GEOLOGY OF THE HANGMAN (LATAH) CREEK FLOOD HAZARD MANAGEMENT AREA, SPOKANE COUNTY, WASHINGTON

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INTRODUCTION

This map fulfills a request by the Spokane County Conservation District to provide expanded geologic mapping for their Hangman Creek Comprehensive Flood Hazard Management Plan.

PREVIOUS WORK

Previous geologic maps of this Management Area were small scale and lacked sufficient detail for management considerations. Pardee and Bryan (1926) noted the relationship between the Latah Formation and the Columbia River Basalt Group in the area. Griggs (1966) first published a 1:125,000-scale map of the western half of the Spokane 1x2 degree quadrangle. He later (1973) extended his mapping eastward and published a 1:250,000-scale map of the Spokane 1x2 degree quadrangle. On the latter map, he changed the designations of some of the pre-basalt units in the area; however, none of those changes occur on the Hangman valley geologic map. Joseph (1990) compiled a 1:100,000-scale map of the Spokane quadrangle that incorporated more detailed interpretations of Pleistocene glacial features (Kiver and others, 1979) and basalt stratigraphy based on Swanson and others (1979). In 1993-94 Wendy Gerstel, Charles Gulick, and Robert Derkey mapped the Quaternary deposits related to the Spokane aquifer recharge and aquifer sensitive areas at a 1:24,000 scale. Several thesis have focused on Hangman Creek geology, the most notable includes Rigby (1982), and Meyer (1999). The geology was entered into GIS by Bea Lackaff of the Spokane County Water Quality Management Program (WQMP). The Spokane County GIS geologic map was available to city and county officials since about 1996; however, it was not published.

STUDY METHODS

This map was originally prepared as an overlay on the Spokane NW, Spokane SW, Spokane SE, Spangle East, and Spangle West 7.5-minute maps. It was digitized and entered into ArcView. Then orthophotos (DNR, 1995) and digital contours (furnished by Spokane County GIS) in ArcView were used to add to and refine contacts on the final version of the map.

SPOKANE AREA GEOLOGIC HISTORY

The following is a brief summary of the geologic history based on our geologic mapping in the Spokane area. Map symbols for the geologic units in Hangman valley map are included in this summary to facilitate the effective use of the geologic map.

We have not attempted to distinguish and map separately all of the various flood events.

Holocene or Recent deposits include units, whcih have been formed in latest Pleistocene and since the end of the Pleistocene by water (**Qal**, **Qb, Qaf**), by water and gravity (**Qmw**), and by wind (**Ql**). In all cases, these deposits may have older components, but for the most part represent recent geologic processes. They make up the majority of the deposits exposed in the Hangman valley; however, they constitute only a small portion of the total sequence of young sediments in the valley.

Glaciers dammed the Clark Fork River near the Montana-Idaho state line. Glacial Lake Missoula formed behind the ice dam, and when it failed, gigantic volumes of water raced through the area carrying tremendous amounts and varying sizes of sediment into the Columbia Basin and downstream along the Columbia River to the Pacific Ocean. Episodes of ice-dam buildup and failure were repeated many times during the Pleistocene with the last episode representing -------. Based on work by Atwater (1986) along the San Poil area of what is now Lake Roosevelt, flood deposits were dated from about 16,000 to 12,400 years before present. Complicating this generally accepted chronology is the occurrence of older radiocarbon dates of 32,000 and more than 40,000 years before present (Meyer, 1999) derived from organic material deposited in a low section of interbedded frood and lacustrine sediment along hangman Creek

In the Spokane area, deep channels of the ancestral Spokane River were filled with very coarse grained, poorly sorted gravel referred to here as flood channel gravel (**Qfcg**). The coarse gravel **Qfcg** is host to the Spokane aquifer. Outside of the deep channels, flood gravel deposits (**Qfg**) are thinner and, commonly, not as coarse grained. A third type of flood deposit is sand (**Qfs**) deposited when floodwaters flowed into an existing glacial lake (glacial Lake Columbia). The sand unit (**Qfs**) is widespread and appears to be the uppermost or highest of the extensive flood deposits. Following deposition of this sand, floods appear to have been smaller and probably contributed to the location of the present course of the Spokane River. Additional glacial deposits (**Qglf**) consist of glacial Lake Columbia deposits of silt and clay that formed in a lake that covered the Spokane area as a result of a ice dam downstream. These lakebed sediments are interbedded with glacial flood deposits that repeatedly entered the lake depositing sets of alternating layers of flood and lake sediments often referred to as rhythmites. The units are distinguished by the predominant clast size and contacts between the three units **Qfcg**, **Qfg**, **Qfs**, and **Qglf** are mostly indistinct. Mass-wasting deposits (**Qmw**) occurred during or shortly after catastrophic flood events, but they range in age up to the present.

Lava flows of the Columbia River Basalt Group (CRBG) were deposited widely over the Columbia Basin. A stratigraphy of basalt flows has been developed through use of whole-rock chemical analyses to distinguish individual basalt flows and sequences of flows. Our analyses were done by the Geoanalytical Laboratory at Washington State University. Two CRBG units have been identified in the Spokane area, (1) Grande Ronde Basalt (**Tgr**), magnetostratigraphic units

R2 and N2 and (2) Wanapum Basalt, Priest Rapids Member (**Twp)**, Rosalia chemical type (Derkey and others, 1998; Tolan and others, 1989). The Priest Rapids Member is the uppermost Columbia River Basalt Group unit identified in the Spokane area.

Underlying and interbedded with the basalt is a sequence of sediments, which Pardee and Bryan (1926) called the Latah Formation (**Tl**). Geographic features at the time consisted of a series of lakes with adjoining hills and mountains. The climate at the time was warm and moist and weathering resulted in development of thick, clay, silt, and sand in soils of the area. The clay, silt, and sand washed down from the adjacent highlands and was deposited in the lake(s). The Grande Ronde Basalt flows that reached the Spokane area often burrowed or sank into the poorly consolidated Latah sediments. They are called invasive flows. When preserved, Latah Formation lakebeds are baked even when they overlie the invasive basalt in the Spokane area (Robinson, 1991; Derkey and others, 1998).

Granitic rocks in the Spokane area were intruded during the late Cretaceous and Eocene (Griggs, 1966, 1973; Weis, 1968; Joseph, 1990). They are best exposed northeast of Hangman valley on Mount Spokane and to the west of Mount Spokane. The granitic rocks are cut by mylonite zones of the Spokane dome and in the proximity of the mylonite zones are foliated; however, none of the granitic rocks exposed in the Hangman Creek valley area are foliated. Because they have not been radiometrically dated, they are designated as Tertiary or Cretaceous (**TKg**).

The granitic rocks intrude quartzite, feldspathic sandstone, shale, and limestone that ranges in age from late Precambrian to early Paleozoic in age. Varying degrees of metamorphism has resulted in weakly metamorphosed sedimentary rocks to gneissic rocks. Although not exposed in the Hangman Creek valley area, Paleozoic rocks were recognized in the Texas-Latah wildcat oil well drilled in 1919 a few miles south of the Interstate 90-Highway 195 interchange (see drill log p. 82-83, Weigle and Mundorff, 1952) in the Hangman Creek valley. The older sedimentary rocks in Hangman Creek valley are considered part of the Ravalli Group (**Ymsr**) of the Precambrian Belt Supergroup (Griggs, 1973; Armstrong and others, 1987; Rehrig and others, 1987; Joseph, 1990).

EROSION AND LANDSLIDE PROBLEMS

The sediments deposited in the Hangman Creek valley can be divided into a lower sequence of glacial flood deposits, a middle sequence of glacial lake deposits with interbedded glacial flood sediments, and an upper sequence of glacial flood sediments and post-glacial-flood alluvial material and volcanic ash. The presence of a lower sequence of glacial flood deposits is know only from water well logs. Sediments in the middle sequence (**Qglf**) consist of multiple layers of silt, fine-grained sand, and clay that accumulated in a glacial lake. Interbedded with the silt, fine-grained sand, and clay is a series of sand and gravel deposited by glacial outburst floods that flowed into the glacial lake. This middle unit occurs along the course of Hangman Creek. It also is found in the steep banks and slopes above Hangman Creek.

The Hangman Creek valley has experienced accelerated erosion and slope stability problems during the last several decades. Some of these problems appear to be a result of road building, housing and business development, as well as accelerated runoff caused by agriculture. Three major factors have contributed to these problems: 1) excavation of land causing slope instabilities and accelerated or redirected water runoff, 2) additional surface water due to irrigation, 3) the re-channeling of the Hangman Creek for road construction. Additionally, flooding of Hangman Creek is believed to be related to upstream, agricultural-induced accelerated runoff and land use changes and flood plain alterations.

The interbedded nature of low-permeability, fine-grained lake sediments and more permeable and coarser grained flood deposits results in flooding, silting of the stream, and landslide hazards. by both later aerial flood waters and stream erosion and covered by floods sediments. The silt/clay layers in the **Qglf** acts as a barrier locally to water descending from the surface. The water then tends to flow horizontally, becoming an agent for slope instability where this situation is combined with steep slopes. Also, these lake sediment layers are involved with block slumping when slopes fail. The interbeds of flood sand and gravel are also susceptible to stream and runoff erosion as are the **Qfs** and **Qfg** units since they are unconsolidated, loose sediments. While this unit was no doubt involved in historical erosional events, the removal of vegetation and the re-channeling of the Hangman Creek during the construction U.S. 195 has left the valley unstable.

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Eugene Kiver and Dale Stradling (1979) previously mapped the Quaternary geology of the Spokane area and accompanied us on numerous trips to examine those deposits. DNR geologist Wendy Gerstel refined the mapping of the Quaternary flood deposits under a contract with the Spokane County Water Quality Management Program (WQMP) in 1993-94. Her mapping was entered into Spokane County's GIS by Bea Lackaff; however, it was not published. Basalt stratigraphy was accomplished by whole-rock chemical analysis performed at the Geoanalytical Laboratory at Washington State University. Steve Reidel assisted us during a two-day visit in the field to examine Columbia River Basalt, and reviewed an earlier version of the map.   The cartographic and editorial staff of the Division of Geology and Earth Resources edited and created the layout for publication.

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EXPLANATION

The following alluvium and glacial flood deposits are Holocene (recent) and Late Pleistocene. They are informal units with no formation or precise time or event intended.

Qal--Alluvium (Holocene) -- Silt, sand, and gravel deposits in present-day stream channels, flood plains, and lower terraces. Consists of reworked glacial flood deposits (units Qfcg, Qfg, and Qfs) and reworked loess. May include small alluvial fans and minor mass wasting deposits that extend onto the flood plain from tributaries.

Qaf--Alluvial fan deposits (Holocene) -- Alluvium consisting of gravel, sand, and silt deposited in fans that form at the base of steep drainages in the map area. Most lack a large source drainage. Deposits are very poorly sorted and have minimal soil development.

Ql--Loess (Holocene and Pleistocene) -- Light to medium brown, unstratified silt with lesser amounts of clay. Locally includes small amounts of fine sand and volcanic ash. Clay is mostly montmorillonite and illite in a ratio of 3:1 as well as minor kaolinite (Hosterman, 1969). Sand and silt are composed of angular quartz with lesser amounts of feldspar and mica. The wind deposited loess depth increases to the southwest in the map area where flood erosion was less effective. Most deposits, except where eroded, will be capped by one or two feet of loess

Qb--Bog deposits (Holocene and Pleistocene) – Peat with lesser amounts of silt, ash, marl (bog lime), and gyttja (freshwater mud with abundant organic matter) deposits, predominantly in channeled scabland depressions, on basalt bedrock (Milne and others, 1975).

Qmw--Mass-wasting deposits (Holocene and late Pleistocene) -- Landslide debris with lesser amounts of debris flow and rockfall deposits; often include interspersed flood deposits. Most mapped landslide debris consists of a mixture of basalt blocks and Latah Formation sediments. Angular basalt blocks range in size from several feet to tens of feet across. Because some of the landslides occurred during glacial flooding, scattered sand and pebble lenses are locally interspersed with the mass-wasting deposits.

Qglf--Glacial lake/glacial flood deposits undifferentiated (Pleistocene) --Tan to gray, fine-grained sand and silt, massive- and thin-bedded lake deposits with interbedded and irregularly distributed glacial-flood sediments of sand and gravel. Unit is exposed in the bed of Hangman Creek and on adjacent bluffs. This unit probably filled most of valley before being dissected by later floods and post flood stream action.

Qfs--Glacial flood deposits, predominantly sand (Pleistocene) -- Gray, yellowish gray, or light brown; poorly to moderately well sorted, medium bedded to massive; subangular to subrounded; medium-fine to coarse sand and granules with sparse pebbles, cobbles, and boulders. The unit may contain beds and lenses of gravel. Some exposures appear speckled because of the mixture of light and dark fragments. Composed mainly of granitic and metamorphic detritus from sources to the east. Unit distribution and thickness is variable due to the irregular underlying topography and preservation when protected from the erosive action of later floods. The majority of the flood sands appear to have been subaqueously deposited when outburst floods flowed into glacial Lake Columbia and at lower energy deposition sites removed from major flood channels.

Qfg--Glacial flood deposits, predominantly gravel (Pleistocene) -- Gray, yellowish gray, or light brown; poorly to moderately sorted; both matrix and clast supported; thick-bedded to massive mixture of boulders, cobbles, pebbles, granules, and sand; also may contain beds and lenses of sand and silt. Locally, boulders can comprise more than 50 percent of the volume in a matrix of mostly pebbles and coarse sand. Deposits in the Four Lakes and Spokane SW quads consist of granitic and metamorphic rocks similar to both local outcrops and those to the northeast and east in Idaho.

Qfcg--Glacial flood-channel deposits, predominantly gravel (Pleistocene)—Gray, yellowish gray, or light brown; poorly to moderately sorted; both matrix and clast supported (openwork); thick-bedded to massive mixture of boulders, cobbles, pebbles, granules, and sand; locally contains beds and lenses of sand and silt. Boulders often comprise more than 50 percent of the volume in a matrix of mostly pebbles and coarse sand and consist of granitic and metamorphic rocks similar to both local outcrops and those to the northeast and east in Idaho plus some locally derived basalt. Primarily, this unit occurs in the main flood channel, which is known to be several hundred feet deep and appears to be filled with flood gravel. Boundaries between flood-channel gravel (Qfcg) and flood gravel (Qfg) are transitional. Flood-channel gravel occurs in the Spokane Valley on the north side of the map.

PRE-QUATERNARY IGNEOUS AND SEDIMENTARY ROCKS

Twp--Wanapum Basalt, Priest Rapids Member (middle Miocene) -- Dark gray to black, fine-grained, dense, basalt containing plagioclase (20-30%), pyroxene (10-20%), and olivine (1-2%) in a mostly glass matrix (40-60%). Unit thickness is variable and in the parts of the Spokane SW 7.5-minute map where the basalt laps up upon pre-Miocene highlands it is very thin. Contact with the underlying Grande Ronde occurs between 2,200 and 2,300 feet elevation. Priest Rapids Member lies directly on pre-Miocene rocks, Latah Formation, or Grande Ronde Basalt. The Priest Rapids Member in the Spokane area is of the Rosalia chemical type, which has higher titanium and lower magnesium and chromium than other flows of Wanapum Basalt (Steve Reidel, Pacific Northwest National Laboratory, oral commun., 1998). The Priest Rapids Member is between 14.5 and 15.3 m.y. old and has reversed magnetic polarity (Reidel and others, 1989)

Tgr--Grande Ronde Basalt, magnetostratigraphic units R2 and N2 (middle Miocene) -- Dark gray to dark greenish gray, fine-grained basalt containing plagioclase (10-30%) as laths and sparse phenocrysts, and pale green augite and pigeonite grains (10-40%) in a matrix of black to dark brown glass (30-70%)

and opaque minerals. The rock is locally vesicular with plagioclase laths tangential to vesicle boundaries. Some vesicles contain botryoidal carbonate and red amorphous secondary minerals. Due to the irregular underlying topography, variable thickness of water saturated Latah Formation (**Tl**) interbeds, and the probable invasive nature of at least some of the Grande Ronde Basalt flows in the area, the thickness is quite variable. Chemical analyses were used to identify magnetostratigraphic units R_2 and N_2 of Grande Ronde Basalt. N_2 basalt generally contains more than 4.5% MgO and less than 2% TiO2. The Grande Ronde Basalt is between 15.6 and 16.5 m.y. old (Reidel and others, 1989).

Tl--Latah Formation (middle Miocene) -- Light gray to yellowish gray and light tan; poorly indurated; lacustrine and fluvial deposits of finely laminated siltstone, claystone, and minor sandstone. The unit commonly weathers brownish yellow with stains, spots, and seams of limonite. It unconformably overlies pre-Miocene rocks or is interbedded with Grande Ronde Basalt (Tgr). Floral assemblages in the Latah Formation indicate a Miocene age (Knowlton, 1926; Griggs, 1976). The Latah is easily eroded and it is commonly blanketed with a cover of colluvium, talus, and residual soils.Page 12

PRE-MIOCENE ROCKS

TKg-- Biotite-rich granitic rock (Eocene) -- light grey with some light pink feldspars, fine to course grained, some porphyritic with feldspar crystals up to 0.5 inches, contains minor hornblende, and zircon, biotite occurs in crystals up to 0.2

inches. The largest granite occurrence underlies the east valley wall at the junction of California and Hangman Creeks.

Ymsr--Ravalli Group (Precambrian Y) -- White, light gray, gray-green, or pale yellowish orange feldspathic sandstone, and siltite; fine- to medium-grained; thin- to medium-bedded with some massive sections. Feldspathic sandstone typically contains 30-70% quartz, 20-30% feldspar, and 1-5% biotite. Siltite contains more feldspar and less quartz. Some quartz-biotite gneiss is exposed west of the junction of Hangman and California Creeks.