AGGREGATE RESOURCES

SAND & GRAVEL *and* CRUSHED STONE POTENTIAL

REDWOOD COUNTY , MN

Produced by the Aggregate Resource Mapping Program
Minnesota Department of Natural Resources Division of Lands and Minerals
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DEPARTMENT OF NATURAL RESOURCES

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PURPOSE

The purpose of this project is to identify and classify potential construction aggregate resources (sand and gravel as well as crushed-stone) in Redwood 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

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 Redwood County, there are 2,215 wells with defined locations (Figure 1), and an additional 394 unlocated wells approximately placed within the county boundary, as of February 2021. 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 398 QDI sites in Redwood 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 109 field observations were logged in Redwood 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.

Aggregate Data Compilation and Interpretation: Sand-and-gravel bearing landforms are typically created by glacial meltwater and non-glacial streams and lakes. Outwash channels, 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.

Crushed-stone potential is based on interpreting existing geologic data, MnDOT Specification for Class A Aggregate (MnDOT 3139.2 A2a), and geologic observations of bedrock made in the field. Depth to bedrock and bedrock type were the two main factors considered when analyzing potential for crushed stone resources. Information used to create crushed stone potential include C-36, Geologic Atlas of Redwood County, Minnesota, field observations, CWI, and LiDAR. Areas currently covered by water and/or wetlands were not included in the crushed stone potential database, and appear as having limited potential.

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.

IDENTIFIED AGGREGATE RESOURCES

Several sources of information were used to identify aggregate pit and quarry locations including topographic maps, aerial photographs, soil surveys, MnDOT files, fieldwork, gravel operators, and other sources. Pits and quarries were inventoried and include a total of 322 gravel pits, 2 sand pits, 4 clay pits, 23 bedrock quarries, 1 metallic mine, and 24 borrow pits. Pits and quarries range in size from less than 1 acre to greater than 50 acres and may be active, inactive, or reclaimed. The sand and gravel or crushed-stone quality vary from site to site. Pits and quarries 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 and quarries was estimated using historic aerial photographs.

Very Small	Small	Medium	Large
under 1 acre	1-5 acres	5-15 acres	over 15 acres

Gravel Pits: Includes sites that have been or are currently being mined.
n = 142 *n = 74* *n = 41* *n = 9*

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 *n = 14* *n = 17* *n = 19*

Sand Pits: Sites that contain a significant amount of sand with little to no gravel.
n = 2

Clay Pits: Sites that have been or are currently being mined for clay and/or kaolin clay.
n = 4

Bedrock Quarries: Sites that were or are currently being mined for bedrock. Either for crushed or dimension stone.
n = 23

Metallic Mines: Sites that were or are currently being mined for metals.
n = 1

OTHER FEATURES

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 = 24

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.
n = 28

FIELD OBSERVATIONS

- Sand and Gravel
- Sand
- Till
- Silt/Clay
- Bedrock

A total of 109 field observations were logged throughout the course of the project. Surficial geologic sediment, glacial stratigraphy, and bedrock 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 and quarries, or that only contained topsoil, are not shown on the map.

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

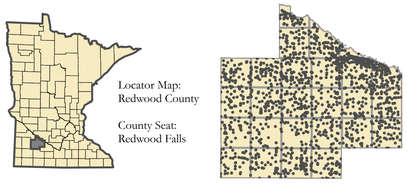

Figure 1: The distribution of the 2,215 wells (as of 02/21) located within Redwood County that were referenced to create this map. There are an additional 394 unlocated wells also referenced for this map though not shown here. Unlocated wells have not been field verified by the MGS for location accuracy.

AGGREGATE POTENTIAL

Aggregate potential is an assessment of the relative probability that a sand and gravel deposit or crushed stone resources 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 "Aggregate 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 aggregate resources 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 alluvial valleys, outwash channels, outwash features, and outwash terraces. Predominant sediment typically consists of gravel with sand to sand with 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 0-35+ feet with 0-5+ 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 moderately good to very good. The quality[6] is moderate to high, relative to other sand and gravel resources within Redwood County.

Mp Moderate Sand and Gravel Potential: Includes landforms such alluvial valleys, outwash features, outwash channels, outwash terraces, ice contact features, and ground moraine. Predominant sediment ranges from sand with minor 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 0-25+ feet with 0-10+ 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 moderately low to high relative to other sand and gravel resources within Redwood 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), very thin layers of sand and gravel, or have significant overburden. Nonsignificant potential regions also coincide where bedrock is at or near the surface, or these units may include aggregate deposits that are too small to map.

Lp Low Sand and Gravel Potential: Includes landforms such as alluvial valleys, alluvial fans, colluvium, outwash features, outwash channels, outwash terraces, ice contact features, ground moraine, and modified ground moraine. Predominant sediment varies and can include sandy till, sand, silt, and sand with minor gravel. The probability that a significant sand and gravel resource exists within this unit is low to moderate. The thickness of the deposits is typically 0-15+ feet with overburden thickness ranging from 0-35+ feet. The sand and gravel resources occurring in this unit are very small to very large in areal extent and textural characteristics are poor to moderately good. The quality ranges from low to moderately high relative to other sand and gravel resources within Redwood County.

Ltd Limited Sand and Gravel Potential: Includes landforms such alluvial valleys, alluvial fans, outwash features, outwash channels, outwash terraces, ice contact features, moraines, ground moraine, modified ground moraine, and bedrock outcrops. The deposits of this unit contain all or one of the following: clay with boulders (till), clay, silt, sand, and 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 0-10+ feet with overburden thickness ranging from 0-50+ feet. The sand and gravel resources occurring in this unit are very small to moderately small 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 Redwood 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.

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	Alluvial Valley; outwash channel; outwash feature; and outwash terrace	Alluvial valley; outwash feature; outwash channel; outwash terrace; ice contact feature; and ground moraine	Alluvial valley; alluvial fan; colluvium; outwash feature; outwash channel; outwash terrace; ice contact feature; ground moraine; and modified ground moraine	Alluvial valley; alluvial fan; outwash feature; outwash channel; outwash terrace; ice contact feature; ground moraine; moraine; modified ground moraine; and bedrock outcrop
Predominant Sediment Description	Gravel with sand to sand with gravel	Sand and gravel to sand with minor gravel	Sand with minor gravel, sand, silt, and sandy till	Till, clay, silt, sand, and organics
Probability [2]	Moderately high to very high	Moderate to high	Low to moderate	Very low to moderately low
Sand and Gravel Thickness (ft)	0-35+	0-25+	0-15+	0-10+
Overburden[3] Thickness (ft)	0-5+	0-10+	0-35+	0-50+
Sand and Gravel Deposit Size (areal extent[4])	Moderate to very large (10-30+ acres)	Small to very large (3-30+ acres)	Very small to very large (<3-30 acres)	Very small to moderately small (<3-10 acres)
Sand and Gravel Textural Characteristics[5]	Moderately good to very good	Moderate to good	Poor to moderately good	Very poor to moderately poor
Sand and Gravel Quality[6]	Moderate to high	Moderately low to high	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.

BASEMAP SYMBOLS

Transportation Features
- 12 MN State Highways
- 51 County Highways and Roads
- Township and other Roads
- Municipal Roads
- Railroad Tracks

Bounding Features
- County
- PLS Townships
- PLS Sections

County Seat and Cities
- County Seat
- Cities

Physical Features
- Lakes
- Rivers and Streams
- Ditches

REFERENCES:

Anderson, H.E., 2003, Aggregate Resources, Sand and Gravel Resources, Renville County, Minnesota. Report 363, Plate A. 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/re_plateA.pdf

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RESULTS

Overall, sand and gravel resources are scarce in Redwood County. Deposits are primarily associated with outwash channels and ice contact features located throughout the county, and are related to multiple advances and retreats of the Des Moines Lobe during the last glaciation (>10,000 year ago). The ice lobe flowed southeast, along the current Minnesota River Valley, within Redwood County, before curving to the south. The change in directional flow of the lobe is inferred from many small parallel ridges within the southern portion of the county. These ridges were likely formed as sediment filled crevasses within the ice and were subsequently deposited as the ice melted. Generally, these features have a coarser texture than the surrounding till and are poorly sorted, but may contain pockets of sorted sediment. Other ice contact features within the county include eskers, formed from water flowing within the ice, sorting material in branched or sinuous patterns. Eskers are generally composed of sorted material and form parallel to ice flow. The majority of these features can be found in the central part of the county, around Wabasso and Clements (Figure 2).

Multiple large outwash channels flowing east to southeast are present within Redwood County. These channels likely formed from large amounts of meltwater as the Des Moines lobe retreated. However, the deep channel currently occupied by the Minnesota River, was significantly down cut by Glacial River Warren ~11,500 years ago, as massive amounts of water drained from Glacial Lake Agassiz, a large glacial lake to the northwest. The scouring and down cutting of this massive river exposed portions of bedrock within the river valley and deposited terrace and outwash sediments to the northwest and southeast of Redwood Falls. The majority of aggregate deposits exist in the large outwash channels currently occupied by the Redwood and Cottonwood rivers, around the Vesta and Lamberton/Sanborn areas, respectively (Figure 2). Portions of these outwash valleys are covered with thick sequences of floodplain deposits, making the potential for aggregate resources lower.

Bedrock resources are abundant in the northern portion of the county with outcrops primarily located within the Minnesota River Valley. However, there is evidence of two small bedrock quarries outside of the river valley, one southwest of Vesta (Inset 1) and the other southwest of Seaforth (Inset 2). Bedrock exposures consist mainly of the Sacred Heart Granite and the Morton Gniess (Setterholm et al, 2016). These resources are the highest and best quality aggregates in the state and are regionally significant sources of aggregate because they meet rigorous specifications for high-performing asphalt and concrete mix designs. In general, bedrock in Redwood County is labeled as either granite or granite/gneiss. Depth of bedrock, for the purposes of aggregate resource mapping, is defined as depth to competent bedrock. Weathered bedrock and kaolin clay is considered part of the overburden thickness in this assessment.

CRUSHED STONE POTENTIAL

SIGNIFICANT CRUSHED STONE POTENTIAL: Includes high and moderate potential map units. The following bedrock lithologic types are interpreted to have significant potential for crushed stone: granite rock and/or granitic gneiss. These bedrock types generally have physical characteristics suitable for producing Class A aggregates, inferred to be thick (greater than 100 feet), and covered by less than 25 feet of overburden. Most of the quarries located within the county are active or inactive dimension-stone or crushed-stone quarries. Dimension-stone quarries are located within rock types that are also suitable for crushed stone aggregate and, for the purpose of this project, are considered as identified crushed-stone resources.

- High Crushed-Stone Potential: Includes granites and/or granitic gneiss intrusive rock exposed at the land surface or buried by less than 10 feet of overburden.
- Moderate Crushed-Stone Potential: Includes granites and/or granitic gneiss intrusive rock buried beneath 10 to 25 feet of overburden.

NONSIGNIFICANT CRUSHED STONE POTENTIAL: Includes low and limited potential map units. Nonsignificant is a term used in this assessment to define mapped areas that contain any of the following conditions: lower quality bedrock units, high quality bedrock units with thick overburden (>25 feet), or areas where higher potential may exist but cannot be verified due to a lack of substantiating data which facilitate a lower probability rating.

- Low Crushed-Stone Potential: Includes granites and/or granitic gneiss intrusive rock buried by 25 to 50 feet of overburden. Low potential also includes areas with little supporting data to substantiate a higher potential classification.
- Limited Crushed-Stone Potential: Includes all rock types with >50 feet of overburden.

Crushed stone potential thematic insets
Near-surface bedrock deposits are depicted at 1:100,000 scale. Bedrock quarries and the county's one metallic mine site are shown on this breakout map along with the two outlying inset maps at lower right.

Crushed stone inset 1:
Outlying crushed stone potential
Vesta Township
T112 R38 S30

Crushed stone inset 2:
Outlying crushed stone potential
Granite Rock Township
T111 R38 S12

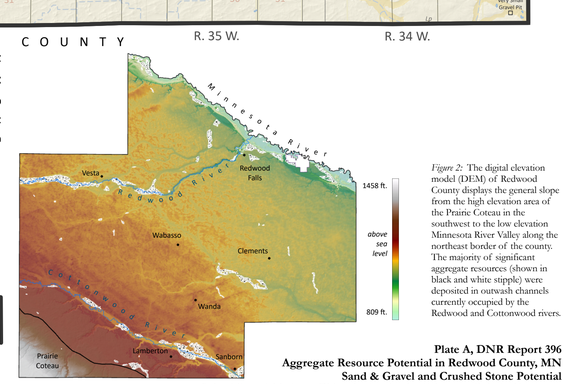

Figure 2: The digital elevation model (DEM) of Redwood County displays the general slope from the high elevation area of the Prairie Coteau in the southwest to the low elevation Minnesota River Valley along the northeast border of the county. The majority of significant aggregate resources (shown in black and white stipple) were deposited in outwash channels currently occupied by the Redwood and Cottonwood rivers.

Plate A, DNR Report 396
Aggregate Resource Potential in Redwood County, MN
Sand & Gravel and Crushed Stone 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
Sand & Gravel and Crushed Stone Potential maps
Based on a 1:50,000 scale MN DNR resource assessment

0 0.5 1 2 3 4 5 6 7 8 Miles

0 0.5 1 2 3 4 5 6 7 8 9 10 Kilometers