Surficial Geologic Map of the Outlet Creek (HUC 12) Watershed, Buena Vista County, Iowa

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Introduction

The Outlet Creek (HUC 12) Watershed (Fig. 1) is located in Buena Vista County, Iowa. It is a unique basin, as it straddles two landform regions (Fig. 2), the Northwest Iowa Plains (NIP) and Des Moines Lobe (DML), and it includes Storm Lake. Both landform regions are formed in thick glacial sediment and have a subdued topography, but interestingly, the Outlet Creek Watershed has less relief than surrounding basins. While it is relatively flat, the topography is still evolving which is altering the catchment area of Outlet Creek, as shown in Fig. 1. The NIP makes up the western portion of the map area and is formed in till of the Middle Wisconsinan (~27-50 ka) Sheldon Creek Formation. Additionally, this region experienced a cold, blustery climate during the Late Wisconsinan (~12-27 ka) which caused landscape-wide periglacial erosion and deflation. As a result of these environmental conditions, there are colluvial deposits across most of the area ranging in thickness from <1 m (3 ft) on some uplands to more than 15 m (50 ft) in the Powell Creek Valley, northwest of Storm Lake. Despite the erosion, there is generally 1 to 2 m (3-6 ft) of loess across the uplands of the NIP in the mapping area. The region lacks the thick loess package of the Loess Hills and Southern Iowa Drift Plain landform regions to the southwest and south as it was not directly downwind (southwest) of the Missouri River during the interval of loess deposition. This was confirmed with 20 soil probes taken in locations in and around the watershed.

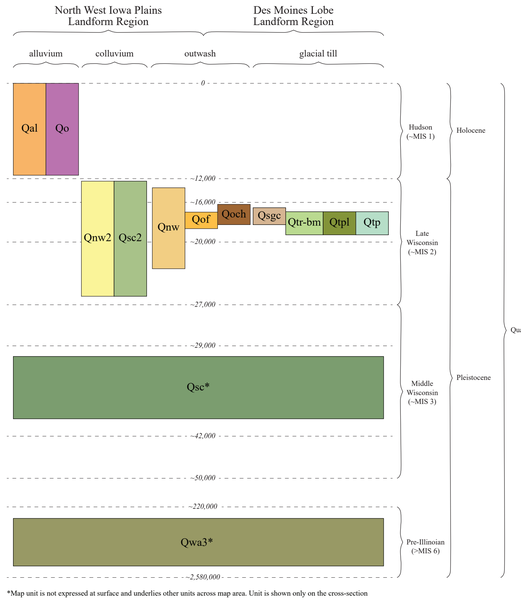
The eastern portion of the mapping area is on the Des Moines Lobe (DML) landform region which represents the most recent glacial advance in Iowa. In general, iravelling from central Canada deposited glacial sediments during the Late Wisconsin. However, regional ice flow markers, such as moraines, indicate that local ice flow was from the east, and the resultant surface reflects its glacial lineage. The sediment at the surface is a clay-rich diamicton of the Dows Formation, and outwash of the Noah Creek Formation forms terraces along Outlet Creek and fills the paleo-Boyer River Valley. The landscape is also defined by numerous glacial landforms, including kettles, eskers, kames, 'washboard' moraines, and the terminal Bemis Moraine, found on the eastern side of the City of Storm Lake. Perhaps most importantly, the DML is also responsible for the formation of the lake.

Continental glaciation causes a significant reorganization of drainage networks, both under the glacier itself and near the ice margins. The mapping area contains abundant evidence for this phenomenon. Today, Powell Creek flows into Little Storm Lake and Storm Lake, and Outlet Creek then carries water to the North Raccoon River, which eventually finds its way to the Mississippi via the Des Moines River (Fig. 3). Prior to the advance of DML ice, Powell Creek emptied into the paleo-Boyer River (which extended further to the northeast) and then flowed into the Missouri River. As ice neared the mapping area, meltwater flowed into the paleo-Boyer River filling it with outwash deposits. Shortly thereafter, the DML reached its local maximum and buried the paleo-Boyer River Valley while it formed the Bemis Moraine. This caused the meltwater to be re-directed into the now dammed Powell Creek which led to the formation of Storm Lake. The influence of the Bemis Moraine is why the eastern shore of Storm Lake is formed largely from coarse glacio-fluvial deposits, while the rest of the lakeshore consists of diamicton. After the ice retreated, Outlet Creek formed on the newly glaciated surface. It could not, however, follow the previous course of Powell Creek as the now empty Boyer River Valley was higher in elevation due to the aggradation of outwash. Water then had to flow east into the newly glaciated landscape, which sat at a lower elevation. The pathway to the newly created North Raccoon River was formed via meltwater channels flowing eastward as ice retreated.

One of the long-term effects of this diversion is that this area is now part of the Mississippi River Basin rather than the Missouri River Basin. This course alteration adds an additional 300 km (~180 mi) to Outlet Creek's long profile (distance to base level or a major river) making the profile shallower. The consequence is that the watershed has had lower stream power (effectiveness of sediment transport) than surrounding channels headed to the Missouri. The end results is that the topography within the Outlet Creek watershed is less incised than the surrounding NIP landscape to the west.

Data collected for this mapping project included 17 drill cores and 20 hand probe locations, as well as investigation of seven exposures, and three gravel pits. Additional information about the surficial mapping units and stratigraphy may be found in the Summary Map Report of The Outlet Creek (HUC12) Watershed, Buena Vista County, Iowa.

Correlation of Map units



*Map unit is not expressed at surface and underlies other units across map area. Unit is shown only on the cross-section

Legend

Map Symbols
- outcrop
- GeoSam point
- drill core
- handprobe
- unit contact
- elevation contour
- bathymetry contour
- cross-section
- water body
- river/stream

Glacial Features
- limit of Late Wisconsinan Advance
- meltwater cutbanks
- 'washboard' moraine
- esker
- meltwater flow
- moraine ridge
- kettle

Road Classification
- U.S. Route
- State Route
- Local road

Description of Map Units

QUATERNARY SYSTEM

HUDSON EPISODE

Qal - Alluvium (DeForest Formation-Undifferentiated) Variable thickness of less than 1 to 5 m (3-16 ft) of very dark gray to brown, noncalcareous to calcareous, stratified silty clay loam, clay loam, loam to sandy loam alluvium and colluvium in stream valleys, on hill slopes, and in closed depressions. May overlie Pre-Illinoian, Middle Wisconsinan, or Late Wisconsinan glacial till, Peoria Formation loess, or Noah Creek Formation sand and gravel. Associated with low-relief modern floodplain, closed depressions, modern drainageways or toeslope positions on the landscape. Seasonal high water table and potential for frequent flooding.

Qo - Wetlands and Depressions (DeForest Formation-Woden Member) Generally 2.5 to 6 m (8-20 ft) of black to very dark gray, calcareous, muck, peat, and silty clay loam colluvium and organic sediments in drained and undrained closed and semi-closed depressions. Overlies gray, calcareous, loam diamicton (Dows Formation-Morgan or Alden members) or sand and gravel (Noah Creek Formation). Associated with low relief features that occupy depressions and riparian zones. Supports wetland vegetation and can be permanently covered by water. High water table.

WISCONSIN EPISODE

Qof - Outwash Fan (Noah Creek Formation) Thickness can be quite variable from 3 to 6 m (10-20 ft) of yellowish brown, coarse-grained sand and gravel. May overlie gray, calcareous, massive, dense loam diamicton (Dows Formation-Alden Member or Sheldon Creek Formation). Narrow, low relief apron that gently slopes away from the moraine front. Seasonal high water table.

Qoch - Outwash (Noah Creek Formation) Generally 3 m (10 ft) to less than 8 m (26 ft) of dark gray, dark grayish brown, dark brown to dark yellowish brown, medium to coarse sand, gravelly sand to pebbly gravel. Overlies gray, calcareous, massive, dense loam diamicton (Dows Formation-Alden Member). In valley positions, it is at the land surface of older terraces. On the modern floodplain it is buried by DeForest Formation alluvium. Low relief landforms expressed as broad terraces, long, narrow, longitudinal terraces, or cuspate-shaped point terraces. Terraces associated with the major valleys are benched on a gray, calcareous, massive, dense loam diamicton (Dows Formation-Alden Member).

Qnw - Sand and Gravel (Noah Creek Formation) Generally less than 8 m (26 ft) thick, but there may be significantly thinner coarse-grained deposits in smaller stream valleys. Yellowish brown to gray, poorly to well sorted, massive to well stratified, coarse to fine feldspathic quartz sand, pebbly sand, and gravel. In the map area the unit overlies middle Wisconsin-age Sheldon Creek Formation This unit encompasses outwash deposits that accumulated in valley trains during the Wisconsin Episode.

Qsgc - Supraglacial Complex (Dows Formation-Pilot Knob or Morgan members) Generally 3 to 20 m (10-65 ft) of yellowish brown, often calcareous and fractured, stratified sand and gravel which may be interbedded stratified loam diamicton. Overlies gray, calcareous, massive, dense loam diamicton (Dows Formation-Alden Member). Moderate to high relief (3 to 15 m) hummocks, beaded ridges, kames, eskers, and associated linked drainages on upland surfaces.

Qnw2 - Sand and Gravel (Noah Creek Formation) Generally 2 to 12 m (7-40 ft) of yellowish brown to gray, poorly to well sorted, massive to well-stratified, coarse to fine feldspathic quartz sand, pebbly sand and gravel with few intervening layers of silty clay. Along many valleys a thin mantle of loess, reworked loess, or fine-grained alluvium (Qal) may be present. This unit includes colluvial deposits derived from adjacent map units and encompasses deposits that accumulated in low relief stream valleys during the Wisconsin Episode. Seasonal high water table and some potential for flooding.

Qsc2 - Periglacial Sediments Shallow to Glacial Till (unnamed erosion surface sediment) Generally 1 to 3 m (3-10 ft) of yellowish brown to gray, massive to weakly stratified, well to poorly sorted loamy, sandy and silty erosion surface sediment. Map unit includes some areas mantled with less than 2 m (6 ft) of Peoria Formation (silt or sand facies). Overlies massive, fractured, slightly firm glacial till of the Sheldon Creek Formation.

Qtr-bm - Till Ridge (Dows Formation-Morgan Member) This landform is associated with the Bemis Moraine. Generally 3 to 5 m (10-16 ft) of yellowish to grayish brown, usually calcareous and fractured, stratified loam to silt loam; stratified sands and gravels to sandy loam diamicton; textures can be quite variable. Overlies gray, calcareous, massive, dense loam diamicton (Dows Formation-Alden Member). The Alden Member in this mapping unit rarely extends to depths greater than 12 to 15 m (39-49 ft); and overlies the Sheldon Creek Formation diamicton. At the DML margin, this landform may be mantled with a thin layer of Peoria Formation silt. Low to moderate relief hummocky landform features exceed 3 to 5 m (10-16 ft) of local relief. Seasonal high water table.

Qtp - Till Plain (Dows Formation-Morgan Member) Less than 8 m (26 ft) of yellowish brown, often calcareous and fractured, stratified loam to silt loam to sandy loam diamicton; textures can be quite variable. Overlies gray, calcareous, massive, dense loam diamicton (Dows Formation-Alden Member). The Alden Member in this mapping area is generally 8 to 20 m (26-66 ft) thick and over lies the Sheldon Creek Formation or Pre-Illinoian diamicton. Low to moderate relief (3 to 8 m), undulating plains with irregular surface patterns. Seasonal high water table.

Qtpl - Till Plain with Discontinuous Elongated Hummocky Ridge Forms (Dows Formation-Morgan Member) Indistinct elongated hummocks are oriented transverse to glacier flow on the till plain with irregular shaped surface patterns. Ridges are predominately low relief (less than 3 m) with some moderate relief features (3 to 8 m). Overall landform exhibits swell and swale topography. Less than 4 m (13 ft) of yellowish to grayish brown, calcareous, fractured, stratified loam to silt loam to sandy loam diamicton; textures can be quite variable. Overlies gray, calcareous, massive, dense loam diamicton (Dows Formation-Alden Member). The Alden Member in this mapping area is generally 8 to 20 m (26-66 ft) and overlies the Sheldon Creek Formation or Pre-Illinoian diamicton. Low relief, (less than 3 m of local relief), slightly undulating plains with irregular surface patterns. Discontinuous elongated ridge forms within the unit are underlain by less than 8 m (26 ft) of yellowish brown, often calcareous, stratified loam to silt loam to sandy loam diamicton. Overlies gray, calcareous, massive, dense loam diamicton (Dows Formation-Alden Member). Seasonal high water table.

MIDDLE WISCONSIN EPISODE

Qsc - Glacial Till (Sheldon Creek Formation-Undifferentiated) Generally 3 to 15 m (10-49 ft) of yellowish brown to gray, calcareous fractured to massive clay loam; at depth, this unit can be variably textured and contain significant sand and gravel bodies. The upper 3 to 7 m (10-23 ft) may be periglacially altered. The presence of Pierre Shale clasts is common. This unit overlies Pre-Illinois diamicton and is only shown on the cross-section.

PRE-ILLINOIS EPISODE

Qwa3 - Till (Wolf Creek or Alburnett formations) Over 50 m (164 ft) of very dense, massive, fractured, loamy glacial till of the Wolf Creek or Alburnett formations. This unit is buried by diamicton of the Sheldon Creek or Dows formations and is shown only on the cross-section.

OTHER MAPPING UNITS

Qpq - Pits and Quarries Sand and gravel pits and rock quarries. Extent mapped as shown on the county soil survey and as identified on aerial imagery.

Qf - Fill Areas of cut and fill associated with major land disturbances including highways, railroads, and other land development. Deposits may be similar in character to those of adjacent map units but may also have significant mantles of fill or deep cuts that expose underlying units.

Acknowledgements

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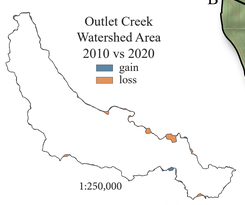


Figure 1. The waterhshed boundary differences between digital elevation maps derived from LiDAR flights in 2010 and 2020. The 2020 boundary was generated for this project.

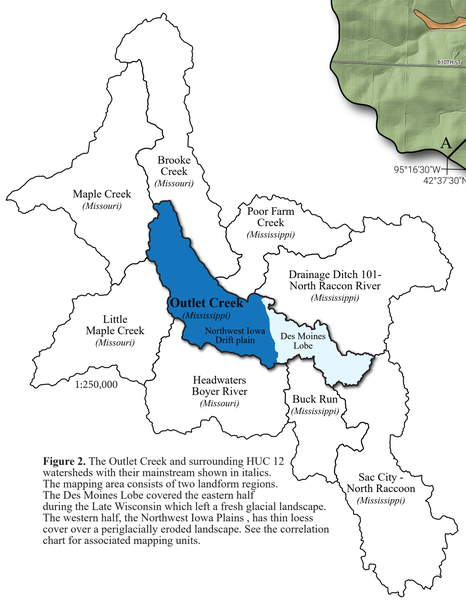


Figure 2. The Outlet Creek and surrounding HUC 12 watersheds with their mainstream shown in italics. The mapping area consists of two landform regions. The Des Moines Lobe covered the eastern half during the Late Wisconsin which left a fresh glacial landscape. The western half, the Northwest Iowa Plains , has thin loess cover over a periglacially eroded landscape. See the correlation chart for associated mapping units.

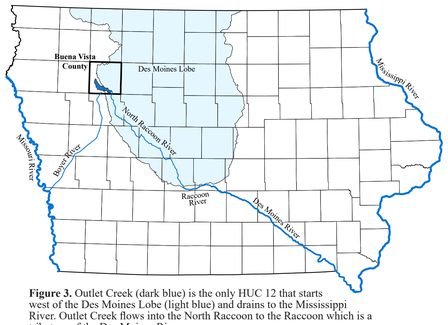
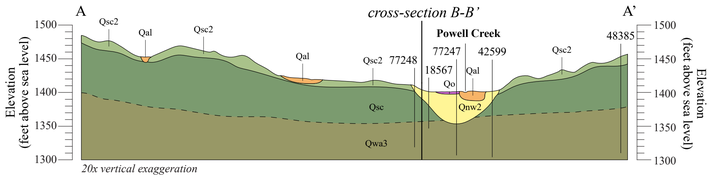
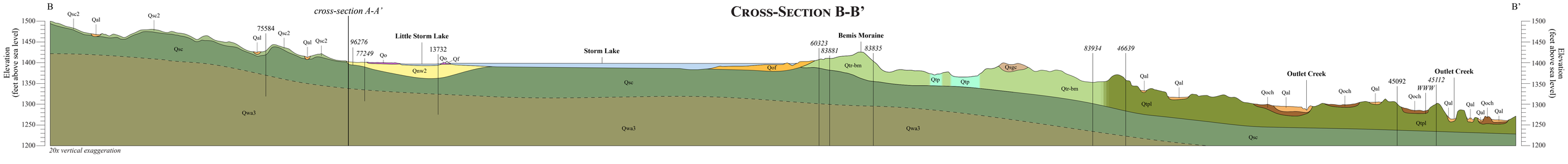


Figure 3. Outlet Creek (dark blue) is the only HUC 12 that starts west of the Des Moines Lobe (light blue) and drains to the Mississippi River. Outlet Creek flows into the North Raccoon to the Raccoon which is a tributary of the Des Moines River.

Cross-Section A-A'



Cross-Section B-B'