the formation. The bit is attached to the lower end of a string

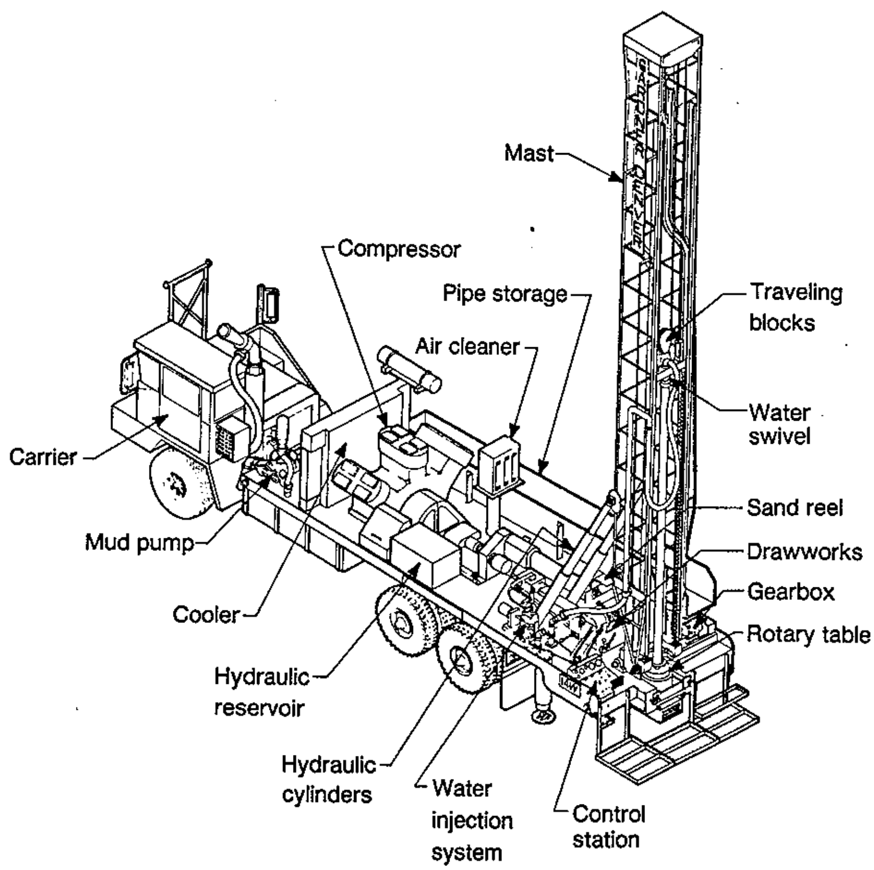

Figure 10.11. Schematic diagram of a direct rotary rig illustrates the important operational components of this truck-mounted drilling machine. This machine, operating with either an air-based or water-based drilling fluid, can drill more rapidly than a cable tool rig. *(Gardner-Denver Company)*

of drill pipe, which transmits the rotating action from the rig to the bit. In the direct rotary system, drilling fluid is pumped down through the drill pipe and out through the ports or jets in the bit; the fluid then flows upward in the annular space between the hole and drill pipe, carrying the cuttings in suspension to the surface. At the surface, the fluid is channeled into a settling pit or pits where most of the cuttings drop out. Clean fluid is then picked up by the pump at the far end of the pit or from the second pit and is recirculated down the hole (Figure 10.12). For relatively shallow wells, 150- to 500-gal (0.6- to 1.9-m^3) portable pits may be used; much larger portable pits, 10,000 to 12,000 gal (37.9 to 45.4 m^3), are used for deeper wells. Mud pits may also be excavated for temporary use during drilling and then backfilled after completion of the well (see Chapter 11 for various mud pit configurations).

Before 1920, the type of rotary drill used in water well drilling was commonly called a whirler. This equipment used the well casing itself as the drill pipe. The lower end of the pipe was fitted with a serrated cutting shoe with an outside diameter a little larger than the drill pipe couplings. The sawteeth of the shoe cut and loosened the materials as the pipe was rotated. Water was pumped under pressure through the pipe to lift the cuttings to the surface. Native clays and silt were depended upon to seal the borehole wall to maintain circulation; prepared drilling fluids were not used. The method was suitable for drilling only relatively small-diameter, shallow wells in unconsolidated formations that did not contain cobbles or boulders.

In the 1930's, shot-hole rotary drills, used for seismograph work in oil exploration, were successfully adapted for drilling small-diameter water wells. Shot-hole machines, however, could not drill the large-diameter holes necessary for water well work because the mud pump and drill pipe were generally too small to circulate enough drilling

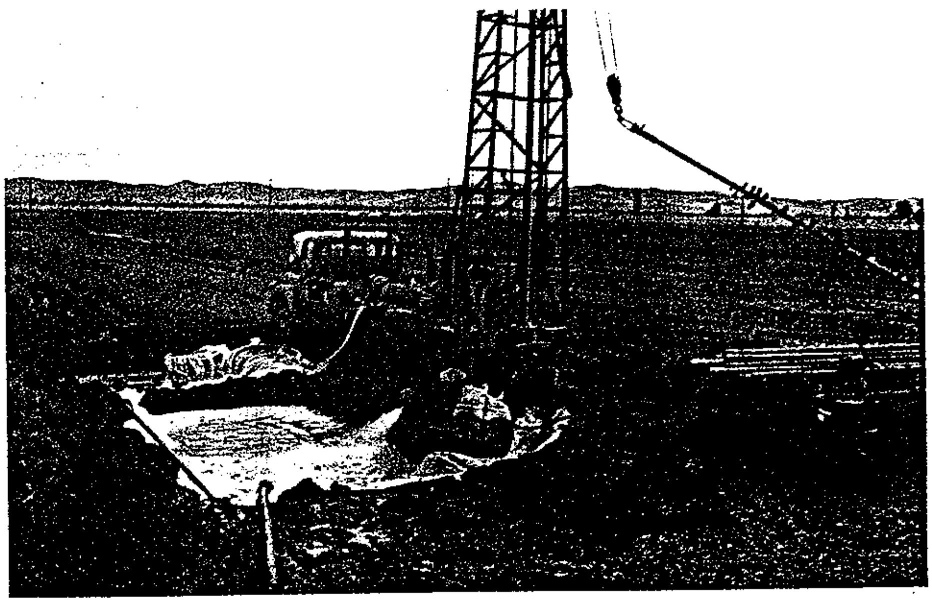

Figure 10.12. Drilling fluid from the borehole flows into the larger pit where the cuttings settle out. The fluid then flows into the second pit through a constricted opening. The mud pump on the rig withdraws drilling fluid from this pit to inject down the drill rods to the bit. This Italian driller has lined the drilling fluid pits with polyethylene film to reduce fluid loss into the ground. Note the homemade hole cleaner or scratcher the driller uses to keep the borehole open during drilling.

Figure 10.13. Drag bits are used in rotary drilling for fast penetration in unconsolidated or semiconsolidated sediments.

fluid to efficiently drill even an 8-in (203-mm) well. In time, truck-mounted portable rigs for drilling large-diameter water wells were developed from oil field exploration technology.

The components of the rotary drilling machine are designed to serve two functions simultaneously: operation of the bit and continuous circulation of the drilling fluid. Both are indispensable in cutting and maintaining the borehole. For economic and efficient operation, rotary drillers must acquire considerable knowledge concerning these factors and how they relate to various formation conditions.

In direct circulation rotary drilling for water wells, two general types of bits are used — the drag bit (fishtail and three- and six-way designs) and the roller cone bit, usually called a rock bit. Drag bits have short blades, each forged to a cutting edge and faced with durable metal (Figure 10.13). Short nozzles direct jets of drilling fluid down the faces of the blades to clean and cool them. Drag bits have a shearing action and cut rapidly in sands, clays, and some soft rock formations, but they do not work well in coarse gravel or hard-rock formations.

Roller (cone) bits exert a crushing and chipping action, making it possible to cut hard formations (Figure 10.14). The rollers, or cutters, are made with either hardened steel teeth or tungsten carbide inserts of varied shape, length, and spacing, designed so that each tooth applies pressure at a different point on the bottom of the hole as the cones rotate. The teeth of adjacent cones intermesh so that self-cleaning occurs. Long, widely spaced teeth are used in bits designed to cut soft clay formations, whereas shorter, closer spaced teeth are used for denser formations. Some roller bits are made with carbide buttons for particularly dense and abrasive formations such as dolomite, granite, chert, basalt, and quartzite.

The tricone bit, used as an all-purpose bit in every type of formation, has conically shaped rollers on spindles and bearings set at an angle to the axis of the bit. Another design has four rollers; two are set at an angle and two are normal to the vertical axis of the bit. The cutting surfaces of all roller bits are flushed by jets of drilling fluid directed from the inside (center) of the bit. The jets can be sized so as to maximize the cutting action of the bit. The jets are also effective in breaking up or washing away soft formation materials.

When hole enlargement becomes necessary, two other types of bits are used — reamers and underreamers (Figure 10.15). A reamer is used to straighten, clean, or enlarge a borehole. This tool sometimes consists of a 10- to 20-ft (3- to 6.1-m) section of drill pipe with specially hardened surfaces on vertical ribs. Other types of reamers are constructed of flanges welded on short sections of drill pipe and mounted between the bit and the stabilizer. In the underreaming process, the borehole diameter is enlarged beneath the permanent casing. Underreamers are particularly useful when a filter pack must be placed around a screen, but the cost of drilling the entire borehole at the larger diameter required for the filter pack would be prohibitive.

The bit is attached to the lower end of the drill pipe, which resembles a long tubular shaft. The drill string usually consists of four parts: the bit, one or more drill collars or stabilizers, one or more lengths of drill pipe, and, in table-drive machines, the kelly (Figure 10.16). Selection of the bottom-hole assembly will depend on the physical conditions of the geologic materials; these include dip of the formation, presence of faults or fractures, and drillability of the formation.

Each drill collar is a heavy-walled length of drill pipe; one or more drill collars are used to add weight to the lower part of the drill-stem assembly (Figure 10.17). The concentration of weight just above the bit helps to keep the hole straight, and provides sufficient weight for the bit to maintain the proper penetration rate. Drill collars fitted with stabilizer bars or rollers are even more effective in drilling straight boreholes. Table 10.1 presents representative data on recommended sizes of drill collars.

Stabilizers are an important component of the bottom-hole tools (Figure 10.18). To be effective in maintaining straight holes in soft formations, the stabilizer must have large wall contact. Increased contact can be achieved by using stabilizers with longer and wider blades, or by using longer stabilizers. The flow of drilling fluid upward around the stabilizer must not be restricted too much, however, because cuttings may pack around the stabilizer. This leads to sticking and a possible loss of circulation if back pressure builds up. Weakening of the formation structure can also result from the pressure increase. Accumulation of cuttings around the stabilizer may also cause local zones of erosion in the bore-

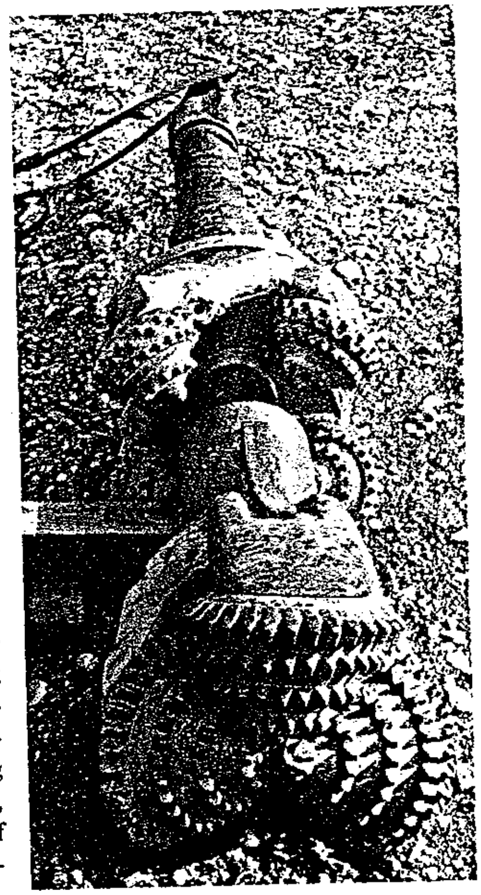

Figure 10.14. Roller or cone-type bits are preferred when drilling consolidated rock. The number of teeth on each roller cone depends on the drilling difficulty. As the rock becomes harder and more difficult to drill, the bit should have more teeth on each cone. For particularly dense or abrasive formations, carbide buttons are used instead of teeth on the roller cones. Roller cone bits are often constructed in configurations that will enlarge the borehole in stages as the bit penetrates the formation. For the bit shown, the primary bit is 17½ in (445 mm) and the reamer is 22 in (559 mm).

hole wall. In relatively hard formations, the stabilizer can perform satisfactorily with less wall contact.

Drill pipe is seamless tubing manufactured in joints that are usually 20 ft (6.1 m) long, although other lengths are available. Each joint is equipped with a tool-joint pin on one end and a tool-joint box on the other (Figure 10.19). Outside diameters of drill pipe used for direct rotary drilling generally range from 2⅜ to 6 in (60 to 152 mm). High circulation rates for drilling fluids in water well drilling require that the drill pipe diameter be adequate to hold friction loss in the pipe to an acceptable level so as to reduce the power required for the pump. For efficient operation, the outside diameter of the tool joint should be about two-thirds the borehole diameter; this ratio may be impractical, however, for holes larger than 10 in (254 mm).

In table-drive machines, the kelly constitutes the uppermost section of the drill string column. It passes through and engages in the opening in the rotary table, which is driven by hydraulic or mechanical means (Figure 10.20). The outer shape of the

Table 10.1. Ideal Size Range for Drill Collars

Hole size, in	Casing size to be run, in OD	Calculated ideal drill collar range, in		API drill collar sizes which fall in the ideal range, in
		Min.	Max.	
6⅛	4½	3.875	4.750	4⅛, 4¾
6¼	4½	3.750	4.875	4⅛, 4¾
6¾	4½	3.250	5.125	3½, 4⅛, 4¾, 5
7⅞	4½	2.125	6.125	3⅛, 3½, 4⅛, 4¾, 5, 6
	5½	4.225	6.125	4¾, 5, 6
8⅜	5½	3.725	6.500	4⅛, 4¾, 5, 6, 6¼, 6½
	6⅝	6.405	6.500	6½
8½	6⅝	6.280	6.750	6½, 6¾
	7	6.812*	6.750	6¾
8¾	6⅝	6.030	7.125	6¼, 6½, 6¾, 7
	7	6.562	7.125	6¾, 7
9½	7	6.812	7.625	6, 6¼, 6½, 7, 7¼
	7⅝	7.500	7.625	7⅝†
9⅞	7	5.437	8.000	6, 6¼, 6½, 6¾, 7, 7¼, 7¾, 8
	7⅝	7.125	8.000	7¼, 7¾, 8
10⅝	7⅝	6.375	8.500	6½, 6¾, 7, 7¼, 7¾, 8, 8¼
	8⅝	8.625*	8.500	8¼
11	8⅝	8.250	9.625	8¼, 9, 9½
12¼	9⅝	9.000	10.125	9, 9½, 9¾, 10
	10¾	11.250*	10.125	10
13¾	10¾	9.750	11.250	9¾, 10, 11
14¾	11¾	8.750	12.000	9, 9½, 9¾, 10, 11, 12†
17½	13⅜	11.250	13.375	12†
20	16	14.000	14.750	14†
24	18⅝	15.500	16.750	16†
26	20	16.000	19.500	16†

*In these instances, the equation used to calculate the ideal minimum drill collar size produces an anomalously high value. See Woods and Lubinski (1954) for a complete discussion on how to determine the best collar size for a specific diameter borehole.

†Not API standard size drill collar.

(Drilco, 1979)

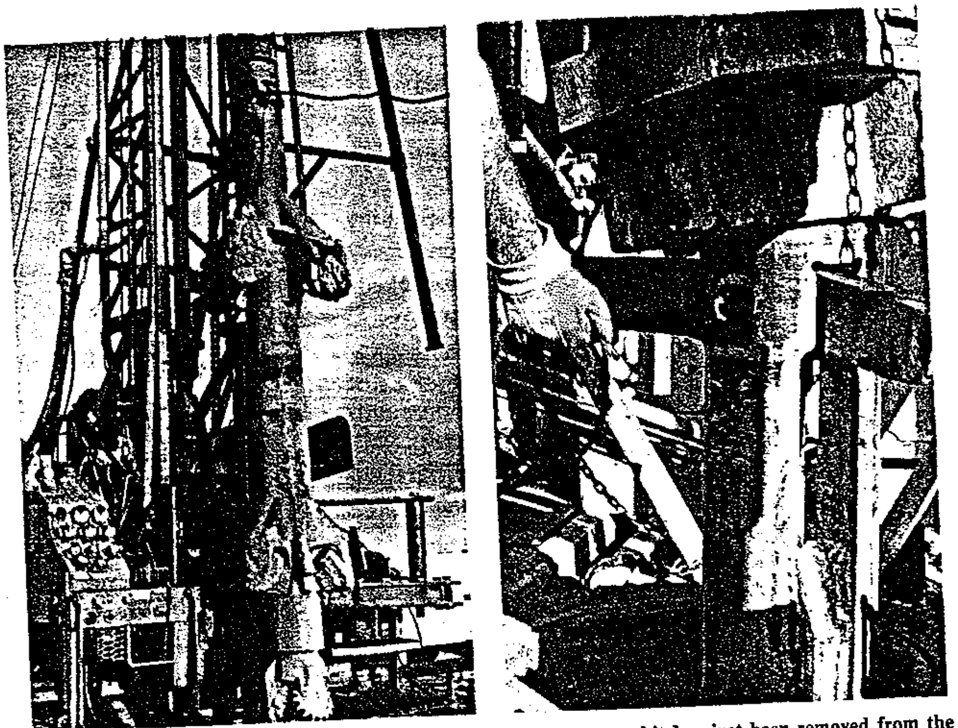

Figure 10.15. On the left, a three-tiered 48-in (1,220-mm) reamer bit has just been removed from the borehole. ***(Snider Drilling Ltd.)*** **For soft sediments, underreamers (right) are constructed of blades that extend outward from the bit.**

kelly may be square or hexagonal, or round with lengthwise grooves or flutes cut into the outside wall. Made about 3 ft (0.9 m) longer than one joint of drill pipe, the kelly has an inside bore that is usually smaller than that of the drill pipe because of the heavy wall thickness required. The square, hexagonal, or grooved circular section of the kelly works up and down through drive bushings in the rotary table. With the bushings properly in place around the kelly, the entire drill stem and bit are forced to turn with the rotary table. While rotating, the kelly slips down through the drive bushings to feed the bit downward as the hole is drilled. The lower end of the kelly is provided with a replaceable substitute joint (sub), called a "kelly saver," that connects to the drill pipe. The sub saves the tool joint on the kelly from excessive wear resulting from the screwing and unscrewing of innumerable sections of drill pipe. The upper end of the kelly connects to a swivel (by a left-hand threaded joint) that is suspended from a traveling block in the derrick (Figure 10.21). A heavy thrust bearing between the two parts of the swivel carries the entire weight of the drill string while allowing the drill pipe to rotate freely.

Some rotary drilling machines use a top-head drive to rotate the drill string (Figure 10.22). In this system, the rotational unit moves up and down the mast; energy is obtained from a hydraulic transmission unit powered by a motor-driven pump.

In both the rotary table and top-head drive mechanisms, the driller can determine the rotation speed depending on the resistance of the formation and the rate of penetration. For shallow boreholes of 200 to 400 ft (61 to 122 m), pull-down pressure may be applied to the bit. Down-hole pressures on the bit can be increased beyond

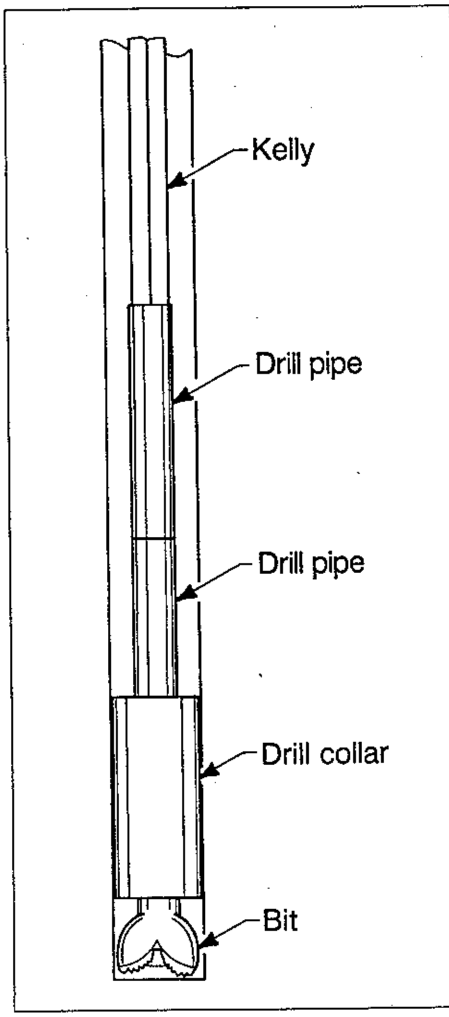

Figure 10.16. The drill string for a direct rotary rig consists of a bit, drill collar or stabilizer, drill pipe, and kelly for table drive units.

the weight of the drill string by exerting a pull-down force derived from the weight of the drilling rig. The chain assemblies (or cables) on the mast are used to transfer part of the weight of the drilling rig to the drill string. Caution should be used to avoid excessive pull-down pressure (weight) because hole deflection (crooked holes) may result. To avoid crooked holes, many drillers will use drill collars that concentrate additional weight on the bit rather than exert pull-down pressure. Rotation speed is adjusted to the pull-down or existing pressures on the bit. In general, the higher the pressure on the bit, the slower the rotation should be. In most deep direct rotary boreholes, the driller must hold back (suspend) part of the drill string weight from the swivel so that the weight on the bit does not become excessive. In general, the driller may start holding back when the weight of the drill string exceeds 10,000 lb (4,540 kg), although the exact figure depends on the bit being used. Bit manufacturers usually indicate the optimum pressure that an individual bit should exert against the formation for maximum cutting rates.

Adding drill rods (pipe) to the drill string or removing rods to change bits or take split-spoon or core samples is a major part of every rotary drilling operation. "Tripping in" and "tripping out" are the terms used to describe the process of running the bit into or pulling the bit from the hole. Most newer drilling rigs have been designed to make this process as fast and automated as possible. With some new machines, it is possible to pull back a 20-ft (6.1-m) rod and remove it from the drill string in approximately 30 seconds. In general, top-head drive machines, especially those equipped with carousels (drill rod storage racks mounted on the mast), offer an advantage in rod handling speed, although recent modifications in table-drive machines have enabled this type of rig to match the speed of the top-head drive rotaries.

When a rod is to be added, the swivel is just above the rotary table (in a table-drive machine). Usually the driller will circulate the drilling fluid for a few minutes to make sure that most of the cuttings are out of the hole to prevent the bit and drill string from sand-locking when the circulation is stopped to add a drill rod. The kelly is raised until the joint between the kelly sub and the uppermost drill rod is just above the drive table. Slips are placed in the table to hold the drill string (Figure 10.23). The kelly is then disconnected and placed out of the way momentarily. A sand line (cable) is joined to another rod section using a quick-release elevator (clamp). The rod is hoisted into place above the rod held in the table and the two are threaded together, usually with the aid of automatic pipe clamps. The slips are removed and the string is lowered by the sand line until the top (tool-joint box) of the just-added drill rod is just above the table. The slips are reinserted, the elevator is removed, and the kelly is rethreaded to the drill string. After lowering the kelly into the drive table, drilling can continue.

In top-head drive machines, no kelly is required and therefore the bottom sub of the hydraulic drive motor is connected directly to the drill rod. Additional rods can be taken directly from a carousel by the top-head drive unit. If the machine is equipped with side storage racks, a sand line must be used to raise the drill rod into position.

Internal pressure created by the drilling fluid can cause a momentary but forceful surge of drilling fluid out of the drill string at the point where the kelly is disconnected from the upper drill rod. Drillers usually break this joint slowly to allow the pressure to dissipate so that drilling fluid is not expelled violently. Occasionally during the addition of a drill rod, drilling fluid may continue to overflow from the top of the rods. Confining pressures within permeable material in the borehole may be causing this flow, but it is more likely that clay "collars" packed around the drill rods are falling deeper into the borehole, thereby pushing drilling fluid back up the center of the rods.

Direct rotary drilling, the most common method, offers the following advantages:

1. Penetration rates are relatively high in all types of materials.
2. Minimal casing is required during the drilling operation.

Figure 10.17. Heavy collars added to the drill string above the bit help keep the borehole straight.

3. Rig mobilization and demobilization are rapid.
4. Well screens can be set easily as part of the casing installation.

Major disadvantages include the following:

1. Drilling rigs are costly.
2. Drilling rigs require a high level of maintenance.
3. Mobility of the rigs may be limited depending on the slope and condition (wetness) of the land surface.
4. Most rigs must be handled by a crew of at least two persons.
5. Collection of accurate samples requires special procedures.
6. Use of drilling fluids may cause plugging of certain formations.
7. Rigs cannot be operated economically in extremely cold temperatures.
8. Drilling fluid management requires additional knowledge and experience.

Figure 10.18. Stabilizers mounted just above the bit in the drill string are important in maintaining a straight borehole. Flat-bar steel plates welded to the stabilizer help maintain borehole diameter and provide channels for the passage of drilling fluid. *(Hydro Drillers)*

DRILLING FLUIDS

Drilling fluid control is essential to efficient rotary drilling. There must be proper coordination of the hole size, drill pipe size, bit type, pump capabilities, and drilling fluid characteristics based on the geologic conditions at the site if drilling is to proceed efficiently. Drilling fluids include air, clean water, and scientifically prepared mixtures of special-purpose materials*. The essential functions of a drilling fluid are to:

1. Lift the cuttings from the bottom of the hole and carry them to a settling pit.
2. Support and stabilize the borehole wall to prevent caving.
3. Seal the borehole wall to reduce fluid loss.
4. Cool and clean the drill bit.
5. Allow cuttings to drop out in the settling pit.
6. Lubricate the bit, bearings, mud pump, and drill pipe.

The viscosity (the degree to which a fluid resists flow under an applied force) of the drilling fluid and the uphole velocity required to remove cuttings will depend on a number of factors that are discussed in Chapter 11. An uphole velocity

*Because the majority of rotary drilled holes are completed using a water-based drilling fluid, air will not be discussed here, but is thoroughly covered in Chapter 11.