[CLASS ID]

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

Thomas Pallua
McMillen Jacobs Associates

Gary Morin
Keynetix Ltd

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

Description

This class examines the methods and benefits gained by implementing a geotechnical BIM, using AutoCAD Civil 3D and HoleBASE SI, for a large infrastructure project in Seattle.

McMillen Jacobs knew it needed better methods for visualizing and improving workflow efficiency when working with geotechnical data than that offered by its legacy gINT system. The firm wanted to use the functionality that Autodesk technology offered; the aim was to enable data to be viewed and analyzed in AutoCAD Civil 3D and to have more uniform branding throughout the company, by creating standardized templates.

The class will cover MJA's journey to the AutoCAD Civil 3D/Keynetix solution; why a change was required; the new workflows developed to incorporate both legacy and new data; as well as the integration of the HoleBASE SI data management system with AutoCAD Civil 3D. The challenges encountered will also be discussed, together with the benefits gained and future opportunities the new technology will enable.

Speaker(s)

Thomas Pallua

Thomas Pallua is an associate engineering geologist at McMillen Jacobs Associates, based in the firm's Seattle office, with 17 years' experience providing geologic/ geotechnical field exploration and geologic modeling services. His exploration experience ranges from organizing, directing, and conducting geological and geotechnical field investigations to performing site reconnaissance and logging test pits and boreholes. He has led numerous geologic mapping efforts to collect lithological and structural data and has also performed numerous evaluations of rock slope and wedge stability. During his career, he has directed installation of monitoring wells, inclinometers, and other geotechnical instrumentation. He also has over ten years' experience with drill and blast hard-rock tunneling.

Gary Morin

Gary Morin originally trained as a civil engineer and has over 30 years of experience working in the production and support of a range of geographic information and CAD software systems. He is now the Technical Director of Keynetix, which he co-founded in 2000 to specialize in geotechnical data management software. He heads up the geotechnical Building Information Modeling (BIM) development, and is responsible for the design and support services for a range of products designed to manage geotechnical data in the BIM process, including the HoleBASE SI Extension, the Geotechnical Module from Autodesk, Inc., and the advanced HoleBASE SI Extension for AutoCAD Civil 3D software. In recent years Morin has been at the forefront of geotechnical BIM and how it can change working practices to enable a better understanding and integration of geotechnical data into the wider construction process.

The project

McMillen Jacobs Associates (MJA) is the prime consultant and geotechnical lead on the tunneled sections of a combined sewer overflow (CSO) project in Seattle, USA. MJA heads up a team of six sub-consultants working on the scheme.

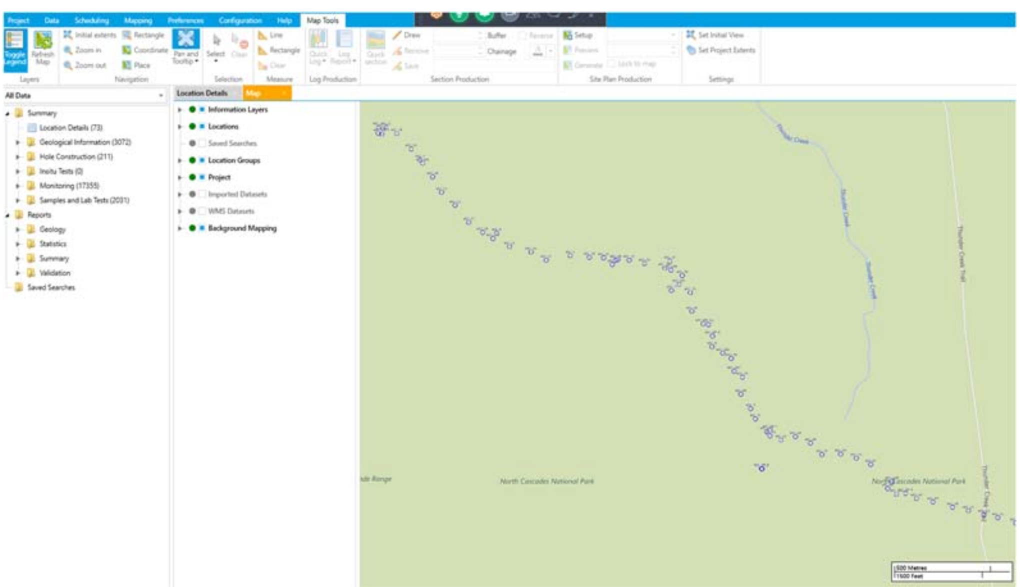
The project comprises a main tunnel for storing stormwater and wastewater during periods of heavy rain, along with shafts, connections to the existing sewer system and a micro-tunnel beneath a navigable canal. A number of diversions and drop structures will be built to carry CSO to the storage tunnel, which will be constructed by a tunnel boring machine.

MJA is responsible for providing geotechnical baseline conditions for the tunnel. This information is being used to develop the geotechnical profile along the alignment and to predict ground and groundwater conditions likely to be encountered during tunnel and shaft construction.

Ground conditions along the tunnel alignment are particularly challenging: highly variable materials, including glacial deposits, aquifers and flowing and running sands. There are numerous underground utilities and the canal to negotiate and there are many stakeholders, as the route passes beneath a densely populated urban area with homes and businesses likely to be affected by construction.

The drivers and needs to change from a legacy system

As would be expected on a major project of this kind, the ground investigation generated large volumes of data: approximately 100 boreholes were sunk along the route and about 17,000 groundwater levels were taken.



EXAMPLE OF BOREHOLE LOCATIONS IN HOLEBASE SI

A key issue for MJA was how to collate this data in a central database and how to quickly interrogate and visualize the results. In particular, MJA wanted to integrate data into AutoCAD Civil 3D and be able to produce reports and other project outputs on common templates with consistent layout and branding.

As part of its drive to improve efficiency and workflow, MJA also wanted to reduce the time that was being wasted importing and exporting data, both to its own systems and to that of the rest of the team. Additionally, it was important that data was inputted accurately as mistakes could be costly.

MJA had been using gINT for several years at the outset of the project started and it soon became clear this legacy system was not going to meet these requirements.

First, data could not be stored centrally in a single enterprise database that allowed collaboration by team members across offices; instead, it was being stored by team members as individual files, on local machines and on different servers (and therefore across offices).

When it came to inputting data, gINT's lack of autofill function slowed data entry. Checking the accuracy of data was also difficult, without a quick way of previewing borehole logs.

Time was also being wasted extracting data. While gINT is powerful, it limited the way data could be accessed by other systems – a key issue for a team made up of different organizations. Exporting profiles (fences) from gINT to AutoCAD was laborious and difficult. There were scaling problems, so different fences were needed (based on the scale of the drawing).

Also, gINT does not have smart functions, so editing the sticks in AutoCAD was difficult (if not impossible), and technicians and engineers needed to expend significant effort to bridge the wide 'interface gap' between the programs. Workflows for updates were painful – any changes had to be double entered into gINT and then re-entered in AutoCAD. This was a time-consuming and laborious.

These issues, plus a lack of significant gINT updates and technical support from Bentley, meant MJA decided it needed a new data management system and turned to Autodesk and Keynetix for a solution. They proposed using HoleBASE SI and its Extension for AutoCAD Civil 3D.

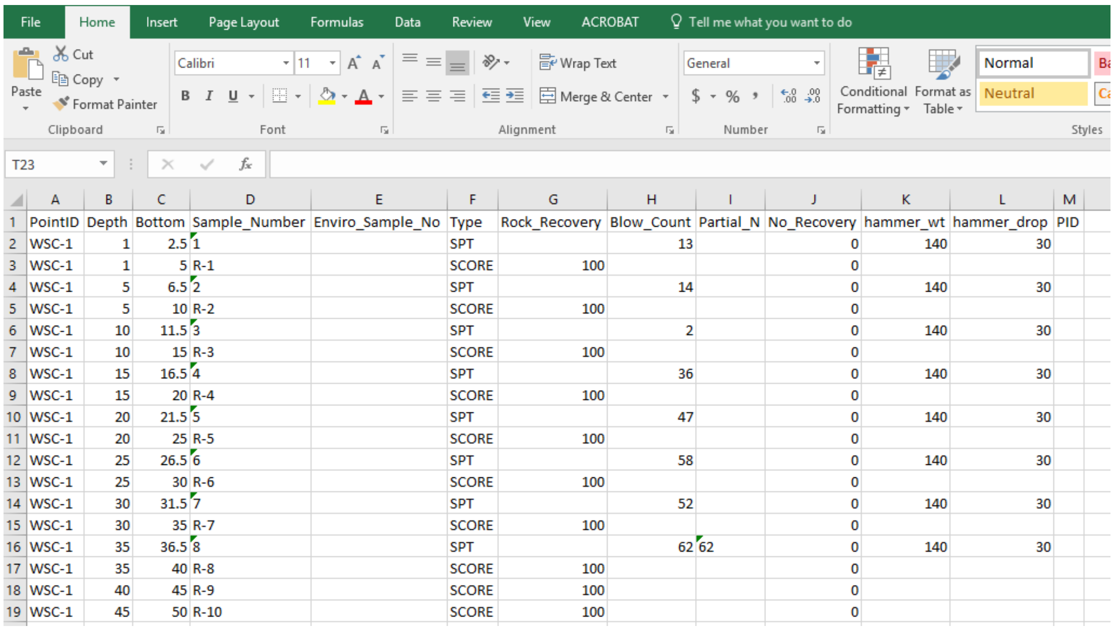
Developing new workflows to incorporate both legacy and new data

HoleBASE SI, like gINT, is a geotechnical data management system, however it has been developed to integrate closely with AutoCAD Civil 3D. It allows users to produce logs, reports, charts and interpretations of data, sometimes within seconds. It can be used to manage geotechnical data throughout the lifetime of a project and gives access to historical information alongside current projects, transforming the way site investigations are archived and managed.

The first step for MJA was to import existing gINT data into HoleBASE SI. Soil and groundwater data from the geotechnical investigations, along with laboratory test data, was supplied by sub-consultants as gINT gpj files.

These gpj files had to be exported into CSV so they could be imported in HoleBASE SI. This can be a lengthy and difficult process, especially with large volumes of data. In 99% of cases, CSV files created with gINT cannot be imported to HoleBASE SI because gINT and HoleBASE SI arrange data differently in Excel and column headers can differ.

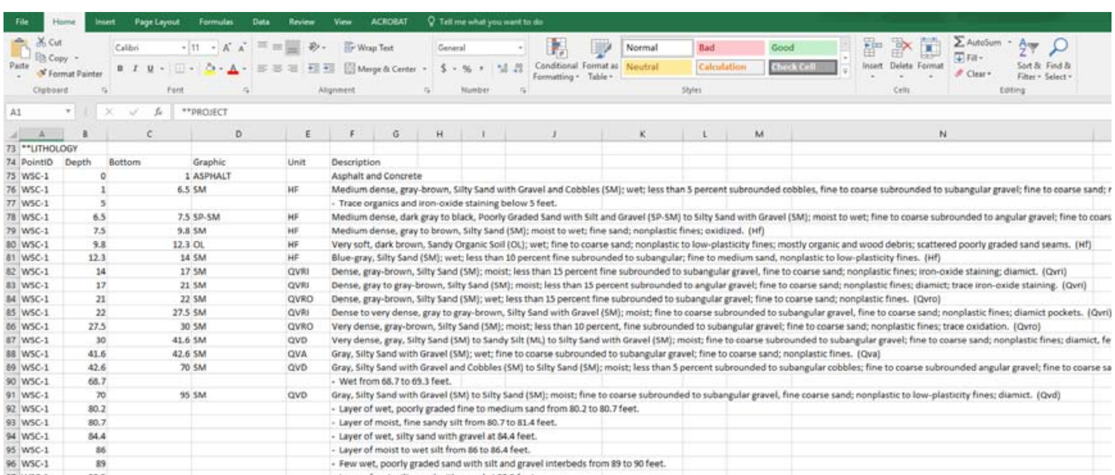
MJA learned the hard way that the best approach was to create CSV files from existing HoleBASE SI projects and use these to create a template. This allowed the team to copy and paste from the gINT CSV file. However, this is not always possible, especially if the only HoleBASE SI project is the one currently being worked on.



	PointID	Depth	Bottom	Sample_Number	Enviro_Sample_No	Type	Rock_Recovery	Blow_Count	Partial_N	No_Recovery	hammer_wt	hammer_drop	PID
2	WSC-1	1	2.5	1		SPT		13		0	140	30	
3	WSC-1	1	5	R-1		SCORE	100			0			
4	WSC-1	5	6.5	2		SPT		14		0	140	30	
5	WSC-1	5	10	R-2		SCORE	100			0			
6	WSC-1	10	11.5	3		SPT		2		0	140	30	
7	WSC-1	10	15	R-3		SCORE	100			0			
8	WSC-1	15	16.5	4		SPT		36		0	140	30	
9	WSC-1	15	20	R-4		SCORE	100			0			
10	WSC-1	20	21.5	5		SPT		47		0	140	30	
11	WSC-1	20	25	R-5		SCORE	100			0			
12	WSC-1	25	26.5	6		SPT		58		0	140	30	
13	WSC-1	25	30	R-6		SCORE	100			0			
14	WSC-1	30	31.5	7		SPT		52		0	140	30	
15	WSC-1	30	35	R-7		SCORE	100			0			
16	WSC-1	35	36.5	8		SPT		62	62	0	140	30	
17	WSC-1	35	40	R-8		SCORE	100			0			
18	WSC-1	40	45	R-9		SCORE	100			0			
19	WSC-1	45	50	R-10		SCORE	100			0			

EXAMPLE OF A CSV EXPORT FROM GINT

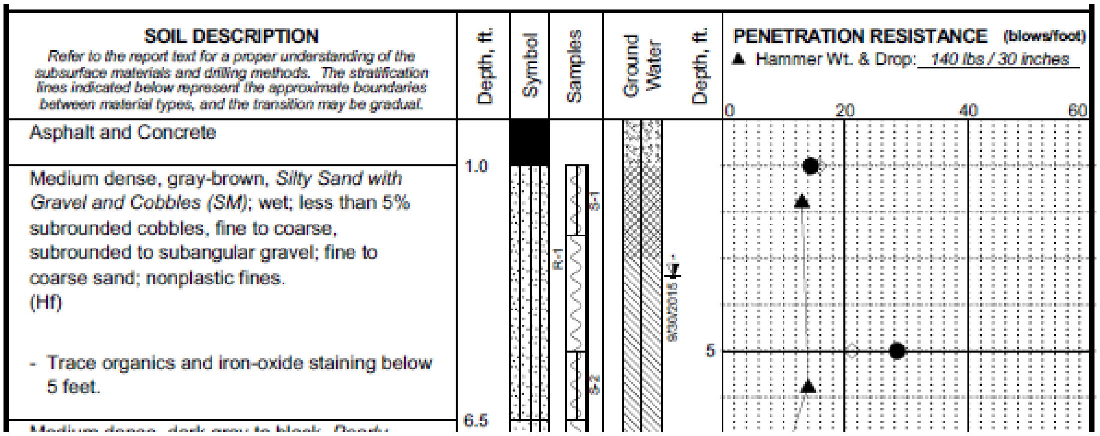
Problem items are Sample Type "SCORE" and Blow Count (no blows for N1, N2 or N3).



73	**LITHOLOGY					
74	PointID	Depth	Bottom	Graphic	Unit	Description
75	WSC-1	0	1	ASPHALT		Asphalt and Concrete
76	WSC-1	1	6.5	SM	HF	Medium dense, gray-brown, Silty Sand with Gravel and Cobbles (SM); wet; less than 5 percent subrounded cobbles, fine to coarse subrounded to subangular gravel; fine to coarse sand; r
77	WSC-1	5				- Trace organics and iron-oxide staining below 5 feet.
78	WSC-1	6.5	7.5	SP-SM	HF	Medium dense, dark gray to black, Poorly Graded Sand with Silt and Gravel (SP-SM) to Silty Sand with Gravel (SM); moist to wet; fine to coarse subrounded to angular gravel; fine to coars
79	WSC-1	7.5	9.8	SM	HF	Medium dense, gray to brown, Silty Sand (SM); moist to wet; fine sand; nonplastic fines; oxidized. (Hf)
80	WSC-1	9.8	12.3	OL	HF	Very soft, dark brown, Sandy Organic Soil (OL); wet; fine to coarse sand; nonplastic to low-plasticity fines; mostly organic and wood debris; scattered poorly graded sand seams. (Hf)
81	WSC-1	12.3	14	SM	HF	Blue-gray, Silty Sand (SM); wet; less than 10 percent fine subrounded to subangular; fine to medium sand, nonplastic to low-plasticity fines. (Hf)
82	WSC-1	14	17	SM	QVRI	Dense, gray-brown, Silty Sand (SM); moist; less than 15 percent fine subrounded to subangular gravel, fine to coarse sand; nonplastic fines; iron-oxide staining; diamict. (Qvri)
83	WSC-1	17	21	SM	QVRI	Dense, gray to gray-brown, Silty Sand (SM); moist; less than 15 percent subrounded to angular gravel; fine to coarse sand; nonplastic fines; diamict; trace iron-oxide staining. (Qvri)
84	WSC-1	21	22	SM	QVRO	Dense, gray-brown, Silty Sand (SM); wet; less than 15 percent fine subrounded to subangular gravel; fine to coarse sand; nonplastic fines. (Qvro)
85	WSC-1	22	27.5	SM	QVRI	Dense to very dense, gray to gray-brown, Silty Sand with Gravel (SM); moist; fine to coarse subrounded to subangular gravel, fine to coarse sand; nonplastic fines; diamict pockets. (Qvri)
86	WSC-1	27.5	30	SM	QVRO	Very dense, gray-brown, Silty Sand (SM); moist; less than 10 percent, fine subrounded to subangular gravel; fine to coarse sand; nonplastic fines; trace oxidation. (Qvro)
87	WSC-1	30	41.6	SM	QVD	Very dense, gray, Silty Sand (SM) to Sandy Silt (ML) to Silty Sand with Gravel (SM); moist; fine to coarse subrounded to subangular gravel; fine to coarse sand; nonplastic fines; diamict, fe
88	WSC-1	41.6	42.6	SM	QVA	Gray, Silty Sand with Gravel (SM); wet; fine to coarse subrounded to subangular gravel; fine to coarse sand; nonplastic fines. (Qva)
89	WSC-1	42.6	70	SM	QVD	Gray, Silty Sand with Gravel and Cobbles (SM) to Silty Sand (SM); moist; less than 5 percent subrounded to subangular cobbles; fine to coarse subrounded angular gravel; fine to coarse sa
90	WSC-1	68.7				- Wet from 68.7 to 69.3 feet.
91	WSC-1	70	95	SM	QVD	Gray, Silty Sand with Gravel (SM) to Silty Sand (SM); moist; fine to coarse subrounded to subangular gravel, fine coarse sand; nonplastic to low-plasticity fines; diamict. (Qvd)
92	WSC-1	80.2				- Layer of wet, poorly graded fine to medium sand from 80.2 to 80.7 feet.
93	WSC-1	80.7				- Layer of moist, fine sandy silt from 80.7 to 81.4 feet.
94	WSC-1	84.4				- Layer of wet, silty sand with gravel at 84.4 feet.
95	WSC-1	86				- Layer of moist to wet silt from 86 to 86.4 feet.
96	WSC-1	89				- Few wet, poorly graded sand with silt and gravel interbeds from 89 to 90 feet.
97	WSC-1	92.5				- Layer of wet, silty sand with gravel at 92.5 feet.

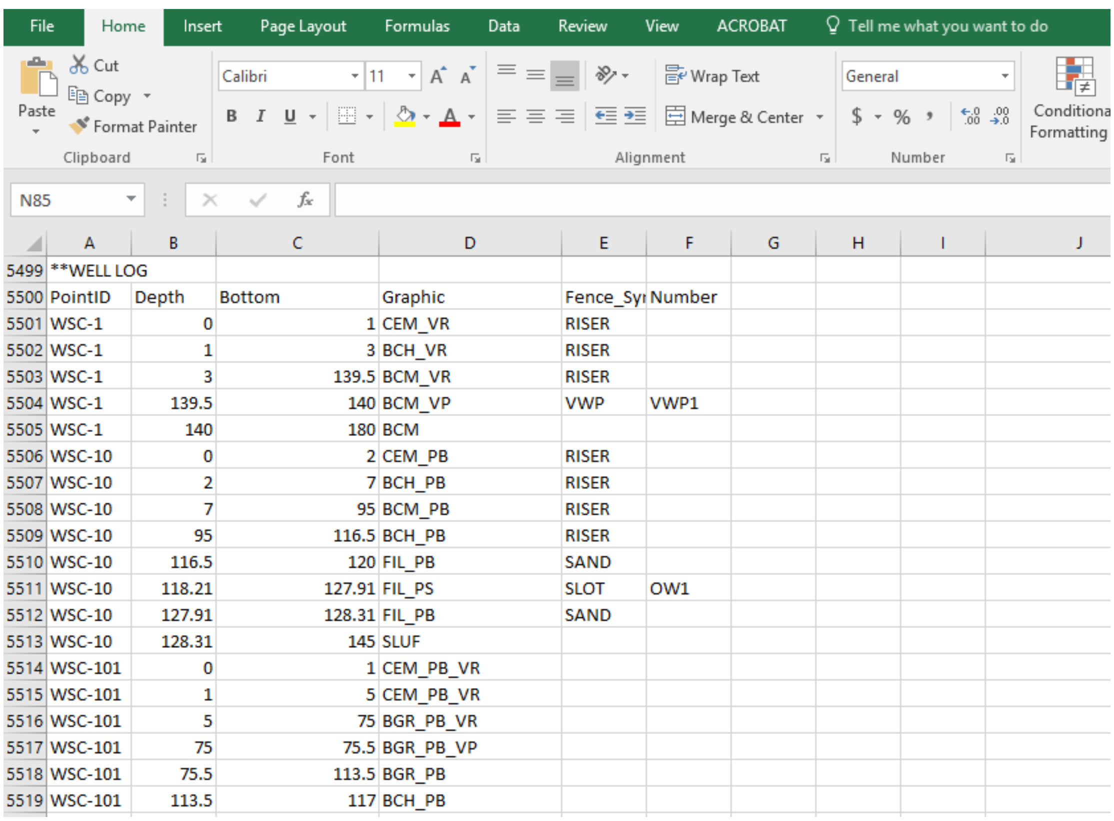
GINT OFTEN INCLUDES IMPORTANT INFORMATION IN FREE FORM TEXT IN DESCRIPTIONS

Another problem MJA ran into was when “depth related comments” appeared in the description column.



INFORMATION HAD TO BE CONVERTED INTO DATA

It is common practice with gINT to type important information in description column as freeform text, as opposed to be stored in the correct location in the database. As part of the input process we had to correct the problem, so that the data could be reused and analyzed.



	A	B	C	D	E	F
5499	**WELL LOG					
5500	PointID	Depth	Bottom	Graphic	Fence_Sy	Number
5501	WSC-1	0	1	CEM_VR	RISER	
5502	WSC-1	1	3	BCH_VR	RISER	
5503	WSC-1	3	139.5	BCM_VR	RISER	
5504	WSC-1	139.5	140	BCM_VP	VWP	VWP1
5505	WSC-1	140	180	BCM		
5506	WSC-10	0	2	CEM_PB	RISER	
5507	WSC-10	2	7	BCH_PB	RISER	
5508	WSC-10	7	95	BCM_PB	RISER	
5509	WSC-10	95	116.5	BCH_PB	RISER	
5510	WSC-10	116.5	120	FIL_PB	SAND	
5511	WSC-10	118.21	127.91	FIL_PS	SLOT	OW1
5512	WSC-10	127.91	128.31	FIL_PB	SAND	
5513	WSC-10	128.31	145	SLUF		
5514	WSC-101	0	1	CEM_PB_VR		
5515	WSC-101	1	5	CEM_PB_VR		
5516	WSC-101	5	75	BGR_PB_VR		
5517	WSC-101	75	75.5	BGR_PB_VP		
5518	WSC-101	75.5	113.5	BGR_PB		
5519	WSC-101	113.5	117	BCH_PB		

GINT WELL LOG GRAPHICS ARE SOMETIMES NOT COMPATIBLE WITH HOLEBASE SI GRAPHICS.

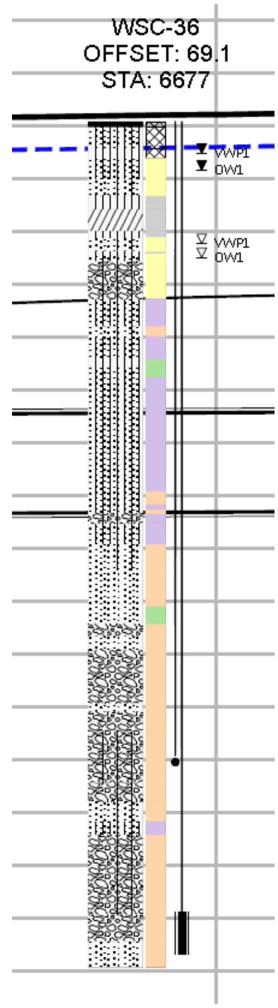
Once the CSV files were working correctly, the import was smooth. The next stage was to create the right templates for MJA’s design submissions. This involved creating borehole sticks or strips that would be displayed on the geotechnical profile along the alignment.

The next hurdle to be overcome was to create strips in Template Studio that would show the data MJA wanted to display in the CAD profile. Although the HoleBASE was sold to MJA with standard templates, the company still had to do some adapting.

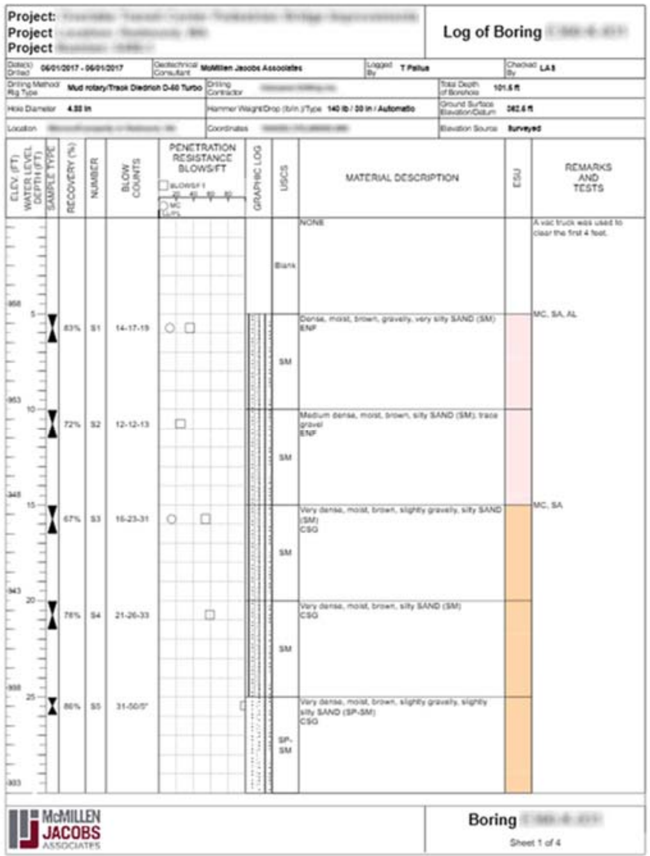
It was important we got this right because of the amount of data (17,000 groundwater readings) that had to be managed and filtered to enable them to be processed and shown (in a reasonable time) in CAD. Without adequate filtering and referencing to the correct columns in HoleBASE SI, the sticks will not show in the CAD profile.

Finally, Keynetix supplied USCS hatch patterns in CAD that matched the ones available in HoleBASE SI and US standards. Additionally, MJA asked Keynetix to help it create color patterns that it uses for engineering soil units (soils or rocks with similar geotechnical parameters and behavior that can be grouped together in order to simplify the geotechnical profile).

The log strip to the right, is created in HoleBASE SI extension for AutoCAD Civil 3D, the hatching, instrumentation and groundwater levels are all automatically plotted based on the data stored in HoleBASE SI.



Although not used in this project, we also created standard borehole log templates, which we could use in future projects, so we could maintain a consistent approach to all our future projects.



STANDARDIZED BOREHOLE LOG TEMPLATES

The process for new data was far smoother. Field data was collected on pLog tablets, and sent directly up to the cloud, which made importing data to HoleBASE SI easier and which removed any need to convert data.

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

The HoleBASE SI Extension for AutoCAD Civil 3D allows quick and easy inclusion of all geotechnical and site investigation data in the BIM process and CAD drawings. Transferring data into AutoCAD from HoleBASE SI can be almost instant: the software allows live data to be accessed directly inside AutoCAD Civil 3D.

The Civil 3D Extension allows the rapid visualization of geotechnical data, providing:

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

- The facility to use standard Autodesk Civil 3D commands to edit and manipulate geological surfaces and styles.

The HoleBASE SI Extension for AutoCAD Civil 3D is the ‘big brother’ system to the Autodesk Geotechnical Module, extending functionality for team working and including downhole parameters in models, sections and site plans.

Faster data management

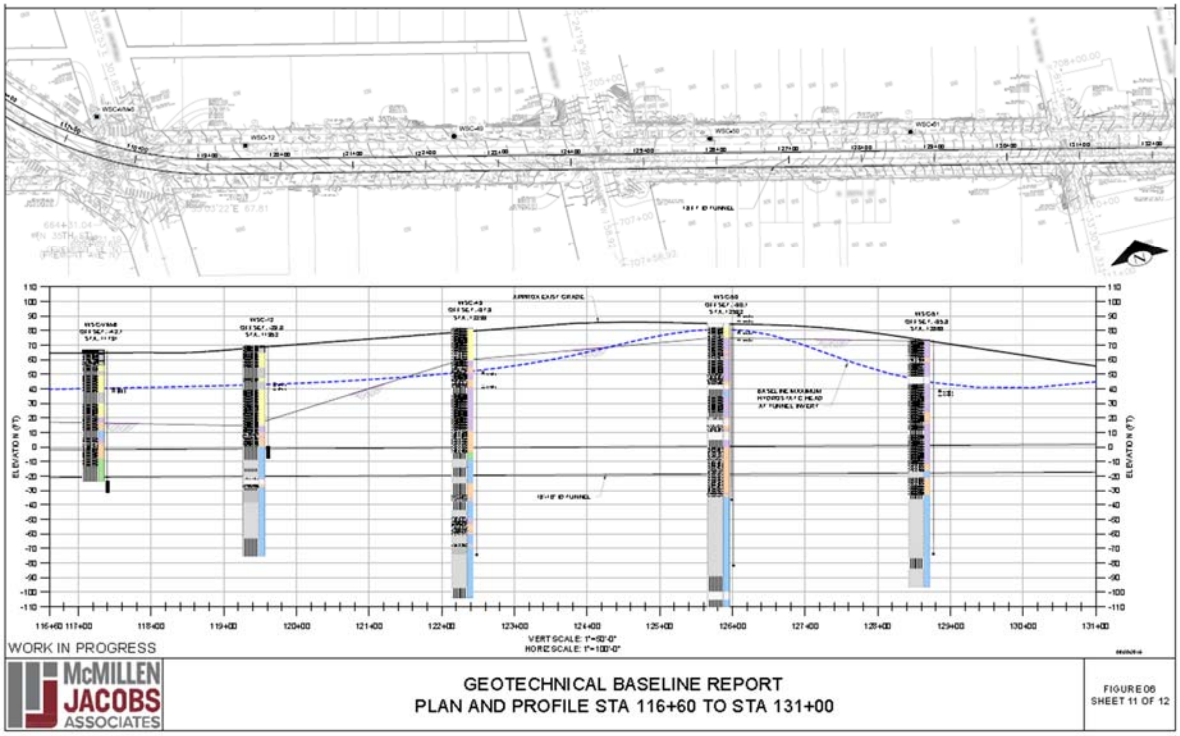
Switching to the new system meant workflows and outputs would be repeatable, allowing the team to quickly access geotechnical data in HoleBASE SI (such as groundwater levels and SPT N values) and to verify it using Quick Logs, which produces borehole log previews. This gave greater opportunity to spot anomalies and identify gaps in the data early on in the process.

The Advanced Description Builder available with HoleBASE SI also allowed MJA to change the soil/rock description column to match the company’s standard format. This meant, data entry could be carried out by anyone, in no particular order, but allowed the soil descriptions to have a consistent format that met the company standards.

STANDARDIZED DESCRIPTION BUILDER

As well as being able to handle large amounts of data, streamlining the workflow enabled MJA to react to any changes to the project – from changes to the alignment to additional borehole and groundwater data – with ease.

Once data was imported, borehole logs and site plans could be drawn in HoleBASE SI or 2D sections and 3D fence diagrams produced in AutoCAD.



SECTION PRODUCED USING HOLEBASE SI EXTENSION FOR AUTOCAD CIVIL 3D

MJA was able to display detailed soil conditions using USGS symbols alongside simplified engineering soil units. This allowed it to simplify complex ground conditions by grouping similar soils into units defined by engineering characteristics.

AutoCAD drawings were exported from AutoCAD Civil 3D and stored in Autodesk Vault, allowing them to be used by the wider team.

Vault and Collaboration for Revit(C4R) address the challenge of working on large projects with a team that spans the globe and uses both AutoCAD, Civil 3D, and Revit.

MJA hosts the Vault server and grants permission through user names and passwords to team members, who can access the files through Vault Client. Collaboration for Revit(C4R) uses BIM360 to store the central model files so all modelers, regardless of physical location, can work in a shared true BIM modeling environment, working on the same central model files, using work groups to protect against simultaneous editing.

Vault not only allows a true shared work space but also manages data shortcuts and the sheet set manager as well. All users have direct and real-time use of the sheet set manager and all its functionality without checking out the sheet set manager file – Vault handles all changes to the sheet set manager in the background.

BIM360, along with managing the central model files for the project, also provides non-modelers access to the current status of construction documents and views of the model, without the need to load special software or having the knowledge of how to use the program.

Allowing engineers to engineer

The new system greatly sped up the data management process and meant geotechnical profiles could be created by technicians, saving time and money. This allowed engineers to focus on understanding geotechnical risks and make better use of their time: understanding ground conditions and behavior, rather than creating profiles and sections.

The benefits and future opportunities geotechnical BIM can deliver

While the benefits of using geotechnical CAD and BIM can be difficult to quantify, they are certainly significant:

- 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.

Deliver value for money through focused site investigation

Site investigations are fundamentally about identifying anomalies in the ground that, if left unidentified, could add considerable cost to a project.

Geotechnical BIM can be a boon during the desk study, presenting an easy way to compile and visualize data from a variety of sources – historic boreholes, site investigation reports, geological survey maps etc. – enabling a better understanding of what is going on, even before a spade (or borehole tool) is put in the ground.

It is important that the desk study is carried out in the context of the project, so incorporating designs and plans (from the overall project BIM, for example) at the desk study stage can ensure that the site investigation is designed with the project clearly in mind.

This means a site investigation is building on (and enhancing) prior knowledge, rather than starting from scratch – it allows sampling, monitoring and testing to be optimized from the outset, offering better value for money in the long run.

React faster on site to investigate potential issues

Nothing beats having a geotechnical engineer on site who can respond to what comes out of the ground during the investigation. Geotechnical BIM can play an important role in helping the engineer, as it enables results to be quickly visualized in context (if, for example, an area of weak, waterlogged ground coincides with a heavy load from a proposed structure), often within 24 hours, if not sooner.

This makes it easier to refine investigations as they proceed. An extra borehole can be sunk, more samples can be taken and instrumentation can be installed, for example, at relatively low cost. If data is only analyzed once fieldwork is over, it can be too late, and too expensive, to investigate further.

Get the complete picture

Geotechnics is like peering at a famous painting through pinholes; each one giving only limited detail. It is how these details are pieced together that counts when building a complete picture of the ground.

Geotechnical BIM offers two benefits in this regard. First, the ability to compile large amounts of data from different sources creates a more comprehensive 3D picture of the ground and second, the ease of drawing cross-sections (in seconds, not hours) allows the model to be viewed from a number of different angles. As a result, geotechnical engineers can gain a better understanding of the ground conditions and are more likely to spot any potential issues.

Alongside increasing the opportunity for identifying anomalies, estimates of material volumes and of contamination, can also be improved. For this project, this led to an environmental remediation program at the site of one of the shafts; a second program is planned at another shaft site.

Communicate with the wider team to improve design and construction

The ability to visualize and share complex geotechnical problems within the design and construction teams can add value to the geotechnical data. On the project, MJA used sections and plans to communicate, however in the future, they would like to also use 3D models to bring the geotechnical report to life, enabling non-geotechnical professionals to relate to, and fully understand, how problems in the ground could affect the project and start to develop and optimize solutions to deal with them.

Improve the client’s understanding of the issues

It is important for clients (and other stakeholders) to understand the significance of any geotechnical problems. It is questionable whether the geotechnical report is the best way of highlighting these.

Geotechnical BIM’s ability to rapidly produce visuals improves the client’s awareness and understanding and should also increase the significance and bearing assigned to the geotechnical aspects of the project.

Geotechnical BIM: delivering better engineering

Clearly, a fully integrated, multidisciplinary BIM, including a ground model, can deliver significant value to both geotechnical engineers and the wider design team.

Geotechnical BIM’s ability to rapidly deliver 2D and 3D visualizations of the ground, from a variety of angles, offers the ability to reduce project risk and costs during construction. Site investigations are more focused and offer better value for money, the understanding of what is going on in the ground is improved and communication of complex problems to non-geotechnical professionals is far easier. It also improves time management and allows engineers to stay focused on technical problems and risks, while CAD designers can spend time on drawings with much less involvement from engineers.

Ultimately, it is an important aid for geotechnical professionals and should increase the value of geotechnical engineering among the project team and in the eyes of the client.