AGGREGATE RESOURCES
SAND AND GRAVEL POTENTIAL
Olmsted County, MN

Produced by the Aggregate Resource Mapping Program
Division of Lands and Minerals

Minnesota Department of Natural Resources
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St. Paul, Minnesota - May 2010

Map Scale 1 : 63,360

Sand and Gravel Potential Mapped at 1:50,000

INTRODUCTION: The purpose of this project is to identify and classify potential sand and gravel construction aggregate resources (sand and/or gravel) in Olmsted County, Minnesota. Having locally available, low-cost construction aggregates is fundamental to building and maintaining public infrastructure and private sector development. This information is intended to assist local planners and others in making 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 the resource. To accomplish these goals, two plates and a comprehensive CD-ROM data set were created. Plate A shows potential sand and gravel resources while Plate B shows potential crushed stone aggregate resources.

There are several factors related to aggregate resources that affect their availability, usability, and supply including the transportation costs, the quality of the material, and land use conflicts. Aggregate materials are high-bulk, low-value commodities, which means transportation costs can account for a considerable amount of the delivered price. Lower construction costs for public and private projects can be achieved by using local aggregate supplies. Aggregate products, such as concrete and asphalt, have specific quality requirements depending on the end use so aggregate deposits must be evaluated in relation to quality standards. At the same time, land-use conflicts between aggregate mining and urban development are becoming more common. Land-use conflicts can be created by cities expanding into adjacent rural areas, as well as new developments covering aggregate resources or occurring adjacent to aggregate resources. As a result, the distance from the aggregate source to its consumers is increasing. Due to the increased use of aggregate material in and around urban areas, aggregate resources are being rapidly depleted.

With these and other issues in mind, the 1984 Minnesota Legislature passed a law (Minn. Stat, sec 84.94, Aggregate Planning and Protection) that directs the Minnesota Department of Natural Resources, in cooperation with the Minnesota Geological Survey and the Minnesota Department of Transportation, to identify and classify potential aggregate resources. When the mapping is completed, the information is provided to local governments and the public. Since this is a reconnaissance-level survey of aggregate resources, site-specific evaluations are still necessary prior to any development of the resource, especially in regard 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: The method used for aggregate mapping integrates traditional geologic mapping techniques, such as field observations and drilling, with Geographic Information Systems (GIS). Sand and gravel mapping is accomplished in several phases: 1) preliminary information gathering consisting of compiling, interpreting, and summarizing data, 2) fieldwork and ground verification of data, and 3) aggregate resource classification.

Data Gathering: The first step in mapping is conducting a literature and data search to obtain a basic understanding of the regional geology. Some of the data used are aerial photographs, topographic maps, digital elevation models, shaded relief maps, subsurface data, gravel pit and quarry data, surficial and bedrock geology, wetlands, lakes, streams, vegetation, soils, land use, as well as several datasets of background information, including roads, railroads, PLSS township-range-section boundaries, and others.

The County Well Index (CWI) database and Aggregate Source Information System (ASIS) are the most used subsurface geologic data sets for constructing a sand and gravel resource map. The CWI is an online database (www.health.state.mn.us/divs/eh/cwi) developed and maintained by the Minnesota Geological Survey and the Minnesota Department of Health that contains basic information for over 300,000 drilled wells throughout Minnesota. Approximately 4608 of these wells are located in Olmsted County and the majority of these wells contain geologic descriptions. ASIS is a data set compiled and maintained by the Minnesota Department of Transportation (Mn/DOT). ASIS consists of aggregate quality data, particle size distribution data, and pit sheets displaying the descriptions of shallow test-hole logs and diagrams of test-hole locations. Subsurface information is important to identifying buried sand and gravel deposits, determining the depth to bedrock, and to identifying the type of bedrock encountered.

Field Work: Several weeks are spent driving every accessible road in the county looking for outcrops and exposures of geologic materials, as well as drilling test holes to further define aggregate deposits. Sediments exposed in road cuts, stream exposures, foundation excavations, judicial ditches, construction projects, trenches (cable, pipe, tiling), and even animal burrows, offer observation sites where surface materials and glacial stratigraphy can be examined. A total of 1695 field observations were logged in Olmsted County. Field work also includes documenting sediment in existing gravel pits, which can provide additional quality data as well as views of stratigraphic cross-sections that help the geologist interpret how the sediment was deposited.

Aggregate Data Compilation and Interpretation: Aggregate resources are identified and classified using a glacial mapping technique known as the landsystems approach. This technique relies on the principle that depositional glacial landforms contain a predictable range of sediments, from sorted sand and gravel, to silts, clays, or unsorted materials. In addition to the landsystems approach, other sediment characteristics, such as color, texture, shape, size, size trends, and patterns help determine how the material was deposited. For example, a particular type of vegetation might prefer well drained soils, such as sand and gravel, and have a distinctive texture, tone, or pattern in aerial photographs. Aggregate bearing features such as eskers, terraces, outwash channels, and other meltwater features can be located using this technique.

Using GIS software, aggregate resources are delineated by layering multiple datasets. Topographic maps (USGS 1:24,000), digital elevation models, shaded relief maps, aerial photographs (multiple sets at varying scales), subsurface data, field observations, location and distribution of existing pits, and soils are used to identify the sand and gravel bearing features. Sand and gravel resources are mapped at a scale of 1:50,000. In order to be consistent with Plate B, Crushed Stone Resources of Olmsted County, the cartographic map of sand and gravel resources is being displayed at a scale of 1:63,360.

AGGREGATE POTENTIAL: The purpose of this study is to provide government agencies and the public with an overview of the distribution of aggregate resources in Olmsted County. This is accomplished by dividing Olmsted County into map units that correlate with the sand and gravel potential characteristics in Table 1. In this study we define sand and gravel potential as an estimation of the probability that an aggregate deposit exists within a given mapping polygon. Over time, the way in which we measure the thickness or quality of an aggregate resource remains relatively constant, but economic and environmental criteria vary through time and from place to place. Consequently, the emphasis of this investigation is placed upon interpretation of geologic evidence at the reconnaissance level and the size of the deposit, rather than upon economic or cultural considerations. This assessment does not imply that economic aggregate deposits exist everywhere within a map unit designated as "Potential Sand and Gravel Resources." Rather, that within such a polygon, geologic processes could have created aggregate deposits at specific sites or as part of landforms within the polygon. While site-specific factors such as ownership, zoning, sensitive or protected areas, and distance to markets contribute to the feasibility of a mine or quarry, they are not considered in this reconnaissance-level study.

SIGNIFICANT POTENTIAL FOR SAND AND GRAVEL RESOURCES: Geologic units that are inferred to contain sand and gravel. These units exhibit geologic characteristics that typically produce sand and gravel resources. Existing gravel pits and Mn/DOT aggregate sources within these units are considered to be identified, or known resources, that increase the level of confidence for a mapping unit.

Hp **High Potential for Sand and Gravel Resources:** Glaciofluvial outwash channels and terrace deposits. Predominant sediment consists typically of sand and gravel to gravel with sand. The probability[1] that a potential sand and gravel resource exists within any mapping unit is moderately high to very high. Thickness of the deposits ranges from 10 to 50+ feet and overburden thickness is less than 10 feet. These resources are moderately large to very large in areal extent[2] and the textural characteristics[3] are moderately good to very good. The quality[4] is typically moderately high to high relative to other sand and gravel resources within Olmsted County.

Mp **Moderate Potential for Sand and Gravel Resources:** Glaciofluvial outwash channels and terrace deposits. Sand and gravel are also found in uplands throughout western Olmsted County. These deposits are interpreted to be glaciofluvial deposits from older glacial advances that have since been covered by sediment of younger glacial advances. Predominant sediment textures range from sand with gravel to sand and gravel. The probability that a potential sand and gravel resource exists within this unit is moderate to moderately high. Deposit thickness ranges from 5 to 50+ feet with less than 20 feet of overburden. These resources are moderately small to very large in size and the textural characteristics are moderate to good. The quality is typically moderate to moderately high.

NONSIGNIFICANT POTENTIAL FOR SAND AND GRAVEL RESOURCES: 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, which are not consistent with significant aggregate resources. These units may include aggregate resources that are too small to map (<10 acres).

Lp **Low Potential for Sand and Gravel Resources:** Glaciofluvial outwash channels and terraces, and upland sand and gravel deposits. Sediments are variable and can include sand, silty sand and gravel, and sand with gravel. The probability that a potential resource exists within this unit is low to moderately low. Thickness of the deposits ranges from 5 to 40+ feet with overburden thickness ranging from 0 to 40+ feet. These resources are moderately small to very large in areal extent and the textural characteristics are moderately poor to moderately good. The quality ranges from very low to moderate.

Ltd **Limited Potential for Sand and Gravel Resources:** Units that include glacial features such as colluvial slopes, till plains, fluvial channels, and alluvial features such as overbank deposits. These units contain one or more of the following: clay with gravel, silt, sand, and/or gravel. The probability that a significant sand and gravel resource exists within this unit is very low to moderately low. The thickness of these deposits ranges from 0 to 15+ feet with overburden thickness ranging from 0 to 100+ feet. The aggregate resources occurring in these units are very small to moderate in areal extent. The textural characteristics are very poor to moderately poor and the quality ranges from very low to moderate.

DEPLETED SAND AND GRAVEL RESOURCES

Depleted Mining Lands: This is an informal designation for the purpose of illustrating the extent of depletion. Depletion information was gathered from aerial photographs and verbal communication for areas showing indication(s) that sand and gravel resources are significantly depleted. For Olmsted County, delineated areas are 20 acres or larger. Indicators include reclamation of mine lands, secondary use of mine lands, and/or reclaimed extent of mine lands bounded by other land uses. Additional resources may exist at depth. Areas labeled as depleted are limited to mine lands where aggregate resources have been partially or entirely extracted and do not include development (i.e. residential or commercial) over resources that have not been mined.

IDENTIFIED SAND AND GRAVEL RESOURCES: Sites where sand and gravel have been or are currently being mined. Sand and gravel mine locations have been gathered from several different sources, including topographic maps, aerial photographs, county records, county highway department maps, soil surveys, Mn/DOT files, fieldwork, gravel operators, and other miscellaneous sources. The gravel mines range in size from less than 1 acre to greater than 50 acres and may be active, inactive, depleted, or reclaimed. The aggregate quality varies. Point size indicates relative areal extent of pit.

Small	Medium	Large	Size in acres
< 5	5-15	> 15	
□	□	□	**Gravel Pits:** Sites that have been or are currently being mined.
⊠	⊠	⊠	**Mn/DOT Identified Gravel Sites:** Sites were identified by Mn/DOT as part of the Aggregate Source Information System (ASIS). Mines and quarries with this designation have been, or are currently being mined. Some sites are located on private property and leases are not necessarily active. Some locations were modified to better correlate to present gravel pit boundaries.
⊡	⊡	⊡	**Gravel Pits Above Crushed Stone Quarries:** Sites that have been, or are currently, being mined. These sites have sand and gravel deposited atop limestone or dolostone bedrock.
⊠	⊠	⊠	**Mn/DOT Identified Gravel Sites Above Crushed Stone Sites:** Sites were identified by Mn/DOT as part of the Aggregate Source Information System (ASIS). These sites contain sand and gravel deposits on top of limestone or dolostone bedrock. Pit-quarries with this designation have been or are currently being mined. Some sites are located on private property and leases are not necessarily active.

GEOLOGIC DATA SOURCES FOR MAP UNIT INTERPRETATION: Field observations and the County Well Index (CWI) database were data sources used in the interpretation of aggregate potential.

- **Field Observations:** A total of 1695 field observations, including 207 gravel pits and quarries, were logged during the fall of 2003 and spring of 2004. Surficial geologic sediment, glacial stratigraphy, and bedrock formations observed in road cuts, stream exposures, foundation excavations, judicial ditches, construction projects, trenches (cable, pipe, tiling), and even animal burrows.
- **County Well Index Locations:** The County Well Index (CWI) is an online database maintained by the Minnesota Geological Survey and the Minnesota Department of Health. The database contains approximately 4063 wells (as of 2007) located in Olmsted County and a majority contain geologic descriptions.

Map Scale 1 : 63,360

1 inch equals approximately 1 mile

0 1 2 3 4 Miles

0 1 2 3 4 5 6 Kilometers

1 centimeter equals approximately 0.63 kilometers

This map was prepared from publicly available information. Every reasonable effort has been made to ensure the accuracy of the factual data on which this map interpretation is based. However, the Department of Natural Resources does not warrant the accuracy, completeness, or any implied uses of these data. Users may wish to verify critical information; sources include both the references here and information on file in the offices of the Minnesota Geological Survey and the Minnesota Department of Natural Resources. Every effort has been made to ensure the interpretation shown conforms to sound geologic and cartographic principles. This map should not be used to establish legal title, boundaries, or locations of improvements.

Table 1: Classification of Sand and Gravel Potential

Characteristics	SIGNIFICANT RESOURCES		NONSIGNIFICANT[5] RESOURCES	
	High Potential	Moderate Potential	Low Potential	Limited Potential
Surficial Geology Features	Glaciofluvial outwash channels and terrace deposits	Glaciofluvial outwash channels and terrace deposits; upland sand and gravel deposits	Glaciofluvial outwash channels and terrace deposits; upland sand and gravel deposits	Colluvial slopes, till plains, fluvial channels, overbank deposits, and alluvial features
Predominant Sediment Description	Sand and gravel to gravel with sand	Sand with gravel to sand and gravel	Sand to sand with gravel	Clay/silt/sand/ sand and gravel
Probability[1]	Moderately high to very high	Moderate to moderately high	Moderately low to moderate	Very low to moderately low
Sand and Gravel Thickness (in feet)	10-50+	5-50+	5-40+	0-15+
Overburden Thickness (in feet)	0-10	0-20	0-40+	0-100+
Sand and Gravel Deposit Size (areal extext[2])	Moderately large to very large (30-50+ acres)	Moderately small to very large (10-50+ acres)	Moderately small to very large (5-50+ acres)	Very small to moderate (0-10+ acres)
Sand and Gravel Textural Characteristics[3]	Moderately good to very good	Moderate to good	Moderately poor to moderately good	Very poor to moderately poor
Sand and Gravel Quality[4]	Moderately high to high	Moderate to moderately high	Moderately low to moderate	Very low to moderate

Classification of Sand and Gravel Potential

Sand and gravel potential is divided into four categories based on the type of geological feature, probability (certainty), sand and gravel thickness, overburden thickness, deposit size (areal extent), textural characteristics (sieve analysis), quality (soundness and durability), and the sediment description as observed in the field (Table 1). For example, a geologic feature, such as an outwash channel, typically contains sand and gravel. If the feature has gravel pits located within its boundaries, sand and gravel were observed at or near the surface, and sand and gravel were encountered in surrounding water wells, the feature has a high probability of containing aggregate. The probability, which is a reflection of the amount and quality of data available, is a major determining factor in identifying and delineating aggregate potential. Areal extent indicates how many acres a resource covers. Good texture indicates that the sediment contains a high percentage of gravel within a resource. The aggregate quality laboratory test results used in this investigation are compiled from Mn/DOT pit sheets. Thickness and overburden are determined from field observations and well information. Therefore, if a deposit has a thickness greater than 10 feet, overburden thickness of less than 10 feet, has high quality and good texture, then the resource is classified as high potential.

The areas defined as nonsignificant sand and gravel resources (low and limited potential) do not meet the above-mentioned criteria. The resources may not exist, are not identified in data sources (very low probability), are too small in areal extent, are too thin, have too thick of overburden, contain significantly more sand than gravel, or do not meet quality specifications.

Footnotes associated with potential sand and gravel resources seen throughout map text and Table 1

[1]*Probability*: The degree of certainty that aggregate exists within a mapping unit largely defined by the amount of available information.

[2]*Areal Extent*: The size, horizontal extent, or distribution of a unit (e.g. area in acres). This attribute does not necessarily reflect the size of an individual map unit but the size of a deposit found within that map unit.

[3]*Textural Characteristics*: Particle size distribution defined as the percent of gravel or sand versus silt or clay (e.g. sieve analysis).

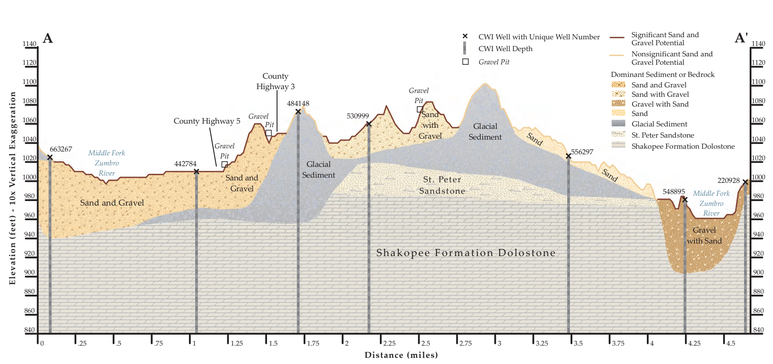
[4]*Quality*: The physical characteristics of the material, such as soundness (e.g. magnesium sulfate test), durability (Los Angeles rattler test), and percent of deleterious rock types such as shale, iron oxide, and unsound chert.

[5]*Nonsignificant*: Term representing aggregate resources that do not meet the criteria for high or moderate aggregate potential. This classification is based on the four criteria listed above as well as overburden thickness and is a relative classification that will change from one county or geographic area to another.

Figure 1: Dominant Sediment Geologic Cross-Section Relative to Sand and Gravel Potential

The cross-section in Figure 1 illustrates the distribution of sand and gravel resources in the very northwest corner of Olmsted County as shown along the line labeled A-A' on Plate A. The interpreted sand and gravel resources are highlighted by the color of the land surface line. The reddish-brown color represents significant sand and gravel resources beneath the line while the yellow parts of the line represent areas of nonsignificant sand and gravel resources beneath the line. The areas with the highest potential for sand and gravel resources along this line are meltwater deposits associated with a past glacial period. The remnant of this glacial meltwater valley is now occupied by the Middle Fork of the Zumbro River.

The cross-section represents nearly 5 miles of surficial deposits in Olmsted County, but there are only 7 wells located along this line. Consequently, the distribution of interpreted sand and gravel resources is only partially based on the geologic information from the 7 located wells. The interpreted potential of the map units along this line are also based on the presence of gravel pits, field observations, landform interpretation, soil data, etc. The more we must rely on interpreted forms of data to delineate sand and gravel map units, such as landform interpretation and soil morphology, the lower the probability assigned to each map unit. The resulting distribution of map units below the surface is more problematic when there are fewer subsurface control points from well data, meaning that the cross-section is only an estimate of how the sediments are distributed beneath the land surface. This emphasizes the need for more site-specific studies when considering the location of a sand and gravel operation. The CWI wells used in this interpretation are indicated in the cross-section including the CWI unique well number listed at the top of each well point.



General References

Andersen, H.E., 2002, Aggregate Resources, Dodge County, Minnesota Department of Natural Resources, Division of Lands and Minerals, Report 357, Plates I, II, III, and IV.

Hobbs, H.C., 1988, Surficial geology of Olmsted County, *in* Geologic atlas Olmsted County, Minnesota. (N.H. Balaban, ed.), Minnesota Geological Survey County Atlas Series Atlas C-3, Plate 3, scale 1:100,000.

Hobbs, H.C., Goebel, J.E., 1982, Geologic map of Minnesota, Quaternary geology, Minnesota Geological Survey State Map Series S-1, scale 1:500,000.

Kuhns, M.J.P., 1988, Geologic resources of Olmsted County, *in* Geologic atlas Olmsted County, Minnesota. (N.H. Balaban, ed.), Minnesota Geological Survey County Atlas Series Atlas C-3, Plate 9, scale 1:100,000.

Mapping Sources

Aerial photograph interpretation, field work, and delineation of mapping units by Steve Kostka, Jon Ellingson, & Ross Hoffman, 2003-2008, Aggregate Resource Mapping Program, Division of Lands and Minerals, Minnesota Department of Natural Resources. Source information included aerial photographs from NAPP (National Aerial Photography Program), 1991-1992, 9" x 9" color infrared photos at 1:40,000; 1991 DOQs (Digital Orthophoto Quadrangles) at 1:12,000 from USGS (United States Geological Survey); FSA (Farm Services Administration) Color Orthophotos collected from the following years; 2003-04, 2005, 2006, 2008; FSA CIR (Color Infrared) Imagery collected in 2008; DRGs (Digital Raster Graphics) at 1:24,000 from USGS; 7.5-minute USGS topographic quadrangles at 1:24,000 (dating from 1964-1992);the Soil Survey Geographic Database for Olmsted County, published November 20th, 2006 from the USDA-NRCS (United States Department of Agriculture - Natural Resource Conservation Service); USGS (United State Geological Survey) National Elevation Dataset's 1-arc second (30m) DEM, and where available 2-foot contour elevation data obtained from Olmsted County and then converted to 1.9-arc second (3M) DEM; CWI (County Well Index) database locations from the Minnesota Geological Survey, downloaded in 2004; and Bedrock Outcrops from the Minnesota Geologic Survey, obtained in 2005.

Base Map Data Sources:

Lakes, rivers, and streams from NWI (National Wetland Inventory), Mn/DOT (Minnesota Department of Transportation) Base map, MN DNR 24K Streams, compiled at 1:24,000 from aerial photography (1979-1988) and USGS quadrangle maps (1980-1990).

PLS (Public Land Survey) townships and sections layers extracted from PLS Project, 2001, MN DNR, Division of Lands and Minerals.

Populated places were derived from the GNIS (Geographic Name Information System) by pulling out the features that were coded as populated places. A selected subset of these was used for this map, 2003.

County boundaries from MN 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, 1993.

Roads from Mn/DOT Base map, Fall of 2006.

Railroad Tracks from Mn/DOT Base map, 2001.

Contour Intervals created by smoothing the 30 Meter Digital Elevation Model (see topographic relief) and then applying ArcGIS 9.3 Spatial Analyst to create the contours.

Topographic relief or hillshade from a 3-meter digital elevation models (DEM) geoprocessed by the Minnesota Department of Natural Resources in 2009 from LiDAR data flown in November, 2008 by Aero-Metrics.

GIS and **Cartography** by Kevin J. Hanson, MN DNR, Division of Lands and Minerals. Copy edited by Nick Kroska, MN DNR Division of Waters.

Transportation Features
- 90 Interstate Highway
- 52 US Highway
- 30 MN Highway
- 25 County Highway
- 111 County Road
- Township & Other Roads
- Municipal Roads
- Railroad Tracks

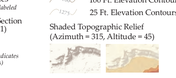
Bounding Features
- County Boundaries
- PLS Township Boundaries
- Section Boundaries *Sections 1,6,31, & 36 labeled*
- A A' Geologic Cross-Section Line (See Figure 1)

Populated Places
- Byron
- Genoa

(Size of font type indicates relative populations)

Physical Features
- *Lakes*
- *Rivers & Streams*
- 100 Ft. Elevation Contours
- 25 Ft. Elevation Contours

Shaded Topographic Relief (Azimuth = 315, Altitude = 45)



Products of this project include a CD/ROM of maps, data, and metadata in a digital format and the following maps:
Plate A, Report 375, Olmsted County Aggregate Resources, Sand and Gravel Potential & **Plate B, Report 375, Olmsted County Aggregate Resources, Crushed Stone Potential**