MEMORIAL STADIUM
SUBSURFACE GEOPHYSICAL INVESTIGATION
State College, Pennsylvania

Prepared for:
State College Area School District
131 West Nittany Avenue
State College, Pennsylvania 16801-4899
September 21, 2012

Prepared by:

THG Geophysics, Ltd.
4280 Old William Penn Highway
Murrysville, Pennsylvania 15668
724-325-3996
www.geo-image.com
THG Project No. 803-5125

TABLE OF CONTENTS

FIGURES

1.0 INTRODUCTION

1.1 Background

The State College Area School District retained THG Geophysics, Ltd. (THG) to investigate an existing sink hole beneath the northern bleachers at the Memorial Stadium, State College, Pennsylvania. THG electrically imaged the stadium in 2003 to determine if sink holes would develop in the playing field. THG determined that the playing field was on top of a large subsidence sink hole that has been plugged with clay and fill. In that study, THG recognized the sink hole beneath the stands that is currently used for storm water drainage; however, that area was not in the scope of work at the time.

1.2 Work Scope

THG conducted an electrical imaging (EI) and gravity survey of the Memorial Stadium and the surrounding area, State College, Pennsylvania from August 20 through August 31, 2012 (Figure 1). The work scope included mapping the footprint of the void beneath the north stadium bleachers. EI was selected as the most appropriate method for imaging the subsurface and microgravity methods were used to determine the sub-regional extent of the Karst feature and its potential impact to the bleachers.

2.0 GEOPHYSICAL METHODS

2.1 ELECTRICAL IMAGING

2.1.1 Theory

Electrical resistance is based upon Ohm's Law:

$$R = \frac{V}{I}$$

Where, resistance, **R** (Ohms), is equal to the ratio of potential, **V** (volts) to current flow, **I** (amperes). Resistivity is the measure of the resistance along a linear distance of a material with a known cross-sectional area. Consequently, resistivity is measured in Ohm-meters. This report presents the geophysical results as geo-electrical profiles of modeled resistivity versus depth, in units of feet.

Electrical currents propagate as a function of three material properties (1) ohmic conductivity, (2) electrolytic conductivity, and (3) dielectric conductivity. Ohmic conductivity is a property exhibited by metals. Electrolytic conductivity is a function of the concentration of total dissolved solids and salts in the groundwater that exists in the pore spaces of a material. Dielectric conductivity is a function of the permittivity of the matrix of the material. Therefore, the matrix of most soil and bedrock is highly resistive. Of these three properties, electrolytic conductivity is the dominant material characteristic that influences the apparent resistivity values collected by this method. In general, resistivity values decrease in water-bearing rocks and soil with increasing:

a. Fractional volume of the rock occupied by groundwater;
b. Total dissolved solid and chloride content of the groundwater;
c. Permeability of the pore spaces; and,
d. Temperature.

Materials with minimal primary pore space (i.e., limestone, granite) or lack groundwater in the pore spaces will exhibit high resistivity values (Mooney, 1980). Highly porous, moist or saturated soil, such as fat clays, will exhibit very low resistivity values. Most soil and bedrock exhibit medium to low resistivity values.

In homogeneous ground, the apparent resistivity is the true ground resistivity; however, in heterogeneous ground, the apparent resistivity represents a weighted average of all formations through which the current passes. Many electrode placements (arrays) have been proposed (for examples see Reynolds, 1998); however, the Schlumberger array has proven to be an effective configuration for imaging voids in bedrock settings. The following Schlumberger array was used in the collection of data:

$$R_i = \frac{\pi a^2}{b}\left[1 - \frac{b^2}{4a^2}\right]R;\ a = 5b$$

Where, $\boldsymbol{R_i}$, resistivity, is related to the number of poles, ***n***, the separation distance between the current source and current sink ***b***, and the pole spacing, **a**.

Imaging depth (*D*) can be approximated using the maximum current and potential electrode separation distance (*AM*) and the pole spacing (*BA*) using the following equation:

$$D = \frac{BA}{2} + \frac{AM}{2}$$

For this survey, BA = 6 ft and AM = 97 ft resulting in a maximum imaging depth of approximately 40 feet. The vertical resolution for this spacing is approximately 2 feet.

2.1.2 Methods

The resistivity survey was performed using the ARES multi-electrode cable system (GF Instruments, s.r.o., Brno, Czech Republic). The survey was conducted using bronze electrodes and stainless-steel cylinder-bearing cables.

2.1.3 Processing

A forward modeling subroutine was used to calculate the apparent resistivity values using the EarthImager program (AGI, 2002). This program is based on the smoothness-constrained least-squares method (deGroot-Hedlin and Constable, 1990; Loke and Barker, 1996). The smoothness-constrained least-squares method is based upon the following equation:

$$J^T g = (J^T J + \mu F)d$$

Where, **F** is a function of the horizontal and vertical flatness filter, **J** is the matrix of partial derivatives, **μ** is the damping factor, **d** is the model perturbation vector and **g** is the discrepancy vector.

The EarthImager program divides the subsurface 2-D space into a number of rectangular blocks. Resistivities of each block are then calculated to produce an apparent resistivity pseudosection. The pseudosection is compared to the actual measurements for consistency. A measure of the difference is given by the root-mean-squared (rms) error.

2.2 GRAVITY

2.2.1 Theory

Microgravity measurements are not readily impacted by cultural noise; consequently, microgravity measurements can be collected in buildings and adjacent to urban development. Microgravity has been used for many geologic purposes; however, for the environmental geophysicist, microgravity is used to determine the presence of subsurface voids, to image subsurface bedrock topography, and to find the depth of waste (Carmichael and George, 1977; Kick, 1985; Stewart, 1980).

Small changes in rock density produce small changes in the gravity field, which can be measured by the microgravimeter. These readings change from day to day due to tidal response and lunar pull, among other phenomenon that have an impact on the earth's gravitational flux. A microgravimeter measures the acceleration due to the earth's gravitational field (in mgal = 0.001 cm/sec^2) using an astatic spring mechanism (Carmichael and George, 1977). The Earth's gravitational field is roughly equivalent to a sphere with variations for sea level and elevation (Milsom, 1989). The 1930 International Gravity Formula (Nettleton, 1971) for calculating absolute gravity is:

$$g_\phi = g_o\left(1 + \alpha \sin^2 \phi - \beta \sin^2 2\phi\right)$$

Where, (***g$_F$***) the theoretical acceleration due to gravity at a given latitude (***F***) and **a** and **b** are constants that depend on the amount of flattening of the spheroid and upon the speed of rotation of the Earth (Reynolds, 1997). Gravity is calculated in g.u. (10 g.u. (10^{-6} m/sec^2) = 1 mgal, a c.g.s. unit).

The International Gravity Formula was refined to the Geodetic Reference System 1967 and is derived thus (Woollard, 1975):

$$g_\phi(1967) - g_\phi(1930) = \left(-172 + 136 \sin^2 \phi\right)\mu \ \text{m/s}^2\ \text{(g.u.)}$$

2.2.2 Gravity Data Reduction

Processing raw gravity data includes corrections for latitude, elevation, Bouguer gravity, tidal, and terrain corrections.

2.2.2.1 Latitude

Latitude corrections were automatically corrected using the LaCoste & Romberg G-600 microgravity meter by subtracting the International Gravity Formula normal datum from the observed gravity:

$$G_l = \frac{8.12 \sin 2L g.u.}{km}$$

Where, ***G$_l$*** is the theoretical local gradient and ***L*** is the latitude.

2.2.2.2 Elevation

The elevation or free-air correction normalizes the gravity data to a given datum that does not have to be sea level. Free-air correction is based upon the free-air correction of 0.3086 mgals/meter (0.0941 mgals/ft). The normal elevation (***E$_n$***) adopted for this survey was 1120 feet above mean sea level (ft amsl) and elevation changes above this were corrected to ***E$_n$*** :

$$g_s = \left(E_m - E_n\right) * 0.0941 mgals/ft + g_m$$

Where, the free-air corrected value ($\boldsymbol{g_s}$) is the sum of the elevation difference between the actual elevation ($\boldsymbol{E_m}$) and the normal elevation times the free-air correction, and the measured gravity ($\boldsymbol{G_m}$) in mgals.

2.2.2.3 Bouguer

Bouguer corrections were applied to the dataset. Bouguer corrections account for the rock mass between the measuring station and sea level. Bouguer (*b*) corrections are based upon:

$$b = 2\pi\rho g_s h$$

Where, Bouguer gravity is related to density (**r** = 2.54 Mg/m^3) and known thickness (***h***) above sea level.

2.2.2.4 Tidal

The LaCoste & Romberg G-600 applied an automatic gravitational tidal correction to all data based upon the diurnal variation in the Earth's position to the moon and Sun.

2.2.2.5 Terrain

Terrain corrections were applied to the background elevation of 1120 ft amsl.

2.2.3 Methods

The microgravity survey was performed using the LaCoste & Romberg G-600. Three hundred and nine records were collected and continuous loops to a base station were performed to insure consistent data.

2.3 MODELING PROGRAM

The SURFER (Golden Software, Golden, CO) three-dimensional modeling program was used to smooth and contour the EI and the microgravity data. The kriging method, a statistical technique for spatial interpolation of data, was used to perform the map gridding. Cokriging, a variant of kriging where the value of the derived variable is estimated by weighted linear combination of neighboring samples (Parks and Bentley, 1996), was determined to be unnecessary due to the limited size of the study.

The profiles were derived from a forward modeling program (IX2D-GM, Interpex, 2012) and consists of the corrected gravity data on an upper graph and the inverted depth profile on the lower graph (Figures 7 and 8). The IX2D program creates a 2-D gravity forward modeled and inversion profile that is based on polygonal models which can be truncated asymmetrically along strike.

2.4 QUALITY ASSURANCE AND QUALITY CONTROL

The interpretation of geophysically-generated data is not an exact science since responses to induced disturbance is affected by many phenomena including buried metals, operator error, precipitation, and net changes in ground saturation conditions. Some sources of spurious data can be overcome through a QA/QC program and use of multiple geophysical methods. The quality control program employed with this study included frequent checks of the equipment and resurveys of lines and locations. The QA/QC program indicates that all geophysical equipment functioned as designed during the survey program.

3.0 GEOPHYSICAL ANALYSES

3.1 INTRODUCTION

Memorial Field is developed into the Karst-forming dolomitic Axeman Formation, a part of the Ordovician-aged carbonate Beekmantown Group. The Beekmantown is reportedly several thousand feet thick in this area (Thompson, 1999). Many Karst features within the State College environs have been identified and mapped (e.g., Hutchinson and Vidarsson, 2006). Many anomalies show only limited surface expression, and the surface expression usually occurs after surface disturbance or from construction; consequently if left undisturbed these features do not seem to readily enlarge or collapse.

EI profiles represent a geoelectrical response to subsurface conditions. The processed readings converted to a color represent solid rock, saturated fractured rock, and saturated voids. Rock is considered to have a reading of greater than 300 Ohm-m (red), saturated voids are represented by a low resistivity reading (less than 35 Ohm-m; blue) and saturated rock is represented by green colors (35 to 300 Ohm-m). Subsurface voids are interpreted as clay-filled and/or fully saturated, thus have a very low apparent resistivity; whereas surrounding limestone has a very high apparent resistivity. Further, it is difficult to electrically separate water-filled voids from clay-filled voids.

Due to the geometry of data collection, no information is available in the upper 3 feet below grade. Instead, this report presents the depth of the base of the shallow anomaly below the bleachers and provides information on the extent of Karst development in and near Memorial Field (Figures 2 and 3).

The differential gravity map provides a sub-regional view of the extent of Karst development within the football field (Figure 3). The differential gravity map shows that Memorial Field is a well-developed clay-plugged sinkhole (Figures 5 and 6).

Memorial Field has served many purposes since State College was incorporated in 1896. The following brief history was collected from a plaque on the western side of the field and from R. A. Smith (2011). Through much of the 19th and beginning of the 20th centuries the depression was used for waste disposal. In the early 1900s the site was cleaned up and; subsequently, used for athletic events. Later through the Works Project Administration in the late 1930s, the site was converted into the present field as a WPA works project.

Limestone mining reportedly occurred within the sinkhole; most of the stone quarrying appears to have occurred for the development of the field and the southern bleachers and not as a separate commercial endeavor.

At some point following the development of the field, a throat to the sinkhole was developed for street drainage and a series of pipes were connected from adjoining streets to the throat of the sinkhole. The throat, located beneath the bleachers on the north side of the field has shown steady subsidence in the decades since street runoff was routed to the sink hole. A major issue with exploiting the throat for disposal of runoff is that the throat will widen and the void beneath will grow due to erosion, dissolution, and subsidence.

3.2 EI INVESTIGATION

In 2003, THG imaged the field with 10 400-ft long profiles and found that the top of the limestone beneath the field is funnel-shaped beneath the field and the interior of the "funnel" is clay-filled (Figure 4). The interpretation did not show the potential for collapse or subsidence.

Structurally, though, clay tends to migrate towards the center or deepest part of the "funnel" over time; however, this phenomenon is not quantifiable within this work scope. Some basinward migration was noticed on the south side in the area of the closed bleachers suggesting that basinward migration is occurring.

The recent work completed in August 2012 included 10 profiles that targeted the throat of the sink hole located beneath the stadium bleachers (Figure 2). The throat has shown historical subsidence and recent subsidence triggered this investigation.

The void below the surface opening (throat) is rimmed with an inferred 5-foot thick cap or roof of dolomite/limestone (Figure 8). The void is estimated to be 40 ft by 50 ft in size aerially (Figures 5, 6, and 7). The base of the void beneath the throat is 20 ft below surface at its deepest part and is almost invariably clay-filled.

Structurally, the top of the void has supported the stands for many years; however, the long-term use of the void as a repository for storm water has probably opened the cavern up and possibly thinned the roof of the feature.

3.3 GRAVITY INVESTIGATION

The gravity investigation was pivotal in determining areas of hazard potential within Memorial Field. Microgravity mapping provides a "view" of the surface of the limestone based upon the assumption that thinner limestone with thicker clay has a lower gravitational "pull" than thicker suites of limestone with less clay (Figures 3, 5, 6, 7 and 8). Clay has a lower specific gravity than dolomite/limestone; consequently, a funnel-shape surface of the dolomite/limestone sink hole can be graphically displayed (Figures 3, 5, 7 and 8).

Profiles of the gravity data using a forward modeling program show a well-developed clay-filled sink hole beneath the bleachers (Figure 8). The south-north profile shows that the deepest portion of the sink hole beneath the bleachers is 20 feet deep and 10 feet wide (Figure 8). The forward model is based upon limited data so the model did not quite meet the same size dimensions as the EI profiles. The east-west model, however, shows that the void is nearly 30 feet wide and 20 feet deep consistent with the EI profiles (Figure 7).

The microgravity data also shows the regional fracture that accounts for the Karst features in this area (Figure 5). The deep-rooted fracture that is inferred to run nearly north-south is documented through 4 features:

(1) the surface subsidence noted near the copse of trees by the western access driveway;
(2) throat of the void;
(3) the deepest portion of the “funnel;” and,
(4) the subsidence noted along S. Fraser Street (Figures 3 and 5).

This fracture system probably opens to a larger series of voids at depths of greater than 60 feet (Figure 4).

3.4 SUMMARY

A sub-regional north-south oriented fracture system is inferred to cut through the center of Memorial Stadium. A sinkhole developed along the fracture trace that is centrally located within the stadium. The sinkhole is filled to grade with clay from the years of drainage, dissolution, weathering and subsidence.

A surface hole or throat to a void located beneath the northern bleachers to Memorial Stadium is situated along the alignment of the sub-regional fracture system. The throat is in communication with the subregional system, probably through a system of well-developed caverns and interconnected fracture-widened voids. The shallow void beneath the bleachers is approximately 40 feet by 50 feet located approximately 5 feet below the current grade and is probably a clay-filled void no deeper than 20 feet below grade at its deepest point.

The throat is currently a discharge point for the storm sewer for approximately 50 acres of area surrounding the stadium. Continued use of the throat for storm water disposal has likely weakened the rock supporting the roof of the void causing subsidence in the area around the inlet to the throat. This subsidence will likely continue as the void grows from erosion and dissolution caused by the continued use as a storm water catch basin.

4.0 CONCLUSION

Approximately 5,300 feet (1 mile) of EI profiles and over 300 microgravity records were collected within and near the Memorial Stadium, State College Pennsylvania.

The findings and conclusions in this report are stated with a reasonable degree of scientific certainty. THG's findings and conclusions are as follows:

- A geophysical survey, consisting of EI and microgravity measurements, of the subsurface at Memorial Stadium; State College, Pennsylvania was completed April 2-3, 2003 and August 20 – 31, 2012;
- The site is an Astroturf-covered football field and contiguous bleachers; with bituminous asphalt, and concrete surface cover;
- The geophysical survey helped map a sub-regional fracture system that has well-developed Karst features;
- Dissolution, erosion and subsidence of the dolomite/limestone in the area of the sub-regional fracture created the sinkhole into which Memorial Stadium was built
- An inlet or throat to a subsurface void beneath the northern bleachers is used for storm water discharge for approximately 50 acres of the surrounding area;
- The void beneath the inlet (throat) is approximately 40 feet long, 50 feet wide, and 20 feet deep and is probably mostly clay-filled:
- The void is hydraulically connected to a north-south sub-regional fracture;
- Surface expression for the dissolution and erosion of the sub-regional fracture was evident in minor subsidence near the driveway entrance to the field on the west side and collapse of the sidewalk and stadium along S. Fraser Street; and,
- Continued use of the inlet for storm water discharge will continue to erode, dissolve and create more subsidence.

5.0 REFERENCES

AGI (2002). EarthImager Program. American Geosciences Inc., Austin Texas.

deGroot-Hedlin, C. and Constable, S. (1990). Occam's inversion to generate smooth, two-dimensional models from magnetotelluric data. Geophysics, V. 55, 1613-1624.

Hutchinson, P.J. and A. M. Vidarsson. (2006). *Case Studies of Mine Voids Using Continuous Vertical Electrical Sounding Methods*. *In*: **Proceedings of the International Conference on Environmental and Engineering Geophysics**, June 4-6, 2006, Wuhan, China.

Loke, M. N., and Barker, R. D., (1996), Rapid least-squares inversion of apparent resistivity pseudosection by quasi-Newton method. Geophysical Prospecting, V. 44, 131-152.

Mooney, H. M. (1980). Handbook of Engineering Geophysics: Volume 2: Electrical Resistivity, Bison Instruments, Inc.

Reynolds, J. M. (1997). An Introduction to Applied and Environmental Geophysics. New York, NY, Wiley.

Smith, R. A., (2011). Origin and Construction of State College's "Sinkhole" Memorial Field. Mansion Notes, V. 33, No.3 Pg 1.

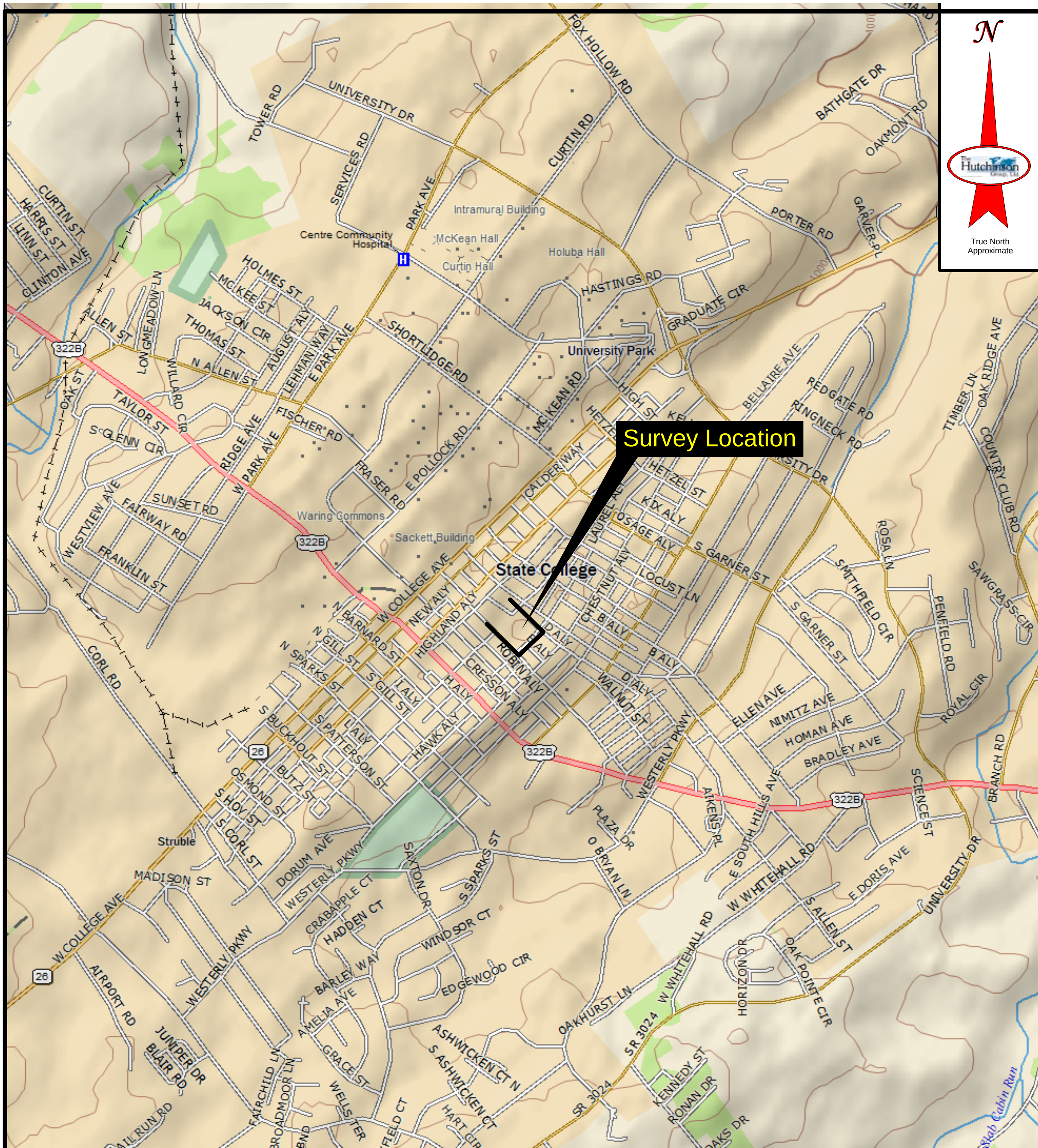


Figure 1
Site Location Map

THG GEOPHYSICS

4280 Old William Penn Hwy
Murrysville, Pennsylvania 15668
(724) 325-3996 Fax: (724) 733-7901

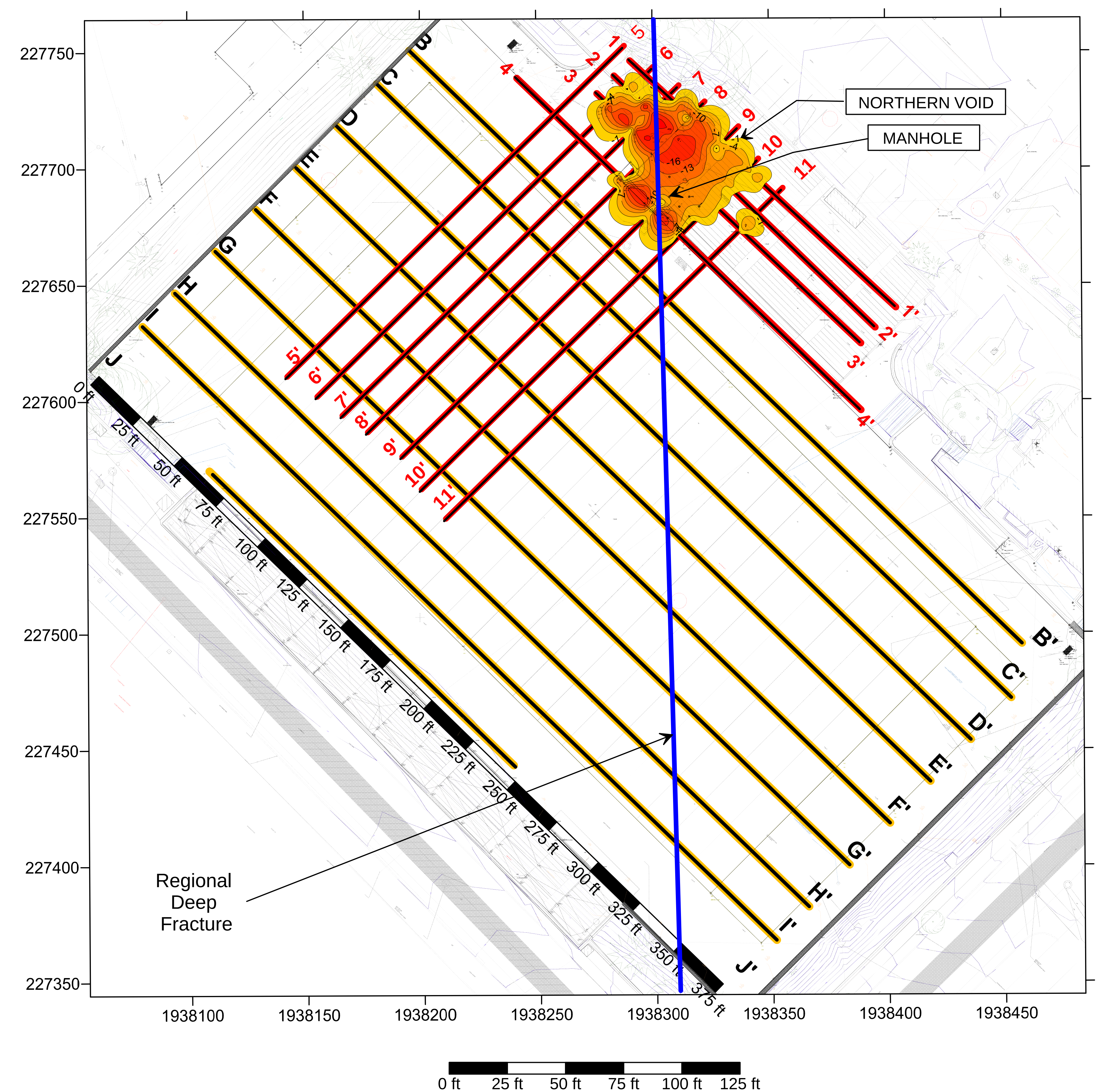
www.geo-image.com

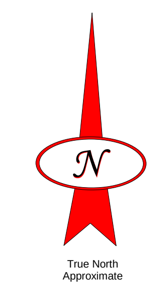
Contour Interval = 20 feet

0 ft 1000 ft 2000 ft 3000 ft 4000 ft 5000 ft

Geophysical Investigation
Memorial Stadium
State College, Pennsylvania

SCALE: 1:24,000	PROJECT NO.: 803-5125	DRAWING NO.: DWG5125F1
DATE : 9/17/12		
DRAWN BY: PJH	SOURCE: 1979 State College USGS 7.5 Minute Topographic Quadrangle	
CHECKED BY: PJH		





Anomaly Map Legend

-1 ft
-4 ft
-7 ft
-10 ft
-13 ft
-16 ft
-19 ft
-22 ft

2012 Northern Depth to Base of Void From EI Data (ft below grade)

Legend

- Profile April 2-3, 2003
- Profile August 20 and 27, 2012

THG GEOPHYSICS
Geophysical and Environmental Services

4280 Old William Penn Hwy
Murrysville, Pennsylvania 15668
(724) 325-3996 Fax: (724) 733-7901
www.geo-image.com

DES	PJH	8/21/12
DRN	PJH	8/21/12
CHK	PJH	8/28/12
REV		
PROJ. MGR.	PJH	8/28/12

PROJECT:
Geophysical Investigation
Memorial Field
State College, Pennsylvania

SCALE: 1 in = 50 ft

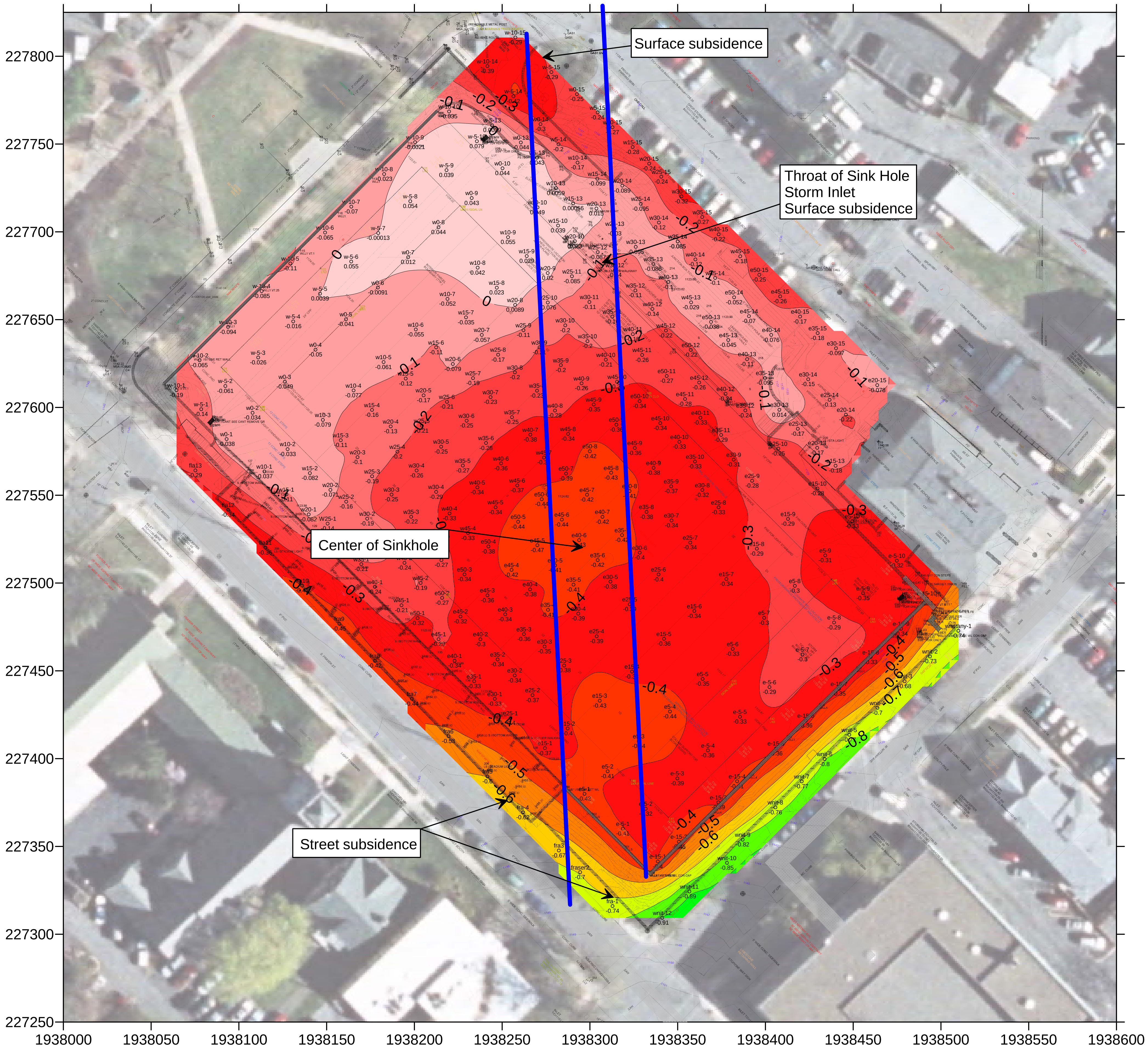
SHEET TITLE:
Figure 2
Depth to Base of Void Map
Based upon EI Mapping

SOURCE: Sweetland, 2012

PREPARED FOR:
State College Area School District
State College, Pennsylvania

PROJECT NO.: 803-5125

DRAWING NO.: DWG5110F2



Legend

- 0.1 mgals
- -0.1 mgals
- -0.3 mgals
- -0.5 mgals
- -0.7 mgals
- -0.9 mgals
- -1.1 mgals
- -1.3 mgals
- -1.5 mgals
- -1.7 mgals
- -1.9 mgals
- -2.1 mgals
- -2.3 mgals

N

True North Approximate

Legend

e45-2 / -0.012 — Gravity Locations with Measurement

Deep-seated Fracture Zone

Notes

Microgravity survey conducted September 4 - 7, 2012 using L & R G-600 differential microgravimeter.

Gravity locations surveyed by Sweetland Engineering
NAD 1983 US State Plane (Pennsylvania, North) coordinate system in feet.

Locations are approximate.

0 ft 50 ft 100 ft 150 ft 200 ft

The Hutchinson Group, Ltd.
Geophysical and Environmental Services
4280 Old William Penn Hwy
Murrysville, Pennsylvania 15668
(724) 325-3996 Fax: (724) 733-7901
www.geo-image.com

DES	PJH	9/17/12
DRN	PJH	9/17/12
CHK	PJH	9/17/12
REV		
PROJ. MGR.	PJH	9/17/12

PROJECT:
Geophysical Investigation
Memorial Field
State College, Pennsylvania

SCALE: 1 in = 50 ft

SOURCE: Sweetland, 2012

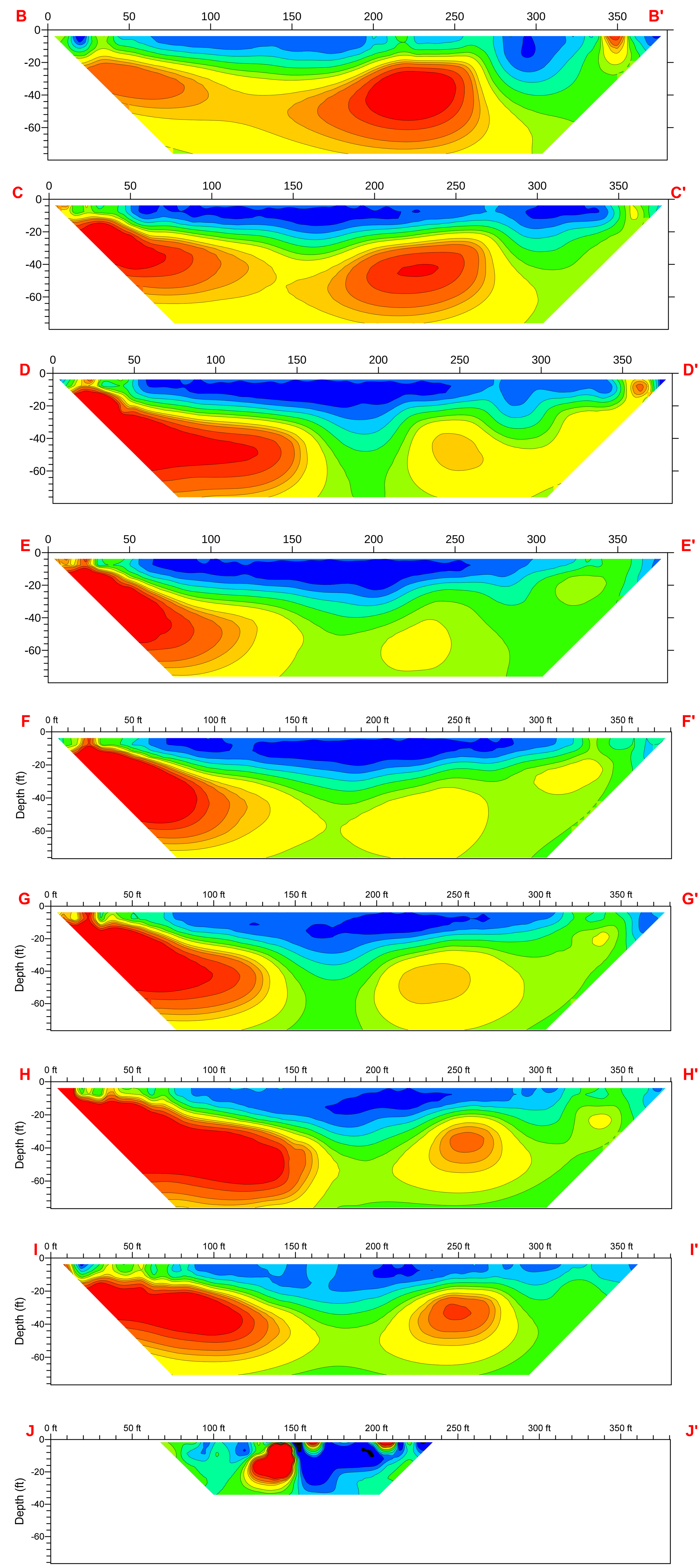
SHEET TITLE:
Figure 3
Tidal-Corrected
Differential Gravity Map

PREPARED FOR:
State College Area School District
State College, Pennsylvania

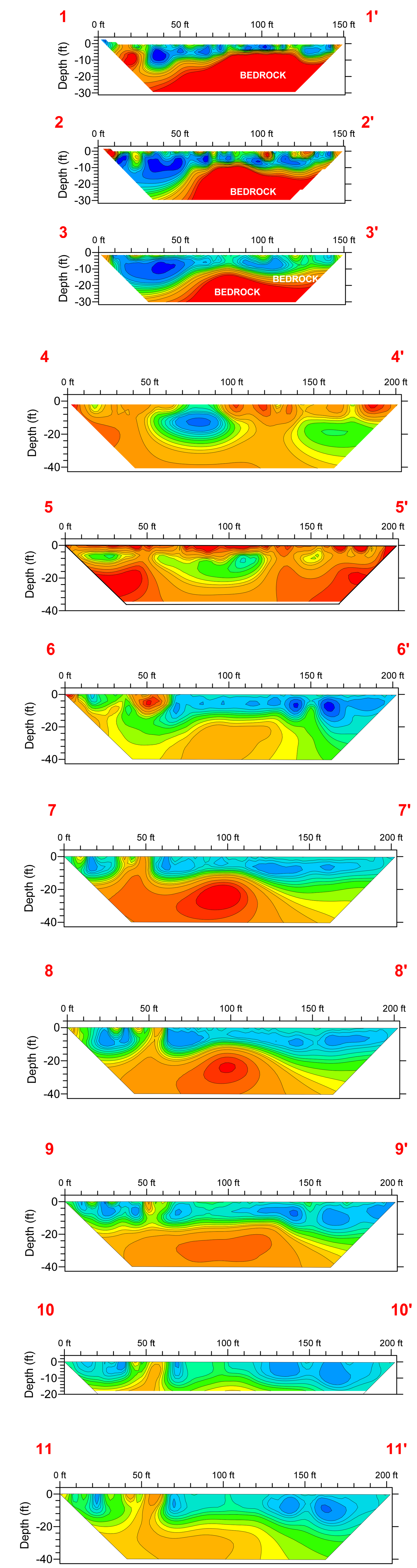
PROJECT NO.: 803-5125

DRAWING NO.: DWG5125F3

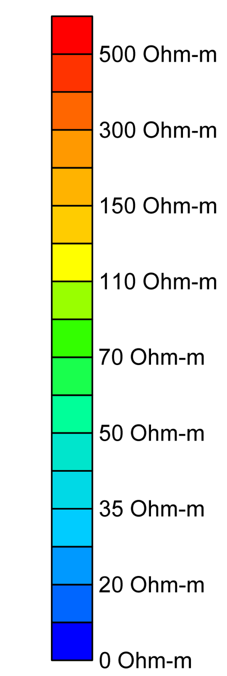
2003 SURVEY



2012 SURVEY



Resistivity Scale (2012)



Resistivity Survey Notes

Electrical Imaging (Resistivity) survey conducted April 2-3, 2003 using ARS Automatic Resistivity Meter with a Schlumberger array of 4-meter spacing. Line A has been removed from original survey. Data reprocessed September 24, 2012.

Second Electrical Imaging (Resistivity) survey conducted August 20, 2012 using ARES Automatic Resistivity Meter with a Schlumberger array of 2-meter spacing.

Third Electrical Imaging (Resistivity) survey conducted August 27, 2012 using ARES Automatic Resistivity Meter with a Schlumberger array of 2-meter spacing.

Horizontal Scale 1 in = 50 ft
Vertical Scale 1 in = 50 ft
No Vertical Exaggeration

THG GEOPHYSICS
Geophysical and Environmental Services
4280 Old William Penn Hwy
Murrysville, Pennsylvania 15668
(724) 325-3996 Fax: (724) 733-7901
www.geo-image.com

DES	PJH	8/21/12
DRN	PJH	8/21/12
CHK	PJH	8/28/12
REV		
PROJ. MGR.	PJH	8/28/12

SCALE: 1 in = 50 ft

SOURCE:

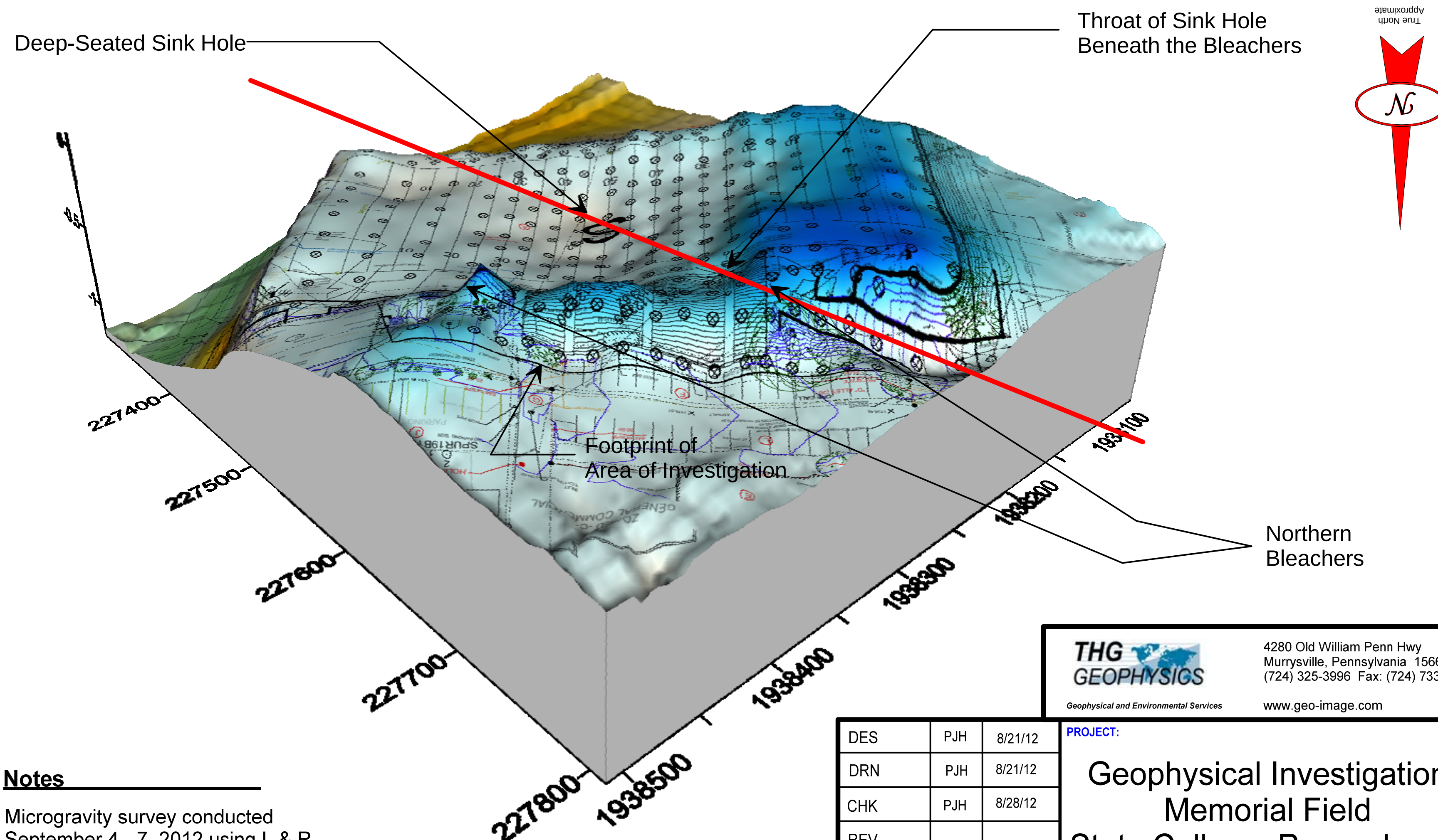
PROJECT:
Geophysical Investigation
Memorial Field
State College, Pennsylvania

SHEET TITLE:
Figure 4
Electrical Resistivity Profiles

PREPARED FOR:
State College Area School District
State College, Pennsylvania

PROJECT NO.: 803-5125

DRAWING NO.: DWG5125F4



Notes

Microgravity survey conducted September 4 - 7, 2012 using L & R G-600 differential microgravimeter.

Gravity locations surveyed by Sweetland Engineering NAD 1983 US State Plane (Pennsylvania, North) coordinate system in feet.

Locations are approximate.

Legend

⊕ Microgravity Record

THG GEOPHYSICS
Geophysical and Environmental Services

4280 Old William Penn Hwy
Murrysville, Pennsylvania 15668
(724) 325-3996 Fax: (724) 733-7901
www.geo-image.com

DES	PJH	8/21/12
DRN	PJH	8/21/12
CHK	PJH	8/28/12
REV		
PROJ. MGR.	PJH	8/28/12

PROJECT:

Geophysical Investigation
Memorial Field
State College, Pennsylvania

SCALE: 1 in = 50 ft

SOURCE: Sweetland, 2012

SHEET TITLE:

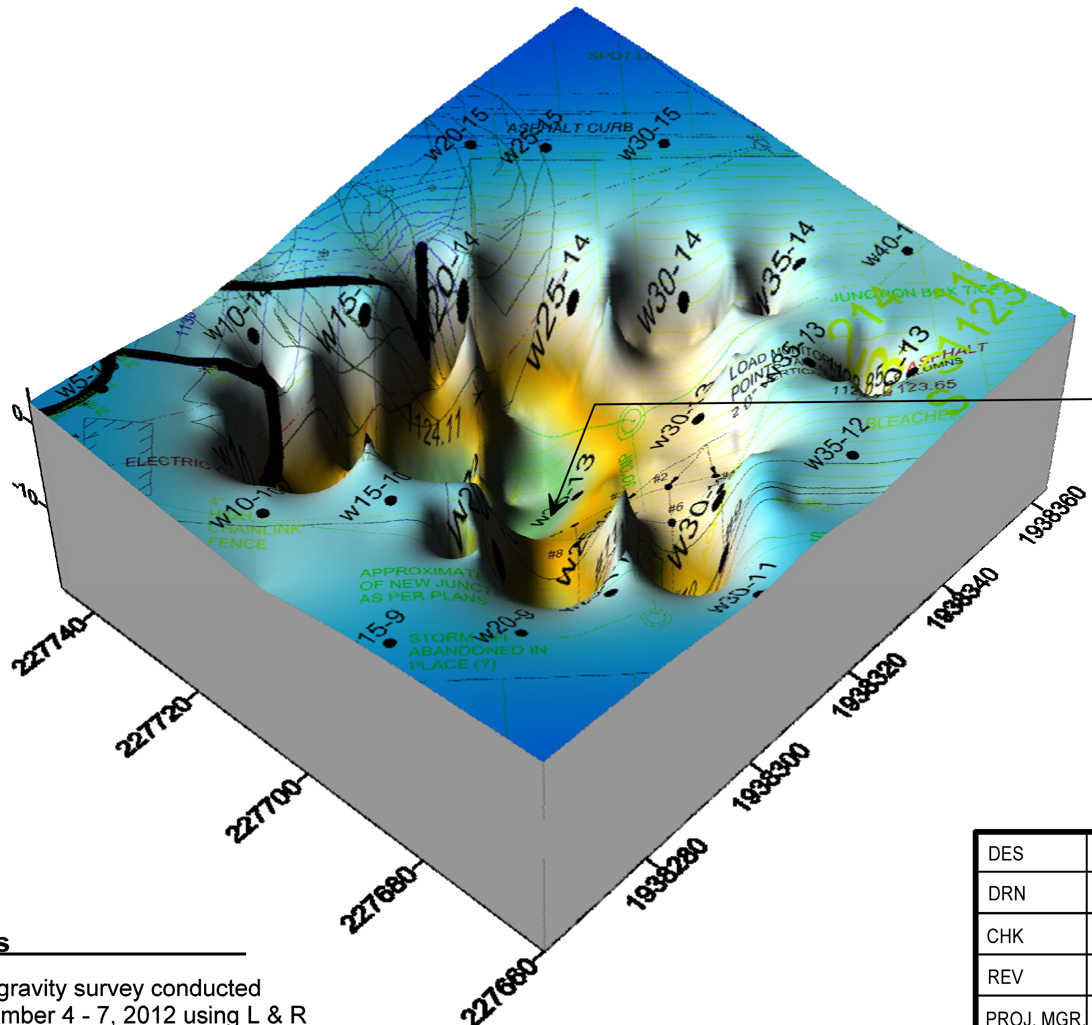
Figure 5
3-D Representation of Corrected Microgravity Response

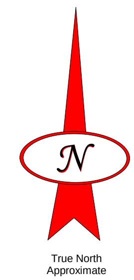
PREPARED FOR:

State College Area School District
State College, Pennsylvania

PROJECT NO.: 316-5125

DRAWING NO.: DWG5125F5





Notes

Microgravity survey conducted September 4 - 7, 2012 using L & R G-600 differential microgravimeter.

Gravity locations surveyed by Sweetland Engineering
NAD 1983 US State Plane (Pennsylvania, North) coordinate system in feet.

Locations are approximate.

THG GEOPHYSICS
Geophysical and Environmental Services
4280 Old William Penn Hwy
Murrysville, Pennsylvania 15668
(724) 325-3996 Fax: (724) 733-7901
www.geo-image.com

DES	PJH	8/21/12
DRN	PJH	8/21/12
CHK	PJH	8/28/12
REV		
PROJ. MGR.	PJH	8/28/12

PROJECT:
Geophysical Investigation
Memorial Field
State College, Pennsylvania

SCALE: 1 in = 25 ft

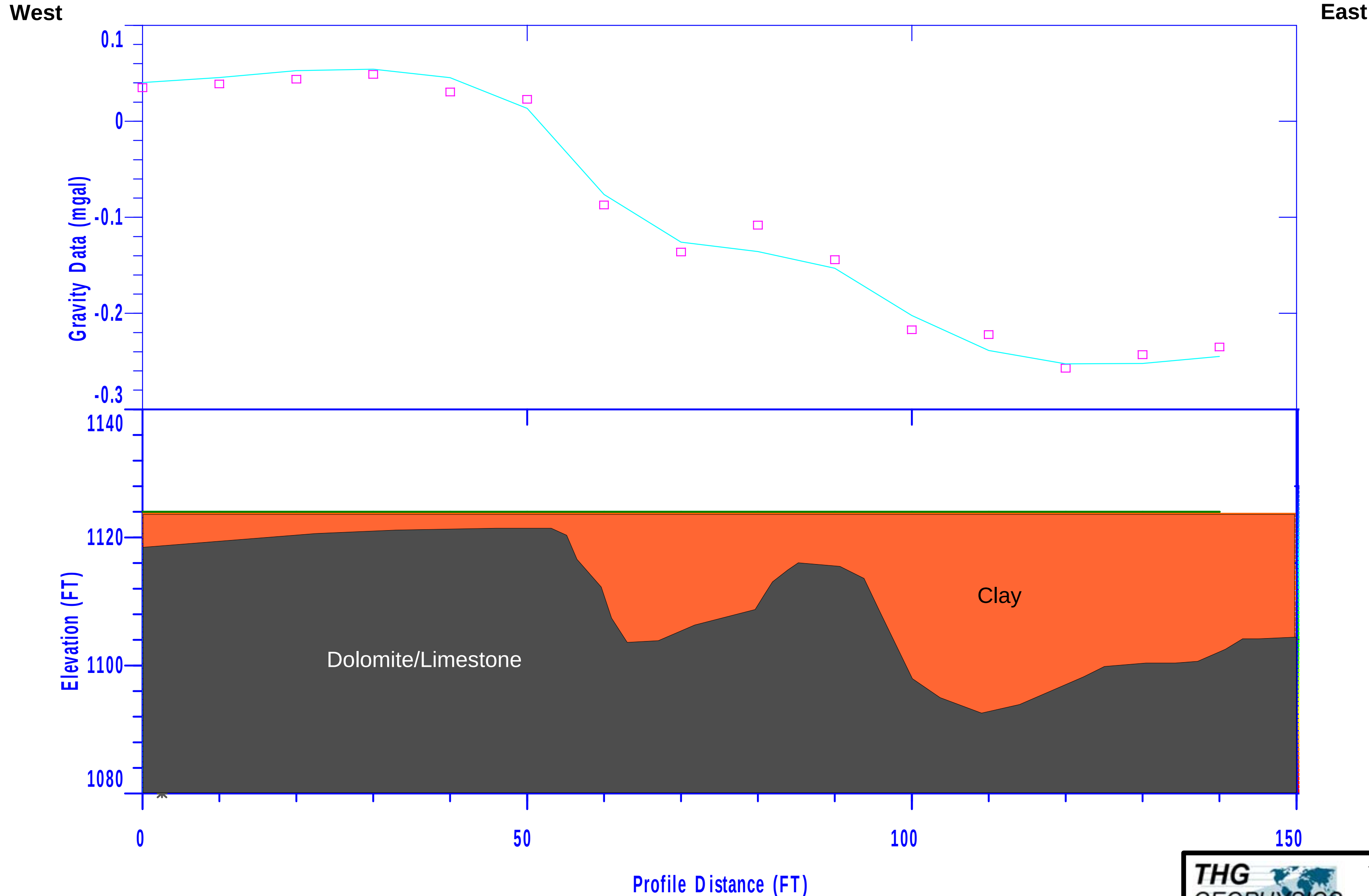
SOURCE: Sweetland, 2012

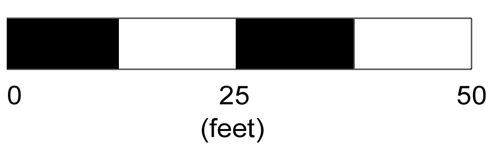
SHEET TITLE:
Figure 6
3-D Representation of Corrected Microgravity Response Throat of Sink Hole

PREPARED FOR:
State College Area School District
State College, Pennsylvania

PROJECT NO.: 316-5125

DRAWING NO.: DWG5125F6

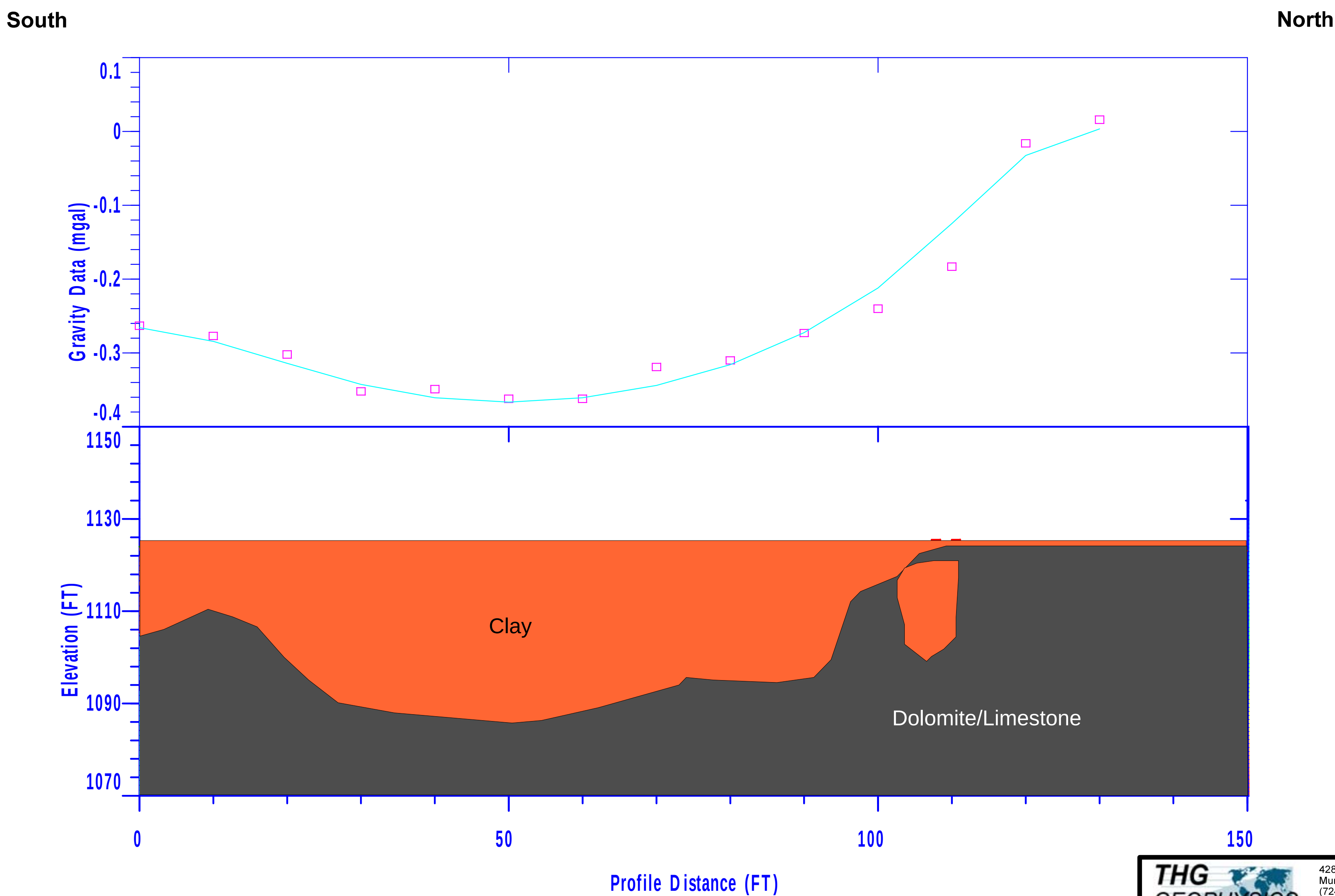




THG GEOPHYSICS
4280 Old William Penn Hwy
Murrysville, Pennsylvania 15668
(724) 325-3996 Fax: (724) 733-7901
www.geo-image.com

DES	KSM	9/17/12	PROJECT: **Microgravity Survey Memorial Field State College, Pennsylvania**
DRN	KSM	9/17/12	
CHK	PJH	9/24/12	SHEET TITLE: **Figure 7 Northern Edge of Field West to East**
REV			
PROJ. MGR.	PJH	9/24/12	
SCALE: As Noted			

PREPARED FOR: State College School District State College, PA	PROJECT NO.: 803-5125
	DRAWING NO.: DWG5125F7



THG GEOPHYSICS
4280 Old William Penn Hwy
Murrysville, Pennsylvania 15668
(724) 325-3996 Fax: (724) 733-7901
www.geo-image.com

DES	KSM	9/17/12
DRN	KSM	9/24/12
CHK	PJH	9/25/12
REV		
PROJ. MGR.	PJH	9/25/12
SCALE:	As Noted	

PROJECT:
Microgravity Survey
Memorial Field
State College, Pennsylvania

SHEET TITLE:
Figure 8
Inverted Microgravity Profile
West 35 Yard Line

PREPARED FOR:
State College School District
State College, PA

PROJECT NO.: 803-5125

DRAWING NO.: DWG5125F8