ARCGIS Online for Interactive Database Management

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ABSTRACT

Coal combustion residual (CCR) closure is complex and requires multi-disciplinary tracking for construction and quality management over long durations and serving a wide range of stakeholders. Accordingly, CCR closure projects require well-designed processes for data collection, storage, organization, and recall. This paper presents implementation of ESRI's ArcGIS Online (AGOL) platform to aggregate content from the field, store and organize data, and allow access to this information both in an online environment and via traditional files (e.g., PDF, MS-Excel).

AGOL is uniquely suited for a large volume of photos and videos collected using smartphones, tablets, and drones. Digital data collection allows for the accumulation of significant amounts of files, so a proper data management strategy is imperative. Each piece of information comes with a host of metadata (e.g., geolocation, time, date) that typical storage methods do not utilize. Moreover, the burden of naming each photo file and creating a storage file structure is cumbersome. Photo storage and effective / efficient recall presents new challenges in data management.

In addition to solving 21st-century problems like photo management, AGOL is a powerful tool for solving age-old problems in construction quality assurance such as generating conventional paper-style forms and / or summary tables. Tablet-based data recording is increasing in popularity and the AGOL environment includes an app for cell phones or tablets called Survey123. The authors have created purpose-built Survey123 applications for use on CCR closure projects with various checklists and fillable forms. This paper describes the implementation of AGOL to-date and includes opportunities for future applications.

INTRODUCTION & OBJECTIVES

Hundreds of facilities in the United States are conducting closure under the U.S. Environmental Protection Agency (EPA) "Disposal of Coal Combustion Residuals from Electric Utilities" national Regulations (1). Coal combustion residual (CCR) closure is complex, with multi-faceted approaches requiring documentation of proper construction and ongoing performance. Closure construction for CCR facilities frequently extends over multiple years and often includes multiple subcontractors performing smaller components of a larger closure design. Records taken daily or multiple times per day over a several-year-duration closure project results in a large amount of documentation to track and manage.

This large quantity of multi-disciplinary tracking for construction and quality management extends over long durations and serves a wide range of stakeholders. The regulatory nature of CCR closure necessitates detailed construction requirements, and documentation of construction to meet these requirements must be frequent, accessible, and able to be seen while in the field.

Documentation must be managed in a way that it may be easily retrieved. In the past, documentation has traditionally been through the use of paper forms, photography, or similar one-off quality observation field collection methods. Filing of forms, photos, and other documentation can be cumbersome and time-consuming. Traditional filing systems are often difficult to navigate and can provide barriers to the timely recall of information.

ArcGIS Online (AGOL) (2) provides an online interface platform to store, view, filter and share large volumes of varying types of data. Data is collected in the field using the Survey123 mobile application that can be accessed via cell phone, tablet, laptop, or other hand-held options. Various data collection forms are created from a desktop, sent to the Survey123 application for field data gathering, and populated to the AGOL site. The interface also allows for email or text message notification with the click of a button for high priority field observations. This paper describes the implementation of AGOL to-date and includes opportunities for future applications.

SYSTEM OVERVIEW

WSP Golder has a Geographic Information Systems (GIS) team that specializes in the creation of AGOL websites and field quality documentation form creation that is tailored to a project's specific needs. An AGOL site can begin with an initial request from a project site and then be expanded and modified throughout the life of that project. The GIS team also provides support for the alteration of tracking forms and the addition of new information to AGOL as project needs evolve.

The design of the customized AGOL platform is directed by the nature of the CCR closure project. Critical areas of construction, observation, maintenance, CCR placement tracking, etc. are identified. Inspection plans are conceptually identified with

respect to locations, frequency, and key factors to observe and record. The vision and goals for the field inspections are identified, including when to notify people and who should be notified of a deficiency, if a report should be sent periodically to key stakeholders, or whether the data should simply be gathered to create a site construction history that can be recalled for future discussions or decisions. Quality management areas could include: clean closure verification; earthworks construction; laboratory and / or in-situ test data (e.g. compaction data); BMP installation and / or performance; geotechnical field investigation records; field samples; and many others.

In a traditional field inspection plan, this would typically be the point where a paper form would be designed, or a shared filing system would be created for photo uploads off a digital camera or cellular phone. A distribution protocol may be created, but it would typically involve a workflow where an individual has to write a report, scan paper documents, or attach other documentation to an email or printed form for distribution. Some sort of manual filing of the documentation may occur as well. Time and effort following the field inspection would be required, including periodic maintenance and clean-up of the filing structure. With the involvement of AGOL and GIS professionals, the field inspection planning changes. Figure 1 depicts the proposed improvements to field inspections achieved through using AGOL.
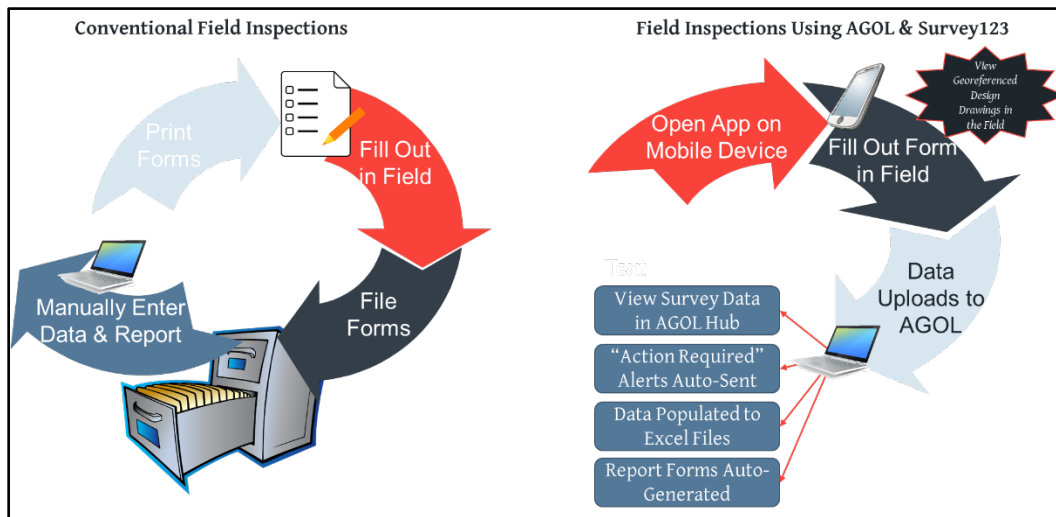

Figure 1. Quality Data Management Comparison

FORM DEVELOPMENT

Unlike in a traditional plan, the GIS professionals can work with anything from mimicking an existing inspection form to creating an electronic form from a bulleted list of items or a conceptual discussion of what should be documented. Through collaboration with the GIS team, engineering design teams, field personnel, and other stakeholders, electronic forms can be designed to meet multidisciplinary needs. Instead of creating a paper form, the inspection will be conducted using a digital device such as a tablet or cell phone. Figure 2 depicts an example of a paper form translated into a simplified digital form using the Survey123 (3) platform.
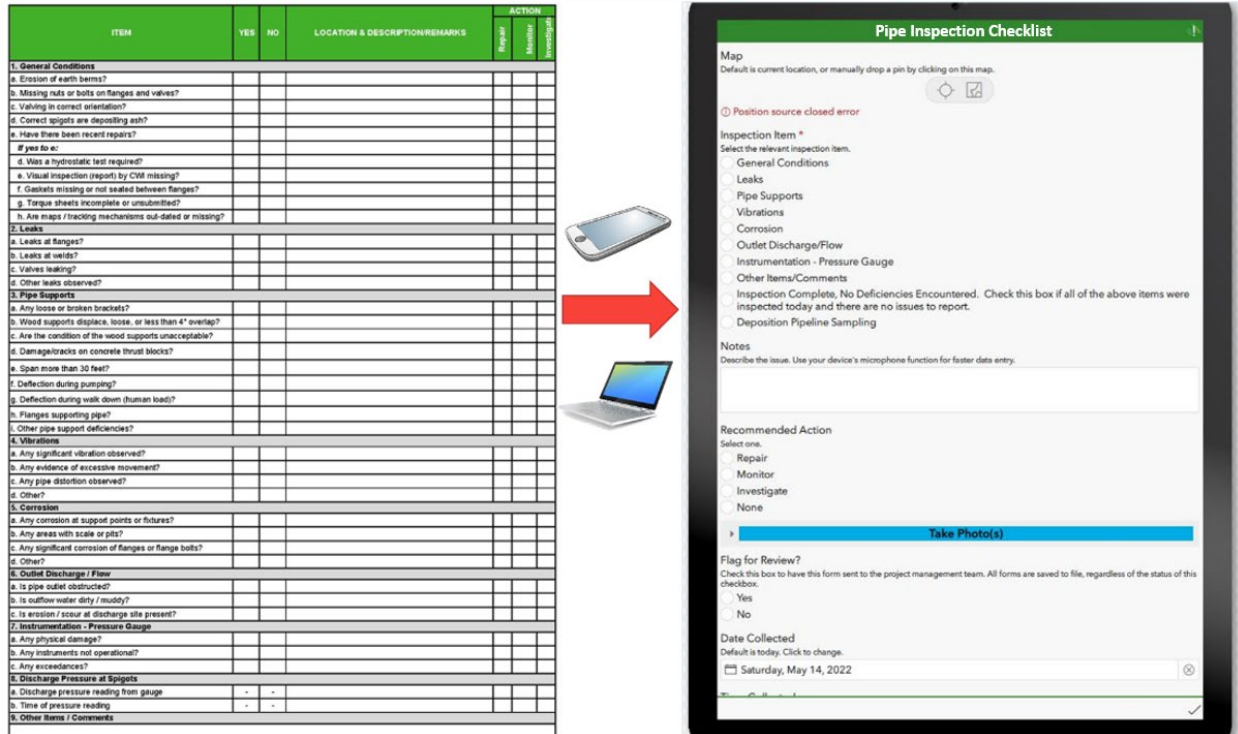
Figure 2. Example Paper Form Translated to Survey123 Form.

Field inspection form design is tailored to the needs of the specific site inspection. Multiple forms are created for the various requirements of a given project site. For a given inspection form, fields are specified for completion in the form of radio buttons, drop-down selections, checkboxes, or text entry fields. Conditional logic may be built into the forms; for example, a group of radio buttons may exist, and by selecting one of the radio buttons, additional fields will appear for completion. Different fields on the form may be selected as "required," where the form may not be submitted without their completion. The option to add photos to the inspection is also a part of the form.

Digital forms are created using Survey123 (3) using one of two methods. The online Survey123 website interface is more user-friendly, does not require GIS skills (although some experience does help), and does have some limited functionality. GIS professionals can also utilize the Survey123 Connect desktop application, which uses MS Excel spreadsheet-based design and has increased functionality to implement dynamic inspection forms. The digital forms as well as the output definitions are created at this stage. Once the forms are created, they will be available for download in the Survey123 mobile application for field inspection. At the option of the team, the forms may also be available for completion on the AGOL website for the given project.

Survey123 field inspection forms are also georeferenced. While location identifier selector can also be added in the fillable form fields, a latitude, longitude, and altitude are automatically recorded. The default location will be determined based on the geolocation of the GPS sensor in the device being used; however, if the user is not located at the observation point (e.g., is viewing something from a vantage point or is

using an electronic device not capable of collecting location data), then the user has the option of opening a map view and dragging the location pin on the map to the inspection point.

OUTPUT DEVELOPMENT

By default, Survey123 data collection produces several outputs. Field data collection populates the project's online AGOL database with form attributes, GPS location of the form submittal, attachments, and photos. An online map on AGOL shows all collected information as it is populated with this database information as well as any number of customizable online geospatial applications. Relevant spatial layers are added to the AGOL platform, including basemaps, aerial imagery, geolocated construction drawings, and other site features extracted from CAD, Google Earth, MS Excel, desktop GIS, or other sources. The information is easily downloadable in many formats depending on the form design, including CAD, GIS, MS Excel, and photos to a folder.

A vision for the desired outputs of the field investigations is critical to the data management design, as the AGOL platform allows for the automated generation of a variety of end-products from the Survey123 field investigations. The completion of the field inspection form can alert team members via email when a critical observation is made; the notification will contain a link to AGOL and the survey point collected. Field personnel have the option to flag items as critical or in need of follow-up in the form collection as well. Portable Document Format (PDF) reports may be autogenerated to customized designs and received in a shared folder, simply by collecting the field inspection (no extra steps, automated program output). Data can be auto-populated to a shared MS Excel table, allowing for the tracking of maintenance items and punch-list creation. This is a non-exhaustive list of the potential autogenerated outputs from the AGOL platform. Using advanced Survey123 and ArcGIS Online tools, as well as 3rd-party applications, an extremely dynamic and entirely automated workflow can be set up, resulting in a number of products /outcomes.

Photo storage, management, and retrieval are improved through the use of AGOL. As part of the database, photos are uploaded as collection points with geospatial information; this survey form becomes a layer on the AGOL map that can be toggled on and off. The photos can also be filtered using the time slider; this powerful tool allows a user to view project progress at a given snapshot in time. The ability to view a known area at a given time using AGOL can provide great value in making design or operational decisions during the CCR closure, and site history is a key factor. Photos are also easier to retrieve, if one knows the dates and areas of interest they would like to focus on. Traditionally, one would need to comb through online folders looking for a photo of a given area, but in AGOL one can use the map viewer to navigate to the area of interest and even filter by a given date range.

An example AGOL website with some key features is displayed in Figure 3. The default map is displayed in the map viewer, however, if additional aerial images or base maps are available, they may be uploaded and populated in the Layers control column outlined on the right. Survey points, by survey, can be toggled on and off as layers as

well; the dots in the center of the Map Viewer depict georeferenced field inspections for the selected Field Results layer. Measurements may be taken directly in AGOL using the Measure button near the top left. Smart Editor allows post-upload editing of inspections from the web-based platform. The Filter button allows for the refinement of survey form points displayed in the Map Viewer. Time Slider allows survey form points to be filtered by date, so that historical construction photos or investigations from a given timeframe may be filtered or observed. Data may also be collected to populate charts developed by our GIS team and displayed in AGOL. The arrow at the bottom-center of the map will expand a data table for attributes of displayed data points.

Figure 3. Example ArcGIS Online Interface.

DATA MANAGEMENT

One of the great advantages to utilizing the AGOL platform is the data management capabilities of the system. AGOL also has the storage capacity to handle large numbers of photos. For example, if one takes ten (10) 5-MB photos of a project in a given survey, then site photos alone can easily exceed 100 GB annually; the AGOL platform can handle these photos' storage as well as inspection data and allow users to view them without taking up local storage. The AGOL interface creates a database from each inspection form and collection point for each form, and all of this data is accessible by AGOL users. Data is simplified and converted for ease of use in the AGOL website interface.

Many clients are sensitive to data accessibility and the sharing of photos and other information. The upload from Survey123 can happen over a wireless internet connection from a non-cellular-accessible tablet, preventing the use of personal mobile devices or the unwanted sharing of sensitive information when taking digital field collection points if the client request such protocols. Bluetooth capability allows the non-cellular tablet to tether to a stand-alone mobile GPS receiver for increased geolocation precision. Data on the AGOL platform is only accessible to those users who are given

access specific portions of the project; data collection and viewing can thus be restricted based on the individual user. Data is housed on the ESRI platform, which is used and trusted by most U.S. regulated industries (2).

WORKING IN THE FIELD

As described above, the field forms will be downloaded to a mobile device using the Survey123 Application. The inspector will open the survey in the application, collect a data point, complete the form, and submit. If the site has internet or cellular connection to the mobile device, then the synchronization from Survey123 to the AGOL cloud database is automatic and immediate. If the site has spotty or non-existent internet or cellular service, then the collection in Survey123 takes place in "offline" mode, and all data is stored on the mobile device; once the mobile device returns to internet connectivity, the upload and synchronization with AGOL takes place. Once data collection and upload is complete, the information is available on the ArcGIS Online cloud. From there, the digital workflow travels through the automated processes, as described previously. No filing or paper form handling are necessary because all of this has been completed automatically.

An additional feature of the Survey123 application is the ability to view base layers in real space when in the field at the project site. Georeferenced design drawings, aerial photos, and other features can be downloaded (when online) to the mobile device. When in the field, using the geospatial data from the mobile device or a tethered GPS receiver, the user may open the map or drawing in Survey123 and see where they are in relation to key design components, critical features, or other areas of interest and can have the experience of "walking on a design drawing".

Effort is put into the field interface, so that the form is easily completed in the field and reduces the potential safety hazards caused when workers take their focus off the project surroundings. Form completion is generally quicker and easier than a traditional paper form and, in the case of cell phone usage, fits in the user's pocket. Without papers, clipboards, pencils and the like to keep track of, personnel can focus on getting into a critical area, conducting the work, documenting required information, and safely egressing.

FUTURE APPLICATIONS

While AGOL has been successfully implemented on many CCR closure projects to-date, there is always the potential for an evolution of future applications for the interface. For example, a current update that we are working on will track the excavation and placement locations of CCRs along with geotechnical data to provide a database of information in the event of future beneficial reuse. The potential applications for these systems are ever evolving, and WSP Golder is constantly looking for ways to improve the field-to-office interface by using these tools.

CONCLUSIONS

ArcGIS Online (AGOL) provides a platform for both storage and significantly improved recall of large quantities of data. Use of the Survey123 app in the field reduces paper and, instead, creates functional and customizable data management. The ESRI systems allow for editing of existing field forms and creation of new forms as project sites evolve and new needs arise. Digital field forms and the AGOL platform allow for a comprehensive web-based management of aerial imagery, design drawings, field inspections, and site photos for communication and understanding between the field and off-site supervision of large CCR closure projects.

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