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16. Abstract

The Louisiana Department of Transportation (LADOTD) has been collecting geotechnical data for many years in a variety of different formats. Accessing this data and combining it with new data for the purpose of design, analysis, visualization, and reporting is difficult because the data has been generated by disparate systems and stored as hard copies, scanned images, various digital formats, or other non-digital formats such as Microfilm. Essentially, there is no single system or repository nor an integrated, systematic approach for collecting, managing, reporting, archiving, and retrieving the vast amount of geotechnical data is collected or generated by LADOTD each year.

With advances in computing capabilities, software tools are now available that streamline the entire data management process from data collection through reporting, archiving, and map-based retrieval/reporting. Dataforensics created a plan to integrate and implement a customized data management system to fulfill the needs of LADOTD. This Enterprise Global Information System (GIS)-based Geotechnical Data Management System is comprised of various off -the-shelf software packages including PLog Enterprise, RAPID CPT, gINT, ArcGIS, and ArcGIS Server. It enables LADOTD to store geotechnical data in a consistent database format while improving the reliability and accessibility to key stakeholders.

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LTRC appreciates the dedication of the following Project Review Committee Members in guiding this research study to fruition.

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LTRC Project No. 10-2GT
State Project No. 30000201

conducted for

Louisiana Department of Transportation and Development
Louisiana Transportation Research Center

May 2013

ABSTRACT

The Louisiana Department of Transportation (LADOTD) has been collecting geotechnical data for many years in a variety of different formats. Accessing this data and combining it with new data for the purpose of design, analysis, visualization, and reporting is difficult because the data have been generated by disparate systems and stored as hard copies, scanned images, various digital formats, or other non-digital formats such as microfilm. There is neither a single system or repository nor an integrated, systematic approach for collecting, managing, archiving, and retrieving the vast amount of geotechnical data collected or generated by LADOTD each year.

With advances in computing capabilities, software tools are available that streamline the entire data management process from data collection through reporting, archiving, and map-based retrieval/reporting. Dataforensics created a plan to integrate and implement a customized geotechnical data management system to fulfill the needs of LADOTD. This Enterprise Global Information System (GIS) -based Geotechnical Data Management System is comprised of various off-the-shelf software packages including PLog Enterprise, RAPID CPT, gINT, ArcGIS, and ArcGIS Server. It enables LADOTD to store geotechnical data in a consistent database format while improving the reliability and accessibility to key stakeholders.

The proposed data management system will have significant implications on LADOTD's ability to respond to what might be termed "extreme events." This refers to the engineering consequences of natural events such as hurricanes and man-induced events, such as bridge and other waterfront structure impacts by ships and barges. In many cases, organizations such as LADOTD are required to be able to return the impacted structure to some level of functionality in a very short period or else demolish and rebuild a replacement structure in a "fast-track" mode. Having this GIS-based geotechnical data management system improves their ability to find, utilize, and share the appropriate geotechnical data to meet these challenging project demands.

Finally, as part of this project, historical site investigation data has been loaded into the LADOTD GIS system. This involved significant data cleaning and conversion from its native format (LADOTD gINT projects, raw CPT data files, consultant data files, etc.) into the database structure developed for LADOTD as part of this project. This includes incorporating scanned documents of boreholes, assuming they are geo-referenced.

ACKNOWLEDGEMENTS

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The authors would like to express thanks to all those who provided guidance and assistance on this project. Specifically, the following LTRC and LADOTD staff contributed to the project: Sarah Collins, Ben Fernandez, Kim Garlington, Gavin Gautreau, Hossein Ghara, Clay Gottschalck, Jeff Lambert, Jim Mitchell, Steve Meunier, David Ringuette, Beth Roberts, Ching Tsai, Hollis Ward, Bert Wintz, Pallavi Bhandari and Murad Abu-Farsakh. In particular, the guidance and assistance from Ben Fernandez and Gavin Gautreau were instrumental in the success of this project.

IMPLEMENTATION STATEMENT

The comprehensive Enterprise GIS-based Geotechnical Data Management system will allow LADOTD to collect, manage, and report geotechnical data significantly more efficiently and consistently. This data management system incorporates borehole data, cone penetration test (CPT) data, lab testing data, and pile load test data.

Additionally, the website developed as part of this project will allow LADOTD to locate existing boreholes, CPT data, and pile load test data on a GIS interface while providing the ability to utilize this data in a variety ways even if it was not originally reported in that format. Users can generate reports dynamically based on the dataset selected on the map-based interface. Additionally, having the data stored in a database allows users to create new reports in the future to utilize this data in different formats as project requirements evolve over time.

Users can combine information with other relevant information such as soil survey maps, geologic maps, quadrangle maps, etc. so that appropriate engineering decisions can be made with minimal time spent searching for data in the various locations it resides today.

This data management system helps meet the needs of the Geotechnical Design section by allowing them to automate various reports they manually compile today. Additionally, it builds on the work completed in project 03-1GT by aiding personnel in the Geotechnical Design section to select proper boring depths, pile depths, etc. by providing easy access to historical data near their project sites. Additionally, the comprehensive data that is stored in the database, including borehole, CPT, vane shear, and laboratory testing data combined with pile load test data, have the potential to improve the pile resistance prediction, and may ultimately reduce the cost of foundation construction.

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INTRODUCTION

The traditional process for managing geotechnical data that LADOTD currently utilizes is similar to the approach utilized throughout a large portion of the geotechnical industry. An example of the inefficient, disconnected, and discontinuous nature of this traditional process is shown in Figure 1, where in each task for the project, a subset of the data already input elsewhere in the process is repeatedly input in separate and disconnected systems. In order to ensure adequate data quality, quality assurance/quality control (QA/QC) should be performed for each of the data entry processes performed; otherwise, errors associated with repeated transcription, as well as typographical, spelling, or even calculation errors may also be introduced in the process.

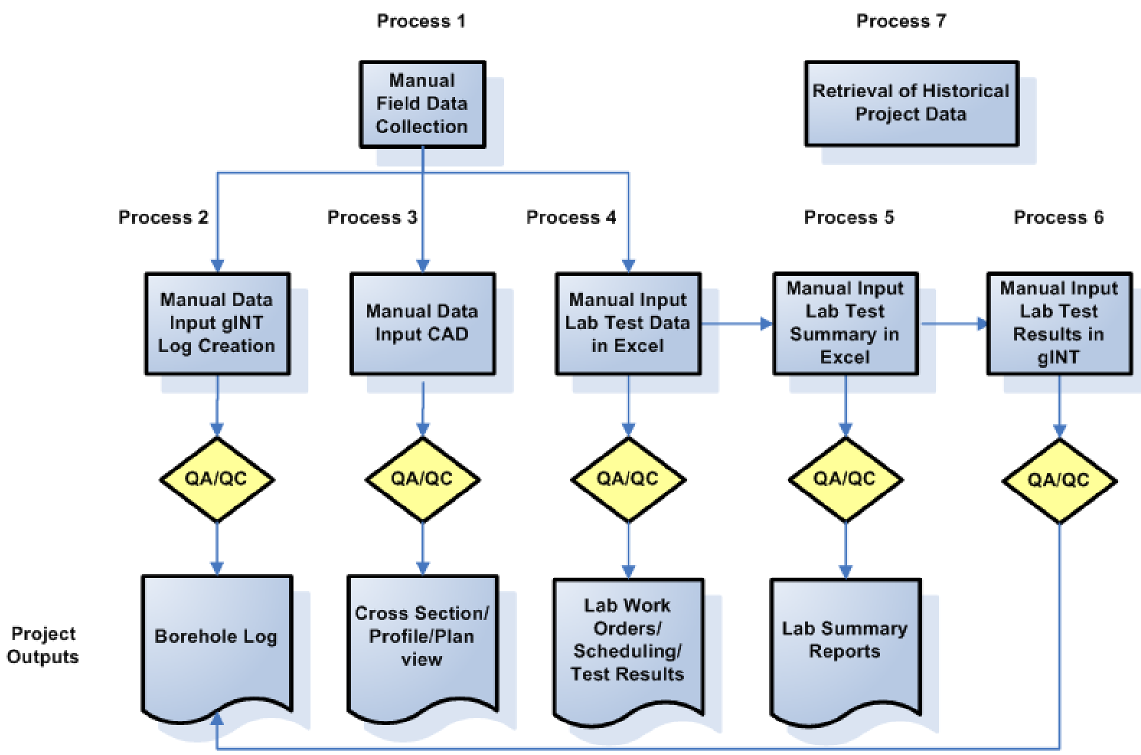

Figure 1
Typical traditional data management process

All of these undesirable inefficiencies and error sources can be overcome by a comprehensive enterprise geotechnical data management system. Within software, a process can be implemented that mimics and facilitates LADOTD business process. This enables significant streamlining of the data management process used on future projects and ensures the long term availability and usability of this data via an Enterprise GIS-based web portal.

With advances in computing capabilities, software tools are available that streamline the entire data management process from data collection through reporting, archiving, and map-based retrieval/reporting. Dataforensics created a plan to integrate and customize a geotechnical data management system to fulfill the needs of LADOTD. This Enterprise GIS-based Geotechnical Data Management System is comprised of various off-the-shelf software packages including PLog Enterprise, RAPID CPT, gINT, ArcGIS, and ArcGIS Server integrated with critical process and workflow components designed and developed as part of this project.

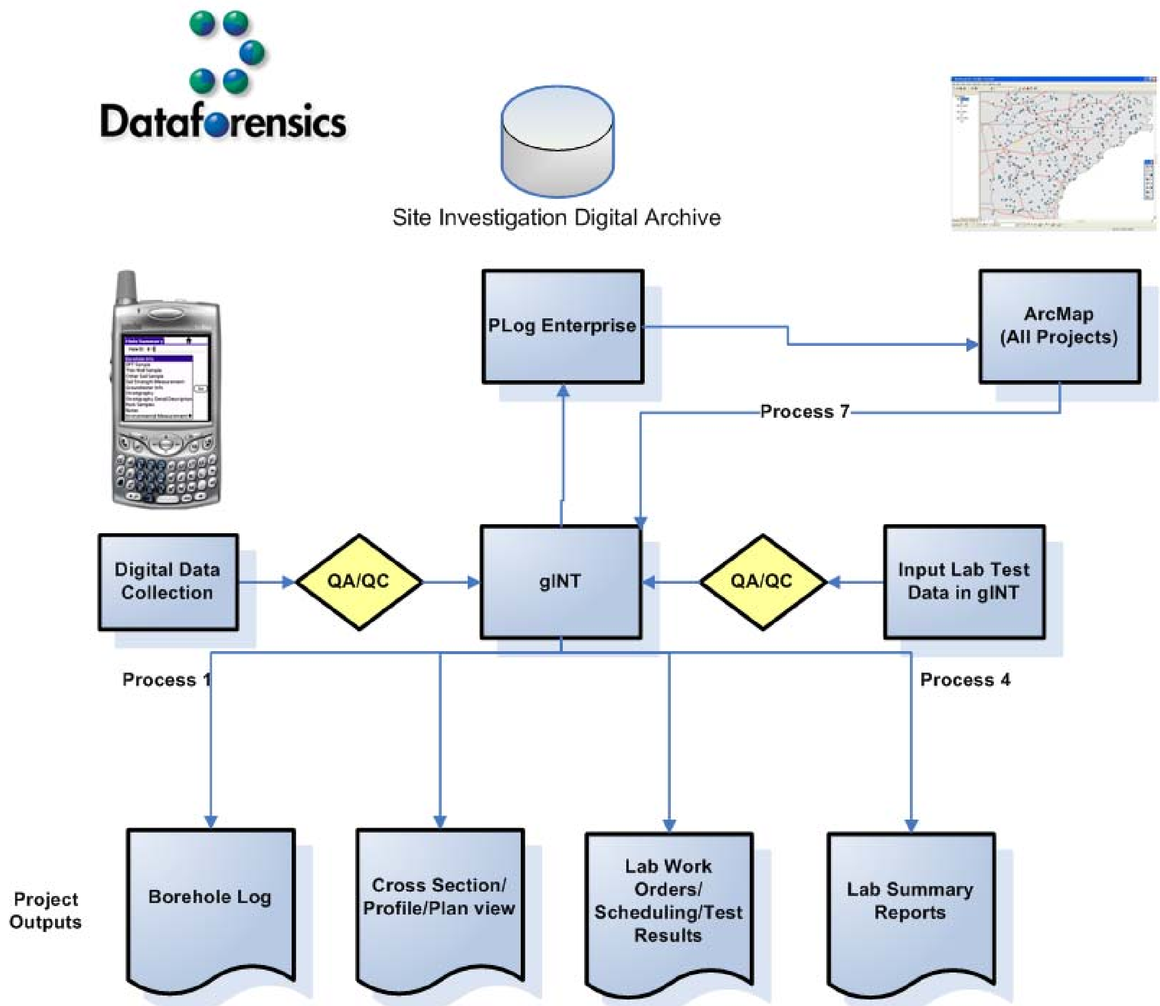

Figure 2
Enterprise GIS-based geotechnical data management system

Figure 2 depicts the data flow within the proposed Enterprise GIS-based Data Management system. Contrasting the data flow for this system with the traditional data management approach shown in Figure 1 highlights numerous achievable efficiencies. Specifically, significant efficiencies result from single source data entry in the field and lab testing data entry in gINT. Furthermore, QA/QC must only be performed once for each data entry point, much of which can be automated via validation rules programmed into the data management system. Finally, having a single integrated system then allows the reports to be generated for all of the various needs without any data duplication. Even if the data is not input in the field digitally, the streamlining is quite significant from that point forward in the system. All of the data can be archived into the PLog Enterprise GIS system, such that it can be re-used and combined with data from future exploration projects.

OBJECTIVE

A typical engineering project is comprised of a number of phases including a review of historical information, a field investigation, a laboratory testing program, office-based analysis and design studies, full-scale test programs of selected components, construction supervision, and post-construction performance monitoring. With the exception of the analysis and design studies phase, all other phases typically result in the generation of information and associated reports, which are used in an integrated fashion to complete the project. Too often, however, these phases are regarded as relatively discrete activities, and this leads to the type of inefficiencies and error sources previously noted. The scope of this project is to allow LADOTD to move to the forefront of research and practice by creating an enterprise GIS-based geotechnical data management system that allows for the integration of historically acquired (likely in non-digital format), recently acquired (likely in digital format), and future acquired data (in digital format) so that not only does the composite database generated for a particular project benefit that project, but it becomes part of a larger knowledge base available for use on other projects being undertaken by LADOTD in the future. In order to realize this goal, Dataforensics identified a scope of work that incorporated tasks and strategies that require expertise in geotechnical engineering, database systems, GIS technologies, process flow, as well as software development and integration.

SCOPE

The scope of the project focused on the creation of comprehensive database structure and reports that facilitate the data management process for geotechnical data including borehole data, CPT data, vane shear data, test pile load test data, and laboratory testing data.

The type of data included in this database structure is limited to:

- Borehole data and laboratory data that is often generated as a result of samples obtained from the borehole.
- Data types for which LADOTD has access to in a nonproprietary, digital format (i.e., CPT data or Test Pile Load Test Data) such that it can be easily imported.
- Data from proprietary data formats such as Geocomp lab testing files and binary data associated with test pile information CAPWAP, WEEP, etc. are not imported into the database as they require the proprietary software to read these files.

Within lab testing, basic laboratory testing of soils including natural moisture/natural density, Atterberg Limits, sieve, hydrometer, specific gravity, Proctor, unconfined compression, and chemical testing are all available in a data format. More advanced strength testing such as consolidation, direct shear, and triaxial have key test results stored in the database but utilize the laboratory testing equipment software for the processing of the data in their proprietary format. The proprietary raw data files for these tests are stored in the database for future usage, as well.

Additionally, data cleansing and data migration tools were developed to clean existing geotechnical data so it can be archived within the PLog Enterprise system. The scope was limited to data compiled in the 03-1GT project including scanned documents for historical boreholes, existing LADOTD gINT projects, gINT projects obtained from consultants, and the LADOTD CPT raw data format. Other older boring logs, pile driving records, load test reports, and other geotechnical data were not archived and would need to be included as a separate project.

A custom web-based workflow management/tracking system was developed to facilitate tracking the status of projects by LADOTD personnel.

Lastly, a customized GIS-based website was created to allow LADOTD personnel to easily visualize and report the data in the geotechnical data management system.

METHODOLOGY

The methodology utilized on this project can be divided into four main tasks with a deliverable associated with each task:

- gINT Database and Report Development
- Workflow Tracking System
- PLog Enterprise Web Portal
- Historical Data Cleansing and Archiving

gINT Database and Report Development

The initial task of the project involved researching the current data management processes and software utilized for processing and storing borehole logs and other geotechnical data within LADOTD. The investigation included interviewing LADOTD personnel using questionnaires and teleconferences, as well as meetings with the PRC committee members; Headquarters Geotechnical Design Group; the Material Laboratory; Information Technology (GIS, Content Manager, etc.); and others. During this process, the types of data to be stored within the system as well as representative examples of the various reporting formats were obtained.

Since streamlining the geotechnical data management process was the primary focus of this study, the next task focused on developing a comprehensive database structure in gINT and PLog Enterprise that encompassed borehole, CPT, vane shear, test pile load test data, and laboratory testing data. Once the database structure was designed, validation rules were added to ensure the quality and reliability of the data was acceptable. A comprehensive description of the validation rules for each table in the database is included in the interim report for the project. Examples of validation rules include:

- Verifying that specific data is input for a particular test or record
- Verifying coordinates are reasonable (i.e., longitude must be negative in Louisiana)
- Verifying a user has the necessary permission to add, edit, or delete a record
- Automating various calculations (N-values, CPT correlations, etc.)
- Verifying samples, layers, and other data types are less than or equal to the depth of the hole

Once the database structure and validation rules were finalized, importers for the LADOTD CPT format and Test Pile Load Test Data were developed to facilitate automatically, loading data types from their native format into the geotechnical data management systems. Additionally, custom correlations for the Zhang & Tumay Fuzzy and Probabilistic Soil Classification system were incorporated into the RAPID CPT software based on research by M. Abu-Farsakh for LTRC/LADOTD *[2]*.

Once data could readily be compiled within gINT, reports were developed based on the requirements determined in the initial task to mimic existing processes whether already in gINT, other software, or manually generated.

Lastly, permission for various groups of users (roles) were assigned in gINT to ensure the reliability of the data and eliminate the potential for data being edited or deleted after it has been reviewed and approved by the appropriate personnel.

Workflow Tracking System

The original intent of this task involved designing and developing a workflow tracking system similar to the one utilized by the Kentucky Transportation Cabinet (KYTC). However, as researchers initiated the design process, it became clear that the tracking system utilized by KYTC was significantly different both in scope and functionality compared with what LADOTD requested.

Accordingly, Dataforensics created a draft design document that was presented to the PRC as part of the interim report including flow charts depicting the business process today and with the proposed system as well as wireframes of the various user interface forms. Feedback was provided at that time and the design was refined further. At that time, specific design details were guided by a member of the PRC, Ben Fernandez, who would be ultimately managing the system. Additionally, the data structure of the ERP system influenced design considerations.

Six weeks after Dataforensics informed LADOTD that the workflow tracking system was available to be reviewed as a beta version with significant functionality above and beyond the KYTC system was added, Dataforensics was informed that a SharePoint site would be a preferred alternative to the workflow system. However, utilizing SharePoint technology had not been indicated to Dataforensics in any of the design phases of the system and would require a substantial amount of effort to modify. Since Dataforensics had already exhausted the budget for the development of the site in its current format, Dataforensics ceased development on the workflow tracking system. Dataforensics believes the system is approximately 90-95% complete and will serve as an excellent design for adapting it to work within SharePoint.

PLog Enterprise Web-Portal

The PLog Enterprise system already contains a PC-based toolbar that runs in ArcGIS (9.2, 9.3 and 10.0) that allows users to visualize their geotechnical data within a simple, map-based user interface. From the map, any report configured in the gINT Database and Report Design task can be generated based on the live data in the PLog Enterprise database. Accordingly, this functionality was duplicated within a web-based environment to facilitate broader access and utilization of the geotechnical data across various LADOTD sections. Essentially, the goal is to make the data in the system accessible via the preconfigured reports developed to facilitate the LADOTD workflow process, but not requiring users to have ArcGIS installed.

Accordingly, a flex-based user interface was developed and combined with a newly developed ASP.NET middleware application that integrates with existing PLog Enterprise functionality. The ASP.NET middleware application and PLog Enterprise are based on .NET framework 4.0. The middleware application utilizes pooling technology to allow multiple simultaneous users to generate gINT reports served in a PDF format directly to the Flex based user interface. A schematic of the system architecture is shown in Figure 3.

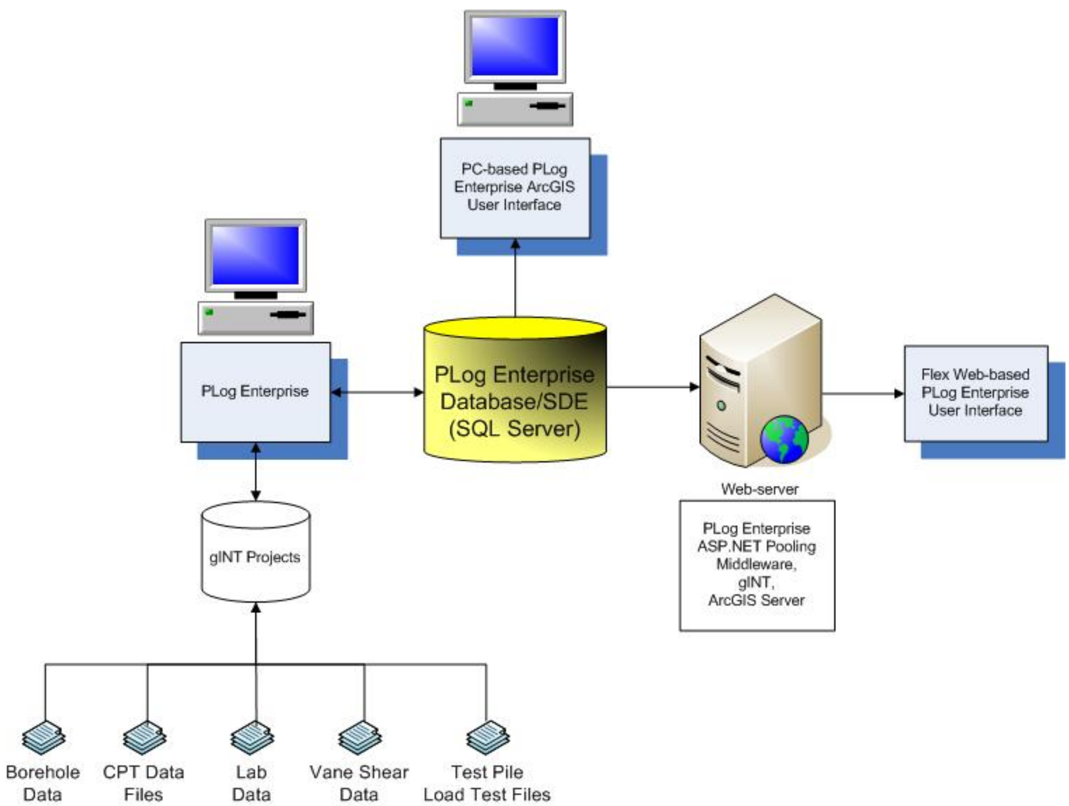

Figure 3
Enterprise GIS-based geotechnical data management system

Historical Data Cleansing/Archiving

A significant amount of effort was required to compile, cleanse, standardize, and archive existing historical data utilized in the 03-1GT project. Data cleansing was the most time consuming of these processes but was key to the future usage of the data. The predominant hurdles that had to be overcome with the various data formats were:

- Raw CPT data files with latitude and longitude in various formats
- Existing borehole data in gINT with latitude and longitude in various formats
- Overloading data fields
- Existing borehole data without coordinates
- Existing CPT data and scanned boreholes without coordinates or with coordinates in another file format
- Categorizing each type of hole
- Incorporating scanned borehole logs into PLog Enterprise
- Nonsensical coordinates
- Conflicts between coordinates determined in project 03-1GT and the current project
- Projects with varying unit systems
- Duplicate Project IDs
- Duplicate data
- Text data that should be numeric

DISCUSSION OF RESULTS

The results of this project can be found in the gINT files provided to LADOTD and will be located on the LADOTD Intranet. A discussion of the results follows.

Raw CPT Data Files Latitude and Longitude

The CPT data files from the 03-1GT project were attempted to be imported into gINT using the LADOTD CPT importer developed as part of this project. It quickly became apparent that the majority of the CPT files could not be imported properly because the latitude and longitude were in a variety of different formats. Accordingly, a VB.NET tool was created to attempt to convert and log the various formats for the latitude and longitude. In this process, six regular expressions were developed for deciphering the latitude and longitude that comprised approximately 18 various formats. The latitude and longitude were predominantly in either a degrees-minutes-seconds format or a decimal-degrees format. However, it is easy to imagine the combinations that can occur: spaces may not exist between each component (degrees, minutes, seconds), the minutes (‘) or seconds (“) symbol may not exist at the end of each component, the “N” or “W” indication in the string may not exist, and/or a “-” may not exist in front of the longitude.

Existing Borehole Data in gINT Latitude and Longitude

The gINT data files compiled as part of this project were significantly more consistent than the raw CPT data files. Only two regular expressions were developed to parse the latitude and longitude into a consistent format, one for decimal degrees and one for degrees, minutes, and seconds.

Overloading Data Fields

The existing gINT data files compiled as part of this project contained multiple data types within the same field [ex. standard penetration test (SPT)_or_ undrained unconsolidated (UU) field in the sample table]. This is a violation of the normal forms of database design because it makes it much more difficult to work with the data. One type of data was the format was the undrained strength and confining pressure for the UU test. It was indicated as 5.933@16.5 where 5.933 is the strength in tons per square foot (tsf) and 16.5 is the confining stress in pounds per square inch (psi). In the same field, there were also blow counts and N-values stored. To determine if it was an N-value, it is stored as N=*value*. To determine if it was three separate blow counts, it was indicated as 1-2-3, where each number is the blow count for a particular interval.

To clean this data, Gavin Gautreau enlisted a student worker to replace all N-values with the individual blow counts in the same format (i.e., 1-2-3). Then, the data was migrated from the old database structure to the new database structure developed as part of this project. During this process, UU data was transferred into its own table with fields for "Confining Pressure" and "Undrained Strength," while the blow counts were separated into three different fields with a fourth field that automatically calculates the N-value.

Existing Borehole Data without Coordinates

The existing borehole gINT data files in some instances lacked coordinates in the gINT file. If boreholes were missing coordinates, Dataforensics requested the coordinates of the holes from LADOTD personnel and added them to the gINT files as latitude/longitude in decimal degrees format. All existing borehole data had coordinates and thus were categorized as "Legacy Boreholes" to allow for differentiation of this Hole Type on the GIS map.

Existing CPT Data without Coordinates

The existing CPT data files in some instances lacked coordinates in the raw data file. In these scenarios, the GIS layers developed as part of 03-1GT were utilized if the coordinates were present there. These CPT soundings were classified as a Hole Type of "CPT." Alternatively, if no coordinates were identified in the GIS coverage, the Excel spreadsheets compiled as part of the 06-6GT project were utilized for identifying the location of the soundings. If no location was known from the spreadsheets, the average location of all known CPT soundings was determined for a project and each sounding with an unknown location was assigned this latitude and longitude. In these scenarios, Hole Type was indicated as "CPT – Est. Location" so that users of the GIS application would see different symbology for these holes and understand that the location is approximate.

Scanned Boreholes without Coordinates

The scanned borehole data in some instances lacked coordinates in the scanned document. In these scenarios, the GIS layers developed as part of 03-1GT were utilized if the coordinates were present there. These boreholes were given a Hole Type of "Scanned Borehole". Alternatively, if no coordinates were identified in the GIS coverage, the Excel spreadsheets compiled as part of the 06-6GT project were utilized for identifying the location of the borehole. If no location was known from the spreadsheets, the average location of all known boreholes was determined for a project and each sounding with an unknown location was assigned this latitude and longitude. In these scenarios, Hole Type was indicated as “Scanned Borehole – Est. Location” so GIS users would see different symbology for these holes and understand that the location is approximate.

Categorizing Each Type of Hole

As indicated in the previous two sections, different hole types were identified depending on the source of the data and the reliability of the location. Other categories were included in the gINT configuration, such as Borehole and Test Pile. Borehole will be utilized by LADOTD as new data is input in the gINT format. Test Pile will be utilized by LADOTD as new test pile load test data is imported into the system. Dataforensics recommends making the “Hole Type” field required in order to ensure differentiation of the points on the GIS map in the future.

Incorporating Scanned Borehole Images

In order to make the scanned borehole logs accessible in the PLog Enterprise system, the scanned boreholes must be added into a gINT project. The process requires adding a new record for each borehole in the Point table and inputting critical metadata such as PointID, HoleDepth, Latitude, Longitude, Hole Type (Scanned Borehole or Scanned Borehole – Est. Location) and inputting the file path for the scanned image in the associated file in the Point table.

Nonsensical Coordinates

For some projects, the latitude and longitude provided in the scanned boreholes were incorrect coordinates (meaning they were incorrectly printed on the scanned log report). Dataforensics identified these coordinates as nonsensical because they contained either minutes or seconds that were greater than 60. In these scenarios, LADOTD employees were utilized to identify the correct coordinates, which were then loaded into the system.

Conflicts between Coordinates Determined in 03-1GT Project and Current Project

For some projects, the latitude and longitude indicated in the ArcGIS layer differed from what Dataforensics identified as coordinates from the CPT data files or other sources. In these scenarios, Dataforensics deferred to coordinates from the 03-1GT project.

Projects with Varying Units

For some of the projects with scanned boreholes, the scanned images were in metric units; thus, the station, hole depth, and elevation values input into the system were converted to English units to be consistent with all the other data. There were no projects in gINT that were provided in metric, so the correspondence file written to convert historical data from the previous LADOTD gINT database format to the database format created as part of this project only supports English units.

Duplicate Project IDs

Several projects could not be imported into the database, because there were already projects with the same identifier and boreholes with the same identifier in the database. The duplicate project IDs were limited to three projects where the Design Number was indicated as "General Engineering." For each of these projects, the Design Number value was changed to the name of the project, e.g., LA 488 Slope Failure, LA 8 Slope Failure, and US 84 Slide.

Duplicate Hole IDs

Several projects that contained duplicate Hole ID's for a Project ID had already been loaded into the PLog Enterprise system. The source of this problem seemed to be in the compilation of data from one of the previous projects; the previous researchers allowed a CPT sounding to be referenced in multiple folders/Excel files. As Dataforensics developed gINT projects, a new project was created based on the name of the folder and then the raw CPT data from the text file was imported. This resulted in the same CPT file being loaded into multiple gINT projects because the same raw data files were present in multiple folders. Table 1 below indicates the folders where duplicate data for specific Project ID and Hole ID combinations resulted.

Table 1
Duplicate CPT data file locations

Project ID	Hole ID	Original Folder Name	Duplicate Folder Name(s)
455-05-62	BT3	DIST 08\RAPIDES\455-05-62\DEE0562	DIST 08\RAPIDES\455-05-62\DEE0562\RAMPD2 DIST 08\RAPIDES\455-05-62\DEE0562\RAMPD9 DIST 08\RAPIDES\455-05-62\DEE0562\RAMPD9T
700-23-0200	CPT1	DIST 03\IBERIA\700-23-0200	DIST 03\IBERIA\700-23-0200\LOREAUVILLE
700-23-0200	CPT2	DIST 03\IBERIA\700-23-0200	DIST 03\IBERIA\700-23-0200\LOREAUVILLE
005-07-0057	1	DIST 02\LAFOURCHE\700-29-0120\005-07-00	DIST 02\ST. CHARLES\005-07-0057
005-07-0057	CPT1	DIST 02\LAFOURCHE\700-29-0120\005-07-00	DIST 02\ST. CHARLES\005-07-0057
005-07-0057	CPT2	DIST 02\LAFOURCHE\700-29-0120\005-07-00	DIST 02\ST. CHARLES\005-07-0057
362-01-0009	B1	DIST 08\NATCHITOCHES\362-01-0009	DIST 08\NATCHITOCHES\362-01-0009\BAYOU NID AIGLE
362-01-0009	B2	DIST 08\NATCHITOCHES\362-01-0009	DIST 08\NATCHITOCHES\362-01-0009\RAT BOIS BAYOU

Project 424-07-21 provided a different set of challenges that expanded on the challenges identified in the previous paragraph. There were 26 CPT soundings in the project, half of which were missing coordinates and the other half already archived in PLog Enterprise. This is a result of the problem identified above, compounded by the fact that the raw data files for the CPT soundings were renamed either in one of the previous projects that compiled the data or when the data was generated. Refer to Table 2, which indicates the duplication of the data. Note that all values are identical, except the Hole ID with the one exception of the total depth for Hole IDs 105+53/CP1. It is Dataforensics assertion that it is very difficult if not impossible to push duplicate soundings at exactly the same start date/time (to a precision of seconds) and to the same total depth to a precision of 0.01 ft. Therefore, the soundings on the right half of the table were removed.

Table 2
Duplicate CPTs from project 424-07-21

Hole ID	Total Depth	Start Date	Hole ID	Total Depth	Start Date
105+53	144.03	11/8/1995 8:13	CP1	144.01	11/8/1995 8:13
113+89	155.31	11/8/1995 10:29	CP2	155.31	11/8/1995 10:29
120+66	154.81	11/7/1995 10:15	CP3	154.81	11/7/1995 10:15
121+42	124.91	11/7/1995 11:21	CP4	124.91	11/7/1995 11:21
122+18	125.31	11/7/1995 0:20	CP5	125.31	11/7/1995 0:20
122+95	127.31	11/7/1995 13:24	CP6	127.31	11/7/1995 13:24
123+71	144.61	11/7/1995 14:30	CP7	144.61	11/7/1995 14:30
124+47	113.51	11/7/1995 15:41	CP8	113.51	11/7/1995 15:41
125+23	135.31	11/7/1995 9:12	CP9	135.31	11/7/1995 9:12
125+98	117.71	11/7/1995 8:05	CP10	117.71	11/7/1995 8:05
126+75	123.81	11/6/1995 16:33	CP11	123.81	11/6/1995 16:33
127+51	118.11	11/6/1995 15:28	CP12	118.11	11/6/1995 15:28
113+90	95.01	11/7/1995 16:46	TESTC2	95.01	11/7/1995 16:46

Text Data that Should be Numeric

In the process of converting data from the old structure to the new structure, there were several instances where various values for elevation or hours after drilling were indicated as the combination of a number and some string describing it (i.e., approximately 0 or 18 hrs). These were manually cleaned as the problems were discovered.

Once all the data was cleaned and converted to a consistent format, it was then loaded into the PLog Enterprise system. A total of 1645 distinct locations were archived in the system. This can be subdivided into the specific Hole Types categorized herein, as shown in Table 3. Note that for the Scanned Boreholes and Scanned Boreholes with Estimated Locations, the exact number of locations is known for those that appear on the map, but in some cases the scanned images contained multiple boreholes, which were not all geo-referenced, therefore more borings may exist than the counted number on the map.

Table 3
Hole types archived in PLog enterprise

Hole Type	Number of Holes
Scanned Boreholes	153*
Scanned Boreholes with Estimated Location	35*
Legacy gINT Boreholes	297
CPT Soundings	1080
CPT Soundings with Estimate Location	11
Boreholes in new gINT Format	69

Process for Archiving Historical Data

During this project, a significant amount of data was archived into the PLog Enterprise system. The process for loading historical data depends on the format of the data. The formats of data that were archived are:

- CPT data files
- LADOTD gINT projects
- Ardaman gINT Projects
- Scanned PDF logs

A description of the process to load the aforementioned files into gINT is described below, followed by a description of archiving the data in PLog Enterprise.

CPT Data Files

CPT Data files can be imported into gINT using RAPID CPT directly.

- Choose the appropriate importer from the Add-ins menu.
- Select the correspondence file (ladot rapid cpt.gci).
- Select the file(s) to import.

Once the data is in gINT, ensure the coordinate system is defined in the Project tab as well as the Hole Type and coordinates in the Point table. Add any other metadata about the Project/Points and then proceed to archiving it in PLog Enterprise.

LADOTD gINT Projects

Dataforensics has written a correspondence file that converts the previous LADOTD gINT project database structure to the new database structure that is more comprehensive. The process to convert the data is:

- Create a gINT project based on the new LADOTD gINT files.
- From the file menu->Import/Export->Import from database.
- Choose the legacy gINT project as the source database.
- Choose the correspondence file (ladot legacy to ladot 2012.gci).
- Click ok.

Once the data is in gINT, ensure the coordinate system is defined in the Project tab as well as the Hole Type and coordinates in the Point table. Add any other metadata about the Project/Points and then proceed to archiving it in PLog Enterprise.

Ardaman gINT Projects

Dataforensics has written a correspondence file that converts the Ardaman gINT project database structure to the new LADOTD database structure. The process to convert the data is:

- Create a gINT project based on the new LADOTD gINT files.
- From the file menu->Import/Export->Import from database,
- Choose the Ardaman gINT project as the source database.
- Choose the correspondence file (ardaman to ladot 2012.gci).
- Click ok.

Once the data is in gINT, ensure the coordinate system is defined in the Project tab as well as the Hole Type and coordinates in the Point table. Add any other metadata about the Project/Points and then proceed to archiving it in PLog Enterprise.

Scanned PDF Logs

The new LADOTD gINT database structure incorporates the capability to include a document associated with each Point (Borehole). The process to load this data into gINT is as follows:

- Create a gINT project based on the new LADOTD gINT files.
- Input the Project Information.
- Input a record in the Borehole table for each separate point location (borehole, CPT, vane shear, etc.). Specify the coordinates for each point and in the Associated File field, specify the filename of the PDF that contains the scanned document.

The coordinate system must be defined in the Project tab, as well as the Hole Type and coordinates in the Point table. Add any other metadata about the point as necessary and then proceed to archiving it in PLog Enterprise.

Archiving Data in PLog Enterprise

Once the data has been loaded into gINT in the LADOTD format, it can then be archived into PLog Enterprise, which automatically makes the data available to anyone utilizing the PLog Enterprise system whether via the web application or ArcGIS. To archive the data in PLog Enterprise, refer to section IV in the PLog Enterprise User’s Manual.

CONCLUSIONS

This project developed a comprehensive geotechnical data management system that will allow LADOTD to streamline their data management process for borehole, lab testing, CPT, in-situ vane, and test pile load test data while providing long-term availability of the data via a web-based GIS portal. By standardizing the database structure, and incorporating validation rules and custom reports LADOTD personnel in various sections can more easily access and report their geotechnical data while simultaneously improving the quality and reliability of the data.

Dataforensics provided a single system for managing all active project data and enabling it to be easily archived into the PLog Enterprise GIS based data management system accessible via a customized web-based GIS, which will allow the Geotechnical Design section access boring logs and other geotechnical documents via the Intranet. The GIS interface can access many different sources and types of data both within and outside the Department. The quick and easy access to valuable data, including the mapping applications in the GIS, will streamline and facilitate the analysis of data.

This project builds upon the work completed in project 03-1GT to create a reference resource that will continue to grow over time that will aid in the evaluation of specific geotechnical site data, which will allow for more accurate and cost effective design decisions. Additionally, this project archived data compiled in the 03-1GT project and the 06-6GT project as the first data loaded into the system. If LADOTD were to try and re-create this same data by re-investigating the same sites, the cost would be at least $16,000,000 ($10000 per borehole/CPT sounding). Accordingly, the return on investment for this task is extraordinary as approximately $20,000 was expended to turn $16,000,000 worth of data into a usable asset.

Various meetings and demonstrations of the system have been given to various members of the PRC. The technology utilized in the system described herein uses off-the-shelf software products PLog Enterprise, RAPID CPT, gINT, ArcServer, Flex and ASP.Net technology. The website is located on the Intranet and is ready to serve the Geotechnical Design section and others in the Department.

RECOMMENDATIONS

Website and Server Maintenance

Website and Server Maintenance: Perpetual licenses were included with research, meaning LADOTD can use the software indefinitely. Maintenance and periodic updates should be applied to the software in order to ensure proper function with an optimal performance. This will require combined efforts and ongoing support of both the GIS Team at LADOTD and Dataforensics. One year of support for RAPID CPT and PLog Enterprise is included in the current contract.

Personnel and Access

It is recommended that a Geotechnical Design section employee be designated to manage the PLog Enterprise system (i.e., upload the gINT projects whether developed by consultants or in-house) so that records are kept timely and accurate in digital format.

The website will be located on the LADOTD Intranet. A goal for a follow-up project should be to open the website to the public. Additional efforts regarding firewalls will need to be implemented for this to occur.

Site/Materials Manager

The incorporation of data from the Site/Materials Manager is unknown at this time. Dataforensics believes that incorporating borehole and lab test data from shallow boreholes into the PLog Enterprise system should be accomplished in order to maximize the value of the LADOTD database. The data types for the basic laboratory testing have been implemented already within the database structure, but reporting capabilities in gINT likely need to be enhanced and tailored to LADOTD's specific requirements. This was outside the scope of this project since it was focused on deep boreholes.

Loading Additional Historical Data

LADOTD now has a platform on which a tremendous amount of historical data can be loaded into the system quite easily. The difficulty involved with loading historical data is obtaining/finding the historical data and/or converting it into the standard format. For historical data that consists of scanned images, there is no conversion necessary. For this type of historical data, it simply requires creating a gINT project and filling in the appropriate project and borehole metadata to identify the project/hole and associating the scanned image with the point(s). A student worker could perform this task with minimal guidance from Dataforensics.

Dataforensics recommends a follow-up project where the budget can be explicitly allocated to pay a consultant to compile the gINT projects and provide to Dataforensics for the work they have performed for the LADOTD in the last few years. This would then provide datasets that can be cleansed and converted into the new LADOTD format.

Workflow Application

Dataforensics recommends a follow-on project to complete the workflow application using SharePoint functionality since it is an internally supported platform that is now available and suitable to manage the workflow related data and documents.

Future Modules

All current and future data should be recorded and stored digitally within PLog Enterprise so that as the data grows, it can be accessed easily via the map-based GIS interface. Enhancements to the system such as incorporating additional data types (i.e. extracting binary data from CAPWAP, WEEP, or the GeoComp systems) could prove to be useful from a data mining perspective over the long term.

Additionally, LADOTD may consider adding spatial and non-spatial data mining algorithms into the system to automatically search for and identify trends in the data that are not obvious until they are specifically examined. Data mining allows users to gain a better understanding of their data by discovering new patterns in their large datasets. PLog Enterprise provides the foundation for this to occur.

ACRONYMS, ABBREVIATIONS, AND SYMBOLS

CPT	Cone Penetration Test
GIS	Geographic Information System
KYTC	Kentucky Transportation Cabinet
LADOTD	Louisiana Department of Transportation and Development
LTRC	Louisiana Transportation Research Center
QA/QC	Quality Assurance/Quality Control
SPT	Standard Penetration Test
UU	Unconsolidated Undrained Triaxial Test

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2. Abu-Farsakh, M., Zhang, Z., and Tumay, M., “Development of MS-Windows CPT Soil Classification Software,” 87th Transportation Research Board (TRB), TRB 2008 Annual Meeting CD-ROM, 2008.

3. Zhang, Z., and Tumay, M., “Statistical to Fuzzy Approach Toward CPT Classification.” *Journal of Geotechnical Engineering*, Vol. 125, No 3, 1999.

4. Alshibli, K., Okeil, A., Alramahi, B., “Update of Correlations between Cone Penetration and Boring Log Data,” LTRC Report 439, FHWA/LA.08/439, 2008.

PLog Enterprise

Enterprise Geotechnical Data Management System

User's Manual

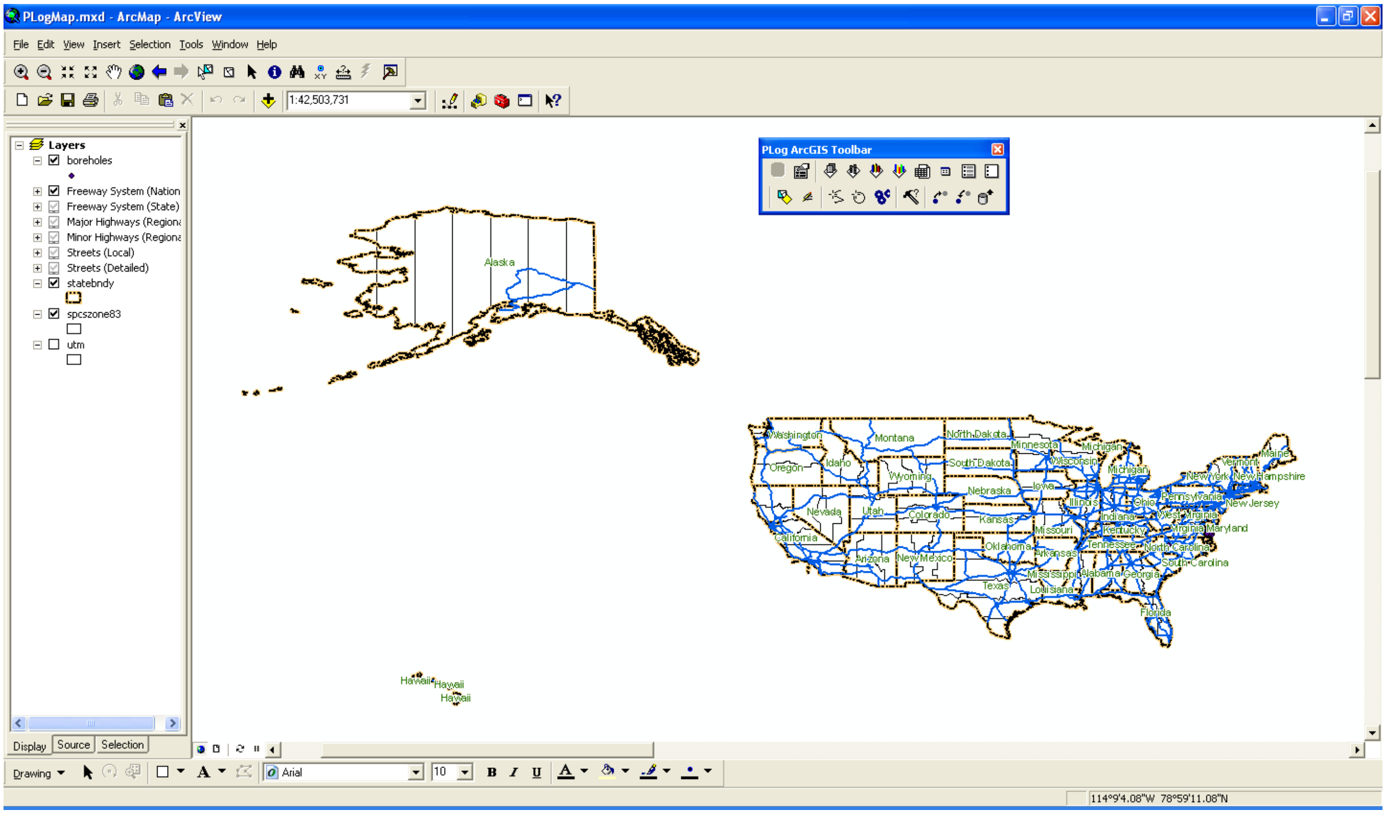


Table of Contents

I. PLog Enterprise Overview

The PLog Enterprise Edition has all the capabilities of the standard edition plus many other features that allow you to get more out of your data. The PLog Enterprise Edition uses an enterprise database (Microsoft SQL Server or Oracle) instead of a Microsoft Access Database as with the PLog standard edition. The SQL Server/Oracle database allows more users to simultaneously use the system, has more data storage capacity, and is scalable (i.e. the database can grow nearly without limit over time by adding new hardware).

Additionally, the PLog Enterprise Edition allows you to archive data from gINT projects into a single database. Instead of having tens or hundreds or thousands of individual gINT projects, all data can be archived into a single database for querying, data mining, and reporting. The PLog Enterprise Edition requires a consistent database structure in order to archive the data.

For a project, once all soil borings, dilatometer test soundings, cone penetration test soundings, test pits, wells, inclinometers, and lab testing have been finalized in gINT, simply archive the data using the PLog Enterprise PC module. All boreholes must have coordinates in order to archive the data, in order to allow the points to be plotted with the GIS application, a key element to the enterprise system. During this process the PLog Enterprise will convert the coordinates (if necessary) from a regional coordinate system such as State Plane, UTM, etc to a global coordinate system, such that all boreholes can be mapped in a single, consistent coordinate system simultaneously. The PLog Enterprise Edition uses WGS 84 with Latitude and Longitude for mapping purposes; however the coordinates you have input for your boreholes are not modified in any way.

Not only can you archive the data, the PLog Enterprise Edition allows you to retrieve data from the Enterprise database as well via a GIS (geographic information system) interface. Using ArcGIS 9.2 or 9.3, you can view all boreholes archived in your database and select specific boreholes on the map to generate any gINT report. Simply choose the boreholes you want report and select the appropriate reporting tool in the GIS.

There are several other capabilities in the PLog Enterprise Edition that help you mine your data. Examples include buffering a project site to determine all boreholes within a specified distance of the site; buffering a linear alignment such as a road, dam, or levee to find all boreholes within a specified distance of the alignment; and a query tool that allows you to generate very complicated queries using a graphical user interface. Additionally, queries can be written in SQL for more advanced and complicated queries.

Queries may be written to facilitate business analyses such as to determine drilling quantities on a weekly or monthly basis, by drill rig, or however you may want to view the data. Other queries may be for engineering purposes. For example, if you are interested in liquefiable soils, you may want to query all SPT data in the upper 15 feet where the blow counts are less than 8 and the soil type is sand or silty sand.

II. PLog Enterprise Roles

Prior to archiving any data, your database administrator (DBA) must add logins for each user in SQL Server Enterprise Manager in SQL Server 2000 or the SQL Server Management Studio in SQL Server 2005 or in Oracle's Management Studio. Database administration is not covered within this manual other than basic guidance that relates to the operation of PLog Enterprise.

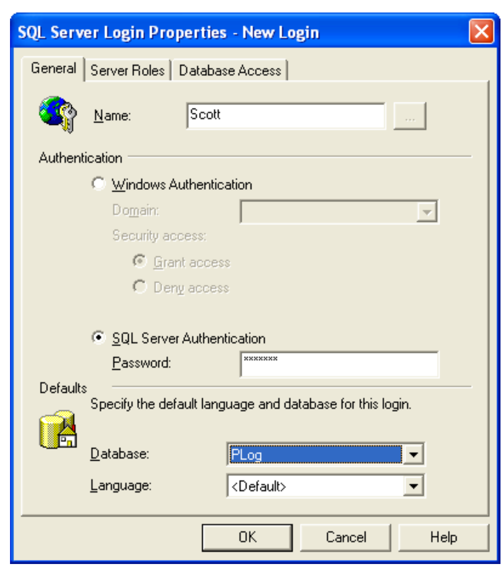
Logins are added under the security tab in the SQL Server Enterprise Manager. For each login, they should be granted access to the PLog and Site Investigation Archive databases. Additionally, logins must be defined as a specific role: Dataforensics Admin, Dataforensics Power User or Dataforensics Standard User. The role determines the capabilities available to a user within PLog Enterprise.

Features available to each role:

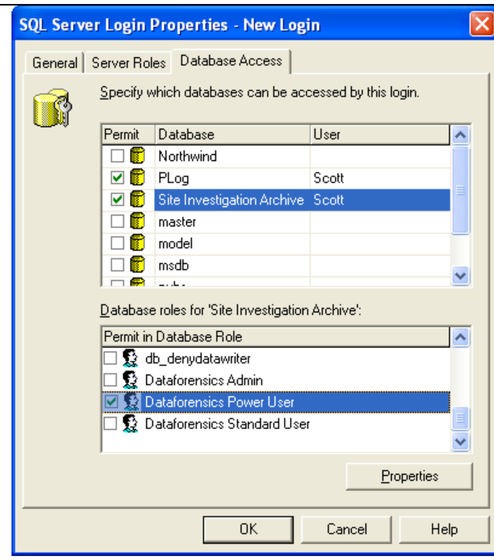
- A **Dataforensics Standard User** can only retrieve data and execute queries.
- A **Dataforensics Power User** can archive and retrieve data as well as save and execute queries.
- A **Dataforensics Admin User** has all the capabilities of the power user and they can upsize the database, define the primary key, and perform the configuration. In the long term, the Admin users will be allowed to re-archive data and also re-upsize the database to add new tables and fields.

Adding a Login for PLog in SQL Server

- Within Enterprise Manager select the Security tab.
- Right click the Logins group and select New Login.
- Fill in the username.
- Select SQL Server Authentication and add a password.
- Select the Database as PLog.



- Click the Database Access tab.
- Check the Permit Checkbox in the PLog and Site Investigation databases.
- Check the appropriate role in the Permit in Database Role list. This should be a Dataforensics Admin, Dataforensics Power User or Dataforensics Standard User.



III. PLog Enterprise Initialization

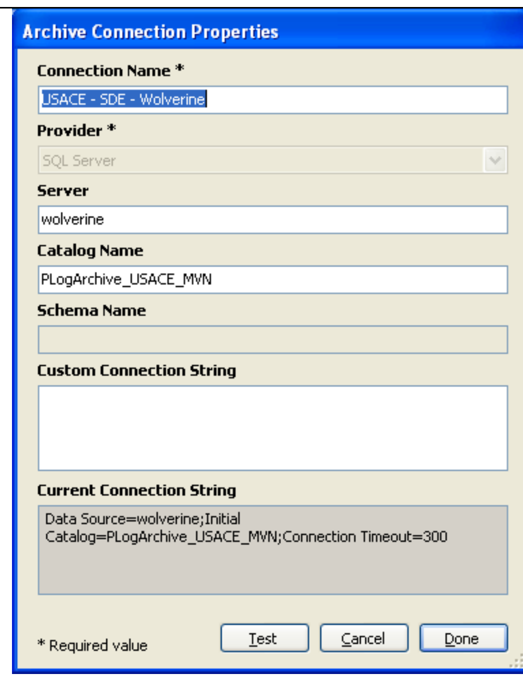
After defining the roles, your DBA may need to perform some basic initialization in order for the archiving process and PLog GIS Toolbar to operate correctly. To begin the initialization process, start the PLog Enterprise Application from the Start menu on your PC. If you setup the connections properly during the installation for the PLog and PLogArchive databases, there shouldn't be a need to modify the connections, but you may want to test each connection. The connections information is stored in the Connections.xml file.

Modifying Connection to Database Server

For large enterprise deployments, it is recommended that this file be stored in a shared location on a server (where the Library.mdb file is located possibly). If you need to change the connection properties, follow the steps below.

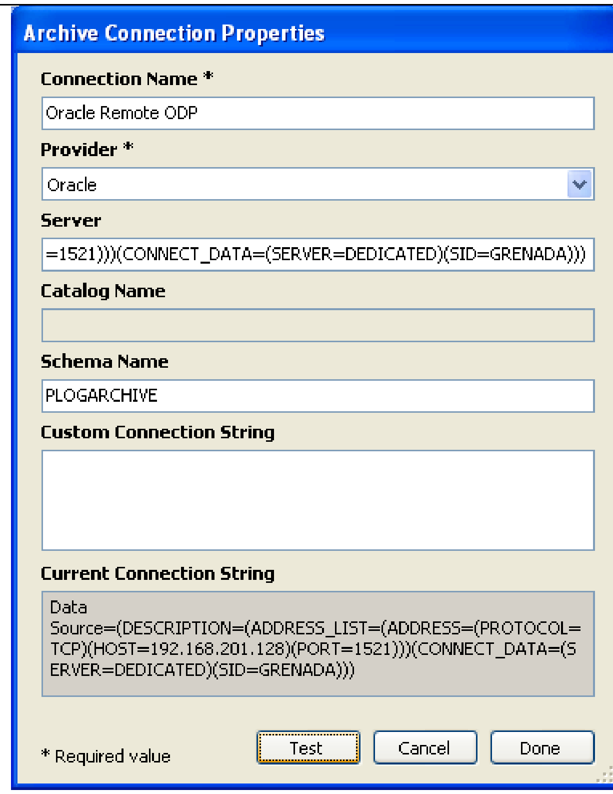
SQL Server Connection Properties

- The screenshot shown to the right indicates how to setup the connection properties for a SQL Server database.
- The server is the name of the SQL Server Database Instance. This is shown at the top of the SQL Management Studio.
- The Catalog Name is the name of the database.
- For testing purposes the first time you create the connection string, add the user id and password prior to clicking the test button. Delete this after verifying the connection the user ID and password after verifying the connection.



Oracle Connection Properties

- The Oracle connection properties are shown to the right. We recommend using the following as your Server. This eliminates the need for TNS or other configuration on each client machine.
- (DESCRIPTION=(ADDRESS_LIST=(ADDRESS=(PROTOCOL=TCP)(HOST=XXX.XXX.XXX.XXX)(PORT=1521)))(CONNECT_DATA=(SERVER=DEDICATED)(SID=YYYYYYYY)))
- XXX.XXX.XXX.XXX (above) is the IP address of the server and YYYYYYYY (above) is the SID of the database server.

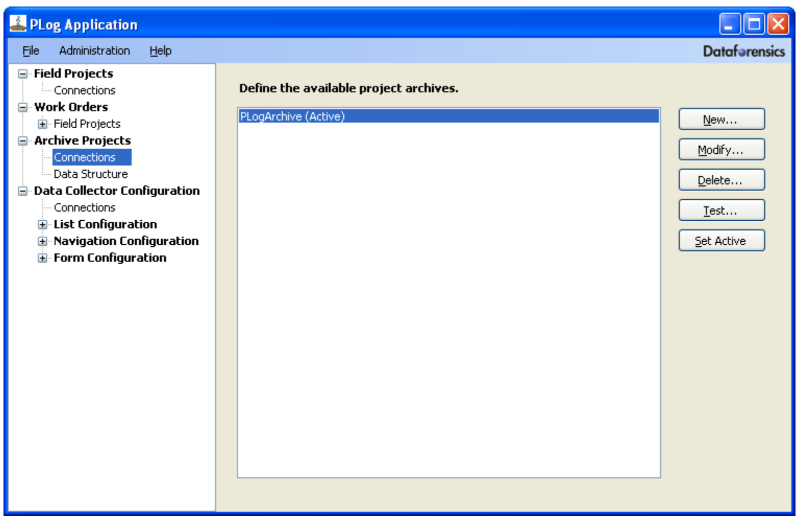


Data Structure

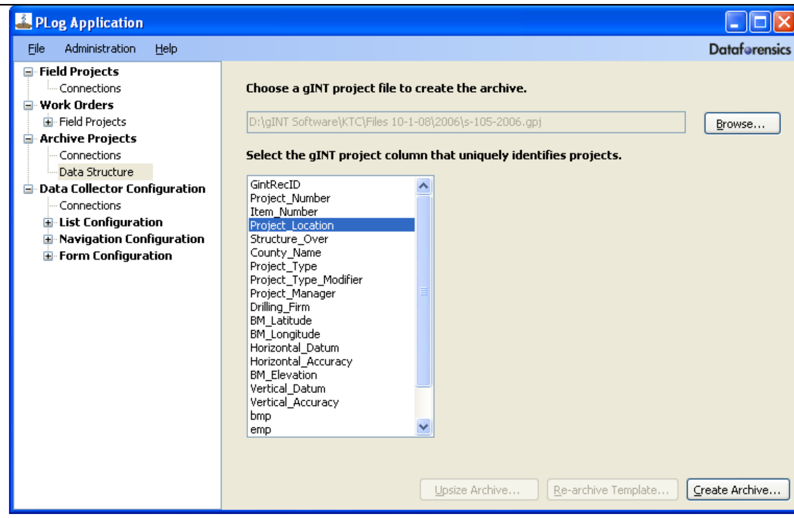
The PLog Enterprise system uses the gINT database structure for your organization as the basis for the database structure within PLog Enterprise. You must first load this structure prior to using PLog Enterprise. The following directions instruct you how to load the data structure.

Before loading the data structure, you must be sure your database has the required minimum to work in PLog Enterprise. Your database must have:

- A column in the project table that uniquely identifies one project from another
- A field in the project table used to define the coordinate system
- If you use projected and unprojected coordinate systems, the database must have fields for geographic and projected coordinates for locating your boreholes, (i.e. fields in your database for Latitude and Longitude (geographic) as well as North and East (projected)).
- If you want to plot different hole types using different symbols on the GIS map you must have a Hole Type field

• At this time, you should now see 4 nodes in the tree – Field Projects, Work Orders, Archive Projects and Data Collector Configuration. • Select the Archive Projects and you should see Connections and Data Structure. • Select the connections node and verify you are using the desired database connection.	

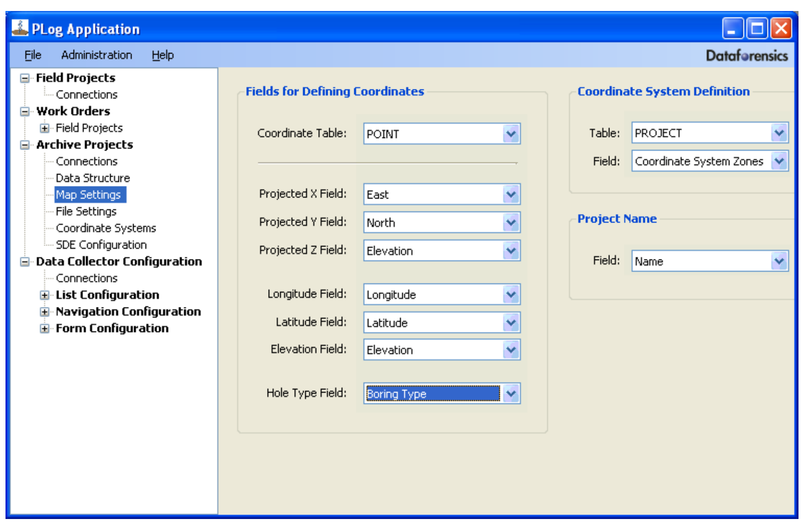
- Select the Data Structure node.
- Choose the gINT project file to use as the basis of the database structure.
- Select the column in the project table that uniquely identifies one project from another.
- Click the Create Archive button. If any errors occur, click View Log on the progress dialog.



Map Settings

In order for PLog Enterprise to map your boreholes in a consistent coordinate system, PLog Enterprise must be able to determine the fields used for your coordinates. PLog Enterprise supports using both projected and unprojected (geographic) coordinates. Projected coordinate systems include UTM and State Plane whereas geographic coordinates are Latitude and Longitude. If you use both geographic and projected coordinates for locating your boreholes, you should have fields in your database for Latitude and Longitude (geographic) as well as North and East (projected). The Configuration Dialog allows you to define the fields used in identifying the coordinate system as well as the fields used for the coordinates.

- Specify the fields in the Point table used for defining the projected and geographic coordinates.
- Specify the field in the Project table used to define the coordinate system.

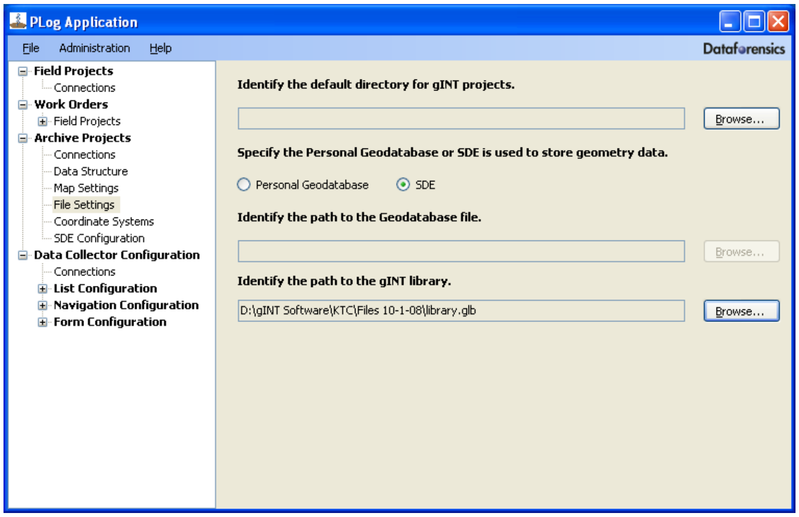


Note: There must be a field in the project table used to define the coordinate system.

Note: If you want to plot different hole types using different symbols on the GIS map you must specify the Hole Type field.

File Settings

In order for PLog Enterprise to map your boreholes in a consistent coordinate system, PLog Enterprise must be able to determine the fields used for your coordinates. PLog Enterprise supports using both projected and unprojected (geographic) coordinates. Projected coordinate systems include UTM and State Plane whereas geographic coordinates are Latitude and Longitude. If you use both geographic and projected coordinates for locating your boreholes, you should have fields in your database for Latitude and Longitude (geographic) as well as North and East (project). The Configuration Dialog allows you to define the fields used in identifying the coordinate system as well as the fields used for the coordinates.

• Specify the default directory where gINT projects are stored on your network. This simplifies accessing the files during archiving. • If you are using SDE (Spatial Database Engine) in ArcGIS select the SDE radio button. • If you are using a personal geodatabase in ArcGIS, select personal geodatabase radio button and then browse to the Boreholedatabase.mdb file.	 Note: The boreholedatabase.mdb file is the personal geodatabase used by ArcGIS for mapping the points. It **must** be located on the server in a shared folder and have been installed previously during the PLog Server installation.

Coordinate Systems and Aliases

You should create a library table in your gINT library that defines the coordinate systems as well as a coordinate systems field in the gINT project such that whenever a user is creating a project in gINT, they select the coordinate system from a standard list of valid coordinate systems that can be mapped in the GIS.

In order for PLog Enterprise to recognize the coordinate systems, this list of coordinate systems must be mapped to the projection and transformation (if necessary) from ArcGIS. Dataforensics provides a mapping of 871 coordinate systems within the PLog Enterprise Edition. This mapping is an Excel file called Complete Coordinate Systems.xls. All that must be done is provide an alias for the appropriate coordinate systems you are using in the Complete Coordinate Systems.xls.

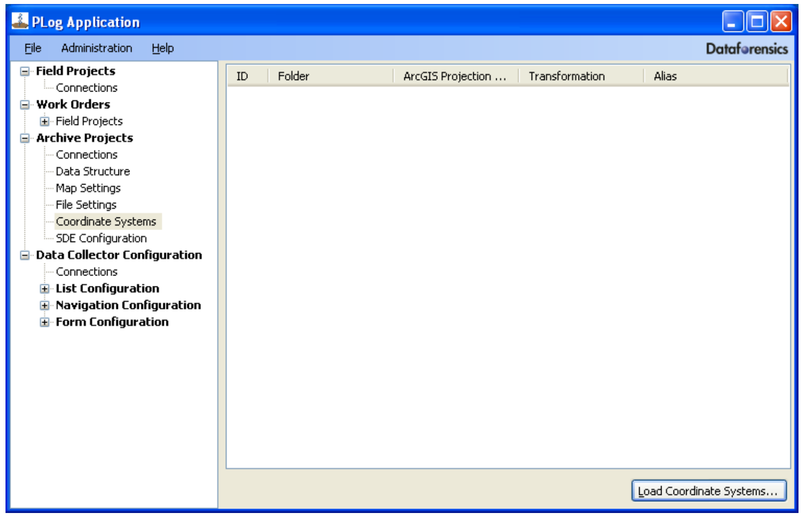
For example, if you are using the Alabama State Plane East Zone in units of feet, you must open the Excel spreadsheet and define this as the alias. In the Excel spreadsheet, you must find the NAD 1983 StatePlane Alabama East FIPS 0101 (Feet) in the ArcGIS Projection Name column. Then copy 'Alabama State Plane East Zone' (or whatever value you have defined in your library table) into the Alias Column.

Repeat this procedure for each coordinate system you need to use. Once you have finished creating the aliases you are ready to load the coordinate systems. Save the Excel file as a tab delimited text file.

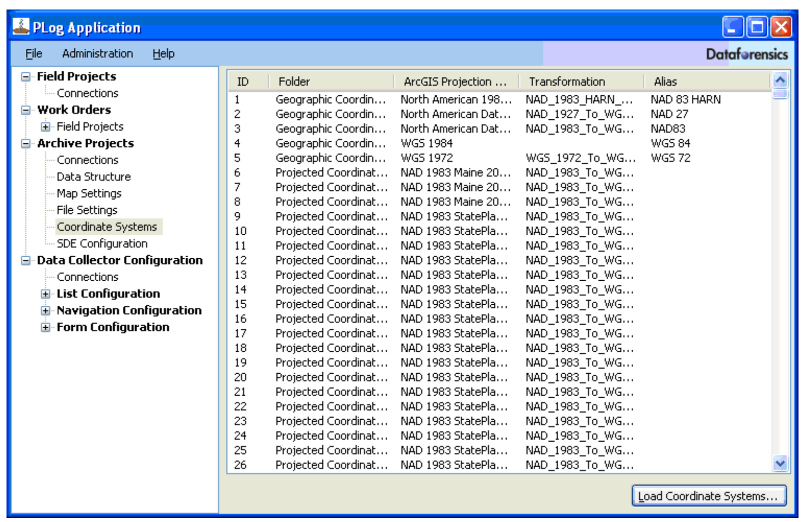
Note: The alias you saved in the Excel file should match the coordinate system name you have added to your coordinate system table in gINT.

Below are the directions for loading the Complete Coordinate Systems.xls once you have mapped your aliases to appropriate coordinate system names.

- Click the Load Coordinate Systems button and select the tab delimited text file.



- Once the coordinate systems have been imported, you should see them in the panel as indicated here.



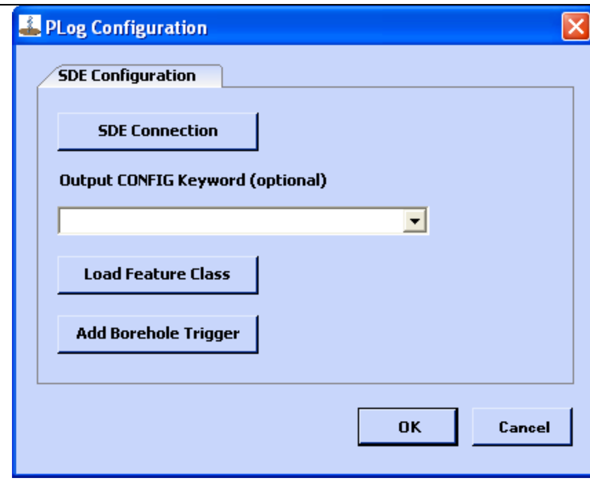
SDE Configuration

Clicking on the SDE Configuration node allows you to determine if your configuration is complete.

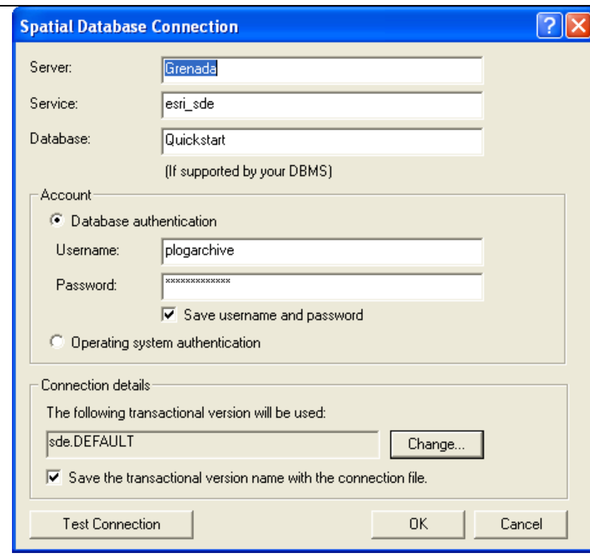
If you are using a personal geodatabase, the configuration is complete.

If you are using SDE, you need to complete the configuration using the PLog ArcGIS toolbar or manually configure the SDE Connection file and Load the Feature Class into the database using ArcCatalog. The directions below detail how to complete the configuration using the PLog Toolbar.

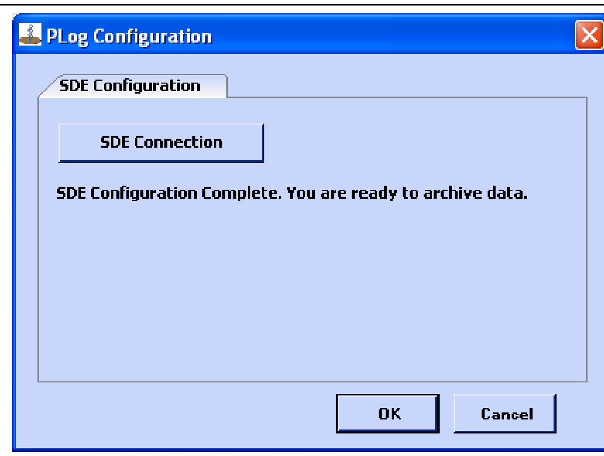
- Start ArcMap.
- If the PLog ArcGIS toolbar has not loaded, refer to Section IV.
- On the PLog ArcGIS toolbar, login using an Administrator role based login.
- Click the Configuration button in the PLog ArcGIS toolbar



- This dialog is the same dialog you get when creating a SDE database connection in ArcCatalog.
- Fill in the values for your SDE connection.
- Select Test Connection to verify the connection succeeds.



- Once you have defined the connection, click the Load Feature Class button and specify any SDE CONFIG keyword.
- Browse to the Boreholedatabase.mdb file located in the shared folder installed previously during the PLog Server installation. Select the file to load the feature class.
- Lastly, select the Add Borehole Trigger to ensure deleting and updating gets cascaded properly from the Point table to the Borehole Feature Class and vice



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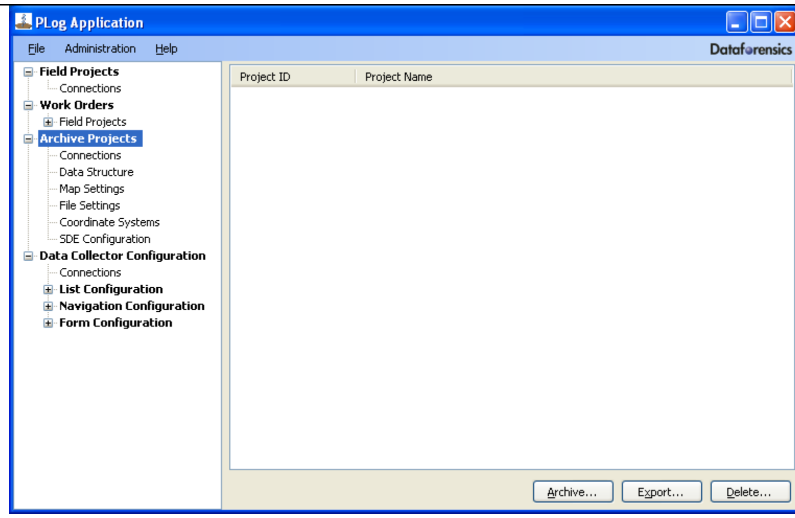
versa. • Once you have loaded the feature class into the Enterprise database, you should see that SDE Configuration is complete.	

IV. Archiving Data

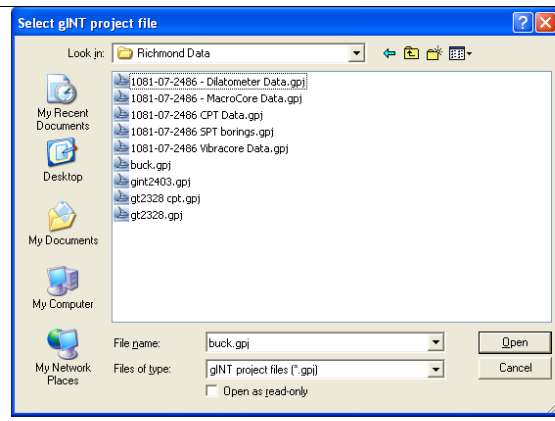
Once you have completed the PLog Enterprise Initialization, you are ready to begin archiving data.

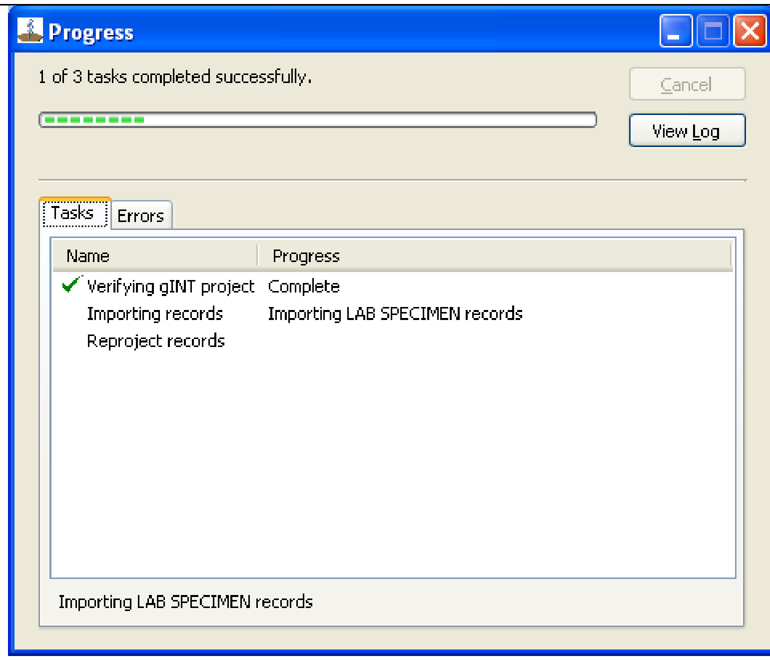
- Click the Archive Projects node in the PLog Enterprise Application.
- Click the Archive button.



- Choose the one or more gINT Projects to archive. Click Open.

Warning: For projects with large amounts of data, such as CPT data, the archiving process can take several minutes.



• If there are any problems during the archiving process, they will be indicated in X in the task panel and you can view the errors in the Errors panel as well as reviewing the error log by clicking View log. • If you have any questions about the error messages contact Dataforensics support.	

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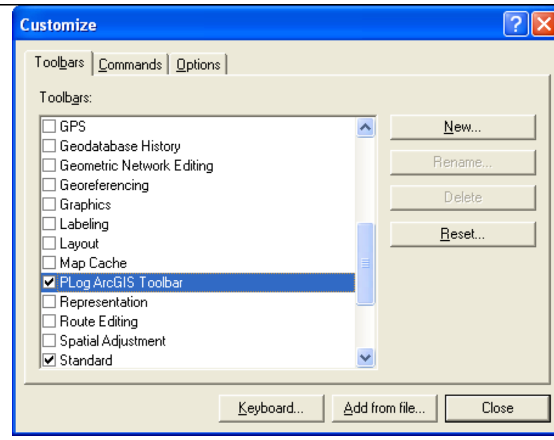
V. PLog GIS Toolbar

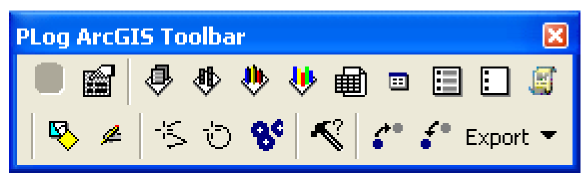
The PLog ArcGIS Toolbar must be enabled within ArcGIS in order to utilize its capabilities. It should be enabled by default, if not follow the directions below.

- Start ArcMap from the Start menu.
- From the Tools menu, select Customize
- In the list of Toolbars, select PLog ArcGIS Toolbar. If it is not shown in the list of toolbars, click File => Add and choose the PLogToolbar.tlb located in the c:\program files\PLog\PLog Toolbar folder or wherever you installed PLog on your PC.
- Click Close



- To the right is a screenshot of the PLog toolbar prior to logging into the system.

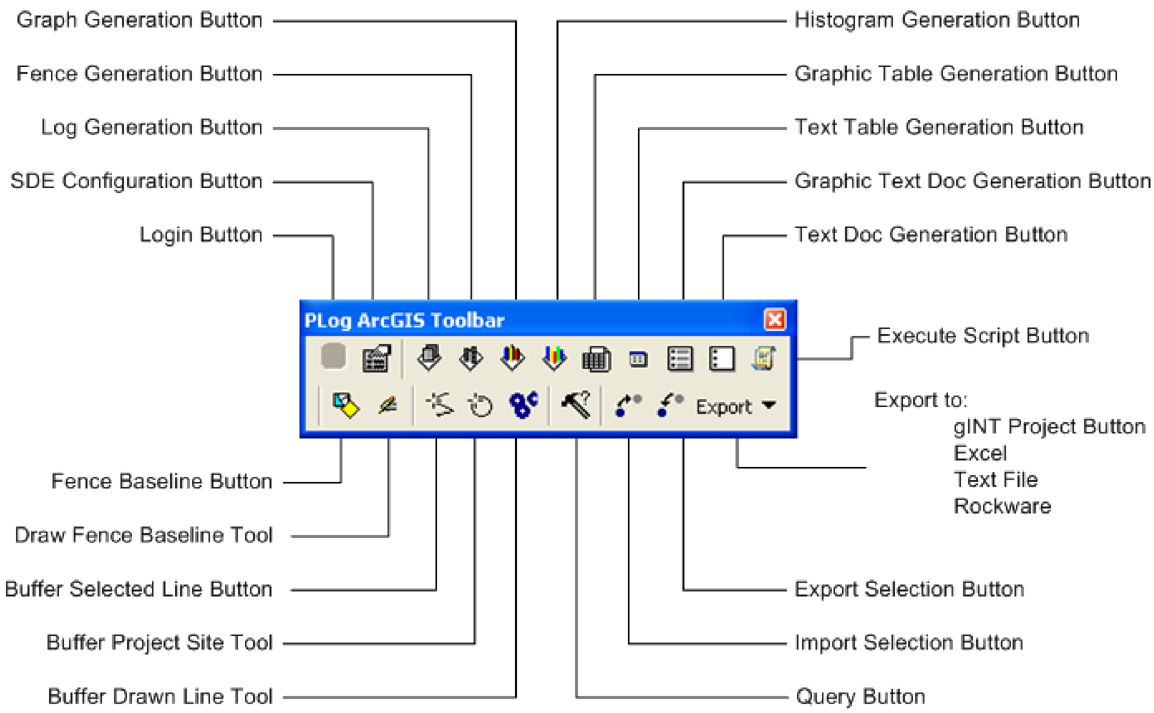
- Once you have logged into the system, the other tools are available. If you hover the cursor over each button, a tooltip is available describing the buttons purpose.



A brief explanation of each of the buttons and tools on the PLog Toolbar is included herein with more detailed explanation following. Refer to the figure below for the name of each button or tool.

- The Login Button allows you to login to the database. Once you have logged in the other tools are activated.
- The Configuration Button allows you to perform the SDE Configuration as described above.
- The Log Generation Button allows you to generate a Log report in gINT from the selected boreholes on the map.
- The Fence Generation Button allows you to generate a Fence report in gINT from the selected boreholes on the map.

- The Graph Generation Button allows you to generate a Graph report in gINT from the selected boreholes on the map.
- The Histogram Generation Button allows you to generate a Histogram report in gINT from the selected boreholes on the map.
- The Graphic Table Generation Button allows you to generate a Graphic Table report in gINT from the selected boreholes on the map.
- The Text Table Generation Button allows you to generate a Text Table report in gINT from the selected boreholes on the map.
- The Graphic Text Doc Generation Button allows you to generate a Graphic Text Doc report in gINT from the selected boreholes on the map.
- The Text Doc Generation Button allows you to generate a Text Doc report in gINT from the selected boreholes on the map.



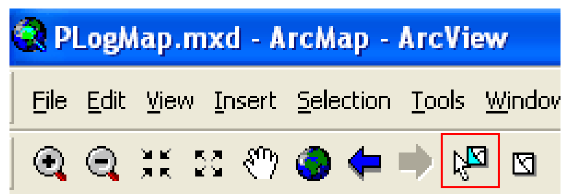
- The Fence Baseline Button allows you to generate a fence report using the selected boreholes and selected baseline in ArcMap.
- The Draw Fence Baseline Tool allows you to draw a baseline in ArcMap and generate a fence report in gINT from the selected boreholes and drawn baseline.
- The Buffer Selected Line Button allows you to buffer a selected line in ArcMap and select the boreholes within your specified distance of the selected line.
- The Buffer Project Site Tool allows you to buffer a point on the map in ArcMap and select the boreholes within your specified distance of the specified point.
- The Buffer Drawn Line Tool allows you to draw a line on the map and buffer it to select the boreholes within your specified distance of the drawn line.
- The Query Button allows you to create and execute queries for data mining purposes.

- The Export Selection Button allows you to export the list of Project IDs and PointIDs to a text file such that they can be reimported and used at a later time.
- The Import Selection Button allows you to import a list of Project IDs and PointIDs from a text file and select them on the map.
- The Export gINT Project Button allows you to export the selected data to one or more gINT projects for further manipulation within gINT.

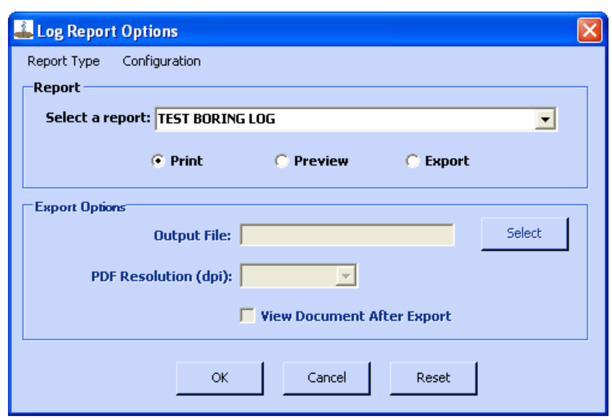
General Report Generation

The following section applies to all of the report styles i.e. logs, fences, graphs, histograms, graphic tables, etc. Separate sections specifically for fences and graphs are included highlighting their specific reporting options.

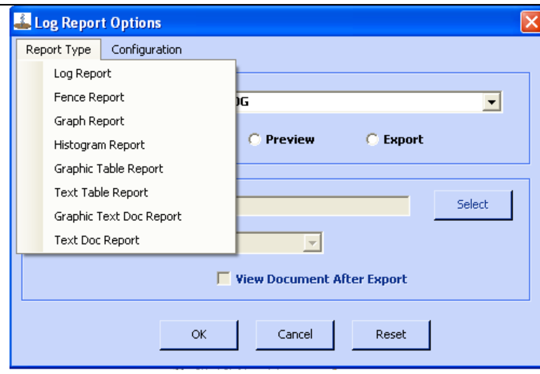
- Select the boreholes you want to generate a report for on the map using the ArcMap selection tool shown to the right.
- Alternatively, the PLog buffering tools, PLog Import Selection Button, or the PLog Query tool can be used. For a detailed explanation on the selection tools refer to Buffer Selected Line Button, Buffer Project Site Tool, Buffer Drawn Line Tool, PLog Import Selection Button or PLog Query Tool.



- Selecting the any of the Report Generation Buttons (logs, fences, graphs, etc.) activates the dialog shown here. This dialog box provides the same reporting options you have in gINT.
- From the dropdown list, choose the report you would like to generate.
- To print the report, choose Print and click OK.
- To preview the report, choose Preview and Click OK.
- To export the report to a pdf or dxf file choose Export. Then click the Select button to specify the file to export it to and the resolution if it is a pdf file.
- If you would like to view the document after export, check the View Document After Export checkbox.

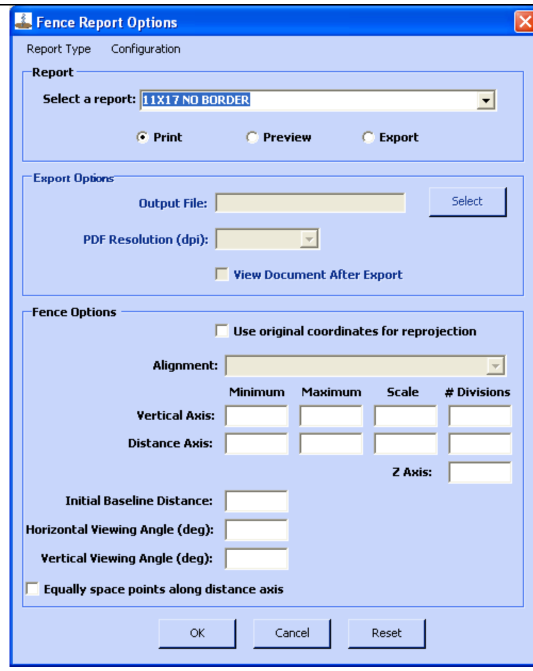


- If you would like to change to a different report style use the Report Type menu at the top and choose the desired report style.



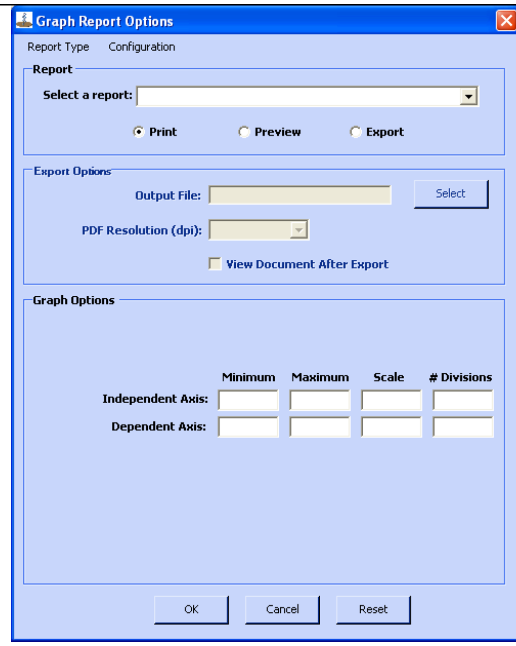
Fence Generation

- For fence report generation, the Fence Options panel is activated allowing the user to specify minimum and maximum values for vertical and distance axes, # divisions, initial baseline distance, viewing angles, etc.
- For details on fence reporting options, please refer to the gINT help. Use the keyword "Fences (Output)" in the index for more information specific to fences.



Graph Generation

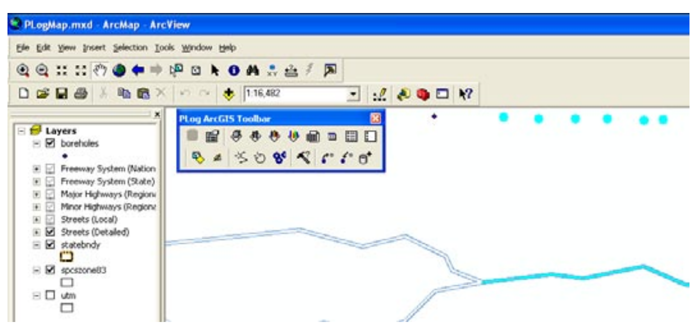
- For graph report generation, the Graph Options panel is activated allowing the user to specify minimum and maximum values for independent and dependent axes, # divisions, and scales.
- For details on graph reporting options, please refer to the gINT help. Use the keyword “Graphs (Output)” in the index for more information specific to graphs.



Fence Baseline Button

The Fence Baseline Button allows you to generate a fence report using the selected boreholes and selected baseline in ArcMap.

- Select the boreholes you want to generate a report for on the map using the ArcMap selection tool shown to the right.
- Alternatively, the PLog buffering tools, PLog Import Selection Button, or the PLog Query tool can be used. For a detailed explanation on the selection tools refer to Buffer Selected Line Button, Buffer Project Site Tool, Buffer Drawn Line Tool, PLog Import Selection Button or PLog Query Tool.
- Select the line used for the baseline from ArcMap using the ArcMap selection tool.
- Click the Fence Baseline Button. When prompted whether or not to generate a fence report, select



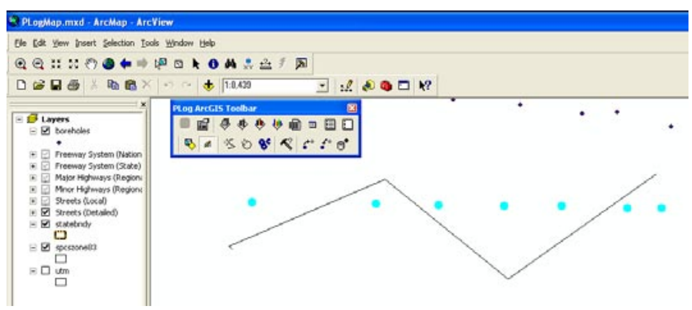
Yes.

- This activates the Fence Report Options dialog as described in the Fence Generation section.

Draw Fence Baseline Tool

The Draw Fence Baseline Tool allows you to draw a baseline in ArcMap and generate a fence report in gINT from the selected boreholes and drawn baseline.

- Select the boreholes you want to generate a report for on the map using the ArcMap selection tool shown to the right.
- Alternatively, the PLog buffering tools, PLog Import Selection Button, or the PLog Query tool can be used. For a detailed explanation on the selection tools refer to Buffer Selected Line Button, Buffer Project Site Tool, Buffer Drawn Line Tool, PLog Import Selection Button or PLog Query Tool.
- Click the Draw Fence Baseline Tool.
- Click the left mouse button at starting point of the line on the map.
- Continue left clicking each point until you reach the end of the baseline.
- Double click the last point to end the polyline.
- When prompted whether or not to generate a fence report, select Yes.
- This activates the Fence Report Options dialog as described in the Fence Generation section.



Buffer Selected Line Button

The Buffer Selected Line Button allows you to buffer a selected line in ArcMap and select the boreholes within your specified distance of the selected line.

<table>
<tr>
<td>

- Select a line for use as the buffer source using the ArcMap selection tool. This may be a road, dam or levee centerline.

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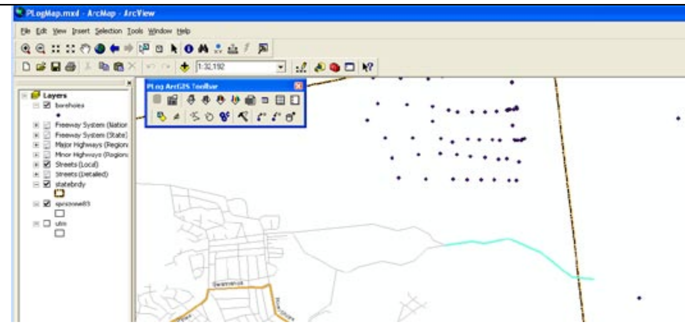
<td>


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<td>

- Click the Buffer Selected Line Button.
- Specify the buffer distance and the units.
- Click OK.

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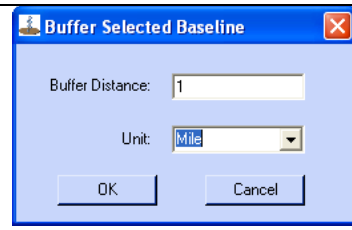
<td>


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<td>

- The image shown to the right is all boreholes within 1 mile of the selected road.

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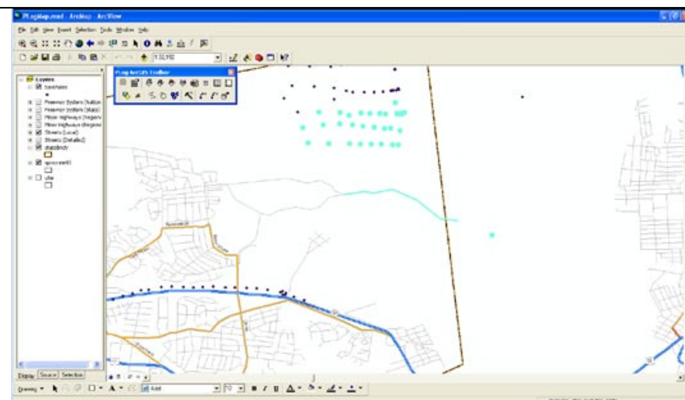
<td>

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</table>

Buffer Project Site Tool

The Buffer Project Site Tool allows you to buffer a point on the map in ArcMap and select the boreholes within your specified distance of the specified point.

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<tr>
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- Click the Buffer Project Site Tool.
- Click on the map where you want to select the boreholes.

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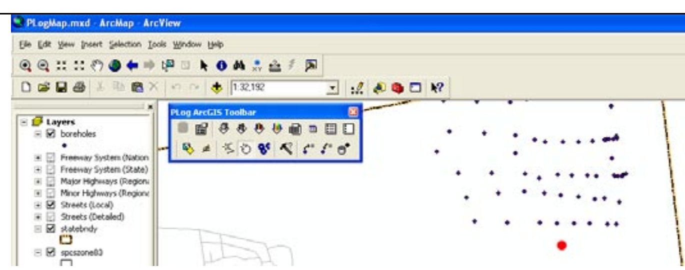
<td>


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- Specify the buffer distance and the units.
- Click OK.

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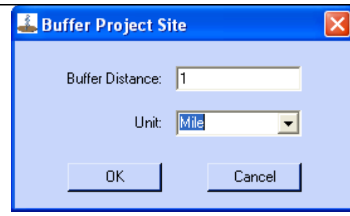

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<td>

- The image shown to the right is all boreholes within 1 mile of the specified point.

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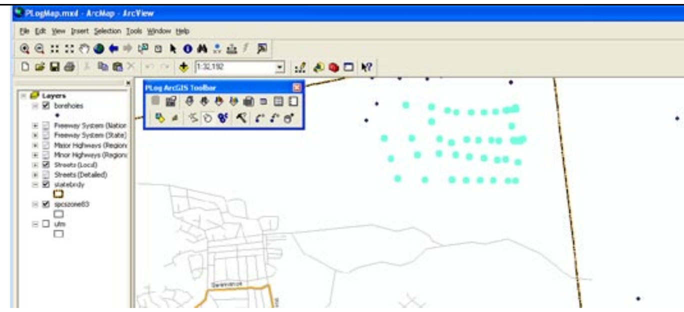
<td>

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Buffer Drawn Line Tool

The Buffer Drawn Line Tool allows you to draw a line on the map and buffer it to select the boreholes within your specified distance of the drawn line.

<table>
<tr>
<td>

- Click the Buffer Drawn Line Tool.
- Draw a polyline on the map to buffer.
- Left click on each vertex of the polyline and then double click to end the polyline.

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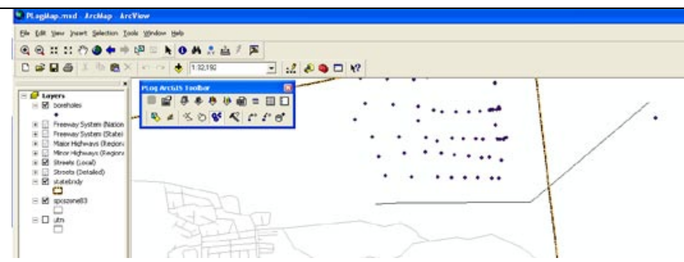
<td>

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<td>

- Specify the buffer distance and the units.
- Click OK.

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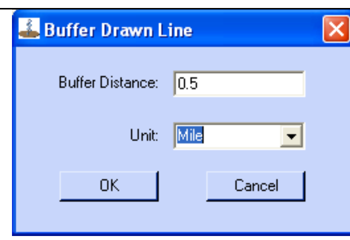
<td>


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- The image shown to the right is all boreholes within 0.5 mile of the drawn line.

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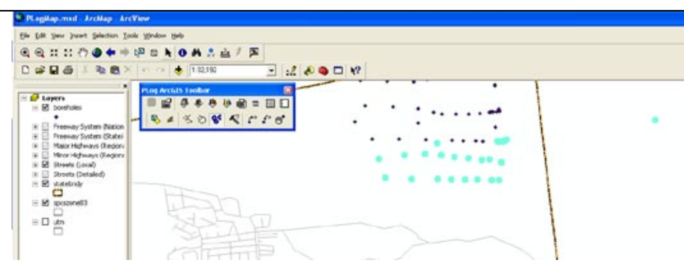
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</table>

PLog Query Tool

The query tool is used for non-spatially querying data in the database, whereas the buffering tools provide spatial querying capabilities. You can create queries based on values found in the database such as (but not limited to) project name, city, or soil type. Examples of a non-spatial query are:

- Find all boreholes where the USCS is an SP or SM and N-Value < 8.
- Find all boreholes where the project city = Atlanta and the state = Georgia.

The latter query is the example shown in the following dialog boxes.

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<td>

- To build a query, start the PLog Query Tool.

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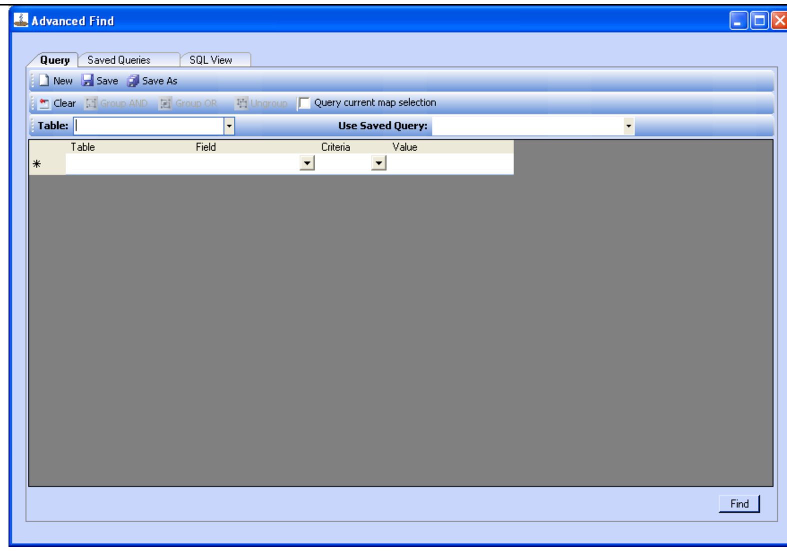
<td>


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<td>

- From the Table dropdown list, choose the table you want to query values from first. In this case, choose the Project table.
- Add the query criteria in the grid. In the first row, select the Field = “City” and the Criteria is “=” and the Value is “Atlanta”.
- Add a second row in the grid by specifying Field = “State” and the Criteria is “=” and the Value is “Georgia”.

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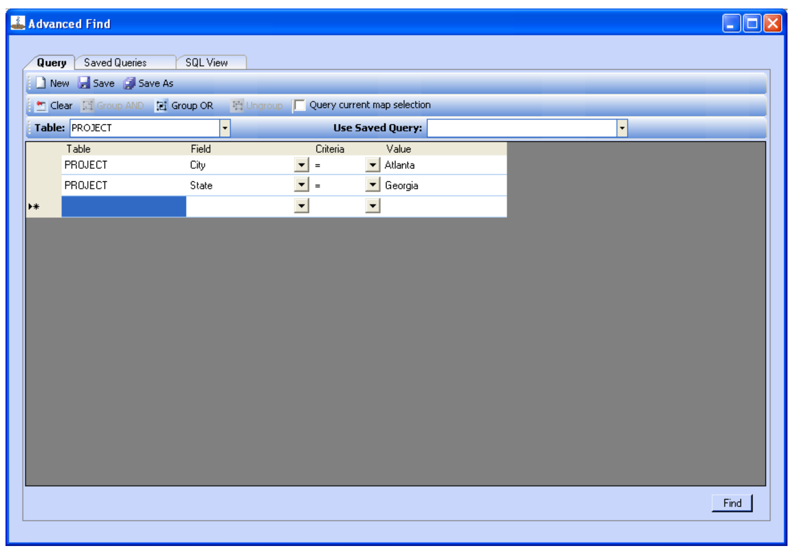
<td>


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<td>

- If you want to only find the values that fully match this criteria you must now specify the Group “And” to indicate the query must be City = Atlanta **and** State = Georgia.
- If you choose the Group “Or” the query would be City = Atlanta **or** State = Georgia. This wouldn’t provide meaningful results if you are only looking for Atlanta because it would return all boreholes in the state of Georgia.

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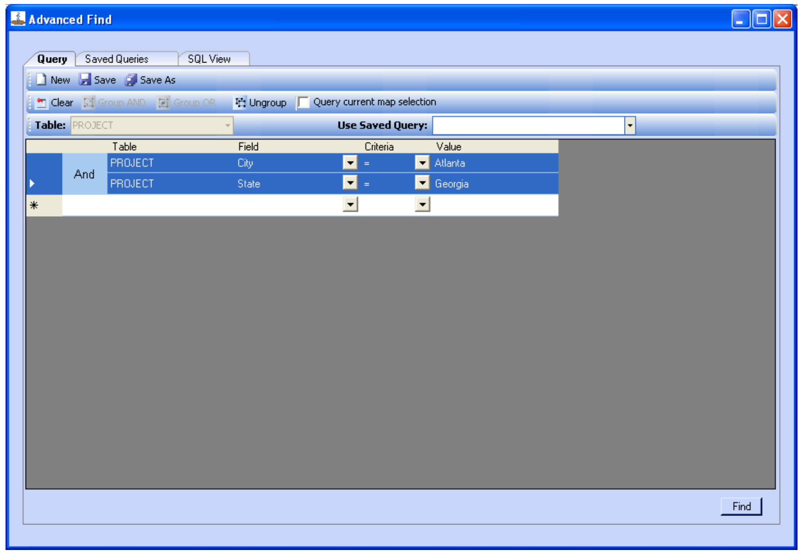

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<td>

- To execute the query, click the Find button. This will select the appropriate boreholes on the map within ArcMap.

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<td>

- To save the query, click the Save button. This activates a dialog where you can specify the name of the query and type a description to help identify what the query will return.

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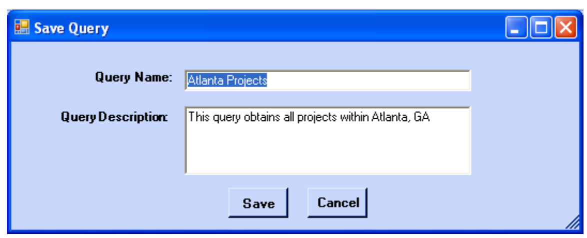

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<tr>
<td>

- To use a previously saved query, select a value from the Use Saved Query dropdown list. Alternatively, you can click the Saved Queries tab and view the list in a grid with more details about the query.
- If you want to clear the current query, choose the Clear button.
- *Warning: if you clear a saved query it will prompt you to save your changes once you close the form or switch tabs.*

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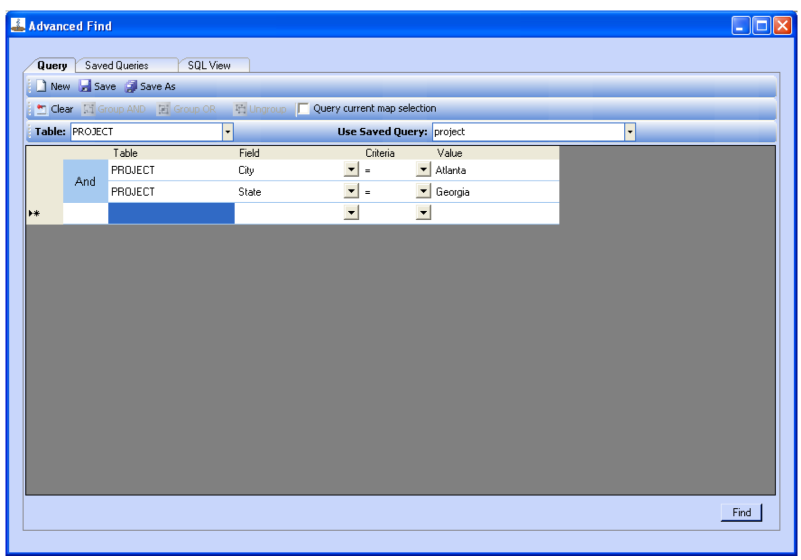

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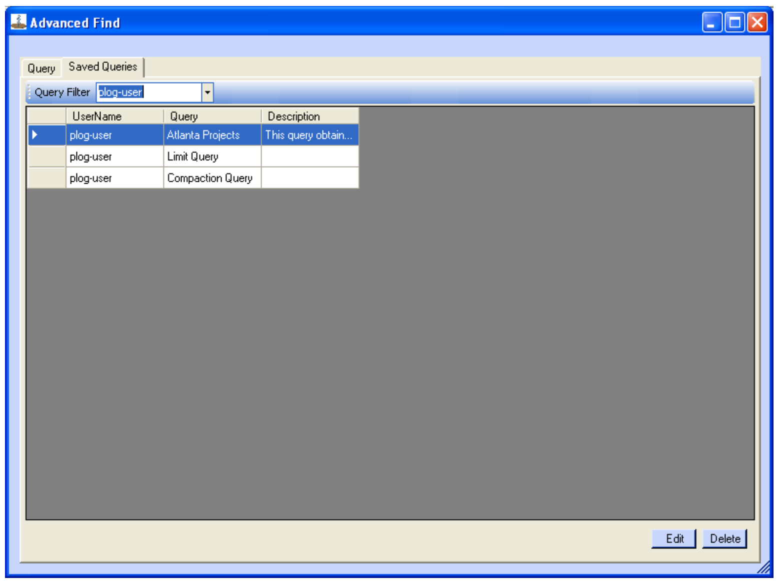
Dataforensics

Saving the query will overwrite the changes. Use Save As if you don't want to affect the original source query.	
• Clicking the Saved Queries tab allows you to view all saved queries and filter them by the user who created the query. • To select or edit a query, simply double click in the gray area to the left of the row you want to select. This selects the query and returns you to the Query tab with the query populated in the grid. • Alternatively, you can highlight the row and select the Edit button on the form. • To delete a query, highlight the row to delete and click the Delete key on the keyboard or the Delete button on the form. • To only see the queries you have created, click on the Query Filter dropdown list and select your username. • *Note: you may also select other usernames to filter queries.*	

PLog Export Selection Button

The Export Selection Button allows you to export the list of Project IDs and PointIDs to a text file such that they can be imported at a later time.

<table>
<tr>
<td>

- Once a selection has been made using the various selection options, it can be saved for future use.
- Click on the PLog Export Selection Button.

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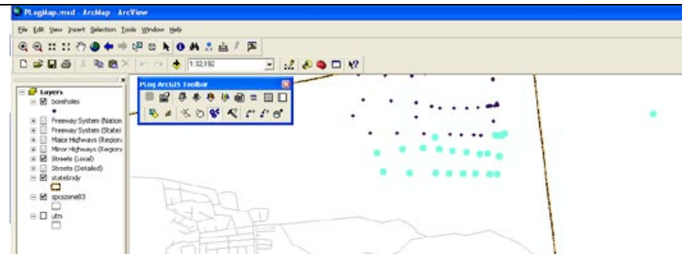
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- In the file selection dialog, select the folder where you want to store the file and name the file.
- Click Save.

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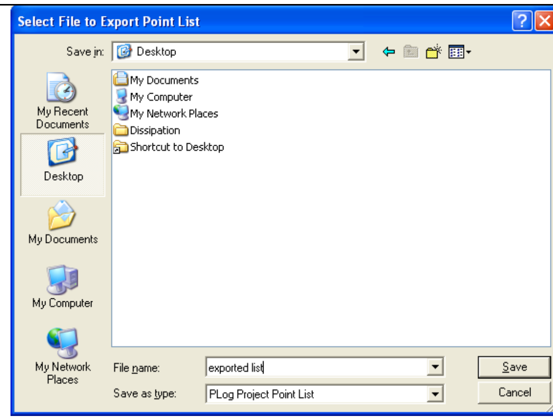
<td>


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</table>

PLog Import Selection Button

The Import Selection Button allows you to import a list of Project IDs and PointIDs from a text file and select them on the map.

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<td>

- Click on the PLog Import Selection Button.
- In the file selection dialog, select the file to import.
- Click Open.

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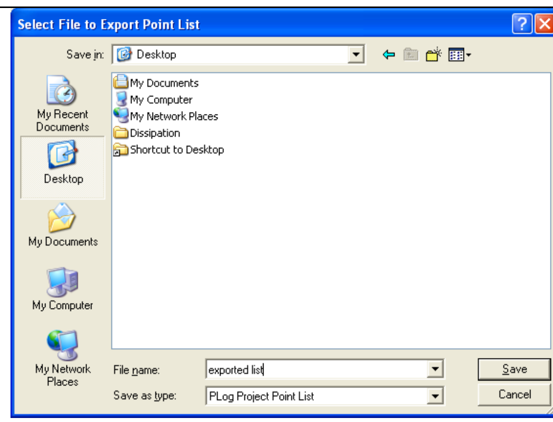
<td>


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- This selects the points on the map specified in the file.

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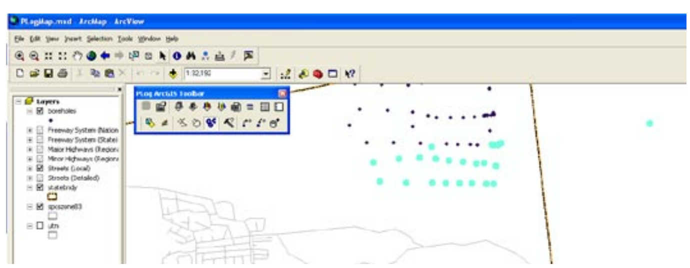
</td>
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</table>

PLog Export

The Export Button allows the user to export the selected data to one or more gINT projects, Excel Files, Rockworks files, or Text files for further manipulation within some other application.

- Select the boreholes you want to generate a report for on the map using the ArcMap selection tool shown to the right.
- Alternatively, the PLog buffering tools, PLog Import Selection Button, or the PLog Query tool can be used. For a detailed explanation on the selection tools refer to Buffer Selected Line Button, Buffer Project Site Tool, Buffer Drawn Line Tool, PLog Import Selection Button or PLog Query Tool.
- Simply choose the folder where you would like the data to be exported.
- Each project in the database will be created as a gINT, Excel, Rockworks or Text file (depending on your chosen export format) with its Project ID as its name.

Dataforensics RAPID CPT

User's Manual

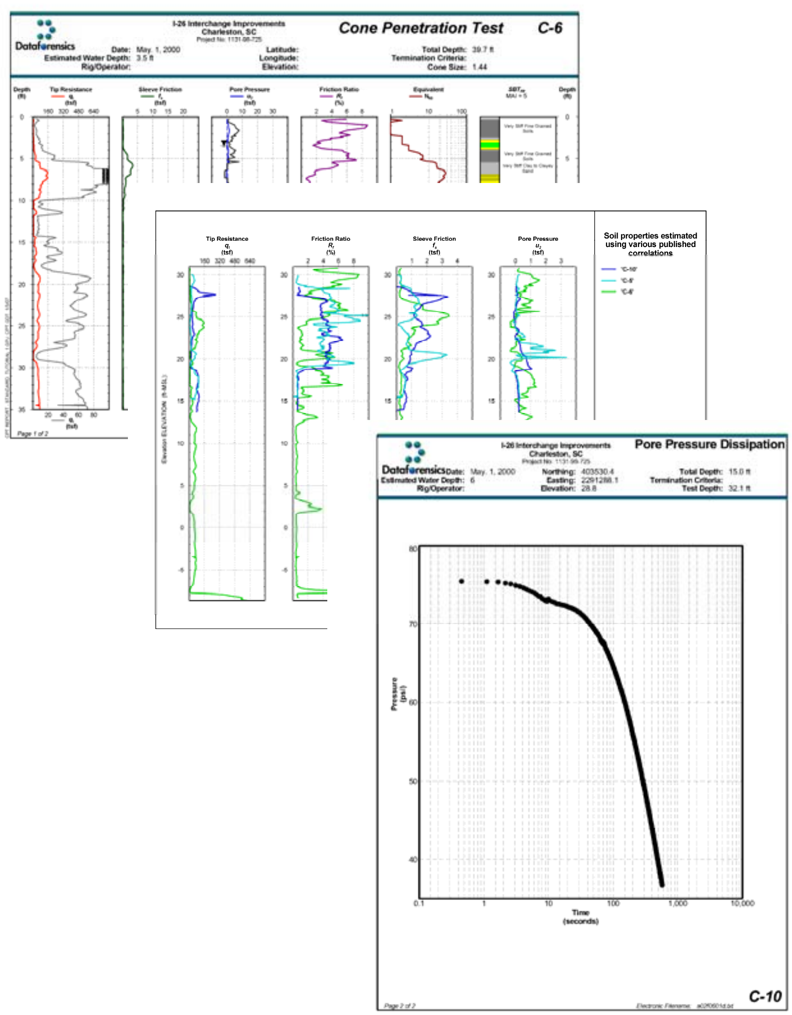


Table of Contents

Introduction

Cone Penetration Testing (CPT) provides engineers with large amounts of data that can be used for analysis, typically up to 20 points per foot of exploration. Each raw data point typically consists of depth, tip resistance, sleeve friction, and pore pressure. Converting this raw data (usually a text file) to something useful that can be analyzed and reported is a tedious and cumbersome process. It requires significant amounts of manual data manipulation (moving, copying and pasting) that is prone to human error. Furthermore, to do anything useful with the data, the engineer must then calculate numerous parameters and correlations that can be used in follow-on design and analysis.

Dataforensics RAPID CPT, a gINT Add-in, eliminates all manual data manipulation, providing a more complete and accurate interpretation of results, faster and easier than ever before. RAPID CPT allows you to import, process, analyze, report and deliver CPT results to your clients.

CPT Data Import

Dataforensics' RAPID CPT makes importing data as easy as a few clicks of a mouse…without any transposition errors. Dataforensics has created the capability to import CPT data, pore pressure dissipation data, and shear wave velocity data from the raw text files and from AGS files. From a menu in gINT, simply choose which type of CPT data to import and select the file(s) to import. All data manipulation is automatically done for you.

CPT Analysis & Reporting

Once the CPT data is imported into gINT, you can start your analysis and reporting. Dataforensics RAPID CPT automatically calculates the following parameters upon importing the data into gINT:

- Normalized Soil Behavior Type based on Friction Ratio– Q_t vs F_r
- Normalized Soil Behavior Type based on Pore Pressure – Q_t vs B_q
- Soil Behavior Type based on Friction Ratio– q_t vs Friction Ratio
- Soil Behavior Type based on Pore Pressure – q_t vs B_q
- Total Density (ρ)
- Relative Density (D_r)
- Void Ratio (e_0)
- Effective Friction Angle (ϕ')
- Constrained Modulus (M)
- Coefficient of Lateral Earth Pressure (K_0)
- Undrained Shear Strength (S_u)
- Overconsolidation Ratio (OCR)
- Sensitivity
- Fines Content
- Equivalent $(N)_{60}$

Any change you make to values that affect the calculations such as total density or water depth, updates all calculations immediately. Thus all changes are reflected immediately on all reports you generate. You no longer have to recalculate values in Excel or whatever program you are using, and then import the data into gINT again to include it on borehole logs, CPT reports, etc. Dataforensics' RAPID CPT allows you to perform the entire analysis and reporting process within one software package. If you change one value in gINT, all values are updated, and all graphs immediately reflect the changes.

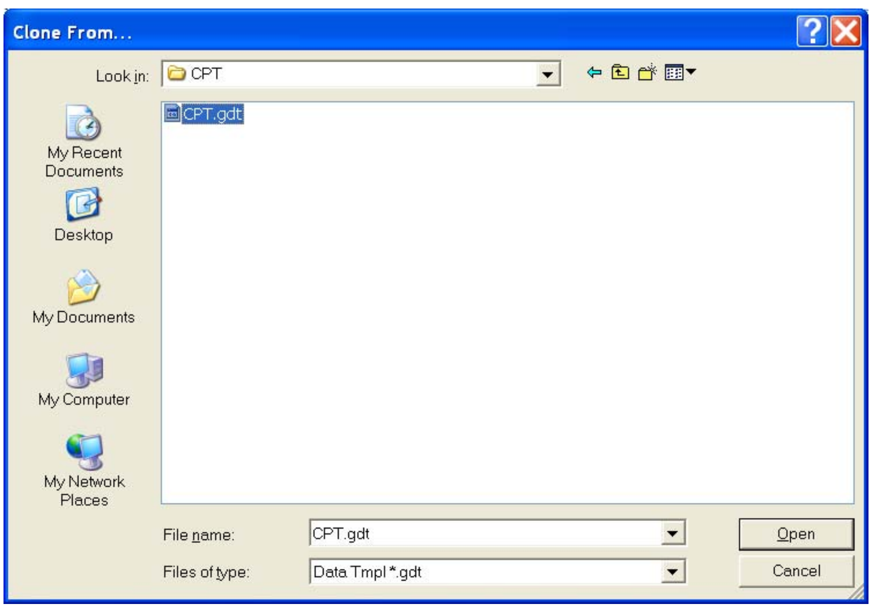
Tutorial 1 – Importing Data

RAPID CPT facilitates analyzing CPT data by removing three of the most cumbersome manual processes involved with analyzing CPT data using traditional tools such as Excel: manipulation of the data, calculating various correlations and parameters, reporting and comparing, data and correlations.

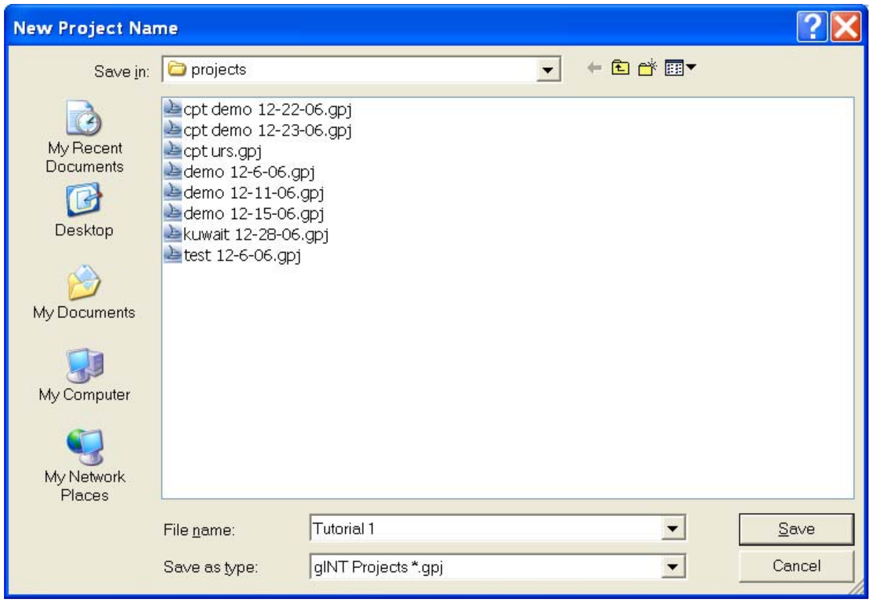
In this tutorial we will illustrate how to import each of the three types of data that can be imported using RAPID CPT: CPT data, Pore Pressure Dissipation Data, and Shear Wave Velocity Data.

Create a new gINT Project

- Start gINT.
- Once you have installed RAPID CPT, verify the RAPID CPT library (CPT Library.glb) or your custom library created by Dataforensics is open in gINT.
- To change the library, go to the File menu in gINT and select ‘Change Library’ and select the appropriate .glb file.
- Create a new gINT project by cloning the RAPID CPT data template (cpt.gdt) or using your custom data template created by Dataforensics.
- To create a new project go to the ‘File’ menu in gINT and select ‘New Project’->’Clone Data Template’.
- Select the CPT.gdt as the source data template.



- Specify a new file name for the new project you are creating. In this example shown below it is named ‘Tutorial 1.gpj’.



Now you are ready to import data into the Tutorial 1 project. You can import as many CPT soundings as you would like into this project.

Import q_t, f_s, u_2 data

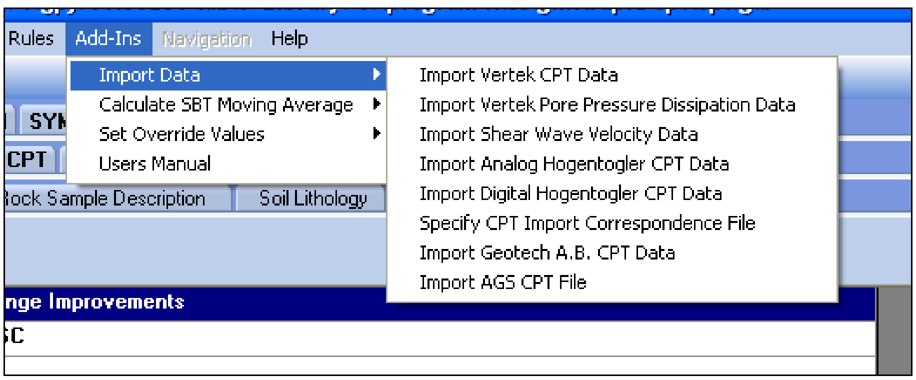
You will import q_t, f_s, and u_2 data from a text file. Currently RAPID CPT supports the following formats:

- Vertek (.ecp) file format. **The stress units for Vertek files can be in tsf, bars, psi, kPa or MPa for q_t, f_s, u_2.**
- Vertek (.dat) file format. **The units for Vertek .dat files are volts.**
- Hogentogler digital file format. **The stress units for the Hogentogler digital files can be in tsf, bars, psi, kPa or MPa for q_c, f_s, u_2.**
- Hogentogler analog file format. **The stress units for the Hogentogler analog files can be in tsf, bars, psi, kPa or MPa for q_c, f_s, u_2.**
- Geotech AB and Envi AB (.cpd) file format. Geotech AB and Envi AB files are only in metric. Therefore, **the stress units for these files can only be in MPa for q_c, q_t, f_s, u_2.**
- ConeTec files (.cor) format. **The stress units for the ConeTec digital files can be in tsf, bars, psi, kPa, MPa, feet of water or meters of water, for q_c, f_s, u_2.**
- Gregg Drilling files (.cor) format. **The stress units for the Gregg Drilling digital files can be in tsf, bars, psi, kPa, MPa, feet of water or meters of water, for q_c, f_s, u_2.**
- A P van den Berg files Gorilla format. **The stress units for these files can be MPa for q_c, f_s, u_2.**
- AGS file format. **The stress units for AGS files are MPa.**

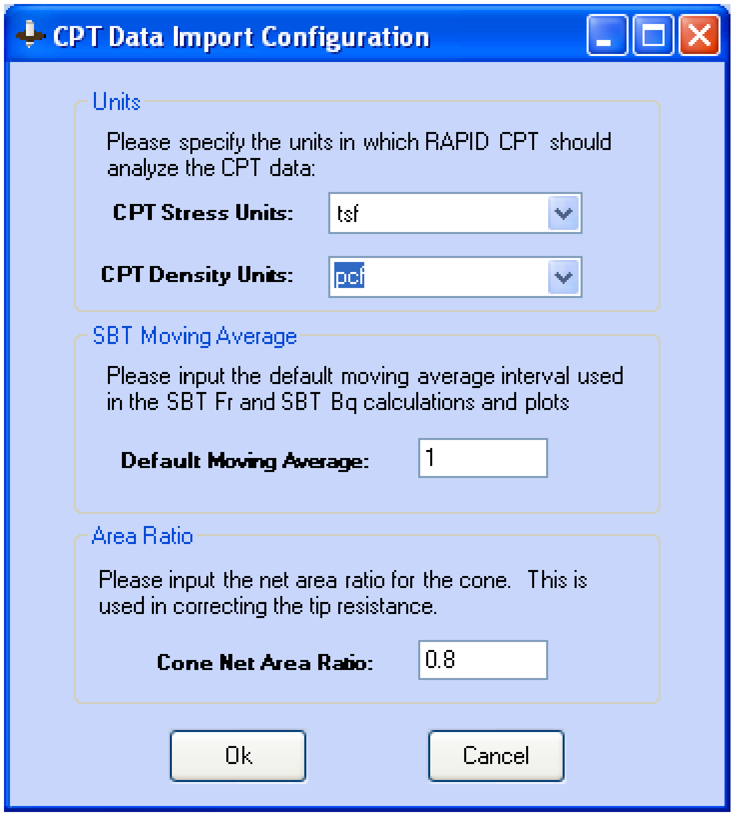
- Units for data in the input file must be in all English or metric units. However, measurements for each item do not need to be the same. For example, an import file can have q_c and f_s in tsf and u_2 in psi.

Other custom importers for other CPT manufacturers can be created upon request.

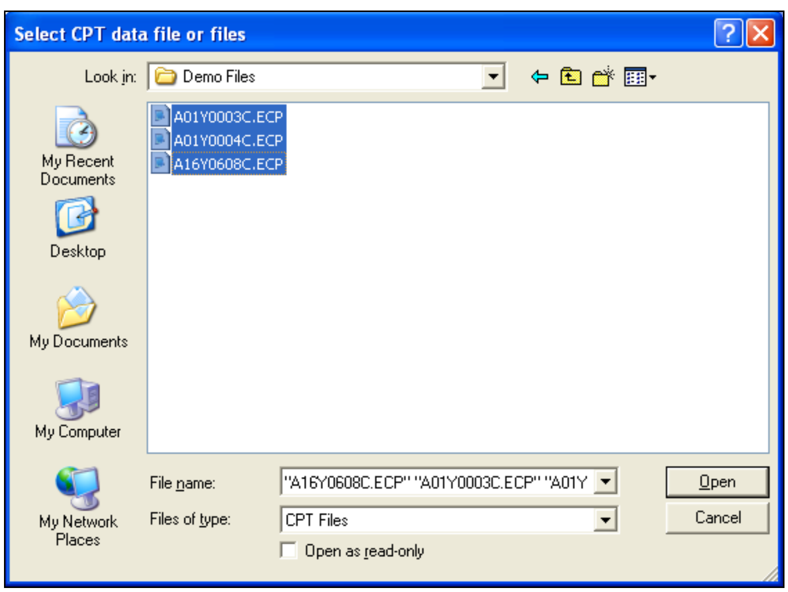
- If you have merged the RAPID CPT Project table fields and the CPT and CPT Data tables in to your company's gINT data template or had Dataforensics create a custom data template for you, you must specify a correspondence file prior to importing the CPT data file so data in the Project and Point tables are imported to the correct fields in your data template. From the Add-Ins menu in gINT, select the Import Data->Specify CPT Import Correspondence File. *Note: You can develop your own correspondence file or Dataforensics can create a correspondence file for you.*
- If you are importing CPT data from an AGS file you must specify a correspondence file prior to importing the CPT data file *even if you are using the standard RAPID CPT data template*. Use the rapid cpt ags import.gci file.
- From the Add-Ins menu in gINT, select the data type you wish to import. Select Import Data->Import Data. Then select the specific CPT data file you wish to import (Vertek, Hogentogler, Geotech AB or AGS).



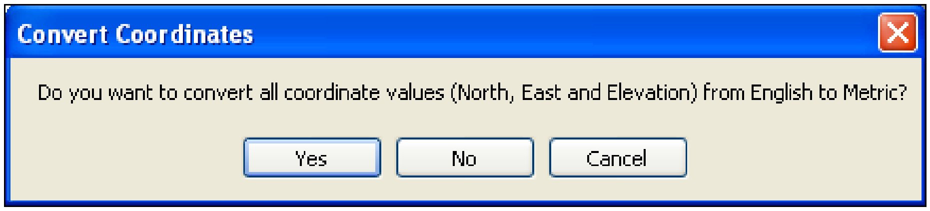
- The dialog shown below will appear. It prompts you to specify the CPT Stress units, CPT Density units, the default moving average for Soil Behavior Type (SBT) and the Cone Net Area ratio. Once the appropriate values are entered in the dialog box select OK.
  - Stress and density units in this dialog box are the units you wish to report the data in, and do not need to be the same units as the file being imported. You may specify the output units to be **tsf, bars, psi, kPa or MPa** for stress units, and **pcf, g/cc, kN/m^3 or Mg/m^3** for density units. Stress and density units must be within the same system (metric or English).
  - Default moving average is used in a moving average calculation for the soil behavior types. A moving average of 1 means each Soil Behavior Type will be plotted. A moving average of 5 means that the Soil Behavior type will be averaged over 5 depth intervals (from 2 depths above to 2 depths below the current depth). This value can always be changed later without having to import the data again.
  - Cone Net Area ratio must be specified for the cone in order to calculate q_t and any subsequent correlations that use it.



- Select one or more CPT data files to import into gINT and click Open. If you have 20 CPT soundings you can select all 20 files at once.



When you import files in English units and are converting them to metric, or vice versa, a pop up will appear asking if you wish to convert the coordinate values (Northing, Easting and Elevation) as well. Select Yes to convert the coordinates along with the CPT data or No to keep the coordinates in the original data form.



Import Pore Pressure Dissipation Data

Next you will import pore pressure dissipation data from a text file. Currently RAPID CPT only supports the Vertek pore pressure dissipation file format. The Vertek pore pressure data will be in a text (.txt) file. Other custom importers for other CPT manufacturers such as Hogentogler, Geotek AB, or A.P. Vandenburg can be created upon request.

- Importing pore pressure dissipation data follows the same process as importing CPT data. From the Add-Ins menu, select Import Data->Import Pore Pressure Dissipation Data.
- Select one or more Pore Pressure Dissipation data files to import into gINT and click Open. If you have 20 dissipation tests you can select all 20 files at once.

Import Shear Wave Velocity Data

Last, you an import shear wave velocity data from Excel spreadsheets. The format that RAPID CPT can import is provided in the sample files. *Note: If you wish to import shear wave velocity information, Dataforensics will send you a formatted Excel sheet.*

- Importing shear wave velocity data follows the same process as importing CPT data. From the Add-Ins menu, select Import Data->Import Shear Wave Velocity Data.
- Select one or more Shear Wave Velocity data files to import into gINT and click Open. If you have 20 soundings with shear wave velocity data you can select all 20 files at once.

Alternatively, this data can be typed into gINT directly.

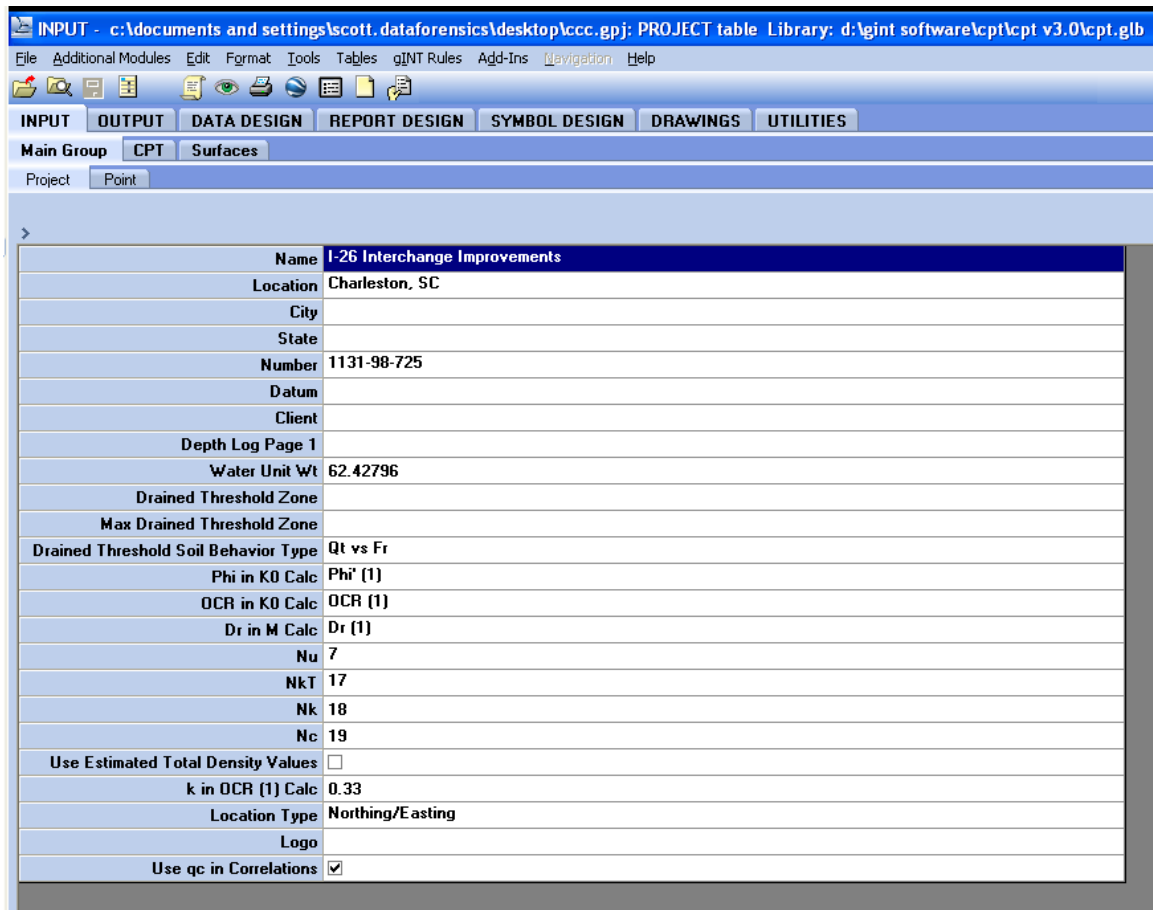
You have now imported all types of data into RAPID CPT and are ready to begin the process of analyzing the data as described in Tutorial 2.

Tutorial 2 – Modifying Default Values with RAPID CPT

The following three figures illustrate data imported by RAPID CPT and how the user can configure RAPID CPT in the project, point and/or CPT table to vary the analysis parameters.

Project Table

In the Project table shown below, the user may specify values for Water Unit Weight, Drained Threshold Zone, Drained Threshold Soil Behavior Type, Phi in K_0 Calc, OCR in K_0 Calc, D_r in M Calc, N_u . $N_{kT,}$ $N_{k,}N_c$, and Use Estimated Total Density Values. Each of these parameters and their effect on the analysis is described. **If you change any of these parameters, you must go to the CPT table and then select from the gINT Rules menu->Recalculate Current Table to ensure all calculations are updated**.



Project Table

Water Unit Weight – If you want to override the default unit weight of water (62.42796 pcf), input a value in this field. The value in this field will affect the hydrostatic pore pressure calculation and consequently the effective stress calculation.

Drained Threshold Zone - This field is used to determine the threshold for specifying whether the soil exhibits drained or undrained behavior based on normalized SBT zones. This affects OCR, S_u, Phi', D_r, M, S_t, and Fines Content calculations. Specify the minimum zone number for which drained behavior will be evaluated - i.e. if 4 is selected, zones 4-9 have drained behavior.

If the SBT is 4 – 9, the correlations for S_u, OCR, $M_{(1)}$ and $M_{(3)}$ and S_t are not calculated. Thus, only values for Phi', D_r, and $M_{(2)}$ correlations which apply to silts and sands are calculated.

Max Drained Threshold Zone - This field is used to determine the maximum threshold for specifying whether the soil exhibits drained or undrained behavior based on normalized SBT zones. This affects OCR, S_u Phi', D_r, M, S_t, and FC calculations. Specify the maximum zone number that drained behavior will be evaluated i.e. if 7 is selected, zones 4-7 have drained behavior. This drained threshold is only used by the normalized soil behavior types.

Drained Threshold Soil Behavior Type – This allows you to specify which Normalized Soil Behavior Type to use in the Drained Threshold Evaluation. The user can specify the Normalized SBT B_q plot or the Normalized SBT F_r plot (zones 1-9).

Phi in K_0 Calc and OCR in K_0 Calc – These fields allow you to specify which value of Phi' and which value of OCR to use in the K_0 (1) calculation.
K_0 (1) = 1 - sin(Phi') * (OCR ^ sin(Phi'))

D_r in M Calc – This field allows you to specify which relative density value is used in the Modulus Calculation. M (2) = q_c * 10 ^ (1.09 - 0.0075 * D_r)

N_u – This field allows you to specify which value of N_u to use in the Su (1) calculation. S_u (1) = (u_2 - u_0) /N_u

N_{kT}.- This field allows you to specify which value of N_{kT} to use in the Su (2) calculation. S_u (2) = (q_t – σ_{vo})/N_{kT}

N_k.- This field allows you to specify which value of N_k to use in the Su (4) calculation. S_u (4) = (q_c – σ_{vo})/N_k

N_c.- This field allows you to specify which value of N_c to use in the Su (5) calculation. S_u (5) = (q_t)/N_c

Use Estimated Total Density Values - Use this field to specify that the total stress calculations should be based on the estimated total density values. If it is false (not selected), RAPID CPT will use the Assumed Total Density in the CPT table. If it is selected as true, it will use the estimated total density values unless you have entered a Total Density for specific depth intervals in the CPT data table.

- When you select Use Estimated Total Density Values as true, RAPID CPT will use the values in the gINT library table "SBT Total Density Values". The values are those detailed in *Cone Penetration Testing in Geotechnical Practice* by Lunne, Robertson, and Powell (1997).

- Any values you have entered for any SBT zone and the associated Total Density in the CPT Total Density table will override the same SBT zone values in the SBT Total Density Values for analysis.

K in OCR(1) Calc – Use this field to specify the k constant in the OCR 1 calculation. If nothing is specified 0.33 is used as a default value.

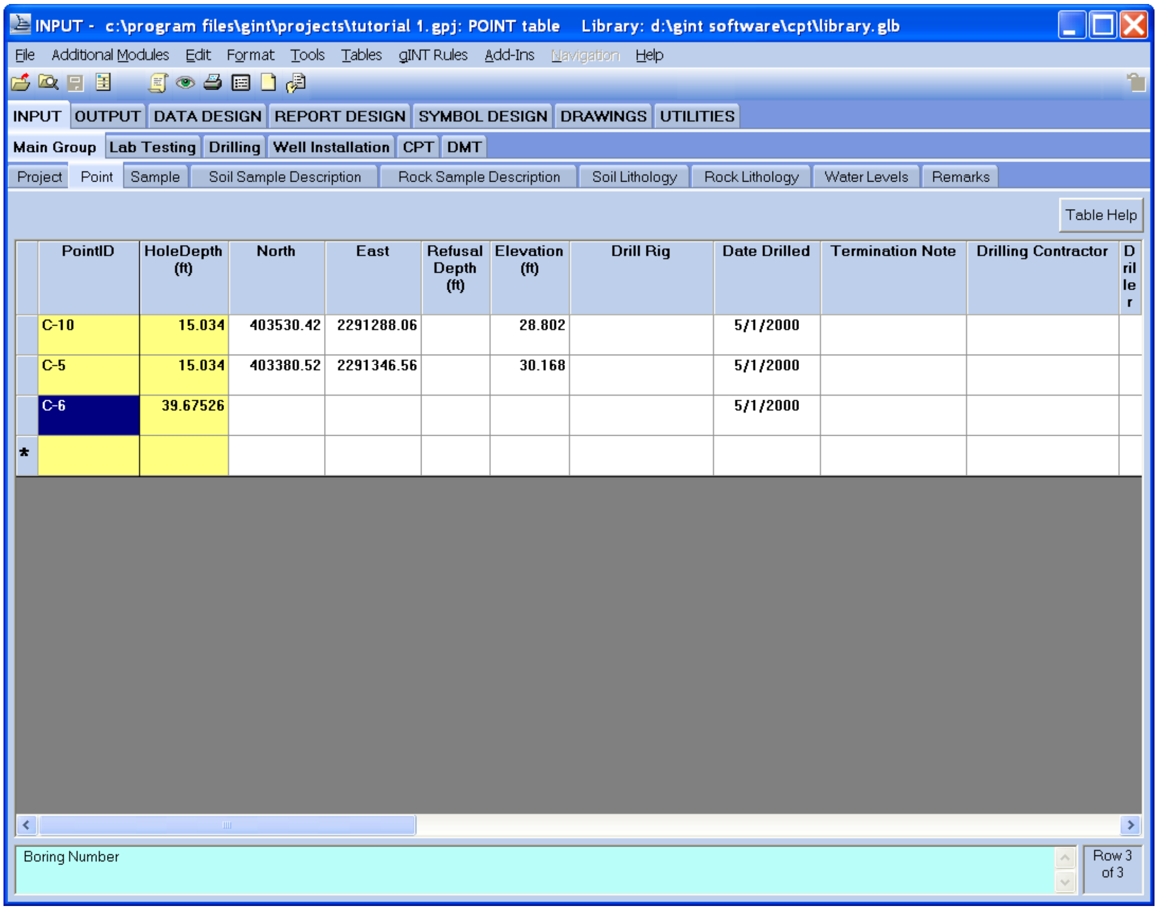
Use q_c in Correlations – Use this field to have RAPID CPT perform all applicable correlations using q_c instead of q_t.

Location Type – Use this field to report either Latitude/Longitude, Northing/Easting or Station/Offset in the header of the CPT reports.

Logo – Use this field to show different logos on the CPT reports. If nothing is specified, the first logo in the Library Table named Logos will be printed. To add other logos to your files, refer to Tutorial 7.

Point Table

There are no fields in the point table which affect the calculations. However, the values in the fields shown below are imported from the CPT data files.

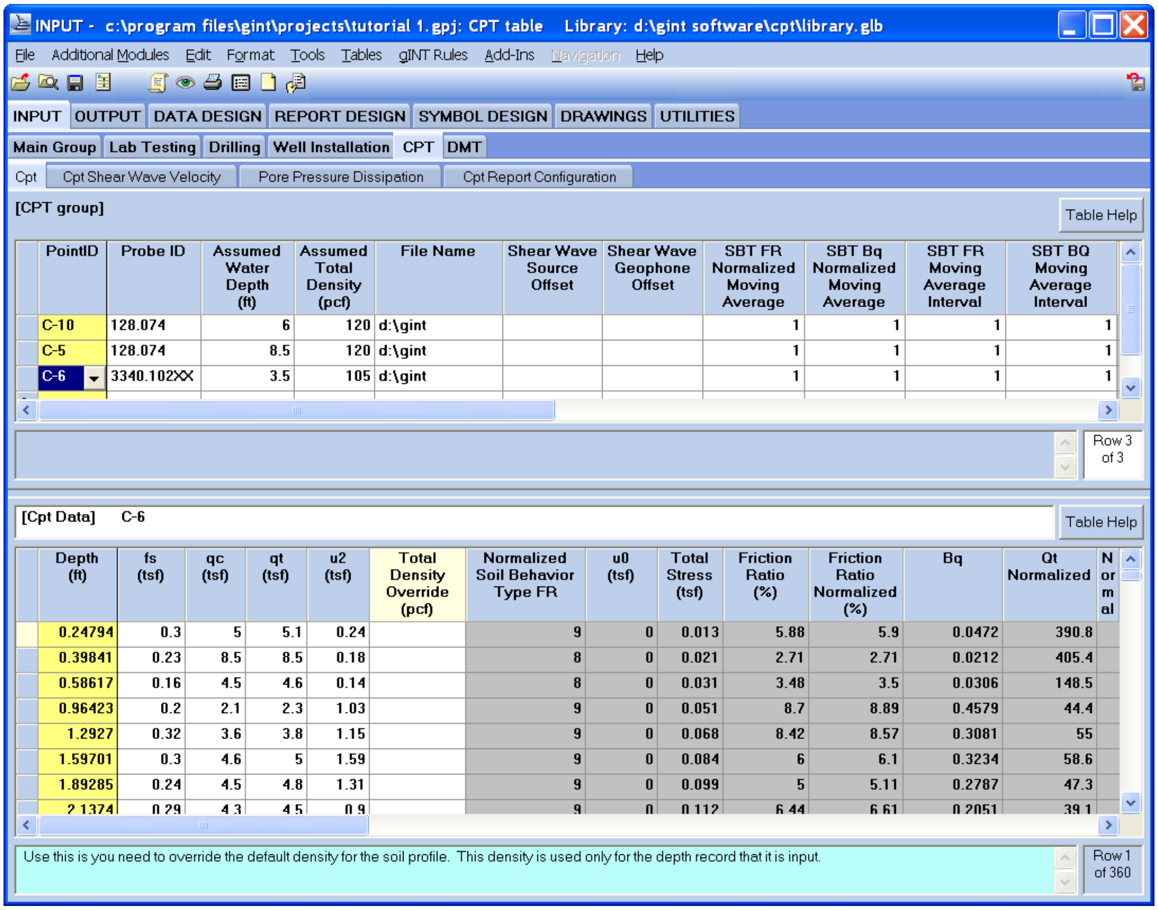


PointID	HoleDepth (ft)	North	East	Refusal Depth (ft)	Elevation (ft)	Drill Rig	Date Drilled	Termination Note	Drilling Contractor	Driller
C-10	15.034	403530.42	2291288.06		28.802		5/1/2000			
C-5	15.034	403380.52	2291346.56		30.168		5/1/2000			
C-6	39.67526						5/1/2000			

CPT and CPT Data Tables

The CPT Table is the parent table which stores information specific to each CPT Sounding, and the CPT Data table stores the f_s, q_c, q_t and u_2 data. The fields Assumed Water Depth, Assumed Total Density, the SBT moving average fields and the Net Area Ratio field (for the cone) in the CPT table affect calculations in the CPT Data table. If any values in this table are modified, all values are recalculated automatically.

Similarly, if any values in the CPT Data table are modified, all fields shown in gray are recalculated automatically.


INPUT - c:\program files\gint\projects\tutorial 1.gpj: CPT table Library: d:\gint software\cpt\library.glb
File Additional Modules Edit Format Tools Tables gINT Rules Add-Ins Navigation Help
INPUT OUTPUT DATA DESIGN REPORT DESIGN SYMBOL DESIGN DRAWINGS UTILITIES
Main Group Lab Testing Drilling Well Installation CPT DMT
Cpt Cpt Shear Wave Velocity Pore Pressure Dissipation Cpt Report Configuration
[CPT group]
Table Help
PointID Probe ID Assumed Water Depth (ft) Assumed Total Density (pcf) File Name Shear Wave Source Offset Shear Wave Geophone Offset SBT FR Normalized Moving Average SBT Bq Normalized Moving Average SBT FR Moving Average Interval SBT BQ Moving Average Interval
C-10 128.074 6 120 d:\gint 1 1 1 1
C-5 128.074 8.5 120 d:\gint 1 1 1 1
C-6 3340.102XX 3.5 105 d:\gint 1 1 1 1
Row 3 of 3
[Cpt Data] C-6
Table Help
Depth (ft) fs (tsf) qc (tsf) qt (tsf) u2 (tsf) Total Density Override (pcf) Normalized Soil Behavior Type FR u0 (tsf) Total Stress (tsf) Friction Ratio (%) Friction Ratio Normalized (%) Bq Qt Normalized Normal
0.24794 0.3 5 5.1 0.24 9 0 0.013 5.88 5.9 0.0472 390.8
0.39841 0.23 8.5 8.5 0.18 8 0 0.021 2.71 2.71 0.0212 405.4
0.58617 0.16 4.5 4.6 0.14 8 0 0.031 3.48 3.5 0.0306 148.5
0.96423 0.2 2.1 2.3 1.03 9 0 0.051 8.7 8.89 0.4579 44.4
1.2927 0.32 3.6 3.8 1.15 9 0 0.068 8.42 8.57 0.3081 55
1.59701 0.3 4.6 5 1.59 9 0 0.084 6 6.1 0.3234 58.6
1.89285 0.24 4.5 4.8 1.31 9 0 0.099 5 5.11 0.2787 47.3
Use this is you need to override the default density for the soil profile. This density is used only for the depth record that it is input.
Row 1 of 360

Tutorial 3 – Setting Total Density Values

The RAPID CPT tool allows you to specify total density values for materials in four different manners. The order of precedence for which density is used in calculations is as follows.

1. Total Density Override with depth
2. Project Specific Total Density values based on the Soil Behavior Type
   - Values in the CPT Total Density Table
   - Values in the Soil Behavior Type Zone in the Library Table SBT TOTAL DENSITY VALUES (if no values are in the CPT Total Density Table.)
3. Assumed Total Density for the entire sounding in the CPT table
4. If no assumed total density is entered for a sounding, 120 lb/ft^3 (18.9 kN/m^3) is assumed.

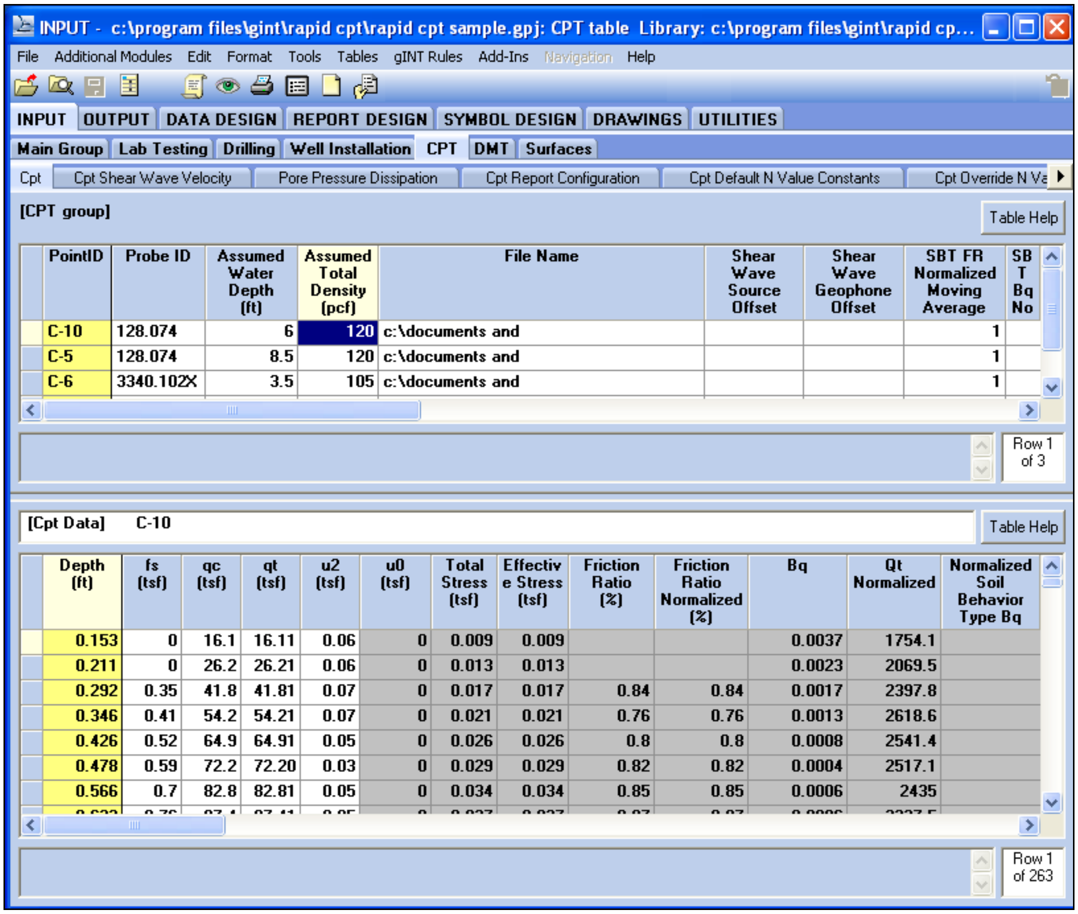
The user's manual herein details how each level works from default up through Total Density Override with Depth.

Default Total Density Values

If there is no unit weight in the CPT raw data file, then after import RAPID CPT will perform an initial analysis using an assumed unit weight of 120 lb/ ft^3 (18.9 kN/m^3).

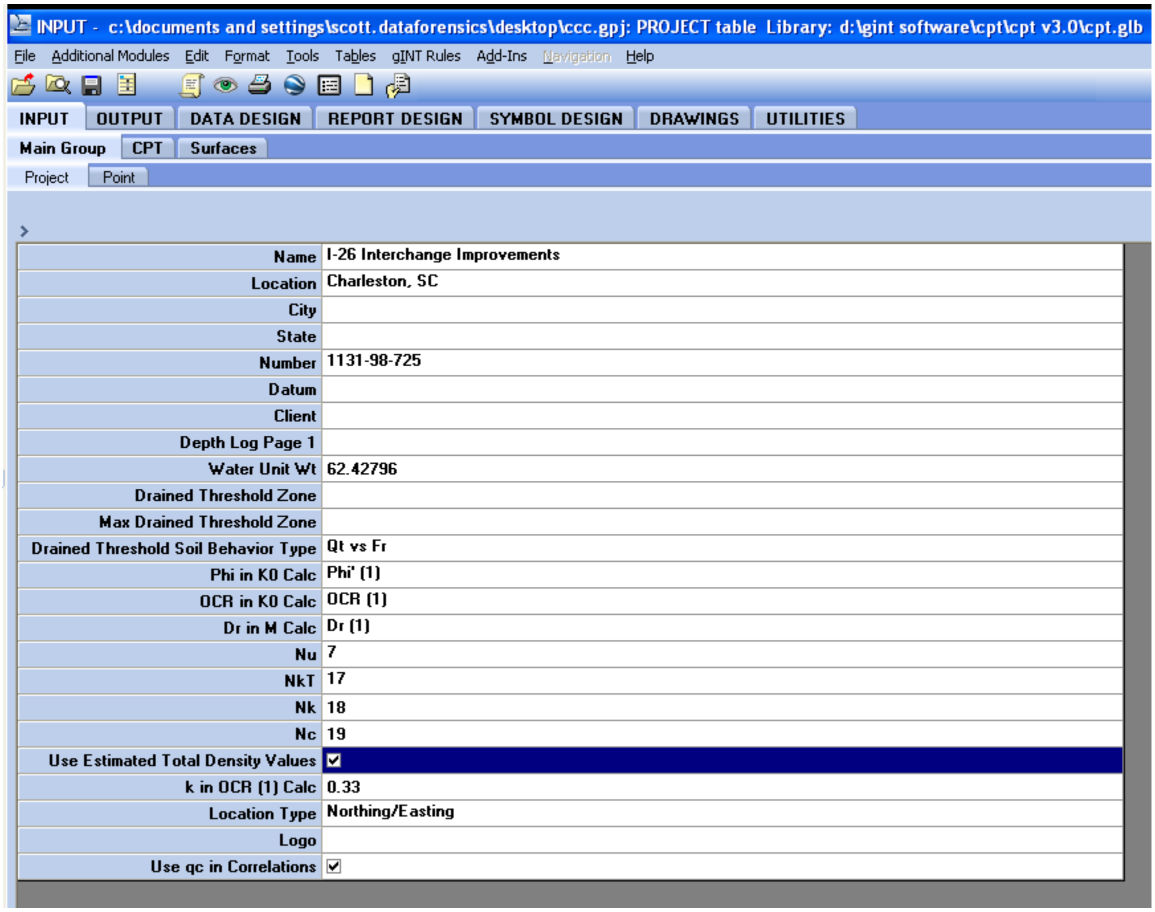
Setting Total Density Values for the entire sounding

If selected CPT data files have an estimated total density, the value will be imported in to the Assumed Total Density field in the CPT table, as shown below. An assumed total density may also be manually entered in the Assumed Total Density field if a value was not present in the CPT data file or if another value for this sounding is preferred for analysis.



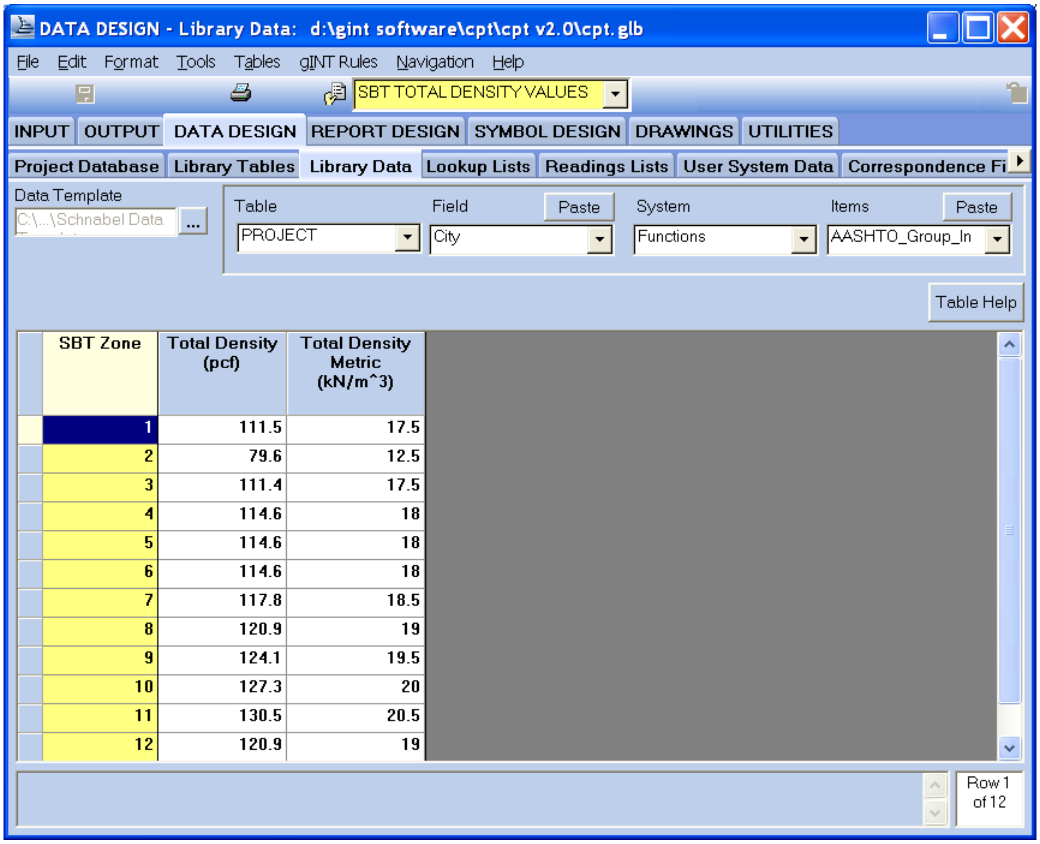
Having RAPID CPT determine the Total Density Automatically

Select the “Use Estimated Total Density Values” field in the project table to have RAPID CPT determine the total density values for each depth interval based on the soil behavior type. Any depth specific density values in the Override Total Density field in the CPT data table will override this setting though.

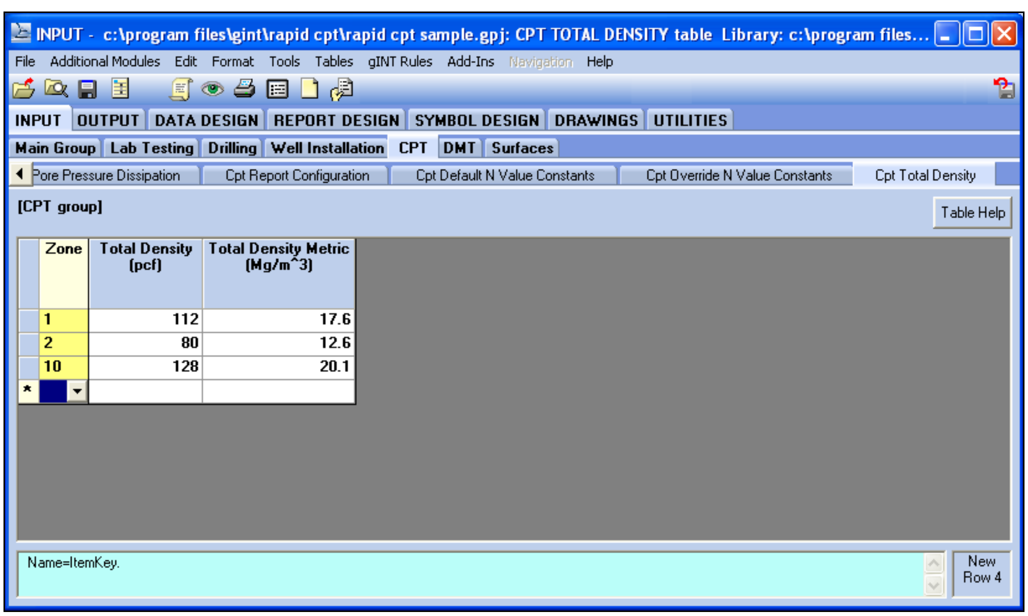


By Default, RAPID CPT will use the Estimated Density values in the library table SBT Total Density Values, which is shown below. The SBT Total Density Values table has the estimated total density values as detailed by Lunne et al (1997).

When setting the Estimated Density based on SBT zone, the non-normalized SBT from the Friction Ratio is used for the evaluation.



If you want to override any or all of the estimated total densities listed in the SBT Total Density Values table in RAPID CPT, you may enter a different estimated total density for each SBT zone in the Input table CPT Total Density. Any Soil Behavior Type Zone with a Total Density value in the CPT Total Density table, as pictured below, will be used as the estimated density for materials of the SBT zone for evaluation in RAPID CPT, unless you have specified Override Total Density values at depth in the CPT data table.



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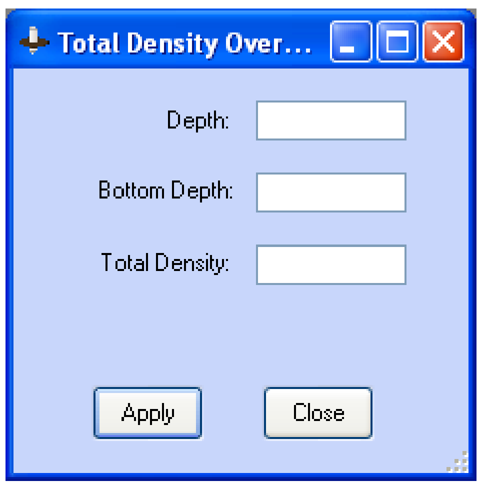
Setting Total Density Values for Specific Depth Intervals

You can specify the total density for materials at specific depth intervals for a sounding. This density value overrides all other density values you may have specified as described above in evaluating CPT data.

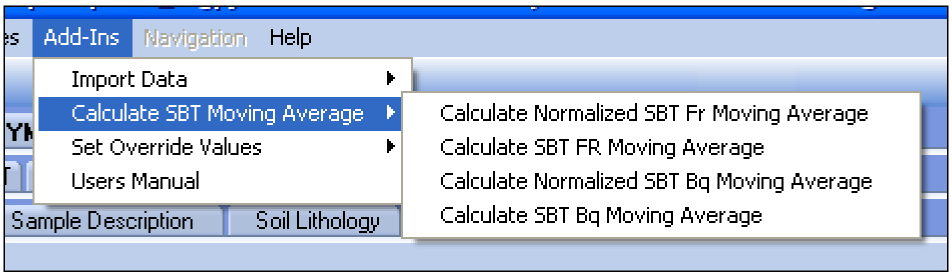
If the density of the soil profile varies it is straightforward to include the variation in the analyses.

- To set the Total Density Override values in the CPT Data table you can input the values directly in the CPT Data table or you can select from the Add-Ins menu Set Override Values->Set Total Density Values.
- The following dialog appears. You now enter a depth, bottom depth and the associated Total Density Override value. Input the values and click Apply. You may repeat this process as many times as necessary.
- Click close to return to the table where you will see the values have been set for the Total Density Override field in the CPT data table.



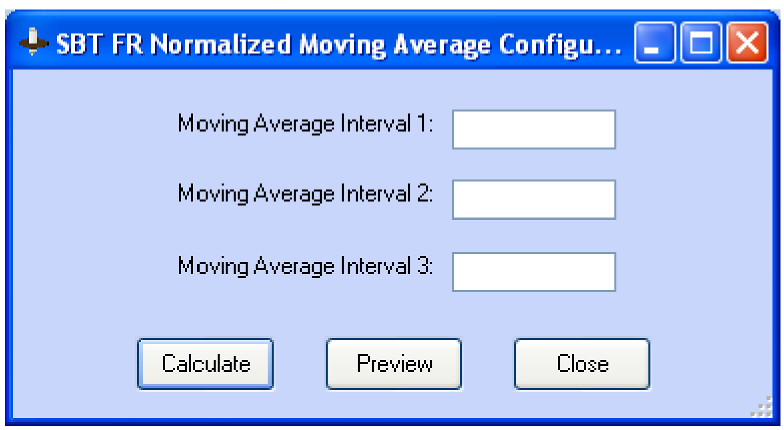
Tutorial 4 – Investigating the Moving Average on the Soil Behavior Type

The RAPID CPT tool allows you to investigate the differences in moving average intervals for each of the four soil behavior types. To view the smoothing effect of moving average variation, select a CPT sounding from the CPT table. Then go to the Add-Ins menu and select Calculate SBT Moving Average and then select one of the four options shown in the Figure below.



Soil Behavior Type Moving Average

- To investigate the smoothing of the Soil Behavior Type based on the Normalized Friction Ratio, select the first option, Calculate Normalized SBT Fr Moving Average, from the menu. The following dialog appears.



Moving Average Intervals

- Input the desired moving average intervals. The moving interval is calculated such that half of the entered interval is taken above and half is taken below the point being averaged. For example, an interval of 5 will average from 2 points above a specific depth to 2 points below the specific depth. Conversely, a moving average of 1 is no averaging.
- To preview the report, click 'Preview'. This calculates the values and then previews the appropriate report automatically (the reports that are used to preview are CPT Report – SBT FR Normalized – 3 Graphs, CPT Report – SBT FR– 3 Graphs, CPT Report – SBT Bq Normalized – 3 Graphs, CPT Report – SBT Bq – 3 Graphs). If you only want to calculate the values but will report them later, click the 'Calculate' button.

Tutorial 5 – Setting N values used in Undrained Shear Strength Calculations

The RAPID CPT tool allows you to specify N values used in undrained shear strength calculations in three different manners. The order of precedence for which N value is used in calculations is as follows.

1. CPT Override N value Constants at the point level
2. CPT Override N value Constants at the project level
3. CPT N values in the Project Table

The user's manual herein details how setting works from default up through CPT Override N value Constants at the point level.

CPT N values in the Project Table

N values in the point table are: N_u, N_{kT}, N_k and N_c. When you import a CPT data file, a default value for each N value is set. If you change the N values and then import new CPT data, the N values are reset to the default value. The default N values set when CPT data is imported are as follows:

- $N_u = 7$
- $N_{kT} = 15$
- $N_k = 15$
- $N_c = 20$

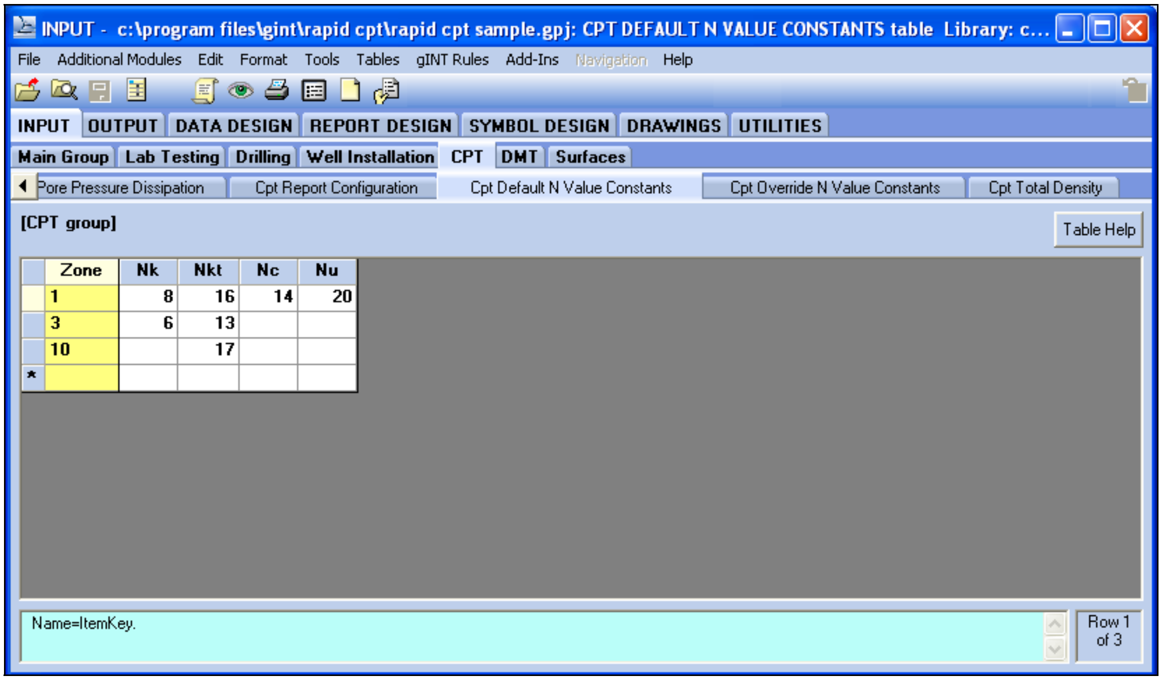
For each N value there is a range of values you can select from a drop down list. The value range is based on the current state of practice in CPT data evaluation.

CPT Default N value Constants by Soil Behavior Type Zones

RAPID CPT allows you to override the N value constants used to evaluate undrained shear strength in the project table with N values based on the Soil Behavior Type Zone.

When setting the N value constants based on SBT zone, the non-normalized SBT based on the friction ratio is used for the evaluation.

To override the project level N value constants based on SBT zone for the entire project go to the CPT Default N Value Constants table in Input. The table is shown below. Select the desired zones you wish to enter an N value override, and enter the desired N value constant. The N value constants used in this table will be used throughout the entire project unless overridden with the N value constants by point described below.

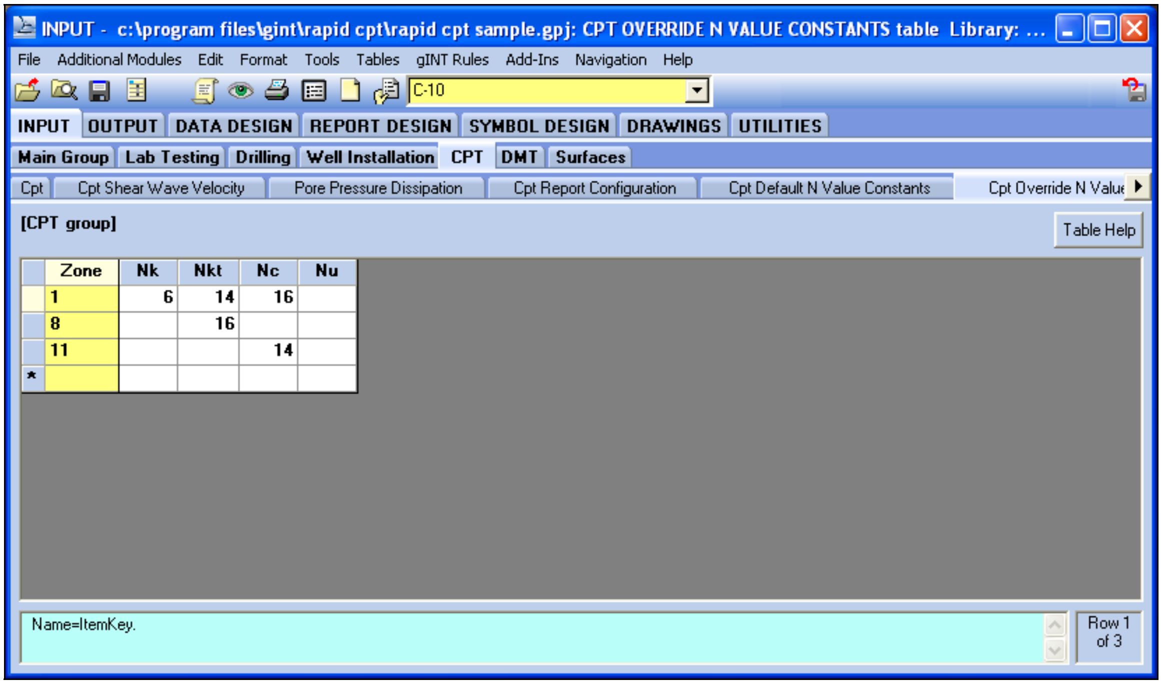


CPT Override N value Constants by Soil Behavior Type Zones

RAPID CPT allows you to override all other N values on a sounding by sounding basis for each SBT zone. This N value constant override will override all other N value constants you have entered within RAPID CPT as described above.

As with the Default N value Constants at the project level, the normalized SBT is used to determine the N values for a soil. You can decide if you wish to use the SBT based on B_q or F_r by selecting the desired condition in the Drained Threshold Behavior Type field in the project table.

To override the project level N values go to the CPT Override N Value Constants table in Input. The table is shown below. First select the sounding you would like to override the N value constants for from the dropdown list at the top of the screen. Then select the desired zones you wish to enter an N value override, and enter the desired N value.


INPUT - c:\program files\gint\rapid cpt\rapid cpt sample.gpj: CPT OVERRIDE N VALUE CONSTANTS table Library: ...
File Additional Modules Edit Format Tools Tables gINT Rules Add-Ins Navigation Help
C-10
INPUT OUTPUT DATA DESIGN REPORT DESIGN SYMBOL DESIGN DRAWINGS UTILITIES
Main Group Lab Testing Drilling Well Installation CPT DMT Surfaces
Cpt Cpt Shear Wave Velocity Pore Pressure Dissipation Cpt Report Configuration Cpt Default N Value Constants Cpt Override N Valu
[CPT group]
Table Help
Zone Nk Nkt Nc Nu
1 6 14 16
8 16
11 14
*
Name=ItemKey.
Row 1 of 3

Tutorial 6 – RAPID CPT Reporting Capabilities

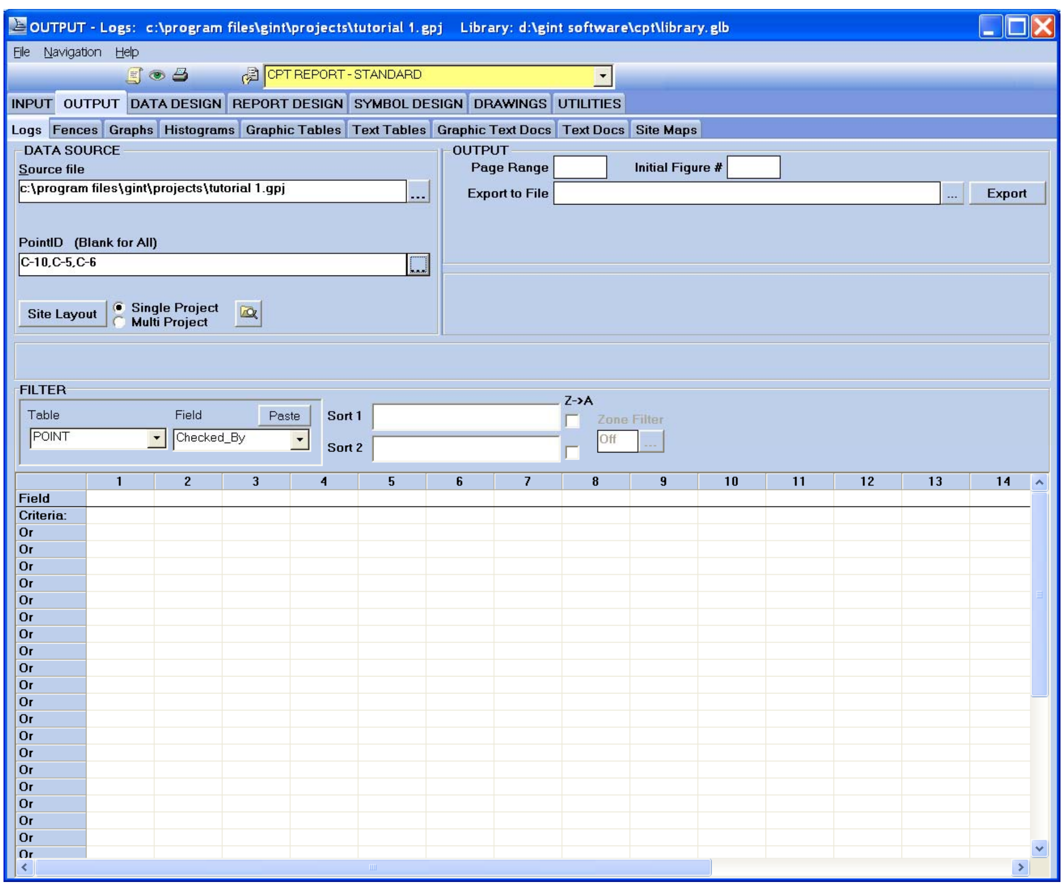
Log Reports (Logs tab in gINT)

There are two log reports that have been created in RAPID CPT that allow for any combination of parameters to be plotted, the CPT Report – Standard and CPT Report Dynamic.

CPT Report – Standard

The CPT Report – Standard is a quasi-static report. It allows the user to plot q_t, f_s, Pore Pressure, Friction Ratio, Normalized Soil Behavior Type based on Friction Ratio, and the user can specify whether to include an equivalent N_{60} plot or a Shear Wave Velocity plot.

- To generate this report, go to the Output module in gINT. From the pull down list at the top, select the CPT Report – Standard as shown below. Select the desired soundings to preview in the PointID field and click the Preview button . If you want to print the report, click the printer button.
- A dialog will appear prompting you to specify if you want to show Shear Wave Velocity plot on the report. Any value input in the associated field, will cause the Shear Wave Velocity to be plotted instead of an equivalent N_{60} plot.



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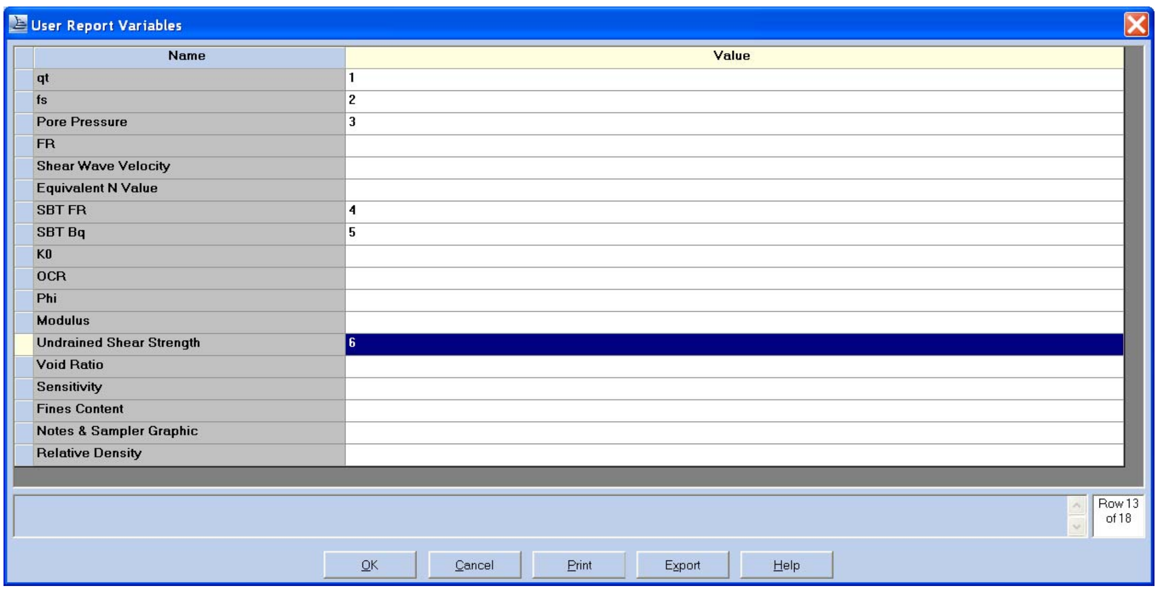
CPT Report – Dynamic

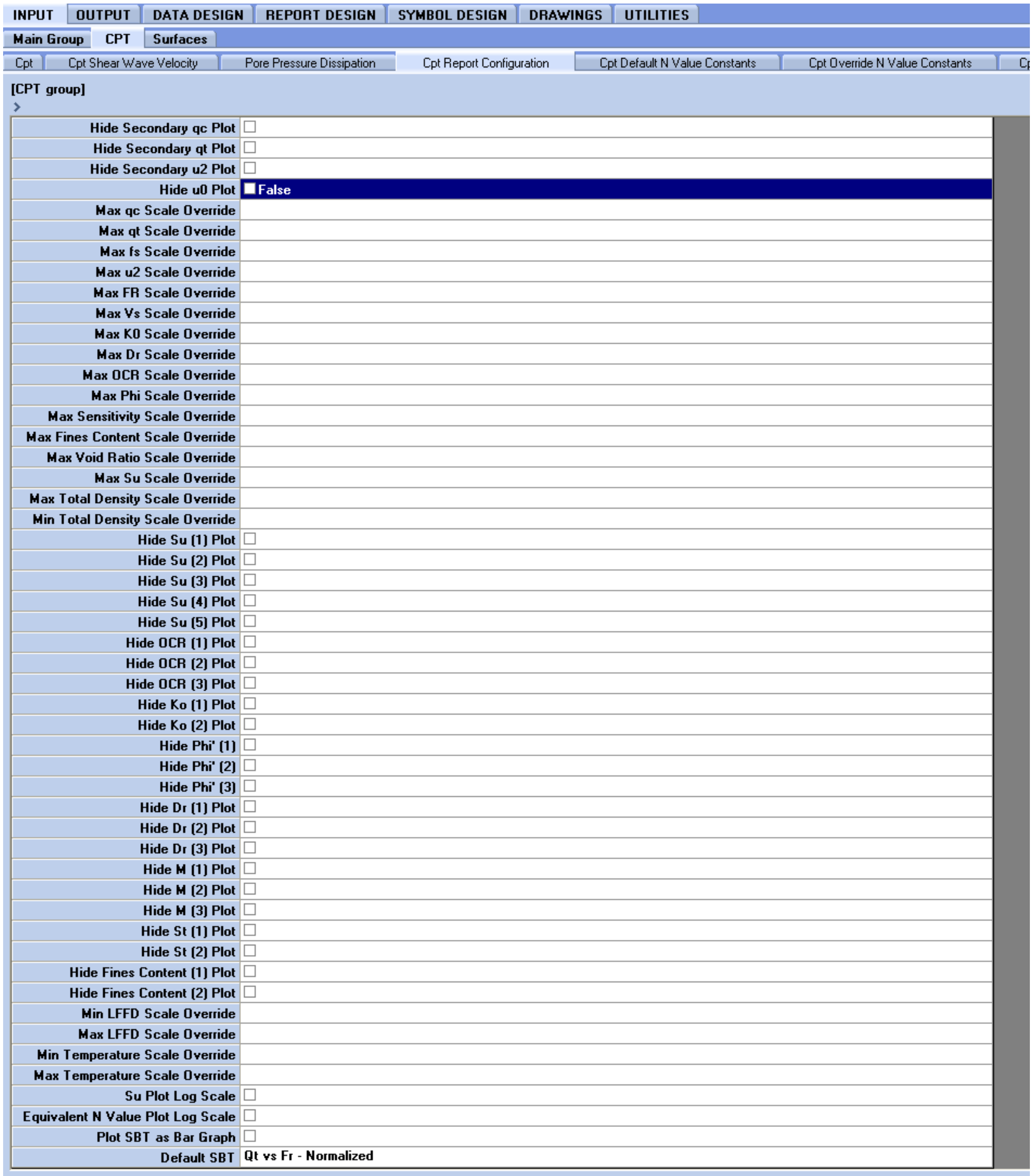
The CPT Report – Dynamic is a completely dynamic report. It allows the user to specify which parameters to include on the report and in which column position the parameter will be plotted. You can specify up to 6 different plots on the dynamic report.

- To generate this report, go to the Output module in gINT. From the pulldown list at the top, select the CPT Report – Dynamic. Select the desired soundings to preview in the PointID field and click the Preview button. If you want to print the report, click the printer button instead.
- The dialog shown below will appear. Input the numbers 1 through 6 in the fields next to the parameter to plot. In the example shown below, the parameters will be plotted in the following order: q_t, f_s, Pore Pressure, Normalized SBT FR, Normalized SBT Bq, and Undrained Shear Strength.



Report Configuration

There are numerous configuration capabilities that apply to all the log forms in RAPID CPT. To modify any of these options, go to the CPT Report Configuration table in Input as shown below.



- By default, the check boxes (Boolean fields) are unchecked (set as false). All items with a check box will be shown as long as the check box is unchecked. If you wish to hide a secondary axis or a specific item, you must enter a check the appropriate box. The following are examples hiding a secondary axis and a specific item.
  - When you display a graph with q_t on it, by default there will be a primary axis and a secondary axis and two plots. To hide the secondary Plot as well as the secondary axis on the q_t plot, check the 'Hide Secondary q_t Plot'.

- The primary axis maximum is determined dynamically based on the maximum value for all soundings in the database unless you input a value in the Override : for the following items: q_c, q_t, f_s, u_2, FR, V_s, K_0, D_r, OCR, Phi, Sensitivity, Fines Content, Void Ratio and S_u.

- The maximum value on the secondary axis is always set as 100 tsf, 200 ksf, 10000 kPa, 10 MPa or 10 Bars for q_t and as 8 tsf, 0.8 psi, 16 ksf, 800 kPa, 0.8 Mpa and 0.8 bars for u_2 and u_0.

- Several options have been added in RAPID CPT 3.0 (shown above) which allow the user to specify the Default SBT used on the reports, how the SBT is plotted as either a bar graph or a graphic column, and either plotting Su and Equivalent N Value on arithmetic or log scales.

Fence Reports (Fences tab in gINT)

There are several fence diagrams included in RAPID CPT, CPT - Elevation 11x17, CPT - Elevation 11x17 with Strata, CPT – Elevation 11x17 dynamic, and 4 overlay fence reports which can be used to do comparisons of a various parameters across multiple soundings.

- To print or preview a fence diagram, follow the same procedure for generating a log report from above, except you first select the Fences tab in gINT.

Graph Reports

There are seven graph reports included in RAPID CPT: The CPT Parameter Plot – q_t, CPT – Parameter Plot SU (1), CPT – Parameter Plot SU (2), CPT – Parameter Plot SU (3), CPT – Parameter Plot SU (4), CPT – Parameter Plot SU (5), and CPT - Pore Pressure Dissipation. The CPT Parameter Plot – q_t graph allows you to select up to 20 different soundings to overlay the q_t value on a single graph. The CPT – Parameter Plot for SU of any number plots all the values for the specified SU parameter in the project. The CPT Pore Pressure Dissipation allows you to view Pore Pressure Dissipation test results.

- To print or preview a graph report, follow the same procedure for generating a log report from above, except you first select the Graphs tab in gINT.

Tutorial 7 – Adding New Logos

To add new logos to your gINT Library, follow these steps:

- Select the Symbol Design tab in gINT.

- Depending on whether the file is an image file or a CAD File, proceed through each section accordingly.

  Bitmap Symbols (.bmp, jpeg, tiff, etc).

  - Select the Bitmap Symbols tab to import a bitmap, jpeg, etc or the Discrete Graphics tab to import .dxf files to use for the logo.

- Go to the File menu and select New and name your logo.
- Click the Load Raster file and choose the image to import.
- Proceed to the next step following discrete graphics.

Discrete Graphics (.dxf)

- Select the Discrete Graphics tab to import .dxf files to use for the logo.
- Go to the File menu and select New and name your logo.
- Go to the File menu and choose Import/Export->DXF Import.
- Choose your file and click Open.

Now that you have imported the image into gINT, add this to the list to be used for specifying the logo. Note that the first logo in the table here is the one that is used by default unless otherwise specified.

- Click the Data Design Tab.
- Click the Library Data Tab.
- From the dropdown list at the top (in yellow), choose Logos.
- Add a new row in this table naming it whatever you want and then choosing either the bitmap symbol, discrete graphic or both.

CPT Correlations

References are in parenthesis next to the appropriate equation.

General

p_a=atmospheric pressure (for unit normalization)
q_t=corrected cone tip resistance (tsf)
f_s=friction sleeve resistance (tsf)
$R_f = 100\% \cdot (f_s/q_t)$
u_2=pore pressure behind cone tip (tsf)
u_0=hydrostatic pressure

$B_q = (u_2-u_0)/(q_t-\sigma_{vo})$
$Q_t=(q_t-\sigma_{vo})/\sigma'_{vo}$
$F_r=100\% \cdot f_s/(q_t-\sigma_{vo})$
$I_c = ((3.47-\log Q_t)^2+(\log F_r+1.22)^2)^{0.5}$ 2
$I_{SBT} = ((3.47-\log(q_c/p_a))^2+(\log F_r+1.22)^2)^{0.5}$ 23

K_o

K_0 (1)	$K_o = (1-\sin\varphi)OCR^{\sin\varphi}$	
K_0 (2)	$K_o = 0.1(Q_t)$	1

Stress History

$OCR = \sigma_p'/\sigma'_{vo}$

(OCR 1)	$\sigma_p' = 0.33(q_t - \sigma_{vo})$	8
(OCR 2)	$\sigma_p' = 0.53(u_2 - u_o)$	9
(OCR 3)	$\sigma_p' = 0.60(q_t - u_2)$	9

N-Value

$N_{60} = (q_t/p_a)/[8.5(1-I_c/4.6)]$ 6

Undrained Shear Strength

S_u (1)	$S_u = (u_2 - u_o)/N_u$	where $7 \le N_u \le 9$	10
S_u (2)	$S_u = (q_t - \sigma_{vo})/N_{kT}$	where $15 \le N_{kT} \le 20$	11
S_u (3)	$S_u = 0.091 * ((\sigma'_{vo}{}^{0.2}) * (q_t - \sigma_{vo})^{0.8}$		21
S_u (4)	$S_u = (q_c - \sigma_{vo})/N_k$	where $15 \le N_k \le 20$	11
S_u (5)	$S_u = q_t/N_c$	where XXX $\le N_c \le$ YYY	
S_u (6)	$S_u = q_c/N_c$	where XXX $\le N_c \le$ YYY	

Drained Friction Angle

φ' (1)	$\varphi' = 17.6 + 11.0\mathrm{Log}[q_t/(\sigma_{vo}')^{0.5}]$	1
φ' (2)	$\varphi' = \arctan[0.1 + 0.38\mathrm{Log}(q_t/\sigma_{vo}')]$	13
φ' (3)	$\varphi' = 30.8\mathrm{Log}[(f_s/\sigma_{vo}')+1.26]$ (for clays or sands)	14
φ' (4)	$\varphi' = 29.5\, B_q^{0.121}\,(0.256 + 0.33\, B_q + \mathrm{Log}(Q_t))$	24

Unit Weight

$\rho = \gamma/\gamma_w$
$\rho = 0.8\mathrm{Log}(V_s)$ V_s in m/sec 17

Dataforensics

Relative Density and Void Ratio

D_R (1) $D_R = 100(q_{c1}/305)^{1/2}$ where, $q_{c1} = q_c/(\sigma_{vo}')^{1/2}$ 1

D_R (2) $D_R = -1.292 + 0.268\ln(q_c \cdot (\sigma_{vo}'^{-0.5}))$ 18

D_R (3) $D_R = (1/2.41)\cdot\ln(q_{c1}/15.7)$ 3

D_R (4) $D_R = 1/2.91 * \ln((q_c/(61* \sigma'_{vo}{}^{0.71}))*100$ 20

$e_o = 1.099 - 0.204\log(q_{c1})$ 1

$E_D = 5\ q_t$ $I_D = 2.0 - 0.14(R_f)$ $K_D = E_D/(34.7\cdot I_D\cdot \sigma_{vo}')$

Compressibility

M (1) = $R_m\ E_D$ where R_m= function(I_D, K_D) see the following table 22

$I_D <= 0.6$	$R_M = 0.14 + 2.36 \log K_D$
$I_D >= 3$	$R_M = 0.5 + 2 \log K_D$
$0.6 < I_D < 3$	$R_M = R_{M,D} + (2.5 - R_{M,D})\log K_D$
	$R_{M,D} = 0.14 + 0.15(I_D - 0.6)$
$K_D > 10$	$R_M = 0.32 + 2.18 \log K_D$
$R_M <$ 0.85	$R_M = 0.85$

M (2) $M = q_c\cdot 10^{(1.09-0.0075D_R)}$ *sands* 1

M (3) $M = 8.25\ (q_t - \sigma_{vo})$ *clays* 1

Sensitivity

S_t (1) $S_t = 7.5/R_f$ 2

S_t (2) $S_t = (q_t - \sigma_{vo})/(15\cdot f_s)$ 2

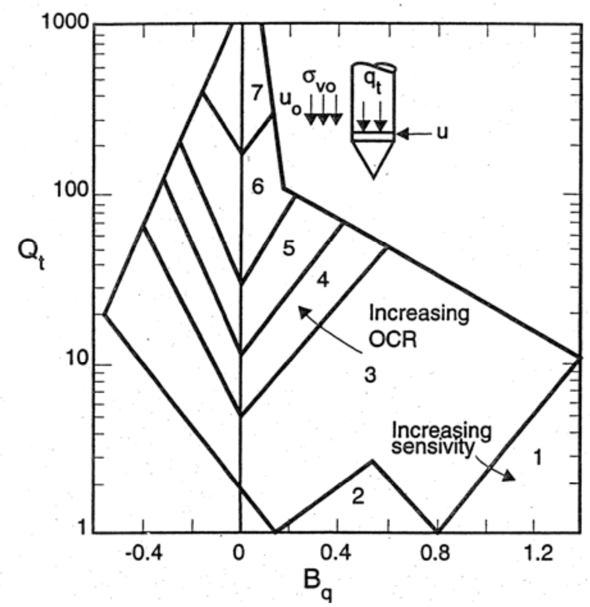
Fines Content

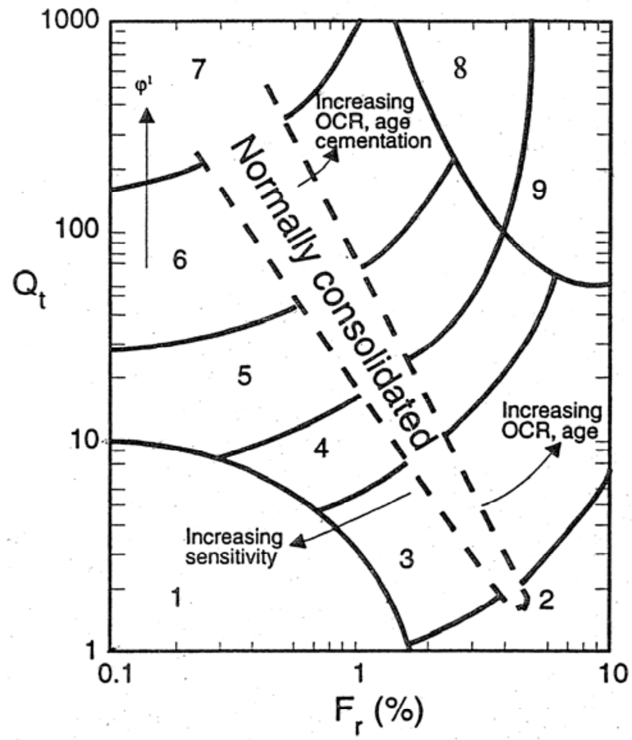
$FC = [(3.58\text{-}\log(q_t))^2+(1.43+\log(R_f))^2]^{1.8}$ 4

$FC = [5.31(I_{cfs})^{2.31}]+9.61$, where $I_{cfs} = [(1.95\text{-}\mathrm{Log}Q_t)^2+(\log F_r+1.78)^2]^{0.5}$ 4

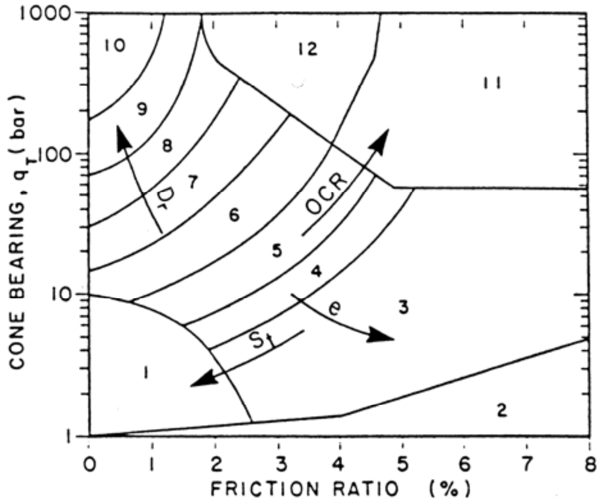
Dataforensics

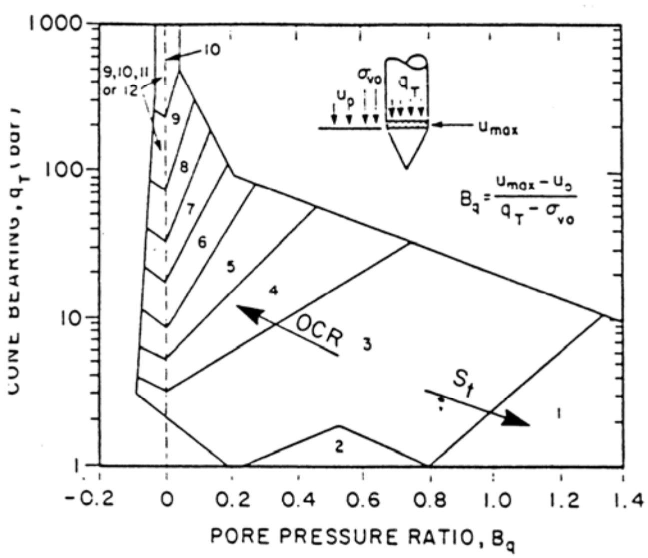
Normalized Soil Behavior Types - Robertson & Campanella (1990)





Non-Normalized Soil Behavior Types – Robertson & Campanella (1986)





Dataforensics

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