STRUCTURE GEOTECHNICAL REPORT
CULVERT AT STA. 627+82.00
ILLINOIS 47 OVER A TRIBUTARY TO THE KISHWAUKEE RIVER
EXISTING SN 056-0246; PROPOSED SN 056-0310
MCHENRY COUNTY, ILLINOIS

For
Strand Associates, Inc.
1170 South Houbolt Road
Joliet, IL 60432

Submitted by
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Technical Report Documentation Page

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11. Abstract

The existing 6-foot tall by 6-foot wide, concrete box culvert carrying Illinois 47 over a tributary to the Kishwaukee River will be removed and replaced with a longer, triple-cell cencrete box culvert. The new culvert center cell will be 7-foot tall by 12-foot wide and the outside cells will be 7-foot tall and 5-foot wide. The culvert's length will be 295 feet out-to-out of headwalls. New fill will be placed on top and around both culvert's ends. The culverts ends will be retained by either T-type or horizontal cantilever type wingwalls. This report provides geotechnical recommendations for the design and construction of the proposed culvert and wingwalls.

Beneath the topsoil, the general lithologic profile encountered during the investigation includes up to 4 feet of medium stiff to hard silty clay loam fill over up to 4 feet of very soft to medium stiff silty clay loam with little organic matter followed by stiff to hard silty clay to silty clay loam. The groundwater level was measured at elevations ranging from 863 to 896 feet.

The design scour elevations are proposed to be at the bottom of the cutoff wall. A layer of soft to medium stiff clay layer was encountered beneath the proposed culvert base at the center and the upstream end; we recommend removing the soft soil and replacing with granular aggregates beneath the center and upstream sections of the culvert. After the proposed removal, total long-term settlements are estimated to be 0.2 to 0.6 inches with a differential settlement of about 0.4 inches over 80 feet.

We recommend the wingwalls be designed for a maximum factored bearing resistance of 5,000 psf. Global stability analyses of the wingwalls show factors of safety meeting the minimum requirement of 1.5.

Wang estimates a temporary steel sheet piling according to IDOT Design Guide 3.13.1 is feasible and sufficient to accommodate stage construction.

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FOR
STRAND ASSOCIATES, INC.

1.0 INTRODUCTION

This report presents the results of our subsurface investigation, laboratory testing, geotechnical evaluations, and recommendations to support the removal and replacement of a culvert crossing Illinois Route 47 (IL-47) at Station 627+82.00 that is about 600 feet south of the intersection between IL-176 West Leg and IL 47. The proposed structure is part of the widening and reconstruction of 1.65-mile-long of IL 47 between Station 565+80 and Station 653+00 in McHenry County, Illinois. A *Site Location Map* is presented as Exhibit 1.

1.1 Proposed Structure

Based on the *Preliminary Type, Size, and Location (TSL) plan Drawings* provided by Strand Associates, Inc. (Strand) on January 19, 2017, Wang Engineering, Inc. (Wang) understands the existing 6-foot wide by 6-foot tall culvert will be removed and replaced with a new and longer triple-cell concrete box culvert. The center cell will be 7-foot tall by 12-foot wide and the outside cells will be 7-foot tall and 5-foot wide. The culvert's length will measure 295 feet out-to-out of headwalls, which is about 140 feet longer than the existing one, and the culvert's width will measure 26 feet out-to-out. The proposed culvert upstream invert elevation will be 892.45 feet and downstream invert elevation will be 892.11 feet; with flow directed from northeast to southwest. The proposed culvert barrel will have bottom elevation slightly lower than the existing. Either T-type or horizontal cantilever wingwall types are proposed to support the widened roadway embankment at both the upstream and downstream ends. The roadway profile grade elevation will be raised up to 4.5 feet at the centerline of the road.

1.2 Existing Structure and Land Use

The existing 6-foot by 6-foot concrete box culvert was constructed in 1936 and has a total length of 155.6 feet and an out-to-out width of 7.0 feet with horizontal cantilever type wingwalls on both ends.

The culvert is skewed approximately 50^{o} with respect to the IL 47 roadway with an upstream invert elevation of 894.65 feet and a downstream invert elevation of 893.83 feet.

The purpose of this investigation was to characterize the site soil and groundwater conditions, perform geotechnical analyses, and provide recommendations for the design and construction of the proposed culvert replacement and wingwalls.

2.0 GEOLOGICAL SETTING

The project area is located along IL 47 about 600 feet south of intersection of IL 176 West Leg and IL 47, in Dorr Townships, McHenry County, Illinois. On the USGS Huntley 7.5 Minute Series Quadrangle map, the project is located in NW ¼ of Section 33, Tier 44 N, Range 7 E of the Third Principal Meridian.

The following review of published geologic data, with emphasis on factors that might influence the design and construction of the proposed engineering works, is meant to place the project area within a geological framework and confirm the dependability and consistency of the subsurface investigation results. For the study of the regional geologic framework, Wang considered northeastern Illinois in general and McHenry County in particular. Exhibit 2 illustrates the *Site and Regional Geology*.

2.1 Physiography

The IL 47 at the culvert location runs through rural setting surrounded by agricultural fields. The surface topography is generally flat with elevation of about 896 feet. The tributary to the Kishwaukee River flows south crossing IL 47 through a 6-foot wide culvert. The culvert crossing the tributary to the Kishwaukee river is located about 600 feet south of the IL 176 West Leg with roadway elevation of about 903 feet. The downstream invert elevation is about 892 feet and the water surface is at about 893 feet elevation.

2.2 Surficial Cover

The project area was shaped during the Wisconsin-age glaciation and about 200-foot thick overburden covers the bedrock. The glacigenic deposits were emplaced during pulsating advances and retreats of an icesheet lobe responsible for the formation of end moraines and associated low-relief till and lake plains (Hansel and Johnson 1996). The surficial cover within the project area consists of organic silt and clay of the Grayslake Peat found discontinuously throughout the project

area. The Grayslake Peat overlies either the clay and silt of the Equality Formation, or the silty clayey diamicton of the Yorkville Member of the Lemont Formation. The clayey diamicton overlies the loamy diamicton of the Tiskilwa Formation or gravelly sand outwash of the Henry Formation. The outwash of the Henry Formation interfingers with the two diamictons.

The Grayslake Peat, less than 10 feet thick, consists of black to brown peat interbedded with gray organic reach sand, silt, and clay and white to light gray marl (Curry and Thomason 2012). The Equality Formation, less than 15 feet thick, consists of brown to gray bedded fine sand, silt, and clay lacustrine deposits (Curry and Thomason 2012). The Henry Formation consists of stratified sand and gravel outwash with thicknesses of about 5 to 10 feet, within the project limits (Curry and Thomason 2012). The Yorkville Member of the Lemont Formation, up to 30 feet thick, consists of yellowish brown to gray silty clay to silty clay loam diamicton that contains lenses of gravel, sand, silt, and clay (Hansel and Johnson 1996, Curry and Thomason 2012). The Tiskilwa Formation, about 65 feet thick, consists of calcareous reddish brown to gray clay loam, loam to sandy loam diamicton that contains lenses of gravel, sand, silt, and clay (Wickham et al. 1988, Curry and Thomason 2012). The Tiskilwa Formation diamicton rests over the Illinoian-age drift of the Glasford formation, which in turn unconformably rests over the Silurian-age dolostone (Curry and Thomason 2012). The diamicton account for about 75% of the subsurface soil.

From a geotechnical viewpoint, the Yorkville Member characterized by low plasticity to moderate, high strength, and low to moderate moisture content and the Tiskilwa Formation characterized by low plasticity, medium to high strength, low moisture content, moderately to highly pebbly (Bauer et al. 1991).

2.3 Bedrock

In McHenry County, the surficial cover rests unconformably on top of Silurian-age and Ordovician-age bedrock. The top of the bedrock lies about 160 to 200 feet below the ground surface (bgs). Structurally, the site is located on the eastern flank of the Wisconsin Arch (Willman 1971). No active faults or underground mines are known in the area.

Our subsurface investigation results fit into the local geologic context. The borings drilled in the project area encountered native sediments consisting of silt and clay with organic, discontinuous occurance of gravel and sand outwash overlie the silty clay diamicton. None of the borings were deep enough to encounter either the loamy diamicton of the Tiskilwa Formation or bedrock.

3.0 METHODS OF INVESTIGATION

The following sections outline the subsurface and laboratory investigations performed by Wang.

3.1 Field Investigation

The subsurface investigation consisted of three soil borings, designated as CUL-04 to CUL-06, drilled by Wang in October and November of 2017. Boring CUL-05ST was drilled to collect one shelby tube sample. The borings were drilled outside of the roadway within the new culvert limits from elevations of 897.8 to 900.4 feet and were advanced to depths of 9.0 to 35.0 feet bgs. The as-drilled northing and easting coordinates were acquired with a mapping-grade GPS unit; boring elevations were surveyed with a level. Stations and offsets were determined from drawings provided by Strand. Boring location data are presented in the *Boring Logs* (Appendix A) and the as-drilled boring locations are shown in the *Boring Location Plan* (Exhibit 3).

An ATV-mounted drilling rig, equipped with hollow stem augers, was used to advance and maintain open boreholes. Soil sampling was performed according to AASHTO T206, *"Penetration Test and Split Barrel Sampling of Soils."* The soil was sampled at 2.5-foot intervals to 30 feet bgs and at 5.0-foot intervals thereafter. Soil samples collected from each sampling interval were placed in sealed jars and transported to the laboratory for further examination and laboratory testing.

Field boring logs, prepared and maintained by Wang geologists, include lithological descriptions, visual-manual soil (IDH Textural) classifications, results of Rimac and pocket penetrometer unconfined compressive strength tests, and results of Standard Penetration Tests (SPT) recorded as blows per 6 inches of penetration.

Groundwater levels were measured while drilling and at completion of each boring. Each borehole was backfilled upon completion with soil cuttings and/or bentonite chips.

3.2 Laboratory Testing

The soil samples were tested in the laboratory for moisture content (AASHTO T265). Atterberg limits (AASHTO T89 and T90) and particle size (AASHTO T88) analyses were performed on selected samples. A one-dimensional consolidation test (AASHTO T216) was performed on a shelby tube sample. Field visual descriptions of the soil samples were verified in the laboratory. Laboratory test results are shown in the *Boring Logs* (Appendix A) and in the *Laboratory Test Results* (Appendix B).

4.0 INVESTIGATION RESULTS

Detailed descriptions of the soil conditions encountered during the subsurface investigation are presented in the attached *Boring Logs* (Appendix A) and in the *Soil Profile* (Exhibit 4). Please note that strata contact lines represent approximate boundaries between soil types. The actual transition between soil types in the field may be gradual in horizontal and vertical directions.

4.1 Lithological Profile

At the surface, the borings encountered 4- to 15-inch thick black silty clay loam topsoil. In descending order, the general lithologic succession encountered beneath the surface includes: 1) man-made ground (fill); 2) very soft to medium stiff silty clau loam with organic matter; and 3) stiff to hard silty clay loam.

1) Man-made ground (fill)

Beneath the surface, the borings encountered up to 4 feet of medium stiff to hard, brown and gray silty clay loam fill. The fill has unconfined compressive strength (Q_u) values of 0.7 to more than 4.5 tsf and moisture content values of 14 to 16%. Boring CUL-04, encountered about 24 inches of black silty clay loam buried topsoil beneath the fill.

2) Very Soft to Medium Stiff Silty Clay Loam with Organic Matter

At elevations of 894.8 to 896.2 feet, Borings CUL-05 and CUL-06 encountered 2 to 4 feet of very soft to medium stiff, brown and gray silty clay loam with little organic matter. This unit is characterized by Q_u values of less then 0.25 to 0.6 tsf and moisture content values of 30 to 52%. Laboratory index testing shows a liquid limit (L_L) value of 49%, a plastic limit (P_L) value of 24%, and an organic content of 9.8%.

3) Stiff to Hard Silty Clay Loam

At elevations of 890.8 to 896.6 feet, the borings advanced through stiff to hard, brown and gray silty clay to silty clay loam diamicton with lenses of gravel and sand. The diamicton has Q_u values of 1.0 to 5.1 tsf with an average of 2.3 tsf and moisture content values of 14 to 19% with an average of 16%. The borings were terminated within this unit. Approximately 5-foot thich of saturated sandy gravel to gravelly loam was encountered in Boring CUL-04 at elevations 891.6 feet, slightly below the proposed invert elevation of 892.1 feet.

Just below the unit 2, Boring CUL-05 encountered about 5-foot thick soft to medium stiff, silty clay loam with Q_u values of 0.5 to 0.6 tsf and moisture content values of 18 to 20%. Laboratory index testing shows L_L value of 28% and P_L value of 13%.

4.2 Groundwater Conditions

While drilling, groundwater was encountered in the gravelly sand interbedded in the lenses within the diamicton at elevation of 863.1 and 891.6 feet (8.8 and 34.8 feet bgs). At the completion of drilling, groundwater was measured at elevations of 893.8 and 895.9 feet (1.9 and 6.5 feet bgs). The tributary to the Kishwaukee River water level is at about 893 feet elevation.

5.0 FOUNDATION ANALYSIS AND RECOMMENDATIONS

Geotechnical evaluations and recommendations for the culvert and wingwalls are included in the following sections. The proposed culvert replacement will have upstream and downstream invert elevations of 892.45 and 892.11 feet, respectively, and the base of the culvert barrel will be installed slightly deeper than the existing. T-type or horizontal cantilever wingwall types will be used to support the roadway embankment widening at both ends.

Wang has performed bearing capacity, settlement, and global stability analyses for the proposed culvert barrel and wingwalls.

5.1 Scour Considerations

The design scour elevation should be taken at the bottom of the cutoff wall (IDOT 2012). For horizontal cantilever wingwalls, the cutoff walls are established 3.0 feet below the culvert invert elevations; whereas for T-type wingwalls, the cutoff walls are established 4.0 feet below the invert elevations. The design scour elevations for horizontal cantilever wingwalls are summarized in Table 1. To prevent local erosion, we recommend placing stone riprap or a concrete apron at the ends of the culvert; this will be particularly important if precast sections are used. This will also prevent sediments from entering and accumulating in the culvert, minimize long-term maintenance, and provide protection to the streambed at the interface.

Table 1: Design Scour Elevations

	Upstream	Downstream
Design Scour Elevations (feet)	889.45	889.11

5.2 Ground Treatment

The subsurface investigation indicates the soils at the upstream and at the middle sections of the culvert base are primarily soft to medium stiff silty clay loam. To mitigate settlement issues and to provide stable working platforms, Wang recommends removal and replacement of soft to medium stiff soil at the upstream and middle sections of the proposed culvert barrel. The recommended removal limits nad depths are:

- from the upstream end of the culvert going 40 feet downstream, for a depth of 1 foot below the proposed bottom of the culvert or to elevation 890.5 feet, and
- the removal should extend 140 feet long downstream, for a depth of 4 feet below the proposed bottom of culvert.

A sketch the proposed removal is shown in Exhibit 5. The replacement material should extend a minimum of two feet beyond each side of the box (IDOT 2016). In addition, the following note should be shown in the plans.

"The limits and quantities of removal and replacement shown are based on the boring data and may be modified by the District Geotechnical and Field Engineers for variable subsurface conditions encountered in the field."

Please note that soil removal may not be necessary at the downstream section since no soft soil was encountered by the boring.

5.3 Bearing Capacity

The T-type wingwalls should be founded at a minimum of 4.0 feet below the invert elevations. After the proposed removal and replacement, the walls should be designed based on a maximum factored soil bearing resistance of 5,000 psf, determined with a bearing resistance factor (ϕ_b) of 0.45 (AASHTO 2016). The wingwalls should be sized and designed based on the information and typical sections shown in IDOT *Culvert Manual* (2017). Sections 4.3 and 4.4.

The culvert wingwalls could also be constructed as horizontal cantilever walls if they are less than 16 feet in length and the wingwall location can be adequately dewatered (IDOT 2017). Horizontal cantilever walls should be designed based on the structural guidelines provided in Section 4.2 of the IDOT (2017). These wingwalls should be founded at a minimum depth of 3.0 feet below the culvert invert elevations.

According to IDOT (2017), the soil lateral pressure acting on the sidewalls of the box culvert should be assumed as an equivalent fluid pressure of 60 pcf. Earth surcharge should be added in non-zero fill conditions and live load surcharge shall be applied to all culverts regardless of fill height as discussed in IDOT (2017) Section 3.4.5.

5.4 Settlement

As discussed in Section 5.2, soft to medium stiff soil will be encountered below the base of the proposed culvert. We estimate up to 2 incehs of settlement under the new culvert and fill loads.After the proposed removal and replacement, we estimate the foundation soils will experience total long-term settlements of about 0.2 to 0.6 inches, with differential settlements of 0.4 inch over 80 feet. We estimate the settlements are suitable for the construction of the proposed culvert and wingwalls.

5.5 Global Stability

The global stability of the fill material to be placed behind the wingwalls was analyzed based on the generalized soil profile described in Section 4.1. The maximum total fill height behind the wingwalls will be about 7 feet with a backfill slope of 1:3 (V:H). We performed global stability analyses for the wingwalls at the west end section. Global stability was analyzed for both undrained (short-term) and drained (long-term) conditions. The analyses were performed with *Slide v6.0* and the results of the evaluations are provided in Appendix C. We estimate a factor of safety (FOS) of 3.0 for undrained soil condition and a FOS of 1.6 for drained soil condition. The FOSs meet the minimum FOS requirement of 1.5 (IDOT 2015).

5.6 Cast-In-Place or Precast Culvert Considerations

After the recommended removal of unsuitable material, the results of the analyses indicate that both the cast-in-place and precast culvert options are appropriate and feasible at the site. The differential settlement will be about 0.4 inch over 80 feet, which will not cause excessive separation of the precast sections. For precast end sections, we recommend considering either a concrete apron or riprap armoring at the downstream invert to protect against scour and erosion that could undermine the precast end section assuming a hydraulic analysis does not indicate a low-scour condition.

5.7 Stage Construction Considerations

The preliminary TSL plan shows a stage construction line for the culvert construction. Wang understands a temporary sheet piling system will be utilized to accommodate stage construction. The sheet piling should be designed based on IDOT Design Guide 3.13.1. Assuming an exposed height of

about 16 feet (from elevation 887.5 feet to 903.5 feet) located at the stage construction line, our evaluations indicate the temporary steel sheet piling is feasible and sufficient.

6.0 CONSTRUCTION CONSIDERATIONS

6.1 Site Preparation

The existing culvert be removed and any vegetation, surface topsoil, and debris should be cleared and stripped where the proposed culvert and wingwalls will be placed. If unstable or unsuitable materials are exposed during excavation, they should be removed and replaced with compacted structural fill as described in Section 6.3. The embankment fill behind the proposed wall will be placed against existing sloped embankment. These existing embankments should be deeply plowed or benched in accordance with IDOT Section 205.03 (IDOT 2016) prior to the placement of fill materials.

6.2 Excavation, Dewatering, and Utilities

Excavations should be performed in accordance with local, state, and federal regulations. The potential effect of ground movements upon nearby utilities should be considered during construction. Excavations for the placement of the culvert barrel should be steeped at no steeper than 1:2 (V:H). Any slopes that cannot be graded at 1:2 (V: H) should be properly shored with temporary sheeting or soil retention systems. Excavated material should not be stockpiled immediately adjacent to the top of slopes, nor should equipment be allowed to operate too closely to open excavations.

During the subsurface investigation, groundwater was encountered at elevation ranging from 863 to 896 feet. The proposed barrel and wingwalls will be established at 889.5 to 891.5 feet elevation which is below the encountered groundwater. Therefore, groundwater may be encountered and temporary sheet piling or cofferdam will be required for dewatering of foundation excavation. Contractor should be prepared for dewatering measures should groundwater be encountered above the proposed excavation depth. Any water that accumulates in open excavations by seepage or runoff should be immediately removed by sump-pump. Depending upon prevailing climate conditions and the time of the year when culvert construction takes place, control runoff and maintenance of existing flows may require temporary water diversion and control.

6.3 Filling and Backfilling

Fill material used to attain the final design elevations should be structural fill material. Coarse aggregate of IDOT gradation CA-6 or pre-approved, compacted, cohesive or granular soil conforming to Section 204 would be acceptable as structural fill (IDOT, 2016). The fill material should be free of

organic matter and debris and should be placed in lifts and compacted according to IDOT Section 205, *Embankment* (IDOT, 2016).

Groundwater may exist beneath the culvert. As mentioned in IDOT (2017), in cases such as replacement below box culvert where dewatering and compaction may not be possible, the pay item "Rockfill" is commonly used. In this case, the following note should be added.

"The Rockfill shall be capped with 6 in. of CA7 and satisfy the Standard Specifications unless otherwise indicated in the Special Provisions. The cost of the capping material shall be included in the pay item for Rockfill."

6.4 Earthwork Operations

The required earthwork can be accomplished with conventional construction equipment. Moisture and traffic will cause deterioration of exposed subgrade soils. Precautions should be taken by the Contractor to prevent water erosion of the exposed subgrade. A compacted subgrade will minimize water runoff erosion.

Earth moving operations should be scheduled to not coincide with excessive cold or wet weather (early spring, late fall or winter). Any soil allowed to freeze or soften due to the standing water should be removed. Wet weather can cause problems with subgrade compaction.

It is recommended that an experienced geotechnical engineer be retained to inspect the exposed subgrade, monitor earthwork operations, and provide material inspection services during the construction phase of this project.

7.0 QUALIFICATIONS

The analysis and recommendations submitted in this report are based upon the data obtained from the borings drilled at the locations shown on the boring logs and in Exhibit 3. This report does not reflect any variations that may occur between the borings or elsewhere on the site, variations whose nature and extent may not become evident until the course of construction. In the event that any changes in the design and/or location of the structure are planned, we should be timely informed so that our recommendations can be adjusted accordingly.

It has been a pleasure to assist Strand Associates, Inc and the Illinois Department of Transportation on this project. Please call if there are any questions, or if we can be of further service.

Respectfully Submitted,

WANG ENGINEERING, INC.

Andri A. Kurnia, P.E.	Corina T. Farez, P.E., P.G.
Senior Geotechnical Engineer	QA/QC Reviewer

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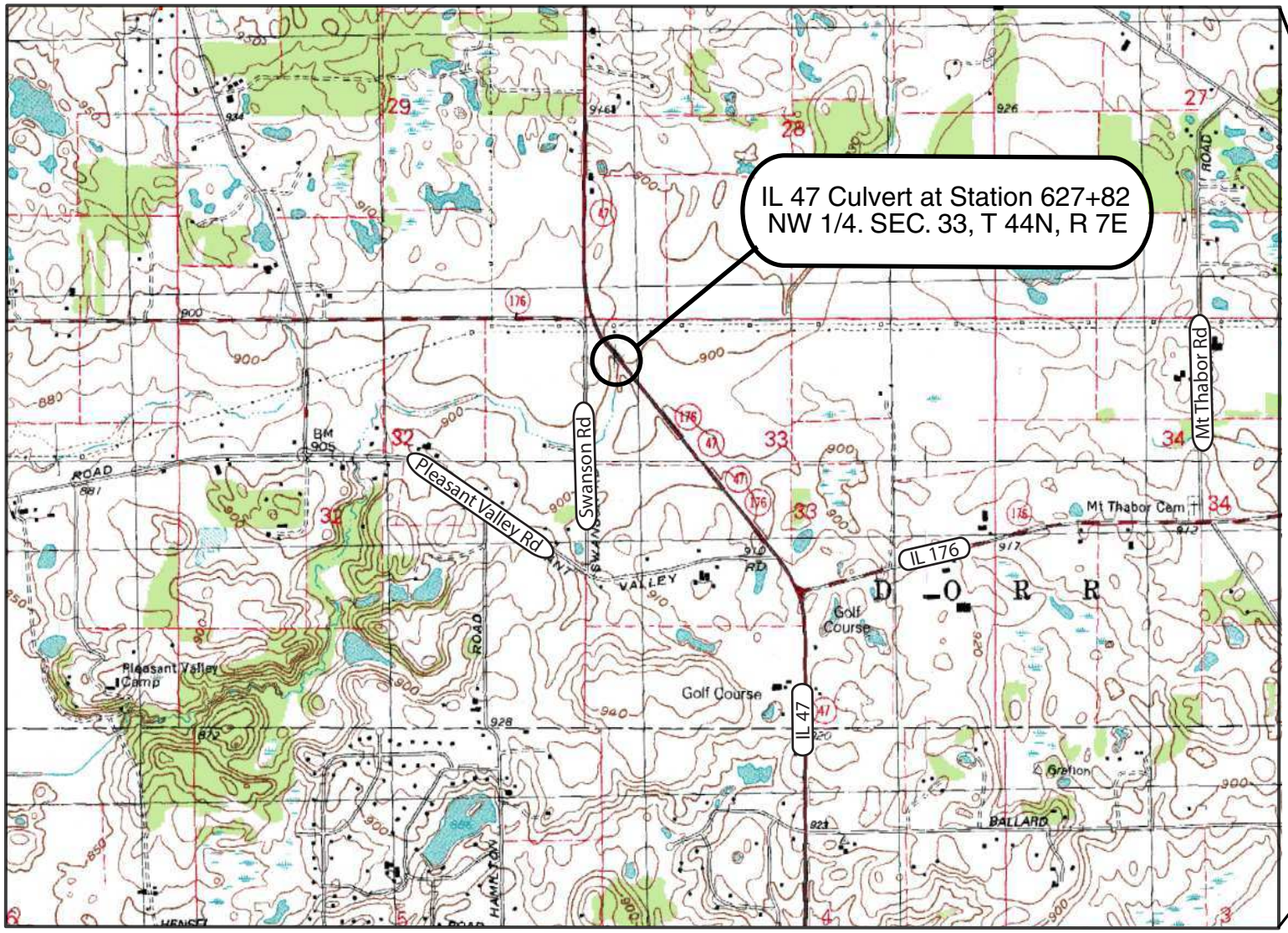
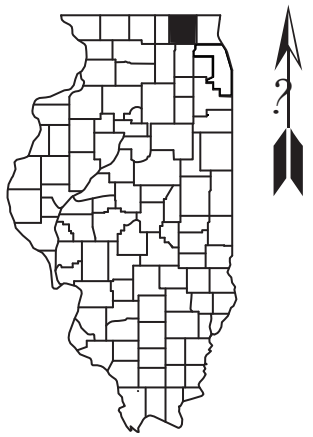
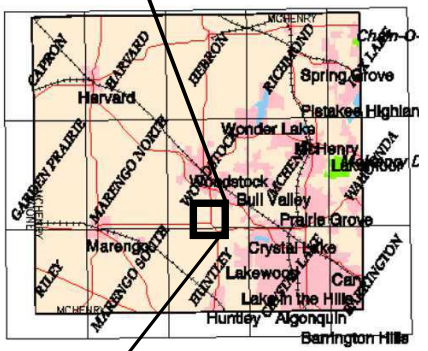
EXHIBITS





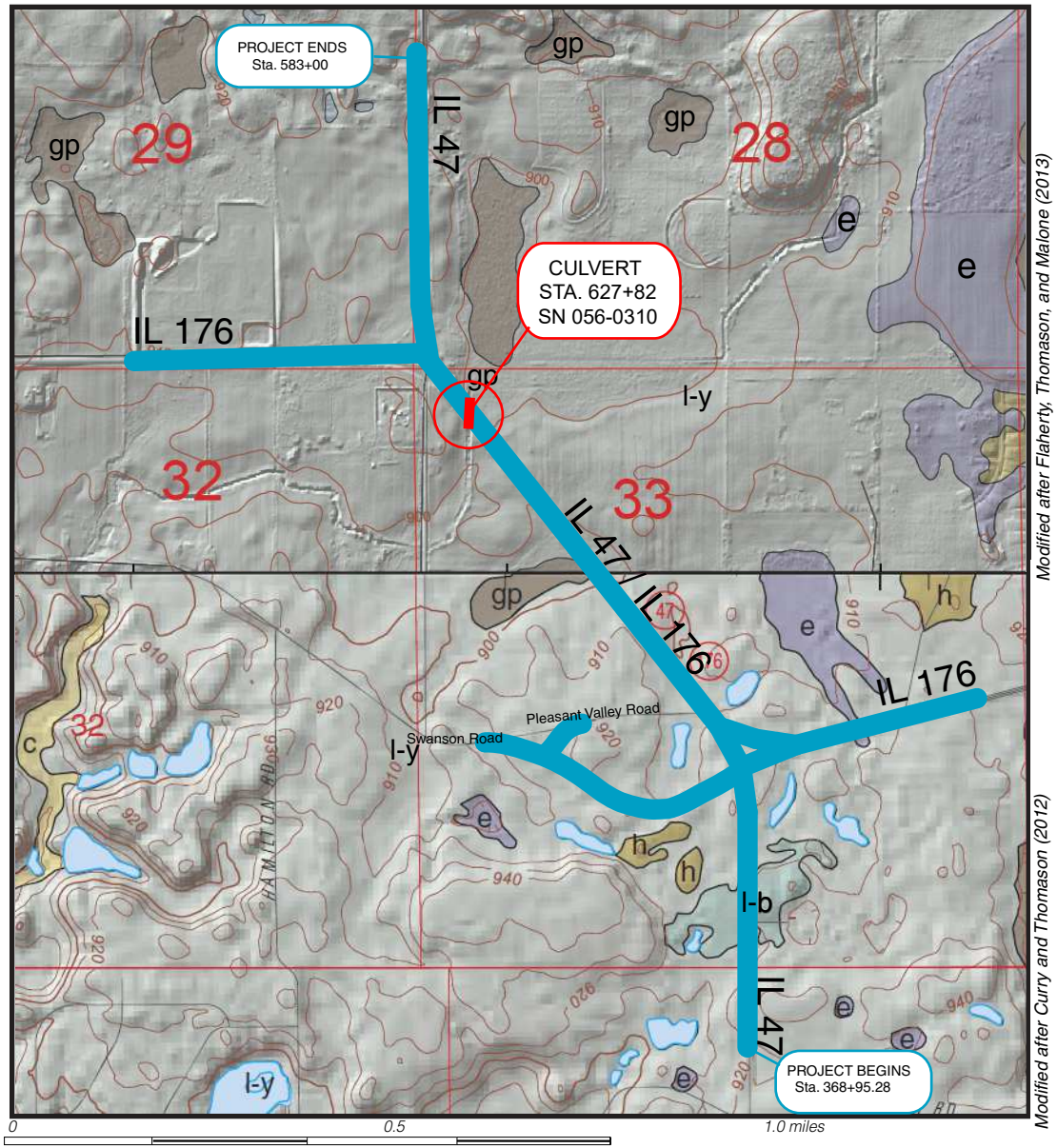


McHenry County

Scale

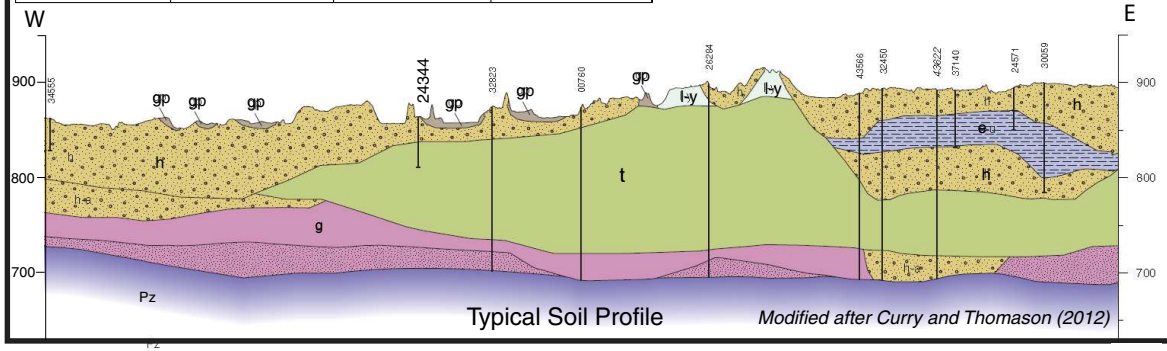
0 1 2 Mile

SITE LOCATION MAP: IL 47 CULVERT AT STATION 627+82, SN 056-0310, MCHENRY COUNTY		
SCALE: GRAPHICAL	EXHIBIT 1	DRAWN BY: RKC CHECKED BY: A. Kurnia
Wang Engineering		1145 N. Main Street Lombard, IL 60148 www.wangeng.com
FOR STRAND ASSOCIATES, INC.		195-13-01



Modified after Flaherty, Thomason, and Malone (2013)

Modified after Curry and Thomason (2012)



Typical Soil Profile

Modified after Curry and Thomason (2012)

REGIONAL GEOLOGY

Wedron Group

- Wadsworth Formation
- Lemont Formation
- Tiskilwa Formation

Modified after Hansel and Johnson (1996)

LEGEND

HUDSON EPISODE

gp — **Grayslake Peat**
Decomposed wetland vegetation and sediment; peat and muck, interbedded sand, silty clay, and marl

WISCONSIN EPISODE

e — **Equality Formation**
Lake deposits in kettles and valleys; silt, clay, and fine sand; layered to massive

h — **Henry Formation**
Proglacial outwash plains downslope of glacial margins; sand and gravel, or sand; with lenses of silt and clay, or diamicton

l-y — **Lemont Fornation, Yorkville Member**
Debris flow deposits and diamicton; silty clay, silty clay loam, and clay, includes layers of sand and gravel

l-b — **Lemont Formation, Batestown Member (Cross section only)**
Debris flow deposits and diamicton; sandy loam to loam with abundant cobbles; includes layers of sand and gravel or silt and sorted sediment

t — **Tiskilwa Formation (Cross section only)**
Till, debris flow deposits, and outwash; clay loam to loam; includes lenses of sand and gravel.

ILLINOIS EPISODE

g — **Glasford Formation (Cross section only)**
Till and debris flow deposits (diamicton) and outwash (sand and gravel); the diamicton is bouldery in places with reddish brown, sandy loam to loam matrix, with abundant lenses, and channel fills of sand and gravel.

PALEOZOIC BEDROCK

Pz — **Bedrock (Cross section only)**
Dolomite, shaly dolomite, and shale

Modified after Curry and Thomason (2012)

SITE AND REGIONAL GEOLOGY: IL 47 CULVERT AT STATION 627+82, SN 056-0310, McHENRY COUNTY

SCALE: GRAPHICAL	EXHIBIT 2	DRAWN BY: C. Marin CHECKED BY: L. Iordache

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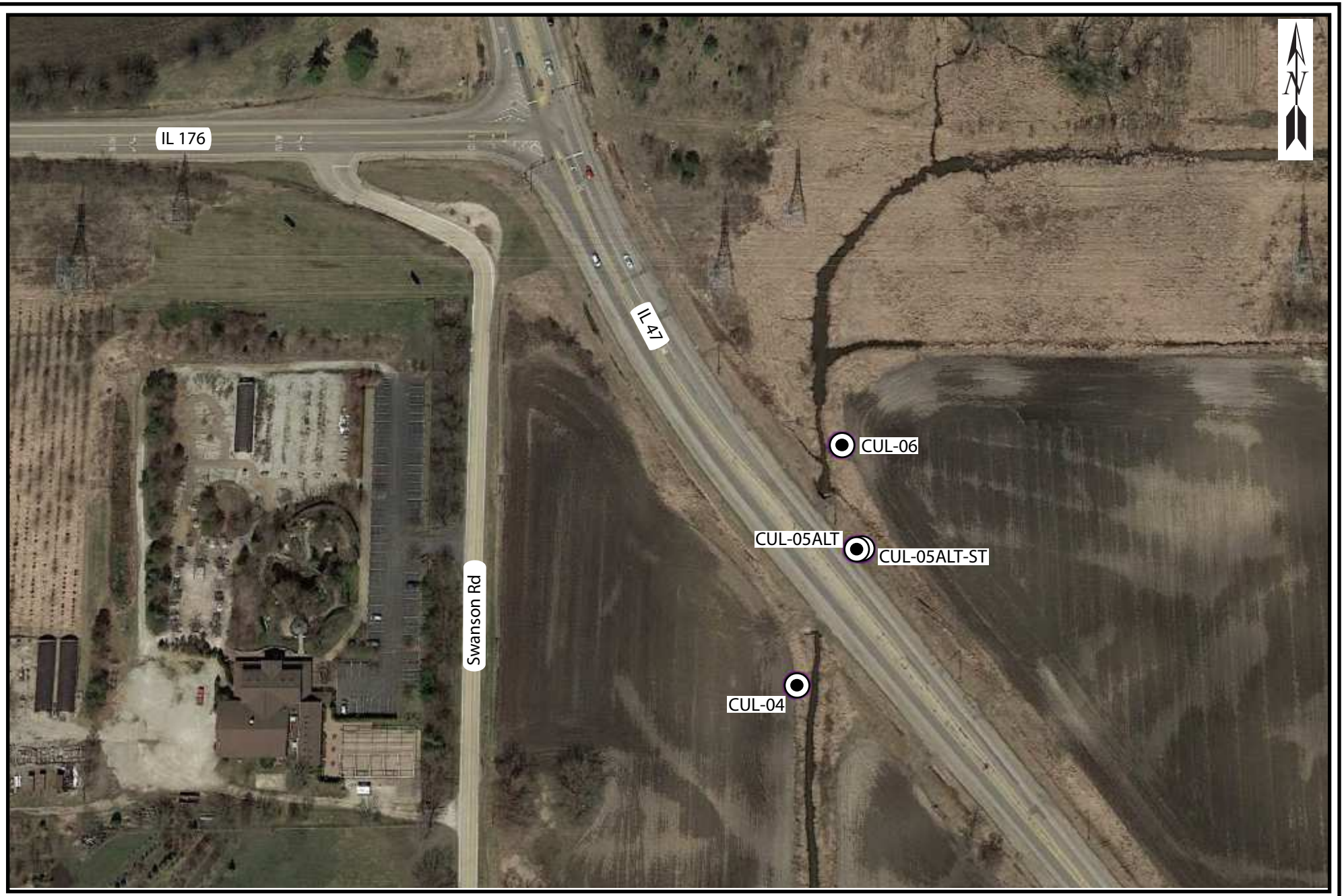

Legend

◉ Culvert Borings

Scale

0 250 500 Feet

BORING LOCATION PLAN: IL 47 CULVERT AT STATION 627+82, SN 056-0310, McHENRY COUNTY

SCALE: GRAPHICAL	EXHIBIT 3	DRAWN BY: RKC CHECKED BY: A. Kurnia

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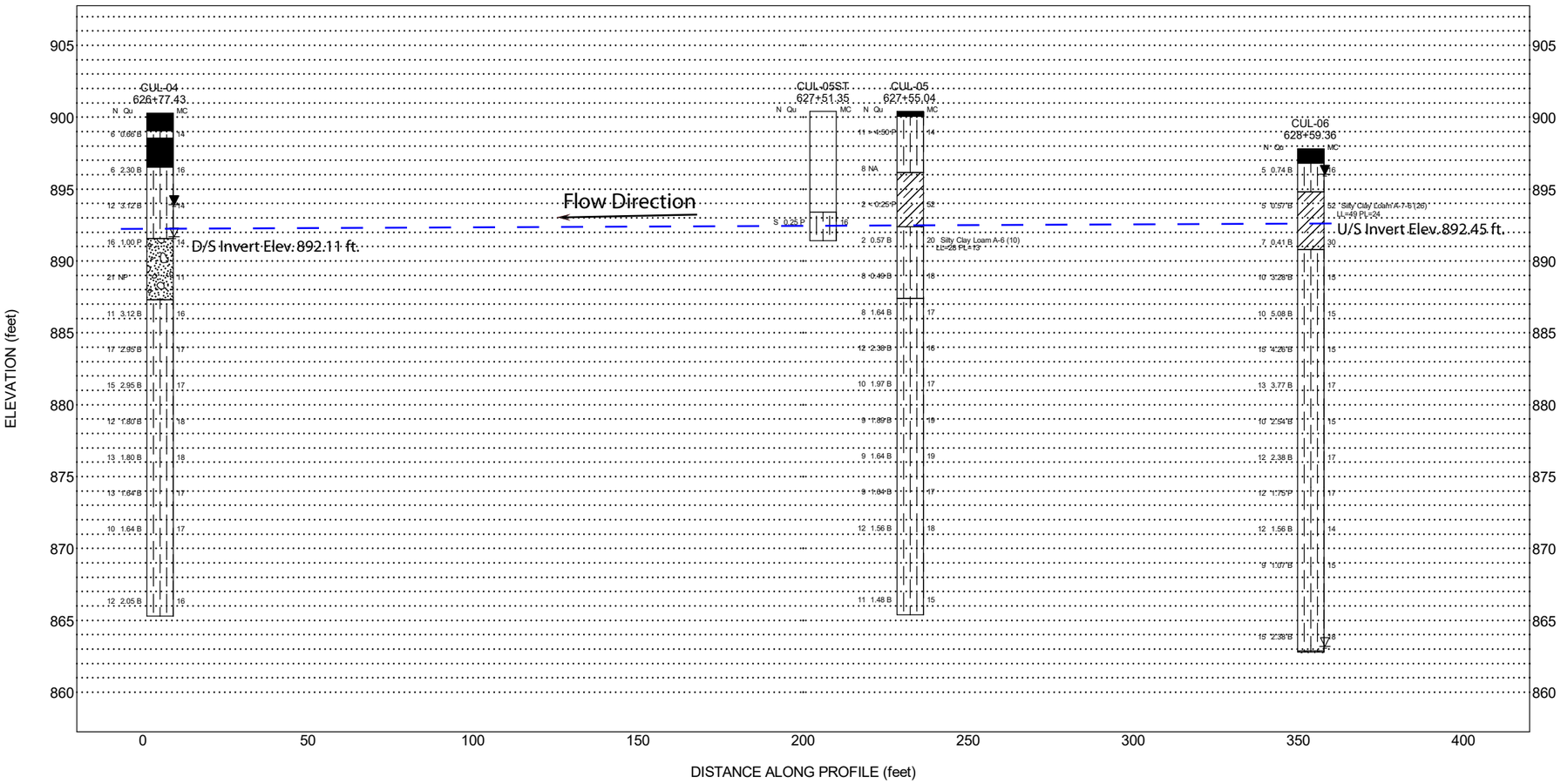
S

N

N



Lithology Graphics

- Topsoil
- IDH Silty Clay, Silty Clay Loam
- Gravelly sand, sandy gravel
- USCS High Plasticity Organic silt or clay

Site Map Scale 1 inch equals 145 feet

Explanation:

CUL-04
626+77.43 — Borehole Number Station

Borehole Lithology

N--N-value, (blw/12 in)
Qu--UC Strength, (tsf)
MC--Moisture Content, (%)

Water Level Reading at time of drilling.

Water Level Reading 24-hr after drilling or at end of drilling

0 40

Horizontal Scale (feet)

Vertical Exaggeration: 4.5x

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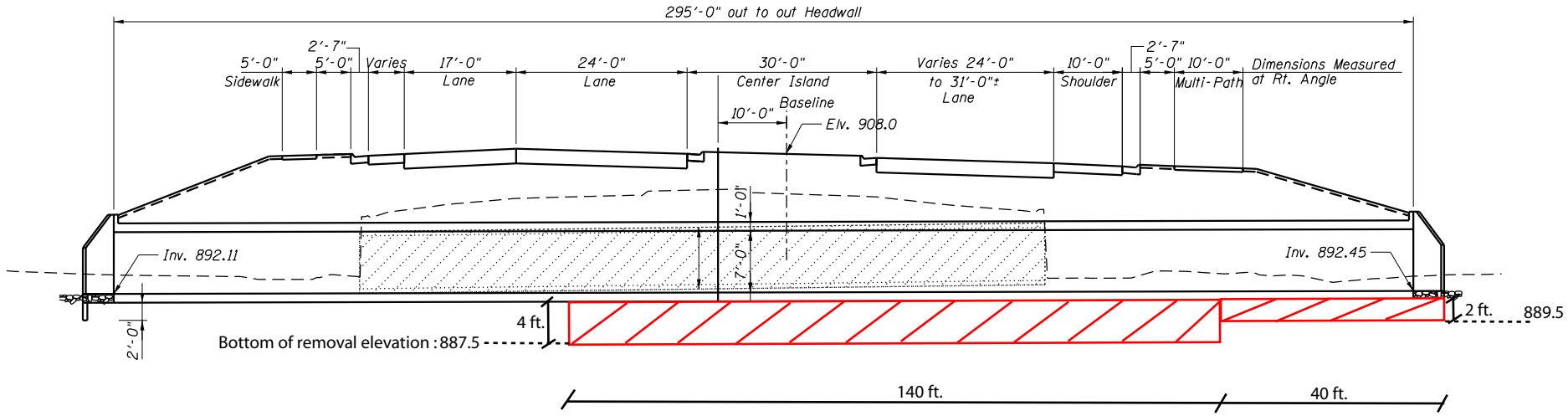
Soil Profile
Culvert at Sta. 627+82, SN 056-0310

WEI SINCE 1982

IL 47 between US 14 and S of IL 176
McHenry County, Illinois

JOB NUMBER	PLATE NUMBER
195-13-01	EXHIBIT 4

› Salvage



REMOVAL AND REPLACEMENT SKETCH: IL 47 CULVERT AT STATION 627+82, SN 056-0310, McHENRY COUNTY

SCALE: GRAPHICAL	**EXHIBIT 5**	DRAWN BY: A. Kurnia CHECKED BY: C. Farez

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APPENDIX A

Wang Engineering

LEGEND FOR BORING LOG

Relative Density of Non-Cohesive Soils	
N-Blows/ 12 inches	**Relative Density Term**
0-3	Very Loose
4-9	Loose
10-29	Medium Dense
30-49	Dense
50-80+	Very Dense

Consistency of Cohesive Soils	
Unconfined Compressive Strength Qu, tsf	**Consistency Term**
<0.25	Very Soft
0.25-0.49	Soft
0.50-0.99	Medium Stiff
1.00-1.99	Stiff
2.00-3.99	Very Stiff
>4.00	Hard

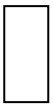
Relative Drilling Resistace	
RDR	**Drilling Resistance Term**
1	Very Easy
2	Easy
3	Moderate
4	Hard
5	Very Hard

Proportional Terms		
Trace	1-9	Percent of Dry Weight
Little	10-19	
Some	20-34	
And	35-50	

Gradation Terminology	
Boulders	>200mm
Cobbles	200mm to 75mm
Gravel	75mm to 2mm
Sand	2-0mm to 0.074mm
Silt	0.074mm to 0.002mm
Clay	<0.002mm

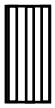
Sample Type Symbols

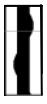

Split Spoon


No Recovery


Geoprobe


Rock Core


Shelby Tube


Auger Cuttings

SS = Split Spoon

ST = Shelby Tube

SPT = Standard Penetration Test

Q_u = Unconfined Compressive Strength

P = Pocket Penetrometer

S = Shear failure of sample, Rimac test

B = Bulge failure of sample, Rimac test

SSA = Solid Stem Augers,

HSA = Hollow Stem Augers,

Drill Rig:

TMR = Truck Mouted Rig

ATV = All Terrain Vehicle Rig

[--%] = SPT Hammer Efficiency


In-situ Vane Shear Test

SPT = Standard Penetration Test

N Value is the sum of the second and the third numbers

04/28/2017

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BORING LOG CUL-04

WEI Job No.: 195-13-01

Client: **Strand Associates, Inc.**
Project: **IL 47 between US 14 and S of IL 176**
Location: **McHenry County, Illinois**

Datum: NGVD
Elevation: 900.30 ft
North: 2034924.71 ft
East: 957622.74 ft
Station: 626+77.43
Offset: 120.6 LT

Profile	Elevation (ft)	SOIL AND ROCK DESCRIPTION	Depth (ft)	Sample Type / recovery	Sample No.	SPT Values (blw/6 in)	Qu (tsf)	Moisture Content (%)
	899.1	15-inch thick, black SILTY CLAY LOAM --TOPSOIL--						
	898.6	Medium stiff, brown SILTY CLAY LOAM, trace gravel --FILL-- --RDR 2--			1	2 3 3	0.66 B	14
	896.6	Black SILTY CLAY LOAM; damp --BURIED TOPSOIL-- --RDR 2--			2	2 2 4	2.30 B	16
		Stiff to very stiff, brown to gray SILTY CLAY LOAM, trace to little gravel; damp to moist --RDR 2--	5		3	5 6 6	3.12 B	14
	891.6	Medium dense, brown SANDY GRAVEL to GRAVELLY LOAM; saturated --possible cobbles-- --RDR 3--	10		4	6 8 8	1.00 P	14
					5	11 12 9	NP	11
	887.3	Stiff to very stiff, gray SILTY CLAY to SILTY CLAY LOAM, trace gravel; damp --RDR 2--	15		6	4 5 6	3.12 B	16
					7	5 8 9	2.95 B	17
			20		8	5 6 9	2.95 B	17
			25		9	5 5 7	1.80 B	18
					10	4 6 7	1.80 B	18
					11	5 5 8	1.64 B	17
			30		12	4 4 6	1.64 B	17
	865.3	Boring terminated at 35.00 ft	35		13	4 5 7	2.05 B	16
			40					

GENERAL NOTES

Begin Drilling: **11-22-2017** Complete Drilling: **11-22-2017**
Drilling Contractor: **Wang Testing Services** Drill Rig: **D50 ATV [88%]**
Driller: **K&K** Logger: **T. Rothschild** Checked by: **C. Marin**
Drilling Method: **2.25 IDA HSA; 140 lb autohammer; Boring backfilled upon completion**

WATER LEVEL DATA

While Drilling: **8.75 ft**
At Completion of Drilling: **6.50 ft**
Time After Drilling: **NA**
Depth to Water: **NA**

The stratification lines represent the approximate boundary between soil types; the actual transition may be gradual.

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BORING LOG CUL-05

WEI Job No.: 195-13-01

Client: **Strand Associates, Inc.**
Project: **IL 47 between US 14 and S of IL 176**
Location: **McHenry County, Illinois**

Datum: NGVD
Elevation: 900.40 ft
North: 2035078.93 ft
East: 957691.23 ft
Station: 627+55.04
Offset: 29.23 RT

Profile	Elevation (ft)	SOIL AND ROCK DESCRIPTION	Depth (ft)	Sample Type / recovery	Sample No.	SPT Values (blw/6 in)	Qu (tsf)	Moisture Content (%)
	900.1	4-inch thick, black SILTY CLAY LOAM						
		--TOPSOIL--						
		Hard, gray SILTY CLAY LOAM, little gravel; damp			1	6 6 5	> 4.50 P	14
		--FILL--						
		--RDR 2--						
	896.2				2	4 4 4	NA	
		Very soft, gray SILTY CLAY LOAM, little organic matter, wood fragments; wet	5					
		--RDR 1--						
		--organic content= 9.8%--			3	1 1 1	< 0.25 P	52
	892.4							
		Soft to medium stiff, gray SILTY CLAY LOAM, trace gravel; moist			4	1 1 1	0.57 B	20
		--RDR 1--						
		--L_L(%)=28, P_L(%)=13--						
		--%Gravel=4.9--	10					
		--%Sand=13.8--						
		--%Silt=55.4--						
		--%Clay=25.9--						
		--A-6 (10)--			5	3 4 4	0.49 B	18
	887.4							
		Stiff to very stiff, gray SILTY CLAY to SILTY CLAY LOAM, trace gravel; damp			6	2 3 5	1.64 B	17
		--RDR 2--	15					
					7	3 5 7	2.38 B	16
					8	3 4 6	1.97 B	17
			20					

Profile	Elevation (ft)	SOIL AND ROCK DESCRIPTION	Depth (ft)	Sample Type / recovery	Sample No.	SPT Values (blw/6 in)	Qu (tsf)	Moisture Content (%)
			25		9	3 4 5	1.89 B	19
					10	3 4 5	1.64 B	19
					11	2 4 5	1.64 B	17
			30		12	3 5 7	1.56 B	18
					13	3 5 6	1.48 B	15
	865.4	Boring terminated at 35.00 ft	35					
			40					

GENERAL NOTES

Begin Drilling: **10-25-2017** Complete Drilling: **10-25-2017**
Drilling Contractor: **Wang Testing Services** Drill Rig: **D50 ATV [88%]**
Driller: **R&K** Logger: **F. Bozga** Checked by: **C. Marin**
Drilling Method: **2.25 IDA HSA; 140 lb autohammer; Boring backfilled upon completion**

WATER LEVEL DATA

While Drilling: **DRY**
At Completion of Drilling: **DRY**
Time After Drilling: **NA**
Depth to Water: **NA**

The stratification lines represent the approximate boundary between soil types; the actual transition may be gradual.

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BORING LOG CUL-05ST

WEI Job No.: 195-13-01

Client: **Strand Associates, Inc.**
Project: **IL 47 between US 14 and S of IL 176**
Location: **McHenry County, Illinois**

Datum: NGVD
Elevation: 900.40 ft
North: 2035078.77 ft
East: 957696.94 ft
Station: 627+51.35
Offset: 33.59 RT

Profile	Elevation (ft)	SOIL AND ROCK DESCRIPTION	Depth (ft)	Sample Type / recovery	Sample No.	SPT Values (blw/6 in)	Qu (tsf)	Moisture Content (%)
		Blind drilled to 7-feet	5					
	893.4							
		Soft, gray SILTY CLAY LOAM --C_c=0.093, OCR=2.4--			1	PUSH	0.25 P	16
	891.4							
		Boring terminated at 9.00 ft	10					
			15					
			20					

GENERAL NOTES

Begin Drilling: **10-26-2017** Complete Drilling: **10-26-2017**
Drilling Contractor: **Wang Testing Services** Drill Rig: **D50 ATV [88%]**
Driller: **K&N** Logger: **F. Bozga** Checked by: **C. Marin**
Drilling Method: **2.25 IDA HSA; 140 lb autohammer; Boring backfilled upon completion**

WATER LEVEL DATA

While Drilling: **NA**
At Completion of Drilling: **NA**
Time After Drilling: **NA**
Depth to Water: **NA**

The stratification lines represent the approximate boundary between soil types; the actual transition may be gradual.

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BORING LOG CUL-06

WEI Job No.: 195-13-01

Client: **Strand Associates, Inc.**
Project: **IL 47 between US 14 and S of IL 176**
Location: **McHenry County, Illinois**

Datum: NGVD
Elevation: 897.80 ft
North: 2035199.29 ft
East: 957674.66 ft
Station: 628+59.36
Offset: 91.5 RT

Depth (ft)	Elevation (ft)	SOIL AND ROCK DESCRIPTION	Sample Type / recovery	Sample No.	SPT Values (blw/6 in)	Qu (tsf)	Moisture Content (%)
	896.8	12-inch thick, black SILTY CLAY LOAM					
		--TOPSOIL--					
		Medium stiff, brown SILTY CLAY LOAM, trace gravel; damp		1	2 3 2	0.74 B	16
		--FILL--					
	894.8	--RDR 2--					
		Soft to medium stiff, brown and gray SILTY CLAY LOAM, trace to little organic matter; moist		2	2 2 3	0.57 B	52
		--RDR 2--					
5		--L_L(%)=49, P_L(%)=24--					
		--%Gravel=0.1--					
		--%Sand=7.0--					
		--%Silt=67.1--					
		--%Clay=25.6--					
	890.8	--A-7-6 (26)--		3	2 3 4	0.41 B	30
		Stiff to hard, gray SILTY CLAY, trace gravel; damp					
		--RDR 2--					
				4	3 4 6	3.28 B	15
10							
				5	3 4 6	5.08 B	15
				6	4 6 9	4.26 B	15
15							
				7	4 5 8	3.77 B	17
				8	4 4 6	2.54 B	15
20							
25				9	4 5 7	2.38 B	17
				10	4 6 6	1.75 P	17
				11	5 7 5	1.56 B	14
30				12	4 3 6	1.07 B	15
35				13	3 5 10	2.38 B	18
	862.9	Gray GRAVELLY SAND; saturated					
	862.8	Boring terminated at 35.00 ft					
40							

GENERAL NOTES

Begin Drilling: **11-20-2017** Complete Drilling: **11-20-2017**
Drilling Contractor: **Wang Testing Services** Drill Rig: **D50 ATV [88%]**
Driller: **K&K** Logger: **T. Rothschild** Checked by: **C. Marin**
Drilling Method: **2.25 IDA HSA; 140 lb autohammer; Boring backfilled upon completion**

WATER LEVEL DATA

While Drilling: **34.75 ft**
At Completion of Drilling: **1.90 ft**
Time After Drilling: **NA**
Depth to Water: **NA**

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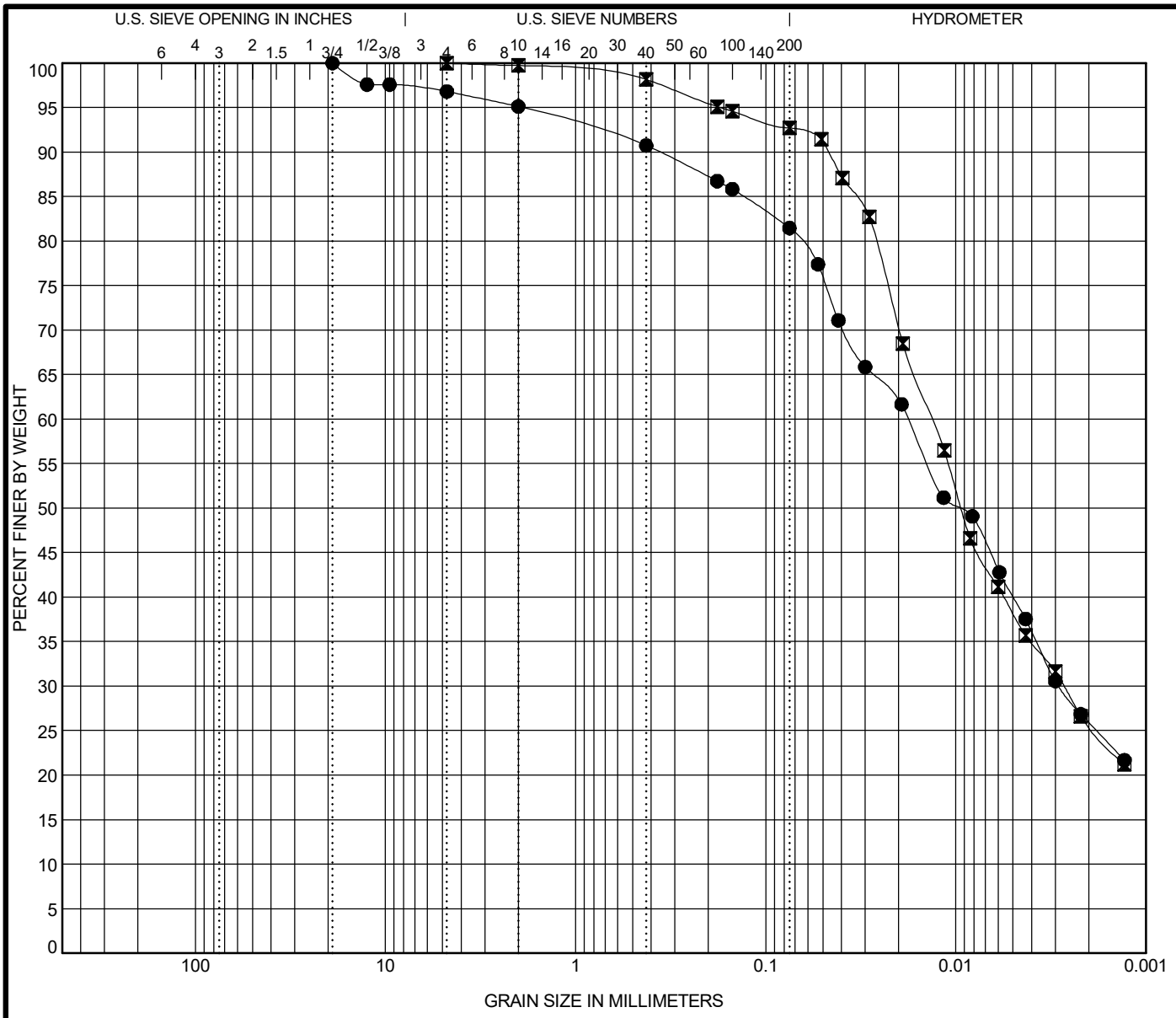
APPENDIX B



COBBLES	GRAVEL	SAND		SILT AND CLAY
		coarse	fine	

	Specimen Identification		IDH Classification	LL	PL	PI	Cc	Cu
●	CUL-05#4	8.5 ft	**Silty Clay Loam**	**28**	**13**	**15**		
⊠	CUL-06#2	3.5 ft	**Silty Clay Loam**	**49**	**24**	**25**		

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	CUL-05#4	8.5 ft	**19**	**0.018**	**0.003**		**4.9**	**13.8**	**55.4**	**25.9**
⊠	CUL-06#2	3.5 ft	**4.75**	**0.013**	**0.003**		**0.3**	**7.0**	**67.1**	**25.6**

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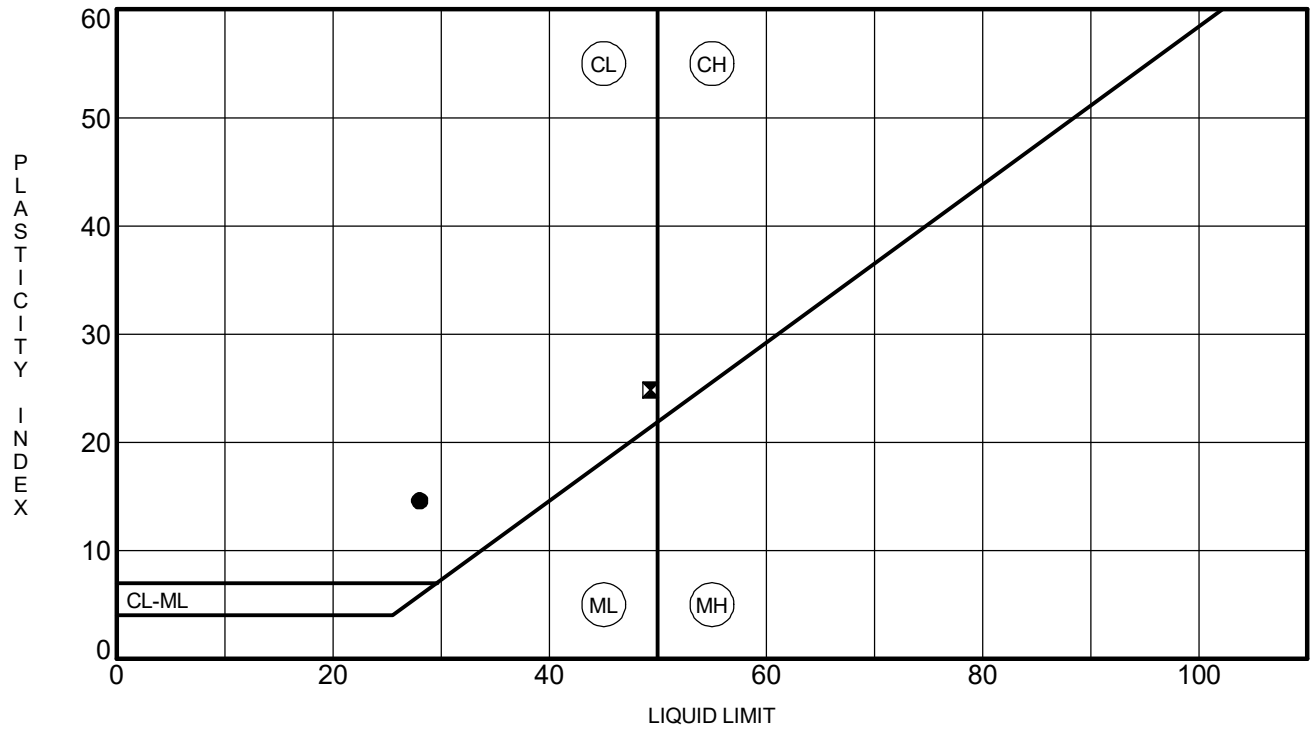
GRAIN SIZE DISTRIBUTION

Project: IL 47 between US 14 and S of IL 176

Location: McHenry County, Illinois

Number: 195-13-01



	Specimen Identification		LL	PL	PI	Fines	IDH Classification
●	**CUL-05#4**	**8.5 ft**	**28**	**13**	**15**	**81**	**Silty Clay Loam**
⧓	**CUL-06#2**	**3.5 ft**	**49**	**24**	**25**	**93**	**Silty Clay Loam**

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ATTERBERG LIMITS' RESULTS

Project: IL 47 between US 14 and S of IL 176

Location: McHenry County, Illinois

Number: 195-13-01

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ONE-DIMENSIONAL CONSOLIDATION TEST

AASHTO T 216 / ASTM D 2435

Project: Illinois Route 47
Client: Strand Associates, Inc.
Soil Sample ID: Boring CUL-05ST, ST#1, 7 to 9 feet
Sample Description: Gray SI CLAY

Tested by: M. Snider
Prepared by: M. Snider
Test date: 12/15/2017
WEI: 195-13-01

Initial sample height =	0.968	in	Ring diameter =	2.498	in
Initial sample mass =	179.85	g	Ring mass =	109.45	g
Initial water content =	15.61%		Initial sample and ring mass =	289.30	g
Initial dry unit weight =	124.95	pcf	Tare mass =	80.66	g
Initial void ratio =	0.378		Final ring and sample mass =	284.17	g
Initial degree of saturation =	100.00%		Mass of wet sample and tare =	255.12	g
			Mass of dry sample and tare =	236.23	g
Final sample mass =	174.46	g	Initial dial reading =	0.01000	in
Final dry sample mass =	155.57	g	Final dial reading =	0.08080	in
Final water content =	12.14%		LL =		%
Final dry unit weight =	134.81	pcf	PL =		%
Final void ratio =	0.278		% Sand =		
Final degree of saturation =	100.00%		% Silt =		
Estimated specific gravity =	2.76		% Clay =		
			In-Situ Vertical Effective Stress =	1500	psf

Compression and Swelling Indices

Compression index C_c =	0.073	**Preconsolidation pressure,s_C**	
Field corrected C_c =	0.093	Casagrande Method =	3615 psf
Swelling index C_s =	0.011	**Over-Consolidation Ratio (OCR) =**	2.41

Load number	Vertical stress	Dial reading	System deflection	Vertical strain	Void ratio	C_v	Cae	Elapsed time
	psf	in	in	%		ft^2/day	%	min
1	100.0	0.01792	0.00010	0.83	0.367	N/A	N/A	720
2	200.0	0.02293	0.00023	1.36	0.360	0.1107	0.02	720
3	500.0	0.03028	0.00058	2.16	0.349	0.2168	0.04	720
4	1000.0	0.03752	0.00090	2.94	0.338	0.2297	0.04	960
5	2000.0	0.04474	0.00135	3.73	0.327	0.2003	0.07	960
6	4000.0	0.05195	0.00193	4.53	0.316	0.2185	0.10	1440
7	8000.0	0.06182	0.00253	5.61	0.301	0.2066	0.15	1440
8	16000.0	0.07452	0.00324	7.00	0.282	0.2020	0.18	1440
9	32000.0	0.08912	0.00413	8.60	0.260	0.2132	0.05	720
10	8000.0	0.08896	0.00295	8.46	0.262	N/A	N/A	2880
11	2000.0	0.08540	0.00198	7.99	0.268	N/A	N/A	720
12	500.0	0.08170	0.00123	7.53	0.275	N/A	N/A	1440

Prepared by: _____ Date: _____

Checked by: _____ Date: _____

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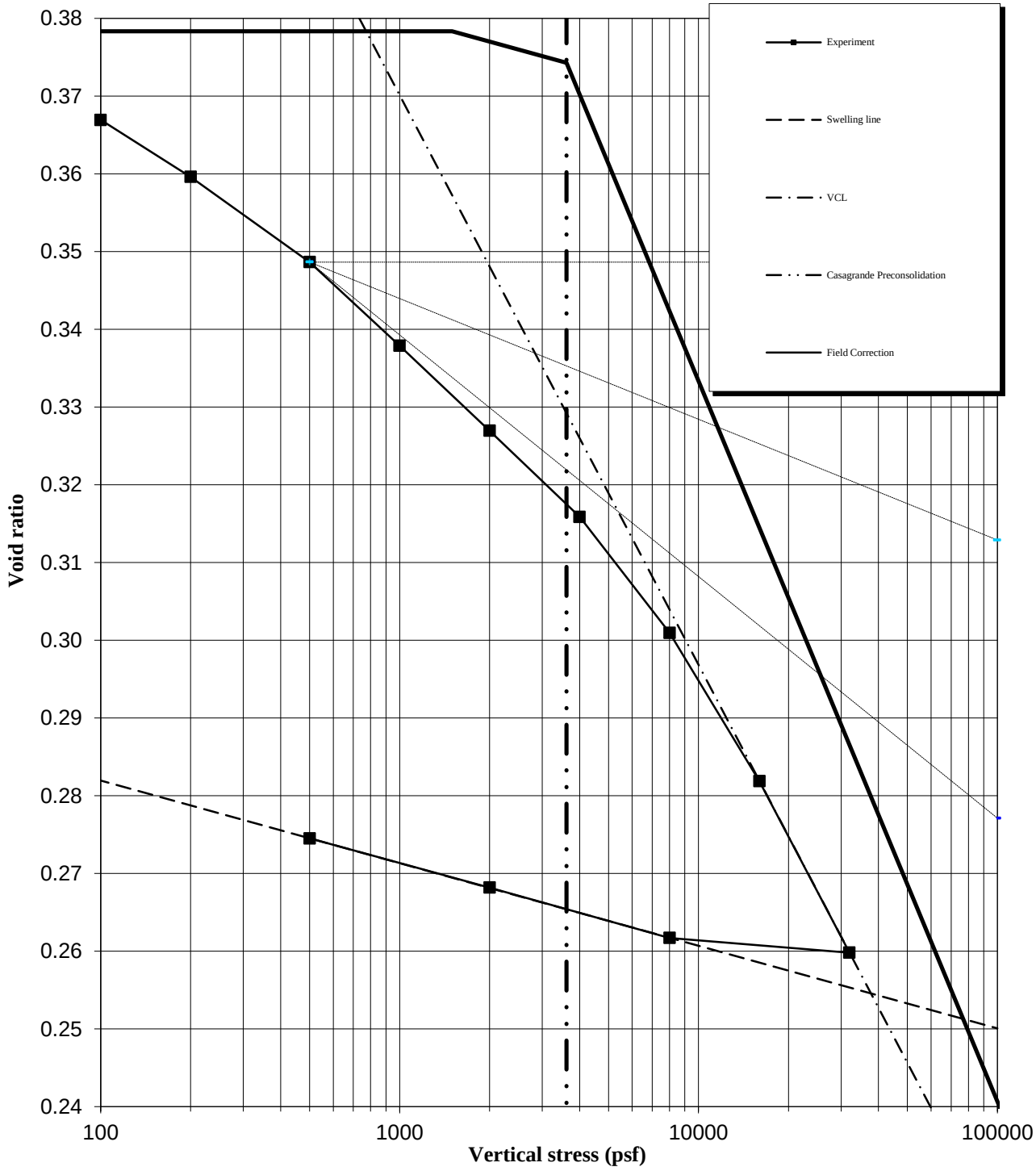
CONSOLIDATION CURVE

Sample CUL-05ST, ST#1, 7 to 9 feet



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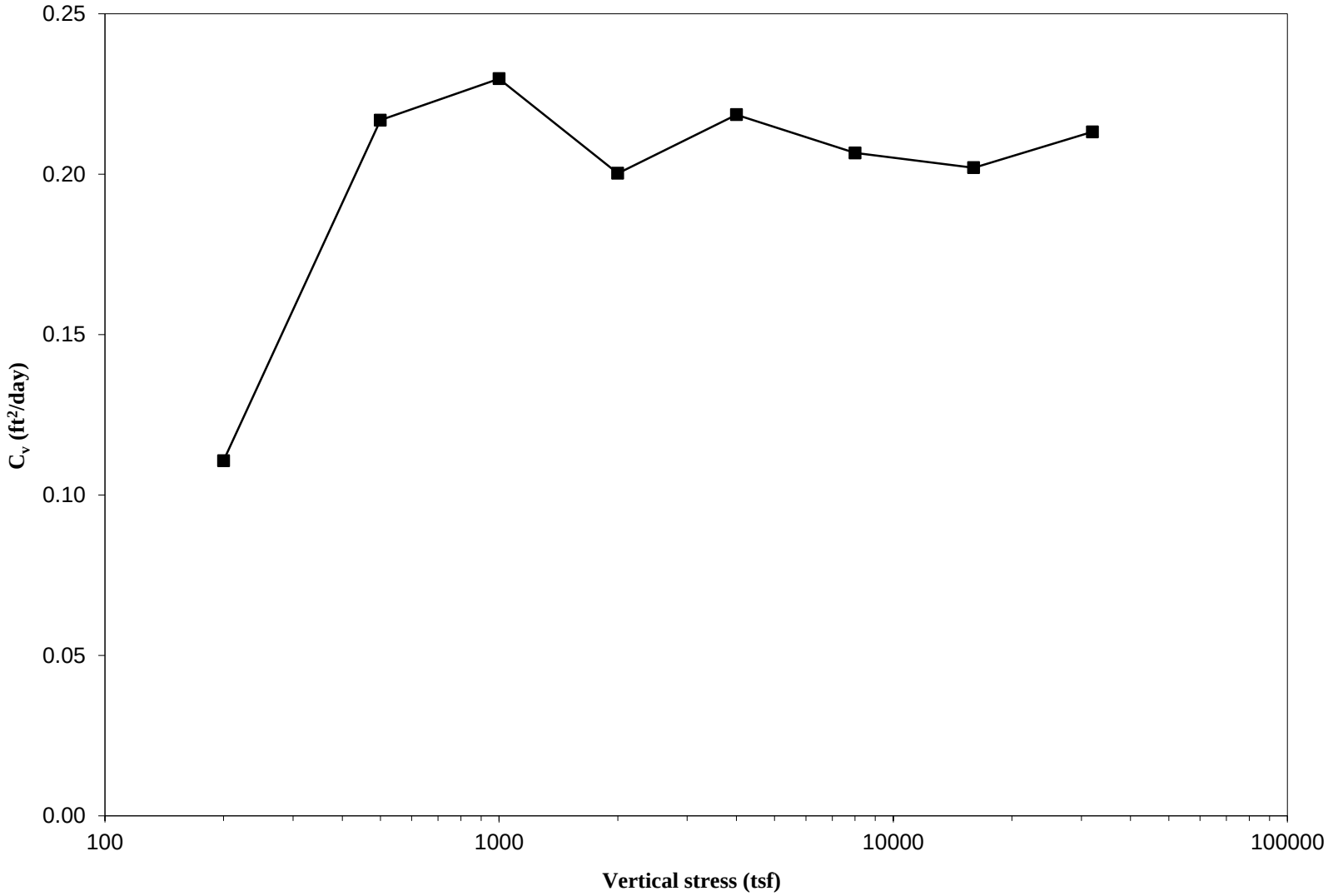
CONSOLIDATION COEFFICIENT (C_v) vs. VERTICAL STRESS

Sample CUL-05ST, ST#1, 7 to 9 feet



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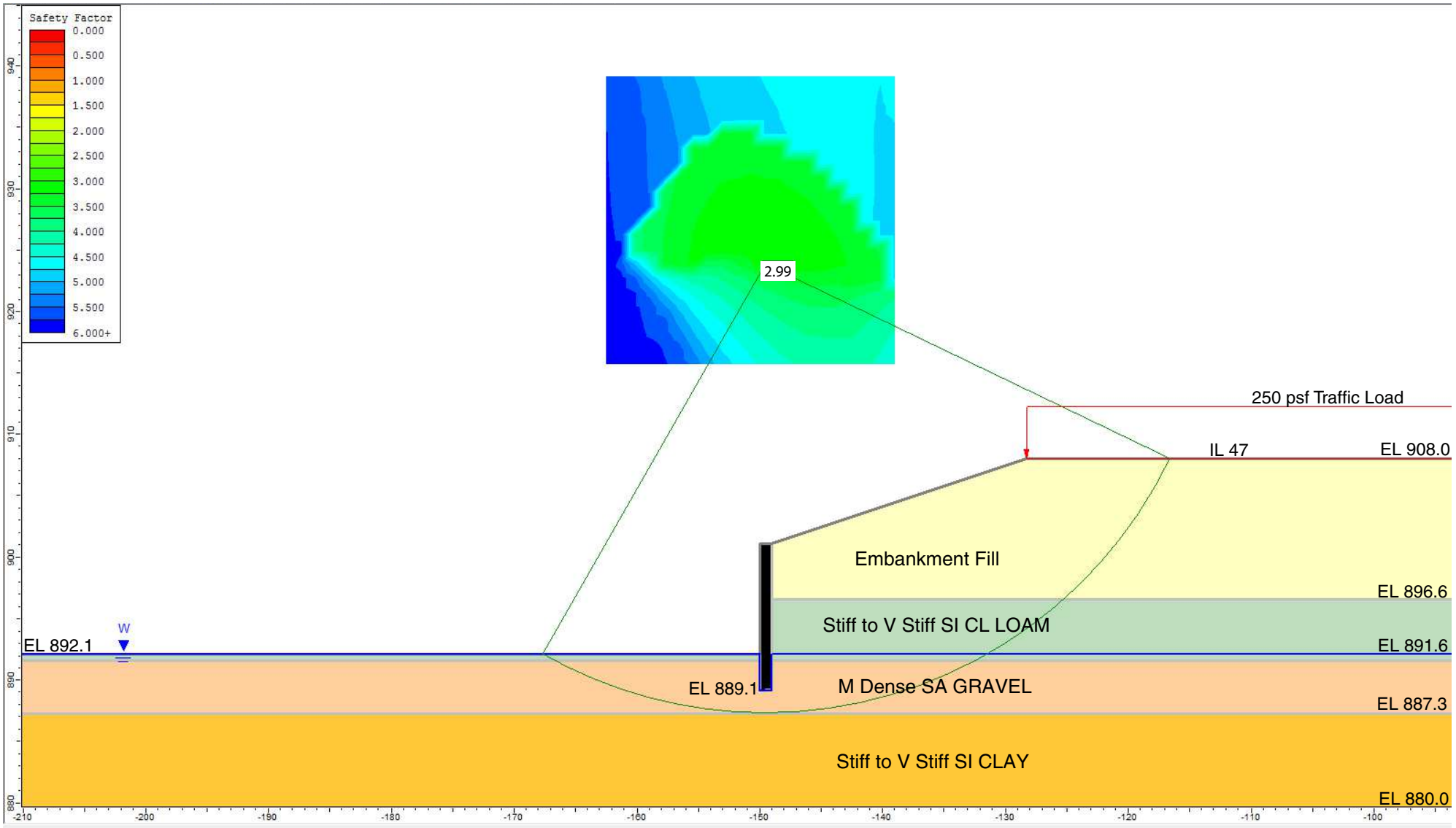
APPENDIX C



Undrained Analysis for Culvert, Reference Boring: CUL-04

Layer ID	Description	Unit Weight (pcf)	Undrained Cohesion (psf)	Undrained Friction Angle (degrees)
1	Embankment FILL	125	1000	0
2	Stiff to V Stiff SI CL LOAM	120	2700	0
3	M Dense SA GRAVEL	125	0	32
4	Stiff to V Stiff SI CLAY	120	2200	0

GLOBAL STABILITY ANALYSIS: IL 47 CULVERT AT STATION 627+82, SN 056-0310, MCHENRY COUNTY

SCALE: GRAPHICAL | APPENDIX C-1 | DRAWN BY: RKC CHECKED BY: A. Kurnia

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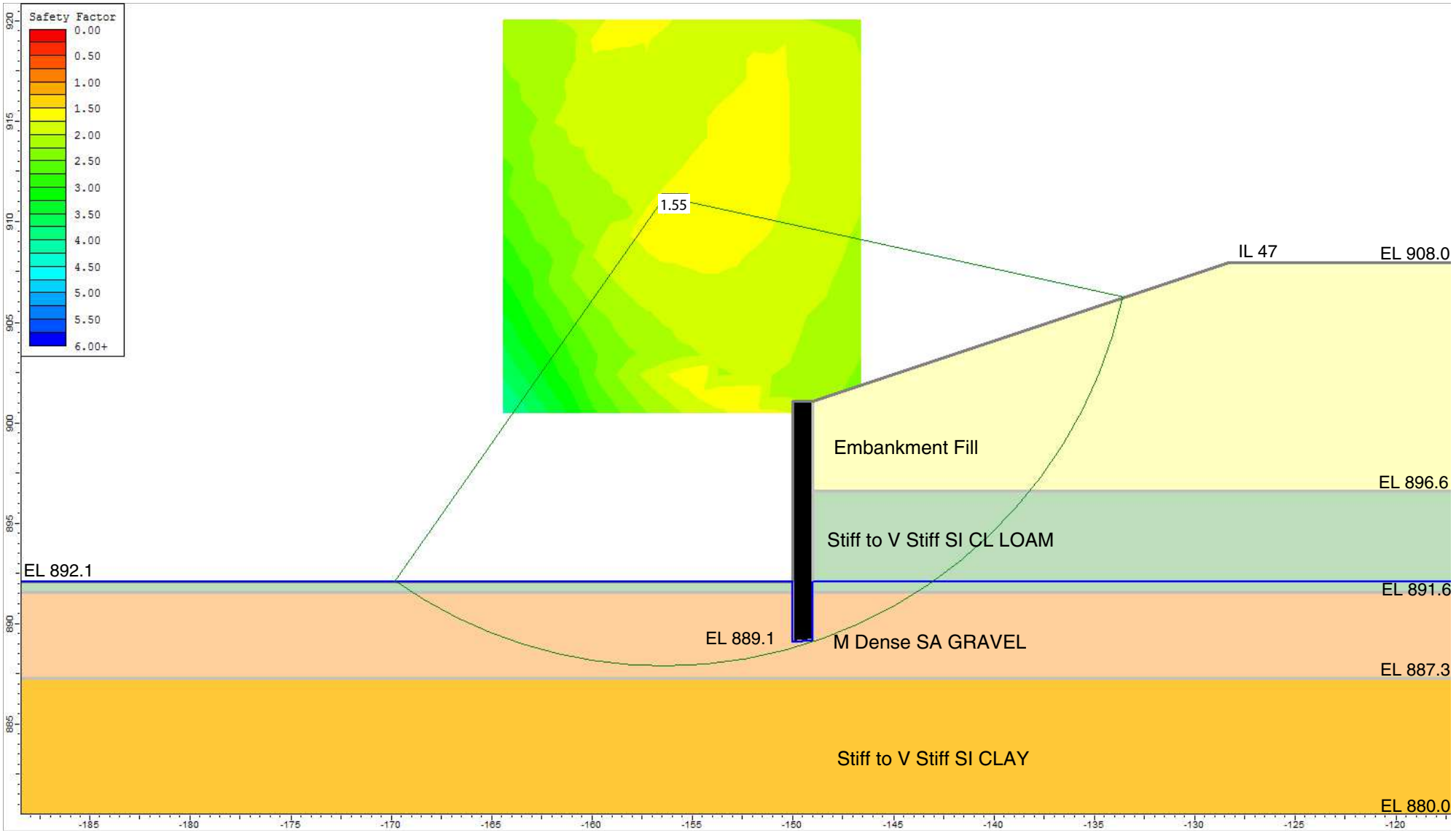

Drained Analysis for Culvert, Reference Boring: CUL-04

Layer ID	Description	Unit Weight (pcf)	Drained Cohesion (psf)	Drained Friction Angle (degrees)
1	Embankment FILL	125	100	30
2	Stiff to V Stiff SI CL LOAM	120	100	31
3	M Dense SA Gravel	125	0	32
4	Stiff to V Stiff SI CLAY	120	100	31

GLOBAL STABILITY ANALYSIS: IL 47 CULVERT AT STATION 627+82, SN 056-0310, MCHENRY COUNTY

SCALE: GRAPHICAL | APPENDIX C-2 | DRAWN BY: RKC CHECKED BY: A. Kurnia

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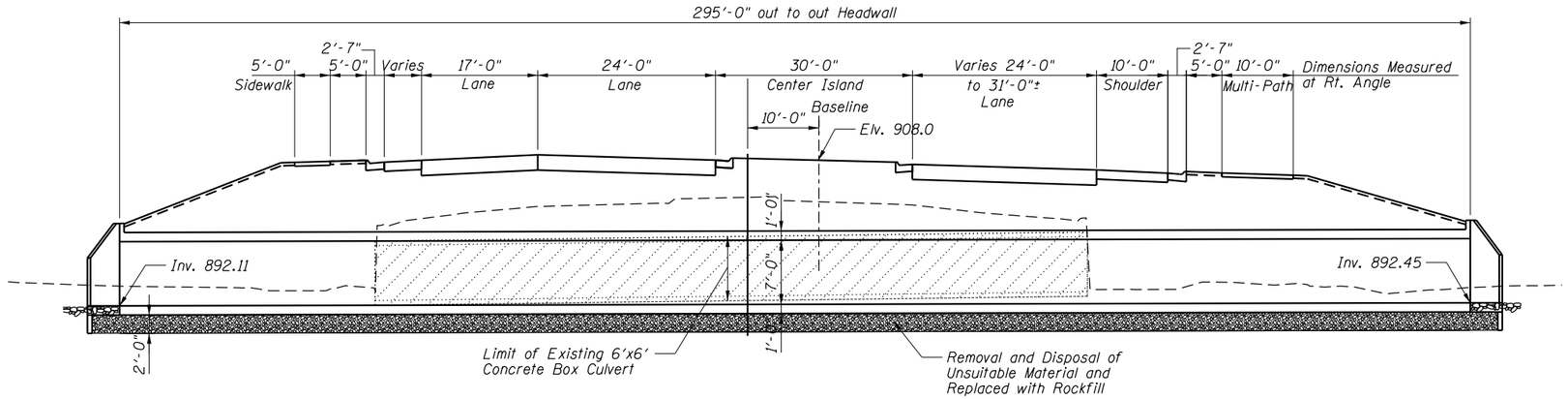
APPENDIX D

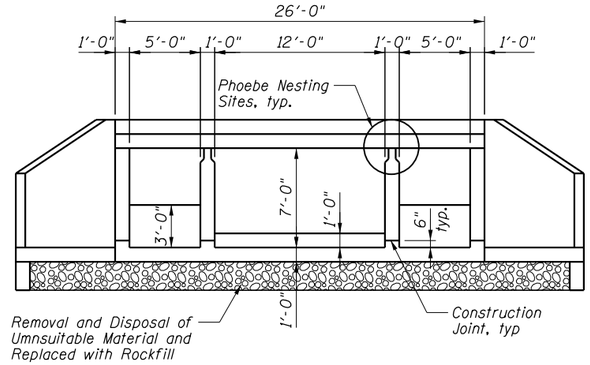
Bench Mark: BM #9-Found bolt at the SW corner of Concrete Box Culvert.
Elevation=901.774

Existing Structure: SN 056-0246 built in 19XX as single 6'x6' R.C. box culvert
155'-0" face to face of curb with culvert length of 155'-6".
Traffic to be maintained utilizing stage construction.

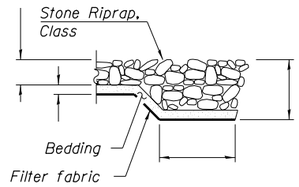
No Salvage



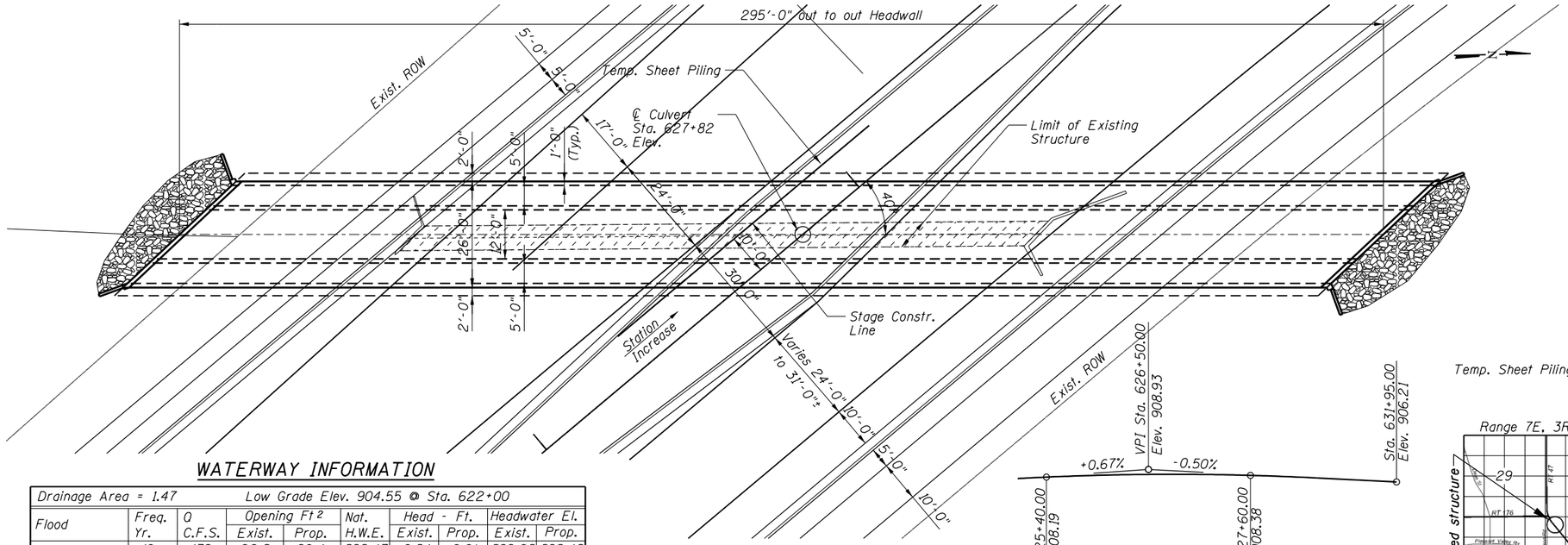
ELEVATION



SECTION THRU BARREL

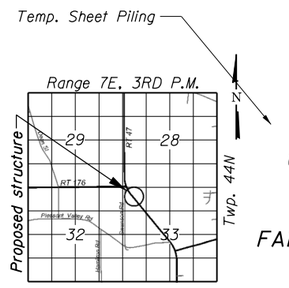


SECTION B-B



PLAN

PROFILE GRADE



LOCATION SKETCH

WATERWAY INFORMATION

Drainage Area = 1.47 — Low Grade Elev. 904.55 @ Sta. 622+00

Flood	Freq. Yr.	Q C.F.S.	Opening Ft² Exist.	Opening Ft² Prop.	Nat. H.W.E.	Head - Ft. Exist.	Head - Ft. Prop.	Headwater El. Exist.	Headwater El. Prop.
	10	139	22.8	90.4	898.47	0.84	0.01	899.28	898.48
Design	50	312	32.2	112.0	900.04	2.15	0.20	902.16	900.24
Base	100	425	34.9	112.0	900.51	2.13	0.46	902.60	900.97
Overtopping									
Max. Calc.	500	609	36.0	112.0	901.08	1.89	1.12	902.92	902.20

HIGHWAY CLASSIFICATION

Rte. - Rte.
Functional Class:
ADT: (20): (20)
ADTT: (20): (20)
DHV:
Design Speed: m.p.h.
Posted Speed: m.p.h.
-Way Traffic
Directional Distribution:

DESIGN SPECIFICATIONS

2017 AASHTO LRFD Bridge Design Specifications, 8th Edition

LOADING HL-93

Allow 50#/sq. ft. for future wearing surface.

DESIGN STRESSES

FIELD UNITS

f'c = 3,500 psi
fy = 60,000 psi (Reinforcement)
fy = 50,000 psi (M270 Grade 50)

GENERAL PLAN AND ELEVATION
ILLINOIS ROUTE 47 OVER KISHWAUKEE RIVER
FAP ROUTE 326-SECTION 105-N-2(15)
McHENRY COUNTY
STATION 627+82
STRUCTURE No. 056-0310

STRAND ASSOCIATES®
1170 SOUTH HOUBOLT ROAD
JOLIET, ILLINOIS 60431
(815) 744-4200

USER NAME = prazalan	DESIGNED - MAG	REVISED -	STATE OF ILLINOIS DEPARTMENT OF TRANSPORTATION
	DRAWN - DJW	REVISED -	
PLOT SCALE = 32.0000 ' / in.	CHECKED - DWG	REVISED -	
PLOT DATE = 1/17/2018	DATE - $PLANDATE$	REVISED -	

GENERAL PLAN AND ELEVATION

SCALE: | SHEET OF SHEETS | STA. | TO STA.

F.A.P. RTE.	SECTION	COUNTY	TOTAL SHEETS	SHEET NO.
326	105-N-2(15)	MCHENRY	STOTS	
		CONTRACT NO. 62B43		
	ILLINOIS FED. AID PROJECT			

MODEL: Default
FILE NAME: N:\dot\170353\CBBEL\Struct\TSL_170353-01.dgn