2012 State Damage Prevention Grant
Development of Utility Locator mobile device application and expansion in use of the excavator mobile device application

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Administration

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16. Abstract

Through a previous grant program, Rutgers Center for Advanced Infrastructure and Transportation (CAIT) in partnership with the State of New Jersey Board of Public Utilities Bureau of Pipeline Safety engaged in the development of a mobile app used by excavators to communicate locate requests using "Virtual White Line". The process describes the communication of digital coordinates connected to create a shape and overlaid on aerial mapping, which combined form a unique means of describing an excavator's area of excavation. Locator feedback from presentations describing this new means of communications strongly voiced the need for a similar application dedicated to the locating community. The impetus for such an app is across-the-board sharing of "the same picture" – the idea of all parties involved in the safe completion of a project by effective communication of an excavation area through the same image.

The objective of the grant was two-fold: develop a locator app that would accept GPS coordinate data and provide locators with a map of the intended area of excavation, and to expand the use of the excavator app developed under the 2009 Technology Development Grant in order to collect user feedback and develop a "best practices" guide. The team was able to develop the locator app, which collected GPS coordinates from locate-request tickets and was able to display a map with an overlay of the virtual white line. In order to deploy the technology, the team solicited various excavators to use the excavator data. Excavators were intrigued by the technology. Many indicated that their internal systems employed underground damage prevention techniques and that the excavator app has the potential to be integrated into their systems once GPS capabilities improve sufficiently so as not to require physical white paint at the excavation site. The team collaborated with various excavators to collect sufficient tickets to test out the locator app and show proof of concept. Current GPS accuracy on mobile platforms consistently provides 3-meter accuracy. Adding external GPS receivers can amplify signal strength and improve accuracy to 1-meter. As the technology improves, and availability of more accurate systems becomes more widely used, the accuracy of GPS coordinates will be sufficient to fully incorporate the mobile device into the one call process.

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Abstract

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Introduction

The US DOT Pipeline and Hazardous Materials Safety Administration (PHMSA) State Damage Prevention Grants provide utility commissions with the opportunity to establish or improve their State Damage Prevention Programs. The grant is established under the authority of the Pipeline Inspection, Protection, Enforcement, and Safety Act (PIPES) of 2006. The Nine elements derived from PIPES 2006 are paramount to a successful and effective Underground Damage Prevention Program. Through a previous grant program, Rutgers Center for Advanced Infrastructure and Transportation (CAIT) in partnership with the State of New Jersey Board of Public Utilities Bureau of Pipeline Safety engaged in the development of a mobile app used by excavators to communicate locate requests using "Virtual White Line". The process describes the communication of digital coordinates connected to create a shape and overlaid on aerial mapping, which combined form a unique means of describing an excavator's area of excavation.

Locator feedback from presentations describing this new means of communications strongly voiced the need for a similar application dedicated to the locating community. The impetus for such an app is across-the-board sharing of "the same picture" – the idea of all parties involved in the safe completion of a project by effective communication of an excavation area through the same image. The common phrase shared by participants, "a picture is worth a thousand words" was prevalent through the locating community, and many locators expressed their interest in seeing maps/images used as aides in their efforts to identify existing facilities in excavation areas. The objective of this research was to develop a tool that would allow utility operators and third party locators to view all the information submitted by and excavator, including the same shape overlaid on aerial mapping, using the "New Jersey Virtual White Line Request" application. The work built on and further enhanced communication between excavator and locator, which initiated through the development of the digital white lining app through the 2009-2011 Pipeline and Hazardous Materials Safety Administration (PHMSA) Technology Development Grant No. DTPH56-09-G-PHPD02.

This project serves as an example for future implementations of different technologies and procedures to improve processes and avoid personal and property loses. The New Jersey Board of Public Utilities (NJ BPU) wants to continue with this important task of updating its processes to minimize losses and enhance public safety. CAIT assembled a team of experts to perform the study. The team consisted of Entek, LLC, Petroleum and Natural Gas Engineering consultant; and Productivity Apex Incorporated, an industrial engineering consultant. The team developed a locator app for a mobile tablet platform, which was deployed in concert with the excavator app. The goal is to develop and demonstrate the capabilities of a new locator app, which integrates with the underground damage prevention safety program. The team collected feedback from both stakeholder groups and developed recommendations to NJ BPU Bureau of Pipeline Safety.

Literature search

Review Federal Legislation, PIPES 2006

The basis for this research is to incorporate damage prevention efforts including effective and timely stakeholder communications. Damage prevention laws facilitate the communication among excavators, NJOCs, and underground facility operators before digging is allowed. Operators must identify and visibly mark the location of underground facilities before digging begins, so excavators avoid damaging underground facilities during excavation. An effective damage prevention program includes the nine (9) elements, as stated in Section 2 of the PIPES Act of 2006:

9 Elements of Effective Damage Prevention

1. **Effective communications between operators and excavators**
2. **Fostering support and partnership of all stakeholders**
3. **Operators use of performance measures for locators**
4. **Partnership in employee training**
5. **Partnership in public Education**
6. **A dispute resolution process that defines the enforcement agency as a partner and facilitator**
7. **Fair and consistent enforcement of the law**
8. **Use of technology to improve the locating process**
9. **Data analysis to continually improve program effectiveness**

Figure 1 - PIPES 2006 Enumerated

The goal of the 9 elements focuses on communication between stakeholders, effective training, partnership with stakeholders, enforcement and employment of technologies to improve the processes. Within these concepts, Utility commissions must operate as partners, facilitators and enforcers. NJOCs serve as medium for communication between all parties, collecting and disseminating locate requests. Excavators are required to participate in the process, both as responsible parties communicating their intent to excavate and safely operating excavation sites. Utility locators are also called to participate in the process, expediently responding to locate requests and locating facilities within the proscribed limits of accuracy. Each stakeholder must have some form of effective communication with the public to educate, protect and serve. Technology developments and data analysis are undertaken within these concepts and definitions. To successfully engage in technology development, researchers must understand the processes of each involved stakeholder. This project set out to establish these concepts from its inception.

Design and Development Process

The design process started by having meetings with stakeholders from NJ BPU Bureau of Pipeline Safety, utility owners and locators, in order to understand their process and requirements for a mobile application able to receive Locate Request Tickets from the New Jersey One Call Center.

Once the locator process was captured and the main functionalities defined, the next step consisted of creating a series of requirements for the tool, detailing the main features and capabilities to be used by locators on their daily activities. These initial requirements were all captured in an Analysis Requirement document which worked as a guide for the development of the tool.

For the technology to be used a review was made; however, it was understood from the beginning that the application would be developed for a mobile device, whether it was a cellphone or a Tablet. Given the versatility of the tablet, being a portable instrument that locators could carry with themselves, offering the capability to connect to a wireless network to download and upload data virtually anywhere. Android was chosen for the operating system given that it was the system used in the previous project for the development of the "New Jersey Virtual White Line Mobile Request" Application. This facilitated the interaction between both, as well as the development of the new Locator Application, given the flexibility that the Android OS offers by having the largest number of equipment or hardware manufacturers to choose from that are using the system. Selecting Android OS offers a great advantage to the users by being a well-known system and having multiple alternatives, from inexpensive to top of the line devices, to run the developed application.

With the technology and requirements established a series of mockup screens were drawn with the intention of providing stakeholders and the developers a simple way to explain and understand the process of receiving and working on a locate request ticket through a mobile device. The screens were designed using specialized rapid wireframing tools that facilitated sharing and presentation capabilities during the design and development phases.

Communication with the New Jersey One Call Center personnel was established in order to support the development of the tool. An email account was setup for Rutgers University Facility-utilities division to receive all the notifications for locate request submitted by the NJ One Call Center to Rutgers. The email account was a Google account, given that there are no requirements or limitations towards the type of accounts to use in this process. With this setup, the application development started and the test environment was setup for testing and debugging.

New Jersey One Call Center Process Diagram

The New Jersey One Call Center process is defined in the New Jersey Statutes Annotated (NJSA) Title 48:2-73 et seq. - Underground Facility Protection Act (UFPA) and enabling rules detailed in New Jersey Administrative Code (NJAC) Chapter 14:2. The New Jersey Process can be represented with the diagram in Figure 2 - New Jersey OCC Process:

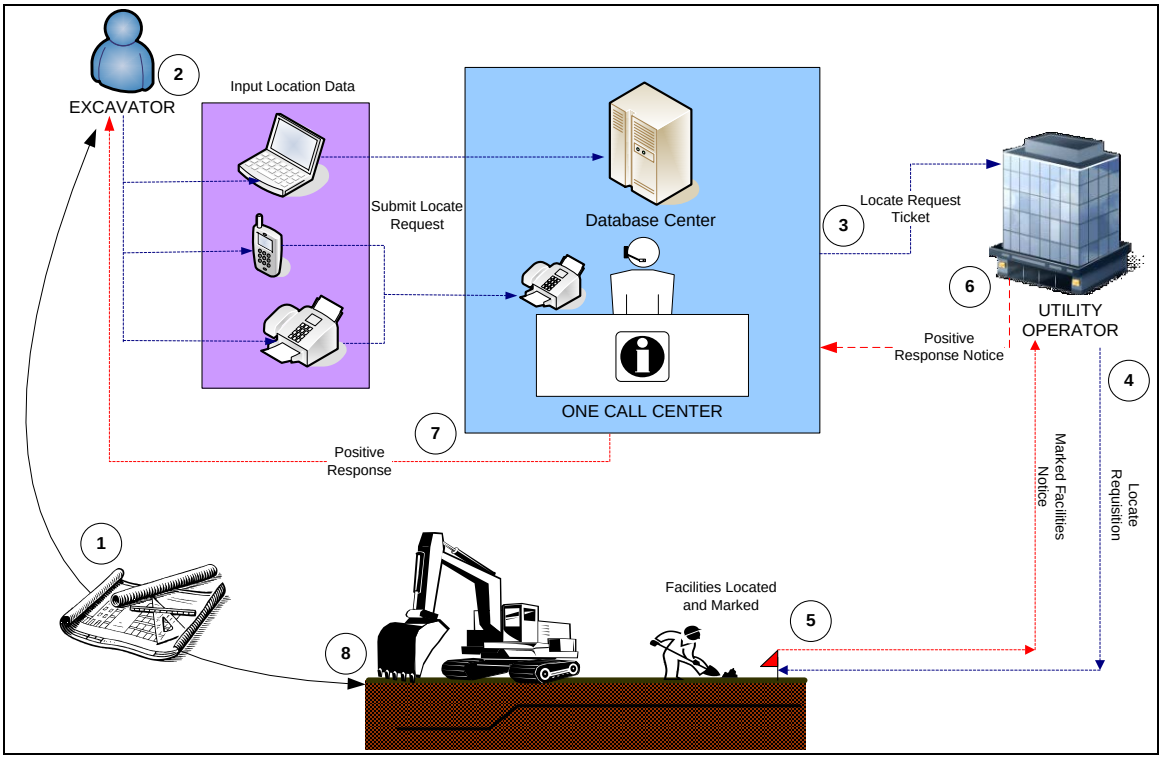
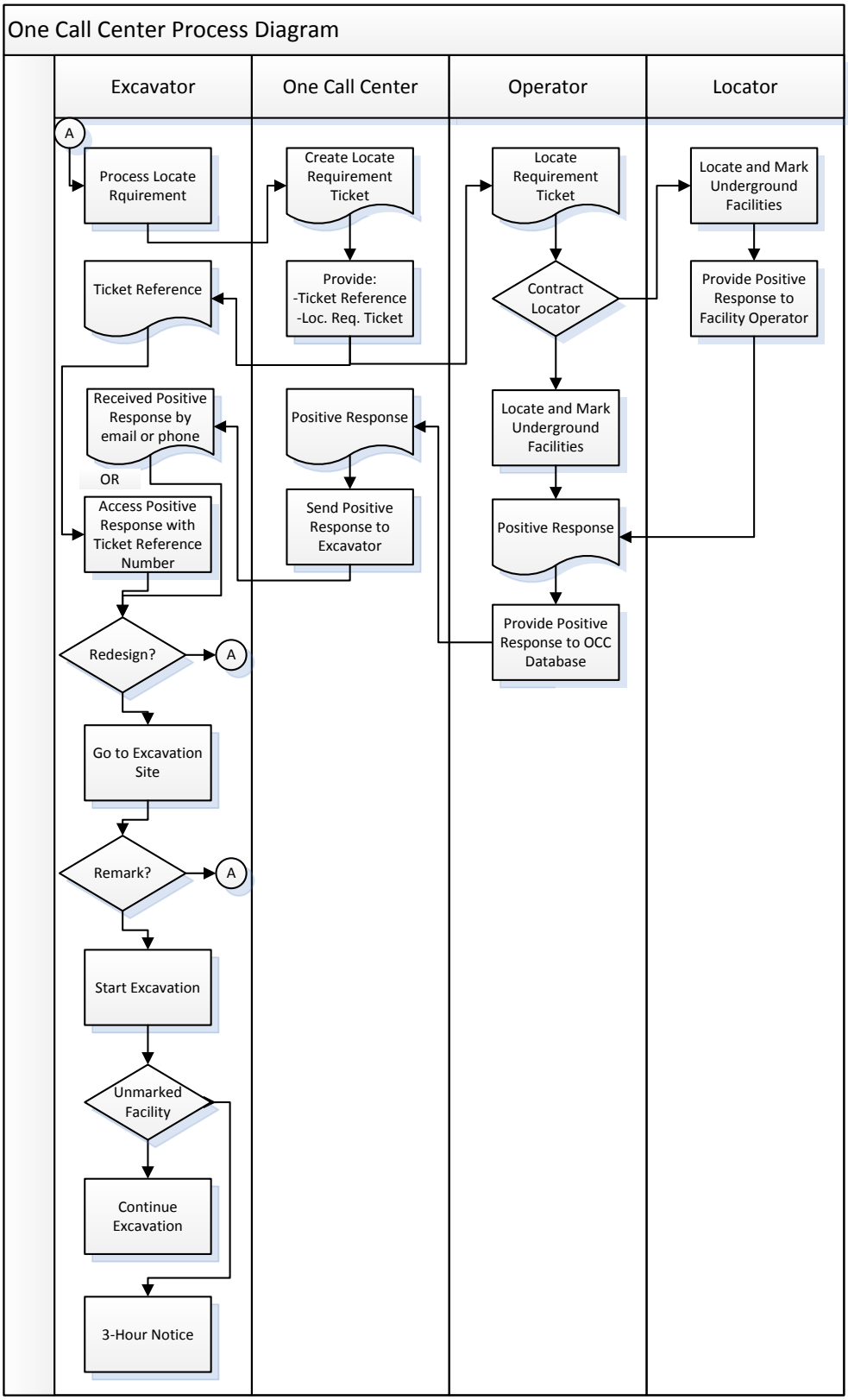


Figure 2 - New Jersey OCC Process

The New Jersey One Call (NJOC) Center process begins when an excavator makes a request to locate and mark underground facilities that could be lying under the excavation site. This process can be performed using a single phone call to the state NJOC, sending a fax locate form, submitting an online request through a computer or a handheld. In New Jersey, the request must three business days prior to the start of excavation.

The person making the request must provide specific details about the location of the excavation site including address, nearest intersections, distance from excavation to roadway curb or frontage, as well as optional data like geographical coordinates (latitude and longitude). Additionally to this, the company information, type of excavation and contact information must be provided. Once the locate request is submitted to the NJOC the excavator will receive a ticket reference number to be able to access the information requested.


One Call Center Process Diagram
Excavator
One Call Center
Operator
Locator
A
Process Locate Rquirement
Create Locate Requirement Ticket
Locate Requirement Ticket
Locate and Mark Underground Facilities
Ticket Reference
Provide: -Ticket Reference -Loc. Req. Ticket
Contract Locator
Provide Positive Response to Facility Operator
Received Positive Response by email or phone
Positive Response
Locate and Mark Underground Facilities
OR
Access Positive Response with Ticket Reference Number
Send Positive Response to Excavator
Positive Response
Redesign?
A
Provide Positive Response to OCC Database
Go to Excavation Site
Remark?
A
Start Excavation
Unmarked Facility
Continue Excavation
3-Hour Notice

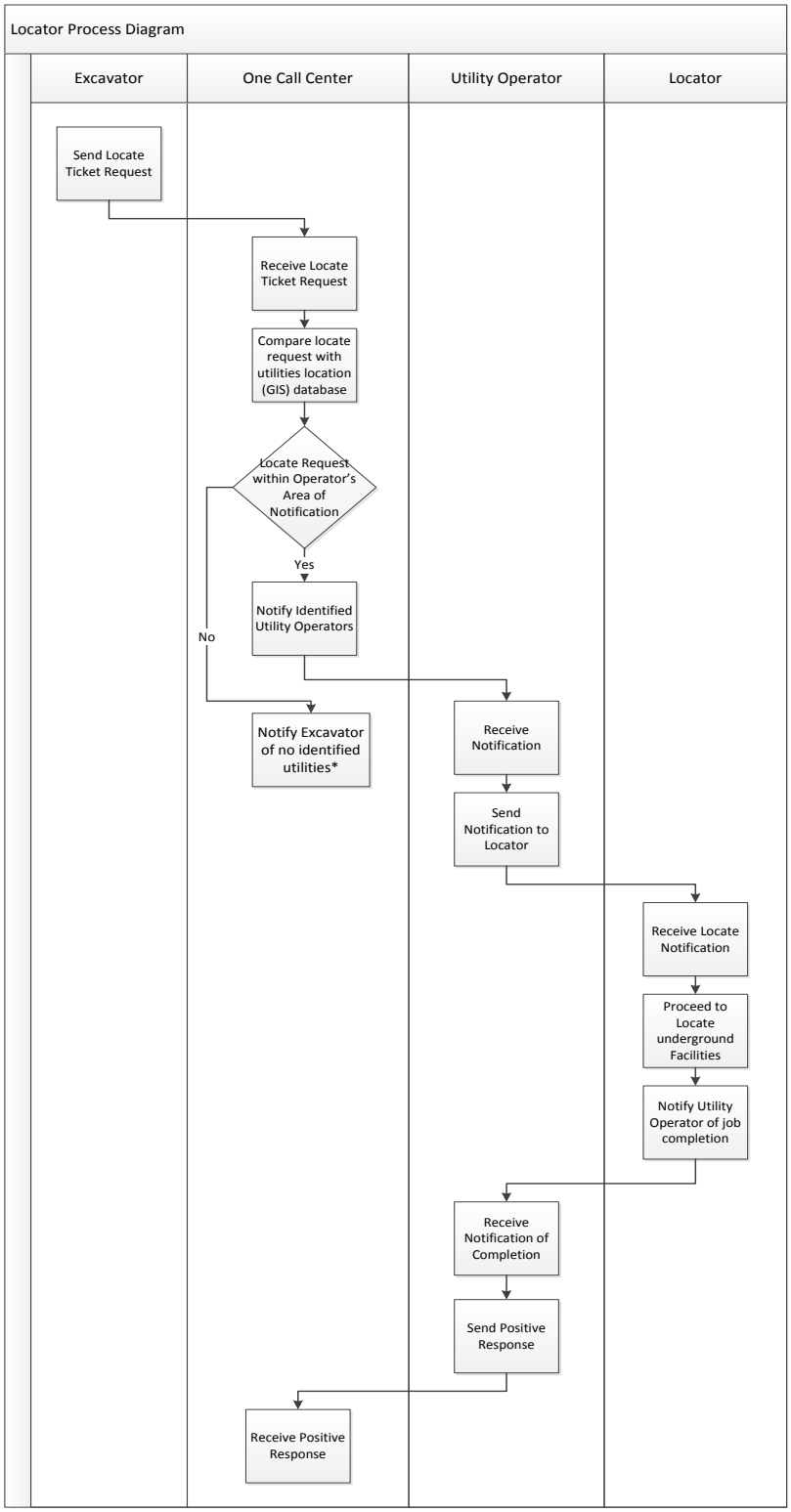
Upon receipt of the locate request, the NJOC overlays the extent of excavation on their grid-based GIS mapping to determine facility owner/operators identified by the corresponding grid or grids. Once the facility operators are identified, the NJOC sends a locate notification ticket to each one of them, prompting their staff to evaluate the site for potential conflicts, and if needed, perform a mark out. Some utility operators contract out their mark out services, in which case NJOC provides notification to the 3rd party locator. The 3rd party locator evaluates the site for potential conflicts and marks out or clears the ticket.

After the mark outs are completed, or if the site is cleared, a participating utility owners/operators or their 3rd party locator generates a Positive Response. This communication to the NJOC serves as notice that the site is ready for the excavation and ensures that all contacted operators have located and marked appropriately their underground facilities on the areas of the planned excavation. NJOC notifies excavators of the positive response via phone, fax or email. Excavators that are registered with NJOCs web portal, ITIC, may also review the positive response online.

Having this information allows the excavation company to make decisions about the redesign and the different procedures to use during the excavation process to avoid situations that could endanger people's life or damage equipment and public infrastructure. The excavator also has the option of requesting a remarking of the facilities in case they were washed or removed by weather conditions.

In the case an unmarked facility is found the excavation process should be stopped immediately and a 3-hour notice should be submitted to the one call center. Once submitted the excavator has the legal right to wait up to three hours before continue digging, giving chance to the utility operator to locate and marked the missing facility. If the locator doesn't arrive within the three hours, the excavator could proceed with the excavation job with extreme caution.

Locator Process Diagram



* The excavator must still coordinate with exempted and non-participating utility operators identified in New Jersey Administrative Code (NJAC) 14:2-4.1
The process starts once the excavator sends the locate request ticket. The One Call Center receives the information and identifies utility operators based on the predefined, GIS-based grid. The center then sends a notification per ticket received to each utility owner detailing the type of work that would be executed and the date, so they can locate and visibly mark any underground facility within the area of excavation. The utility operators receive the notification, assign it, and send it to a locator.

The locator then proceeds to go to the area of excavation described in the locate ticket request and visibly marks the location of any underground facility within the area and its surroundings. This is performed with the used of special color paint sprays, flags and stakes; each one signaling a particular type of utility, like gas lines, electricity, water, etc. Once the work is done, the locator notifies the utility owner that the site was located and marked, and the job is completed by sending a positive response message back to the One Call Center indicating that the area has been already marked. The One Call Center may take this message and notify the excavator that one of the affected utility operators has marked the area of work.

New Jersey One Call Center Process

New Jersey prescribes explicit basic requirements of underground facility operators. The Administrative Code outlines these requirements[1]:

(a) An underground facility operator shall ensure that it is fully equipped and available to receive from the One-Call center the information required under N.J.A.C. 14:2-3.2 regarding a planned excavation or demolition.
(b) Within three business days after receiving information from the One-Call center regarding a planned excavation or demolition, an underground facility operator shall do either of the following:
    1) If the underground facility operator owns, operates or controls any underground facilities on the site, the underground facility operator shall mark out the site as required under N.J.A.C. 14:2-5, except if a facility is exempt from markout requirements under N.J.A.C. 14:2-4.1(b) or (c). If an underground facility operator does not own or operate a facility, but controls it, the operator is responsible for compliance with this paragraph; or
    2) If the underground facility operator does not own, operate or control any underground facilities on the site, the underground facility operator shall make a reasonable effort to notify the excavator of that fact.

[1] N.J.A.C. 14:2-4.2

(c) For the purposes of (b) above, an underground facility operator shall be deemed to control all portions of an underground facility carrying metered service, which are not located on the customer's side of the meter, regardless of who owns the property. For example, if a residential electric customer owns an underground electric line, which provides electricity from the street to the customer's electric meter in an area served by overhead electric lines, the electric utility shall be deemed to control that underground electric line.
(d) An underground facility operator shall provide to the excavator specifications for supporting any underground facility on the site which requires physical support during excavation or demolition, including the type, strength and arrangement of the support. In accordance with N.J.A.C. 14:2-3.3(e)4, if the parties mutually agree, the underground facility operator shall provide such support.
(e) If an underground facility operator receives a request from the One-Call center for an emergency markout, the underground facility operator shall:
    1) Immediately dispatch appropriate personnel to the site in accordance with the emergency provisions at N.J.A.C. 14:2-4.4; or
    2) If the underground facility operator does not own, operate or control any underground facilities on the site, the operator shall immediately notify the excavator of that fact. If the underground facility operator cannot confirm that the excavator is aware that the underground facility operator does not own, operate or control any underground facilities on the site, the operator shall immediately dispatch appropriate personnel to the site.
(f) The requirements at (e) above shall apply to all underground facility operators that receive a request from the One-Call center for an emergency markout, regardless of whether the underground facility operator's facilities are involved in the emergency or not.

Utility operators are required by law to maintain the capability to receive notification tickets and respond within three (3) business days for routine tickets and immediately dispatch personnel for emergency tickets.

In defining their intended area of excavation, excavators in New Jersey are given a regulatory definition of the white lining process. This option provides excavators with a flexible means of defining their extent of work. The code indicates that where appropriate to clearly identify the site of a planned excavation or demolition, the excavator may choose to mark the perimeter of the site in white, prior to notifying the One-Call center. The code provides examples such as small sites, nonlinear excavations, and spot excavations such as a soil borings, mailboxes, sign posts, or tree plantings. The code also provides the utility operator/locator with explicit direction regarding the markout of white lined areas of excavation:

(c) If an excavator has marked the perimeter of a proposed excavation or demolition site with white in accordance with N.J.A.C. 14:2-3.2(c) through (e), an underground facility operator shall mark out all of the operator's facilities that lie within the white perimeter marking, and

in addition all facilities outside the white perimeter that are within ten feet of the white marking.[2]

The regulation provides utility companies and excavators a proscribed "buffer" that should theoretically protect both parties from insufficient underground utility information. That is, provided that the excavator properly identifies the area of excavation and the utility locator adequately defines the existing underground utilities.

The process of disseminating notification requests from excavator to utility operator/locator is the responsibility of the One-Call Center. It should be noted that the One-Call Center has developed a protocol for collecting and distributing information between excavator and locator. The protocol is based explicitly on the administrative requirements of New Jersey Administrative Code. The state employs a contractor to manage and operate the One-Call Center, and as such instructs the contractor in the manner in which locate-requests must be collected, including specific language that must be included in order for the locate-request to be accepted and released to the utilities or 3rd party locators for marking out.

Review NJ One Call Center operations

The New Jersey Board of Public Utilities (BPU) contracts out the operation and management of the One-Call Center to an outside vendor – One Call Concepts, Inc. The Center's operations are administered by the BPU as outlined in NJAC 14:2. The OCC operates 24-hours a day, 7-days a week. Ticket volume for the Center reaches over 535,000 locate-requests per year and submits approximately 3,440,000 notifications to Utility Operators[3].

The majority of the volume is handled via live phone operators that manually collect information from excavators. The information is collected on a proprietary software package that incorporates a Graphic User Interface (GUI) with a data collection/processing server. The One-Call Center Operator (NJOC) guides the excavator through a series of pre-developed questions designed to respond to the regulatory requirements. In identifying the location of excavation, the operator uses the GUI to sketch the area of excavation, which prompts the interface to identify Utility Operators in the affected area. The software incorporates the State's grid system as a means of identifying utility operators in a given area. The grid is a system used in New Jersey and consists of 1/16th of a mile by 1/16th of a mile squares. The system is tied to (World Geodedtic Survey) WGS 84 coordinates, more commonly known as lat-long (or Latitude/Longitude) coordinates, which is the baseline datum set used by the most widely recognized GPS equipment. The entire state is divided using the grid, and tied to ortho-photographic mapping (TIGER Maps - **T**opologically **I**ntegrated **G**eographic **E**ncoding

[2] N.J.A.C. 14:2-5.1(c)

[3] New Jersey One Call data provided October 2013

and **R**eferencing system supported by the US Census Bureau) provided through the NJ Geographic Information Network[4]. Utility operators are required to provide the NJOC with mapping or other means to describe the extents of their facilities and regions in NJ in which they operate. Each grid is populated with the information provided by the utility operators and serves as a means of notifying those utility operators in service within any given identified square of an excavator's intent to excavate as defined in a locate-request ticket. As a whole, the system incorporates over 700 utility operators in the grid.

Ticket management software used by Operators

Utility operators generally have a ticket management software and protocol to address various tasks such as collecting incoming locate requests, sorting tickets by various parameters, assisting management in assigning tickets, tracking progress and submitting positive response. During early rounds of interviews with utility operators, the team recognized that these sophisticated software packages were nearing a "total package" solution to managing locate requests. Since the scope of this grant was limited to the development of a tool that received and displayed the virtual white line created by the excavator app, it was decided that the tool developed within this scope would be an efficient, low cost solution for ticket management, which could be deployed to excavators that did not currently use more sophisticated ticket management software. With this approach, the team sought to provide a tool for operators that currently receive tickets via phone or fax, while providing a flexible tool that could be "dovetailed" into other ticket management software if needed

The development of this software app did raise concerns about the potential competition against privately developed software solutions. During initial conversations, several companies, including the contractor operating the one call center indicated that the development of this app could potentially compete with currently available ticket receiving applications. The team understands that a component of the new app will provide similar functionality to other ticket management and receiving applications, however the overarching goal of the development is to demonstrate the capability of conveying virtual white line overlaid on an aerial map. This new method of communicating locate requests is anticipated to facilitate communications between the excavator's intent to excavate and the locator's understanding of the proposed dig site.

Original System Requirements for the Locator App

In order to begin developing the new locator app, the team met with stakeholders to identify needs, features, and capabilities desired in the new platform. The following listing outlines the requirements presented by the various stakeholders, including the BPU, the One Call Center, Utility operators and utility locators:

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[4] Website - https://njgin.state.nj.us/NJ_NJGINExplorer/DataDownloads.jsp

1) Receive tickets from New Jersey One Call Center

Users (locators) would like to receive Locate Request Notifications on an Android mobile application.

Requirements

R101	The Locator App shall be able to receive Locate Request Tickets coming from the New Jersey One Call Center
R102	The Locator App shall be able to receive specific tickets for specific utility operators using ID credentials or email addresses
R103	The Locator App shall be able to receive tickets using the latest version of the Schema: OutboundTicket.xsd.

2) Manage Locate Request Tickets

Users would like to store and manage locate request tickets. The app shall provide the functionality of saving, assigning (owning), completing, and deleting locate request tickets.

Requirements

R201	The Locator App shall receive locate request tickets from the utility operator designated email address
R202	The Locator App shall store locate request tickets
R203	The user shall be able to own a particular locate request ticket
R204	The user shall be able to delete locate request tickets
R205	The user shall be able to mark as completed a locate request tickets

3) Open Locate Request Tickets

Users would like to open Locate Request Tickets and see all the information sent by the New Jersey One Call Center through an email or through the schema.

Requirements

R301	The user shall be able to open locate request tickets
R302	The Locator App shall display all the information sent by the New Jersey One Call Center that is contained in the Locate Request Ticket

NOTE: The following requirements will depend on the data and functionalities provided by the NJ One Call Center:

4) Display Excavation area on a Map

Users would like the Locator App to display the shape of the excavation area over a map of the excavation location using an Open Source Mapping Service (Google maps, Bing Maps, or any

other). The app shall be able to display a shape based on the shapes given on a valid schema provided by New Jersey One Call Center.

Requirements

R401	The Locator App shall display the shape of the excavation area on a map of the excavation location using a free Open Source Mapping Service like Google maps, Bing Maps, or any other. NOTE: Valid A valid schema containing this shapes shall be provided by New Jersey One Call Center

5) Navigate to Locate Request Ticket Location

Users would like the Locator App to help search the location of excavation indicated in the Locate Ticket Request.

Requirements

R501	The Locator App shall allow the user to open directly from the app the Google Maps Application installed on the device to search for the given address. NOTE: This feature can be developed if a valid address or a GPS coordinate is provided in the Locate Request Ticket.

6) Send Positive Response to New Jersey One Call Center

Users would like to send positive response to the New Jersey One Call Center once they have located all underground facilities in the area of excavation.

Requirements

R601	The Locator App shall allow the user to send Positive Response Tickets to the New Jersey One Call Center NOTE: A schema shall be provided by the New Jersey One Call Center in order to send a valid Positive Response Ticket

Initial Mockup Screens for the NJ Locator App

Mockup screens are just a simple representation of the look and feel of the final product. They are used during the design phase of a product or tool to facilitate the visualization of the different features that it may offer. The mockup screens for the NJ Locator App were built taking into consideration the fact that the device in which it will reside would be touchscreen; hence, making the functionality of the tool very interactive to the user.

The initial Mockup Screens for the NJ Locator App are presented below:

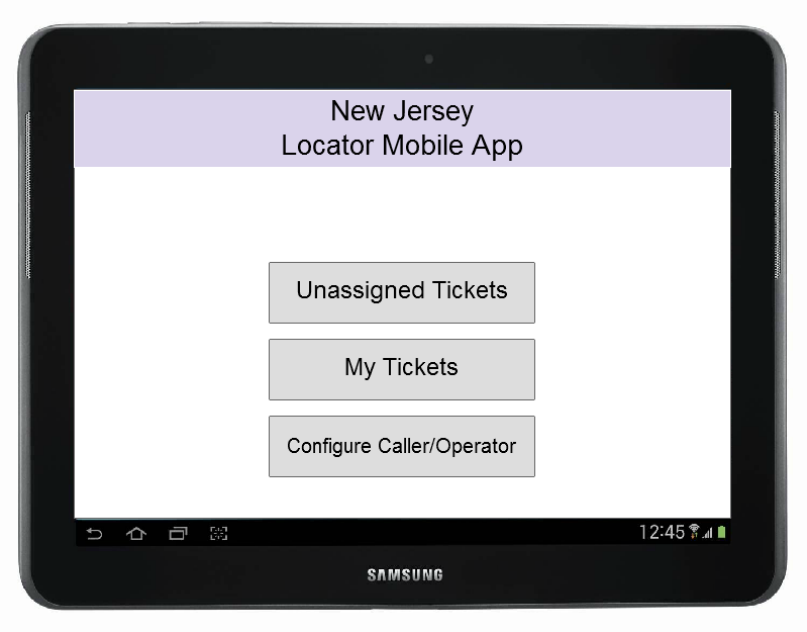


Figure 3 - Mobile App Welcome Screen

Figure 4 – Unassigned Ticket Folder Screen

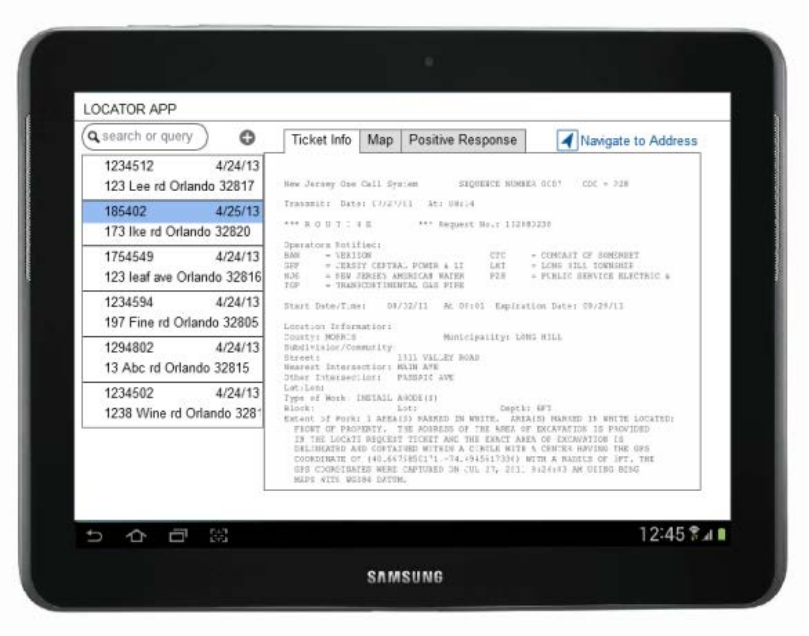


Figure 5 – My Ticket Folder Screen

Figure 6 - Ticket Review and Completion Screen with Action Tabs

The main screen of the app would contain an Unassigned Tickets button to review the tickets from the utility operator designated email. The My Tickets button would take the user to the tickets he claimed ownership of or were assigned to him. Finally, a configuration button for allows the user to configure different setups.

The Locator App would show all the tickets that were received in the designated utility operator email and would display at least the ticket number, the address of the excavation, and the date received. This is screen was just a prototype, it was determined later what kind of information had to be displayed on this screen. The user would tap on the ticket and it would open.

Once the ticket opens, the user would be presented with all the information regarding that particular ticket, in a similar way as it is presented in the email. As an additional feature, the user would be able to tap somewhere in the screen to navigate to the excavation address. It was later decided to convert the excavation address into a link that once tapped it would open the navigation feature in Google maps and guide the user to the site.

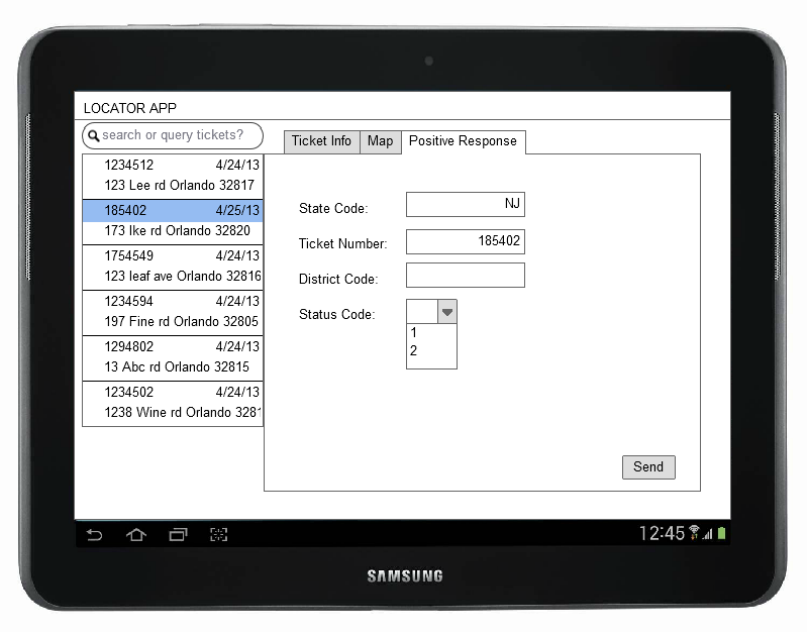


Figure 7 - Positive Response Screen

Figure 8 - Locator App Mapping Feature Screen

Another option considered was to divide the screen into two sections. In one, the user would see all the tickets owned by him. In the other section the user would be able to navigate between the ticket info tab, the map tab, and the positive response tab.

In the Map tab the user would be able to see the location of the excavation area. The shape of the excavation area would be presented if the ticket was submitted using the excavator app. The shape would be parsed using the GPS coordinates contained within the Extent of work sentence created by the app. In fact, the Locator app may render the shape disregarding how the ticket was submitted as long as it has the Extent of work sentence containing the GPS coordinates for the shape.

The Positive Response tab would allow the user to send the positive response to the NJ One Call Center using the status codes provided by them in the New Jersey Ticket Check Manual.

All of these screens were used during the development process to approve new features and modify others. Once the real screens were developed on the tablet, changes and additions were done using those ones as a reference.

Final Screens for the NJ Locator App

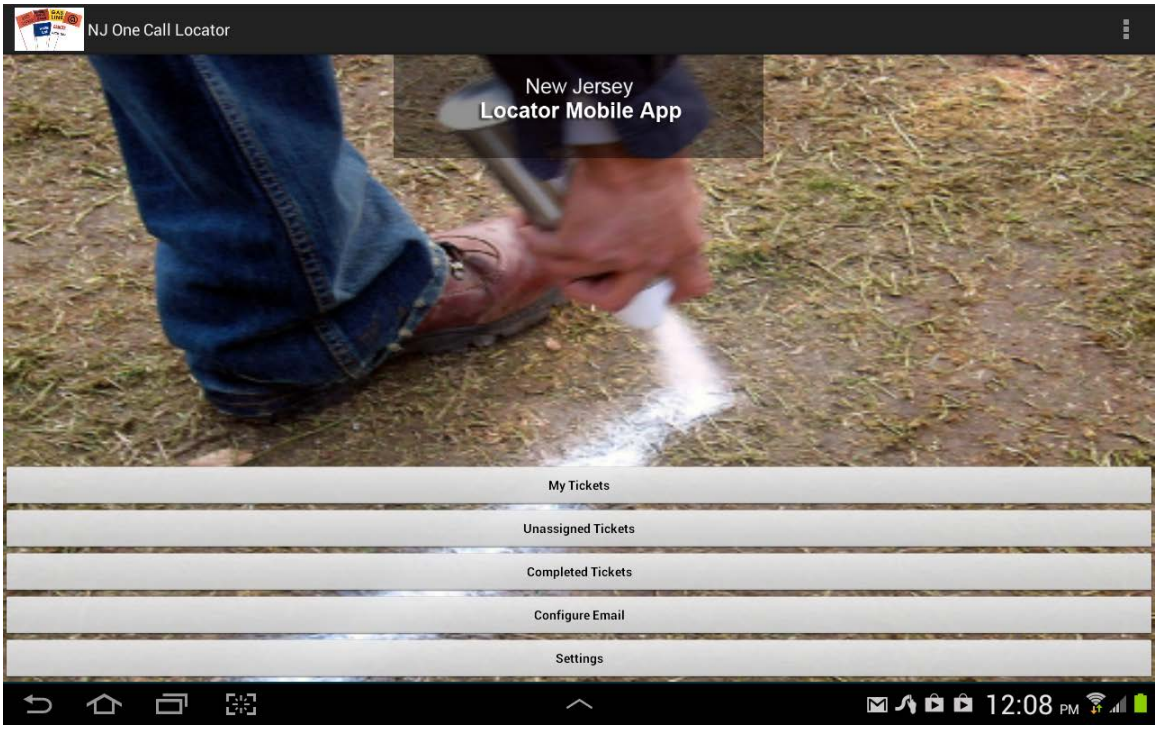


Figure 9 - Locator App Welcome Screen

The main screen of the app allows users to view in the My Tickets section the Tickets they owned or were assigned to them. In the Unassigned Ticket section users can view all the tickets sent to a particular ticket operator email, this email is configurable from the Configure Email section, allowing any locator to receive tickets from a particular utility operator as long as an email account was setup with the One Call Center to receive locate request tickets. The completed tickets will allow user to view ticket which excavation areas were already located and marked, whether positive response was sent or not. User also may configure the time intervals in which the application will retrieve tickets from the email account.

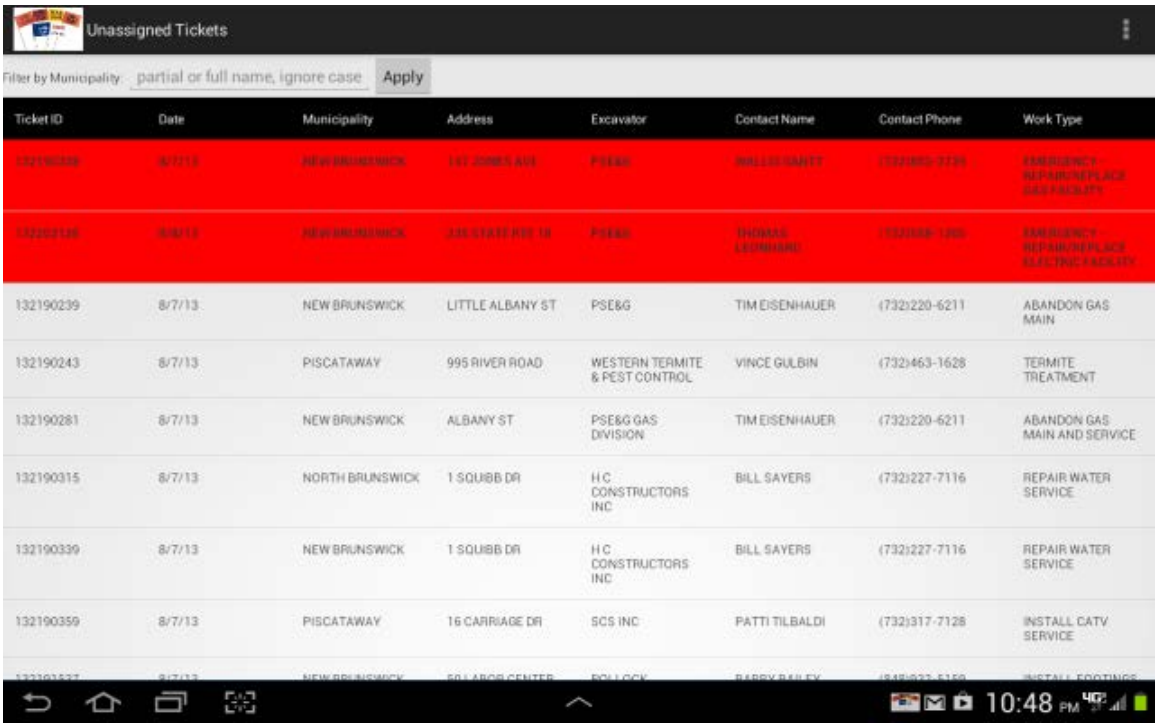


Figure 10 - Locator App Unassigned Tickets Screen

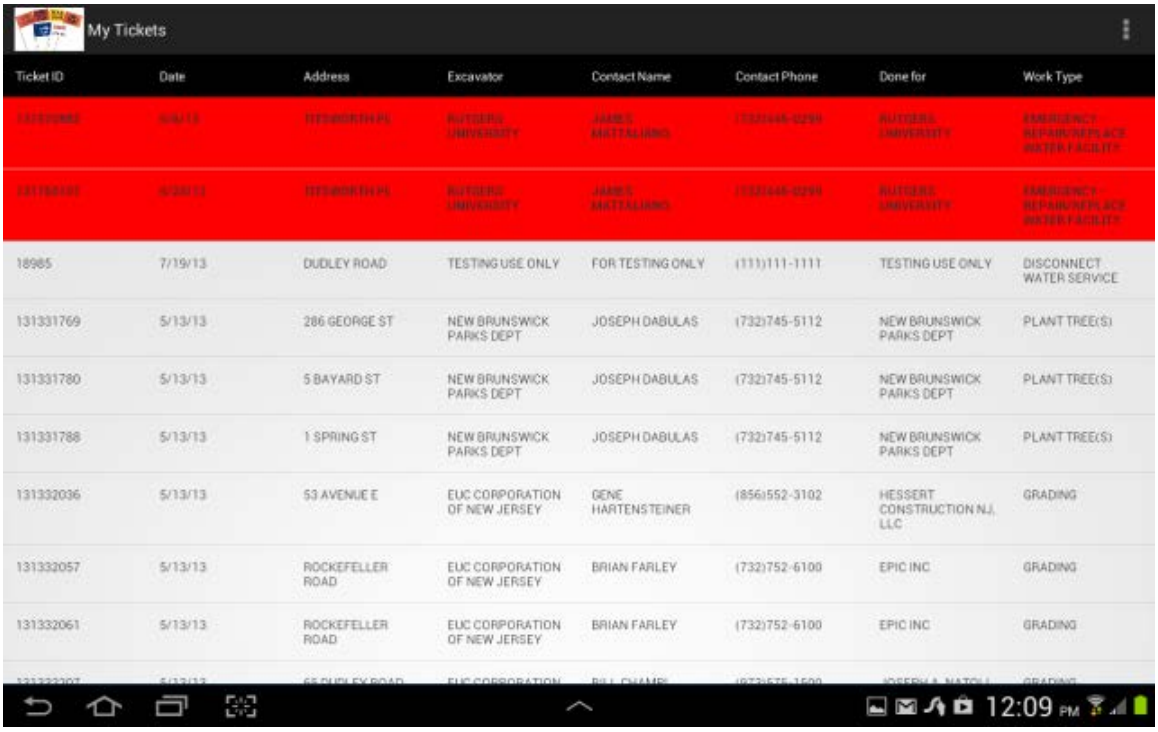


Figure 11 - Locator App My Tickets Screen

In the unassigned ticket section the user will be able to tap any ticket and this will be sent to the My Tickets section. Emergency tickets are highlighted in red, and regular tickets are not highlighted. From here users can tap on owned tickets and open them.

Users also have the option to search for tickets in certain municipalities and the tool will filter all the tickets within that location. Users may also add all the tickets within one municipality to the My Tickets section.

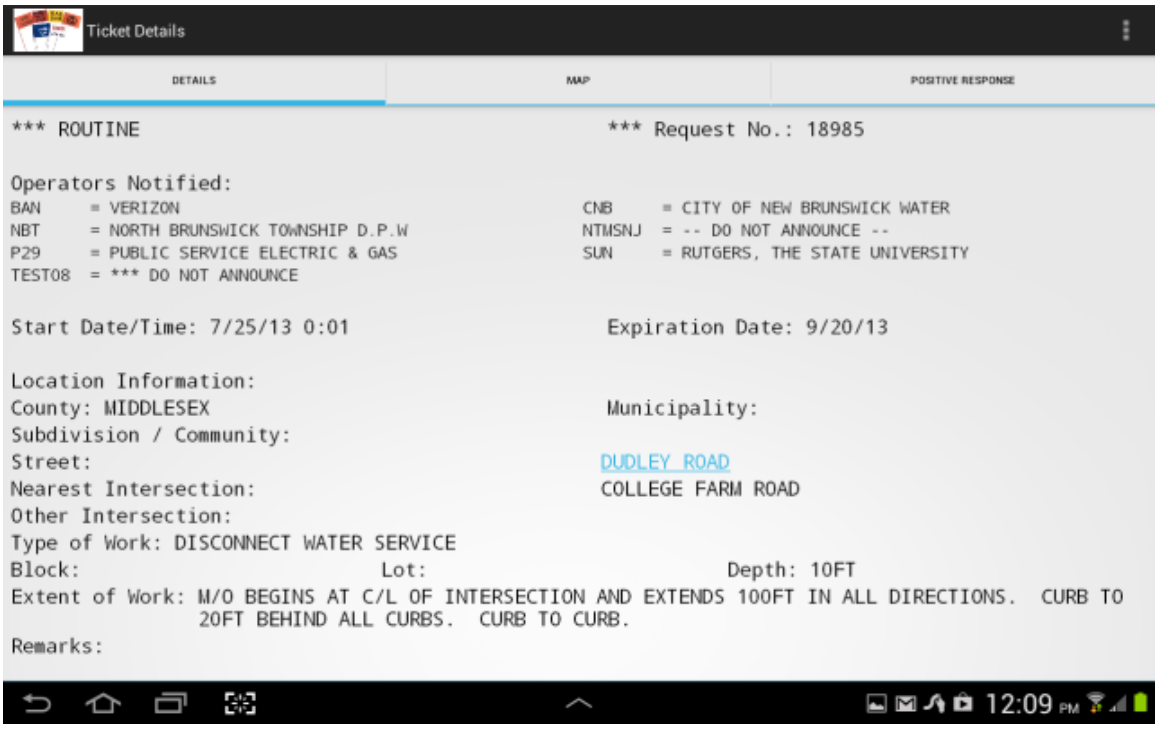


Figure 12 - Locator App Ticket Detail Screen

Once a ticket is open he details will show up. In the details the user will find all the information related to the area of excavation, excavator name, contact number and all the information regarding the location, type of work and extent of work.

By selecting the Map tab, the app will display a map with the location of the excavation. If the ticket was sent through the New Jersey Excavator mobile application or any other similar source that would generate the sentence in which the GPS coordinates are contained, only then the shape of the area of excavation would be render on the map.

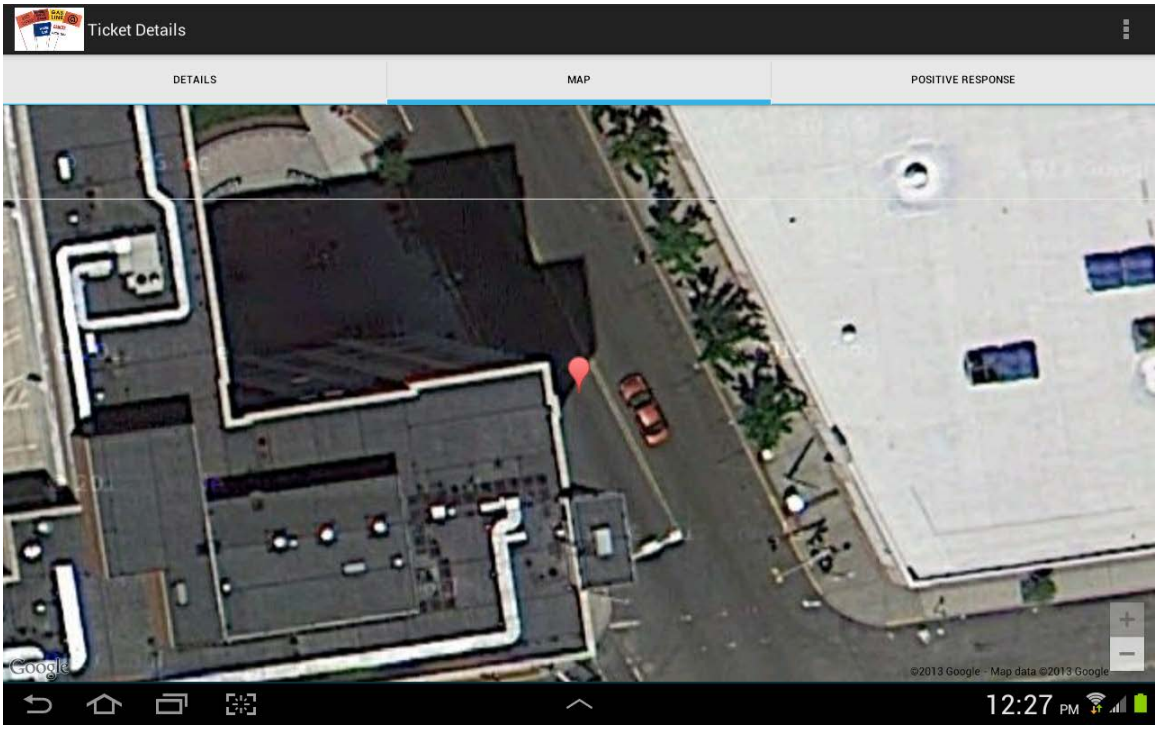


Figure 13 - Locator App Ticket Detail Map Screen

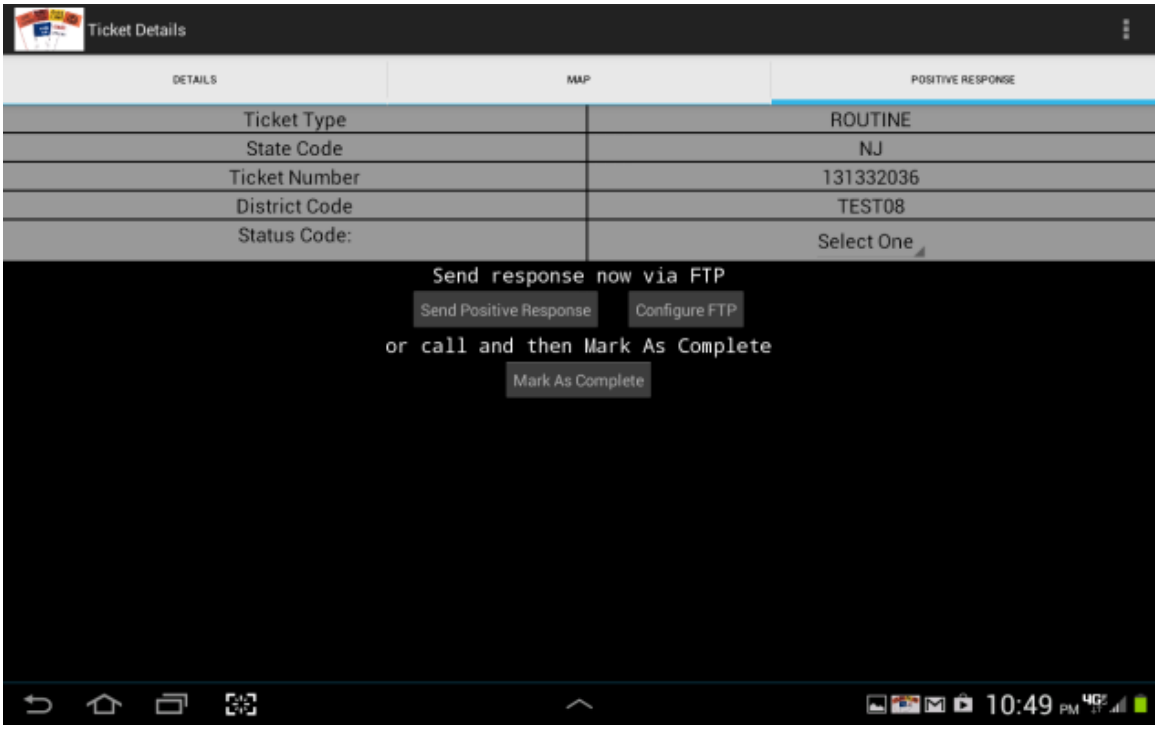
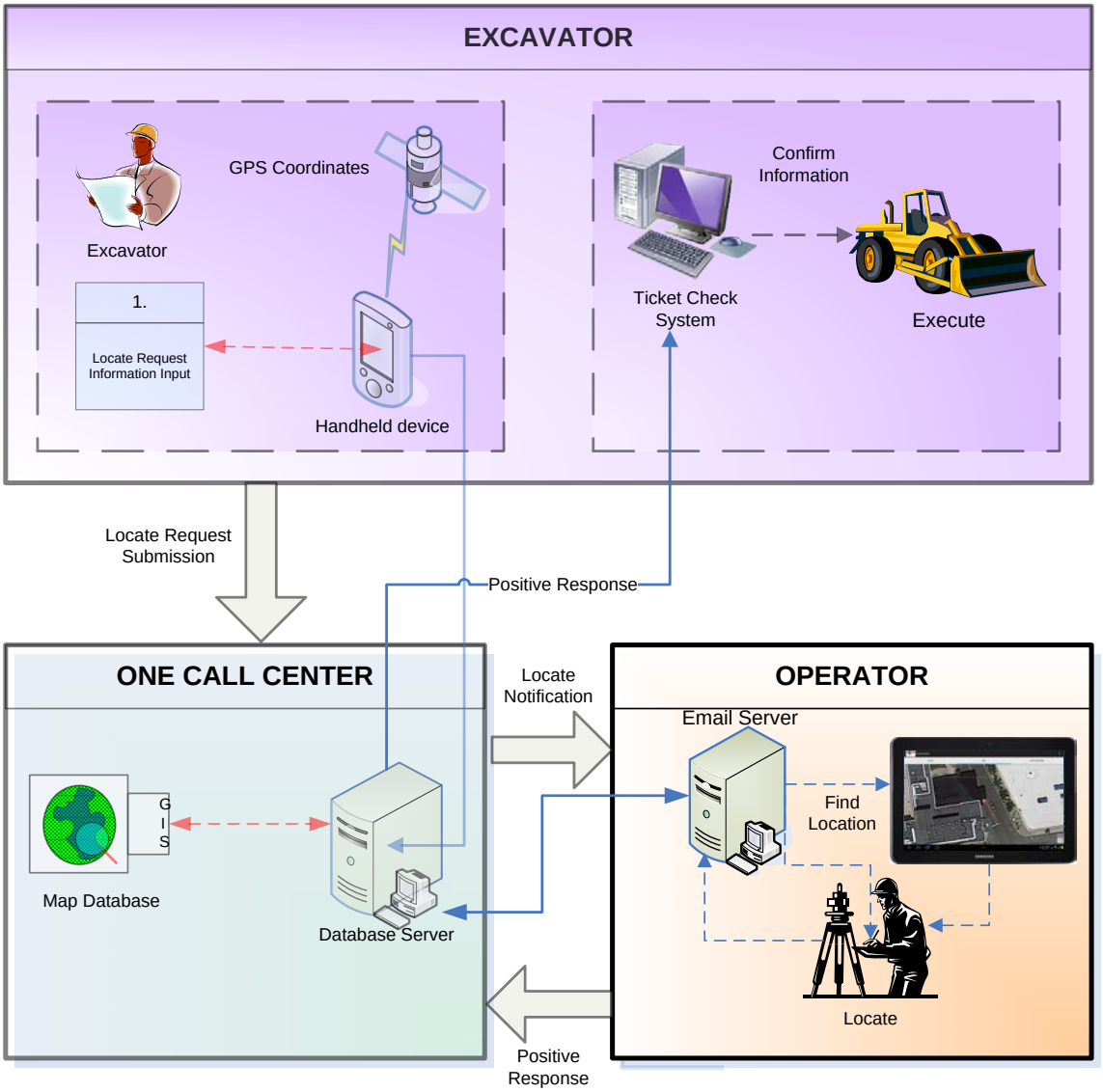


Figure 14 - Locator App Positive Response Screen

In the Positive response tab users will be able to configure the FTP server to send positive response and send the positive response for a particular ticket. If users don't want to send the positive response, they can mark the ticket as completed and the tickets will be sent to the Completed Tickets section.

Help pages were also developed for every screen in the Locator app to guide the user on how to use the mobile application.

Architecture Diagram of the system



Versions Log of the NJ Locator App

NJ Locator App	Release Date	Fixes/Enhancements
Version 1.0	5/31/2013	Original version delivered to customer.
Version 1.1	6/7/2013	**1)** Fixed: If email password is changed after the first time the app is launched, the app will no longer function properly with Gmail. **2)** Fixed: Details page had a lot of information running off the right hand side of the screen, including ticket number and occasionally the Extent of Work.
Version 1.2	6/19/2013	**1)** Added Error dialog if you try to hit OK on the credentials page if either the username or password is empty. **2)** Added Date to My Tickets, Unassigned Tickets and Completed Tickets screens when listing the tickets.
Version 1.3	7/8/2013	**1)** Improved error cases on the back end when sending positive response. Since we don't know what exactly has been happening when Vikas tries to send an FTP and it fails, and because it is intermittent and has not been reproduced, all we can try to do is guess what is happening and guard against as many error cases as we can think of. **2)** Added support for the geometry to be drawn for tickets originating from the excavator app. **3)** Added in My Tickets - tap and holding on a ticket in the list will prompt for a choice to either remove the ticket from the device or to move the ticket to the Unassigned Tickets list. **4)** Added in Completed Tickets - tap and holding on a ticket in the list will prompt for a choice to Remove the ticket from the device, move the ticket to the My Tickets list, or move the ticket to the Unassigned Tickets list.
Version 1.4	8/6/2013	**1)** Added "Configure FTP" button on the POSITIVE RESPONSE tab when viewing the Ticket Details page for a ticket. Clicking this button brings up another screen to populate the server, username, and password for uploading a positive response .xml file. The server is defaulted to **ftp.managetickets.com**, and the username and password are defaulted blank. After populating these fields, they will be saved and will not need to be changed unless they become invalid by the FTP server. **2)** Removed "Done For" column on My Tickets, Unassigned Tickets, and Completed Tickets. **3)** Added "Municipality" column after "Date" column on My Tickets, Unassigned Tickets, and Completed Tickets. **4)** Fixed Municipality by populating with the City instead of Subdivision. **5)** Added a row, on the Unassigned Tickets list to allow for filtering by municipality. Type partial text for the name of a municipality (case does not matter), and then tap the "Apply" button. Only tickets that match that search will be displayed in the list. To get all tickets to be displayed again, delete all text in the text box and tap on the "Apply" button again. A button will be displayed called "Add All Filtered Tickets" after tapping on the "Apply" button if there is text in the text box. Tapping this button will move all tickets to the My Tickets list that meets the criteria of the search.
Version 1.5	8/9/2013	**1)** Fixed spelling for “Add All Filtered Tickets” button in the Unassigned Tickets section.

Current GPS capabilities of modern Tablets

Current GPS accuracy on mobile platforms consistently provides 3-meter accuracy. Adding external GPS receivers can amplify signal strength and improve accuracy to 1-meter. Various critical upgrades are accomplished through coupling advanced GPS receivers to standard tablet technologies. Primarily, the upgraded GPS unit incorporates a chipset that prioritizes position accuracy over power consumption and time to fix. By reprioritizing, the GPS receiver can increase accuracy, achieving 1-meter of accuracy almost 70% of the time[5].

Accuracy with the base model as well as the upgraded GPS receivers varies greatly depending on the cover experienced during data collection. Unobstructed view to satellites will produce the greatest accuracy, while canopy cover, infrastructure density or other interference will reduce accuracy. While upgraded systems will provide increased accuracy over base models, their ability to overcome cover/interference is limited.

The setup to achieve 1-meter accuracy is currently available to the general public however the cost of such systems is several thousands of dollars. This high initial cost to achieve higher level accuracy needed to define the area of excavation severely limits the number of excavators that may use the technology. However, as the technology improves and availability of more accurate systems becomes more widely used, the use of the excavator app will become a more attractive alternative for excavators.

Alternative positioning systems

Dense urban networks, obstructions to satellite signals and other drawbacks limiting GPS accuracy have led to research in alternative positioning systems. Readily available signal technology employed in many mobile devices has been used by companies like AT&T and Microsoft research. These include WiFi, Infrared, radio signals as well as less common signals like ultrasound. Widespread adoption of these technologies is limited since the technology is resource intensive, requiring dense base station network as well as extensive calibration efforts.[6]

Cellular positioning has become another area of research. The extensive wireless communication network and infrastructure provide a unique opportunity to track mobile clients, even while moving through the network. Location is typically achieved via two-way communication between device and cell towers. The most common method of positioning/locating is called Cell identification, or Cell ID. This method relies on the cell tower position that the device is communicating with. There are methods to enhance this location ID, such as using timing

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[5] http://blogs.esri.com/esri/arcgis/2013/07/15/smartphones-tablets-and-gps-accuracy/

[6] Transactions in GIS, 2009, 13(s1): 5-26, “Accuracy of iPhone Locations: A Comparison of Assisted GPS, WiFi and Cellular Positioning”, Zandbergen, Paul A., Department of Geography, University of New Mexico

advance, which is a calculation of the time the signal travels from tower to device. This is referred to as Enhanced Cell ID or E-CID.[7] While these technologies are promising in their ability to enhance location identification, many research publications indicate that accuracies for these technologies are significantly reduced and range between 300 and 500 meters.[8]

Field deployment of locator app and expansion in the use of the Excavator App

In order for the team to fully test the newly developed locator app, excavators would need to begin submitting tickets incorporating shape data, or virtual white lines, via the excavator app to the one call center. This required an expansion of the use of the "NJ virtual white line request" app, otherwise known as the excavator app.

While the team solicited operators to volunteer to pilot the new locator app, the team also approached the New Jersey One Call Center (NJOC) to identify a utility owner that received locate request tickets via phone or fax. The NJOC identified Rutgers University Facilities – Utilities Division as a utility owner that received notification tickets via fax. This offered the team an opportunity to work within the university footprint in the pilot experiment. The team approached university facilities personnel to identify the technicians that would use the tablet and app. In turn, discussions with the technicians assisted the team in identifying potential excavators to use the excavator app. The team approached the following excavators offering the use of the excavator app:

- H C Construction Inc.
- BUIST Inc.
- Taylor Wiseman & Taylor
- Nafe Construction Corp.
- J Fletcher Creamer & son
- Whirl Construction
- Rutgers University-Facilities, Utilities Department
- Rutgers University- Facilities, Maintenance Department
- SCS Inc.
- Pollock Brothers Group
- SA and Sons Construction

Excavators were intrigued by the technology. Many indicated that their internal systems employed underground damage prevention techniques and that the excavator app has the potential to be integrated into their systems once GPS capabilities improve sufficiently so as not

[7] Zandbergen, Paul A., "Accuracy of iPhone Locations: A Comparison of Assisted GPS, WiFi and Cellular Positioning" Transactions in GIS, 2009, 13(s1): 5-26

[8] von Watzdorf, S., Michahelles, F., "Accuracy of Positioning Data on Smartphones", 2010

to require physical white paint at the excavation site. Some companies already used the internet based system, I-TIC, which does not require physical white lining. Several companies did already employ the practice of white lining, and thus, using the excavator app was a seamless transition.

The team was able to identify one excavator and two utility operators to participate in pilot testing of the two mobile apps. Pollock Brothers, Inc. served as an excavator in the footprint of Rutgers University Facilities – Utilities Division, one of the two utility operators participating in the locator app pilot testing. The second locator app pilot test utility operator was Public Service Electric & Gas (PSEG). The following screenshots represent sample markout requests as well as subsequent mapping in the locator app:

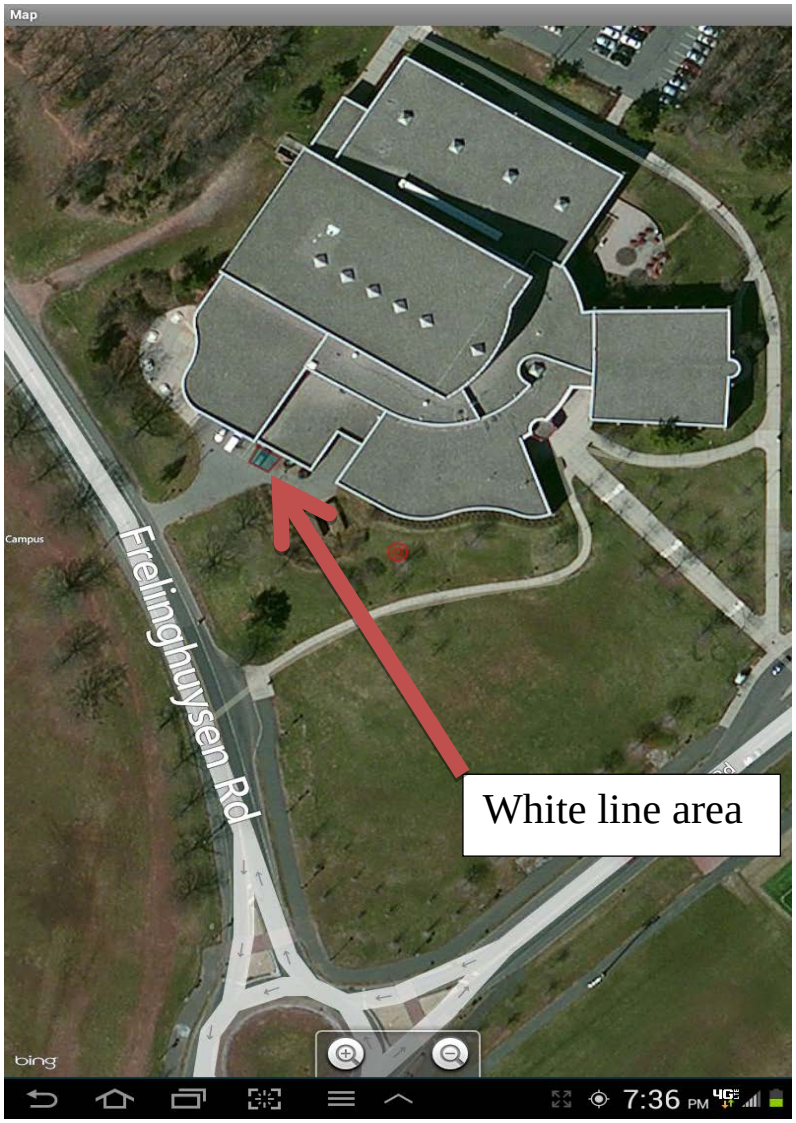

Figure 15 - Markout request of 656 Bartholomew Rd (Sonny Werblin Recreation Center, Busch Campus) using the excavator app for the installation of a protective bollard

Figure 16 - Mapping feature in locator app displaying 656 Bartholomew Rd (Sonny Werblin Recreation Center, Busch Campus) proposed excavation site

Figure 17 - Photo of 656 Bartholomew Road excavation site.

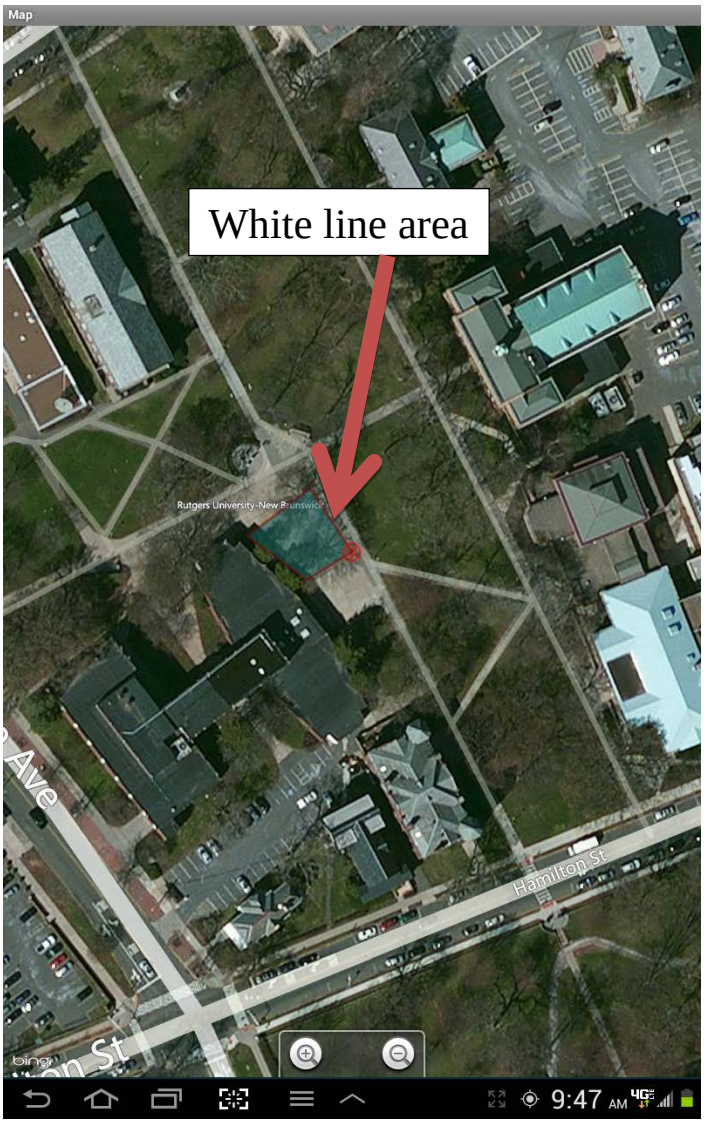

Figure 18 – Markout request of 43 College Ave (Scott Hall) using excavator app to remove and replace sidewalk and curb sections.

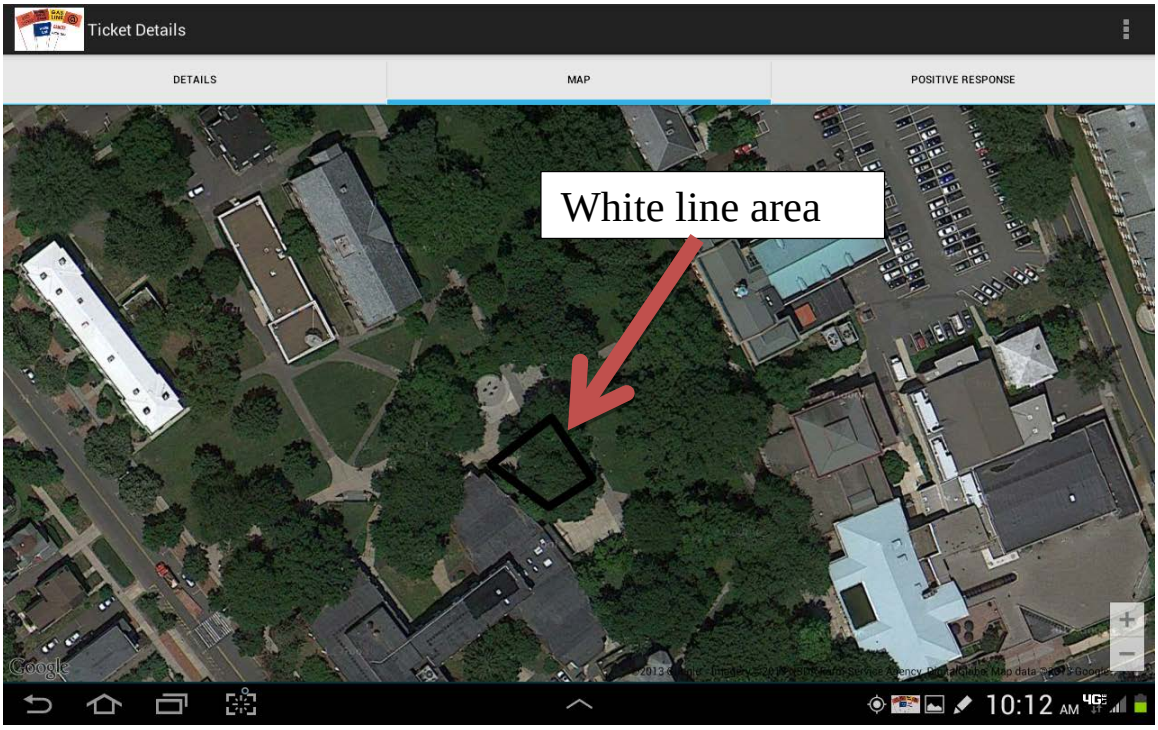

Figure 19 - Mapping feature in locator app displaying 43 College Ave (Scott Hall) excavation site.

Figure 20 - Photo of 43 College Ave excavation site.

Figure 21 – Markout request of 120 Hospital Rd(Bauer Track and Field Complex, Livingston Campus) using excavator app for installing concrete pad for bench.

Figure 22 - Mapping feature in locator app displaying 120 Hospital Rd(Bauer Track and Field Complex, Livingston Campus) excavation site.

Figure 23 - Photo of 120 Hospital Road excavation site.

The following pilot excavation project details the step-by-step process used to submit a locate request. The process starts by filling out the locate request using the excavator app - NJ Virtual White Line Request. The excavator defines the area of excavation using four (4) GPS coordinates and provides the regulatory-based information, then submits the locate request.

Figure 24 - Markout request of 17-29 Mine St using the excavator app to remove and replace of sidewalk.

The mapped area of excavation is mapped by the locator app, which can be used by locating technicians to mark out underground facilities. The locator app provides all the information included in a locate request ticket sent by the New Jersey One Call Center.

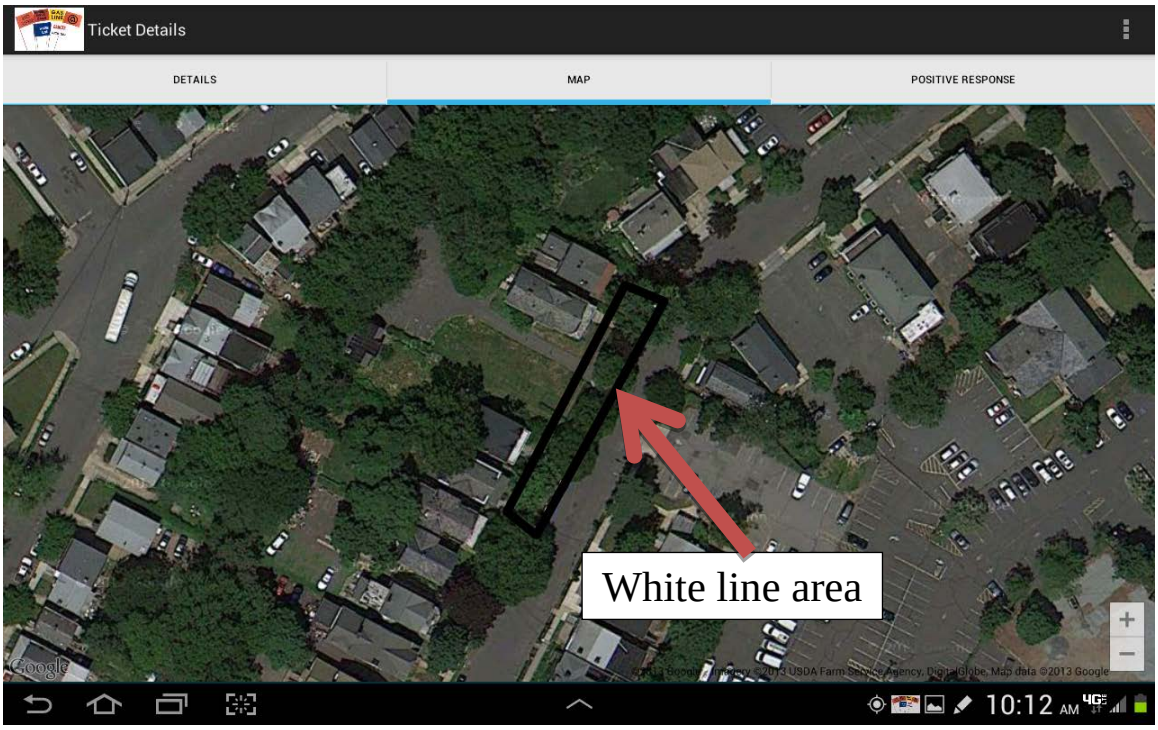

Figure 25 - Mapping feature in locator app displaying 17-29 Mine St proposed excavation site.

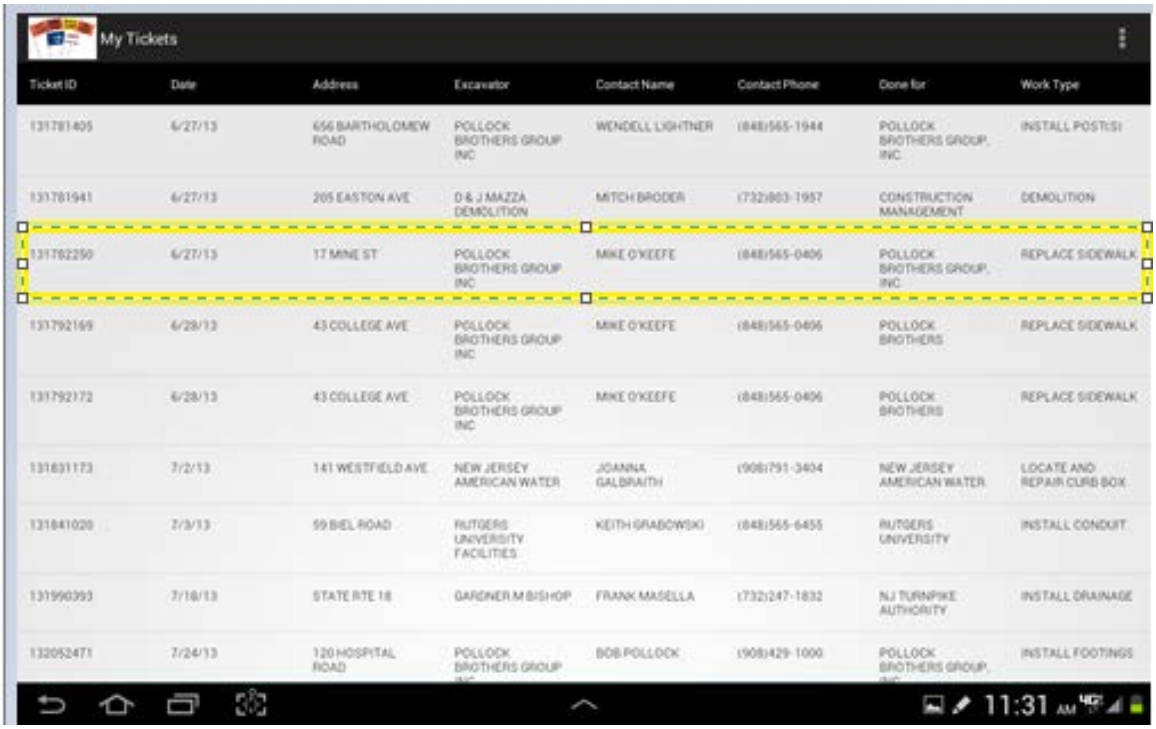

Figure 26 - My Ticket folder in locator app showing the markout request for 17-29 Mine Street.

In addition to the locate request ticket, the app provides the mapping function that can be used to view the area of excavation, as defined by the excavator using GPS coordinates. The ticket also includes the GPS coordinates in the “Extent of Work” field.

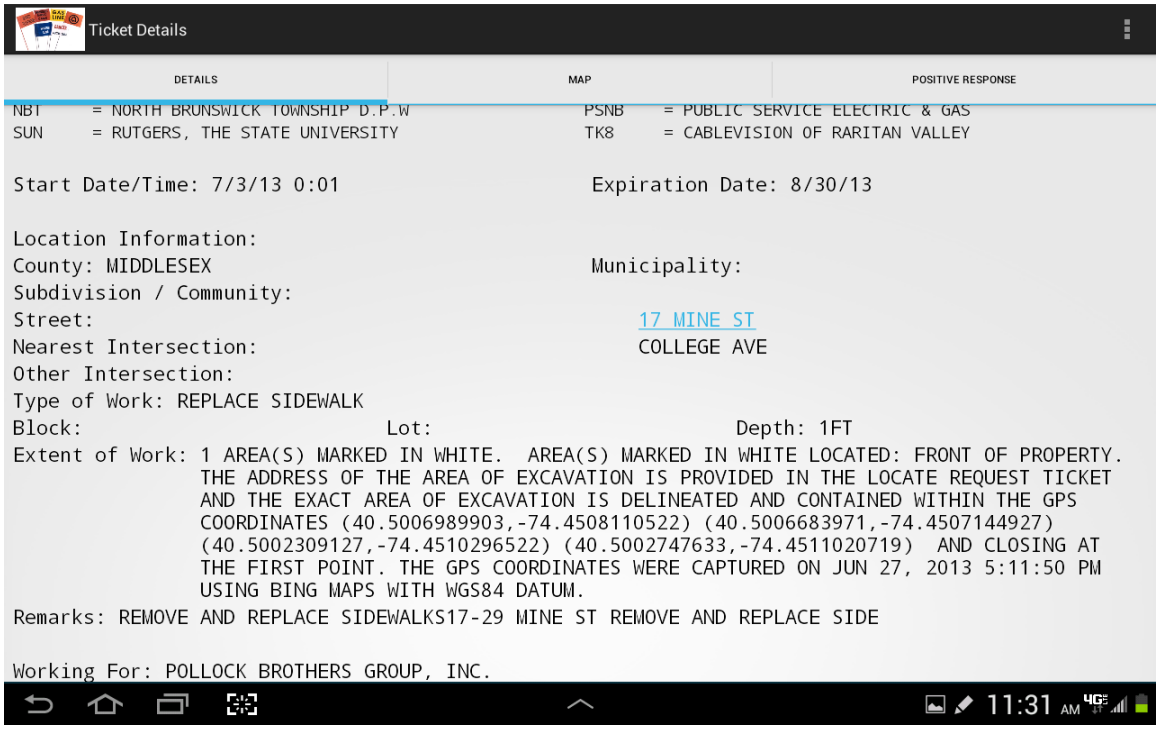

Figure 27 - Ticket details screen on locator app showing details of markout request for 17-29 Mine Street.

Figure 28 - Images depicting the completed markout for the 17-29 Mine Street markout request.

Lastly, the locator has the option to submit a positive response notification to the New Jersey One Call Center. This notification serves as a means for the locator to notify the New Jersey Once Call Center that the ticket has been cleared or marked. This is a recent addition to the one call process, which was added to the locator app as an add-on to further demonstrate the technology's capabilities.

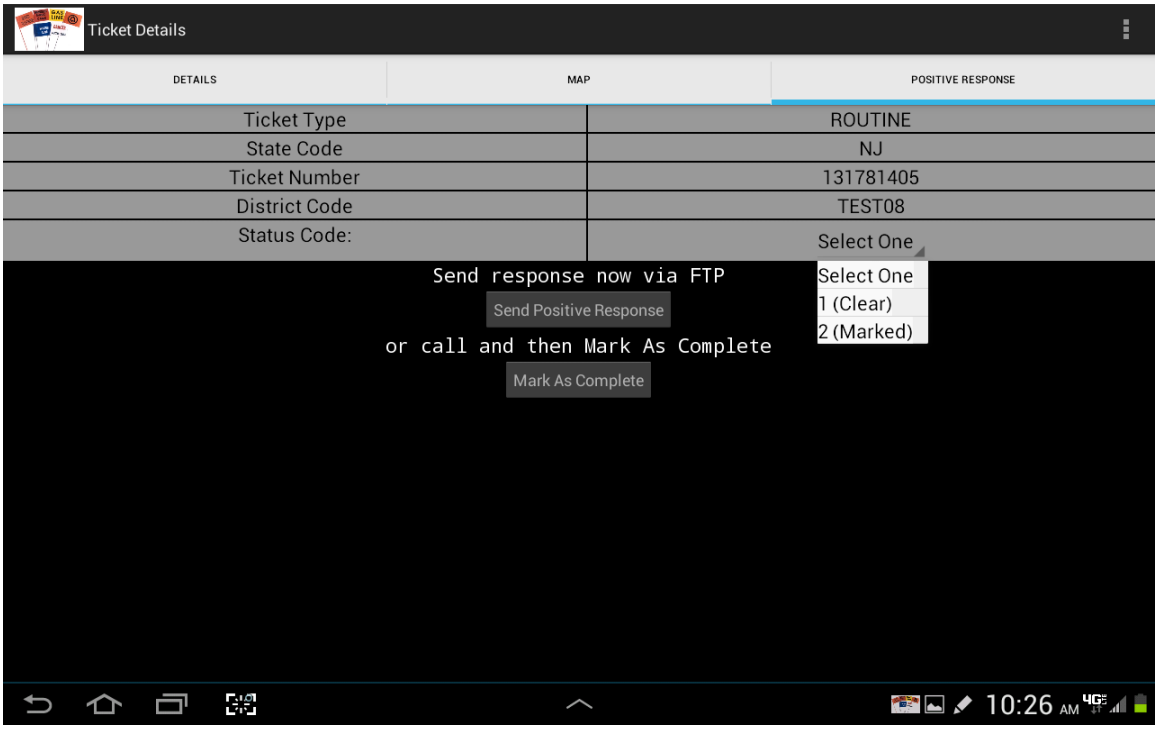

Figure 29 - Positive Response screenshot indicating “Clear” and “Marked” options.

Figure 30 - Markout request of 1303 Centennial Avenue using the excavator app to relocate gas service.

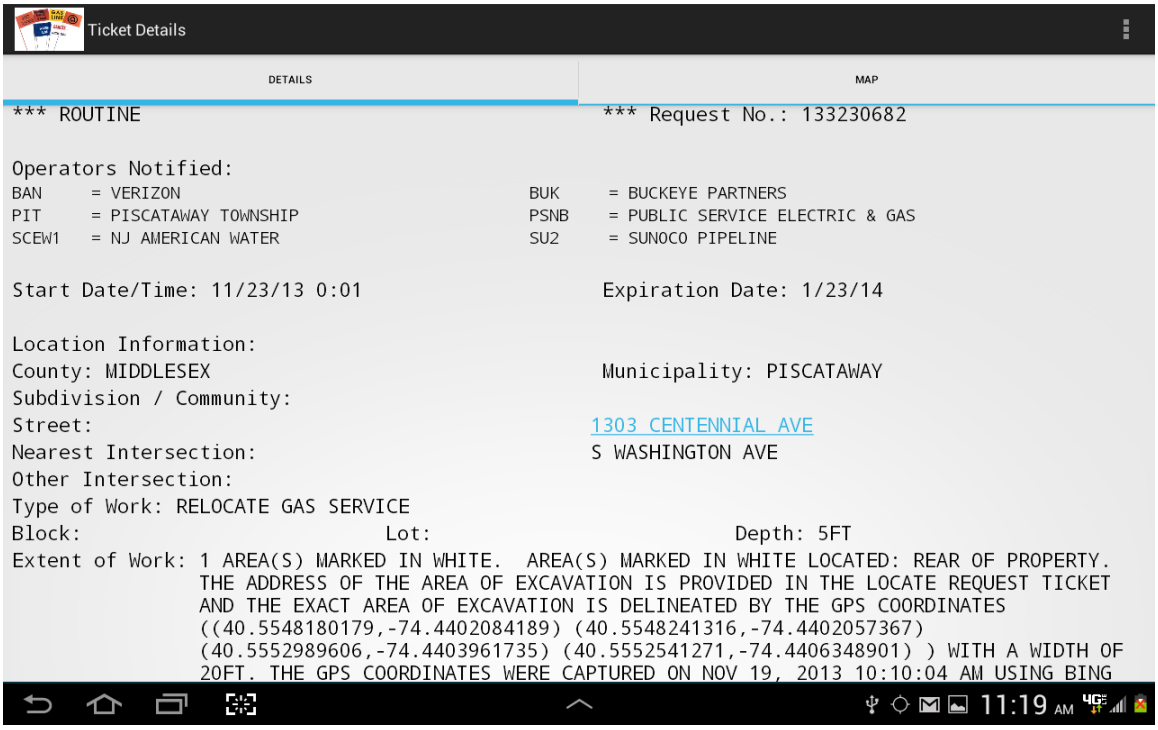

Figure 31 - Ticket details screen on locator app showing details of markout request for 1303 Centennial Avenue.

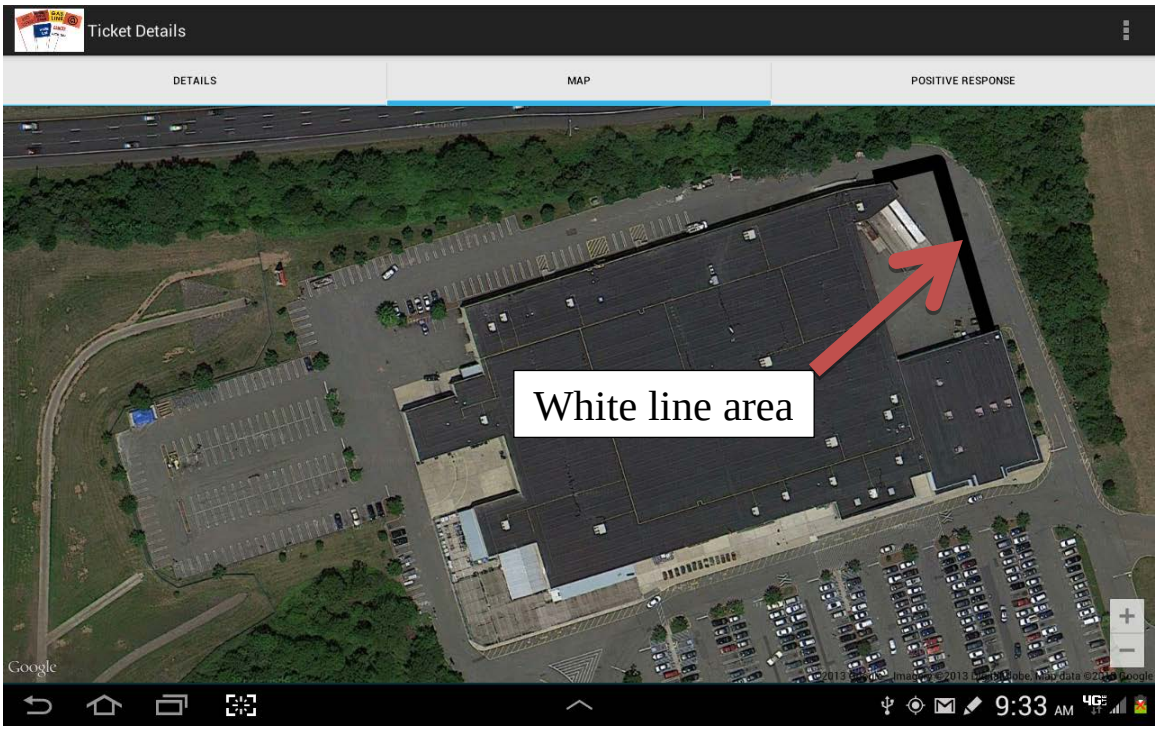

Figure 32 -Mapping feature in locator app displaying 1303 Centennial Avenue excavation site.

Figure 33 Markout request of 101 N Ward Street using the excavator app to relocate gas service.

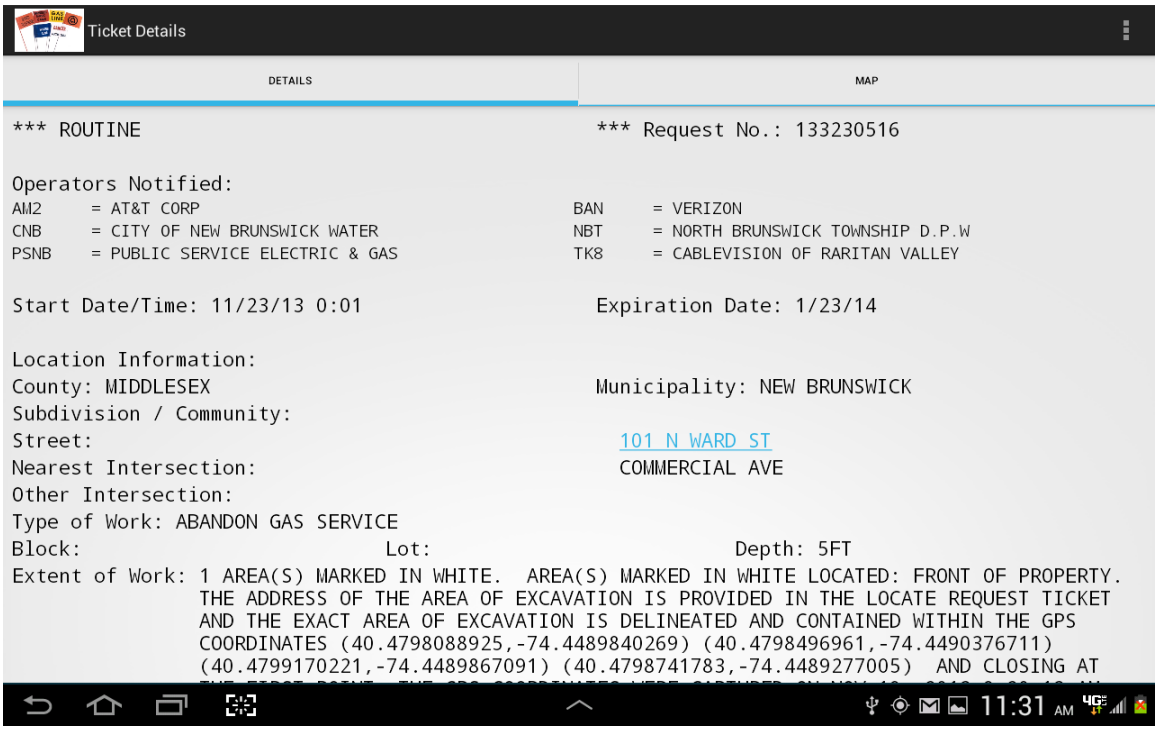

Figure 34 - Ticket details screen on locator app showing details of markout request for 101 N Ward Street.

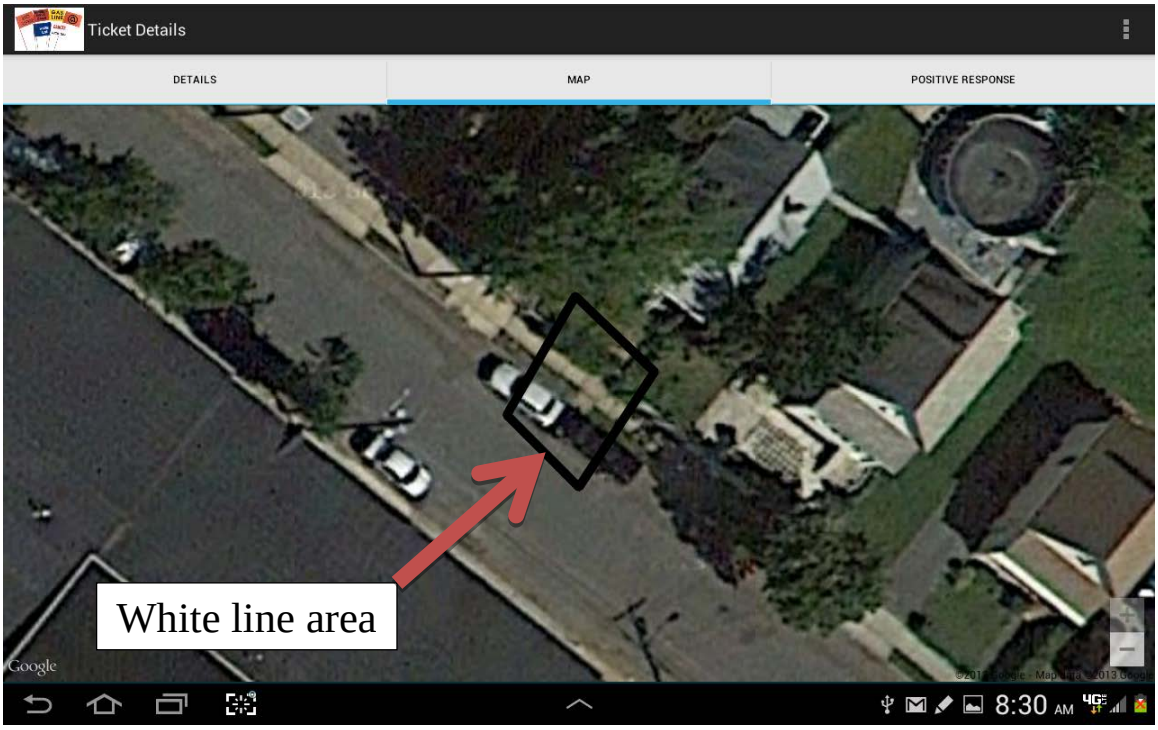

Figure 35 - Mapping feature in locator app displaying 101 N Ward Street site.

Feedback

The two apps were deployed concurrently in order to monitor progress of the new technology, as it interacts. The process is optimized when excavators notify their intent to excavate via the excavator app, along with GPS coordinates of their dig site; and the locator reviews the notify ticket via the locator app, using the mapping feature. Two utility operators pilot tested the combination of locator and excavator app, Public Service Electric & Gas (PSEG), and Rutgers University Facilities – Utilities Division. The goal of pilot testing was to demonstrate the tools' capabilities, establish proof of concept, and identify potential improvements.

Both companies had low notify ticket volumes involving the excavator app during the trial. Thus a limited number of tickets provided GPS coordinates. Testing the full capabilities of the locator app was focused on those tickets that provided GPS coordinates. In addition, tickets that were submitted through the currently available one-call process (phone, fax, web-based), were also reviewed for the positive response capabilities.

Amongst the locator app capabilities, users noticed ticket management and response features provided a solid platform that could be incorporated into existing system protocols. In particular, the locator app's ability to identify emergency/routine tickets, delegate tickets to locate technicians, view mapping, and submit positive response for completed tickets were identified as features that could help improve their existing protocols. Some users indicated that features incorporated into the locator app were available in other ticket management solutions. While the

research team recognizes that certain features of the locator app are currently available as solutions for locators; the team also recognizes that in order to test the main developments of the grant, the team would need to incorporate these developments within a rudimentary ticket management framework. The capabilities developed are thus a delivery mechanism used to incorporate the GPS mapping capabilities required to create mapping from tickets generated through the excavator app.

Users suggested that the functionality and advances developed in the locator app could be incorporated into a comprehensive ticket management software solution. The administrative and reporting features included in ticket management software such as timesheet submittal, units completed, tech completing work, and others would benefit from the capabilities developed in the locator app. In addition, companies with multiple facilities would benefit from the locator app capabilities if it were incorporated within their ability to manage multiple facilities (gas and electric for example). Based on the feedback provided, users would consider incorporating app features within their currently existing management systems. Such integration would result in improved underground damage prevention through increased communication between stakeholders.

Guidance for encouraging further use of the excavator app

The team approached excavators within the footprint of the locator app pilot testing in order to drive GPS coordinate-driven notify requests with the goal of expanding the use of the excavator app. A majority of the excavators that the team approached did not opt to use the excavator app. One excavator, Pollock Brothers, Inc. pilot tested the app. Through their testing, the excavator noted that the app was an additional step, rather than a time-saver. The excavator suggested that submitting notification tickets in lieu of physical white lining would save time and be preferred over the as-tested protocol, requiring both virtual and physical white lining. The team also engaged Rutgers facilities in the use of the excavator app. The Rutgers Facilities staff indicated that the low turnout could be attributed to the white lining requirement, which severely detracts the use of the excavator app. Their staff solicited participation in the use of the excavator app, but suggested that their effort could be bolstered if excavators were allowed to submit requests without the use of physical white lining.

PSEG staff also tested the excavator app and provided valuable feedback. Their staff noted that the excavator app would be well suited for “zero address” markout, those that do not require a physical address due to their remote location or other special feature. This feature was not developed in the original research effort because the team believed excavators would forego the numerous data fields required to complete a ticket. This may be a potential area of improvement in the excavator app.

While the original intent of this task was to develop a "best practices" guideline, the team recognizes through this effort that further enhancements to the excavator app are required for

full-deployment and excavator acceptance of the new excavator app. Possible improvements include, incorporating more intricate aspects of white lining including work undertaken at or through intersections, highway work, “zero address”, and other work beyond the existing capabilities of the app. Improvements to the excavator app could also be incorporated into the newly designed locator app.. This will be accomplished through maintaining the XML schema provided by the One Call Center.

Conclusions

New technologies provide innovative ways to communicate. Incorporating such technologies in underground damage prevention provides new tools for excavators to dig safely. The objective of this study was two-fold: develop a locator app that would accept GPS coordinate data and provide locators with a map of the intended area of excavation, and to expand the use of the excavator app developed under the 2009 Technology Development Grant in order to collect user feedback and develop a “best practices” guide. The team was able to develop the locator app, which collected GPS coordinates from locate-request tickets and was able to display a map with an overlay of the virtual white line. In order to deploy the technology, the team solicited various excavators to use the excavator data.

As in the Technology Development Grant (TDG), the storyboard development process focused on a locator app that could function within the current regulatory process. Specifically, the existing regulation may not adequately address the use of WGS coordinates and aerial mapping as the sole descriptors for the area of excavation. The team continued to operate under the consensus reached during the TDG, which required excavators using the mobile app to delineate the area of excavation to use the accepted practice of white lining in addition to submitting their locate-request through the mobile app. By incorporating white lining into the current grant cycle, the research was able to convey the current level of GPS accuracy built-in to mobile and tablet devices. Excavators and locators agreed that the locator app successfully recreated the intent to excavate from the excavator app. The research team notes that with improvements in GPS accuracy, we can anticipate a time when higher GPS accuracies will be achieved, thus providing a clear path to adopting the demonstrated technologies within the underground damage prevention program.

Another central theme in the research involved the amount of typing users would accept. The team hypothesized that users would accept a minimal amount, given the relatively small keyboard and limited operability of a mobile device. However, the use of a tablet increased users’ acceptance towards the amount of typing, and even caused users to request features that would expand on typing required in various fields. This finding suggests that future versions of the apps could consider such features as “zero address” tickets in the excavator app, and advanced ticket management and delegation features.

The applications were successfully tested, with an expansion of testing completed during the extension period. The team recruited excavators to submit locate requests as well as assisted locators in using the locator app to locate facilities based on the defined area of excavation. Excavators were intrigued by the technology. Many indicated that their internal systems employed underground damage prevention techniques and that the excavator app has the potential to be integrated into their systems once GPS capabilities improve sufficiently so as not to require physical white paint at the excavation site. The team collaborated with various excavators to collect sufficient tickets to test out the locator app and show proof of concept. Current GPS accuracy on mobile platforms consistently provides 3-meter accuracy. Adding external GPS receivers can amplify signal strength and improve accuracy to 1-meter. As the technology improves, and availability of more accurate systems becomes more widely used, the accuracy of GPS coordinates will be sufficient to fully incorporate the mobile device into the one call process.

At this time, the project was finalized with a practical analysis of implementing the two apps. As discussed in the body of the report, GPS accuracy and its technology are continuing to improve and will, in the near future, be within acceptable tolerances for use within the underground damage prevention program. Based on the findings, the team is recommending that the underground damage prevention program postpone development of the “best practice” guide until GPS technologies attain the required levels of accuracy for implementation.

The locator application development and testing, which included an expansion of the excavator app, was conducted without causing significant disruption to the New Jersey One Call Center processes. Although a “best practices” manual could not be developed for the excavator app due to the low volume of tickets generated, the feedback from excavators identified critical changes that could be made to significantly improve participation.

The two apps demonstrated in this project are compatible with any Android OS smartphone and can be adapted to communicate with XML based internet communication systems. Once GPS accuracy improves in mobile and tablet platforms, the two apps can be upgraded from “proof of concept” to fully deployable apps that can be seamlessly integrated into the current network of communication media available to excavators and locators. The integration would directly respond to 9 element legislation and support underground damage prevention efforts thorough improved communication between stakeholders.