Making the change to AutoCAD Civil 3D and HoleBASE SI for Geotechnical BIM

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Learning Objectives

- The drivers and needs to change from a legacy system
- The new workflows needed to incorporate both legacy and new data
- The capabilities delivered by integrating HoleBASE SI and AutoCAD Civil 3D
- The benefits and future opportunities geotechnical BIM can deliver

McMillen Jacob Associates Background

- Engineering Consultants
- Over 20 offices with 400+ staff
- Markets
  - Transportation
  - Water Resources
  - Hydropower
  - Conveyance
- Services
  - Engineering/Underground Eng./Geotech
  - Design/Permitting
  - CM
  - Dispute Resolution

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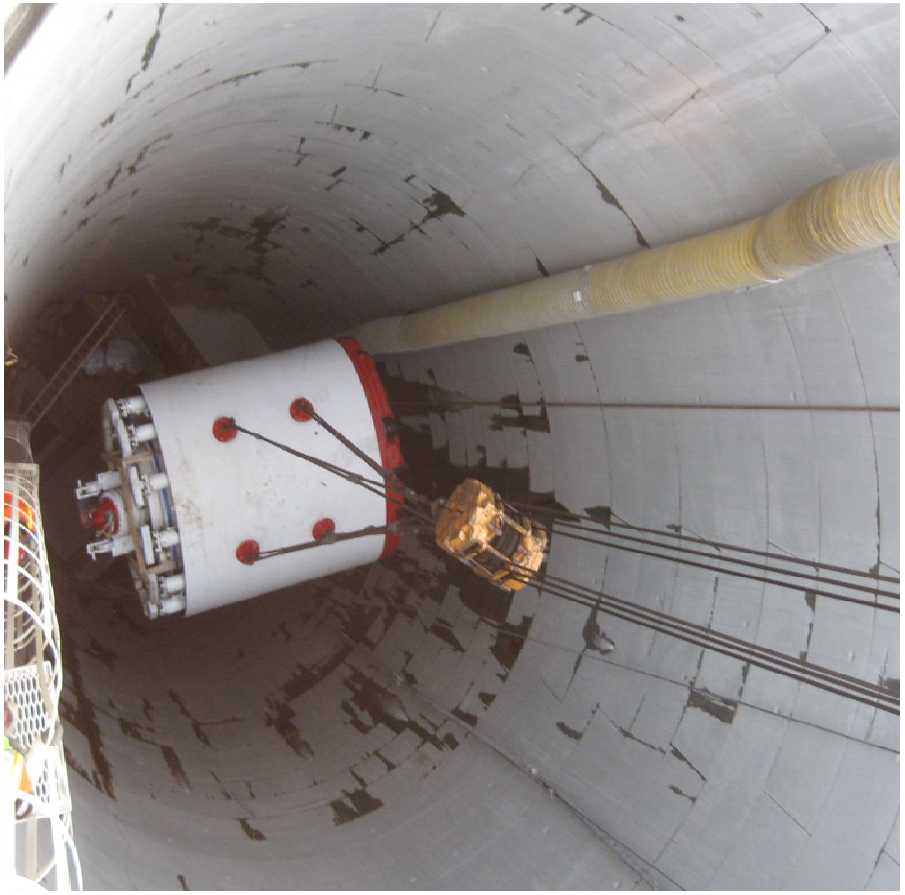
The Project Team Structure

- MJA are prime consultant and geotechnical lead
- Six Sub consultants
- Provide geotechnical baseline conditions
- Develop geotechnical profile for tunnel
- Predict ground and groundwater conditions
- Design tunnel and shafts
- Design civil structures

The Project

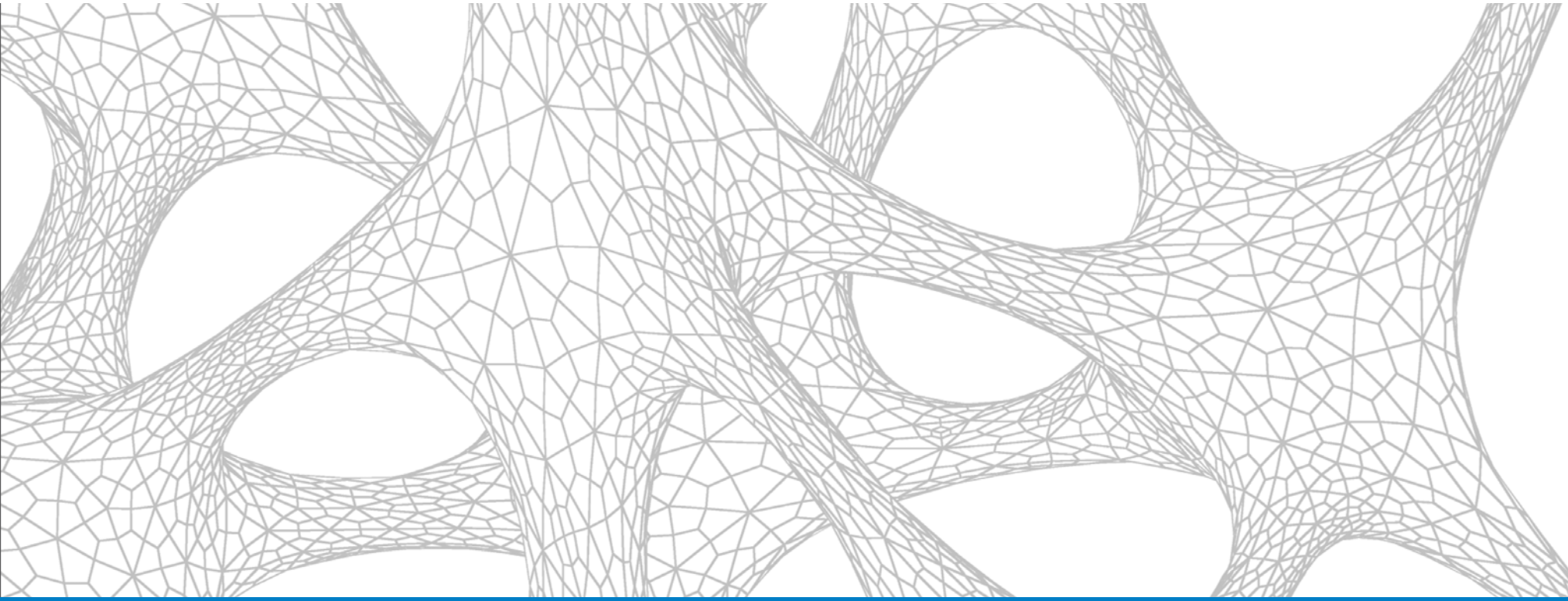
- Bored tunnel for Combined Sewer Overflow (CSO)
  - Associated shafts, connections to existing facilities with micro-tunnel (78-inch) beneath navigable canal
  - Diversions and drop structures
  - Storage Tunnel (18.83 ft) to store storm- and wastewater
- Construction with TBM and M-TBM



TBM being lowered in vertical access shaft

The Project

- Combined Sewer Overflow (CSO)
  - Sewer pipes that carry both wastewater and stormwater
  - When pipes get too full they overflow into near bodies of water (acts like “safety valve” preventing backups)
  - Economical way to handle waste- and stormwater, rather than separate them
  - Advantage: when rainfall is low to moderate, both storm- and wastewater go to treatment plant before being discharged
  - Disadvantage: during heavy rains, untreated storm- and wastewater may be discharged



The drivers and needs to change from a legacy system

Large amount of Data

- Over 70 boreholes supplied by sub contractor
  - Using Bentley gINT
- 17,000 Ground water levels
- MJA replacing legacy gINT with HoleBASE SI and AutoCAD Civil 3D

Desire for uniformed approach

- The legacy Geotechnical Management system used, Bentley gINT
- Architecture of system did not facilitate a standard configuration
  - Each project was a individual file based system
  - Often on stored local machines
  - Each project individually configured

Various Technology Issues

- No significant update to legacy software for 9 years
- Poor support and customer service

Inefficient Data Entry and Workflows

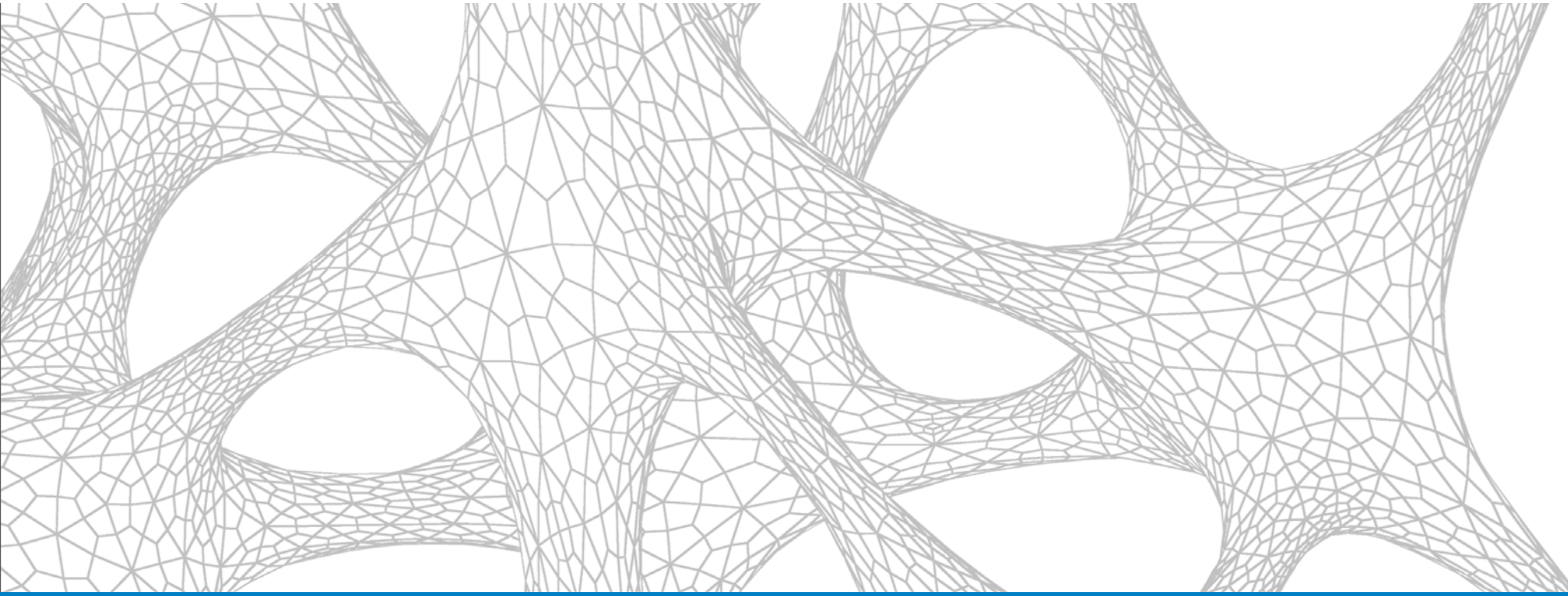
- A lot a lot of time was being wasted entering data
  - No AutoCorrect or spellchecking
  - No auto fill to speed up data entry
  - No quick previews

Inefficient Data Entry and Workflows

- Creation Geotechnical Sections very slow
  - Export gINT ==> Import AutoCAD
  - Lots of post processing in AutoCAD
  - Updates to Data…

Summarising: MJA wanted

- A centralised coordinated approach to geotechnics
- Employing standardise approach on all projects
- Improve efficiency in data entry
- System designed with a data-driven approach, so data can be queried
- Much closer integration with AutoCAD Civil 3D
- Rapidly create and visualise cross sections (profile views)
- Up to date technology with better customer support



Developing new workflows to incorporate both legacy and new data

The proposed solution

MJA identified

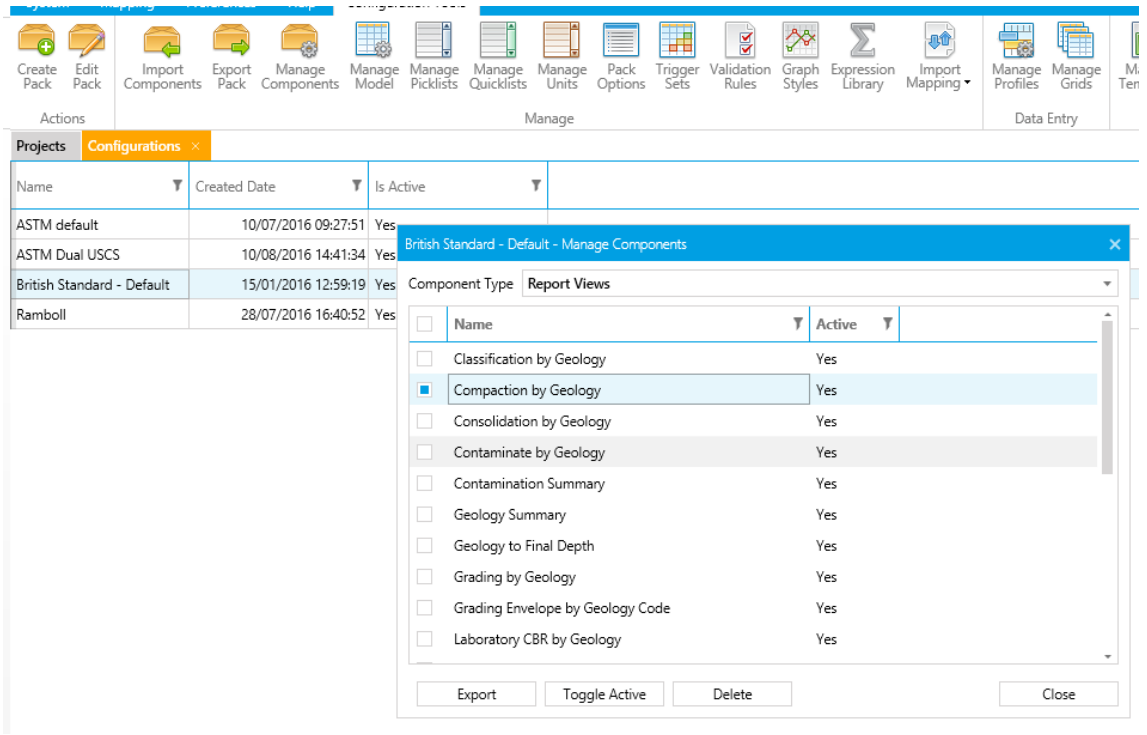
HoleBASE™ SI PROFESSIONAL

Keynetix | Geotechnical Data Software Transformed

- Close integration with AutoCAD Civil 3D
- Centralised geotechnical data management
- Relatively easy to use and configure
- On going development
- Friendly Support

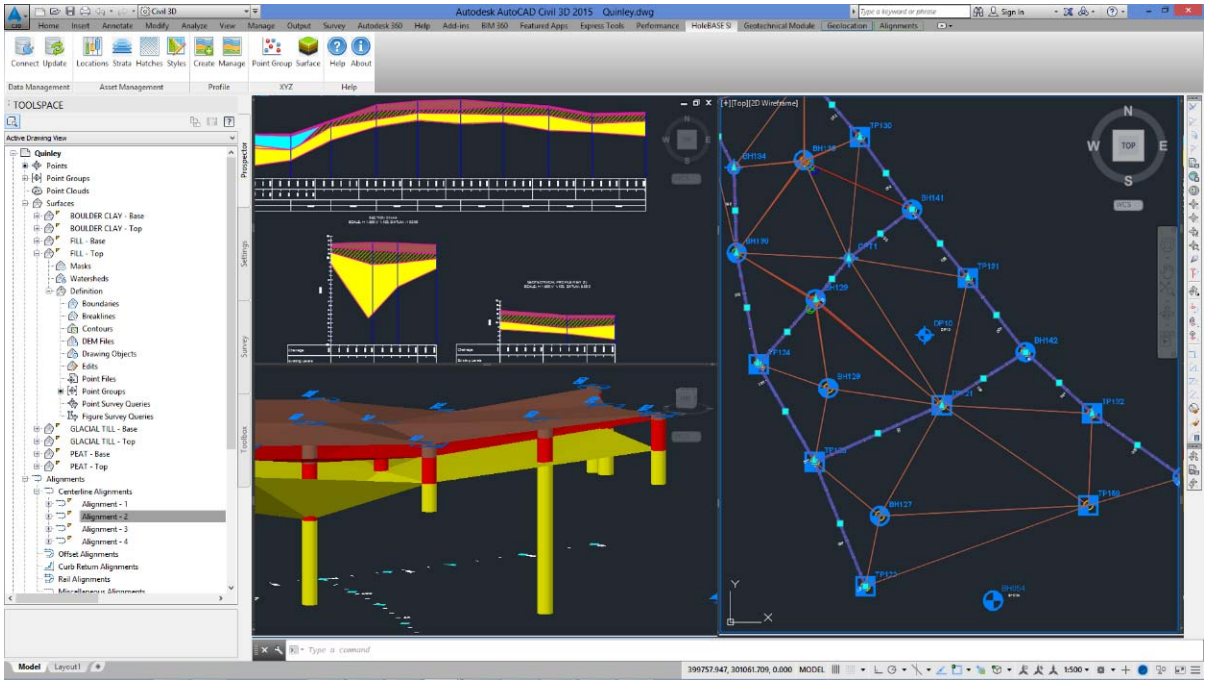
Centralised Geotechnical Data Management

- Configurable and scalable
- Central SQL server
- Standardise configuration
- Standard Templates
- Data driven design
- Possibility to query



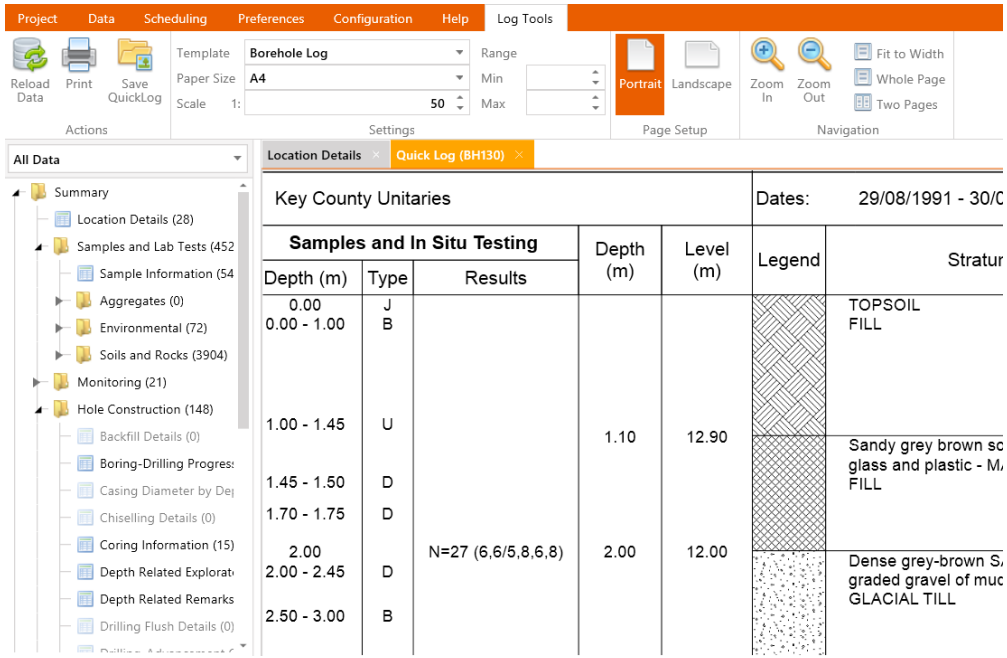
HoleBASE SI: Dynamic integration

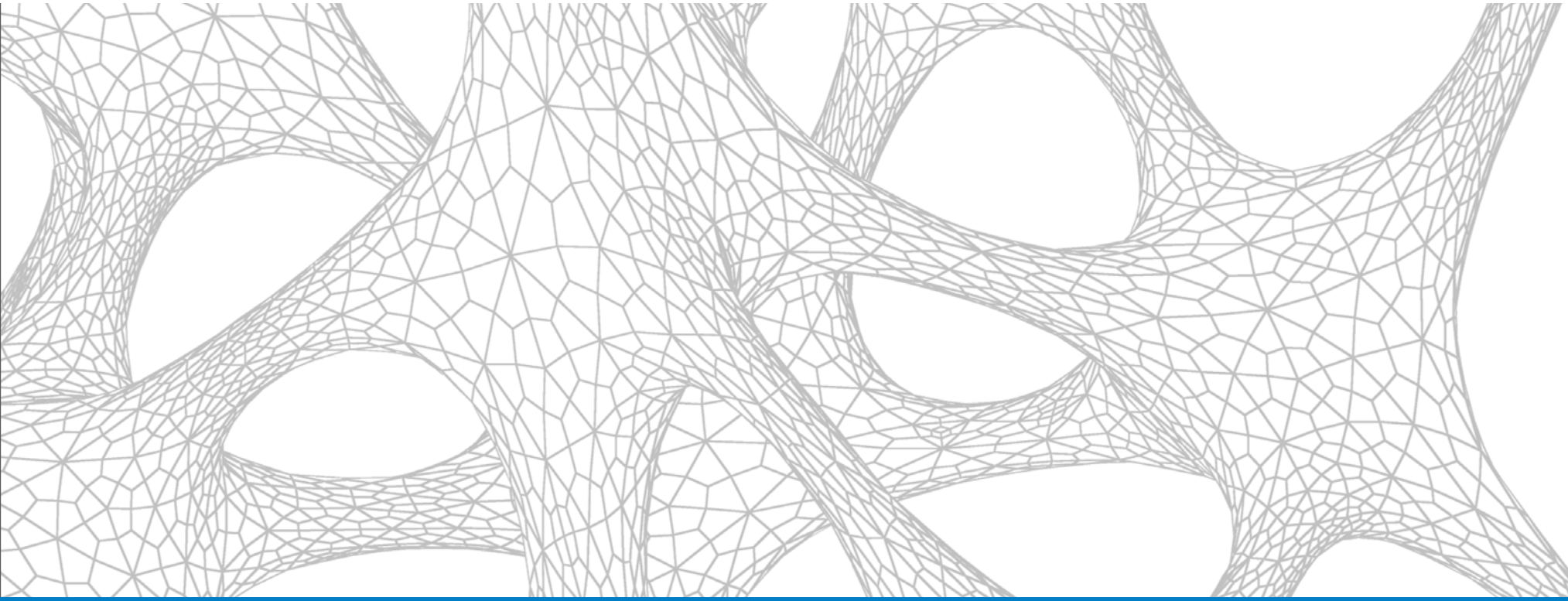
- Streamlined workflows with AutoCAD Civil 3D for seamless access to geotechnical data



Relatively easy to use and configure

- Easier interface
- Less training required
- Responsive





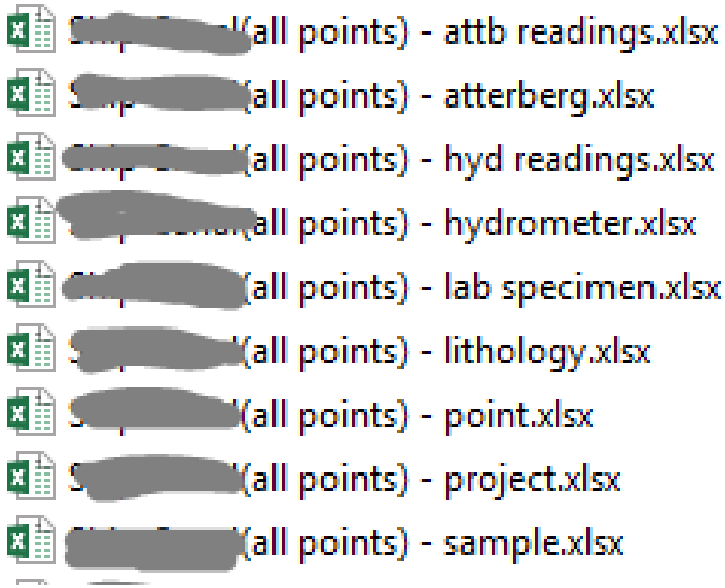
Incorporate legacy system in the workflow

Importing existing gINT data into HoleBASE SI

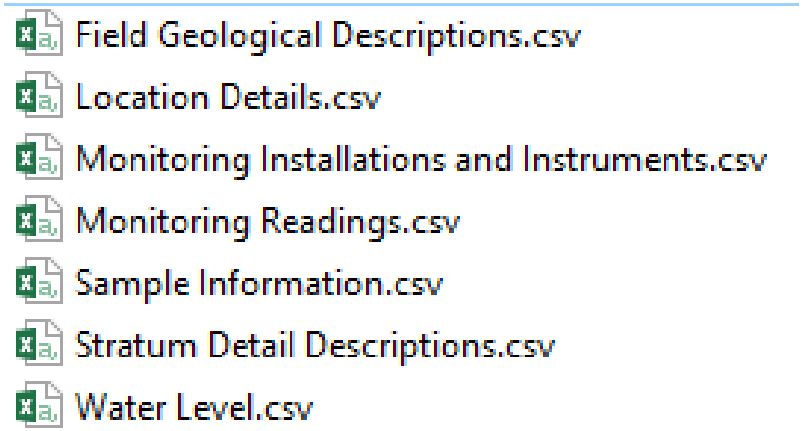
- Data was supplied by sub contractor.
- gINT does not have a standard database schema

- gINT export to XLS
- HB uses set files and CSV format
- XLS files needed to be renamed with correct CSV file names

File naming formats



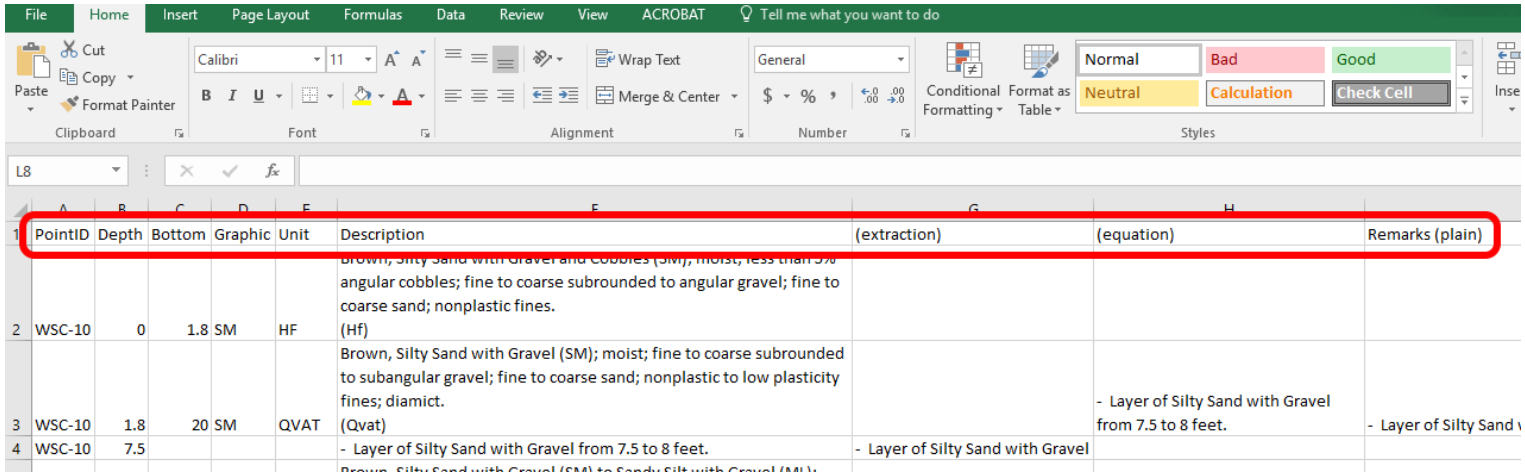
gINT



HoleBASE SI

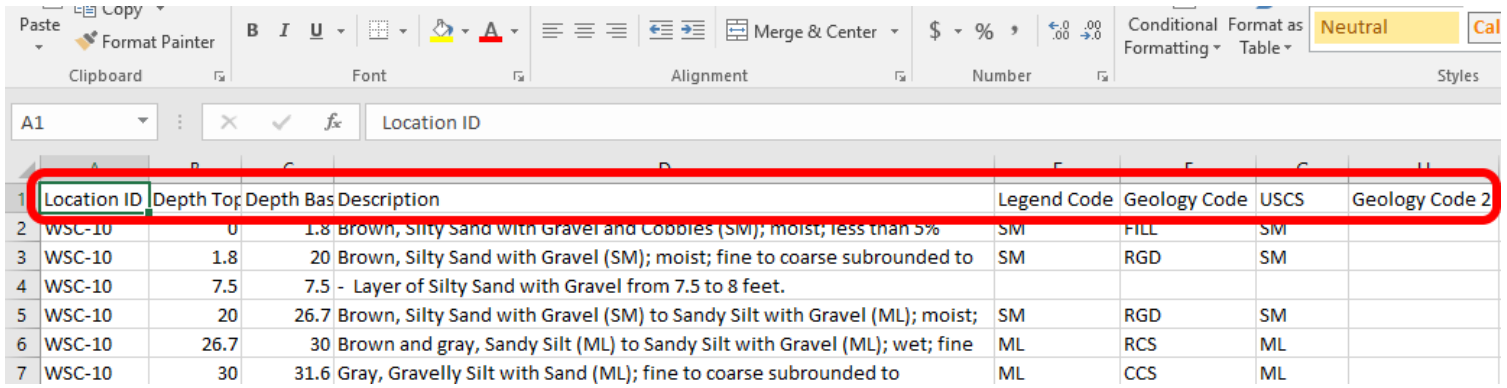
Column Names

gINT



	PointID	Depth	Bottom	Graphic	Unit	Description	(extraction)	(equation)	Remarks (plain)
2	WSC-10	0	1.8	SM	HF	angular cobbles; fine to coarse subrounded to angular gravel; fine to coarse sand; nonplastic fines. (Hf)			
3	WSC-10	1.8	20	SM	QVAT	Brown, Silty Sand with Gravel (SM); moist; fine to coarse subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines; diamict. (Qvat)		- Layer of Silty Sand with Gravel from 7.5 to 8 feet.	- Layer of Silty Sand
4	WSC-10	7.5				- Layer of Silty Sand with Gravel from 7.5 to 8 feet.	- Layer of Silty Sand with Gravel		

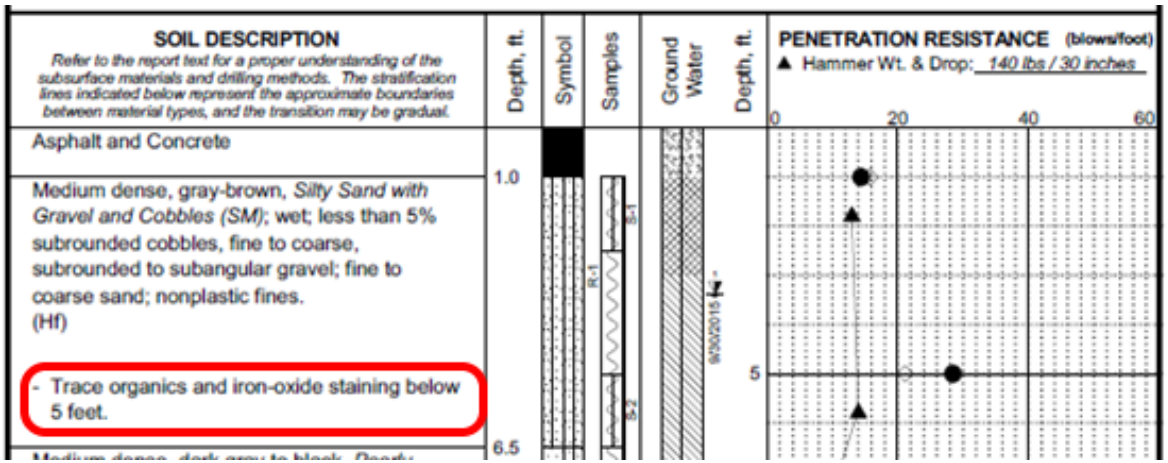
HoleBASE SI



	Location ID	Depth Top	Depth Bas	Description	Legend Code	Geology Code	USCS	Geology Code 2
2	WSC-10	0	1.8	Brown, Silty Sand with Gravel and Cobbles (SM); moist; less than 5%	SM	FILL	SM	
3	WSC-10	1.8	20	Brown, Silty Sand with Gravel (SM); moist; fine to coarse subrounded to	SM	RGD	SM	
4	WSC-10	7.5	7.5	- Layer of Silty Sand with Gravel from 7.5 to 8 feet.				
5	WSC-10	20	26.7	Brown, Silty Sand with Gravel (SM) to Sandy Silt with Gravel (ML); moist;	SM	RGD	SM	
6	WSC-10	26.7	30	Brown and gray, Sandy Silt (ML) to Sandy Silt with Gravel (ML); wet; fine	ML	RCS	ML	
7	WSC-10	30	31.6	Gray, Gravelly Silt with Sand (ML); fine to coarse subrounded to	ML	CCS	ML	

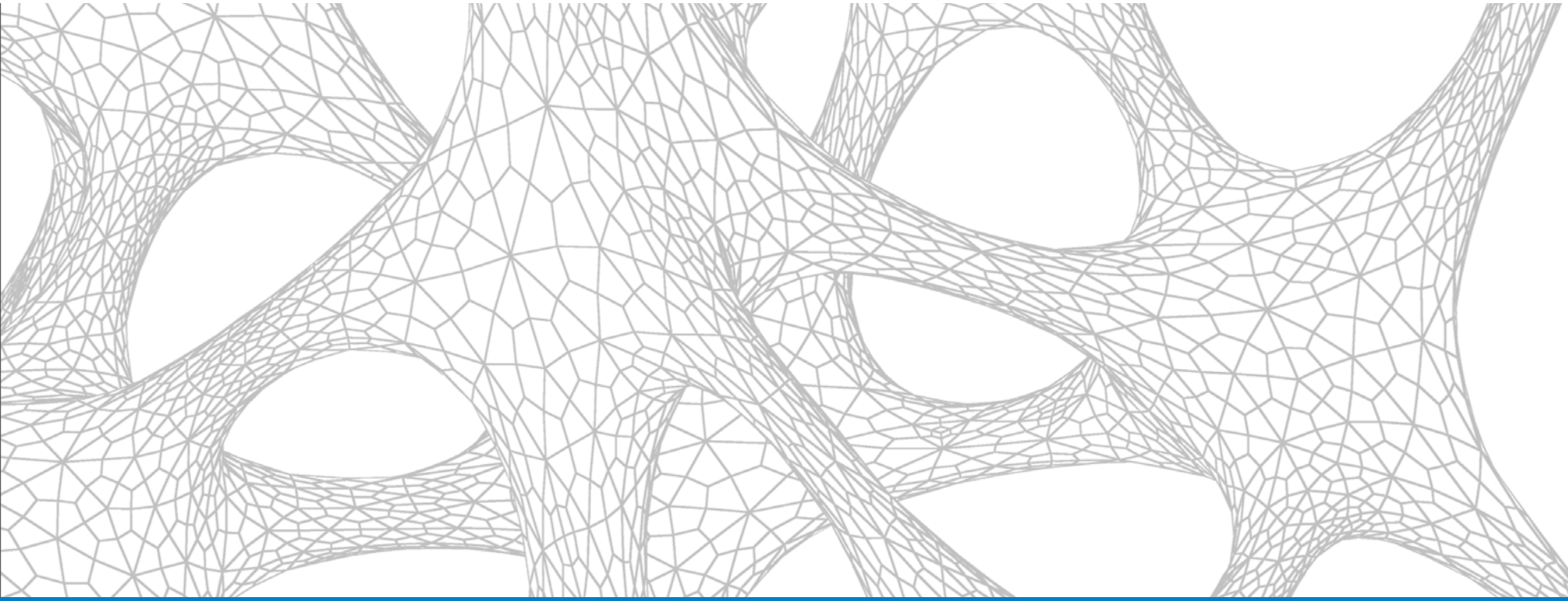
Other import issues

- Separating data from text remarks
  - Common practice in gINT



Importing: Lessons learnt

- Creating the correct format CSV files was painful and tedious.
- A “Mapping” file should have been used
  - Import directly from gINT to HoleBASE SI
- In the future uses data collection with pLog, which is quick and easy

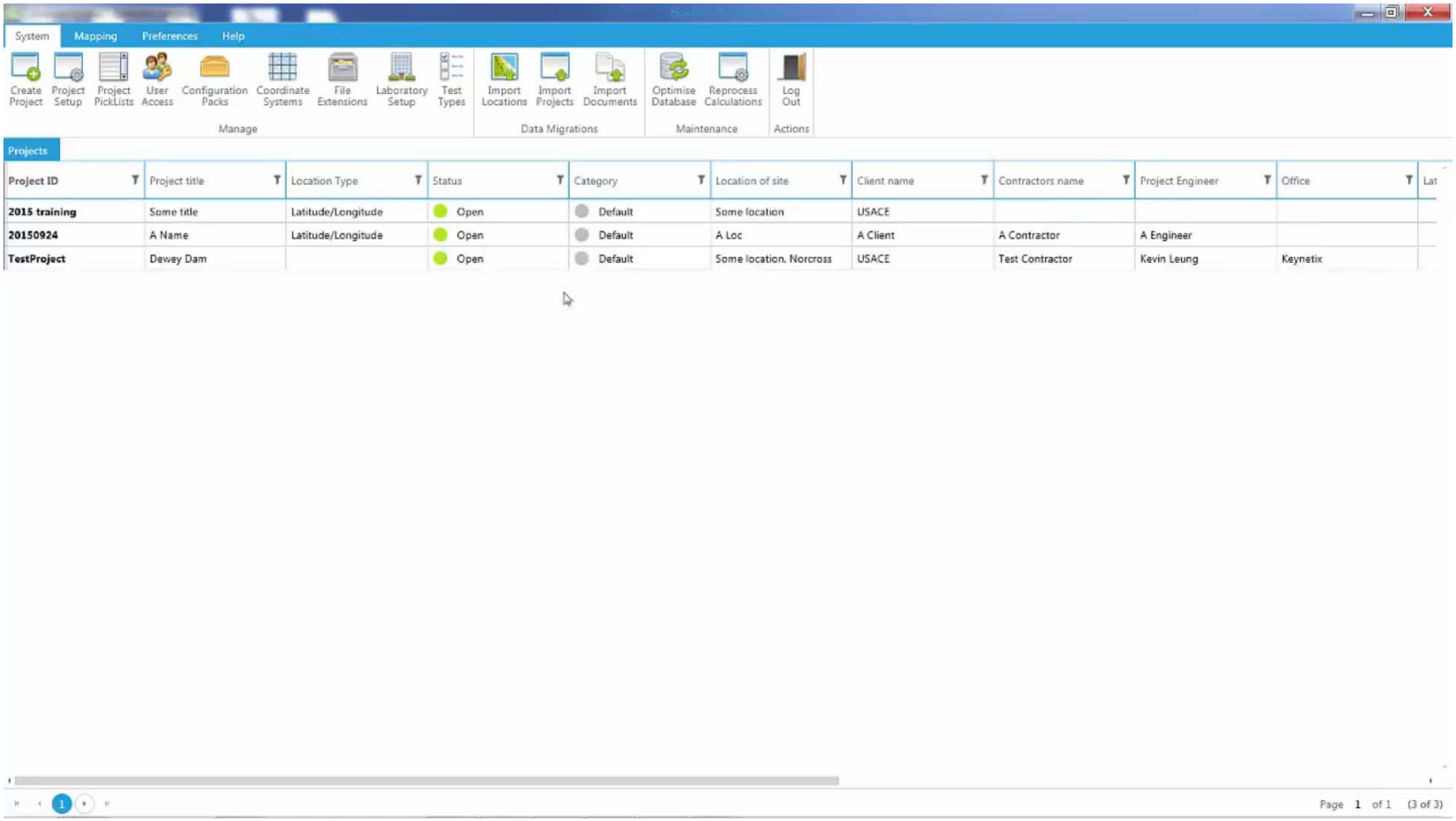


Developing new workflows that boost efficiency

Data capture with pLog

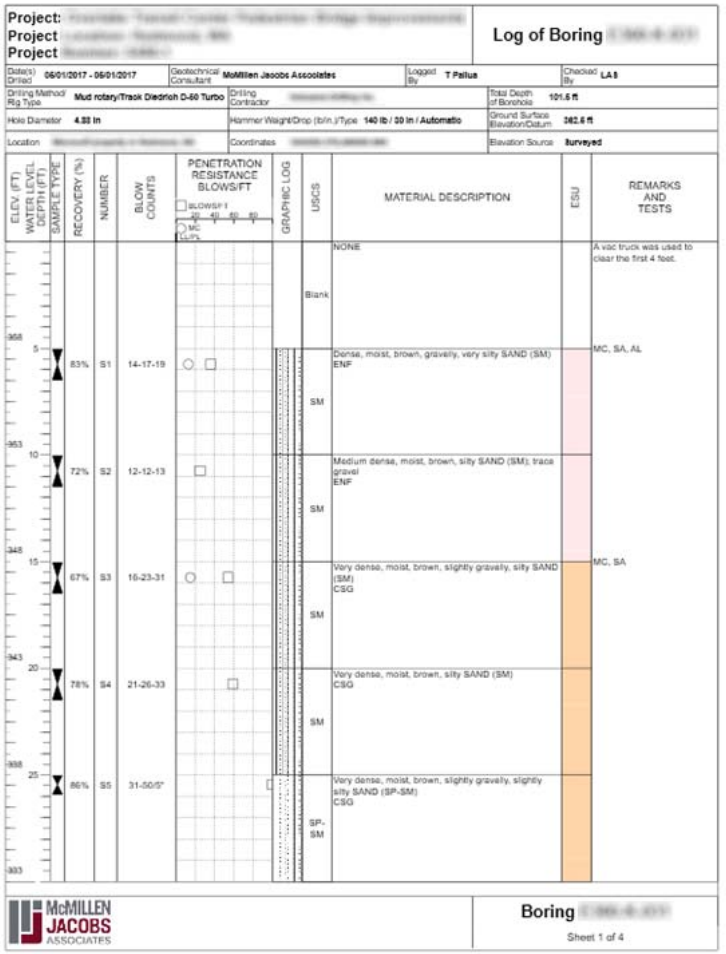
- On site Data Capture
- Use by MJA for new boreholes
- pLog Enterprise direct import into HBSI
- Data in only entered once
- Advanced Description Builder helps with standardization process

Plog to HoleBASE SI import



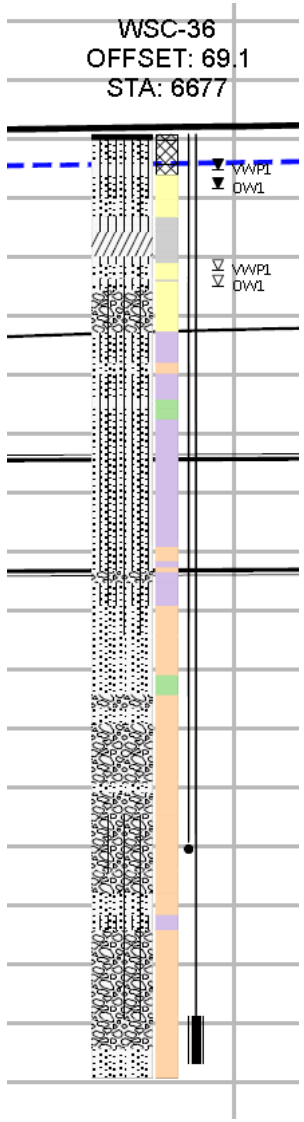
Creating Borehole Templates

- New standard for organisation
- Created in HoleBASE SI Template studio.
- Available for all new projects



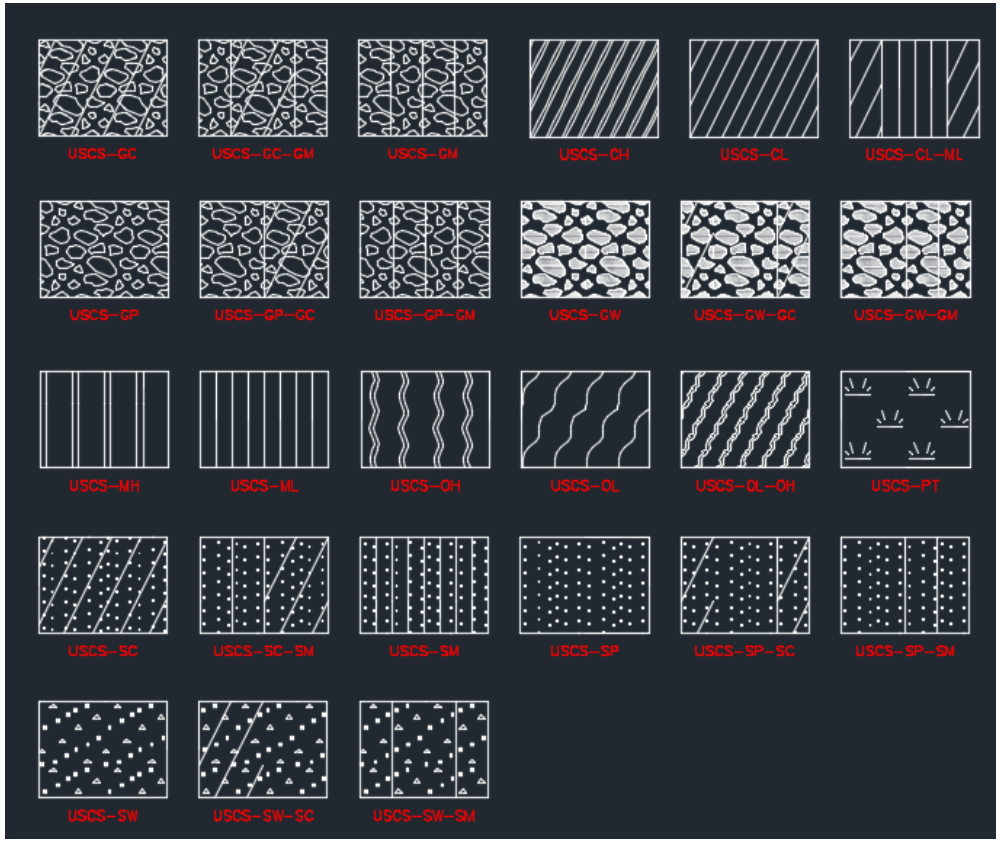
New Log Strip for AutoCAD Civil 3D

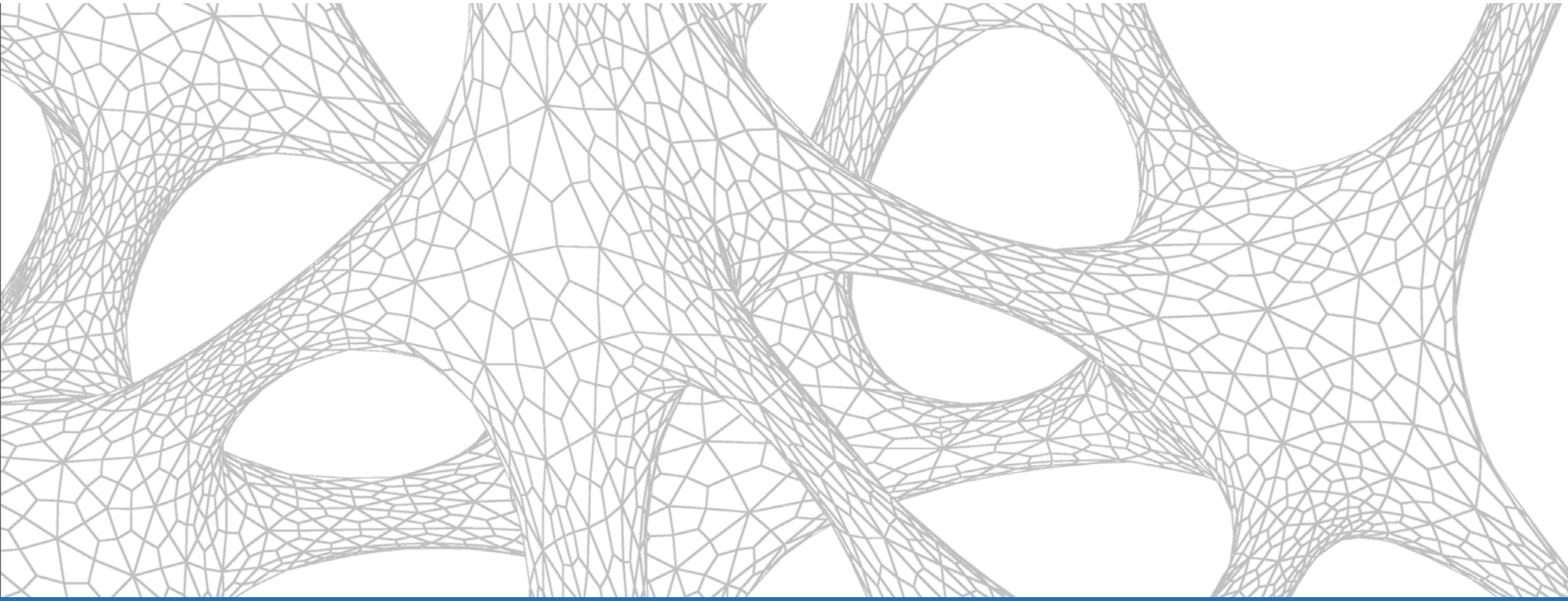
- Created in Template Studio
- Two graphics columns
  - USCS (Unified Soil Classification System)
  - ESU (Engineering Soil Unit)
- Ground water level
  - Themed of event
- Instrumentation
  - Piezometer



Standardised Hatch Patterns

- For USCS
- For ESU
- Used in AutoCAD Civil
- Configured in HoleBASE

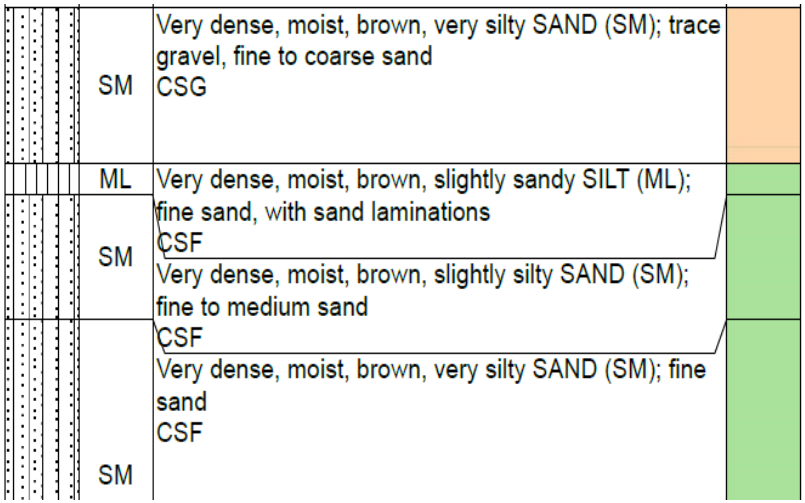




The capabilities delivered by integrating HoleBASE SI and AutoCAD Civil 3D

Faster Data Management

- New system meant workflows and outputs would be quick and repeatable
- Greater opportunity to spot anomalies
- Quickly Identify gaps in the data
- Advanced Description Builder used for consistent soil descriptions



Faster Data Management

- Before we followed procedures on laminated guides for field work

Faster Data Management

Green Gray | Olive Gray | Yellow Red | Brown Yellow | Red Brown | Light Brown | Brown | Dark Brown | Gray Purple | Gray Blue | Blue Green | Light Gray | Gray | Dark Gray

UNIFIED SOIL CLASSIFICATION SYSTEM

FIELD IDENTIFICATION PROCEDURES
(Excluding particles over 3 inches and basing fractions on estimated weight)

Coarse Grained Soils: More than 50% retained on No. 200 sieve	Gravel: More than 50% retained on No. 4	Clean Gravel: Less than 5% fines	Well graded gravel, gravel-sand mixtures with little or no fines		GW
			Poorly graded gravel, gravel-sand mixtures with little or no fines		GP
		Gravel with Fines: More than 12% fines	Silty gravel, gravel-sand-silt mixutres (non-plastic or clayey fines as determined below)		GM
			Clayey gravel, gravel-sand-clay mixtures (plastic or clayey fines as determined below)		GC
	Sand: More than 50% passing No. 4 sieve	Clean Sand: Less than 5% fines	Well graded sand, gravelly sands with little or no fines		SW
			Poorly graded sand, gravelly sands with little or no fines		SP
		Sand with Fines: More than 12% fines	Silty sand, gravel-sand-silt mixtures (non-plastic or silty fines as determined below)		SM
			Clayey sand, gravel-sand-clay mixtuers (plastic or clayey fines as determined below)		SC
Fine Grained Soils: More than 50% passing No. 200 sieve			**Dry Strength**	**Dilatancy**	**Toughness and Plasticity**	
	Silts and Clays	Liquid limit less than 50 (OL if >30% organics by volume)	None to low	Slow to rapid	None to low	ML
			Medium to high	None to slow	Medium	CL
			Low to medium	Slow	Low	OL
		Liquid limit greater than 50 (OH if >30% organics by volume)	Low to medium	None to slow	Low to medium	MH
			High to very high	None	High	CH
			Medium to high	None to very slow	Low to medium	OH
Highly Organic Soils (>50% organics)			Readily identified by color, odor, spongy feel, frequently with fibrous texture			PT

Dual symbols (e.g. GP-GM, SW-SC, CL-ML) are used to indicate soil having properties that place them between groups such as soils with 5%-12% fines.

Border line symbols (e.g. CL/CH, GM/SM) are used for soils with properties that do not distinctly place them in a specific group.

Description Order of Terms
1 Relative density or consistency
2 Moisture content
3 Color
4 'Slightly' constituents (5-12%)
5 Modifier constituents (12-30%)
6 'Very' constituents (>30%)
7 MAJOR CONSTITUENT
8 (USCS symbol);
9 Trace descriptors
10 Plasticity, dilatency, toughness, etc.
11 Grain size, rounding, gradation, etc.
12 Structure, bedding, cementation, mineralogy, organics, odor, etc.
13 (Geologic unit)

Examples:
Dense, wet, gray, gravelly SAND (SW); trace silt, well graded fine to coarse sand, fine subangular gravel, homogeneous (Qva)

Hard, moist, dark gray, slightly gravelly, very sandy CLAY (CL); fine gravel, low plasticity, laminated with gray SILT (Qvlc)

Moisture Content

Description	Criteria
Dry	Absence of moisture, dusty, dry to touch
Slightly moist	Perceptible moisture
Moist	Damp but no visible water
Very moist	Water visible but not free draining
Wet	Visible free water, usually from below water table

Modifiers and Estimated Percentage

Modifiers	Criteria
Trace	Particles present at levels estimated at <5%
Slightly	Particles present at levels estimated at 5% to 12%
Clayey, silty, sandy, or gravelly	Particles present at levels estimated at 12% to 30%
Very	Percentage of minor constituent estimated to be >30%
With (cobbles or boulders)	Present at any concentration, estimate percentage

Gradation

Gradation	Description
Well graded	Approximately equal amount of all grain sizes
Poorly graded	Predominately one size (uniformly graded) or a wide range of sizes with a missing intermediate size (gap graded)

Relative Density (Coarse Grained Soils)

Density	SPT (N) (Blows/Ft.)	15 lb Dynamic Cone (Blows/1.75")	Field Test
Very loose	0 to 4	0 to 4	Penetrated 3 ft. or more with 1/2" hand probe
Loose	5 to 10	5 to 12	Penetrated 1-2 ft. with 1/2" hand probe
Medium dense	11 to 30	>12	Penetrated 3-12 in. with 1/2" hand probe
Dense	31 to 50		Penetrated 1-3 in. with 1/2" hand probe
Very dense	>50		Penetrated <1 in. with 1/2" hand probe

Consistency (Fine Grained Soils)

Consistency	SPT (N) (Blows/Ft.)	Torvane (psf)*	Pocket Pen. (psf)*	Field Test
Very soft	0 to 1	250	500	Easily penetrated several inches by thumb. Extrudes between thumb and fingers when squeezed
Soft	2 to 4	250 to 500	500 to 1,000	Easily penetrated one inch by thumb. Molded by light finger pressure.
Medium stiff	5 to 8	500 to 1,000	1,000 to 2,000	Can be penetrated over 1/4" with moderate pressure. Molded by strong finger pressure.
Stiff	9 to 15	1,000 to 2,000	2,000 to 4,000	Indented about 1/4" by thumb, but penetrated only with great effort.
Very stiff	16 to 30	2,000 to 4,000	4,000 to 8,000	Readily indented by thumbnail.
Hard	>30	>4,000	>8,000	Indented with difficulty by fingernail.

* Shear strength
** Unconfined compressive strength

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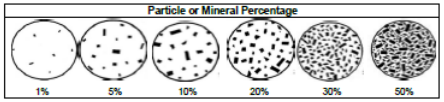
Faster Data Management

Particle or Mineral Percentage



Dilatancy

Description	Criteria
None	No visible change in the specimen.
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing.
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing.

Dry Strength

Description	Criteria
None	The dry specimen crumbles into powder with mere pressure of handling.
Low	The dry specimen crumbles into powder with some finger pressure.
Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure.
High	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface.
Very High	The dry specimen cannot be broken between the thumb and a hard surface.

Toughness

Description	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak, soft.
Medium	Medium pressure is required to roll the thread to near the plastic limit. The thread and the lump have medium stiffness.
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness.

Rounding

Organics

Description	Content (Percent Volume)
Occasional	Less than 1%.
Scattered	1% to 10%
Numerous	10% to 30%

Bedding

Description	Criteria
Very thinly laminated	Less than 1/16" thickness (1.5mm)
Thinly laminated	1/16" - 1/4" thickness (1.5mm - 6mm)
Laminated	1/4" - 3/4" thickness (6mm - 2cm)
Very thinly bedded	3/4" - 2 1/2" thickness (2cm - 6cm)
Thinly bedded	2 1/2" - 6" thickness (6cm - 15cm)
Medium bedded	6" - 24" thickness (15cm - 60cm)
Thickly bedded	2' - 6' thickness (60cm - 2m)
Pocket	Small, erratic deposit, less than 12" maximum dimension
Lensed	Inclusion of small beds of different soils that are thin at edges and pinch out.
Homogeneous	Same color and appearance throughout.
Scattered	One or less per 12" thickness.
Frequent	More than one per 12" thickness.

Discontinuity and Structure

Description	Criteria
Jointed	Discontinuity or fracture without visible displacement.
Faulted	Discontinuity or fracture with displacement of sides relative to one another.
Brecciated	Contains angular fragments of cohesive soil.
Inclined	Dipping or rotated beds or discontinuities, note angle from horizontal.
Fissured	Breaks along definite planes of fracture with little resistance.
Slickensided	Fracture planes appear polished or glossy, sometimes striated.
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown.

Cementation

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger

Grain Size

Term	Grain Size	Example
Boulder	Greater than 12" (30cm)	Basketball or larger
Cobble	3" - 12" (75mm - 30cm)	Fist to basketball
Gravel coarse	3/4" - 3" (20mm - 75cm)	Thumb to fist
Gravel fine	No. 4 sieve - 3/4" (5mm - 20mm)	Peak to thumb
Sand coarse	No. 10 sieve - No. 4 sieve (2mm - 5mm)	Rock salt to pea
Sand medium	No. 40 sieve - No. 10 sieve (0.4mm - 2mm)	Sugar to rock salt
Sand fine	No. 200 sieve - No. 40 sieve (0.08mm - 0.4mm)	Flour to sugar
Fines	Passing No. 200 sieve (<0.08mm)	Grains not visible

Graphic Log Symbols

Symbol	Description
	A well defined change in units which was clearly seen in a sample, or noted in cuttings or drilling behavior.
	A gradational change in units which was clearly noted.
	A change in unit which was not clearly defined, either because of sample interval or
	End of exploration / total depth.

Well Down Hole Materials

Hatch	Description
	3/4" bentonite chips
	Neat cement
	Slough of formation materials
	Bentonite-cement grout
	10-20 silica sand
	PVC well screen 0.020" slot, 2" diameter, Sch 40

HCl Reaction

Description	Criteria
None	No visible reaction
Weak	Some reaction, with bubbles forming slowly.
Strong	Violent reaction, with bubbles forming immediately.

Plasticity

Description	Criteria
Nonplastic	A 1/8" (3mm) thread cannot be rolled at any water content.
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.

Sample Symbols

Fill	Indication
■	Sample was retained.
I	The sample was used for logging only and discarded in the field.
☒	Sample was not recovered.

Key to Samplers

Code	Sampler
DM	D&M type 3.25" O.D. split barrel sampler with liner
SPT	2" O.D. split barrel
S	3" O.D. split barrel sampler with liner
T	3" O.D. thin wall (Shelby Tube)
CC	Continuous Core
G	Grab Sample

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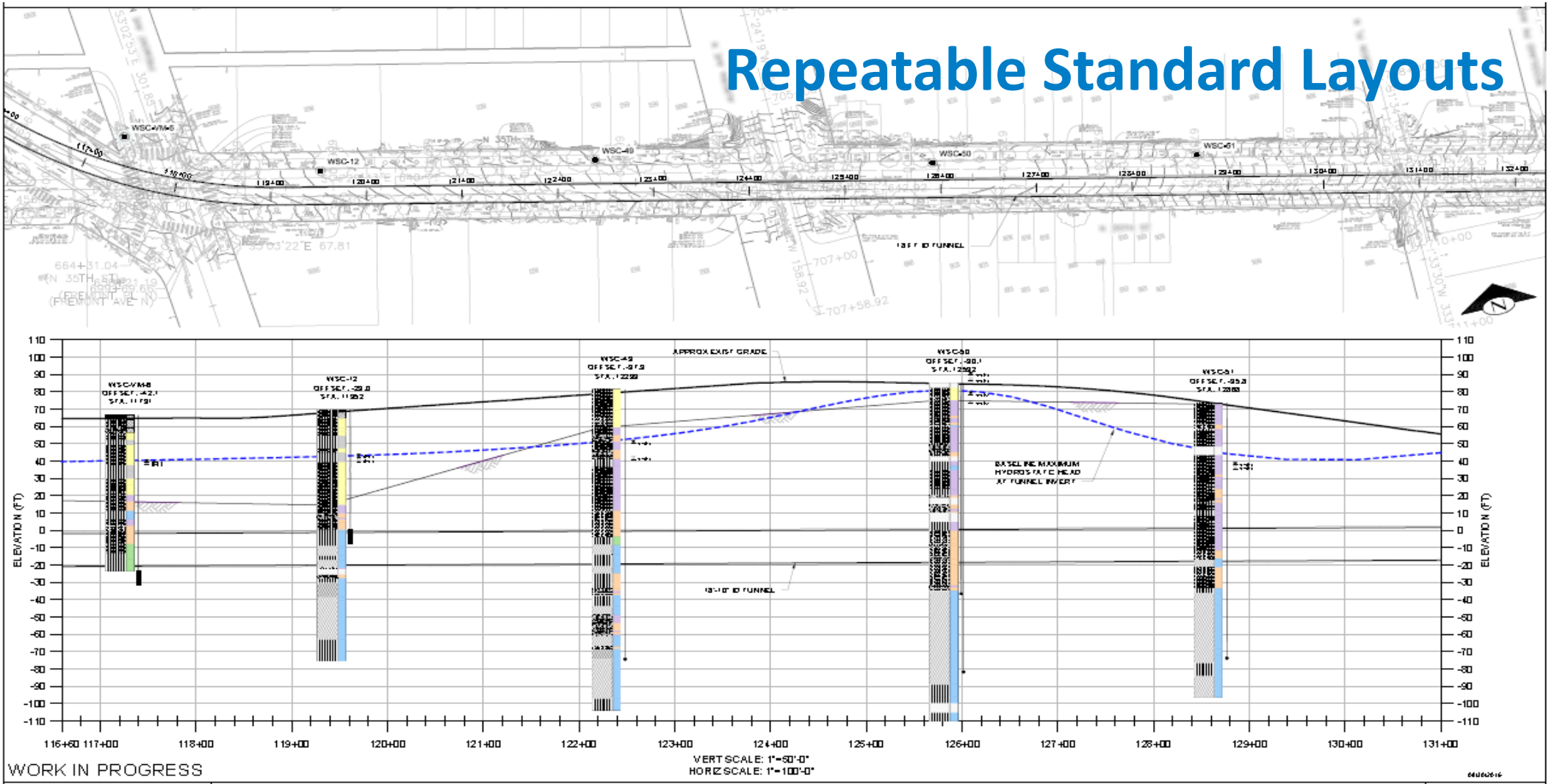
HoleBASE to AutoCAD Civil Integration Provides:

- Dynamic Integration of geotechnical and site investigation data in the AutoCAD Civil 3D environment
- Create dynamic geotechnical profiles and sections in seconds as opposed to hours
- Visualization of geotechnical boring data, allowing creation of 3D borehole layouts and sub-surfaces
- Create Civil point groups and surfaces from data stored in HoleBASE SI

Repeatable Standard Layouts



WORK IN PROGRESS

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GEOTECHNICAL BASELINE REPORT
PLAN AND PROFILE STA 116+60 TO STA 131+00

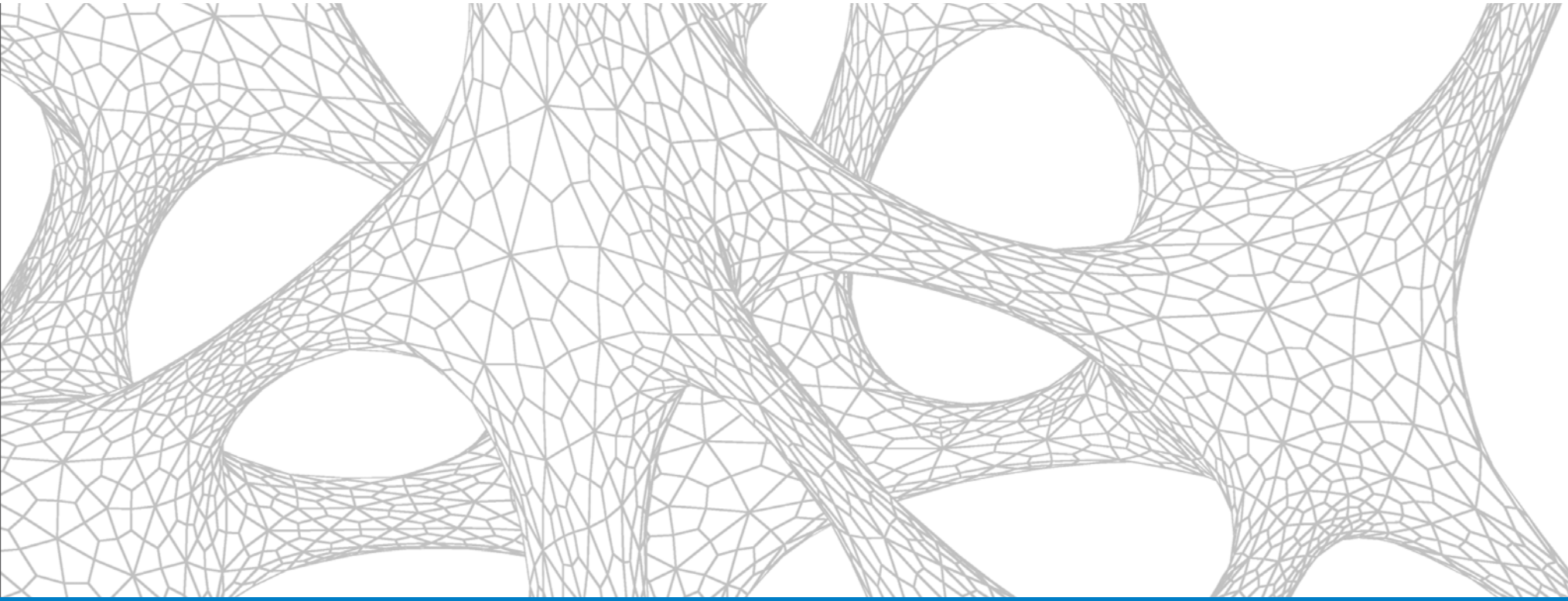
FIGURE 06
SHEET 11 OF 12

Allowing engineers to engineer

Faster workflows and efficient process

=

More time for engineering



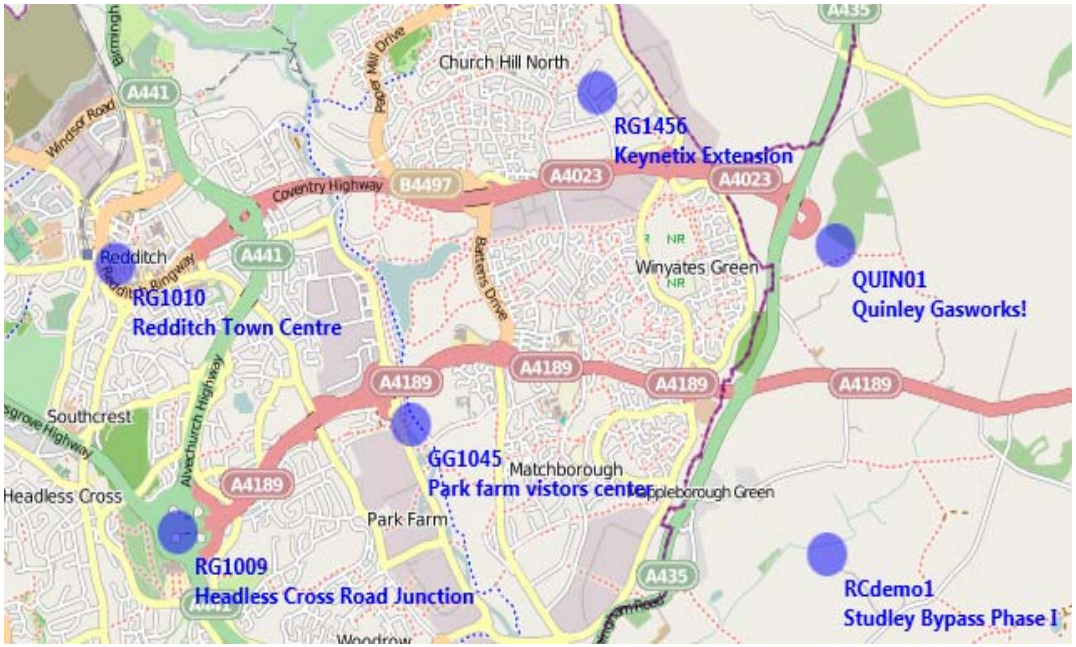
The benefits and future opportunities geotechnical BIM can deliver

Potential Benefits

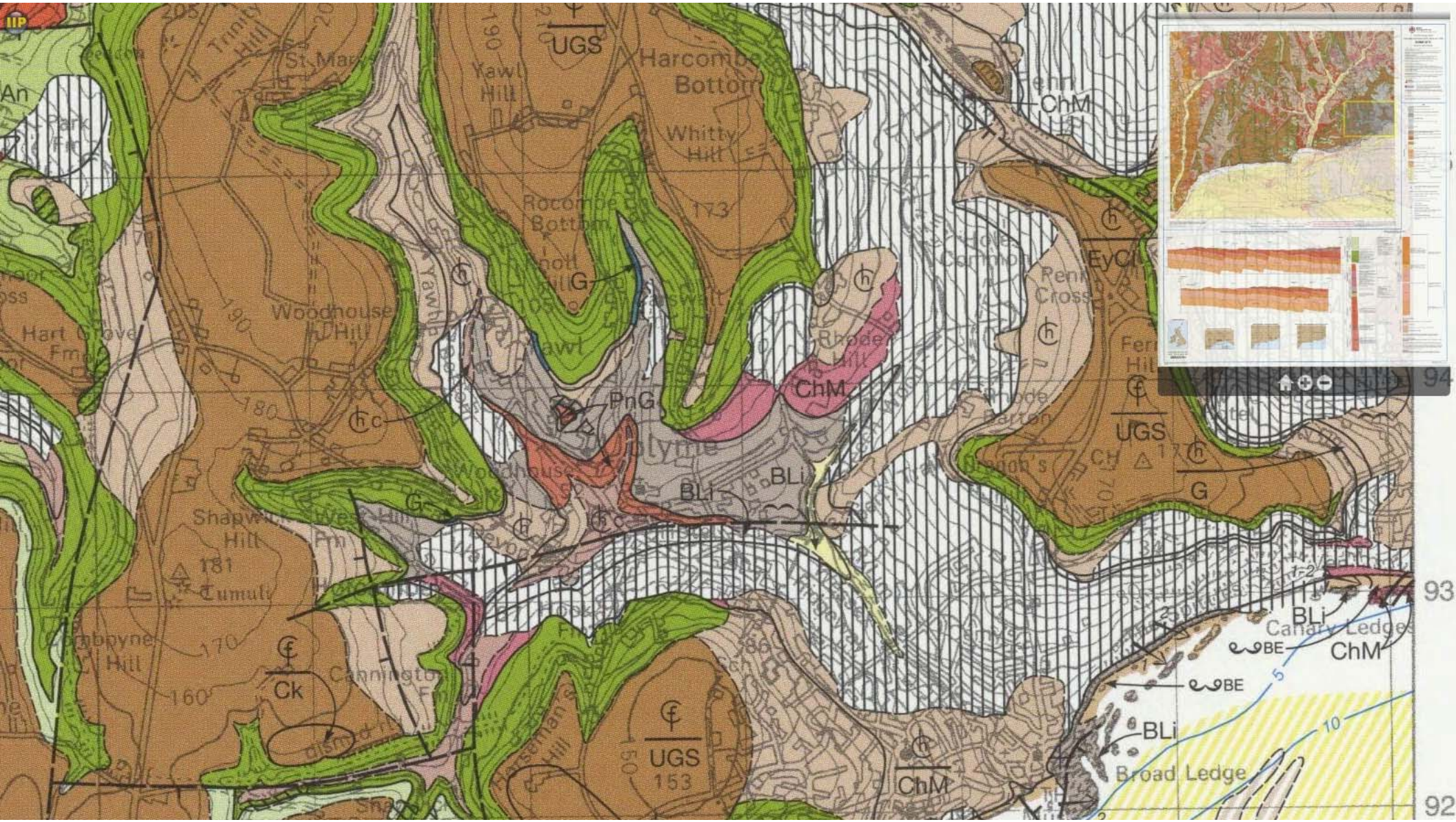
- Desk studies and site investigations are more focused
- Engineers can react faster to potential issues on site
- A more complete picture of the ground can be built
- Understanding of ground behavior is improved, leading to better design
- Communications within the design team, as well as with the client and other stakeholders are improved.

Focused Desk Studies

- Build upon and refine previous knowledge
- We may already have experience in the area




• Access both PDF
and Digital Projects


UGS
Harcombe Bottom
Yawl Hill
Whitty Hill
ChM
Rocombe Bottom
173
EyCl
Woodhouse Hill
G
PnG
ChM
BLi
UGS
Shapwick Hill
181
Cumulus
Ck
UGS
153
ChM
1-2
BLi
Canary Ledge
BE
ChM
BE
BLi
Broad Ledge
5
10
94
93
92

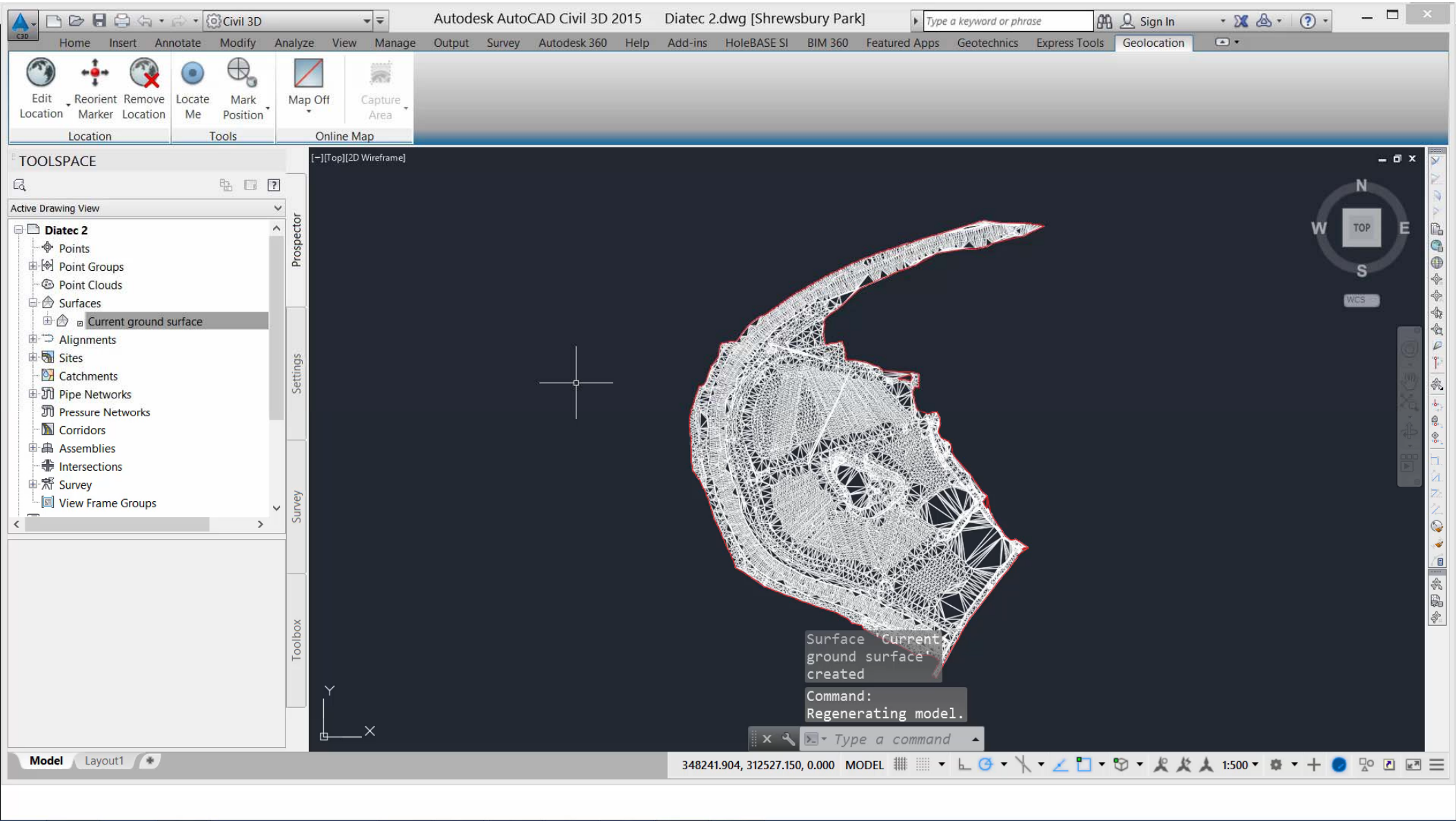
Aerial Photos

React faster to potential issues on site

- Field Data can captured and quickly see in context.
- Speeds up process
- Can react faster
- Mobilize equipment while drillers are on site

A More Complete Picture

- Better understand and visualise data in context
- Rapidly view down hole data
- In context with the proposed site plan
- Better understand were potential problems may occur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Express Tools
Geolocation
Edit Location
Reorient Marker
Remove Location
Locate Me
Mark Position
Map Off
Capture Area
Location
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Surfaces
Current ground surface
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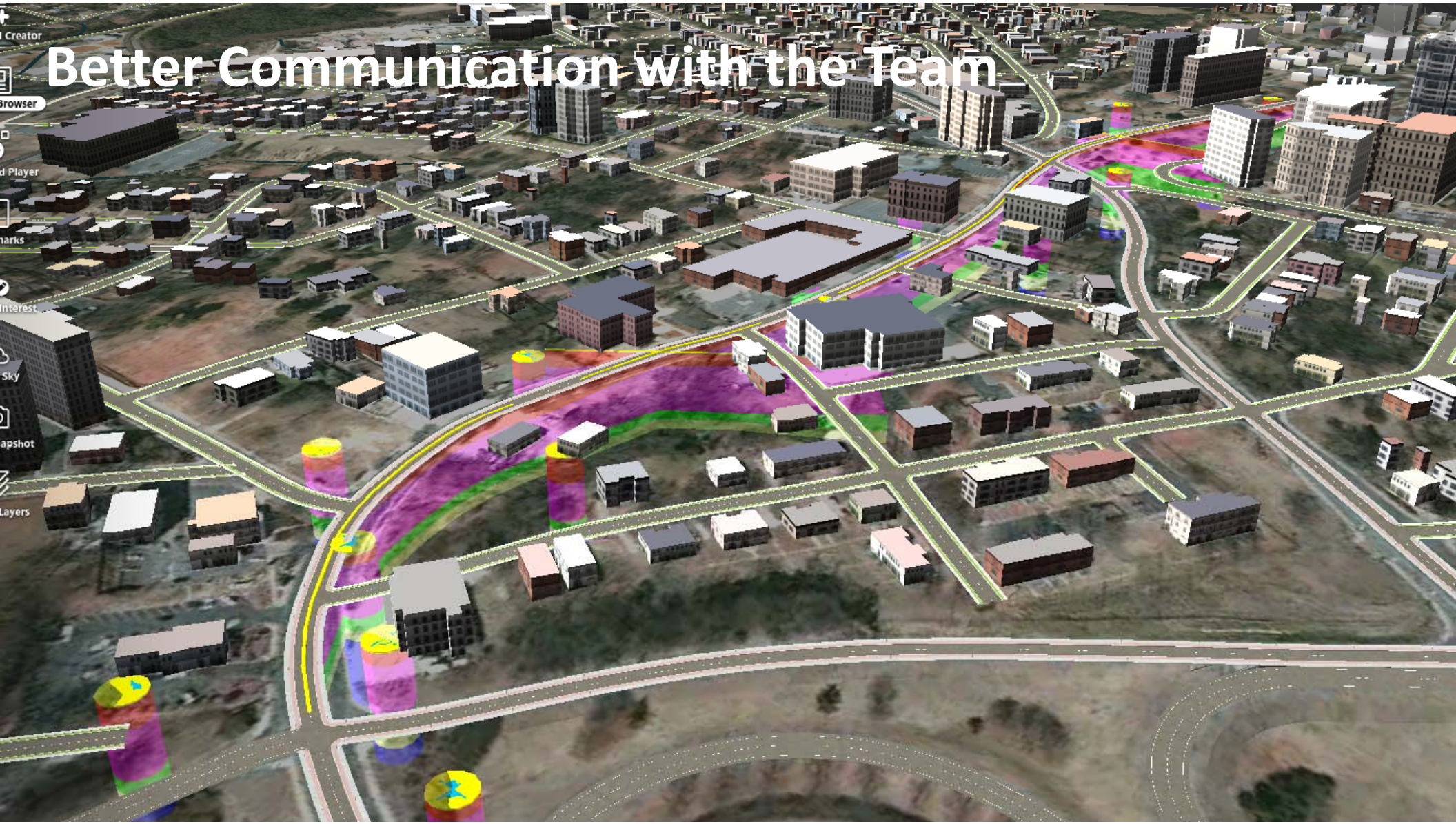
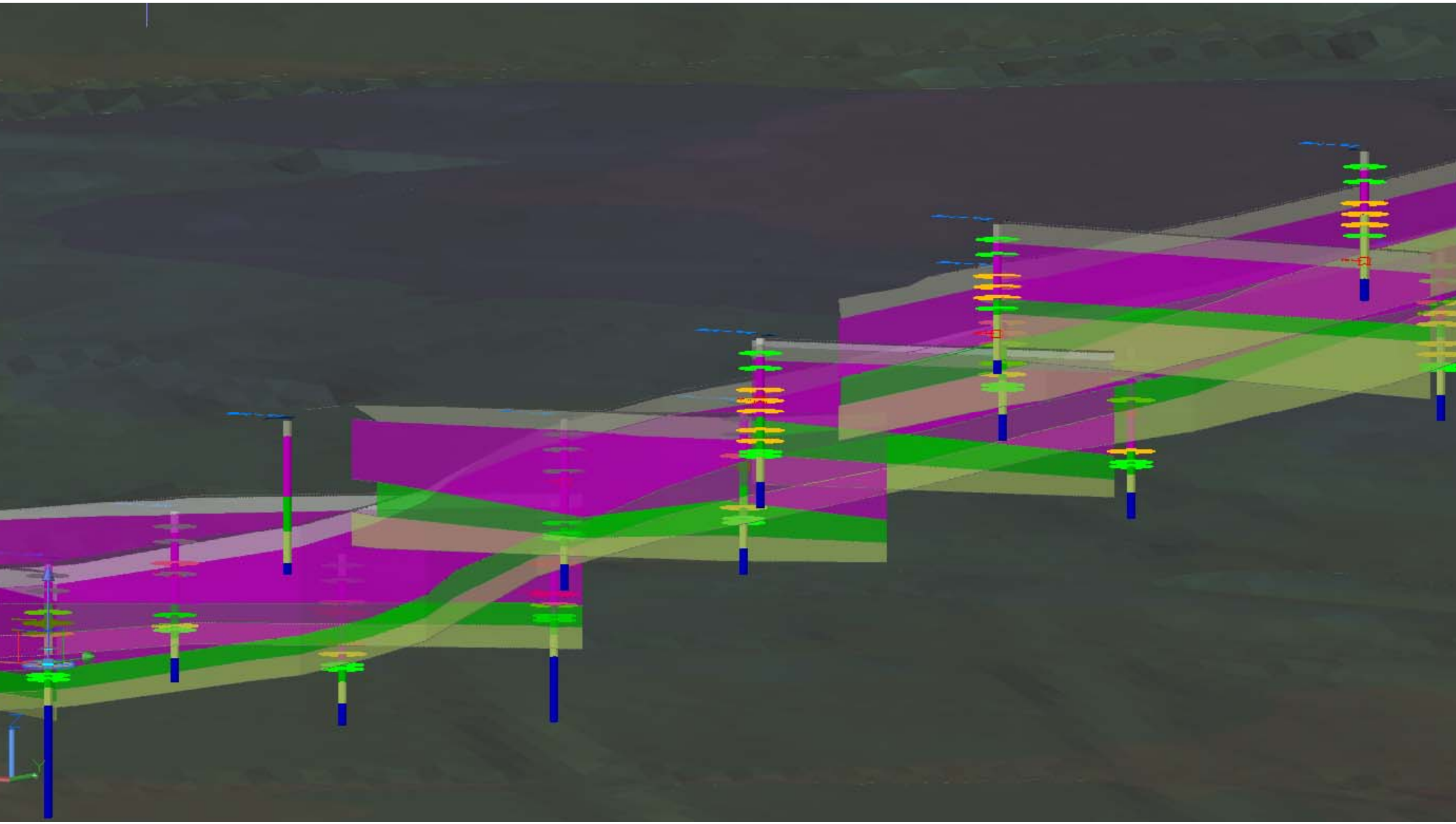

Better Communication with the Team



Q & A

McMILLEN JACOBS ASSOCIATES

Keynetix

Geotechnical Data
Software Transformed