AGGREGATE RESOURCES

SWIFT COUNTY SAND *and* GRAVEL POTENTIAL

Produced by the Aggregate Resource Mapping Program
Minnesota Department of Natural Resources Division of Lands and Minerals
Funded by the Legislative-Citizen Commission on Minnesota Resources (LCCMR)

DEPARTMENT OF NATURAL RESOURCES

St. Paul, Minnesota - September, 2022
Mapped by Chad Crotty

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND

PURPOSE

The purpose of this project is to identify and classify potential construction aggregate resources (sand and gravel) in Swift County, Minnesota. This mapping was completed in accordance with the Minnesota Statute Section 84.94 directing the Department of Natural Resources (DNR), in cooperation with the Minnesota Geological Survey (MGS) and Minnesota Department of Transportation (MnDOT), to provide information to local governments in order to plan and protect future supplies of aggregate resources. This map and accompanying databases are intended to inform comprehensive land use and zoning decisions regarding aggregate resources, introduce aggregate resource protection, spread the burden of development, and promote orderly and environmentally sound development of resources. Having locally available, low-cost construction aggregates is fundamental to building and maintaining public infrastructure and private sector development.

Aggregate materials are high-bulk low-value commodities, which means transportation costs account for a considerable amount of the delivered price. Lower construction costs for public and private projects can be achieved by accessing local aggregate supplies. In addition to transportation costs, land use conflicts can affect the availability, usability, and supply of aggregate. Land use conflicts, such as cities expanding into adjacent rural areas, aggregate resource deposits being covered by new developments, new developments occurring adjacent to aggregate resources, and/or land use designations that exclude aggregate mining, are becoming more common. Specifications for the construction of roads and bridges require higher quality aggregate, which may be available only in limited and specific areas. The need and increased use of aggregate material in and around regional economic centers are depleting permitted supplies. As a result, aggregate resources are becoming less available and the transportation distances are increasing, which is passed on in costs to the consumer.

This is a regional reconnaissance-scale map. Site-specific evaluations are still necessary prior to any development of the resource, especially in regards to aggregate quality or environmental review. Factors such as ownership, zoning, protected waters and wetlands, environmental permitting, and other individual site characteristics are not part of the geological resource data summarized here.

METHODOLOGY

Map compiled using Geographic Information Systems (GIS).

Data Gathering: Literature reviews and data searches are conducted to obtain a basic understanding of the regional geology. Some of the data gathered includes aerial photographs, topographic maps, digital elevation models, shaded relief maps, subsurface data, gravel pit and quarry data, existing maps of surficial and bedrock geology, published papers and reports, land use, as well as several datasets of background information, including roads, railroads, PLS township, range, and section boundaries, and other data.

The County Well Index (CWI) database, the Aggregate Source Information System (ASIS), and Quaternary Data Index (QDI) are important datasets used to interpret subsurface geology and for creating aggregate potential resource maps. CWI is an online database (https://mnwellindex.web.health.state.mn.us/) developed and maintained by MGS and the Minnesota Department of Health. These resources contain basic information for over 300,000 wells drilled throughout Minnesota. In Swift County, there are 1,111 wells with defined locations (Figure 1), and an additional 229 unlocated wells that have been approximately placed within the county boundary. The majority of CWI logs contain geologic descriptions used to determine depth and thickness of sediments and bedrock. ASIS is a dataset compiled and maintained by MnDOT that consists of aggregate quality data, sand and gravel grain size analysis, and pit sheets displaying the descriptions of shallow test-hole logs with diagrams of test-hole locations. The QDI is an internal working database maintained by MGS that consists of field collected data and analysis, from soil borings to gravity and aeromagnetic data. There are currently 293 QDI sites in Swift County.

Fieldwork: Several weeks were spent driving accessible roads in the county looking for outcrops and exposures of geologic materials to further define aggregate deposits. Sediments exposed in artificial (e.g. road cuts, trails, foundation excavations, construction projects) and natural (e.g. stream cuts and animal burrows) exposures offer sites where surface materials and glacial stratigraphy can be observed. A total of 160 field observations were logged in Swift County. Fieldwork also included documenting sediment in existing gravel pits, which provided additional quality data and views of stratigraphic cross-sections. These larger views into the structure of the subsurface layers allowed the geologist to interpret the depositional setting and thereby better predict the extent of the deposit.

Sand and Gravel Data Compilation and Interpretation: Aggregate bearing landforms are typically created by glacial meltwater and non-glacial streams and lakes. Sand-and-gravel-bearing features such as outwash channels, glacial lake/deltaic features, and other more complex landforms that were created in contact with, or beneath the ice, are distinguished on this map using a land systems approach. This involves the identification of the processes by which glacial landscapes were created, and can provide predictions about the occurrence of a particular sediment type within a given feature. Other sediment characteristics such as color, texture, and grain shape, also help determine how the sediment was deposited. These substrates also have distinctive tones or patterns when viewed from aerial photographs. Furthermore, a particular vegetation type might prefer well-drained soils, such as sand and gravel.

Using GIS software, aggregate resources were delineated by layering multiple datasets. Topographic maps (USGS 1:24,000), high resolution elevation data (LiDAR), shaded relief maps, aerial photographs, subsurface data, field observations, the location and distribution of existing pits, and soil surveys, CWI, ASIS, and QDI were used to identify features containing sand and gravel resources. Aggregate resource information was mapped at a scale of 1:24,000 and compiled at a scale of 1:50,000.

Printed Map Scale 1:100,000

Based on a 1:50,000 scale MN DNR resource assessment

0 0.5 1 2 3 Miles

0 0.5 1 2 3 4 Kilometers

BASEMAP SYMBOLS:

Transportation Features

- 12 — MN Highway
- 51 — County Highways and Roads
- Township and Other Roads
- Municipal Roads
- Railroad Tracks

Bounding Features

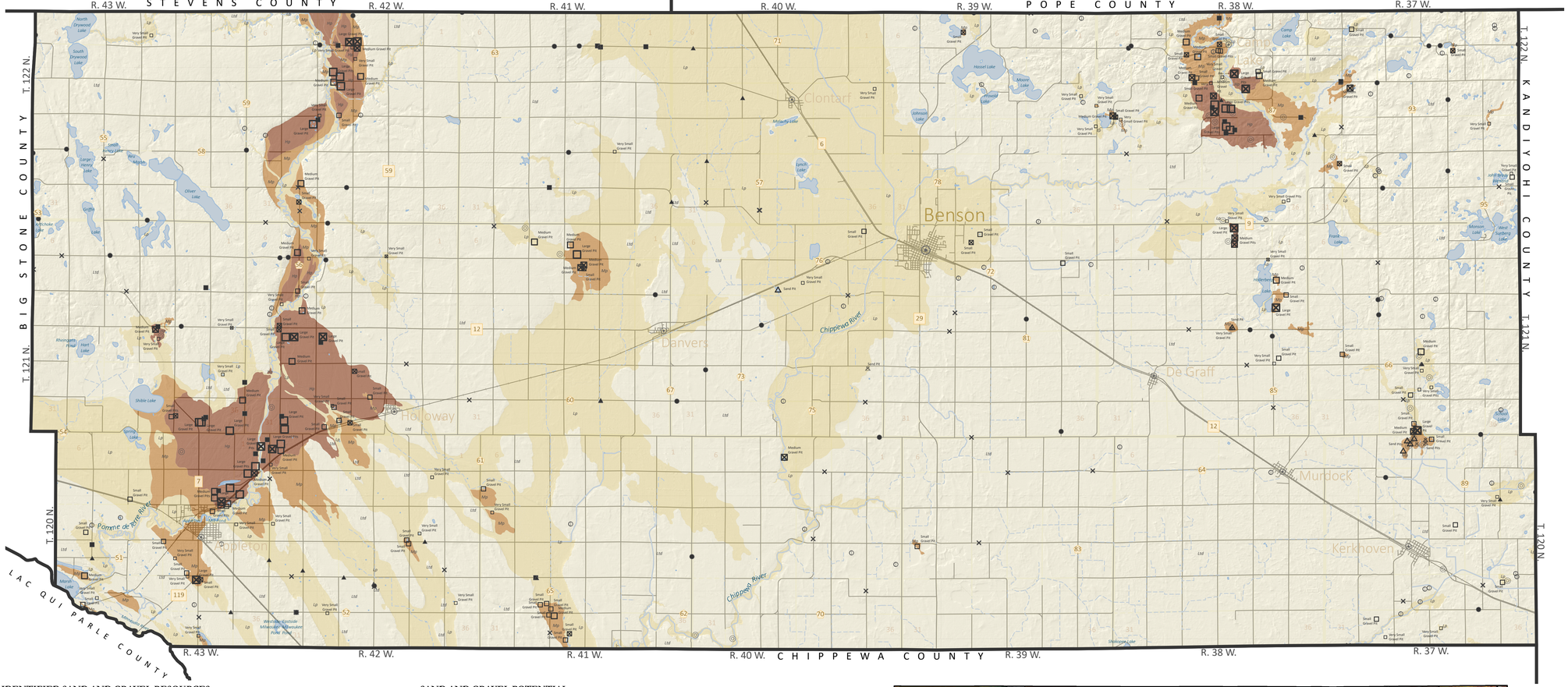
- County
- PLS Townships
- PLS Sections

County Seat & Cities

- County Seat
- Cities

Physical Features

- Lakes
- Rivers and Streams
- Ditches



IDENTIFIED SAND AND GRAVEL RESOURCES

Several sources of information were used to identify gravel pit locations including topographic maps, aerial photographs, soil surveys, MnDOT files, fieldwork, gravel operators, and other sources. Gravel pits range in size from less than 1 acre to greater than 50 acres and may be active, inactive, or reclaimed. The sand and gravel quality vary. Pits were placed in a category based on the relative areal extent of the total mining footprint as of 2021. The size of some fully reclaimed pits was estimated using historic aerial photographs.

Very Small	Small	Medium	Large
under 1 acre	1-5 acres	5-15 acres	over 15 acres
n = 42	n = 41	n = 22	n = 21
n = 4	n = 18	n = 14	n = 15

Gravel Pits: Includes sites that have been or are currently being mined for varying percentages of sand and gravel

Gravel Pits - MnDOT ASIS: Sites were identified by MnDOT as part of the Aggregate Source Information System (ASIS). Although identified as a potential resource location, sites have not necessarily been mined or geologically evaluated. Some locations were modified to better correlate to present gravel pit boundaries.

n = 6 — Sand Pits: Sites that contain a significant amount of sand with little to no gravel.

n = 5 — Sand Pits – MnDOT ASIS: Sites contain significant amount of sand with little to no gravel and were identified by MnDOT as part of ASIS. Although identified as a potential resource location, sites have not necessarily been mined or geologically evaluated. To better correlate with the present sand pit boundaries, some of the locations were modified.

OTHER FEATURES

n = 54 — Borrow Pits: Contains other unconsolidated sediment like clay, silt, and clay with boulders and do not contain significant amounts of sand and/or gravel. Include sites that have been or are currently being mined.

n = 29 — Prospects: Indicates a site that has been prospected and/or leased by MnDOT. A prospected classification does not necessarily imply that the source is actually producing aggregate. In fact, it may only indicate an aggregate deposit that was at one time leased by MnDOT and whose aggregate quality has been tested, but from which no material has ever been excavated.

FIELD OBSERVATIONS

- ■ Sand and Gravel
- ▲ Sand
- ● Till
- × Silt/Clay

A total of 160 field observations were logged throughout the course of the project. Surficial geologic sediment and glacial stratigraphy were observed in road cuts; stream exposures; excavations, such as judicial ditches, construction projects, and (cable, pipe, tiling); and animal holes. Some field observations taken within pits or that only contained topsoil are not shown on the map.

Field observations are symbolized by primary material type observed, and separated into four categories: **Sand and Gravel** (includes gravel and sand, sand and gravel, silty sand and gravel, and sand minor gravel); **Sand** (includes sand minor gravel, sand, silty sand, and fine sand); **Till** (includes boulders, sandy till, and till); and **Silt/Clay** (includes silt and clay). Note, the following symbols may appear in different shades due to the over-layering of sand and gravel potential map units.

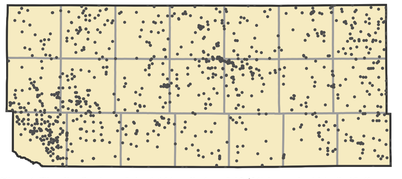


Figure 1: The distribution of the 1,111 wells (as of 02/21) located within Swift County that were referenced to create this map. There are an additional 229 unlocated wells also referenced for this map though not shown here. Unlocated wells have not been field verified by the MGS for location accuracy.

Table 1: Classification of Sand and Gravel Potential

Characteristics	SIGNIFICANT RESOURCES		NONSIGNIFICANT[1] RESOURCES	
	High Potential	Moderate Potential	Low Potential	Limited Potential
Surficial Geology Landforms	Outwash feature; outwash channel; collapse feature; and glacial lake/delta	Alluvial valley; outwash feature; outwash channel; ice contact feature; glacial lake/delta; glacial lake; modified ground moraine; moraine complex; and tunnel valley	Alluvial valley; outwash feature; outwash channel; ice contact feature; glacial lake/delta; glacial lake; end moraine complex; modified ground moraine; moraine complex; modified end moraine; modified moraine complex; ground moraine; tunnel valley; and interlobate complex	Alluvial valley; outwash channel; ice contact feature; glacial lake/delta; glacial lake, end moraine complex, modified ground moraine, modified moraine complex, moraine complex, ground moraine, tunnel valleys, and interlobate complexes. The deposits of this unit contain all or one of the following: clay with boulders (till), clay, silt, sand, gravel and/or organics. The probability that a significant sand and gravel resource exists within this unit is very low to moderately low. The thickness of the deposits is typically less than 10 feet but can range from 0-20+ feet with overburden thickness ranging from 0-50+ feet. The sand and gravel resources occurring in this unit are very small to very large in areal extent and textural characteristics are moderately poor to moderately good. The quality ranges from moderately low to moderately high relative to other sand and gravel resources within Swift County.
Predominant Sediment Description	Sand and gravel	Sand and gravel to sand with gravel	Till, silt, sand with minor gravel	Till, clay, silt, sand, gravel, organics
Probability [2]	High to very high	Moderate to high	Low to moderately high	Very low to moderately low
Sand and Gravel Thickness (ft)	0-50+	0-40+	0-25+	0-20
Overburden[3] Thickness (ft)	0-10+	0-15+	0-30+	0-50+
Sand and Gravel Deposit Size (areal extent)	Moderate to very large (10-30+ acres)	Small to very large (3-30+ acres)	Very small to very large (under 3 to 30+ acres)	Very small to moderate (under 3 to 15 acres)
Sand and Gravel Textural Characteristics[5]	Good to very good	Moderate to good	moderately poor to moderately good	Very poor to moderately poor
Sand and Gravel Quality[6]	Moderately high to high	Moderate to high	Moderately low to moderately high	Very low to moderately low

Footnotes on sand and gravel potential classification, Table 1

[1]**Nonsignificant:** Aggregate resources that do not meet the criteria for high or moderate aggregate potential according to the characteristics listed in Table 1. This is a relative classification that changes from one mapping region to another.

[2]**Probability:** The degree of certainty that aggregate exists within a map unit largely defined by the amount of available information. Many gravel pits verify the certainty for many map units classified as high potential.

[3]**Overburden:** The material that lies above the sand and gravel that must be removed to access a deposit.

[4]**Areal Extent:** The size, horizontal extent, or distribution of a unit (e.g., area in acres). This attribute describes the size of a deposit found within a given polygon.

[5]**Textural Characteristics:** Particle size distribution, defined as the percentage of gravel or sand vs. silt or clay (e.g., sieve analysis).

[6]**Quality:** The physical characteristics of the material, such as soundness (e.g., magnesium sulfate test), durability (L. A. Rattler test), and percent of deleterious rock types such as iron oxide, disintegrating rock, or unsound chert. Field observations supplement historic data.

SAND AND GRAVEL POTENTIAL

Sand and gravel potential is an assessment of the relative probability that a sand and gravel deposit exists within a given mapping unit. Almost all emphasis is placed upon geologic evidence, physical parameters such as areal extent, and interpretation at the reconnaissance level, rather than upon economic feasibility, site-specific level of evaluation, or other related parameters. This assessment does not imply that economic aggregate deposits exist everywhere within a given map unit designated as "Sand and Gravel Potential," but rather, that within such a map unit, geologic processes were active that could have created aggregate deposits within certain map units. Geologic measurements of sand and gravel deposits such as thickness or overburden remain constant, but economic criteria and environmental permitting vary across time and at different locations. Important site-specific factors such as ownership, zoning, protected waters and wetlands, sensitive or protected environments, permitting, distance to markets, royalties, and individual site characteristics, such as access, all contribute to the feasibility of mining specific parcels; however, these factors are not considered in this reconnaissance-level study.

SIGNIFICANT SAND AND GRAVEL POTENTIAL: Geologic units that are inferred to contain sand and gravel resource potential. These units have data exhibiting geologic characteristics associated with sand and gravel-bearing landforms. Existing gravel pit and MnDOT aggregate sources within these units are considered to be identified, or known resources, that increase the level of confidence for that mapping unit.

Hp — High Sand and Gravel Potential: Includes landforms such as outwash features, outwash channels, collapse features, and glacial lake/deltas. Predominant sediment typically consists of sand and gravel. The probability[2] that a potential sand and gravel resource exists within any map unit is high to very high. Deposit thickness is typically greater than 20 feet, but ranges from 0-50+ feet with 0-10+ feet of overburden[3]. The sand and gravel resources occurring in this unit are moderate to very large in areal extent[4] and the textural characteristics[5] are good to very good. The quality[6] is moderately high to high relative to other sand and gravel resources within Swift County.

Mp — Moderate Sand and Gravel Potential: Includes landforms such as alluvial valleys, outwash features, outwash channels, ice contact features, glacial lake/deltas, glacial lake, modified ground moraine, moraine complex, and tunnel valleys. Predominant sediment ranges from sand with gravel to sand and gravel. The probability that a potential sand and gravel resource exists within any map unit is moderate to high. Deposit thickness is typically greater than 15 feet, but in some landforms can range from 0-40+ feet with 0-15+ feet of overburden. The sand and gravel resources occurring in this unit are small to very large in areal extent and the textural characteristics are moderate to good. The quality is typically moderate to high relative to other sand and gravel resources within Swift County.

NONSIGNIFICANT[1] SAND AND GRAVEL POTENTIAL: Units that generally have little or no potential for significant aggregate resources or lack sufficient data to support a classification of significant aggregate resources. These units typically contain clay, silt, fine sand, unsorted sediments (till), or very thin layers of sand and gravel. Units may include aggregate resources that are too small to map or with significant overburden.

Lp — Low Sand and Gravel Potential: Includes landforms such as alluvial valleys, outwash features, outwash channels, ice contact features, glacial lake/deltas, modified ground moraine, end moraine complex, moraine complex, and tunnel valleys. Predominant sediment varies and can include till, silt, and sand with minor gravel. The probability that a significant sand and gravel resource exists within this unit is low to moderately high. The thickness of the deposits is typically less than 10 feet but can range from 0-25+ feet with overburden thickness ranging from 0-30+ feet. The sand and gravel resources occurring in this unit are very small to very large in areal extent and textural characteristics are moderately poor to moderately good. The quality ranges from moderately low to moderately high relative to other sand and gravel resources within Swift County.

Ltd — Limited Sand and Gravel Potential: Includes landforms such alluvial valleys, outwash channels, ice contact features, glacial lake/deltas, glacial lake, end moraine complex, modified end moraine complex, modified ground moraine, modified moraine complex, moraine complex, ground moraine, tunnel valleys, and interlobate complexes. The deposits of this unit contain all or one of the following: clay with boulders (till), clay, silt, sand, gravel and/or organics. The probability that a significant sand and gravel resource exists within this unit is very low to moderately low. The thickness of the deposits is typically less than 10 feet but can range from 0-20 feet with overburden thickness ranging from 0-50+ feet. The sand and gravel resources occurring in this unit are very small to moderate in areal extent and textural characteristics are very poor to moderately poor. The quality ranges from very low to moderately low relative to other sand and gravel resources within Swift County. A limited potential rating includes the circumstance where characteristics are unknown; there was insufficient data to give a higher ranking; limited access to an area for further investigation; and/or no obvious landform-sediment association.

BASE MAP DATA SOURCES:

Lakes, rivers, streams, and drainage ditches from DNR PWI (Public Waters Inventory), 2022; PLS (Public Land Survey) townships and sections layers extracted from PLS Project, 2013, DNR, Division of Lands and Minerals; Cities by the Minnesota Geospatial Information Office (MnGeo). County boundaries from DNR, derived from combination of 1:24,000 scale PLS lines, 1:100,000 scale TIGER, 1:100,000 scale DLG, and 1:24,000 hydrography lines, 2013; Roads from MnDOT Base map, 2012; Railroad Tracks from MnDOT Base map, 2015; Hillshade from a 3-meter LiDAR from DNR and MnGeo, 2012.

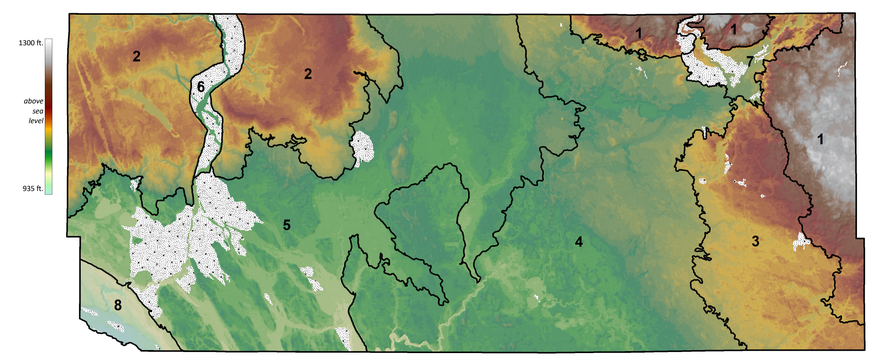


Figure 2: The digital elevation model (DEM) of Swift County displays how the higher elevation areas of the Alexandria moraine (1), the Big Stone moraine (2), and general ground moraine (3), confined the Glacial Lake Benson plain (4) and Glacial Lake Benson delta (5). The DEM also displays how the majority of significant aggregate resources (shown in black and white stipple) were deposited from water flowing through the Pomme de Terre spillway (6), Swift Falls delta (7), and the River Warren gorge (8). These geologic regions are discussed in further detail in the *Results* section of the text.

RESULTS

Aggregate resources in Swift County are primarily related to outwash and deltaic deposits within and around the former extent of Glacial Lake Benson, a short-lived proglacial lake that existed during the last glaciation (over 10,000 years ago). This lake was constrained to the east by the Alexandria moraine and to the west by the Big Stone moraine (Figure 2). These regions of higher elevation are composed of thick sequences of glacial till, deposited by multiple pulses of ice from the northeast to the northwest prior to the formation of the lake. The location of these moraines and the extent of the glacial lake created an uneven distribution of aggregate resources across the county.

The full extent and history of Glacial Lake Benson is short-lived and complex (Rittenhour et al, 2015). An initial lake elevation of 1,050 feet above sea level (a.s.l.) was suggested by Diedrick and Rust (1975), based on soil mapping. Further investigation by Rittenour et al (1998), suggests a lake elevation of ~1,075 feet a.s.l., based on strandline data. These elevations of 1,050 and 1,075 feet a.s.l. were used to map out the extent of Glacial Lake Benson deposits and lake-modified till, respectively, except where data suggested otherwise. The Glacial Lake Benson plain (Figure 2) is mostly composed of silt, clay, and lake-modified till, and is generally not a significant source of aggregate. The bulk of aggregate deposits occur where water flowed into the lake, primarily through the Pomme de Terre spillway, the Swift Falls delta, and in an area west of the Chippewa River to the Big Stone moraine, referred to here as the Glacial Lake Benson delta.

Most aggregate resources in the western portion of the county are located within the Pomme de Terre spillway, a large outwash channel now occupied by the Pomme de Terre river, and within deltaic sediments deposited as this spillway flowed into Glacial Lake Benson. Coarser deltaic sediments are generally located north of Appleton and Holloway, and gradually become finer to the south. Additionally, finer deltaic deposits exist from just east of the Big Stone Moraine to an area along the Chippewa River. These deposits are generally 5-15 feet thick and are composed of fine to coarse sheet-like sands that were deposited as water flowed into Glacial Lake Benson from the north. There are also coarse outwash deposits in the southwest corner of the county, within the River Warren gorge. This large outwash channel, now occupied by the Minnesota River, was created during the draining of a large glacial lake to the north, Glacial Lake Agassiz, likely after Glacial Lake Benson had already been drained.

In the eastern portion of the county, aggregate resources are concentrated in the northeast, within a collapsed deltaic feature and outwash channels flowing into Glacial Lake Benson. The collapse feature was likely created when a delta formed on or within glacial ice that subsequently melted. These deposits consist of alternating layers of fine to coarse sand and gravel, in faulted beds that appear to dip to the south. The outwash channel flowing into the Swift Falls delta from the north is also composed of fine to coarse sand and gravel, with deposits becoming finer to the south. The far northeast portion of the Swift Falls delta appears to consist mostly of washed till and fine sand deposits, with a few minor bars of sand and gravel.

REFERENCES

Crotty, C.M, and Arends, H.E., 2021, Aggregate Resource Potential in Kandiyohi County, Minnesota. Report 383, Plate A. Minnesota Department of Natural Resources, Division of Lands and Minerals, Scale 1:63,360 with digital data. https://files.dnr.state.mn.us/lands_minerals/aggregate/kandiyohi_sandandgravel.pdf

Diedrick, R.T., and Rust, R.H., 1975, Glacial Lake Evidence in Western Minnesota as Interpreted From the Soil Survey, Journal of the Minnesota Academy of Science, Vol. 41 No. 1, p. 9-12.

Hamilton, J.D., Bauer, E.J., Chandler, V.W., Steenberg, J.R., Staley, A.E., 2019, C-46, Geologic Atlas of Kandiyohi County, Minnesota. Minnesota Geological Survey. Retrieved from the University of Minnesota Digital Conservancy, https://hdl.handle.net/11299/202737

Harris, K.L., 2003, C-15 Geologic atlas of Pope County, Minnesota [Part A], Minnesota Geological Survey. Retrieved from the University of Minnesota Digital Conservancy, https://hdl.handle.net/11299/58560

Patterson, C.J., 1999, Quaternary geology-upper Minnesota River basin, Minnesota [Part A], Minnesota Geological Survey. Retrieved from the University of Minnesota Digital Conservancy, https://hdl.handle.net/11299/59765

Rittenour, T.M., Geiger, K.L., and Cotter, J.F.P., 1998, Glacial Lake Benson, west-central Minnesota; In: C.J. Patterson and H.E. Wright Jr. eds., Contributions to Quaternary Studies in Minnesota, Minnesota Geological Survey Reports of Investigations No. 49, p. 97-102.

Rittenour, T.M., Cotter, J.F.P., and Arends, H.A., 2015, Application of single-grain OSL dating to ice-proximal deposits, glacial Lake Benson, west-central Minnesota, USA, Quaternary Geochronology 30, p. 306-313.

Map and Data Disclaimer:

Plate A, DNR Report 409
Aggregate Resource Potential in Swift County, MN
Sand and Gravel Potential

Products of this project include print maps, GIS data, web services, and metadata: visit dnr.state.mn.us/lands_minerals/aggregate_maps