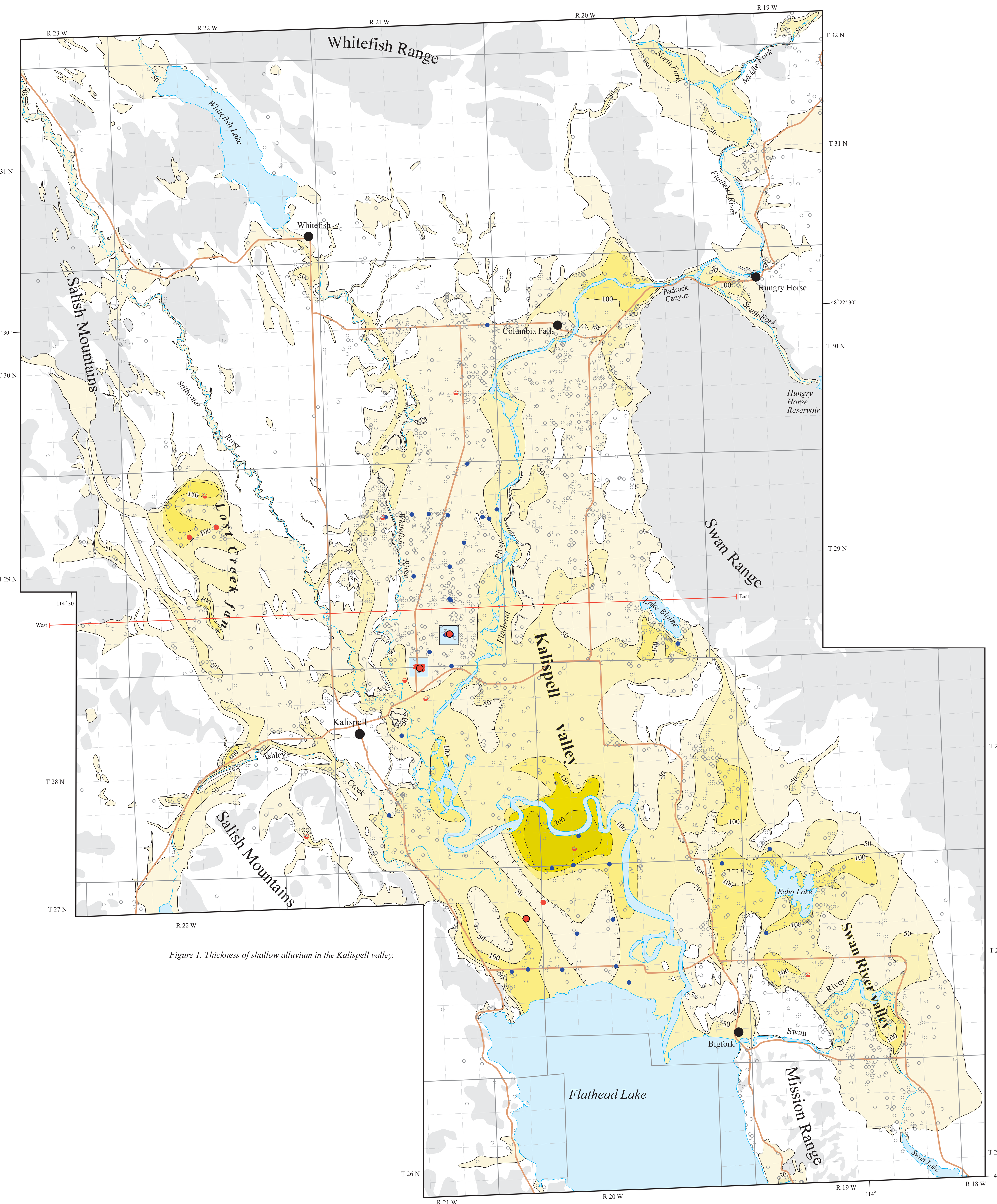
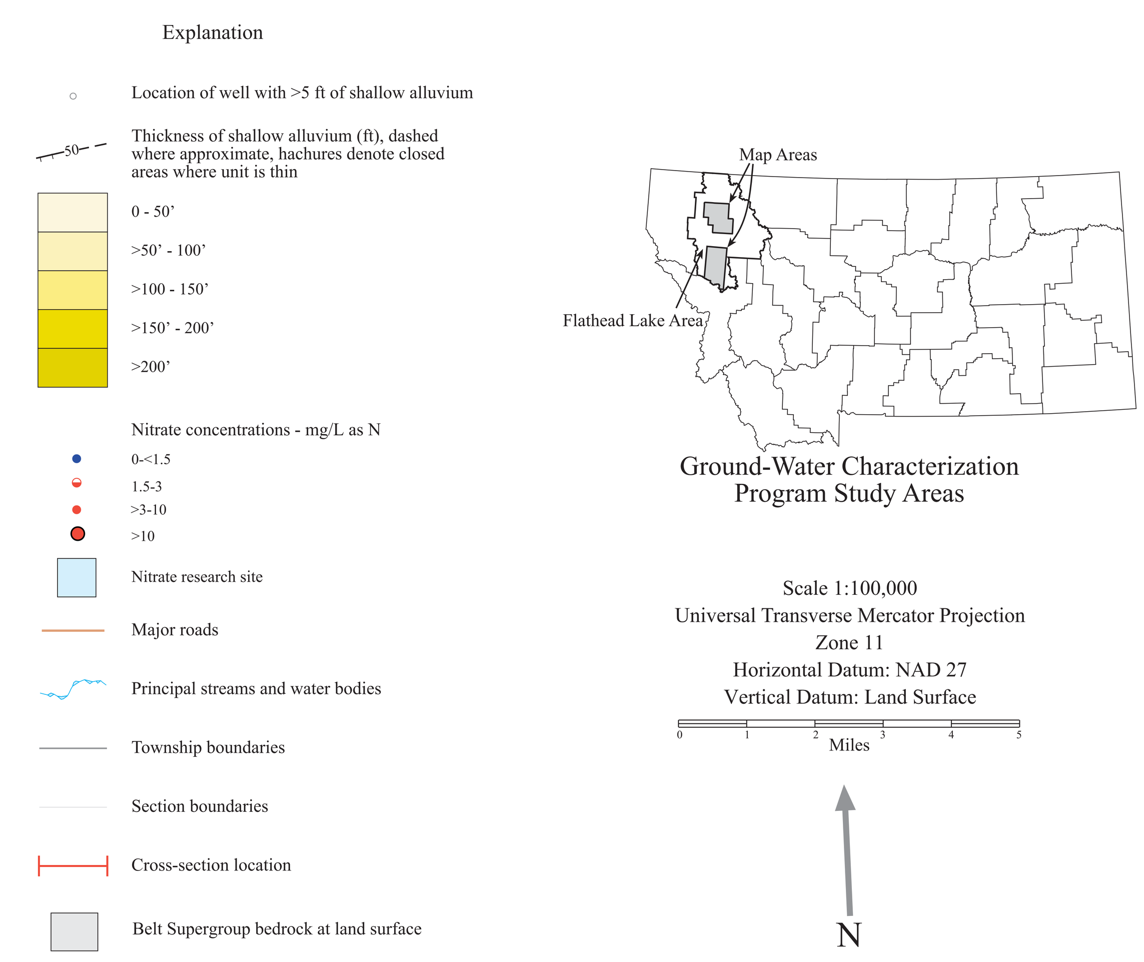


Figure 1. Thickness of shallow alluvium in the Kalispell valley.



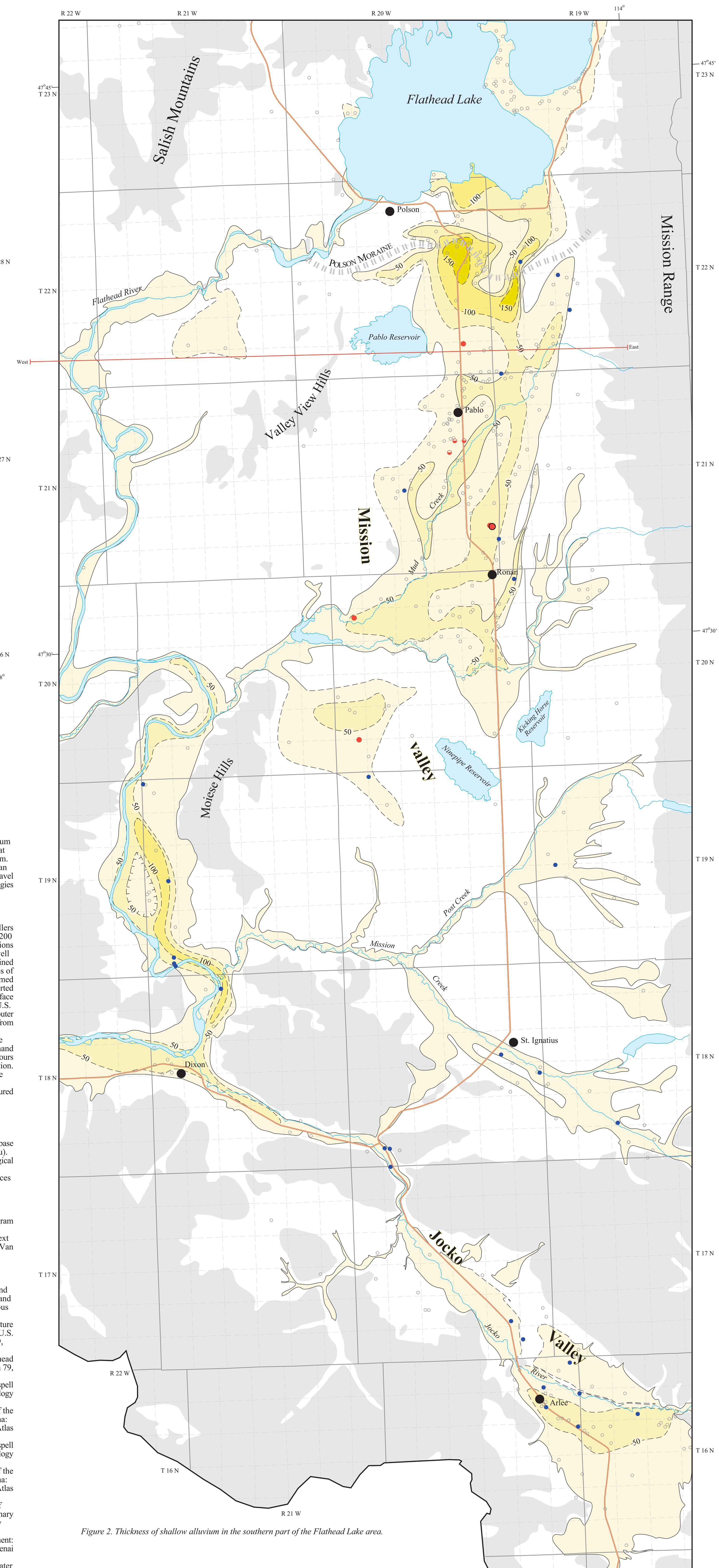


Figure 2. Thickness of shallow alluvium in the southern part of the Flathead Lake area.

Thickness of Shallow Alluvium, Flathead Lake Area, Flathead, Lake, Missoula, and Sanders Counties, Montana

by

Larry N. Smith

Author's Note: This map is part of the Montana Bureau of Mines and Geology (MBMG) Ground-Water Assessment Atlas for the Flathead Lake Area ground-water characterization. It is intended to stand alone and describe a single hydrogeologic aspect of the study area, although many of the area's hydrogeologic features are interrelated. For an integrated view of the hydrogeology of the Flathead Lake Area the reader is referred to Part A (descriptive overview) and other Part B maps of the Montana Ground-Water Assessment Atlas No. 2.

INTRODUCTION

This map shows the generalized thickness of sand and gravel (including minor amounts of silt and clay and wind-blown sand) that are present near land surface in the Flathead Lake area. These surficial deposits are called the "shallow alluvium." The extent of shallow alluvium in the Kalispell and part of the Swan River valleys is shown in figure 1; the extent of these deposits in the Mission and Jocko valleys is shown in figure 2.

The shallow alluvium occurs within stream valleys, on alluvial fans, in stabilized wind-blown (eolian) dune fields, in previous beach and deltaic positions of Flathead Lake, or in areas of glacial outwash (sand and gravel deposits of streams in front of former glaciers). The shallow alluvium overlies older deposits and bedrock, including Proterozoic Belt Supergroup (bedrock) and Tertiary sedimentary rocks in the mountains, and glacial and post-glacial unconsolidated sediments in the mountains, foothills, and valleys (fig. 3; Johns, 1970; Harrison and others, 1986, 1992; Ostenaa and others, 1990; Smith, 2002b; Smith and others, 2000). Interpretation of drillers logs of water wells and examination of surface exposures in the field show that the shallow alluvium is widespread, but can be correlated with confidence in the subsurface only where thicknesses reported on the logs are greater than 5 ft.

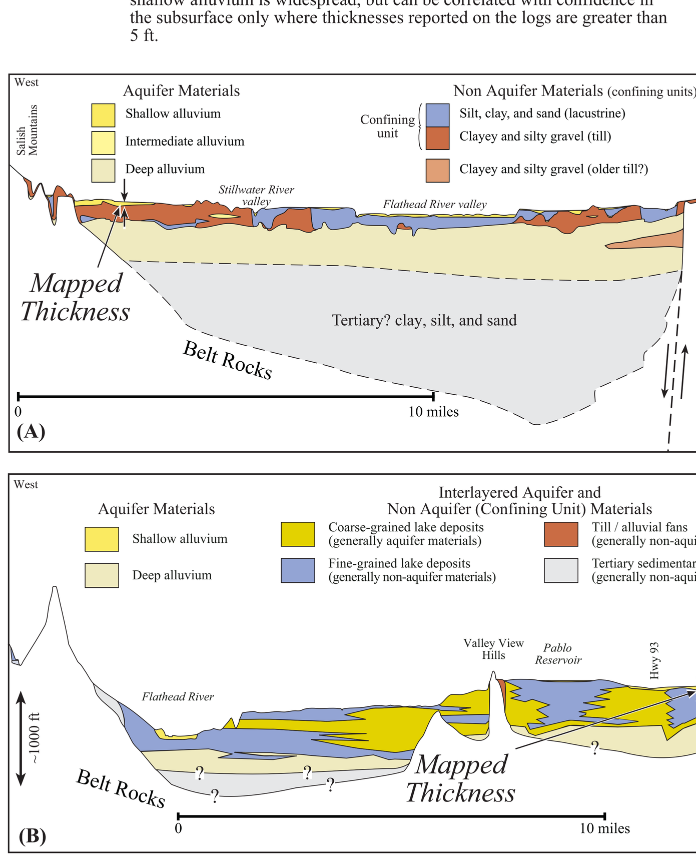


Figure 3. (A) Diagrammatic cross section showing the stratigraphy of basin-fill units in the Kalispell valley, (B) Diagrammatic cross section showing the stratigraphy of basin-fill units in the Mission valley.

OVERVIEW OF BASIN-FILL STRATIGRAPHY

The Kalispell, Mission, and Jocko valleys are areas where the bedrock has been structurally down-dropped relative to neighboring uplifted Salish, Swan, Whitefish, and Mission mountain ranges. Within the valleys, bedrock has been encountered in drill holes mostly near their perimeters. In parts of the Kalispell and Mission valleys bedrock is overlain by a deep alluvial unit from which large volumes of water are produced locally (LaFave, 2002c, d). Deep alluvium was likely deposited both before and during glacial advance into the valley. The deep alluvium is overlain by a complex sequence of till (deposits of glacial ice) and glaciolacustrine sediments (deposits in lakes neighboring glaciers) throughout the Flathead Lake area. Glacier(s) partially or completely filled the Kalispell, Swan River, and Mission valleys, forming a blanket-like deposit of till at depth and a mantle over much of the bedrock in the foothills and mountains. Silty, clayey, and gravely glaciolacustrine sediments were deposited south and west of the glacier terminus near Polson (in Glacial Lake Missoula), and within and north of the present Flathead Lake basin as the glacier receded and the ancestral Flathead Lake covered most of the Kalispell valley. The sediments directly above the deep alluvium in the valleys north of Flathead Lake make up a nearly continuous upper confining unit (fig. 3A), whereas in the Mission valley south of Flathead Lake the glaciolacustrine sediments host aquifers in many locations (fig. 3B).

Glaciolacustrine deposits and till are overlain in many areas by about 50 ft of shallow alluvium. Deltaic sandy and silty sediments in the area between Kalispell and Flathead Lake (Noble and Stanford, 1986) and glacial meltwater deposits (outwash) overlie glaciolacustrine deposits and till in areas outside active river valleys. Greater than 50 ft of shallow alluvium, such as along the incised modern valleys of the Flathead, Whitefish, Stillwater, and Swan Rivers (fig. 1) and along Mud Creek (south of Flathead Lake; fig. 2), were deposited as the rivers partially cut through the glacial deposits and the valleys were partially backfilled with alluvium. This shallow alluvium unit may contain shallow ground water that is generally not hydraulically connected to the deep aquifer.

The sequence of unconsolidated geologic units (from older to younger—deep alluvium, till, glaciolacustrine deposits, and shallow alluvium) represents deposition during one or more glacial advance and retreat cycles. Although the stratigraphy can be generalized as a layered sequence, intertonguing between either the deep or the shallow alluvium units and the intermediate confining beds complicate the relationships between the geologic and hydrologic units. Intertonguing between the shallow alluvium and glaciolacustrine units occurs in the northern Swan River valley, Lost Creek fan area (fig. 1), and in the Mission valley (fig. 2) where glacial outwash was deposited in glacial lakes, as described below. In these areas, permeable (aquifer) and impermeable (non-aquifer) sediments are interlayered. Because few wells penetrate the entire sequence of aquifer and non-aquifer materials, correlations between well logs are problematic, making maps of these areas imprecise.

VARIATION IN THICKNESSES

Thickness variations in the shallow alluvium were caused by erosion of underlying units before its deposition, by intertonguing between the shallow alluvium and finer-grained glaciolacustrine sediments, and by irregularities in the land surface. Thicknesses are generally less than 50 ft and decrease laterally toward the edges of the shallow alluvium, which are defined by the mapped geologic boundaries of various sand and gravel bodies (Ostenaa and others, 1990; Smith, 2002b; Smith, unpubl. mapping). Although thicknesses generally increase near some major streams in the area, notably the Whitefish, Flathead, and Swan Rivers, due to backfilling of river scours with sand and gravel, the thickest accumulations of shallow alluvium are apparently related to other processes.

Thicknesses of shallow alluvium are greatest in the southern part of the Kalispell valley, at the Lost Creek fan area, in the northern Swan River valley, and just southeast of Polson. In the southwestern portion of the Kalispell valley (fig. 1; T. 27–28 N., R. 21 W.) the shallow alluvium reaches thicknesses greater than 100 ft in two elongate areas that may represent paleochannels along a prior course of the Flathead River. The greatest thicknesses of alluvium are in the south-central Kalispell valley (centered on sec. 31, T. 28 N., R. 20 W.) where a subcircular accumulation of sand and gravel exceeds 200 ft in thickness. This deposit, like similar-sized accumulations on the Lost Creek fan (T. 29 N., R. 22 W.), in the Columbia Falls area (centered on secs. 2, 3, 10, and 11, T. 30 N., R. 20 W.), and south of Lake Blaine (centered on sec. 35, T. 29 N., R. 20 W.) may be related to outwash fan deposition during glacial retreat. Similarly, the thickest accumulation of shallow alluvium south of Flathead Lake (T. 22 N., R. 19–20 W.) may be part of an outwash fan where a glacial stream cut through the Polson moraine. These outwash fans may have been either deposited at land surface or in glacial lakes. Shallow alluvium deposits emanating from the outwash fan along the Polson moraine are distributed to the south-southwest along the Mud Creek drainage, averaging thicknesses of about 50 ft.

NITRATE

Where shallow alluvium is thick enough below the water table, it is a source of ground-water. Because the aquifers are unconfined, near-surface, and unprotected from surface sources of pollutants, water quality in these unconfined aquifers can be compromised. Nitrate concentrations in milligrams per liter as nitrogen (mg/L-N) are often used to illustrate contamination of aquifers by domestic septic and agricultural sources. Nitrate contamination of ground water in the shallow alluvium has been shown in the Flathead River valley north of Flathead Lake (Evergreen aquifer) (Noble and Stanford, 1986) and has been highlighted as a concern in the Mission and Jocko valleys (Makepeace and Mladenich, 1995). High nitrate concentrations are well documented at two sites northeast of Kalispell where 35 wells were sampled in the mid-1980's (fig. 1).

Although recent Ground-Water Characterization Program work for the Flathead Lake area emphasized water quality in the deeper aquifers (LaFave, 2002a, b), data from 127 wells sampled for nitrate are in the Ground-Water Information Center (GWIC) database for water in the shallow alluvium. These nitrate data were collected between 1975 and 2000 and are shown on the maps (figs. 1, 2). Of the 127 wells sampled, 3 had at least one sample that exceeded the health standard of 10 (mg/L-N); 11 wells had samples that were between 3.0 and 10 mg/L-N, a level that suggests possible contamination by surface sources (Madison and Brunett, 1984). Most wells (80%) showed either non-detectable concentrations or concentrations less than 1.5 mg/L-N (figs. 1, 2). Although the available analyses show local nitrate contamination of the shallow alluvium, the geographical coverage and dates of sampling are not sufficient to discern if there is a regional contamination problem.

MAP USE

These maps can be used to evaluate locations where shallow aquifers may exist and to help determine the location of sand and gravel resources near the land surface. Productive water wells occur mostly along stream valleys where the shallow alluvium is continually saturated with water. Most wells completed in the shallow alluvium are along the Flathead River between Columbia Falls and Flathead Lake (fig. 1). Many wells were also completed in areas of outwash south and southeast of Lake Blaine (fig. 1) and along Mud Creek, Mission Creek, and the Jocko River (fig. 2). Aquifers in the shallow alluvium are locally important where alluvium or outwash was deposited on till in isolated areas (e.g., south half T. 31 N. R. 21 W.). In these areas, outwash was deposited by glacier-margin streams (Smith, 2002b). Further mapping of these features may help to locate productive wells.

In areas where the shallow alluvium is greater than 100 ft thick, unconfined aquifers are more likely to be hydraulically connected to deeper aquifers. The presence of thick shallow alluvium over the deep aquifer may delineate areas where the deep aquifer is more sensitive to contamination from near-surface sources. For example, in the Lost Creek fan area, greater thicknesses of sand and gravel at the surface occur in an area where the deep alluvium is mapped at a depth of about 100-200 ft (Smith, 2002a), suggesting that ground water could flow from the shallow alluvium to the deep alluvium.

The map may also show where shallow alluvium may be greater than about 50 ft. Some of these locations may contain prospective sand and gravel resources for mining. Additional work is required to characterize the lithologies and map the volumes of the deposits.

MAP CONSTRUCTION

Thicknesses of shallow alluvium were derived from about 9,700 drillers logs of wells that completely penetrated the shallow alluvium, about 4,200 of which showed its thicknesses greater than 5 ft. Only wells with locations reported to a precision of 1/4 of a section or smaller were used. Most well locations are those reported by drillers. However, some locations were refined by comparison of anomalous geologic descriptions with street addresses of the property or by talking to the well owners and about 11% were confirmed by field visits. The depth to the base of the unit for each point was converted to altitudes above sea level values by subtracting the depth from land-surface altitudes. Land-surface altitudes at well locations were obtained from U.S. Geological Survey digital elevation models (DEMs) using ArcInfo™ computer software. Comparison of well-location altitudes determined in the field from topographic maps with those derived from the DEMs showed that the differences between calculated values and field-determined values were generally less than 5 ft in the valleys. The altitudes were contoured by hand and then digitized. Because of the imprecise nature of driller log data, contours were drawn only where multiple data points supported the contour location. The thickness of the shallow alluvium was calculated by subtracting the altitude of the base of the unit from the land surface altitude unit using ArcInfo™ software. The resulting thickness grid was smoothed and contoured using ArcInfo™. Thickness contours were then redrawn by hand and redigitized.

DATA SOURCES

Water-well driller logs and well locations are stored in the GWIC database at Montana Bureau of Mines and Geology (http://mbmggwic.mtech.edu). Ground-surface topographic data are from the 1:24,000-scale U.S. Geological Survey DEMs for western Montana. Public Land System Survey data, hydrography, and roads were obtained from Montana's Natural Resources Information System, Helena (http://nris.state.mt.us/).

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