Development of an engagement plan on green stormwater infrastructure

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Abstract

Green infrastructure (GI) as a decentralized solution of stormwater management can be affected by the public opinion during its implementation. To improve its public awareness, an engagement plan has been built for the Green Infrastructure Living Laboratory (GILL) project in Philadelphia to engage the public in green stormwater infrastructure (GSI) sites data collection. Sensor data and engagement information, such as images and comments, will be transmitted via cell modem to a cloud based database. Housed in a cloud platform, a Monitoring and Maintenance App (MMA) will be designed and developed by Drexel team to enable easy access to information to learn about the project and view real-time data at GSI project sites. MMA will also facilitate public discussion and create pathways for contributing to site-specific data collection, inventory management and report generation. Interpretive signage, large format data displays, web pages, and other interactive and social media will also engage pedestrians, students in classrooms, and the public at large to raise awareness of the GILL effort.

1 Introduction

An Engagement Plan will be developed with the dual goals of making the public aware of the monitored green stormwater infrastructure (GSI) sites and engaging the public in GSI data collection. This plan is associated with the Green Infrastructure Living Laboratory (GILL) project established to monitor GSI in the University City District of Philadelphia. Funded by Philadelphia Water Department (PWD), the project is managed by Drexel University through its Sustainable Water Resource Engineering (SWRE) lab. GSI facilities, including green roofs, rain gardens,

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permeable pavement, rainwater harvesting cisterns, and other decentralized stormwater management practices (SMPs), will be monitored by the team, and interactive web apps and other engagement tools will be developed.

Sensor data will be transmitted via cell modem to a cloud based database. Using Vista Data Vision (VDV), a data management platform previously obtained by Drexel with funds from the National Science Foundation, this data can then be displayed in real-time in different formats on password protected websites. Drexel can create customized dashboards for different users. One password/website could be created for PWD, another for the public, and a third for teachers/professors who might use specific data streams in classroom activities. Drexel recognizes the potential sensitivity of some of the data being collected, and in the Engagement Plan, will specify the design of the different web pages, indicating exactly which data will be posted on which site. VDV can also be used to enable controlled downloading of time series data to which individuals are granted access.

A web-based application ("web app"), Monitoring and Maintenance App (MMA), will be developed by Drexel's APP Lab. The APP Lab is available to all students across the university, facilitating formal and informal collaboration between groups spanning vastly different fields of study. Throughout the GILL project thus far, GILL student researchers have been working with APP lab students and staff to develop MMA that is optimized for smartphones, incorporating information spanning all of the GILL project sites. MMA will allow pedestrians passing by sites to upload photos, view monitoring data, and qualitatively identify characteristics of the GSI site (e.g. full of litter, eroding soils, ponded water, dead plants, etc.) from their smartphones. To enable this type of interaction and engagement, Drexel plans to host both real-time sensor data collected in the GILL as well as community-contributed information (notes, photos, and discussions) on a secure cloud-based server system. Sensor data is transmitted either via cell modems to a cloud database. This data is then integrated for display in real time through MMA and additional websites.

2 Methods

2.1 Project Goals

A primary goal of GILL project is engaging students, residents, and visitors to learn about GSI and the Green City, Clean Waters program. This engagement plan was designed to specifically

address this objective, with the dual goals of increasing public awareness of the monitored GSI sites and also engaging citizens in GSI data collection. Both aims will be largely facilitated through MMA, enabling easy access to information to learn about the project and view real-time data at GSI project sites. MMA will also facilitate public discussion and create pathways for contributing to site-specific data collection. Interpretive signage, large format data displays, web pages, and other interactive and social media will also engage pedestrians, students in classrooms, and the public at large to raise awareness of the GILL effort.

2.2 Public engagement

To enhance public engagement with the GILL program, a suite of online services is developed to support and enhance MMA. MMA offers general information about the project, an opportunity to engage as Citizen Scientists by contributing observations and photos from site visits, and will soon provide near real-time measurement data from GSI sites. The typical process involves manually collecting field data during a GSI site visit, taking notes and photos, and transferring manually collected data to digital files. The GILL project seeks to streamline this process by allowing individuals (who could be part of the research team, students or the general public) to collect data using smart phones, automatically contributing that data digitally to the project database. Additionally, different methods are investgated to align MMA with PWD maintenance practices as outlined in the PWD Maintenance Manual [1].

2.3 Mobile Web Application for Public Engagement

The mobile app builds upon systems and knowledge developed through prior "Citizen Scientist" projects (public engagement in scientific research) developed by the research team, in particular the measurewith.us website. Citizens routinely upload data regarding general site conditions, litter accumulation, interactions with the public, wildlife observations, and qualitative information that can be used to validate sensor observation through a web portal. MMA will target at Drexel students (student organizations and undergraduate civil engineering classes) as participants and asking them to perform similar tasks. These groups are detailed in the Recruitment of Participants section of this document.

MMA adds new functionality specific to this project. For those seeking to learn more about the project and potentially contribute data and observations, MMA serves as a more convenient alternative to accessing online resources on a laptop or desktop. Each user is able to easily upload their photos and findings to the project database right at the site and also explore

information related to their site location. Upload functions have been developed for use in organizing data collected at each GILL site by the research team and by others (e.g. the general public, interns, etc.) who are engaged with the GILL project.

2.4 Recruitment of Participants

In order to recruit participants for this project, the project plans to make use of the Drexel undergraduate student population. Drexel is home to many student organizations involved with various civic and environmental topics. The project plans to engage them by aiding their endeavors through (co-sponsoring events), providing another resource for their interests, and offering data for their projects. Below are just a few of the organizations considered partnering with:

- **Drexel Green Initiative** - The Drexel Green Initiative is dedicated to transforming Drexel's campus into a sustainability leader. The initiative covers all aspects of operations, buildings, academic initiatives and student life and is responsible for the strategic plan to further sustainable practices and policies.
- **Drexel Smart House** - Drexel Smart House is a student led organization dedicated to promoting undergraduate research and public involvement in sustainability and advanced technologies through their local smart home.
- **Drexel Sierra Club** - Drexel Sierra Club seeks to protect and appreciate the environment by working to reduce Drexel's environmental impact and taking hiking, camping, and other outdoor trips.
- **Urban Growers** - The Drexel Urban Growers mission is to cultivate a diverse network of students and community residents that enables continuous and sustainable access to fresh food through urban gardening.

The students from one of Drexel's Civil Engineering classes, Hydrology (CIVE 430), will also be recruited. A module will be created for these students where they would be asked to quantify the performance of the GSI site while learning basic hydrologic processes and empirical methods for quantifying them. For example:

- Estimate inflow volumes through the curve number approach.
- Investigate trends in the precipitation record.
- Estimate canopy interception based on the vegetation on site.

- Estimate evapotranspiration using the climate station data and the Penman Monteith equation,
- Perform infiltration tests on site.

3 Mobile app

3.1 Credential system

Currently, app users are able to submit photos and observations. These photos and comments are inspected by a human moderator for quality assurance, prior to being made visible to other users. A tiered interaction model was developed with two types of users: public and admin. Public users can view the live status and historical engagements of all GSI sites anonymously. However, a login is required to add their engagements. Admin users have some extended options for maintenance and management, such as updating a maintenance event log, managing equipment in a project, and viewing reports. More detail on these options is provided in the following sections. This also enables paths for project engagement beyond the mobile app (surveys, email lists, and social media).

To better engage with the public and to track such engagement, user credential information is necessary with their engagements. These accounts will provide a better way to communicate with the app's users and also collect useful information from them related to the project. This will allow us to tailor the app experience for users based on their level of engagement. Google authentication API is used to transplant google credential to MMA. But individual privacy is always a concern and must be taken into consideration. To limit any issues with the collection of personal data, users will only be required to provide an email address that their account can be associated with. Further information such as a first and last name and other basic demographic information will be optional.

Another feature of MMA is to obtain the GPS coordinates of the user's phone, allowing us to suggest the nearest site. User's permission is needed to enable this feature. All of this data is encrypted and securely stored in the database.

The credential framework contains two types of users: public and admin. Public users can view the live status and historical engagements of all GI sites anonymously. However, a login is required to add comments or photos. Admin users have some extended options for maintenance and management, such as updating a maintenance event log, managing

equipment in a project, and viewing reports. More detail on these options is provided in the following sections.

3.2 Server-side Architecture

A full cloud based "back end" system (Amazon Web Services) has been designed and deployed for collecting the raw monitoring data and hosting the public-facing website data and user visible content. A general architecture diagram for MMA and server system development is given below (adapted from the GILL project's QA report):

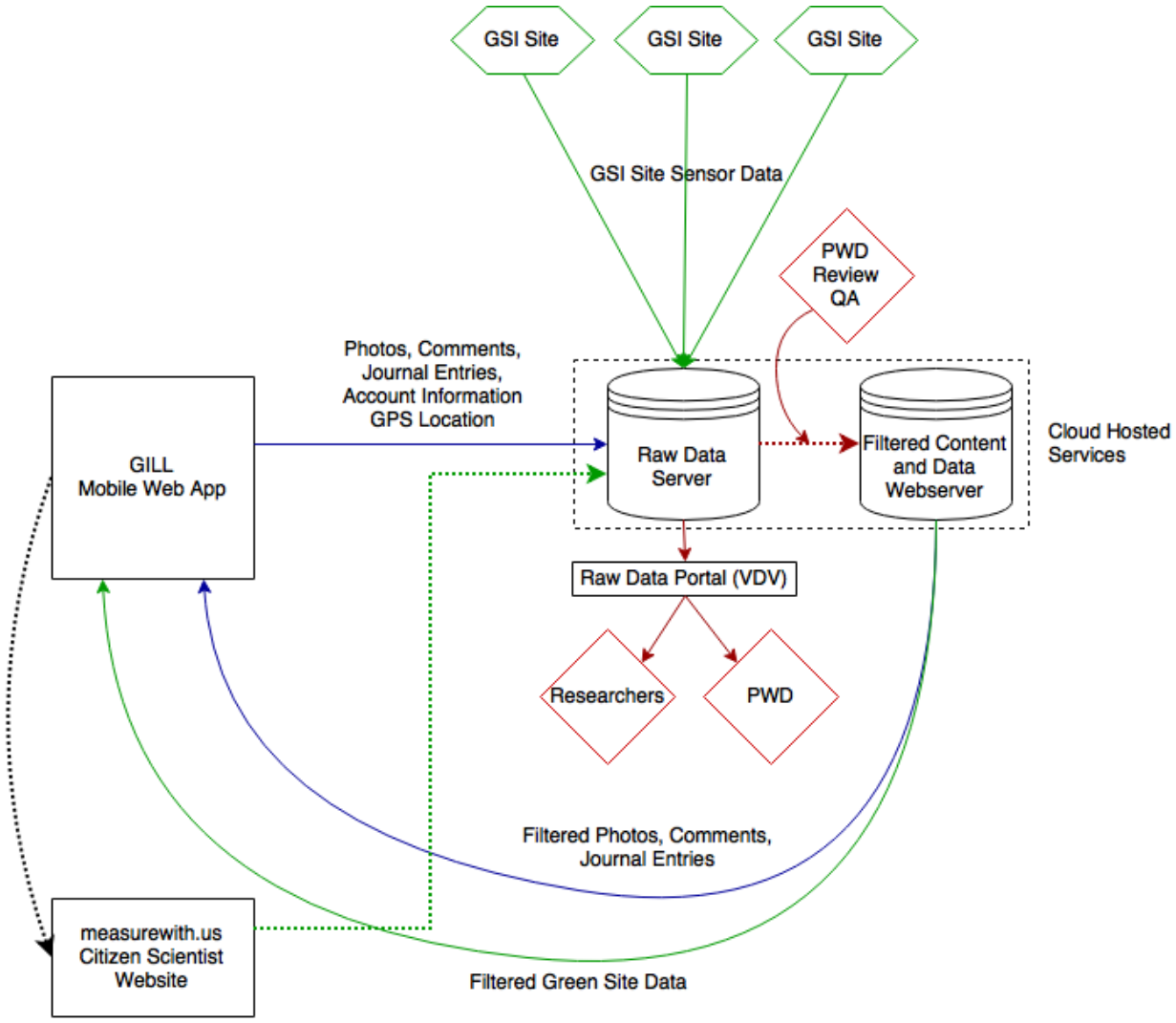


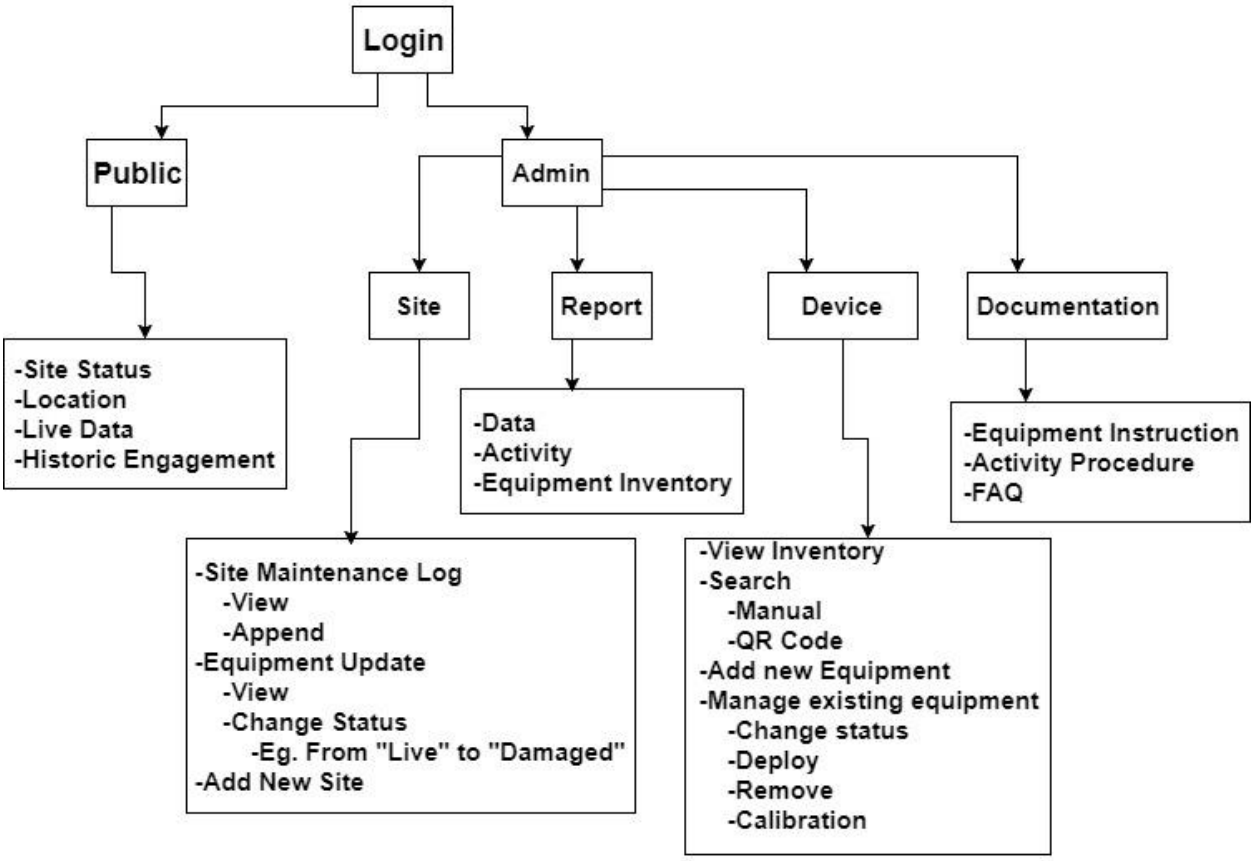
Figure 4- System architecture diagram for web-based services that form the "back end" of the GILL mobile web application.

In this system, content created by MMA users and data from the GSI sites is uploaded directly to cloud databased. This raw data is available to researchers through a raw data portal website, requiring separate authentication. The raw data and public contributions will be filtered by researchers and reviewers from the PWD for quality assurance and will be made available to MMA for public consumption.

This web-based architecture also makes it easy to link to additional resources and engagement opportunities through PWD and the measurewith.us project.

3.3 Functionalities

All functionalities that will be developed into MMA are illustrated in Figure 2 and will be explained in this section.



3.3.1 Public engagements

GSI sites are usually publicly accessible and thus provide opportunities for casual engagement of passersby. The MMA will include a page that displays basic information about each GSI site, including an image, a brief description of the site and its location, and some live monitoring data streams. Public users will be able to view historical data gathered at the site, as well as upload their own images or write their own comments after logging in with a Google account.

Figure 3 shows the options for public users. The public can access the site selection page from the home page. The public user will then click on a site of interest and access the site information and historical engagements.

Figure 3- App functionality diagram for public users

3.3.2 Admin project management

Admin usage of MMA will simplify the maintenance logistics and project management. Three categories of admin functionalities are included in MMA design: Site Maintenance, Device Maintenance and Project Reports. Each of these functions are described below.

3.3.2.1 Site Maintenance

Site maintenance activities are more involved than the basic site status updates undertaken by the public. Once pictures or comments submitted by the public identify a site as in need of maintenance, such as irrigation, cleaning, repair, etc., it is assumed that the site will be visited by a maintenance team member. This maintenance worker could use the MMA to view the historical maintenance log for the site, review the site equipment inventory, and otherwise obtain a briefing on the site's history. The maintenance inspector will then use the MMA to log maintenance activities she performs during her visit. This log could include a diagnosis of the site problems, actions taken to resolve the problem, and additional work needed.

For example, a visitor notices that a soil moisture data feed is no longer providing accurate data, and submits a comment to that effect through the MMA. A maintenance worker is dispatched to the site, and uses the same app to change the sensor status from "Live" to "Damaged". Later, after replacing the damaged sensor, the maintenance worker can use the app to upload the serial number of the new sensor and even provide its sensor calibration data. The maintenance worker could also use the app to track what happens to the damaged sensor, as it is sent to the laboratory for testing.

Administrative users can also use the MMA to add new sites or sensors. The hierarchy of site maintenance functions in the MMA for admin users is shown Figure 4. Similar to the public engagement function, admin users can route to the site selection page from the home page. In the site selection page, the admin user can add a new site to the system or manage the existing sites by editing the equipment information and adding events.

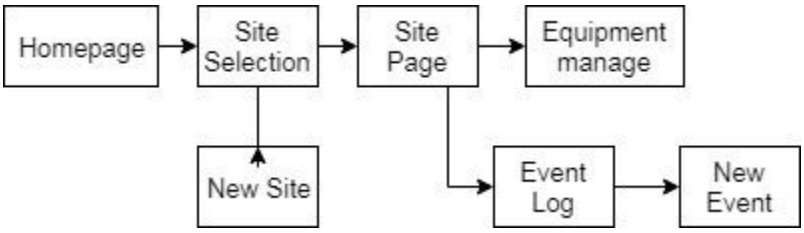


Figure 4- Arrangement of various functions for site maintenance application for admin users

3.3.2.2 Device management

Device management is key in managing a remote sensing project. The MMA will include functions to check detailed device information, change device usage status, and conduct device calibration of all equipment in a project. A device could be queried either manually by inputting its serial number, or automatically by scanning its QR code in the field. When adding a new device, whose information cannot be found in the database, administrator users are required to provide details of the device before generate its QR code.

The arrangement of device management functions for admin users is shown in Figure 5. Admin users can access the device list page from the home page. All devices, either deployed or not, will be listed on this page. Admin users can also use a search function to find a specific device

based on the serial number of the device or through its QR code. For existing devices, a calibration value can be logged to add to the sensor's calibration curve. In addition, admin users can manage an idle device by either deploying or removing it.

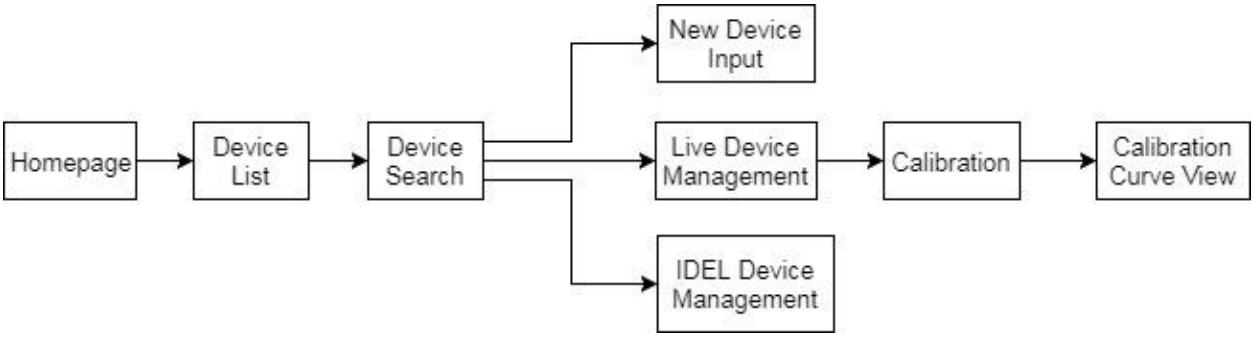


Figure 5- Arrangement of various functions for the device management for admin users

3.3.2.3 Report

The report function provides a summary of monitoring and/or maintenance data logged for a particular site. Figure 6 shows the arrangement of report generation functions. Real-time visualized data can be seen with the data view option. Recent activities and all site devices for each site can be accessed from the activity and device view pages, respectively. Together, these reporting functions provide the research and/or maintenance teams with a real-time update on the operational status and performance of any GSI site in the database. Equipment inventories, and maintenance frequency tables can also be generated to for all projects and sites.

Reference:

http://phillywatersheds.org/doc/GSI%20Maintenance%20Manual_v2_2016.pdf