AGGREGATE RESOURCES

SAND *and* GRAVEL POTENTIAL

SIBLEY COUNTY, MN

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 Nicholas Borchardt

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 Sibley 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.

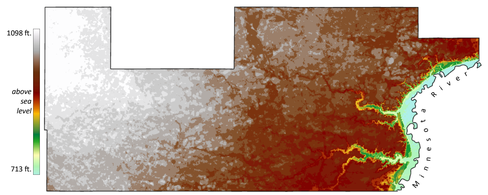

Figure 1: The digital elevation model (DEM) of Sibley County displays a gentle slope from west to east that is a relatively flat hummocky terrain. To the east, the DEM highlights the deep incision that Glacial River Warren carved out along the border of the county. The green to yellow in the main channel are outwash terraces and the blue is present day Minnesota River flood plain deposits that contain varying thickness of fine alluvial sediments over coarse outwash deposits.

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 Sibley County, there are 1,625 wells with defined locations (Figure 2), and an additional 267 wells with unverified locations 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 240 QDI sites in Sibley 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 209 field observations were logged in Sibley 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, bars, terraces, 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.

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 bars, outwash channels, and outwash terraces. Predominant sediment typically consists of gravel and sand to silt, sand or gravel. The probability[2] that a potential sand and gravel resource exists within any map unit is moderately high to very high. Deposit thickness ranges from 0-60+ 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 moderate to very good. The quality[6] is moderate to very high relative to other sand and gravel resources within Sibley County.

mp Moderate Sand and Gravel Potential: Includes landforms such as alluvial plains, alluvial valleys, colluvial features, ice contact features, outwash channels, and outwash terraces. Predominant sediment includes sand and gravel, sand, and till with pockets of sand or gravel. The probability that a potential sand and gravel resource exists within any map unit is moderately low to high. Deposit thickness ranges from 0-45+ feet with 0-20+ feet of overburden. The sand and gravel resources occurring in this unit are moderately small to very large in areal extent and the textural characteristics are moderately poor to good. The quality is typically moderately low to moderately high relative to other sand and gravel resources within Sibley 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 terraces, alluvial valleys, colluvial features, ice contact features, outwash channels, and outwash terraces. Predominant sediment varies and can include till with pockets of sand or gravel to silty sand and gravel. The probability that a significant sand and gravel resource exists within this unit is low to moderate. The thickness of the deposits ranges from 0-15+ feet with overburden thickness ranging from 0-50+ feet. The sand with gravel resources occurring in this unit are small to moderately large in areal extent and textural characteristics are poor to moderate. The quality ranges from low to moderate relative to other sand and gravel resources within Sibley County.

ldd Limited Sand and Gravel Potential: Includes landforms such alluvial terraces, alluvial valleys, collapse features, colluvial features, ground moraine, ice contact features, outwash channels, outwash terraces, stagnation features, and tunnel valleys. The deposits of this unit contain all or one of the following: till, clay, silt, organics, sand, and/or gravel. The probability that a significant sand and gravel resource exists within this unit is very low to moderate. The thickness of the deposits ranges from 0-10+ feet with overburden thickness ranging from 0-90+ feet. The sand and gravel resources occurring in this unit are very small to smaller in areal extent and textural characteristics are very poor to moderate. The quality ranges from very low to moderate relative to other sand and gravel resources within Sibley 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.

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. 201 pits were inventoried and include a total of 86 gravel pits, 49 sand pits, and 66 borrow pits. Gravel pits range in size from less than 1 acre to greater than 50 acres and may be active, inactive, reclaimed or partially 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 (under 1 acre)	Small (1-5 acres)	Medium (5-15 acres)	Large (over 15 acres)
n = 36	n = 30	n = 3	n = 1
n = 0	n = 1	n = 6	n = 9

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 = 47 Sand Pits: Sites that contain a significant amount of sand with little to no gravel.

n = 2 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 = 66 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 = 48 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 209 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 hand auger holes in construction projects, trenches, animal holes, and test holes drilled with a Giddings Soil Probe. Some field observations taken within pits 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 with sand, gravel and sand, sand and gravel, sand with gravel, and silty sand and gravel); **Sand** (includes sand, fine sand, and silty sand); **Till** (till, and sandy till); and **Silt**. Note, the following symbols may appear in different shades due to the over-layering of sand and gravel potential map units.

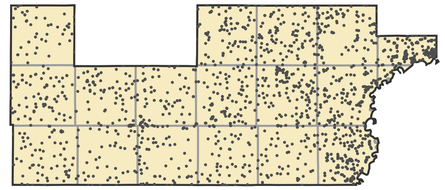

Figure 2: The distribution of the 1,625 wells (as of 02/21) located within Sibley County that were referenced to create this map. There are an additional 267 unlocated wells also referenced for this map though not shown here. Unlocated wells have not been field verified by the MGS for location accuracy.

RESULTS

Sand and gravel resources are scarce in much of Sibley County owing to the glacial history of the region. The surface sediment of Sibley County was deposited primarily by an ice lobe called the Des Moines lobe. Advancing from the northwest approximately 14,000 years ago, the Des Moines lobe deposited unsorted sediment, called till, that is characteristically clay rich. The associated rock lithologies of the Des Moines lobe include shale and carbonates, impacting the overall quality of the sand and gravel deposited by this glacier. Much of the western and central portion of the county consists of Des Moines lobe till deposited as a low relief, hummocky moraine having limited aggregate potential. Small, isolated ridges and knobs of fine-grained sediment can be observed in association with the moraine. These features are interpreted as ice-contact ridges consisting of till with pockets of sand or gravel and classified as having moderate, low or limited aggregate potential.

Most of the aggregate resources are concentrated within the Minnesota River Valley along the eastern border of the county (Figure 1). As the last ice age was ending, a large glacial lake formed in western Minnesota and Canada. With a surface area of 280,000 square kilometers (110,000 square miles) at a depth of more than 120 meters or 395 feet deep, the lake was larger than all the Great Lakes combined. About 13,500 years ago, the southern margin of the lake breached near Browns Valley, Minnesota, forming Glacial River Warren. The catastrophic flow eroded a valley up to 5 miles wide at its headwaters, which flowed southeast to Mankato then turned northeast to the Twin Cities. Glacial River Warren then deposited thick sequences of sand and gravel (60+ feet), as terraces, outwash bars, and channels. The quality and overall classification of these deposits are higher due to the incorporation of older, more competent sediments as the glacial river eroded its valley.

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 terrace; outwash channel; outwash bar	Alluvial Plain; alluvial valley; colluvial feature; ice contact feature; outwash channel; outwash terrace	Alluvial terrace; alluvial valley; colluvial feature; ice contact feature; outwash channel; outwash terrace	Alluvial terrace; alluvial valley; collapse feature; collusial feature; ground moraine; ice contact feature; outwash channel; outwash terrace; stagnation feature; tunnel valley
Predominant Sediment Description	Gravel and sand to silt, sand, gravel	Sand and gravel, sand, and till with pockets of sand or gravel	Till with pockets of sand or gravel, silty sand and gravel	Till, clay, silt, sand, organics, gravel
Probability [2]	Moderately high to very high	Moderately low to high	Low to moderate	Very low to moderate
Sand and Gravel Thickness (ft)	0-60+	0-45+	0-15+	0-10+
Overburden[3] Thickness (ft)	0-10+	0-20+	0-50+	0-90+
Sand and Gravel Deposit Size (areal extent[4])	Moderate to very large (10-30+ acres)	Moderately small to very large (5-30+ acres)	Small to moderately large (3-20 acres)	Very small to small (<3-5 acres)
Sand and Gravel Textural Characteristics[5]	Moderate to very good	Moderately poor to good	Poor to moderate	Very poor to moderate
Sand and Gravel Quality[6]	Moderate to very high	Moderately low to moderately high	Low to moderate	Very low to moderate

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.

REFERENCES

Anderson, H.E., 2003, Aggregate Resources and Surficial Geology, Renville County, Minnesota. Report 363, Plate A and B. Minnesota Department of Natural Resources, Division of Lands and Minerals, Scale 1:100,000 with digital data. https://files.dnr.state.mn.us/lands_minerals/rc_plate/A.pdf

Colgan, P.M., Mickelson, D.M., and Cutler, P.M., 2003, Ice-Marginal Terrestrial Landsystems: Southern Laurentide Ice Sheet Margin, Chapter 6. Retrieved from: https://www.gvsu.edu/cms4/asset/88606F7E-E51E-C373-3EAD7C0ADF849C3A/colgan_2003.pdf

Ellingson, J.B., 2000, Significant Aggregate Resource Deposits, Aggregate Resources and Surficial Geology, Nicollet County, Minnesota, Report 343, Plate II and III. Minnesota Department of Natural Resources, Division of Lands and Minerals, Scale 1:100,000 with digital data. https://www.dnr.state.mn.us/lands_minerals/aggregate_maps/completed/nicollet.html

Lusardi, B.A., Runkel, A.C., and Meyer, G.N., 2011, Geologic Atlas of Sibley County, Minnesota [Part A]. Minnesota Geological Survey. Retrieved from the University of Minnesota Digital Conservancy. https://hdl.handle.net/11299/116056

Ojakangas, R.W., and Matsch C.L., 1982, Minnesota's Geology. University of Minnesota Press

Patterson, Carrie J., 1997, RI-47 Contributions to the Quaternary Geology of Southwestern Minnesota. Minnesota Geological Survey. Retrieved from the University of Minnesota Digital Conservancy, https://hdl.handle.net/11299/60826

Sims, P.K., and Morey, G.B., 1972. Geology of Minnesota: A Centennial Volume. Minnesota Geological Survey. Retrieved from the University of Minnesota Digital Conservancy, https://hdl.handle.net/11299/57318

Plate A, DNR Report 410
Aggregate Resource Potential in Sibley 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

Printed Map Scale 1:100,000

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

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.