Management Plan and Aggregate Resource Notes for the Proposed Industrial Township Gravel Pit, St. Louis County, Minnesota

Project 334-30
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The above photograph shows the texture of the sand and gravel excavated at test hole 9 at the Industrial Township Site. The black bars on the scale are one inch long. The photo was taken October 23, 2006.

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INTRODUCTION

A field investigation by a MN DNR Lands and Minerals (LAM) geologist in 2006 identified a potentially commercial deposit of crushable aggregate in part of the southeast quarter of the southeast quarter of Section 16, T. 51N., R. 17W., Industrial Township, St. Louis County (Figure 1). An estimated 130,000 cubic yards of crushable cobble-rich aggregate, plus significant quantities of sand, may be extractable from about 11.9 acres.

This site, the Industrial Township Site, is about 1.3 miles east of the village of Burnett, Minnesota and 1 mile west of State Highway 33. County Road 7 parallels the northern lease boundary and provides public road access to the site. The site is on School Trust Land administered by MN DNR Forestry at the Cloquet, Minnesota office.

DNR plans to offer an Earth Materials Lease to allow extraction and processing of aggregate at this site. The lease will be awarded to the successful applicant in a competitive bid process.

This report consists of two sections: 1) Pit Management Plan and, 2) Resource Notes; they provide information specific to the Industrial Township Site. The lessee and land manager may use this report as a guide in planning and development of the pit. The Resource Notes section includes data and interpretations generated by DNR geologists.

PIT MANAGEMENT PLAN

Lease Area

The lease area covers approximately 11.9 acres (Figure 1). The lease boundary closely represents the approved ultimate pit limits and area of disturbance for this deposit. The lease boundary extends to the southern and eastern property lines. The landowner to the south has had the property line along the southern portion of the lease area surveyed and placed several pins along the common property line. The boundary to the north is constrained by the road setback and to the northeast and west is constrained by buffers to wetlands and Beartrap Creek, a designated trout stream. There are no wetlands within the lease boundary.

Much of the entire lease area is variably populated with small trees. A portion of the lease area along the west side and north side contains more mature trees.

Timber damages for the entire 11.9 acres of the lease area will be determined by DNR Forestry and included in the billing when the lease is issued.

There is a steep slope near the western part of the lease that has semi-mature trees. This slope dips to the west toward Beartrap Creek. Timber management and mining in this area will require different protocol to recover the significant resource there. Disturbances on the lower part of the slope within 50 feet of the base of the slope are prohibited. Additional details are provided in the Specific Provisions section below.

Permits

A permit may be required from DNR Division of Ecological and Water Resources if dewatering actions are proposed. Written approval for dewatering is also required from the Division of Forestry area forester in the Cloquet office, who is the land manager in the district of this lease. Ditching outside the lease boundary is prohibited. Burning permits are required before anything is burned.

A conditional use permit for extractive uses is not required for state lands.

All applicable State permits are required, such as a Pollution Control Agency Stormwater Permit, for example.

Mining Plan

The mining goal is to extract all of the available marketable aggregate within the lease area and to ensure that phased reclamation occurs in logical areas as the operation progresses.

Extraction of the best grade of material, also known as high-grading, is not allowed. An example of high-grading would be where an operator mines a relatively small seam of

high-value material while leaving behind very significant quantities of material adjacent that have become unmarketable due to the area being high-graded. DNR expects the lessee will manage the pit for the long-term so that all of the lease area can be eventually mined by the lessee.

Beartrap Creek, located west of the lease area, is a designated trout stream (Figure 1). If pit operations are not staged carefully there is a risk that runoff from stormwater could leave the lease area somewhere along the western lease boundary. Some specific risks would be 1) stormwater that funnels toward the access road at the northwest part of the lease and 2) when mining activities approach the western boundary. DNR expects the lessee will pay special attention to minimize the risk.

DNR does not expect that significant quantities of aggregate occur below water within the lease area. The lease states mining shall stay 3 feet above water. In the future if the Lessee determines there may be significant marketable aggregate below water, Lessee shall indicate their intent to mine below water to the land manager before doing so anywhere on the lease. The lessee shall submit for consideration a brief plan including locations, depth, and timing for written approval from the land manager. An onsite meeting with a LAM geologist may substitute for the brief plan. At that time the DNR may provide additional guidance or stipulations related to the eventual character of those future wetlands or ponds.

Site preparation

The lessee shall clear the trees from any areas scheduled for mining as they desire, as long as the vegetative ground cover remains intact. In preparation for expected mining in the upcoming year, the lessee shall salvage the ground cover and topsoil to a depth of at least 5 inches. Lessee should strip and prepare only enough area to cover what they expect to mine in the coming season. This best management practice is intended to reduce the risk for erosion and establishment of weeds. Burning permits are required if anything is to be burned. Lessee shall add the ash to the reserved topsoil piles.

The lessee shall strip and preserve at least the top five inches of soil, even if the actual thickness of the topsoil is less, and preserve it in piles, mounds, or windrows within the lease area. Windrows shall not be placed against or inside the tree line. If areas are encountered where the topsoil is thicker than five inches, the entire topsoil layer shall be salvaged. The lessee shall also include the varied vegetative debris and short vegetation that may be present into the salvaged soil piles. The lessee shall seed the salvaged topsoil piles and other stripping materials within 60 days of placement unless they are to be used for reclamation within 60 days of placement. Seeding protocol is described in the reclamation section below. These piles will eventually be spread over the disturbed areas for final reclamation.

Stripping should not occur earlier than 30 days before mining is to occur, especially during the growing season. The amount of land cleared and stripped should approximately match the amount of land expected to be mined during that calendar year to reduce the risk of weed infestations.

Lessee shall leave a 50 foot buffer of intact trees, brush, and other vegetation between the right of way of County Road 7 and the pit. The buffer is intended to provide a visual barrier to the pit and also restrict unauthorized access and does not encumber significant quantities of aggregate resources.

Lessee shall take precautions to prevent stormwater runoff generated on disturbed lands within the lease area from entering the low lands just west of the lease area, which lead to Beartrap Creek. Additionally, special precautions are required when working near the west side of the lease area (see Specific Provisions below).

Mine sequencing

DNR expects that mining will generally progress in a logical manner that allows for phased reclamation. To accomplish this, DNR expects that the lessee's mining plan considers mining certain areas ahead of others so as to create a pit edge that can be permanently reclaimed at an early date. High-grading is not allowed. This means that DNR expects that certain portions of the site will be mined to the deposit boundary, mine boundary, economic limit, or other logical edge prior to significantly expanding into other areas.

Events that may occur late in the mine life include mining in the vicinity of the steep bank at the west side of the lease (to more easily address erosion control) and mining near the southern property line. DNR encourages the lessee to mine to or through the southern property line with permission of the affected landowner. LAM geologists are available to hear concerns and alternate proposals.

Specific provisions

Lessee will be required to fence areas, or otherwise prevent access to mining areas upon request of the land manager if they are deemed unsafe to the public. The lessee shall gate the entrance into the pit.

The lessee is required to manage storm water so that it stays within the pit perimeter. Settling basins are permissible.

There is a buffer of about 30 feet or more between wetlands and the lease boundary. The lessee shall manage their activities so that at least three (horizontal) to one (vertical) final sloping (3:1) can be accomplished in final reclamation without encroaching on the buffers between the pit and the wetlands. Rounding of the top of the slope to blend with surrounding terrain may occur within the buffer. Unmarketable materials, except topsoil, may be used to backfill against steep slopes for reclamation.

DNR encourages that when mining activities occur near any wetlands, that those activities be completed in a single mining episode so that those localized areas can be reclaimed the same year as the disturbance. This will lessen impacts to species dependent on those wetlands. This is a DNR goal and is not mandatory.

Lessee shall, to the extent that is logical and reasonable, stage their work so that specific areas can be completely mined out and no longer needed for staging so that those areas can be permanently reclaimed.

Reclamation of depleted or mined-out areas, unless needed for staging, shall be completed before winter or no later than June 1st of the following year.

Steep slope—west side of lease

DNR expects the lessee will manage pit operations to effectively eliminate the chance of a direct discharge of stormwater to the west into the low land adjacent to Beartrap Creek. One technique that could be considered and is approved would be to mine westward from inside the pit. Topsoil and vegetation on the steep slope would not be stripped prior to mining. As the area is mined westward, topsoil, root wads, and other vegetative debris would slide into the pit as the soils are undercut by mining. Lessee shall salvage reasonable amounts of these topsoil and debris mats into the topsoil piles. Mining westward shall cease, at least temporarily, when the natural berm between the pit and the steep slope is lowered to about 5 feet. At this point, mining further west is prohibited until the pit floor adjacent to the berm is lowered, effectively increasing the height of the berm. Lessee shall also be cognizant and proactive of the risk that stormwater from within the pit could flow parallel to the natural berm and flow toward Beartrap Creek at a low point in the berm or near the access to the highway, where elevations are lower.

There is a buffer of at least 50 feet between the western lease boundary and the toe of the steep slope. Lessee shall ensure there are no disturbances of any kind beyond the lease boundary in this area and the trees within the buffer remain.

Invasive Species

The lessee will be obligated to control or eradicate noxious weeds according to Minnesota Statute Chapter 18.75-18.91 and, if directed by the land manager, certain other weeds consistent with site management plans and DNR Operational Order 113.

The Minnesota Department of Agriculture defines the species covered under the noxious weed law and which should be controlled and which should be eradicated. Currently they list 26 terrestrial plant species that are covered by the law on the following web link:

http://www.mda.state.mn.us/plants/badplants/~/media/Files/plants/weeds/noxiouslists.ashx

Primary directives of the DNR Operational Order 113 are to “enter clean and leave clean” and enter weed-infested areas last and clean before leaving the infested areas to minimize the risk of spreading invasive species to non-infested areas.

Reclamation

One of the goals of reclamation is to return the site to forest. Another goal is to provide landscaping that encourages infiltration of precipitation and discourages runoff. Infiltration helps sustain the health of Beartrap Creek.

All reclamation costs are borne by the lessee. The upland areas shall be reclaimed to a condition consistent with timber production. This includes shaping banks to blend with adjacent topography and placement of excess stripping, if available, and the reserved topsoil. Lessee may be directed to place excess non-granular stripping in certain areas, such as the steeper slopes, to enhance vegetative growth.

Topsoil will be spread on all mined and significantly disturbed areas ready for reclamation. Temporary reclamation, which could include placement of topsoil, may be required on areas experiencing long periods of inactivity if directed by the land manager, even if those inactive areas may undergo future mining. As stockpiles of topsoil increase, judgments will be made on how much topsoil should be placed in different areas receiving reclamation. When five inches of topsoil are effectively salvaged prior to mining, there should be sufficient topsoil to spread to an average depth close to five inches. There should be no bare spots in areas that receive four to five inches of topsoil dressing.

Topsoil shall be spread to an average depth of at least two inches, at minimum, in areas ready for revegetation. This means, after spreading with heavy equipment, that most locations should have at least two inches, some locations will have three or four inches, and small areas on the order of about ten square feet or less may have less than one inch of topsoil or be barren.

Reclamation in areas where gravel is mined below the water table, if applicable and approved, shall include gentle sloping into the water to a depth of five feet for public safety.

Seed mixes: temporary and permanent

Cool season temporary seed mixes Mn/DOT #100 (winter wheat), #110 (oats), and #150 are recommended for seeding the topsoil and other stripping stockpiles and any other disturbed areas benefiting from temporary vegetative stabilization. Additional seeding may be required if the existing cover is inadequate to prevent establishment of invasive weeds and erosion. Re-seeding on an annual basis may be necessary when Mn/DOT mixes #100 and #110 are used.

DNR shall approve the seed mix to be used for final reclamation. The seed mix and protocol for establishment of permanent vegetation will be evaluated when portions of the pit are eligible for permanent reclamation and when the pit is about to exceed ten acres in size. Factors to consider at that time may include reforestation options, and other currently unknown land use considerations with the fundamental goal of generating current or future revenue. MN State Seed Mix 36-311 (Woodland Edge NE) is approved at this time.

RESOURCE NOTES

Fieldwork

A DNR geologist completed 17 test holes in the lease area in summer and fall of 2006 (Figure 2). Three other holes, holes 6 through 8 were dug some distance north of the highway on state land but are not depicted in Figure 2 and are not discussed further, although information about them is in the appendices. Holes 1 through 5 were completed with a Hyundai 110-7 Excavator to a maximum depth of 14 feet. Holes 9 through 20 were drilled with a Mobile B80 drill truck with 10 inch solid stem auger. Hole 1 was deepened by drilling. The deepest hole (#9) was drilled to a depth of 36 feet, and 8 other holes (10, 11, 13, 14, 16, 17, 19, 20) were drilled to at least 30 feet. Geologic logs of the test holes and gradation (sieve) data are presented in Appendices 1 and 2, respectively. GPS coordinates for the test holes are presented in Appendix 3.

Lab Work

DNR personnel in Hibbing sieved 33 raw samples from the 17 test holes for gradation analysis following Mn/DOT sieving protocol.

Data Summary

The DNR interpretation is that marketable aggregate occurs to or beyond the red lease outline depicted in Figures 1 and 2. Highest uncertainty is in the vicinity of the wetland northeast of the lease area and the lease area paralleling the highway. The property lines and buffers to wetlands and the road constrain the extent of the lease boundary. DNR does not anticipate any mining beyond the lease boundary.

The gravel deposit appears consistent with typical gravel deposits of the North Shore of Lake Superior in terms of kinds (or colors) of gravel and sand contained within the deposit.

This gravel deposit varies both laterally and with depth. Descriptions of the test holes are found in Appendix A. In all test holes a coarse, often cobble-rich gravel of variable thickness is the uppermost aggregate layer encountered. This layer ranges from 3.5 to 16 feet in thickness (Figure 2). It is thinnest in the north central part of the lease area. A gravelly sand or well graded sand (no or very little +3/4") occurs beneath the coarse gravel in about half of the holes, and beneath that, or directly beneath the coarse gravel in the holes where gravelly sand is absent, a medium to fine sugar sand occurs. The sugar sand grades with depth in most holes to very fine sand at depths typically around 30 feet.

Loamy sand to sandy loam overburden ranging in thickness from 0 to 8 feet overlies the coarse aggregate (Figure 2). The overburden is 2 feet or less in 9 of the test holes. The overburden appears to be thickest in the swales and other low areas. The site is quite hummocky. The overburden may be amenable to blending with the gravel to make road base.

Sieve results indicate the percent crushable (+3/4 inch) in the uppermost coarsest gravel ranges from 7% in test hole 10 to a high of 56% in test hole 14, with more than half of the holes containing crushable values greater than 25% (Appendix B). Because of the high rock content in most of the gravel, the sands beneath the coarse gravel may be amenable to blending with the gravel depending on the commodities desired.

Sieve results indicate the minus 200 fraction from the uppermost coarse gravel ranges from 1.0 to 4.4% except in test holes 13, 14, and 17 where the minus 200 ranges from 6.1 to 10.6% (Appendix B). Most of the samples of the fine gravel to graded sand intervals were less than 3% minus 200. The minus 200 fractions for the sugar sand and fine sand intervals ranges from 2.6 to 46.1%. These intervals had nearly 100% passing the #10 sieve.

No quality tests were done on the samples. No hardness tests were run on the pebbles. No potentially deleterious rocks or spall were observed in the field.

Water Levels

Water table was not encountered in any of the test holes except possibly test hole 5. Test holes 17, and 20 encountered moisture at the bottom of the hole. Test holes 5, 17, and 20 were dug or drilled to depths of 11 feet, 31.5 feet, and 31 feet respectively. Most of the deposit in the interior of the lease area is at a much higher elevation and therefore expected to be above water.

Digital Data Summary

Photographs documenting the site, test hole excavation and sampling were taken and are available upon request. An ArcGIS shapefile of test hole locations is also available upon request. The test hole locations are labeled with an identification number that corresponds to the test holes labels used in the Figures, Tables, and Appendices in this report.

GLOSSARY

boulder– a stone (usually rounded) larger than 256 mm (10 inches) in diameter.

cobble– a stone larger than 64 mm (2.5 inches) and smaller than a boulder.

deleterious material– any material that detracts from the quality of a sand or gravel product, and if deleterious materials are present in sufficient quantities the gravel product may be unsuitable for particular uses. Common deleterious materials are shale, iron oxides, unsound chert, clay balls, and other soft particles.

feature– a physical phenomenon that exists on the earth's surface, such as a lake, valley, or hill.

GIS–**G**eographic **i**nformation **s**ystem, a computer system for the input, editing, storage, maintenance, analysis, and output of spatial information. Each type or category of data is commonly thought of as a separate layer of information.

GPS–**G**lobal **p**ositioning **s**ystem, a satellite-based system which, in conjunction with a receiver, determines locations on the earth's surface.

gravel– an accumulation of granular material, usually deposited by running water, which contains sufficient pebbles and larger stones to be marketable as gravel. When listed as a percentage of gravel, it is a measurement or estimate of the amount of the material, by weight, that is larger than 2 mm (commonly described as plus #10 mesh or retained on the #10 mesh).

landform– any naturally occurring recognizable physical form or feature on the earth's surface, such as hill, valley, esker, plain, plateau, mountain.

overburden– material of any nature that overlies a deposit of useful material.

pebble– stones ranging in size from 4mm (0.16 inch) to 64 mm (2.5 inch) in diameter.

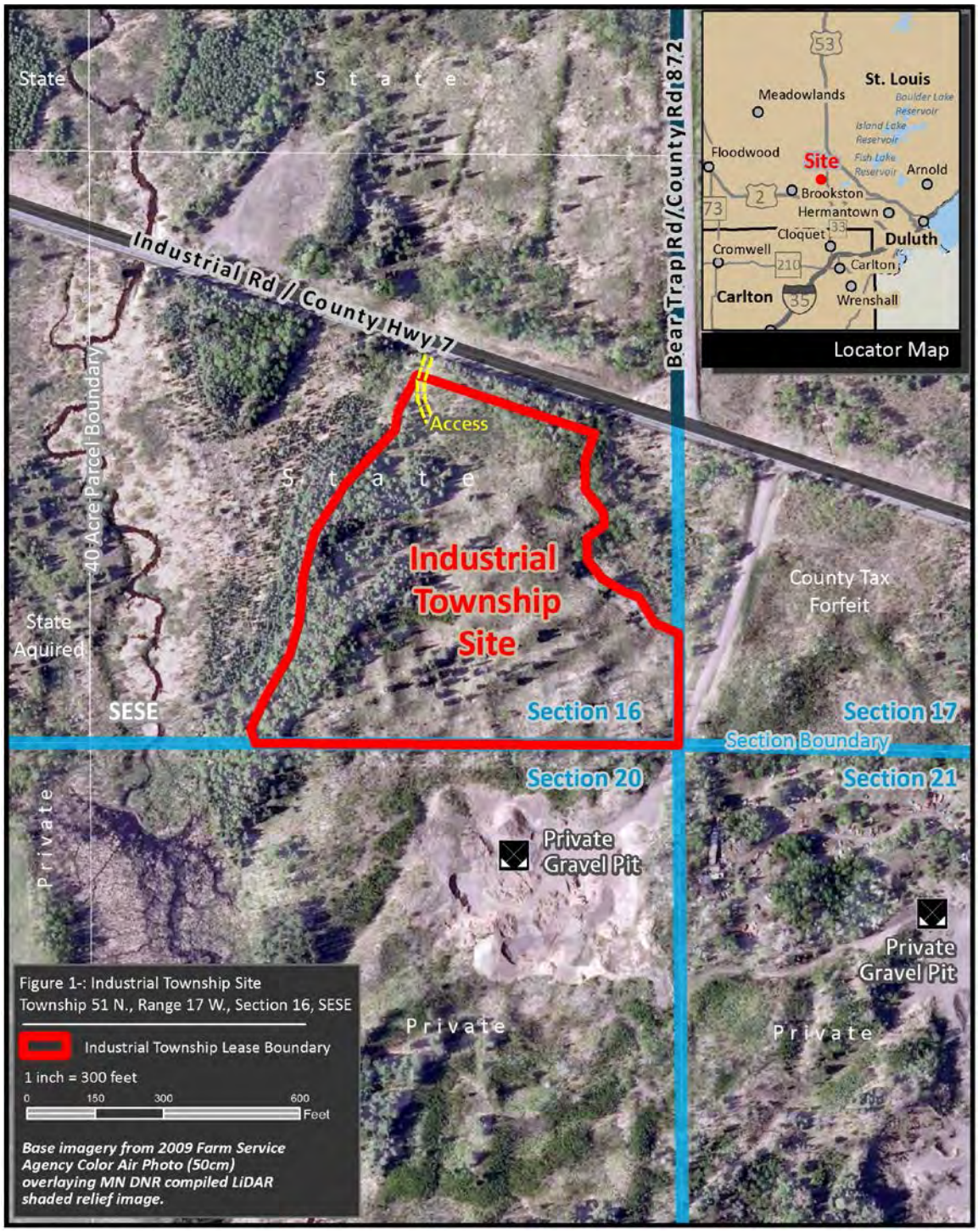

Figure 1. Industrial Township Site Lease Map. The red outline depicts the lease area relative to nearby features. The lease area represents about 11.9 acres in part of the Southeast ¼ of the Southeast Quarter of Section 16, Township 51 North, Range 17 West, St. Louis County. The stream on the west edge of the map is Beartrap Creek, a trout stream. The gravel pit to the south is private.

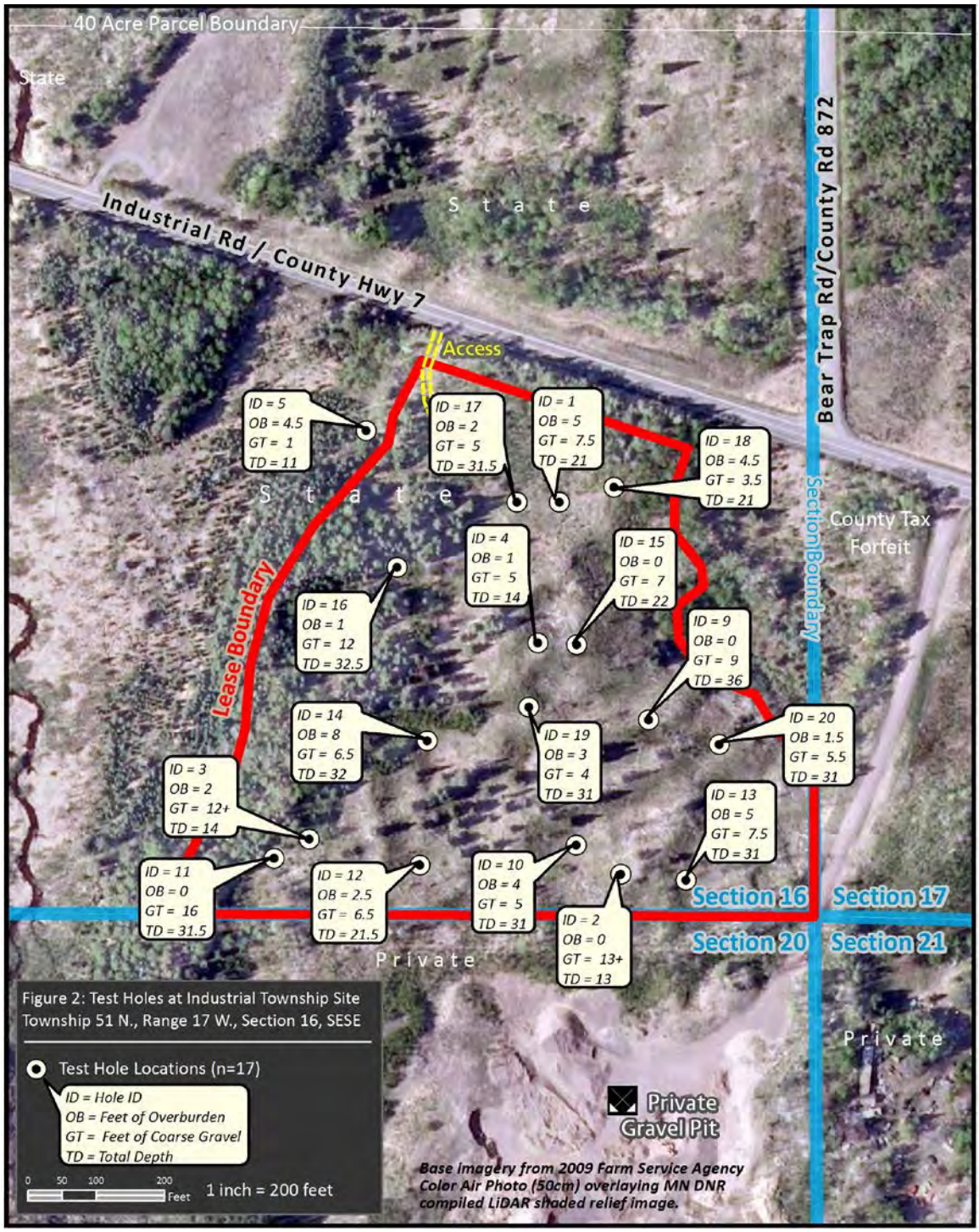

Figure 2. Test holes within and near the lease area are depicted as white circles filled with a black dot. The box adjacent to each circle includes the ID number for the test hole and data about the hole. Data displayed includes feet of overburden, feet of gravel, and total depth of the test hole, in that order. Sand occurs below the gravel. Sixteen test holes are located within the lease area and one, test hole 5, is located outside the lease boundary. Test hole 5 did not reveal marketable aggregate.

Appendix A. Descriptions of Test Holes—Industrial Township Site.

Each test hole is labeled with a unique test hole ID number. Several attributes are recorded for each layer of sediment observed in each hole. These attributes include: thickness of sediment layer, whether the water table was encountered, color, fines (texture), grading (sorting), sediment, layer, percent gravel, dominant clast size, maximum clast size, whether the layer was sampled, and additional comments. The test hole log is recorded using numerous abbreviations. The expansions of the abbreviations used are listed below.

Abbreviations used to describe the test holes

Abbreviations used for Color: lt = light, dk = dark, gry = gray, blk = black, brn = brown, yel = yellow, org = orange, grn = green

Abbreviations used for Fines: c = coarse, s = sandy, vs = very sandy, sli = slight, m = moderately

Abbreviations used for Grading: w = well, p = poor, m = moderately

Abbreviations used for Sediment: grvl = gravel, grvly = gravelly, sd = sand, sdy = sandy, slty = silty, vf = very fine, f = fine, m = medium, c = coarse, carb = carbonate, bldr = boulders, calc = calcareous, occ = occasional, sli = slightly, tr = trace, ts = topsoil, w/ = with

Abbreviations used for Moisture: d = dry, m = moist, w = wet

Other abbreviations used: drlg = drilling, rx = rocks, " = inch, ~ = approximately, TH = test hole, N/A = not applicable, NM = not measured

Appendix A. Geologic log descriptions of twenty test holes dug at the Adolph site in 2006. See above for descriptions of abbreviations used in this table. Intervals sampled for gradation tests are indicated in the comments column. Holes 6, 7, and 8 were dug north of the county road and not within the lease area.

Test Hole ID	From (feet)	To (feet)	Water Table (feet)	Color	Fines (C, S, VS)	Grading (W, P)	Sediment	% Gravel (field est +#10)	Dominant clast (inches)	Max clast (inches)	Moisture (d, m, w)	Comments
1	0	0.5		blk	-	-	sandy loam	0			d	
1	0.5	3		v. lt brn	s	p	silty very fine sand	tr			d	
1	3	5		brn	s	p	fine sand, silt/clay	tr		1	m	
1	5	6.5		red brn	-	p	silt to sand w/ f. grvl	15	-	1.5	m	silty occurs in 3" layers.
1	6.5	12		brn red	c	w	s&g	45	1.5	5	m	upper 1 ft siltier than rest. Clean in lower. Superior lobe. Pretty good sample, layers dip gently N. Sample #01001 taken from 6.5-14 feet.
1	12	14		gry brn	c	w	sd w/ f. grvl	35	1/2	3	d	
1	14	15.5		gry	vs	p	silt loam	0	-	-	m	
1	15.5	19		gry	sli	p	f & med sand	0	-	-	d	
1	19	21		red gry	c	mw	med sand	0	-	-	d	similar to sand in TH 17
2	0	0.3		blk	s	-	sdy loam	-	-	4	d	
2	0.3	1.5		lt brn	s	w	slty c. grvl	65	2	10	d	

Test Hole ID	From (feet)	To (feet)	Water Table (feet)	Color	Fines (C, S, VS)	Grading (W, P)	Sediment	% Gravel (field est +#10)	Dominant clast (inches)	Max clast (inches)	Moisture (d, m, w)	Comments
2	1.5	8		red brn	c	w	sd w/ grvl	40	1.5	9	d/m	lots of 1-2". Sample #02002 from 1.5 to 8 ft.
2	8	13		red gry	c	w	sd w/ occ. grvl	10	1/2	2	d/m	more grvl w/ depth, pure sd in upper, top of sand dips to SSW approx 1.5 feet over 8 ft following the contour. Sample #02003 from 8 to 13 ft.
3	0	2		v. lt brn	s	p	vf sd & slt	tr	2	-	d	varied thickness to 3 feet
3	2	6		red brn	c	w	s&g	50	1.5	5	m	
3	6	14		dk red brn	c	w	sd w/ f grvl	30	3/4-1/4	8	m	grvl layer at 10-12 feet w/ few 6" cobbles. Possibly coarser near 14 feet, approx. 6" vf sd layer at 12 feet. Sample #03004 from 2 to 14 feet.
4	0	0.3		blk	-	-					d	
4	0.3	1		lt brn	vs	p	slty f sd	50			d	
4	1	6		brn	s		c. grvl	60	2	6	d	5-6" cobbles common, difficult drilling
4	6	14		brn gry			sd w/ grvl	10	1/2	1	m/d	mix m sd & slty c grvl. Sample #04005 from 6 to 14 ft.
5	0	0.4		blk	-	-	sdy loam	0	-	-	m	
5	0.4	4.5		lt brn	-	p	slty f sd	tr	-	6	m	occ cobble, appears to be subtle layers

Test Hole ID	From (feet)	To (feet)	Water Table (feet)	Color	Fines (C, S, VS)	Grading (W, P)	Sediment	% Gravel (field est +#10)	Dominant clast (inches)	Max clast (inches)	Moisture (d, m, w)	Comments
5	4.5	5.5		red brn	vvs	p	silt w/ grvl	35	1	6	m	grvly till?
5	5.5	11	5' 9"	red brn	vs	p	slty m sd, f sd	15	-	2	m/w	No sample taken, about 10 feet lower elevation than loading area next to road
6	0	5"		blk	s	p	topsoil sd loam	-	-	-	d	
6	5"	3.5		org brn	vs	p	sdy slt loam	tr	2	2	m	w/ pebbles, not common, till?
6	3.5	14		gry brn	c	w	f-m sd	tr	3/8	1	m	Sample #06006 from 3.5 to 14 ft.
7	0	0.4		blk	-	-	sdy	-	-	-	d	
7	0.4	3.5		lt org brn			sdy silt loam				d	
7	3.5	8		dk brn	c&s	w	sd w/ c grvl		2	6	m/w	Sample #07007 from 3.5 to 8 ft.
7	8	12		brn red	-	p	vf sd & slt	5	1.5	8	m	large cobble s in stiff matrix, Superior lobe till. Water seepage at 8 ft.
8	0	0.4		blk	s	p	topsoil				d	
8	0.4	3		lt brn	s	mp	sdy slt loam & f sd	tr	1	2	d	

Test Hole ID	From (feet)	To (feet)	Water Table (feet)	Color	Fines (C, S, VS)	Grading (W, P)	Sediment	% Gravel (field est +#10)	Dominant clast (inches)	Max clast (inches)	Moisture (d, m, w)	Comments
8	3	12		dk red brn	c	w	sd	3	3/8	1	m	lots of blk sd. Sample #08008 taken from 3 to 14 feet.
8	12	14		lt gry	c	w	m sd	0-3	1/4	1/2	m	lots of blk sd.
9	0	4.5		dk brn	s	w	c grvl	65	1/2-2 1/2	7	d	rare cobbles >5", tougher cobbles at 1.5, 2.5 feet. 1-2" topsoil max on ridge top. Sample #09009 from 0 to 4.5 ft.
9	4.5	9		brn	s	w	sd w/ grvl	20	1/2	1.5	d	varied sd & f grvl. Sample #09010 from 4.5 to 9 ft.
9	9	15		red gry	c	w	sand w/ occ grvl	10	1/4	1	d	varied sd layers--m to c sd & pea grvl. Sample #09011 from 9 to 15 ft.
9	15	~25		red gry	c	w	sd	tr	1/8	1/2	d	Sample #09013 from 15 to 25 ft.
9	~25	36		lt brn	s	p	f-vf sd	0	-	-	d	Sample #09014 from 25 to 36 ft.
10	0	0.3		blk	s	p	loamy sd	0	-	-	d	3 1/2" blk topsoil root mass
10	0.3	1		lt org brn	c	p	vf sd	0	-	-	d	loess?
10	1	2		white brn	c	p	vf sd	0	-	-	d	loess?
10	2	4		brn	vs	p	slty loam	20	1	2	m	flow till, blendable
10	4	9		dk brn	s	w	sd w/ grvl	35	3/4	4	m	rx at 5-6 feet. Sample #10014 from 4 to 9 ft.

Test Hole ID	From (feet)	To (feet)	Water Table (feet)	Color	Fines (C, S, VS)	Grading (W, P)	Sediment	% Gravel (field est +#10)	Dominant clast (inches)	Max clast (inches)	Moisture (d, m, w)	Comments
10	9	16		brn	s/ms	p	f-m sd	0	-	-	d	Sample #10015 from 9 to 16 ft.
10	16	20		red brn	s	w	slty m-f sd	0	-	-	w	
10	20	31		brn	sli	p	m-f sd	0	-	-	d	f sd at 29-31 feet, finer sd than 9-16 foot layer
11	0	4		dk brn	s	w	c grvl	70	2-3	5	d	nothing >5"
11	4	13		brn	s	w	sd w/ grvl	35	1/2-1	2.5	d	Cleaner than above layer
11	13	16		brn	sli	mw	sd w/ occ grvl	10	1/4	1	d	Sample #11016 taken from 0 to 16 ft.
11	16	22		gry brn	sli	mp	f-m sd	0	-	-	d	f sd at 20-22 feet. Sample #11017 taken from 16 o 31.5 ft.
11	22	31.5		gry brn	sli	mw	f sd	tr	3/8	3/8	d	Some vf sd & m sd layers. Sample #11017 taken from 16-31.5 feet.
12	0	2.5		red brn	s	p	vf sd & slt	tr	-	1	d	Not chunky- like loess
12	2.5	9		brn	s	w	c grvl		2-3	6	d	Rock at 2.5, steady cobbles 2.5-9 feet. Slow drilling, tough cobbles at 5 feet. Poor recovery.
12	9	~12		brn	vs	p	slty f sd	tr	3/8	1/2	w/m	Not till, not chunky. Contact at ~12 feet uncertain.
12	~12	15		red gry	c	w	sd	tr	1/8	1/4	d	Possible slight contamination from above. Sample #12018 from 12 to 15 ft.
12	15	21.5		lt brn	c	mp	f sd	0	-	-	d	

Test Hole ID	From (feet)	To (feet)	Water Table (feet)	Color	Fines (C, S, VS)	Grading (W, P)	Sediment	% Gravel (field est +#10)	Dominant clast (inches)	Max clast (inches)	Moisture (d, m, w)	Comments
13	0	2		lt brn	c	p	vf sd	0	-	-	d	
13	2	5		brn	vs	p	slty vf sd & slt	tr	-	-	m	
13	5	9		dk brn	s	w	m grvl & sd	45	3/4-1.5	3	d	Sample #13019 taken from 5 to 12.5 ft.
13	9	11		red gry	mc	p	sd	tr	-	-	d	Sample #13019.
13	11	12.5		red gry	c	w	sd w/ grvl	25	3/4	1.5	d	Less grvl at depth. Sample #13019.
13	12.5	21		red gry	c	w	sd w/ occ grvl	10	1/8	1.5	d	Sample #13021 from 12.5 to 21 ft.
13	21	29		gry brn	mc	p	m-f sd	0	-	-	d	finer than above. Sample #13022 from 21 to 29 ft.
13	29	31		lt brn	mc	p	vf sd	0	-	-	d	
14	0	2		lt yel brn	NA	p	sdy loam, vf sd w/ slt	0	-	-	d	not chunky.
14	2	8		yel brn to dk brn	NA	p	sdy loam	0	-	-	m/w	Some moisture.
14	8	14.5		dk brn	s	w	sd & c grvl	50	1.5-3	6	d	Tough drlg 10-14.5 feet, no more cobbles deeper than 14.5 feet. Sample #14022 from 8 to 14.5 ft.
14	14.5	18		red brn	mc	mw	sd w/ grvl	20	1/2	1.5	d	Crunching to 18 feet. Sample #14023 taken from 14.5 to 22 feet.

Test Hole ID	From (feet)	To (feet)	Water Table (feet)	Color	Fines (C, S, VS)	Grading (W, P)	Sediment	% Gravel (field est +#10)	Dominant clast (inches)	Max clast (inches)	Moisture (d, m, w)	Comments
14	18	22		gry brn	mc	mp	f-m sd	tr	-	-	d	Sample #14023.
14	22	29		brn	s	mw	sd w/ grvl	20	1-1.5	2.5	d	Not much c. sand. Sample #14024 taken from 22 to 29 ft.
14	29	32		gry brn	s	mp	f-m sd	0	-	-	d	
15	0	5.5		dk brn	s	w	c grvl	70	1.5-3	7	d	Cobbles at surface below topsoil. Very tough rock at 4.5 feet. Sample #15025 taken from 0 to 7 feet.
15	5.5	7		red blk	sli	w	sd w/ grvl	20	1/2	2	d	Sample #15025.
15	7	14		brn gry	sli	mw/mp	f-m sd	tr	1/8	3/8	d	Varied layers. Sample #15026 from 7 to 14 ft.
15	14	22		brn gry	sli	mp	f sd	0				Sample #15027 from 14 to 22 ft.
16	0	1		org brn	vs	p	sdy slt loam	15	1.5	-	d	
16	1	4		dk brn	s	w	c grvl	60	2.5	5	d	Tough at 2.5 feet, poor recovery. Sample #16028 taken from 1 to 13 ft.
16	4	7		brn	sli	w	sd w/ grvl	20	1/2	2	d	Sample #16028
16	7	13		red gry	sli	w	f grvl & sd	55	3/8	2.5	d	Some contamination of fines in spl. Sample #16028.
16	13	17		red & blk	c	w	c sd	10	1/8	1/2	d	Sample #16029 from 13 to 32.5 ft.
16	17	22		red gry	mc	w	m sd	0	-	-	d	mostly m sd & finer. Sample #16029.

Test Hole ID	From (feet)	To (feet)	Water Table (feet)	Color	Fines (C, S, VS)	Grading (W, P)	Sediment	% Gravel (field est +#10)	Dominant clast (inches)	Max clast (inches)	Moisture (d, m, w)	Comments
16	22	32.5		red & blk	c	w	c sd w/ f grvl	35	1/8-3/8	2	d	Possible pebbles at 25-26 ft and slower drlg. Slow advance due to angular c sd. Pebble at 32 ft. Too much resistance, refusal at 32.5 ft. Sample #16029.
17	0	2		lt org brn	vs	p	f sd & slt	10	1	7	d	
17	2	4		dk org brn	s	w	sd w/ grvl	40	3/8	2	d	Sample #17030 taken from 2 to 7 ft.
17	4	7		red blk	c	w	c sd w/ f grvl	20	1/4	1	d	Sample #17030
17	7	13		lt gry	c	mp	f-m sd	tr	1/2	-	d	Sample #17031 from 7 to 29 ft.
17	13	27		blk & red	c	w	sd	tr	-	-	d	Very clean, falls/rolls off auger flights. Sample #17031 from 7 to 29 ft.
17	27	29		blk & red	c	w	c sd	5	1/8	3/8	d	Sample #17031.
17	29	31.5		brn gry	s	p	slty vf sd	0	-	-	m	
18	0	4.5		org brn	s/vs	p	slty vf sd	tr	1-2	4	d	Not chunky, no clay
18	4.5	8		brn	s	w	c grvl w/ sd	60	1/2-1 1/2	3	d	
18	8	11		white gry	c	mp	f sd	0	-	-	d	

Test Hole ID	From (feet)	To (feet)	Water Table (feet)	Color	Fines (C, S, VS)	Grading (W, P)	Sediment	% Gravel (field est +#10)	Dominant clast (inches)	Max clast (inches)	Moisture (d, m, w)	Comments
18	11	21		lt gry	c	p	vf sd	0	-	-	d	Occ f-m sd. No sample taken
19	0	3		lt org brn	s	p	vf sd	tr	-	-	d	
19	3	7		dk brn	s	w	c sd w/ grvl	40	3/8 & 1 1/2	4	d	V difficult cobble at 5 ft, poor recovery.
19	7	19		white gry	c	mw	f-m sd	0	-	-	d	Sample #19032 from 7 to 19 ft.
19	19	31		lt gry	c	p	f sd w/ vf sd	0	-	-	d	Sample #19033 from 19 to 31 ft.
20	0	1.5		org brn	s	p	vf sd w/ grvl	NM	-	-	d	
20	1.5	7		dk brn	s	w	c grvl	70	1 1/2-3	7	d	Tough rx at 2, 4 & 5 feet. Sample #20034 from 1.5 to 7 ft.
20	7	13		gry brn	s	w	sd	tr	3/8	-	d	Mostly m sd. Sample #20035 from 7 to 18 ft.
20	13	18		red & blk	c	w	c sd	tr	1/8	3/8	d	Colorful. Sample #20035 from 7 to 18 ft.
20	18	26		gry brn	sli	w	sd	0	-	-	m	Mostly m sd, finer at depth. Sample #20036 from 18 to 26 ft.
20	26	29		gry brn	s	mp	f sd	0	-	-	d	Finer at depth. Moist vf sd at bottom of hole
20	29	31		gry brn	s	p	vf sd	0	-	-	m	No water table

Appendix B. Gradation tests for the Industrial Township site. Samples correspond to the test holes described in Appendix A.

		Project #	33430	33430	33430	33430	33430	33430	33430	33430	33430	33430
		Sample #	01001	02002	02003	03004	04005	06006	07007	08008	09009	09010
		Hole ID	1	2	2	3	4	6	7	8	9	9
		From	6.5	1.5	8	2	6	3.5	3.5	3	0	4.5
		To	14	8	13	14	14	14	8	14	4.5	9
		Feet of material	7.5	6.5	5	12	8	10.5	4.5	11	4.5	4.5
	Sieve #											
Percent by weight of total sample passing respective sieves	4"	100mm	100	100	100	100	100	100	100	100	100	100
	3"	75mm	100	100	100	100	100	100	100	100	100	100
	2.5"	63mm	96	100	100	93	100	100	95	100	85	100
	2"	50mm	92	98	95	92	100	100	92	100	84	100
	1.5"	37.5mm	85	89	95	85	99	100	88	100	79	100
	1.25"	31.5mm	81	85	93	81	99	100	83	100	75	97
	1"	25mm	76	83	91	78	99	100	79	99	68	95
	3/4"	19mm	71	77	88	72	98	100	73	99	58	92
	5/8"	16mm	68	73	86	68	98	100	70	99	54	91
	1/2"	12.5mm	64	69	84	65	97	100	67	98	48	88
	3/8"	9.5mm	59	65	81	60	96	100	63	98	43	85
	#4	4.75mm	48	54	75	51	94	99	54	95	32	76
	#10	2.0mm	39	46	67	42	92	99	47	93	26	64
	#16	1.18mm	30	35	60	34	90	99	40	90	21	55
	#30	0.60mm	19	14	46	19	83	99	22	77	16	43
	#40	0.425mm	14	8	34	11	73	98	14	66	12	37
	#50	0.30mm	10	5	22	6	55	95	8	47	9	26
	#100	0.15mm	5	3	12	3	19	63	3	16	5	11
	#200	0.075mm	1.1	1.0	3.3	1.9	5.3	23.5	1.9	5.0	2.6	2.8

Appendix B. (continued)

		Project #	**33430**	**33430**	**33430**	**33430**	**33430**	**33430**	**33430**	**33430**	**33430**	**33430**
		Sample #	09011	09012	09013	10014	10015	11016	11017	12018	13019	13020
		Hole ID	**9**	**9**	**9**	**10**	**10**	**11**	**11**	**12**	**13**	**13**
		From	9	15	25	4	9	0	16	12	5	12.5
		To	15	25	36	9	16	16	31.5	15	12.5	21
		Feet of material	6	10	11	5	7	16	15.5	3	7.5	8.5
	Sieve #											
Percent by weight of total sample passing respective sieves	4"	100mm	100	100	100	100	100	100	100	100	100	100
	3"	75mm	100	100	100	100	100	100	100	100	100	100
	2.5"	63mm	100	100	100	100	100	100	100	100	100	100
	2"	50mm	100	100	100	100	100	100	100	100	95	100
	1.5"	37.5mm	100	100	100	96	100	93	100	100	87	99
	1.25"	31.5mm	100	100	100	96	100	91	100	100	78	97
	1"	25mm	100	100	100	95	100	87	100	100	72	96
	3/4"	19mm	100	100	100	93	100	82	100	100	66	94
	5/8"	16mm	99	100	100	90	100	79	99	100	64	93
	1/2"	12.5mm	99	100	100	89	100	76	99	100	61	93
	3/8"	9.5mm	98	100	100	86	100	71	99	100	57	92
	#4	4.75mm	95	99	100	76	100	64	99	98	50	90
	#10	2.0mm	91	98	100	62	99	58	99	94	46	86
	#16	1.18mm	85	97	100	50	98	52	98	87	42	80
	#30	0.60mm	54	76	99	29	93	40	97	66	33	49
	#40	0.425mm	34	54	99	20	88	32	95	50	29	27
	#50	0.30mm	16	28	97	13	74	20	88	32	24	12
	#100	0.15mm	4	14	78	6	41	14	45	21	13	5
	#200	0.075mm	0.8	1.1	35.9	4.0	16.5	3.2	18.8	2.5	7.9	1.4

Appendix B. (continued)

		Project #	**33430**	**33430**	**33430**	**33430**	**33430**	**33430**	**33430**	**33430**	**33430**	**33430**
		Sample #	13021	14022	14023	14024	15025	15026	15027	16028	16029	17030
		Hole ID	**13**	**14**	**14**	**14**	**15**	**15**	**15**	**16**	**16**	**17**
		From	21	8	14.5	22	0	7	14	1	13	2
		To	29	14.5	22	29	7	14	22	13	32.5	7
		Feet of material	8	6.5	7.5	7	7	7	8	12	19.5	5
	Sieve #											
Percent by weight of total sample passing respective sieves	4"	100mm	100	100	100	100	100	100	100	100	100	100
	3"	75mm	100	100	100	100	100	100	100	100	100	100
	2.5"	63mm	100	96	98	100	94	100	100	96	100	100
	2"	50mm	100	93	97	93	87	100	100	89	99	100
	1.5"	37.5mm	100	80	97	87	79	100	100	78	98	98
	1.25"	31.5mm	100	72	96	81	71	100	100	77	98	96
	1"	25mm	100	66	95	80	65	100	100	73	97	94
	3/4"	19mm	100	62	95	77	55	100	100	69	96	90
	5/8"	16mm	100	60	94	76	51	100	100	65	95	86
	1/2"	12.5mm	100	58	93	75	46	100	100	62	93	82
	3/8"	9.5mm	100	56	92	74	43	100	100	59	91	77
	#4	4.75mm	99	50	88	71	34	99	100	51	85	65
	#10	2.0mm	99	48	82	69	27	97	100	47	79	54
	#16	1.18mm	99	45	78	67	22	95	100	42	69	43
	#30	0.60mm	96	38	71	65	14	86	99	32	42	25
	#40	0.425mm	92	34	65	63	10	77	99	26	31	19
	#50	0.30mm	79	28	55	58	7	64	96	18	19	14
	#100	0.15mm	35	17	30	34	3	40	73	9	7	10
	#200	0.075mm	11.8	10.6	13.2	18.3	1.7	17.8	29.1	4.4	1.9	6.1

Appendix B. (continued)

		Project #	**33430**	**33430**	**33430**	**33430**	**33430**	**33430**
		Sample #	17031	19032	19033	20034	20035	20036
		Hole ID	**17**	**19**	**19**	**20**	**20**	**20**
		From	7	7	19	1.5	7	18
		To	29	19	31	7	18	26
		Feet of material	22	12	12	5.5	11	8
	Sieve #							
Percent by weight of total sample passing respective sieves	4"	100mm	100	100	100	100	100	100
	3"	75mm	100	100	100	100	100	100
	2.5"	63mm	100	100	100	93	100	100
	2"	50mm	100	100	100	89	100	100
	1.5"	37.5mm	100	100	100	75	100	100
	1.25"	31.5mm	100	100	100	64	100	100
	1"	25mm	100	100	100	55	100	100
	3/4"	19mm	100	100	100	44	100	100
	5/8"	16mm	100	100	100	38	99	100
	1/2"	12.5mm	100	100	100	34	99	100
	3/8"	9.5mm	100	100	100	30	99	100
	#4	4.75mm	99	100	100	23	97	99
	#10	2.0mm	97	99	100	20	95	99
	#16	1.18mm	94	99	100	18	90	98
	#30	0.60mm	81	94	99	15	70	89
	#40	0.425mm	70	84	98	13	58	77
	#50	0.30mm	52	58	95	11	43	54
	#100	0.15mm	19	23	78	6	13	17
	#200	0.075mm	7.1	4.8	46.1	3.3	3.2	2.6

Appendix C. GPS coordinates for Test Holes (TH_ID) at the Industrial Township site. Coordinates were captured by a hand-held Garmin GPSmap 76S with WAAS correction. The Y_PROJ and X_PROJ fields represent UTM NAD83 Zone 15 Northing and Easting coordinates, respectively.

TH_ID	LAT	LONG	Y_PROJ	X_PROJ
1	46.89681555	-92.49302150	5193822	538617
2	46.89531955	-92.49267298	5193656	538645
3	46.89546799	-92.49449613	5193672	538506
4	46.89624961	-92.49315200	5193759	538608
5	46.89710699	-92.49414853	5193854	538531
6	46.89865873	-92.49216302	5194028	538682
7	46.90088673	-92.49219194	5194275	538678
8	46.90287634	-92.49346054	5194496	538580
9	46.89593855	-92.49250635	5193725	538657
10	46.89543748	-92.49293525	5193669	538625
11	46.89539306	-92.49470324	5193664	538490
12	46.89536171	-92.49385114	5193660	538555
13	46.89529331	-92.49229353	5193654	538674
14	46.89586001	-92.49380244	5193716	538559
15	46.89624231	-92.49292301	5193759	538625
16	46.89655747	-92.49397343	5193793	538545
17	46.89681681	-92.49326960	5193822	538599
18	46.89687322	-92.49269888	5193829	538642
19	46.89599262	-92.49320749	5193731	538604
20	46.89583722	-92.49209329	5193714	538689