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MATERIALS SURVEY OF BROWN COUNTY

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## Table of Contents

Introduction	Page	1
Bedrock Geology	Page	2
Glacial Geology	Page	6
Materials Provinces	Page	9
Conclusions	Page	18
Selected Bibliography	Page	19
Appendices		
1. Drill hole logs	Page	20
2. Sand and gravel pits and quarries	Page	32
3. Natural exposures and road cuts	Page	42

## List of Illustrations

- Figure 1. Materials provinces of Brown County
- Figure 2. Bedrock formations of Brown County
- Figure 3. Glacial Geology of Brown County

## Materials Survey of Brown County

### Introduction

The purpose of this report is to give a general description of geologic materials in Brown County. The area adjacent to the Fox River Valley is emphasized. For convenience the county is divided into 17 provinces (fig. 1). They are defined by topography and the nature of the materials as seen in drill holes, natural exposures, road cuts, sand and gravel pits, and quarries. Each province is summarized in the text of the report. For details of the materials in various places refer to Appendix # 1 (drill holes), Appendix # 2 (sand and gravel pits, and quarries), and Appendix # 3 (natural exposures and road cut observations).

Each materials province presents unique problems in addition to acquisition of materials, such as those encountered in excavations and in the foundations for bridges and other structures. However, except for the included information on general topography and materials present, no attempt is made to discuss them.

The study is financed by funds from the State Highway Commission, under the auspices of the State Geological Survey. Field studies and preparation of this report were accomplished in the period from June 12, 1961 to September 2, 1961. All previous materials reports for the county, available drilling logs in the files of the Soils Laboratory of the State Highway Commission, and pertinent published literature (see selected bibliography) were examined. Mapping in the field and office was accomplished on topographic maps and aerial photographs. A Mobile Drill B-36 power auger was made available for one month by the State Highway Commission. No field assistants were provided.

## Bedrock Geology of Brown County

Brown County is underlain by northeast-southwest striking, and southeast dipping bedrock units which in order of their appearance from west to east (fig. 2) are the Galena-Platteville dolomite (known also as the Black River-Trenton), Cincinnati (Maquoketa or Richmond) shale, and Niagara dolomite. The age of the bedrock units becomes progressively younger from west to east across Brown County. A west to east cross section of the county would show the Galena-Platteville dolomite occupying the area from the Fox River westward; the Cincinnati shale overlying the Galena in a narrow belt in central Brown County; and the Niagara dolomite capping the older formations in eastern Brown County. Formations older than the Galena-Platteville dolomite are found in wells, and outcrop in Outagamie County.

Surface exposures and outcrops of the Galena-Platteville dolomite are found in the stream channel of the Fox River, along Duck Creek, in the stream bed of the Samisco River, and in other scattered exposures in creek beds. In most areas of its occurrence this formation is covered by a variable thickness of lake sediments and (or) glacial till. It dips southeast (south 70 degrees east) at a rate of 30-35 feet per mile (W.J. Drescher, 1953, p. 6). Variations in this general direction of dip are present locally. This formation has an unconformable surface upon which the overlying shale, when present, rests. When the shale is not present, the top of the Galena-Platteville, therefore, presents an irregular surface underlying the glacial and lake deposited materials. This irregularity of the bedrock surface is also partly due to the unequal glacial deformation and abrasion by moving ice. The Galena-Platteville has a thickness of 250 feet when the thickness has not been altered by erosion (W.J. Drescher, 1953, p. 10).

The Galena-Platteville dolomite (Middle Ordovician) is a light gray to blue gray dolomite containing irregular clayey laminae through the rock, and thin shale partings ranging from a few inches to fractions of an inch in thickness between beds from three inches up to three feet. The dolomite weathers to a buff colored, irregular surface. The rock is finely crystalline, impervious, and generally compact.

The boundaries of the Cincinnati shale are not specifically known because of the lack of exposures of the contact. The formation is overlain by a variable thickness of lake deposits and (or) glacial drift. This formation is poorly exposed because of its susceptibility to stream erosion, and because of its easy removal along the major axis of ice movement (Fox River Valley). An exposure near Holland, another northwest of Bellevue, and a third northeast of the City of Green Bay mark the general trend of this formation. The hill in the vicinity of Holland is a remnant of Cincinnati shale. The shale is unconformably overlain by the Niagara dolomite, but the contact between these two formations is generally obscured. It has a thickness of 325 feet (W.J. Brascher, 1953, p. 10) in areas where it is protected by the overlying Niagara dolomite.

The Cincinnati shale (Upper ordovician) is a blue gray shale, containing some brown zones. Lenses of sand are present between alternating beds of shale and thin bedded, gray, shaly dolomite. Sometimes lenses of iron coated fragments of shaly material and iron pebbles exist between the shale and the overlying dolomite. One of these lenses according to Thwaites, 1957, p. 835 is present at DePere. These lenses are known as the *Weda hematite*.

The Niagara dolomite (Lower Silurian) is a yellow to gray, fine- to coarse-grained, partly brecciated, crystalline dolomite. Where fossils have

been dissolved, the dolomite is vesicular. Generally it is thick bedded, though it may be thin bedded in part. It weathers to a rough, craggy, pitted surface.

The Niagara dolomite underlies a variable thickness of glacial till in eastern Brown County. The transition from Cincinnati shale to dolomite is marked by an escarpment rising in a steep westward-facing cliff with as much as 250 feet of relief. However, the escarpment generally exposes only 5 to 15 feet of dolomite which dips 1-2 degrees southeast. Small outcrops of dolomite also are found east of the escarpment in some stream beds and where the glacial till covering is locally absent. The escarpment is composed of the lower members (Mayville and Byron) of the Niagara dolomite. To the east additional, younger, members of the Niagara make up bedrock controlled hills which rise above the level of the surrounding countryside. The complete thickness of the dolomite is 360 feet (W.J. Drescher, 1953, p. 10).

### Glacial geology of Brown County

Most of the unconsolidated material of Brown County was deposited directly or indirectly from glacial ice, or from lakes associated with ice. The glacial history mainly concerns the sub-stages of the Wisconsin stage of glaciation (fig. 3). The Neokian substage occurred approximately 30,000 years ago and is the oldest glaciation noted. No record is found of events following until the Cary substage when ice covered the county between 12,500 and 16,000 years ago. Deglaciation was complete during the Two Creeks interval from 11,000 to 12,500 years ago when forests covered Brown County. Ice readvanced during the Valdres substage between 9,500 to 11,000 years ago and then disappeared from Wisconsin.

The Fox River valley was a major axis for ice movement during the Cary and Valdres substages and probably during the Neokian. The valley was the first area into which the ice moved, contained the thickest ice during the height of glaciation, and was the last area from which the ice melted. It provided a structurally low bedrock route through which ice could move easily. Also it provided a site for the formation of large glacial lakes during advance and retreat of ice fronts.

The structure, color, and composition of material and the type of landform in which the material occurs is used to piece together the glacial history. Material deposited from glacial ice can be divided into two general categories. These are till and glacio-aqueous deposits. Till is unstratified and unsorted glacial drift that is derived from the ice without being subsequently moved or washed by glacial meltwater. The till of Brown County generally consists of small boulders, cobbles, and pebbles mixed with reddish brown dolomite flour, clay, silt, and quartz sand. The till forms ground moraine knobs and swales, terminal moraine ridges, and drumlins. The glacio-aqueous materials

are washed materials of stratified or semi-stratified clay, silt, sand, and gravel which have been deposited on land or in lakes by glacial meltwater. These materials are in glacial lake beds, kames, outwash plains, eskers, and crevasse fillings. Much of Brown County contains a surface cover of till. Portions of the county have surface lake sediments, and a few localities have deposits of gravel.

Following is a brief description of the substages of the Wisconsin glaciation of Brown County.

#### Rockian substage

No Rockian drift is found at the surface in Brown County. Subsurface presence of a pre-Cary (Rockian) glaciation is indicated in the vicinity of the City of Green Bay in two well logs (Thwaites and Bertrand, 1957, p. 849). There the pre-Cary material is reported as a brown to pink dolomitic till. No other deposits of Rockian till are known in Brown County.

#### Cary substage

The Cary ice advanced into the county from the north and covered all of Brown County. As the ice advanced into the Fox River valley proglacial lakes formed in front and along the sides of the ice tongue. As the ice thickened, it advanced southward up the valley, to the west up the dip slope of the Galena-Platteville dolomite, and to the east and southeast over the Niagara escarpment. The southward margin of the Cary ice extended into southern Wisconsin, therefore ice moving across Brown County reworked the previously deposited glacial drift and eroded the bedrock surface. Erosion was most severe along the edge of the Niagara escarpment and to the west along the outcrop of the Galena-Platteville dolomite. During late Cary times the ice began to thin. Stagnation occurred first in the upland areas to the west and east of the Fox River valley. Actively moving ice could have been in the valley while melting,



stagnating ice was at the higher elevations. It was during this phase that gravel, lake, and till deposits were formed. As the last remaining Cary ice melted in the valley additional glacier lakes were formed. Ice could have remained in the valley for many decades or centuries after the uplands were free from ice.

#### Two Creeks interval

It is a matter of conjecture as to the actual length of time that elapsed from the time the last vestiges of Cary ice melted in the Fox River valley to the time when the Valdres substage ice began to enter the valley. During this time, the Two Creeks interval, a spruce forest developed. Presence of this forest is shown by logs, branches, cones, and needles in a transported (not in place) deposit northeast of the City of Green Bay.

#### Valdres substage

The Valdres ice generally followed a path similar to the earlier Cary ice. Lakes were formed in front of the advancing ice in the Fox River valley lowland. The Valdres ice also thickened until it advanced up the dip slope of the Galena-Platteville dolomite and over the crest of the Niagaran escarpment. In the Fox River valley the Valdres ice moved over Cary till and lake sediments, in some cases Two Creeks deposits, and proglacial lake deposits and gravel laid down in front of its own advancing ice front. As the ice moved over the escarpment and up the bedrock surface to the west, the Valdres ice either over-rode or picked up much of the previously deposited glacial drift. It is a problem to determine whether gravel deposits are over-ridden Cary gravels or actual Valdres deposits when the Two Creeks beds are not present and where some of the Valdres till is found intermixed with the gravel. During stagnation of Valdres ice, washed materials, till, ice-pounded lake sediments, and outwash

gravels were formed. A large glacial lake known as Later Lake Oshkosh was formed in the Fox River valley during the waning stages of the Valdres substage. Valdres till is the most prevalent surface deposit in the county.

#### Recent deposits

Since Valdres time, streams have eroded the county most intensely along the margins of the Fox River and, especially the Niagaran escarpment, where gullies and downcut streams extend into the river. Locally alluvium deposited in the stream beds, consists of clay mud, fine sand, sand, and in some cases thin veneers of gravel. Sand dunes were formed on the surface when wind erosion affected exposed beds of fine lake sediments.

## Materials Provinces

### Province # 1

Province 1 topographically is a broad hill which stands 20-35 feet above the surrounding countryside in the vicinity of Holland in the extreme southwest corner of Brown County. It is characterized by a thin (5-15 feet) cover of Valderr red-clayey till containing less than 5 percent of small stones of which most are dolomite. The underlying Galena Dolomite is too deeply buried for quarrying and no deposits of washed materials are known. See drill hole 4<sup>3</sup> and road cut # 11.

### Province # 2

Fox River Valley area, province 2, topographically is a low, rolling plain traversed by streams heading along the adjacent escarpments and from the headlands. The area is covered by Valderr red-clayey till 5-15 feet thick in the northern portions of the province and 15-30 feet thick in the southern part. In most places the till overlies lake sediments consisting of very fine sand, fine sand, silt and clay. In the central and western portions of the province in a few places the till rests on Galena Dolomite and in the eastern parts on Cincinnati Shale. No quarry sites are known, and neither the till nor the lake sediments is a favorable source source of construction aggregates. For further details refer to drill holes 1, 2, 3, 4, 29, 30, 33, 34, 39, 40, 44, 45, 50, 51, 52, 53, 54, well log 7, road cut 13, stream cuts 14, 23, and 26, natural outcrops 16, 28, and 31, and information note 21.

### Province # 3

Province 3 topographically consists of isolated low valleys along streams where the Galena Dolomite west of the Fox River is exposed or nearly exposed by stream erosion. The province is characterized by a thin cover (0-12

feet) of Valders red-clayey till overlying Galena Dolomite. Near the contact of the till and dolomite the till contains weathered dolomite underlain by fresh, hard, unweathered stone. Quarry locations are available, but the development of quarries is hampered by heavy stripping (up to 12 feet of clayey till) away from the stream channels, and by serious drainage problems along the streams. Also the Galena Dolomite is a poor quality road material when used for concrete and base course aggregate. See drill hole # 26, and natural outcrop # 30. Also refer to locations 1, 20, 57, 58, 62, and 63.

#### Province # 4

Province 4 in northwestern Brown County topographically is a rolling plain which is dissected by small streams generally flowing from west to east. A series of low knolls, generally trending north-south contain small amounts of washed sand. The province is characterized by a cover of Valders red-clayey till, 5-20 feet in thickness on Galena Dolomite. Overlying the till, sand dunes are found in a few places. The dune sand is too fine to be used as sub-base (sand lift material), and no known deposits of construction aggregate exist within the till. Development of quarry locations in the Galena Dolomite would be severely hampered by heavy stripping (up to 20 feet of clayey stripping) and by drainage problems. See drill holes # 20 and 48. Also refer to location 10.

#### Province # 5

Province 5 is a sandy area north west of the Fox River, which topographically consists of irregular, dissected hills and valleys. The province has a surface covering of from 5 to 25 feet of Valders red-clayey till. In most places the till covers lake sediments consisting of fine sand, silt, and clay. In some places these lake sediments are coarse enough to serve as sand lift. In this province north of State Trunk Highway 32, sand dunes are especially numerous.

These dunes lie on top of the clayey till or the lake sediments. The lake sediments are from 5-50 feet thick and are underlain by Galena Dolomite. The dolomite is too deeply buried to provide quarries. The till contains no known deposits of construction aggregate, and the dune sand is too fine to be used as sand lift. For further details refer to drill holes 5, 6, 7, 9, 10, 11, 12, 13, 14, 15, 17, 18, 22, 25, 47 and 49. Refer to road cut 29, and 32 and surface exposure 35. Also refer to locations S-1, S-15, S-16, S-17, S-18, S-19, S-20, S-21, 21, 22, 53, and 55.

#### Province # 6

Province 6 in northwestern Brown County contains sand and gravel in a rolling plain dissected by the Suamico River and its tributaries. This province is characterized by a cover of Valdres red-clayey till (5-15 feet in thickness) overlying in some places deltaic zones of coarse sand and gravel and in most places zones of lake sediments consisting of fine sand and silt. The deltaic zones contain stones up to 6 inches in diameter mixed with layers of coarse sand, pea gravel, and fine sand. Pockets of silt and clay are mixed with the coarse zones. The above material is underlain by Galena Dolomite. Although 5 holes were drilled in this province without encountering any sizable deposit, some further exploration for sources of coarse sand and gravel is warranted. Coarse aggregates present are variable in thickness, lateral extent, and texture. See drill holes 16, 19, 21, 23, 24. Also refer to locations 2, 54, 56, 59.

#### Province # 7

Province 7 is the lowland northwest of the City of Green Bay and along the west shore of Green Bay. Topographically this province is a low, flat, marshy plain adjacent to Green Bay. The province is characterized by thin (0-5 feet) of soil and silt overlying lake sediments consisting of silt, fine

sand, and clay. Underlying the lake sediments is Galena Dolomite, too deeply buried for quarrying. The lake sediments are generally too fine to be used as sand-lift, and no known deposits of coarse aggregate are known. See drill hole # 8 for further details.

#### Province # 8

Province 8 is a small area in southern Brown County, east of the Fox River. This province is covered by 5 to 15 feet of Valdres red-clayey till that overlies coarse, poorly-sorted, clayey gravel. The gravel is found in crevasse fillings at the northwest end of an esker that trends southeast into Calumet County. The gravel deposits have been worked extensively and limited yardage of poorly sorted, clayey gravel remains.

#### Province # 9

Province 9 lies east of Fox River and trends northeast-southwest parallel to the Niagaran escarpment. The province topographically is a severely dissected series of knolls parallel to the escarpment. The dissection was accomplished by streams formed from springs in the escarpment and from streams flowing across the escarpment. The province is characterized by 15-35 feet of Valdres red-clayey till that overlies Cincinnati Shale and lower ledges of Niagaran Dolomite, or in some places lake sediments consisting of fine sand, silt, and clay. The dolomite is too deeply buried to offer convenient locations for quarries. No known deposits of coarse construction aggregate lie between the till and the bedrock. In some places stream-bed deposits of gravel are found on the surface but are of insignificant volume. See drill hole 31 and 38, stream cut 24, road cut 27, and location 40.

#### Province # 10

Province 10 is a narrow northeast-southwest area trending parallel to

the Niagaran escarpment and immediately adjacent to it. The province is marked topographically by a severely dissected terrace which has been eroded by streams formed from springs in the escarpment and from streams flowing across the escarpment. This narrow province is characterized by a zone of sandy gravel lying between the till of Province 9 and the west edge of the Niagaran escarpment. The gravel deposits are composed of coarse gravel zones, sandy zones, zones composed of lake sediment that are interstratified with the gravel, and dolomitic debris from the Niagaran escarpment. The dolomitic debris containing boulders up to 3-4 feet in diameter is especially common near the escarpment. The province is covered by Valdres red-clayey till containing 5-10% of dolomitic stone ranging from small stones up to 3-4 foot blocks. The depth of the till ranges from 5-15 feet with the greater thickness in the area furthest from the escarpment. Underlying the till and gravel is Cincinnati Shale and lower ledges of Niagaran dolomite. This province has been extensively worked with two large pits (Locations 30 and 31) being the most prominent. Reserve areas and potential gravel locations are found close to the escarpment in a long narrow belt. Much variation in the size of the material, the quality of the material, and the depth of the stripping occurs in this province. The lower ledges of the Niagaran Dolomite offer poor locations for quarries because of the depth of the overlying materials. See drill holes 35, 36, and 37. Also refer to locations 23, 24, 30, 31, 32 and 39.

#### Province # 11

Province 11 is a sandy area of dissected lake sediments in the Town of Preble east of the City of Green Bay. Topographically the province is a high upland plain which is severely dissected by Baird Creek and its tributaries. There is as much as 100 feet of relief from Baird Creek to the top of the upland plain in the western part of this province. The locality is characterized by an

area of sandy lake sediments deposited between the Valdars ice and bedrock areas. The lake sediments are overlain by Valdars red-clayey till which contains 5-10% of stones ranging up to 6 inches in diameter of which the majority are dolomite. The thickness of the till ranges from 2 to 10 feet. The till and lake sediments are underlain by Niagaran Dolomite which outcrops in some places along Baird Creek. The province does not offer favorable topographic locations for quarries, nor for locations of sources of sand-lift material because of the proximity of industrial and residential areas in the Town of Preble. See drill hole 46, and road cut 19, and natural exposure 18. Also refer to locations S-11, S-12, S-13, S-14, S-6, 13 and 15.

#### Province # 12

Province 12 is a sand and gravel area in the eastern portion of the Town of Preble, east of the City of Green Bay. Topographically the province is a gently rolling, upland plain which is dissected by Baird Creek and its tributaries. This locality is characterized by the presence of a layer of coarse aggregate ranging from 4-15 feet in thickness, which is overlain by Valdars red-clayey till containing 5-10% of stones. The stones are from small size up to 6 inches in diameter and chiefly dolomite. Underlying the coarse aggregate zone are fine sands, silts, and clays of lake deposited materials. Underlying all the above deposits is the Niagaran Dolomite. The dolomite is too deeply buried to serve as an area for quarry development. The zone of coarse aggregate, containing crusher-size material up to 8 inches in diameter is mixed with sand and pea gravel, and is not thick enough to provide large yardage without using a broad surface area. The lake sediments are too fine grained to serve as a source of construction aggregate. See drill holes 28 and 32. Also refer to location 64.



### Province # 13

Province 13 is the linear edge of the Niagaran escarpment of dolomite which rises sharply above the land to the west. The eastward slope of the escarpment is occupied by a till covered rolling plain. The dolomite where exposed but not quarried is weathered to a rough, craggy, pitted surface. Where exposed in quarries it is a coarsely crystalline gray dolomite. Near the surface (top of the escarpment) the dolomite is thinly bedded with layers from 2 inches to 6 inches in thickness. Downward the beds become thicker ranging up to three feet in thickness. Overlying the dolomite is Valders red-clayey till which contains 10-15% of stones ranging up to 6 inches in diameter of which most are dolomite. The depth of this clay ranges from 0 feet at the western crest of the escarpment to 12 feet to the east away from the crest. The province already contains numerous quarries, and offers other potential quarry locations which would offer a 40-60 foot working face, minor drainage problems, and a good quality crushed stone with large volume reserves. See read out 9 and natural exposures 3, 15, and 33. Also refer to locations 3, 11, 25, 26, 28, 29, 33, 35, 36, and 3-3.

### Province # 14

In eastern Brown County Province 14 combines separated areas that topographically are rolling plains having knobs and swales of Valders red-clayey till. Niagaran Dolomite underlies 5-15 feet of till. This province has local deposits of reworked stoney till and alluvial deposits of washed sand and gravel in small channels on top of the till. No known deposits of washed construction aggregates are found between the till and the underlying bedrock. The Niagaran Dolomite offers locations for quarry development which are less favorable than those in Province 13. See drill holes 27, 58, 59, 63, 64, and 67, natural

exposures 4 and 22, and road cuts 5, 8, 12, and 17. Also refer to locations 8-4, 8-5, 14, 16, 46, 47, 37, and 38.

#### Province # 15

Several separated areas in eastern Brown County which topographically are rolling plains are hummocky areas comprise Province 15. Fifteen to twenty-five feet of Valders red-clayey stoney till overlies Niagaran Dolomite. In this province deposits of reworked stoney till are suitable for surfacing town gravel roads. Small outwash aprons and small kames are available at the surface. No washed aggregate are known between the till and the underlying Niagaran Dolomite. The dolomite is generally too deeply buried to provide favorable sites for quarry locations. In the area in the vicinity of Denmark, till of Cary age underlies the Valders till which in some places has been eroded away. See drill holes 41, 42, 55, 56, 57, 60, 61, 62, 66, 68, 69, and 70 and road cuts 6 and 25. Also refer to locations 8-2, 60 and 61.

#### Province # 16

Province 16 is an irregular area in northeastern Brown County, which topographically consists of stream valleys which were former glacial drainage ways. The valleys lie between bedrock-controlled hills. The province is characterized by alluvial deposits of coarse crusher-sized gravel containing stones up to 4 feet in diameter. The coarse aggregate is overlain by a thin layer (1-10 feet) of Valders red-clayey, stoney till and by a veneer of fine sand and silt. The till contains 15-20% of stones up to 8 inches in diameter most of which are dolomite. The coarse aggregate is underlain by sandy gravel which rests on Niagaran Dolomite. This province offers a good source of coarse aggregate. See road cuts 2 and 34. Also refer to locations 17, 18, and 19.

### Province # 17

Province 17 consists of discontinuous terraces along the valleys of the Nechota River and its tributaries in southeastern Brown County. The province is characterized by alluvium of silt, clay, and coarse gravel (2-6 feet in thickness) overlying layers of clean coarse sand and gravel. Most stones are less than 3 inches in diameter, but some large boulders up to three feet in diameter are present near the contact with the underlying Niagara Dolomite. The gravel zones some of which contain up to 60% of material above  $\frac{1}{4}$  inch in diameter are 8 to 10 yards thick above the water table. This province has been worked extensively, and several gravel pits are present. The terraces are still good sources of coarse construction aggregate. See road cut 1 and natural exposure 10. Also refer to Brown County Locations 8-7, 8-9, 8-10, 5, 6, 7, 8, 9, 41, 42, 43, 44, 45, 48, 49 and 50.

### Conclusions

Seventeen materials provinces are described in this report. Of these gravel can be obtained in limited quantities from provinces 6, 8, 10, 12, 16 and 17. Quarry sites for Niagaran dolomite are best located in province 13 and secondly in province 14. Quarry sites for Galena-Platteville dolomite require heavy stripping in provinces 2, 3, and 4. Sand lift might be obtained from provinces 5, 6, 8, 10, and 11. Some till in province 15 is suitable for town needs. Other provinces contain little but fill.

### Selected Bibliography

- Drescher, W.J., 1953, Ground-water conditions in artesian Aquifers in Brown County, Wisconsin: Geological Survey Water Supply Paper 1190, 49 pages.
- Hotchkiss, W.O. and Steidtmann, E., 1914, Limestone Road Materials of Wisconsin: Wisconsin Geological and Natural History Survey, Bulletin 64, 137 pages.
- Prouty, C.E., 1960, Lower Paleocene and Pleistocene Stratigraphy Across Central Wisconsin: Michigan Basin Geological Society Annual Field Trip Excursion, 35 pages.
- Steidtmann, E., 1924, Limestones and Marls in Wisconsin: Wisconsin Geological and Natural History Survey, Bulletin 66, 208 pages.
- Thwaites F.T., 1943, Pleistocene of Part of Northeastern Wisconsin: Bulletin of the Geological Society of America, v. 54, p. 87-144.
- Thwaites, F.T. and Bartrand, K., 1957, Pleistocene Geology of the Door Peninsula Wisconsin: Bulletin of the Geological Society of America, v. 68, p. 831-880.

APPENDIX 1

Drill holes, using Mobile Drill 13-36 auger

Drill hole 1

Location NW $\frac{1}{4}$  of the SE $\frac{1}{4}$  of Sec. 11, T. 22N., R. 19E.

Elevation at top of hole 662 feet

- 1 ft. Sandy soil
- 3 ft. Medium to fine, clean sand
- 1 ft. Very fine, silty sand
- 15 ft. Clayey silt
- 1 ft. Reddish blue clay
- 7 ft. Alternating beds of silt and very fine sand

Elevation bottom of hole 633 feet

Drill hole 2

Location SE $\frac{1}{4}$  of the SE $\frac{1}{4}$  of Sec. 36, T. 23N., R. 19E.

Elevation at top of hole 642 feet

- 1 ft. Sandy silty soil
- 4 ft. Red, clayey till
- 18 ft. Reddish brown, silty clay

Elevation at bottom of hole 619 feet

Drill hole 3

Location SW $\frac{1}{4}$  of the NE $\frac{1}{4}$  of Sec. 18, T. 23N., R. 20E.

Elevation at top of hole 664 feet

- 1 ft. Clayey soil
- 10 ft. Red, stoney till

Elevation at bottom of hole 653 feet

Drill hole 4

Location NW $\frac{1}{4}$  of the SE $\frac{1}{4}$  of Sec. 7, T. 23N., R. 20 E.

Elevation at top of hole 664 feet

- 1 ft. Clayey soil
- 1 ft. Silty, red clay
- 14 ft. Reddish clay till

Elevation at bottom of hole 648 feet

Drill hole 5

Location SE $\frac{1}{4}$  of the NE $\frac{1}{4}$  of Sec. 31, T. 24N., R. 20E.

Elevation at top of hole 723 feet

- 1 ft. Sandy soil
- 9 ft. Medium to fine sand
- 5 ft. Silty fine sand
- 15 ft. Sandy silt
- 17 $\frac{1}{2}$  ft. Fine sand alternating with silt

Elevation at bottom of hole 675 $\frac{1}{2}$  feet

Drill hole 6

Location NW $\frac{1}{4}$  of the SW $\frac{1}{4}$  of Sec. 20, T. 24N., R. 20E.

Elevation at top of hole 680 feet

- 1 ft. Sandy soil
- 3 ft. Fine sand
- 6 ft. Sandy silt
- 5 ft. Clayey silt
- 4 ft. Silt

Elevation at bottom of hole 659 feet

Drill hole 7

Location NW $\frac{1}{4}$  of the SW $\frac{1}{4}$  of Sec. 8, T. 24N., R. 20E.

Elevation at top of hole 680 feet

- 1 ft. Clayey soil
- 1 ft. Red clay
- 8 ft. Silty clay
- 3 ft. Clay and silt (in water)

Elevation at bottom of hole 667 feet

Drill hole 8

Location SE $\frac{1}{4}$  of the SW $\frac{1}{4}$  of Sec. 23, T. 25N., R. 20E.

Elevation at top of hole 585 feet

- 1 ft. Sandy soil
- 18 ft. Fine silty sand
- 3 $\frac{1}{2}$  ft. Fine sand (in water)

Elevation at bottom of hole 562 $\frac{1}{2}$  feet

Drill hole 9

Location NE $\frac{1}{4}$  of the SE $\frac{1}{4}$  of Sec. 28, T. 25N., R. 20E.

Elevation at top of hole 645 feet

- 1 ft. Sod and top soil
- 4 ft. Red clay till
- 2 ft. Sandy gravel
- 5 ft. Sand, red color, medium grained
- 5 ft. Sand, fine to medium grained
- 6 ft. Sand, medium grained

Elevation at bottom of hole 622 feet

Drill hole 10

Location SE $\frac{1}{4}$  of the SW $\frac{1}{4}$  of Sec. 15, T. 25N., R. 20E.

Elevation at top of hole 643 feet

- 1 ft. Soil and sod
- 2 ft. Fine silt
- 3 ft. Stoney red till
- Hole stopped by stones

Elevation at bottom of hole 637 feet

Drill hole 11

Location SW $\frac{1}{4}$  of the NW $\frac{1}{4}$  of Sec. 15, T. 23N., R. 19E.

Elevation at top of hole 705 feet

- 1 ft. Sandy, silty soil
- 26 ft. Medium grained, quartz sand

Elevation at bottom of hole 678 feet

Drill hole 12

Location NE $\frac{1}{4}$  of the NE $\frac{1}{4}$  of Sec. 2, T. 23N., R. 19E.

Elevation at top of hole 705 feet

- 1 ft. Sandy, silty soil
- 5 ft. Very fine, well sorted sand
- 7 ft. Fine sand, well sorted
- 14 ft. Fine to medium sand

Elevation at bottom of hole 678 feet

Drill hole 13

Location SE $\frac{1}{4}$  of the SE $\frac{1}{4}$  of Sec. 8, T. 23N., R. 20E.

Elevation at top of hole 641 feet

- 1 ft. Coarse sand and gravel
- 3 ft. Silt, red color
- 2 ft. Very fine, well sorted sand
- 3 ft. Medium grained sand
- 2 ft. Sandy gravel
- 5 ft. Coarse sand

Elevation at bottom of hole 625 feet

Drill hole 14

Location NE $\frac{1}{4}$  of the NE $\frac{1}{4}$  of Sec. 11, T. 24N., R. 19E.

Elevation at top of hole 759 feet

- 2 ft. Silty, clayey soil
- 2 ft. Red clayey till
- 1 ft. Clayey, silty fine sand
- 22 $\frac{1}{2}$  ft. Fine to medium sand

Elevation at bottom of hole 736 $\frac{1}{2}$  feet

Drill hole 15

Location SW $\frac{1}{4}$  of the NE $\frac{1}{4}$  of Sec. 18, T. 24N., R. 20E.

Elevation at top of hole 700 feet

- 1 ft. Silty soil
- 1 $\frac{1}{2}$  ft. Fine, well sorted sand
- 13 $\frac{1}{2}$  ft. Silt

Elevation at bottom of hole 684 feet

Drill hole 16

Location SE $\frac{1}{4}$  of the SW $\frac{1}{4}$  of Sec. 12, T. 25N., R. 19E.

Elevation at top of hole 722 feet

- 1 ft. Silty soil
- 2 ft. Red clay till
- 3 ft. Silty, sandy clay
- 26 ft. Fine to medium sand

Elevation at bottom of hole 690 feet

Drill hole 17

Location SE $\frac{1}{4}$  of the SE $\frac{1}{4}$  of Sec. 31, T. 25N., R. 20E.

Elevation at top of hole 712 feet

- 1 ft. Very fine sand
- 1 ft. Silty sand
- 3 ft. Fine sand
- 21 ft. Medium to fine sand

Elevation at bottom of hole 686 feet



Drill hole 18

Location  $SW\frac{1}{4}$  of the  $SE\frac{1}{4}$  of Sec. 5, T. 25N., R. 20E.

Elevation at top of hole 849 feet

3 ft. Very fine sand

2 ft. Medium sand

3 ft. Silt

31 ft. Very fine sand

Elevation at bottom of hole 811 feet

Drill hole 19

Location  $SW\frac{1}{4}$  of the  $SW\frac{1}{4}$  of Sec. 12, T. 25N., R. 19E.

Elevation at top of hole 740 feet

1 ft. Silty soil

3 ft. Clayey gravel

3 ft. Silty sand

15 ft. Medium sand

11 ft. Fine sand

Elevation at bottom of hole 707 feet

Drill hole 20

Location  $SW\frac{1}{4}$  of the  $NE\frac{1}{4}$  of Sec. 3, T. 25N., R. 19E.

Elevation at top of hole 760 feet

4 ft. Silty clay and sand

2  $\frac{1}{2}$  ft. Reddish brown clay, stoney

Drill hole stopped by stones

Elevation at bottom of hole 753  $\frac{1}{2}$  feet

Drill hole 21

Location  $NE\frac{1}{4}$  of the  $SW\frac{1}{4}$  of Sec. 1, T. 25N., R. 19E.

Elevation at top of hole 761 feet

1 ft. Clayey soil

3 ft. Stoney red till

2  $\frac{1}{2}$  ft. Sand, medium to coarse

Elevation at bottom of hole 732  $\frac{1}{2}$  feet

Drill hole 22

Location  $NE\frac{1}{4}$  of the  $NE\frac{1}{4}$  of Sec. 34, T. 25N., R. 19E.

Elevation at top of hole 765 feet

1 ft. Clay soil

5 ft. Till, red, stoney

8 ft. Sand, fine grained

2 ft. Silt

11  $\frac{1}{2}$  ft. Sand, fine to medium grained

Elevation at bottom of hole 737  $\frac{1}{2}$  feet

Drill hole 23

Location  $SW\frac{1}{4}$  of the  $SE\frac{1}{4}$  of Sec. 1, T. 25N., R. 19E.

Elevation at top of hole 773 feet

1 ft. Silty soil

6  $\frac{1}{2}$  ft. Gravel, clay bound

Drill hole stopped by stones

Elevation at bottom of hole 765  $\frac{1}{2}$  feet

**Drill hole 24**

Location NW $\frac{1}{4}$  of the SE $\frac{1}{4}$  of Sec. 1, T. 25N., R. 19E.

Elevation at top of hole 766 feet

1 $\frac{1}{2}$  ft. Silty soil

6 ft. Gravel, silty, clayey

28 $\frac{1}{2}$  ft. Sand, fine, well-sorted

Elevation at bottom of hole 731 feet

**Drill hole 25**

Location SW $\frac{1}{4}$  of the SE $\frac{1}{4}$  of Sec. 29, T. 25N., R. 20E.

Elevation at top of hole 730 feet

$\frac{1}{2}$  ft. Sandy soil

4 ft. Sand, medium grained, silty, red stained

35 ft. Sand, medium, clean

Elevation at bottom of hole 690 $\frac{1}{2}$  feet

**Drill hole 26**

Location SW $\frac{1}{4}$  of the NW $\frac{1}{4}$  of Sec. 22, T. 25N., R. 19E.

Elevation at top of hole 744 feet

2 ft. Till, stoney, red

1 $\frac{1}{2}$  ft. Sandy gravel

6 ft. Till, stoney, red

5 ft. Clay, brown

Elevation at bottom of hole 729 $\frac{1}{2}$  feet

**Drill hole 27**

Location NW $\frac{1}{4}$  of the NW $\frac{1}{4}$  of Sec. 2, T. 23N., R. 21E.

Elevation at top of hole 760 feet

1 ft. Clayey soil and sod

2 $\frac{1}{2}$  ft. Red, stoney clay till

3 $\frac{1}{2}$  ft. Brown clay

4 ft. Silty clay

4 ft. Purple clay

Elevation at bottom of hole 744 feet

**Drill hole 28**

Location NE $\frac{1}{4}$  of the SW $\frac{1}{4}$  of Sec. 35, T. 24N., R. 21E.

Elevation at top of hole 752 feet

1 ft. Sod and clay soil

1 ft. Silt

2 ft. Dirty clayey gravel

8 ft. Coarse gravel, stones up to 3 inches in diameter in drill cuttings

Drill hole stopped by stones

Elevation at bottom of hole 740 feet

**Drill hole 29**

Location NW $\frac{1}{4}$  of the NE $\frac{1}{4}$  of Sec. 21, T. 23N., R. 21E.

Elevation at top of hole 692 feet

1 ft. Clay soil and sod

8 ft. Till, red, stoney

9 ft. Till, red brown

3 ft. Clay, brown

Elevation at bottom of hole 671 feet

Drill hole 30

Location SE $\frac{1}{4}$  of the NE $\frac{1}{4}$  of Sec. 20, T. 23N., R. 21E.

Elevation at top of hole 650 feet

7 $\frac{1}{2}$  ft. Clay soil

10 ft. Till, stoney, red

7 $\frac{1}{2}$  ft. Blue-brown clay

Elevation at bottom of hole 631 feet

Drill hole 31

Location SW $\frac{1}{4}$  of the SW $\frac{1}{4}$  of Sec. 1, T. 22N., R. 20E.

Elevation at top of hole 710 feet

1 ft. Clayey, silty soil

14 ft. Clay, very dense, red-brown, stoney

Elevation at bottom of hole 695 feet

Drill hole 32

Location SW $\frac{1}{4}$  of the SW $\frac{1}{4}$  of Sec. 35, T. 24N., R. 21E.

Elevation at top of hole 763 feet

1 $\frac{1}{2}$  ft. Clay soil

3 ft. Till, red stoney

6 ft. Sandy gravel

13 ft. Sand, fine, well-sorted

Elevation at bottom of hole 749 $\frac{1}{2}$  feet

Drill hole 33

Location SE $\frac{1}{4}$  of the SW $\frac{1}{4}$  of Sec. 24, T. 23N., R. 21E.

Elevation at top of hole 792 feet

1 ft. Sod and clay soil

9 ft. Till, red, stoney

Drill hole stopped by stones

Elevation at bottom of hole 782 feet

Drill hole 34

Location NE $\frac{1}{4}$  of the SW $\frac{1}{4}$  of Sec. 23, T. 23N., R. 21E.

Elevation at top of hole 750 feet

2 ft. Sod and clay soil

8 ft. Till, red, stoney

6 ft. Till, red-brown

3 ft. Clay, dense, blue-brown clay

Elevation at bottom of hole 731 feet

Drill hole 35

Location SE $\frac{1}{4}$  of the NW $\frac{1}{4}$  of Sec. 12, T. 22N., R. 20E.

Elevation at top of hole 842 feet

6 ft. Till, very stoney, red

2 ft. Till, dense, red, stoney

Drill hole stopped by stone

Elevation at bottom of hole 834 feet

Drill hole 36

Location  $SE\frac{1}{4}$  of the  $NW\frac{1}{4}$  of Sec. 12, T. 22N., R. 20E.

Elevation at top of hole 746 feet

6 ft. Till, stoney, red

7 ft. Clay, blue-brown, very dense

6 ft. Clay, brown, some stones

5 ft. Silty clay (in water)

Elevation at bottom of hole 722 feet

Drill hole 37

Location  $NE\frac{1}{4}$  of the  $NW\frac{1}{4}$  of Sec. 14, T. 22N., R. 20E.

Elevation at top of hole 843 feet

4 ft. Till, red stoney

2 ft. Silt

6 ft. Clay, blue-brown, very compact

Hole bottomed on large stone or possibly bedrock

Elevation at bottom of hole 831 feet

Drill hole 38

Location  $NE\frac{1}{4}$  of the  $SE\frac{1}{4}$  of Sec. 22, T. 22N., R. 20E.

Elevation at top of hole 824 feet

1 ft. Clay soil

6 ft. Till, red, stoney

3 ft. Gravel, clay bound

Drill hole stopped by this stoney zone

Elevation at bottom of hole 814 feet

Drill hole 39

Location  $SE\frac{1}{4}$  of the  $NE\frac{1}{4}$  of Sec. 7, T. 21N., R. 20E.

Elevation at top of hole 677 feet

10 ft. Till, red, stoney

3 ft. Till, brown-red

Drill hole stopped by stones

Elevation at bottom of hole 664 feet

Drill hole 40

Location  $SE\frac{1}{4}$  of the  $SE\frac{1}{4}$  of Sec. 36, T. 22N., R. 19E.

Elevation at top of hole 670 feet

1 ft. Silty soil

$3\frac{1}{2}$  ft. Silty, clayey sand

3 ft. Sand, very fine

14 ft. Clay, red, stoney

Elevation at bottom of hole 648 feet

Drill hole 41

Location  $SE\frac{1}{4}$  of the  $SE\frac{1}{4}$  of Sec. 12, T. 21N., R. 21E.

Elevation at top of hole 901 feet

1 ft. Clay soil

$6\frac{1}{2}$  ft. Very stoney, red till

Drill hole stopped by stones

Elevation at bottom of hole 893 feet

Drill hole 42

Location NE $\frac{1}{4}$  of the NE $\frac{1}{4}$  of Sec. 16, T. 21N., R. 21E.

Elevation at top of hole 882 feet

1 ft. Clay soil

7 ft. Till, red, stoney

Elevation at bottom of hole 874 feet

Drill hole 43

Location NE $\frac{1}{4}$  of the NW $\frac{1}{4}$  of Sec. 34, T. 21N., R. 20E.

Elevation at top of hole 764 feet

1 ft. Clay soil

4 ft. Clay till, red stoney

1 ft. Shale and clay

Drill hole bottomed in shale

Elevation at bottom of hole 758 feet

Drill hole 44

Location NW $\frac{1}{4}$  of the NE $\frac{1}{4}$  of Sec. 19, T. 22N., R. 20E.

Elevation at top of hole 661 feet

2 ft. Sod and clayey soil

12 ft. Till, red

2 ft. Fine, silty sand

6 ft. Clay, reddish-brown

4 ft. Silt, clayey

6 ft. Silt

Elevation at bottom of hole 627 feet

Drill hole 45

Location NE $\frac{1}{4}$  of the NW $\frac{1}{4}$  of Sec. 4, T. 22N., R. 20E.

Elevation at top of hole 644 feet

1 ft. Sod and clayey soil

6 ft. Till, red, stoney

25 ft. Clay, red-brown, very dense

Elevation at bottom of hole 612 feet

Drill hole 46

Location SE $\frac{1}{4}$  of the NW $\frac{1}{4}$  of Sec. 13, T. 24N., R. 21E.

Elevation at top of hole 642 feet

1 ft. Clay soil

3 $\frac{1}{2}$  ft. Till, red, silty

Hole stopped by bedrock

Elevation at bottom of hole 637 $\frac{1}{2}$  feet

Drill hole 47

Location NW $\frac{1}{4}$  of the NW $\frac{1}{4}$  of Sec. 19, T. 25N., R. 20E.

Elevation at top of hole 730 feet

1 ft. Silty soil

10 ft. Gravelly sand

13 ft. Medium sand, well-sorted

10 ft. Fine sand

Elevation at bottom of hole 696 feet

Drill hole 48

Location  $SE\frac{1}{4}$  of the  $SW\frac{1}{4}$  of Sec. 5, T. 25N., R. 19E.

Elevation at top of hole 782 feet

1 ft. Soil, sandy, silty

8 ft. Clay, silty (no stones)

Hole stopped by stone - possibly bedrock

Elevation at bottom of hole 773 feet

Drill hole 49

Location  $NE\frac{1}{4}$  of the  $SW\frac{1}{4}$  of Sec. 26, T. 24N., R. 19E.

Elevation at top of hole 720 feet

2 ft. Soil, clayey, silty

4 ft. Till, red, stoney

2 ft. Silty clay

10 ft. Very fine sand

16 ft. Silt

5 ft. Blue-brown clay

Elevation at bottom of hole 691 feet

Drill hole 50

Location  $SW\frac{1}{4}$  of the  $NE\frac{1}{4}$  of Sec. 2, T. 22N., R. 19E.

Elevation at top of hole 669 feet

2 ft. Clay soil and sod

16 ft. Red, clay till

2 ft. Silty clay (wet)

Elevation at bottom of hole 649 feet

Drill hole 51

Location  $SW\frac{1}{4}$  of the  $SW\frac{1}{4}$  of Sec. 11, T. 22N., R. 19E.

Elevation at top of hole 668 feet

8 ft. Till, stoney red

14 ft. Silty clay (8 feet in water)

Elevation at bottom of hole 646 feet

Drill hole 52

Location  $NE\frac{1}{4}$  of the  $NE\frac{1}{4}$  of Sec. 27, T. 22N., R. 19E.

Elevation at top of hole 662 feet

4 ft. Till, red

16 ft. Silty clay

3 ft. Silt in water

Elevation at bottom of hole 639 feet

Drill hole 53

Location  $SW\frac{1}{4}$  of the  $NE\frac{1}{4}$  of Sec. 13, T. 22N., R. 19E.

Elevation at top of hole 642 feet

6 ft. Till, red, stoney

12 ft. Clay, red-brown, very dense

Elevation at bottom of hole 624 feet

Drill hole 54

Location  $SE\frac{1}{4}$  of the  $SE\frac{1}{4}$  of Sec. 19, T. 23N., R. 20E.

Elevation at top of hole 642 feet

6 ft. Till, red, stoney

13 ft. Clay, silty (in water)

Elevation at bottom of hole 623 feet

Drill hole 55

Location SW $\frac{1}{4}$  of the SE $\frac{1}{4}$  of Sec. 24, T. 23N., R. 22E.

Elevation at top of hole 685 feet

8 ft. Till, stoney red

12 ft. Clay, blue-brown

2 ft. Clay, brown (in water)

Hole stopped by stones - possibly bedrock

Elevation at bottom of hole 663 feet

Drill hole 56

Location SW $\frac{1}{4}$  of the SE $\frac{1}{4}$  of Sec. 1, T. 24N., R. 22E.

Elevation at top of hole 768 feet

1 ft. Soil, clayey

13 ft. Till, red, stoney

Hole stopped by stones - possibly bedrock

Elevation at bottom of hole 754 feet

Drill hole 57

Location SE $\frac{1}{4}$  of the NW $\frac{1}{4}$  of Sec. 25, T. 25N., R. 22E.

Elevation at top of hole 746 feet

1 ft. Soil, clayey

14 ft. Till, red, stoney

Hole stopped by stones - possibly bedrock

Elevation at bottom of hole 731 feet

Drill hole 58

Location NE $\frac{1}{4}$  of the NW $\frac{1}{4}$  of Sec. 36, T. 24N., R. 22E.

Elevation at top of hole 856 feet

8 ft. Till, red, stoney

3 ft. Till, brown-red, stoney

Hole stopped by stone - possibly bedrock

Elevation at bottom of hole 845 feet

Drill hole 59

Location SW $\frac{1}{4}$  of the SW $\frac{1}{4}$  of Sec. 12, T. 23N., R. 22E.

Elevation at top of hole 918 feet

2 ft. Silty soil

2 ft. Clayey silt mixed with red clay

Hole bottomed on stone - possibly bedrock

Elevation at bottom of hole 914 feet

Drill hole 60

Location SW $\frac{1}{4}$  of the SW $\frac{1}{4}$  of Sec. 1, T. 22N., R. 22E.

Elevation at top of hole 856 feet

1 ft. Clay soil

9 $\frac{1}{2}$  ft. Till, red, stoney

Hole stopped by stones - possibly bedrock

Elevation at bottom of hole 845 $\frac{1}{2}$  feet

Drill hole 61

Location SW $\frac{1}{4}$  of the SE $\frac{1}{4}$  of Sec. 22, T. 22N., R. 22E.

Elevation at top of hole 842 feet

6 $\frac{1}{2}$  ft. Till, stoney, red

Drill hole stopped by stones

Elevation at bottom of hole 835 $\frac{1}{2}$  feet

Drill hole 62

Location NW $\frac{1}{4}$  of the NE $\frac{1}{4}$  of Sec. 24, T. 22N., R. 22E.

Elevation at top of hole 823 feet

7 ft. Silty, sandy, very stoney, reworked till

Hole stopped by a large stone

Elevation at bottom of hole 816 feet

Drill hole 63

Location NW $\frac{1}{4}$  of the NE $\frac{1}{4}$  of Sec. 9, T. 23N., R. 22E.

Elevation at top of hole 802 feet

6 ft. Till, stoney, red

Drill hole stopped by stones

Elevation at bottom of hole 796 feet

Drill hole 64

Location SW $\frac{1}{4}$  of the NE $\frac{1}{4}$  of Sec. 22, T. 24N., R. 22E.

Elevation at top of hole 832 feet

5 $\frac{1}{2}$  ft. Till, stoney red

Elevation at bottom of hole 827 $\frac{1}{2}$  feet

Drill hole 65

Location NW $\frac{1}{4}$  of the NW $\frac{1}{4}$  of Sec. 32, T. 22N., R. 22E.

Elevation at top of hole 918 feet

1 ft. Clayey soil

8 ft. Till, red, stoney

2 ft. Clay, red, brown

3 ft. Clay, gray-brown

6 ft. Clay, brown, dense

A stone wedged in the hole stopped the progress of the drill

Elevation at bottom of hole 898 feet

Drill hole 66

Location SE $\frac{1}{4}$  of the SW $\frac{1}{4}$  of Sec. 8, T. 22N., R. 22E.

Elevation at top of hole 870 feet

1 ft. Clay soil

10 ft. Till, stoney, red

3 ft. Brown, silty clay

Hole stopped by stone - possibly bedrock

Elevation at bottom of hole 856 feet

Drill hole 67

Location SW $\frac{1}{4}$  of the SW $\frac{1}{4}$  of Sec. 20, T. 23N., R. 22E.

Elevation at top of hole 800 feet

1 ft. Soil, clayey

13 ft. Till, red, stoney

Hole stopped by stone wedged in drill hole

Elevation at bottom of hole 786 feet

Drill hole 68

Location SE $\frac{1}{4}$  of the NW $\frac{1}{4}$  of Sec. 15, T. 22N., R. 22E.

Elevation at top of hole 902 feet

7 ft. Till, stoney, red

Hole stopped by concentration of stones in till

Elevation at bottom of hole 895 feet



Drill hole 69

Location NW $\frac{1}{4}$  of the NW $\frac{1}{4}$  of Sec. 33, T. 22N., R. 21E.

Elevation at top of hole 948 feet

7 $\frac{1}{2}$  ft. Till, stoney, red

Drill hole stopped by stones

Elevation at bottom of hole 941 $\frac{1}{2}$  feet

Drill hole 70

Location NE $\frac{1}{4}$  of the NW $\frac{1}{4}$  of Sec. 24, T. 21N., R. 21E.

Elevation at top of hole 878 feet

6 ft. Till, stoney, red

Hole stopped by stones

Elevation at bottom of hole 872 feet

Drill hole 71

Location SE $\frac{1}{4}$  of the SE $\frac{1}{4}$  of Sec. 28, T. 22N., R. 22E.

Elevation at top of drill hole 871 $\frac{1}{2}$  feet

1 ft. Black silty topsoil

4 ft. Brown sand

3 ft. Brown gravelly clay

3 $\frac{1}{2}$  ft. Silt

5 $\frac{1}{2}$  ft. Clayey silt

30 ft. Gravelly silt

6 ft. Gray sand and gravel

8 ft. Gray silty clay

Elevation at bottom of drill hole 811 $\frac{1}{2}$  feet

Drill hole 72

Composite of three drill holes on the south side of the City of DePere in what would be the Sec. 27, T. 23N., R. 20E.

2-8 ft. Fine sand and gravel

40-50 ft. Red and brown clay

2-3 ft. Fine sand

20-25 ft. Red clay

5-6 ft. Dolomite

## APPENDIX 2

### Sand and gravel pits and quarries

Following is a partial list of examples of sand and gravel pits, and quarries found in various portions of Brown County. This list is by no means complete, but does give a guide to the various types of deposits present in the county. Refer to the materials province descriptions and the materials province map (Fig. 1) for more complete overall guide as to areas favorable and unfavorable for obtaining road construction aggregate.

Sand and gravel pits (Locations 8-9, 8-10, 5, 8, 42, 43, 44)  
Location Sec. 36, T. 22N., R. 22E.

All these locations are found in Section 36 within close proximity to one another. There are two small sand and gravel pits and several undeveloped areas. Again these deposits are found in terraces along and adjacent to the Meschota River. Generally this area in Section 36 has not been extensively developed. This area offers good possibilities for development into large volume sand and gravel deposits.

Following is a generalized section of the material found in these gravel pits.

2-6 ft. Stoney clay stripping  
4-8 ft. Sand, coarse to medium grained  
5-14 ft. Sandy gravel  
Rock content ranging from 15-30% having material  
generally not exceeding 2 inches in diameter

Gravel pits (Locations 6, 7, 41)  
Location SW of the SW $\frac{1}{4}$  of Sec. 25, and E $\frac{1}{4}$  of the SE $\frac{1}{4}$  of Sec. 26,  
T. 22N., R. 22E.

These three gravel pits encompassing almost 60 acres are found in terraces along the Meschota River. There are two terraces in the area. The working face extends from the water level of the river up into the second terrace. Material of these pits is washed sand and gravel with crusher sized

material available. These pits have been extensively worked and a limited yardage of material remains.

Following is a generalized description of the material found in these three pits.

- 1-6 ft. Stony clay till stripping
- 8-30 ft. Coarse sand and gravel containing from 30-70% of material above  $\frac{1}{4}$  inch in size with stones up to eight inches in diameter

Gravel pit (Location 52)

Location  $3\frac{1}{4}$  of the  $NE\frac{1}{4}$  of Sec. 22, T. 22N., R. 22E.

A sand and gravel pit along a low outwash terrace along the Neshota River. The pit is low and will be subjected to drainage problems. The pit contains coarse gravel and sand.

A typical section of this pit would show:

- 1-2 ft. Sandy soil stripping
- 6-10 ft. Crusher gravel with clean sand with from 40-60% of the material above  $\frac{1}{4}$  inch in size. Stones up to 10 inches in diameter

Gravel pit (Location 9)

Location  $SE\frac{1}{4}$  of the  $SE\frac{1}{4}$  of Sec. 22, T. 22N., R. 22E.

A gravel pit in an outwash containing an estimated 10,000 yards of coarse gravel. This pit is adjacent to the Neshota River.

- 2-3 ft. Stony red clay stripping
- 4-7 ft. Sand and gravel containing clay pockets with from 20-35% above  $\frac{1}{4}$  inch in diameter

Gravel pits (Locations 8-7, 48, 49, 50)

Location  $SW\frac{1}{4}$  of Sec. 3 (49 & 50) T. 22N., R. 22E.

$SE\frac{1}{4}$  of Sec. 4 (48)

$NE\frac{1}{4}$  of the  $NE\frac{1}{4}$  of Sec. 10 (8-7)

These four sand and gravel pits are found in terraces along the upper portions of the Neshota River. The pits are within close proximity to each other. The pits contain coarse gravel and sand. The area offers good prospects of developing additional sources of coarse aggregate as well as further working of

the existing pits.

A typical section of the pit is given as follows:

- 2-4 ft. Sandy, stoney stripping
- 6-10 ft. Coarse gravel with 30-50% of the material above  $\frac{1}{4}$  inch in size

Gravel pit (Location 45)

Location  $SW\frac{1}{4}$  of the  $SE\frac{1}{4}$  of Sec. 13, T. 23N., R. 22E.

Gravel pit in a low terrace along a valley floor which contains coarse gravel with an estimated 24,000 yards of material.

A generalized section for this location is given as follows:

- 1-2 ft. Sandy soil and dirty gravel
- 4-8 ft. Coarse gravel, containing 50-60% of material above  $\frac{1}{4}$  inch in size and has stones up to 6 inches in diameter

Gravel pits (Locations 17, 18, 19)

Location  $SE\frac{1}{4}$  of the  $NE\frac{1}{4}$  of Sec. 34, T. 25N., R. 22E. (17)

$NE\frac{1}{4}$  of the  $SW\frac{1}{4}$  of Sec. 26, T. 25N., R. 22E. (18)

$SW\frac{1}{4}$  of the  $NE\frac{1}{4}$  and

$SE\frac{1}{4}$  of the  $N\frac{1}{2}$  of Sec. 36, T. 25N., R. 22E. (19) Two pits

These four gravel pits are found in outwash drainage ways. The pits have extensively been worked. The area offers favorable possibilities for development of additional sources of coarse gravel.

A generalized section of the material found in these pits is given as follows:

- 1-3 ft. Stony clay stripping
- 6-20 ft. Coarse gravel (boulders up to 3 feet in diameter) and sand. The coarser material is near the top and the material becomes finer downward.

Quarries (Locations 46, 47)

Location  $NE\frac{1}{4}$  of the  $NE\frac{1}{4}$  of Sec. 26, T. 24N., R. 22E. (46)

$SW\frac{1}{4}$  of the  $N\frac{1}{2}$  of Sec. 20, T. 23N., R. 22E. (47)

Two small quarries in Niagara dolomite. Location 47 is not being used.

These quarries are found in an area east of the Niagara escarpment in places where the till cover is thin. Large yardages of dolomite are potentially available

under heavy stripping.

A generalized section for these two quarries is given as follows:

3-6 ft. Stoney, red clay stripping  
10-15 ft. Massive, bluish gray dolomite

Sand pits (Locations S-11, S-12, S-13, S-14)

These locations are found in the town of Preble in sections 33, T. 24N., R. 21E. and 3, T. 23N., R. 21E.

These four sand locations are found in an area underlain by sand and fine lake sediments. Numerous other unnumbered sand pits and undeveloped sand areas exist in the town.

Following is a generalized section for these four sand pits.

2-5 ft. Red, stoney, till stripping  
10-25 ft. Sand, fine to medium, contains thin lenses of gravel.  
Less than 15% above  $\frac{1}{4}$  inch in size

Quarries (Locations 3, 11, 25, 26, 28, 29, 33, 35, 36)

All the above locations are found along the edge of Niagara escarpment. These locations offer favorable sites for quarry operations. For example, a 30-40 foot working face is common, drainage is natural, and the quality of the stone is generally good.

Following is generalized description of the Niagara dolomite found at the above locations:

1-8 ft. Red, clay till stripping  
8-40 ft. Niagara dolomite, beds 2 inch to three feet in thickness, grayish white to bluish gray, some chert

Sand and gravel pits (Locations 23, 24, 30, 31, 32, 39, 40)

All the above locations are found in a belt along the edge of the escarpment. The material of these pits is sand, gravel, and silt that was deposited by ice up against the escarpment. The pits have been extensively worked and limited yardage of good material remains. The pits show a great variation in type of aggregate.

Following is a generalized description of the above locations:

- 4-12 ft. Red, stoney clay till
- 2-6 ft. Sand, fine to medium grained, sometimes stained red, lenses of gravel
- 4-15 ft. Coarse gravel 30-50% above  $\frac{1}{4}$  inch in size, lenses of silt, contains large dolomite slabs and boulders near the escarpment
- 5-15 ft. Sand and gravel, generally fine to medium sand, lenses of gravel, silt layers

Quarries (Locations 34, 37, 38)

- Location SE $\frac{1}{4}$  of the NW $\frac{1}{4}$  of Sec. 2, T. 22N., R. 21E. (34)
- SW $\frac{1}{4}$  of the SE $\frac{1}{4}$  of Sec. 34, T. 22N., R. 21E. (37)
- NE $\frac{1}{4}$  of the NE $\frac{1}{4}$  of Sec. 3, T. 21N., R. 21E. (38)

These locations are found in the area to the east of the Niagaran escarpment. The quarries involved are not being operated at this time. However these localities represent typical occurrences of Niagara dolomite in the till area east of the escarpment. A potentially large volume of dolomite is available but there will be heavy stripping. The dolomite is generally similar to other Niagara quarry locations.

Sand (Locations S-2)

Location NE $\frac{1}{4}$  of the NE $\frac{1}{4}$  of Sec. 29, T. 21N., R. 20E.

Small sandy kame which has no value for large scale road projects.

A section is given as follows:

- 5 ft. Red clay
- 2 ft. Silty gravel
- 1 ft. Sand
- 6 ft. Red clay
- 2 ft. Coarse sand

Sand (Location S-3)

Location NE $\frac{1}{4}$  of the NE $\frac{1}{4}$  of Sec. 29, T. 21N., R. 20E.

Small sand deposit which is of not any value for large scale road projects. The sand is a superficial deposit on the edge of the Niagara escarpment.

- 2 ft. Gravelly soil
- 8 ft. Sand, fine to medium, contains gravel lenses

Sand (Locations S-4, S-5, S-6)

Location  $SW\frac{1}{4}$  of the  $SW\frac{1}{4}$  of Sec. 2, T. 21N., R. 20E. (S-4)

$SE\frac{1}{4}$  of the  $SE\frac{1}{4}$  of Sec. 3, T. 21N., R. 20E. (S-5)

$SE\frac{1}{4}$  of the  $NW\frac{1}{4}$  of Sec. 3, T. 21N., R. 20E. (S-6)

The above three locations are small local deposits that do not offer good locations for large scale road projects. S-4 is being used as a dump. Locations S-5 and S-6 are undeveloped locations. The sand and gravel is local and of insufficient volume to provide for large reserves.

Sand and gravel (Locations 21, 53)

Location  $NW\frac{1}{4}$  of the  $N\frac{1}{2}$  of Sec. 9, T. 23N., R. 20E. (21)

$NW\frac{1}{4}$  of the  $NW\frac{1}{4}$  of Sec. 9, T. 23N., R. 20E. (53)

Two adjacent sand and gravel pits. These pits have been extensively worked and a limited amount of yardage remains. The area in which these pits are found does offer favorable possibilities for exploration for sand lift material. The pits contain layers of sand alternating with lenses of gravel.

Sand and gravel (Locations S-1, 22)

Location  $NW\frac{1}{4}$  of the  $SE\frac{1}{4}$  of Sec. 4, T. 23N., R. 20E. (S-1)

$SW\frac{1}{4}$  of the  $NE\frac{1}{4}$  of Sec. 4, T. 23N., R. 20E. (22)

These two locations are found in an area which has been platted.

~~They are~~ of no further value for road projects.

Gravel pit (Location 14)

Location  $NW\frac{1}{4}$  of the  $SW\frac{1}{4}$  of Sec. 17, T. 24N., R. 22E.

This gravel pit is found in an area east of the Niagaran escarpment consisting of reworked till. Sited for town road surfacing but not for other aggregate uses.

Gravel pit (Location 15)

Location  $NW\frac{1}{4}$  of the  $N\frac{1}{2}$  of Sec. 1, T. 24N., R. 21E.

A sand and gravel pit found in beach sands along the shore of Green Bay. The deposit is of insufficient volume and quality to provide for a large scale road project. A generalized section is given as follows:

2-3 ft. Sandy soil stripping  
4-6 ft. Sand with lenses of gravel  
2-6 ft. Sand (Into water table)

Former gravel pit (Location 16)

Location SW $\frac{1}{4}$  of the NW $\frac{1}{4}$  of Sec. 3, T. 22N., R. 24N.

This pit has been abandoned and filled in. It consisted of reworked till. No further value.

Sand and gravel pit (Location 10)

Location SE $\frac{1}{4}$  of the NE $\frac{1}{4}$  of Sec. 30, T. 25N., R. 19E.

A small sand deposit in extreme western Brown County. Insufficient volume and poor quality make this deposit unsuitable for any large scale road project.

Sand and gravel pit (Location 13)

Location SE $\frac{1}{4}$  of the NE $\frac{1}{4}$  of Sec. 14, T. 24N., R. 21E.

This location consists of an outcrop of Cincinnati shale. No value for road aggregate materials except for fill.

Quarries (Locations 1, 20)

Locations NW $\frac{1}{4}$  of the NW $\frac{1}{4}$  of Sec. 15, T. 24N., R. 20E. (1)

SW $\frac{1}{4}$  of the SW $\frac{1}{4}$  of Sec. 10, T. 24N., R. 20E. (20)

These two locations are quarries in the Niagara dolomite. Location 1 is abandoned and filled with water. Location 20 is the huge Duck Creek quarry. A generalized section of the dolomite found at Location 20 is given as follows:

1-2 ft. Clay, loamy stripping  
20-40 ft. Bluish gray dolomite, beds from 4 inches to three feet in thickness

Dune sand deposits (Locations 8-15, 8-16, 8-17, 8-18)

Locations SE $\frac{1}{4}$  of the SE $\frac{1}{4}$  of Sec. 31, T. 24N., R. 20E. (8-15)

NW $\frac{1}{4}$  of the SE $\frac{1}{4}$  of Sec. 30, T. 24N., R. 20E. (8-16)

NE $\frac{1}{4}$  of the SE $\frac{1}{4}$  of Sec. 33, T. 25N., R. 20E. (8-17)

SW $\frac{1}{4}$  of the SW $\frac{1}{4}$  of Sec. 28, T. 25N., R. 20E. (8-18)

These four locations are typical of the type of dune sand sources that are present in northwest Brown County. The sand is fine and contains no material



over  $\frac{1}{2}$  inch in diameter. Seventy-five to eighty percent of the material is retained on the Number 50 screen size.

Sand and gravel pit (Location 2)

Location NE $\frac{1}{4}$  of the NE $\frac{1}{4}$  of Sec. 11, T. 25N., R. 19E.

A small gravel pit in outwash along a drainageway. Material found is fine with little material over 4 inches in diameter.

Gravel pits (Locations 54, 56)

Locations Middle of Sec. 13, T. 25N., R. 19E. (54)

NE $\frac{1}{4}$  of the SE $\frac{1}{4}$  of Sec. 15, T. 25N., R. 19E. (56)

Two large gravel pits found in Valdres age delta kames. There is great variation in the size of material, and the type of material found. Pockets of silt, zones of coarse gravel, layers of sand are found intermixed. These deposits were formed from stagnating Valdres ice.

Undeveloped locations 57, 58

Locations SE $\frac{1}{4}$  of the NW $\frac{1}{4}$  of Sec. 22, T. 25N., R. 19E. (57)

SE $\frac{1}{4}$  of the NW $\frac{1}{4}$  of Sec. 23, T. 25N., R. 19E. (58)

Two undeveloped locations in low terraces along streams which are tributaries to the Suamico River. The deposits are stream deposits and are of insufficient volume to provide for large scale road projects.

Sand and gravel pit (Location 55)

Location SE $\frac{1}{4}$  of the SE $\frac{1}{4}$  of Sec. 28, T. 25N., R. 20E.

A gravel pit found adjacent to the present route of USH 41. The pit can not be extended because of the close proximity of the Highway. The deposit contains sand, coarse sand, and limited amounts of fine gravel.

Sand (Location S-19)

Locations E $\frac{1}{4}$  of the SE $\frac{1}{4}$  of Sec. 17, T. 25N., R. 20 E.

SW $\frac{1}{4}$  of Sec. 16, T. 25N., R. 20E.

A large volume dune sand deposit containing fine Eolian sand. No development has taken place at this location.

Sand (Location S-20)

Location NW $\frac{1}{4}$  of the NE $\frac{1}{4}$  of Sec. 20, T. 23N., R. 20E.

A developed pit containing coarse sand and medium sand. A portion of this pit is being used as a dump. The location contains an estimated 60,000 yards of reserve.

Sand (Location 8-21)

Location NE $\frac{1}{4}$  of the SE $\frac{1}{4}$  of Sec. 28, T. 25N., R. 20E.

An undeveloped sand location across USH 41 from previously reported location 55. Seventeen feet of sand were revealed in a drill hole at this location. The location is adjacent to the present route of USH 41.

Sand and gravel pits (Location 59)

Location S $\frac{1}{2}$  of the NW $\frac{1}{4}$  of Sec. 12, T. 25N., R. 19E.

NE $\frac{1}{4}$  of the SW $\frac{1}{4}$  of Sec. 12, T. 25N., R. 19E.

A location composing three shallow gravel pits in a valley of a tributary of the Sumico River. A typical section is given as follows:

- 1 ft. Sandy, clay soil
- 2-4 ft. Silty, clay-bound coarse gravel
- 2-6 ft. Gravelly sand, stratified horizontally

Gravel pits (Locations 60, 61)

Locations SW $\frac{1}{4}$  of the SW $\frac{1}{4}$  of Sec. 23, T. 21N., R. 20E. (60)

NE $\frac{1}{4}$  of the NE $\frac{1}{4}$  of Sec. 23,  
NW $\frac{1}{4}$  of the NW $\frac{1}{4}$  of Sec. 24,) T. 21N., R. 20E. (61)

Two gravel pits in reworked moraine that are suitable mainly for surfacing town roads.

Quarry (Locations 62, 63)

Locations SW $\frac{1}{4}$  of the NE $\frac{1}{4}$  of Sec. 27, T. 23N., R. 19E. (62)

SW $\frac{1}{4}$  of the SW $\frac{1}{4}$  of Sec. 30, T. 23N., R. 20E. (63)

These two locations are found in the Galena dolomite. They are found in areas where stream erosion has removed all or part of the overlying red Valders Till. A typical section is given as follows:

- 4-15 ft. Red, clay till stripping
- 15-25 ft. Blue-gray dolomite, beds from 4 inches to three feet in thickness, contains thin shale partings

Sand and Gravel pits (Number 64)

Location Sec. 35, T. 24N., R. 21E.

This location consists of several pits in Section 35. The material consists of coarse sand and gravel overlying sand. A typical section is given as follows :

- 3-14 ft. Red, clay till stripping
- 4-15 ft. Coarse sand and gravel with 20-50% of the material above  $\frac{1}{2}$  inch in diameter
- 3-4 ft. Gravelly sand containing less than 20% of the material above  $\frac{1}{2}$  inch in diameter
- 10-20 ft. Sand, medium grained towards the top becoming finer grained downward

## APPENDIX 3

### Road cuts and natural exposures

Following is a partial list of examples of natural exposures of glacial materials and bedrock outcrops in various portions of Brown County. This list is by no means complete, but does give a guide to the type of evidence that is obtainable by checking road cuts and natural exposures.

1. Location NE $\frac{1}{4}$  of the SE $\frac{1}{4}$  of Sec. 36, T. 22N., R. 22E. - Road cut  
2 ft. Clayey, silty soil  
7 ft. Coarse, fairly clean gravel  
This material is exposed in a gravel terrace near Denmark, Wisconsin.
2. Location SW $\frac{1}{4}$  of the NW $\frac{1}{4}$  of Sec. 25, T. 25N., R. 22E. - Road cut  
1 $\frac{1}{2}$  ft. Clayey soil  
5 ft. Clayey, gravelly till  
This is reworked till along the edge of a drainage way
3. Natural outcrop of Niagara dolomite in the SE $\frac{1}{4}$  of the NE $\frac{1}{4}$  of Sec. 29, T. 25N., R. 22E., where 8-10 feet of badly weathered, light-gray to buff dolomite are exposed in the edge of the escarpment. This exposure is typical of those found along the edge of the escarpment.
4. Road out exposure. An exposed face of 3-4 feet of severely weathered Niagara dolomite is found in the SW $\frac{1}{4}$  of the SW $\frac{1}{4}$  of Sec. 27, T. 25N., R. 22E. This exposure is found along the north edge of a bedrock controlled hill that rises 80 feet above the level of the land to the north, which is floored by dolomite. This exposure and the hill in which it occurs is an excellent site of Niagara dolomite occurring in an area east of the escarpment. The hills are covered by till, but the major cause of topographic relief is the bedrock occurrence in the hills.
5. Location NE $\frac{1}{4}$  of the NE $\frac{1}{4}$  of Sec. 26, T. 24N., R. 22E. - Road cut  
Four feet of stoney, red, Valdres till is exposed on the west side of CTR P. This is a typical road cut exposure of till in the part of Brown County east of the Niagaran escarpment.
6. Road out - Along both sides of CTR T in the SE $\frac{1}{4}$  of Sec. 33, and the SW $\frac{1}{4}$  of Sec. 34, T. 23N., R. 22E., stoney red Valdres till is exposed in the road cut.
7. Example of well record - Location SE $\frac{1}{4}$  of the SE $\frac{1}{4}$  of Sec. 23, T. 21N., R. 19E.  
8 ft. Red, clay, Valdres till  
76 ft. Cincinnati shale

8. Location NE $\frac{1}{4}$  of the NE $\frac{1}{4}$  of Sec. 20, T. 23N., R. 22E. - Road out  
Four feet of stoney, red, Valdars till is exposed in a road out on the north side of STN 29
9. Location SW $\frac{1}{4}$  of the NW $\frac{1}{4}$  of Sec. 34, T. 23N., R. 21E. - Road out  
Five feet of stoney, red, Valdars till is exposed on the north side of CTH NM. This is just one of many such exposures along CTH NM between Kolb and USN 141.
10. Bedrock natural exposure - Location SE $\frac{1}{4}$  of the SE $\frac{1}{4}$ , Sec. 31, T. 23N., R. 22E.  
Niagara dolomite is exposed in the stream bed of the Neeshota River. This occurrence of dolomite is typical of those found elsewhere in stream beds where erosion has exposed ledges of dolomite.
11. Location NW $\frac{1}{4}$  of the NE $\frac{1}{4}$  of Sec. 34, T. 21N., R. 19E. - Road out outcrop  
Exposure in ditch of Cincinnati shale on the west side of CTH D. Surface beds of blue-green shale are exposed at this point.
12. Location SE $\frac{1}{4}$  of the NW $\frac{1}{4}$  of Sec. 17, T. 24N., R. 22E. - Road out  
Four feet of stoney, red, Valdars till is seen. This is a typical exposure of till in this part of Brown County.
13. Location NW $\frac{1}{4}$  of the SW $\frac{1}{4}$  of Sec. 11, T. 21N., R. 19E. - Road out  
Four feet of red, clayey till is exposed in a road out on the east side of CTH D.
14. Location - Sections 14, 23, 25, 26, T. 21N., R. 19E. - Stream out exposure  
Plum creek has eroded outcrops which in several places expose red, clayey, Valdars till.
15. Location SW $\frac{1}{4}$  of the SE $\frac{1}{4}$  of Sec. 34, T. 23N., R. 21E. - Natural outcrop  
Blue-gray Niagara dolomite outcrops in a stream bed where the overlying Valdars till have been removed.
16. Location E $\frac{1}{2}$  of the SW $\frac{1}{4}$  of the SW $\frac{1}{4}$  of Sec. 15, T. 23N., R. 21E. - Natural outcrop  
Two to three feet of Cincinnati Shale outcrop in a creek bed. Shale and dolomite beds are exposed that are thinly bedded.
17. Location NW $\frac{1}{4}$  of the NE $\frac{1}{4}$  of Sec. 14, T. 21N., R. 20E. - Road out  
Five feet of stoney, red, Valdars till is seen in a road out on the west side of a town gravel road.
18. Location SE $\frac{1}{4}$  of the NE $\frac{1}{4}$  of Sec. 14, T. 24N., R. 21E. - Outcrop  
Cincinnati shale is exposed in a gully where eight feet of thin bedded blue-green beds of shale are seen.
19. Location SW $\frac{1}{4}$  of the NW $\frac{1}{4}$  of Sec. 33, T. 24N., R. 21E. - Road out  
Eight feet of fine sand and silt are exposed in this out. The area is in the Town of Preble and is typical of the type of exposure that can be found in this area.

20. Location SW $\frac{1}{4}$  of the NW $\frac{1}{4}$  of Sec. 25, T. 22N., R. 19E. - Road cut  
A nine foot exposure of red, clayey, Valdars till is seen in a stream bank on the west side of CTH D. This exposure is typical of those found on the west banks of the Fox River.
21. Location - Sec. 10, T. 23N., R. 21E. - Information of landowners  
According to verbal information from owners of property in section 10 the depth of bedrock is between 122-135 feet. Several people were asked about wells and all responses were in the above range of depth.
22. Location NE $\frac{1}{4}$  of the NW $\frac{1}{4}$  of Sec. 7, T. 21N., R. 21E. - Natural exposure of Niagara dolomite  
Surface exposure of dolomite in a creek bed. There is no section as just the surface of the dolomite is seen.
23. Location in the Williams Grant on both sides of USH 41, .4 mile south of Lawrence School - Stream out  
Five feet of clayey, red, Valdars till is exposed in the banks of a stream.
24. Location SW $\frac{1}{4}$  of the SW $\frac{1}{4}$  of Sec. 11, T. 22N., R. 20E. - Stream out  
Nine feet of red, clayey till exposed in a stream out. This material is exposed in an area northwest of the escarpment in a dissected area.
25. Location NE $\frac{1}{4}$  of the NE $\frac{1}{4}$  of Sec. 34, T. 22N., R. 22E. - Road out  
Road out exposed the following material:  
1 ft. Clayey soil  
2 ft. Red, clayey, stoney till (Valdars)  
3 ft. Silty, sandy, clay (Cary till?)
26. Location NE $\frac{1}{4}$  of Sec. 31, T. 23N., R. 20E. - Stream out  
Five to eight feet of red, clayey till is shown in the banks of a stream on the southeast side of USH 41. Numerous exposures of till exist in stream eroded banks in southwestern Brown County.
27. Location NW $\frac{1}{4}$  of the NW $\frac{1}{4}$  of Sec. 12, T. 22N., R. 20E. - Road cut  
An exposure on the northeast side of a town gravel road, red, clayey till is shown overlying fine lake sand. This out is found in the dissected terrace northwest of the escarpment.
28. Location SW $\frac{1}{4}$  of the SW $\frac{1}{4}$  of Sec. 29, T. 23N., R. 21E. - Natural outcrop  
Shaley, fossiliferous, Niagara dolomite along the lower part of the Niagaran escarpment.
29. Location SE $\frac{1}{4}$  of the NE $\frac{1}{4}$  of Sec. 26, T. 24N., R. 19E. - Road out  
Exposed 3-4 feet of fine, silty sand. Lake sediment exposures will be very common in this part of Brown County.

30. Location  $N\frac{1}{2}$  of the  $W\frac{1}{2}$  of Sec. 18, and  $N\frac{1}{2}$  of the  $W\frac{1}{2}$  of Sec. 17, T. 25, R. 20E.  
Outcrop of Galena-Flatville dolomite

Galena-Flatville dolomite is exposed in the stream bed of the Sumner River just east of Flintville. The river flows over ledges of dolomite.

31. Location  $N\frac{1}{2}$  of the  $W\frac{1}{2}$  of Sec. 28, T. 23N., R. 21E. - Natural outcrop  
Cincinnati shale outcrop. A three foot face of thin bedded, soft, shale is exposed.

32. Location  $SE\frac{1}{4}$  of the  $SE\frac{1}{4}$  of Sec. 36, T. 24N., R. 19E. - Road cut  
Red, clayey till overlying fine lake sediments.

33. Natural exposure.

There is practically no red drift covering the Niagara dolomite in the  $SE\frac{1}{4}$  of Sec. 31, T. 23N., R. 21E. and the  $W\frac{1}{2}$  of Sec. 6, T. 22N., R. 21E. The ice moving over the escarpment either was too thin to deposit much till or the till have been removed by subsequent erosion.

34. Road cut

Along both sides of CTH P in Sections 26 and 25, T. 25N., R. 22 E., a very stoney (stones up to 8 inches in diameter), clayey, silty gravel is exposed. The rock is dolomite in a clay-silt matrix. This is an alluvial deposit along a drainage way.

35. Location  $N\frac{1}{2}$  of  $W\frac{1}{2}$  of Sec. 32, T. 25N., R. 20E. - Surface exposure of fine, dune sand

A surface exposure of fine, silty dune sand. Dune sand exposures shown both as surface blowouts and in road cuts are very common in northwestern Brown County.