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GIS Use in Fill Material Tracking and Logistics for a Remedial Engineering Project

ArcGIS, ESRI

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A geospatial GIS site-specific database developed for use in the implementation of an Engineering Work Plan (EWP) for a remedial cover system project in New York City.

Table of Contents

List of Acronyms

GIS	Geographic Information Systems
ESRI	Environmental Systems Research Institute, Inc.
EWP	Engineering Work Plan
NYSDEC	New York State Department of Environmental Conservation
MQA	Material Quality Assurance
CQA	Construction Quality Assurance
FOP	Fill Operations Plan
SCO	Soil Cleanup Objectives
PPH RR	Protection of Public Health Restricted Residential
PGW	Protection of Groundwater
GWS	Groundwater Standard
BUD	Beneficial Use Determination
FAR	Fill Acceptance Request

Abstract

A geospatial GIS site-specific database was developed for use in the implementation of an Engineering Work Plan (EWP) for a remedial cover system project in New York City that requires detailed tracking of approximately 6 million cubic yards of fill material. The database includes a real time data entry system (e.g., tracking of material sources, barcoded bills of lading, material quantities, vertical and horizontal placement locations of each load of fill materials), and various web-based interfaces for interacting with and displaying the contents of the database. The database was developed per the requirements of the site specificEWP. The database was structured to meet project objectives with ample data storage ability by carefully selecting appropriate data field types, implementing coded value domains, and utilizing common relational database concepts. While certain data characteristics were maintained to minimize data storage needs, the database was developed with capabilities to incorporate attachments such as photographs and pdfs, therefore providing additional functionality and usability that were key to the project, reducing reporting costs and improving efficiency.

The project involved importing and placement of approximately 6 million cubic yards of fill material to complete the environmental remediation at the site. Given the magnitude of material requirements, the fill material was sourced from numerous suppliers and as such tracking and placement of materials was one of the most important components in the implementation of the project. The tracking of fill materials could be completed with significant efficiency and accuracy in an innovative way with the use of the latest GIS applications including ArcGIS for Desktop, ArcGIS Online and ArcGIS Collector Application. Several innovative handheld user interface hardware gadgets were utilized for data entry. In this data entry procedure, GIS provided with readymade user interface application and work flow that could be customized to fit project needs and details. Some of the key geospatial analytics included gathering of geospatial data using the Collector Application, display and manipulation of geospatial data in ArcGIS online, strategic manipulation of data in ArcGIS for Desktop enabling querying and reporting to meet project needs.

The GIS specific functions including data gathering capabilities, geospatial analysis, querying and reporting functions not only increased the efficiency on searching of historical data but also improved the quality assurance and quality control capabilities on the project. Given the application capabilities and fluid nature, these or similar tool would be considered to add value to a project, reduce man hours for QA/QC as well as serve as powerful reporting objects in a wide range of applications.

1.0 Introduction

The project site (Site) located in Staten Island, New York included approximately 440-acres of upland area. In accordance with a Modified Order of Consent with the New York State Department of Environmental Conservation (NYSDEC) to address environmental remediation at the Site an Engineering Work Plan (EWP) was developed for the construction of a Surface Cover. The Surface Cover included placement of approved fill materials in upland areas of the Site in 12” compacted lifts. The fill material must meet acceptable physical and chemical placement criteria to prevent unacceptable exposure of Site related constituents to potential human health and environmental receptors. To facilitate redevelopment of the Site, in addition to soil materials, asphalt, concrete, and other development related features protective of potential receptors were approved for use as Surface Cover. The types and criteria of the Surface Cover Layers are listed in Table 1.

Table 1 – Surface Cover

Surface Cover Layer	Material Type	Chemical Criteria	Physical Criteria
Cover Layer/Landscape	Soil	Ecological SCO	Vegetative/Topsoil
		PPH RR and PGW SCO	Vegetative/Topsoil
Cover Layer/Development Feature	Concrete, Asphalt, Clay	Ecological SCO for Clay	Impervious – Building, Roadway, Basin
Middle Layer	Amended Dredge, Soil, RUCARB	Commercial and PGW SCO (or) Commercial and GW Standards	Geotechnical Criteria and 4-ft above SHGW
Bottom Layer	Unamended Dredge, Soil, RUCARB	Commercial and PGW SCO	Geotechnical Criteria

The installation of the Surface Cover will address the potential exposure pathways that include direct contact and inhalation exposure to constituents in existing surface soils. The EWP included several quality assurance plans associated with the placement of Surface Cover materials for the Site. These plans describe the chemical criteria (i.e., Material Quality Assurance) and physical criteria (i.e., Construction Quality Assurance) of Surface Cover fill materials and the methods to be employed to ensure compliance with these criteria. The EWP included a Fill Operations Plan (FOP) that detailed fill material tracking requirements to ensure only approved material is imported and placed at the site.

2.0 Material Acquisition

The project involved importing and placement of over 6 million cubic yards of fill material to complete the environmental remediation at the site. Given the magnitude of material requirements, the fill material was sourced from numerous sources and suppliers. In order to ensure the fill material met the pertinent chemical and physical criteria, due diligence activities were conducted as part of material selection, acceptance and approval. Pre-existing data and/or characterization data for each material source (typically associated with each project) was compiled to support evaluation of the material for a

Beneficial Use Determination (BUD) request or Fill Acceptance Request (FAR) that are part of the NYSDEC material acquisition framework.

3.0 GIS Database

To support the FOP and various quality assurance plans in the EWP, a site-specific Database was implemented utilizing Environmental Systems Research Institute, Inc. (ESRI) ArcGIS software to monitor and track the placement of fill material at the Site.

ESRI is known as a nationally and internationally recognized industry leader in the development of Geographic Information Systems (GIS) software. The site-specific Database was developed utilizing the ArcGIS software package that was envisioned to embrace the most recent advancements in GIS technology.

3.1 Database Structure

The Database was developed to serve as a real time data entry system, with various web-based interfaces for interacting with and displaying the contents of the Database. A comprehensive list of database fields was identified to capture the information necessary per the EWP. Using site-specific data as base layers, preliminary data tables and fields were established within the database. Typical dataset tables included material delivery data, list of suppliers, settlement plates, testing results, staging area, elevation data, etc. The data tables were structured to minimize the data storage requirements by carefully selecting appropriate data field types, implementing coded domain values. ArcGIS for Desktop software licensed by ESRI® was utilized with publications to the ArcGISonline web-based interface. Nominal and industry standards for hardware security such as geo-redundancy servers, for data security including daily data backup, and user security, including authorized read/write access user credentials were implemented. As an added security feature, edit tracking records were established. The Database was secured to prevent editing or deletion of data by unauthorized individuals and only accessible via individually assigned user accounts. The user accounts allowed establishment of read/write access to the data thus preventing editing or deletion of the data by unauthorized individuals in addition to facilitating edit tracking. Edit tracking feature recorded the date, time, and user who created the individual database record as-well-as the date, time, and user name of the last person to modify the record.

Field data collection was completed with the use of iPads with cell phone data connectivity that allows the collected data to be added to the database in real-time. The iPads were paired with hand-held barcode scanners that allow the scanning and direct entry of barcoded information from the bills of lading, delivery vehicles, driver identification cards, etc. To improve location accuracy, the iPads were paired with higher accuracy GPS units. For data gathering, site specific layer hosted on ArcGISonline and accessed via ArcGIS Collector application was utilized. The collector layers were published with specific features and fields to minimize the interferences and time taken for data collection thus improving efficiency.

The Database was created with the capability to incorporate attachments, such as JPEG or PDF file types. Photographs of bills of lading, weight tickets, delivered materials, etc. can be directly entered into the Database eliminating the need to manage and relate certain documents separately from the database. Managing these documents within the database created a comprehensive repository of data that provides better functionality and usability for project.

3.2 Data Gathering

Subsequent to approval of a BUD/FAR, a site specific bill of lading (BOL) or manifest was created for each BUD/FAR. Each BOL/manifest included specific information for generator, processor, supplier, shipper, delivery site, BUD/FAR number, material description, quantity, signature fields, and certifications as applicable and a unique barcode number for material tracking. Pertinent additional information was included on a case-by-case basis. Each BOL/manifest was printed on a one to five part regular or carbonless papers and provided to the supplier or shipper as applicable. Each truck delivering fill material to the site carried the unique site specific BOL/manifest. The truck was inspected and logged into a computer at the scalehouse and directed to material delivery phase on-site. At the delivery phase, the BOL/manifest was inspected as well as the delivered material was inspected for quality control and location of delivery/placement was logged into the Database using ArcGIS Collector application. For in-water barge deliveries, a BOL/manifest was completed for each load and entered into the Database. The material in each barge was inspected prior to offloading and at the locations of staging/placement. The locations of placement were logged into the Database using ArcGIS Collector application. The daily tracking data logged into the scalehouse computer and the iPad devices was synced into the Database. Subsequent to syncing, QA/QC procedures were completed for the data and reports were generated and distributed. The Database was used for generating daily, weekly, biweekly, monthly, annual, project total, BUD/FAR completion reports as well as for contractor tracking and invoicing reports.

4.0 Conclusion

Over the course of the project about 2 million features with various data fields were collected over an approximately 4 year period. The Database sensitivity and response to accessibility and user loads were maintained at satisfactory levels and only one down time was observed due to an issue with external third party link server. Overall the Database functional goals were considered to be achieved. Depending on future needs, additional expansion may be warranted.