**Recycled Material Web Map: Connecting Consumers and Producers**

Prepared for the

Recycled Materials Resource Center

by

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**16. Abstract**

An online Geographic Information System (GIS) web application that connects producers and consumers of recyclable material was developed to assist engineers and contractors in the beneficial reuse of recycled materials in transportation projects. The Recycled Material Web Map is comprised of four core layers: producers, stockpiles, specifications, and case studies. Producers of recycled material can locate their facility and enter contact information. The stockpile layer, connected to the producer layer, allows facility managers to add or update information about their recycled material stockpiles including material type(s), application(s), availability, and cost. Multiple stockpiles can be associated with each producer. The specification layer includes both Department of Transportation (DOT) specifications and environmental regulations pertaining to the beneficial reuse of nonhazardous recycled material based on specific location, material type, and application. The case study layer locates projects that successfully utilized recycled materials and includes information regarding the material type, application, volume data, and any additional documentation. As potential consumers of recycled material, engineers and contractors can pinpoint the location of a construction project, search for sources and quantities of recycled material that meet project specifications, and contact material producers. The web map utilizes search capabilities to locate nearby stockpiles to minimize transportation costs that typically dictate the use of large volumes of materials. The Recycled Material Web Map provides key information that engineers and contractors need to successfully utilize recycled materials, thereby preserving limited natural resources and benefiting the project and society as a whole. The web map is available at http://rmwm.caps.ua.edu.

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# Executive Summary

An online GIS web application that connects producers and consumers of recyclable material was developed to assist engineers and contractors in the beneficial reuse of recycled materials in transportation projects. The Recycled Material Web Map is comprised of four core layers: producers, stockpiles, specifications, and case studies. Producers of recycled material can locate their facility and enter contact information. The stockpile layer, connected to the producer layer, allows facility managers to add or update information about their recycled material stockpiles including material type(s), application(s), availability, and cost. Multiple stockpiles can be associated with each producer. The specification layer includes both DOT specifications and environmental regulations pertaining to the beneficial reuse of nonhazardous recycled material based on specific location, material type, and application. The case study layer locates projects that successfully utilized recycled materials and includes information regarding the material type, application, volume data, and any additional documentation.

As potential consumers of recycled material, engineers and contractors can pinpoint the location of a construction project, search for sources and quantities of recycled material that meet project specifications, and contact material producers. The web map utilizes search capabilities to locate nearby stockpiles to minimize transportation costs that typically dictate the use of large volumes of materials. Currently, the Recycled Material Web Map is being populated with producer facility information and stockpile data. Specifications and regulations have been collected and integrated into the website for Wisconsin, Virginia, Pennsylvania, Minnesota, Illinois, Georgia, AASHTO, FHWA, and EPA. The Recycled Material Web Map provides key information that engineers and contractors need to successfully utilize recycled materials, thereby preserving limited natural resources and benefiting the project and society as a whole.

The Recycled Material Web Map was developed and is hosted at the Center for Advanced Public Safety (CAPS) at The University of Alabama and was funded through a pooled fund supporting the Recycled Material Resource Center (RMRC) at the University of Wisconsin-Madison. The web map is available at http://rmwm.caps.ua.edu.

# 1.0 Introduction

Over a half of a billion tons of recyclable material including construction and demolition debris, foundry sand, coal combustion products, and slags are produced each year in the United States *(1)*. Nonhazardous waste products generated from manufacturing, industry, and electric utilities have the potential to be reused for a variety of transportation construction applications. Currently, the widespread use of these potentially recyclable materials is deterred by a lack of information. To feel comfortable, an engineer or contractor needs to: understand the beneficial use of a material, understand the specifications and regulations that apply to a material, be able to locate an available source of recyclable material, and see examples of this material used in other projects.

Extensive research has been conducted on the engineering uses and applications of recycled material; however, there are limited tools available to map the locations of the material generators and stockpiles. The Texas Department of Transportation (TxDOT) Reclaimed Materials Supplier Map provides an example of a GIS-based online map that spatially displays the locations of recycled material generators and processors. Users can add and edit recycled material facilities. Facilities can be identified by searching for districts, counties, and/or material type. Each material type is associated with a unique symbol, and the map can be thematically mapped by toggling on/off material type(s) in the legend. In addition, zoom options including zoom to county, clustering, and circle measure are included. The circle measure tool allows the user to search for facilities in a specified radius of a chosen location *(2)*. However, this application does not include information about the generator quantities, cost, or material applications. As of 2015, the tool is no longer available online. In 2003, TxDOT conducted a separate study to create an information system prototype to track the availability, location, and material specifications of nonhazardous recyclable materials for transportation construction projects. While the prototype website successfully tracked various recycled materials, the website is no longer active. Researchers concluded that the system itself worked well and the technology was useful, but full-implementation of the system was not feasible because of competition, confidentiality, and the immaturity of recycling infrastructure at the time *(3)*.

The majority of the material exchange online applications reviewed, at the national, regional, and state level, provide a listing of recycled material advertisements without a location based map of the suppliers. There are several of these listing-type websites that operate on a national scale such as the American Foundry Society (AFS). The AFS website provides a directory system of more than 2,500 metal casters, which can be searched by alloy, process, casting weight, country, and/or state *(4)*. The directory does not include a location map, quantities available, or cost. Additionally, several of the Environmental Protection Agency (EPA) regions have initiated waste exchange listing websites as well. The Resource Exchange Network for Eliminating Waste tool provides EPA Region 6 (Arkansas, Louisiana, New Mexico, Oklahoma, Louisiana and Texas) with a listing-type material exchange website. The listings are sorted by material type and include contact information and a brief description of the material.

Location (city, state), quantity, and cost information is included in the descriptions, but a location map is not provided *(5)*. There are a large amount of listing-type material exchange websites on a state or local level. Websites were reviewed for the following states: Pennsylvania, Iowa, Maine, Minnesota, and North Carolina. Some states had more advanced and inclusive websites than others, but none of them featured mapping capabilities *(6, 7, 8, 9, 10, 11)*. Figure 1 illustrates the North Carolina Waste Trader website material availability page, exemplifying the standard listing-type web application used across the nation as opposed to the inclusion of a web-based location map *(11)*.

Many studies have been conducted on the recycled material properties and their use in specific construction applications. In addition, there are numerous material exchange websites that provide a way for facilities and companies to post available and/or wanted material type(s), quantities, cost, and material characteristics. However, there is a gap in available technology that connects the producers to the consumers of recycled materials on a location basis, in addition to the parameters listed above. The objective of the Recycled Material Web Map is to close this gap by creating an online GIS-based tool that includes location and availability of recycled material sources, past projects that successfully used recycled material, and specifications and

## NORTH CAROLINA WasteTradeR

**Materials Available**    **Materials Wanted**    **Need Help?**

**List of waste materials available:**

Date listed ▼  Descending ▼  Sort

**SEARCH LISTINGS**
Search keyword(s)  Go

| Material Name | Amount on Hand | Frequency Available | Price ($) | City | State | Date Listed |
|---|---|---|---|---|---|---|
| Lumber | 200 board feet | one time, continuous | 2 dollars per board foot | Waxhaw | NC | 11/04/15 |
| 3 Ring Binders | 300 binders | annually | $0 | Durham | NC | 11/02/15 |
| Meltblown Nonwoven Textiles | 60,000 lbs. | Monthly | Market pricing | High Point | NC | 10/29/15 |
| Silica Matting Agent | 540 lbs | one time | $1 per pound | Lillington | nc | 10/16/15 |
| Sand | about 0.25 gallon | one time | free upon pick up | Durham | NC | 09/14/15 |
| Oak Mats Rough Ground | 4000 cu yds | one time | | Jarvisburg | NC | 06/23/15 |
| sheetrock | 20+ tons | monthly | FREE | Lillington | NC | 04/28/15 |
| PVC Pipe | 3000 pounds | quarterly | .05 | Charlotte | NC | 04/01/15 |

regulations that pertain to the use of recycled material in construction projects.

**Figure 1.  North Carolina Waste Trader website material availability results (11).**

# 2.0 Methodology

A typical software development cycle was performed to design the Recycled Material Web Map. As part of the development, a thorough literature review of existing recycled material exchange websites was performed, meetings with the project advisory group were held, and extensive prototyping and testing of site components was carried out.  Based on the findings of the literature review and correspondence with the advisory group, four map layers were identified as key components of the Recycled Material Web Map.  These layers are: producers, stockpiles, specifications/regulations, and case studies.  With these four core layers and associated information, the Recycled Material Web Map provides valuable information in a user-friendly online tool to promote recycled material use in transportation projects.
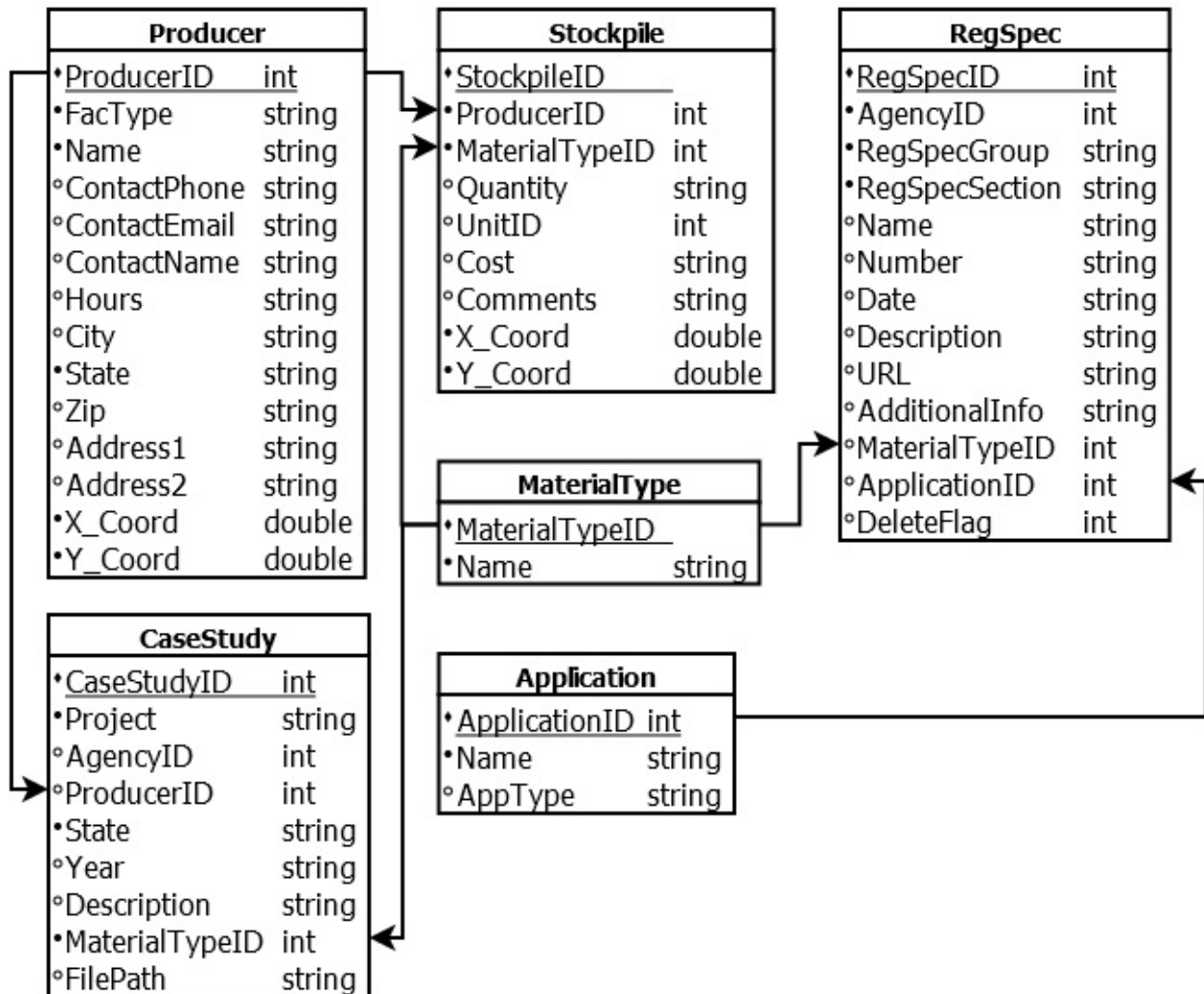
The four layers of the Recycled Material Web Map each provide spatially related information to aid in the use of recycled material in transportation projects.  The producer layer includes contact information for facilities that generate recyclable material.  Facility managers can update material type, application, and quantity information in the stockpile layer.  Every stockpile is associated with a producer, but producers are not required to have active stockpiles. Both producers and stockpiles can be designated historic if the material is no longer available or after a period of inactivity.  To keep the information current on the website, producers can supply a web service that automatically updates the stockpile quantities.  If a service is not available, the producer can be automatically contacted by email to confirm that their stockpile quantities are up to date.  If the stockpile information is out-of-date (older than nine months), the stockpile(s) will time out and become historic to ensure quality map data.

Department of Transportation specifications and environmental regulations that pertain to the beneficial reuse of industrial byproducts or other recyclable materials were collected for six states (Wisconsin, Virginia, Pennsylvania, Minnesota, Illinois, and Georgia) and three federal agencies (American Association of State Highway and Transportation Officials (AASHTO), Federal Highway Administration (FHWA), and Environmental Protection Agency (EPA)) to populate the regulation and specification layer.  Hyperlinks to the specific sections of these regulatory documents at the state and federal agencies are available on the web map and are searchable by state, material, and application.

The case study layer locates construction projects that successfully utilized recycled material.  In addition to the material type(s) and application(s) used in the project, the additional information stored in the case study layer include a synopsis of the project, pictures, and any other project documentation such as final reports or presentations.

**Recycled Material Web Map Database**

The Recycled Material Web Map utilizes a relational database to store information that can be edited and updated online by users with appropriate authorization.  The table schema for the website is shown in Figure 2, where tables are depicted as boxes that contain attributes and relationships between the parameters of the core layers of the web map are shown as arrows. The producer contact information is linked to both stockpiles and case studies.  Stockpiles are associated with both producers and material type.  Specifications and regulations contain both material and application type information.  Material type(s) are recorded for each case study, and

| Producer | |
|---|---|
| •ProducerID | int |
| •FacType | string |
| •Name | string |
| °ContactPhone | string |
| °ContactEmail | string |
| °ContactName | string |
| °Hours | string |
| °City | string |
| •State | string |
| °Zip | string |
| °Address1 | string |
| °Address2 | string |
| •X_Coord | double |
| •Y_Coord | double |

| Stockpile | |
|---|---|
| •StockpileID | |
| •ProducerID | int |
| •MaterialTypeID | int |
| °Quantity | string |
| °UnitID | int |
| °Cost | string |
| °Comments | string |
| •X_Coord | double |
| •Y_Coord | double |

| RegSpec | |
|---|---|
| •RegSpecID | int |
| •AgencyID | int |
| •RegSpecGroup | string |
| •RegSpecSection | string |
| °Name | string |
| °Number | string |
| °Date | string |
| °Description | string |
| °URL | string |
| °AdditionalInfo | string |
| °MaterialTypeID | int |
| °ApplicationID | int |
| °DeleteFlag | int |

| MaterialType | |
|---|---|
| •MaterialTypeID | |
| •Name | string |

| CaseStudy | |
|---|---|
| •CaseStudyID | int |
| •Project | string |
| °AgencyID | int |
| °ProducerID | int |
| •State | string |
| °Year | string |
| °Description | string |
| •MaterialTypeID | int |
| °FilePath | string |

| Application | |
|---|---|
| •ApplicationID | int |
| •Name | string |
| °AppType | string |

the producer who supplied the recycled material can optionally be connected to the case study. There are several additional linking tables used to normalize the database that are not included in Figure 2.
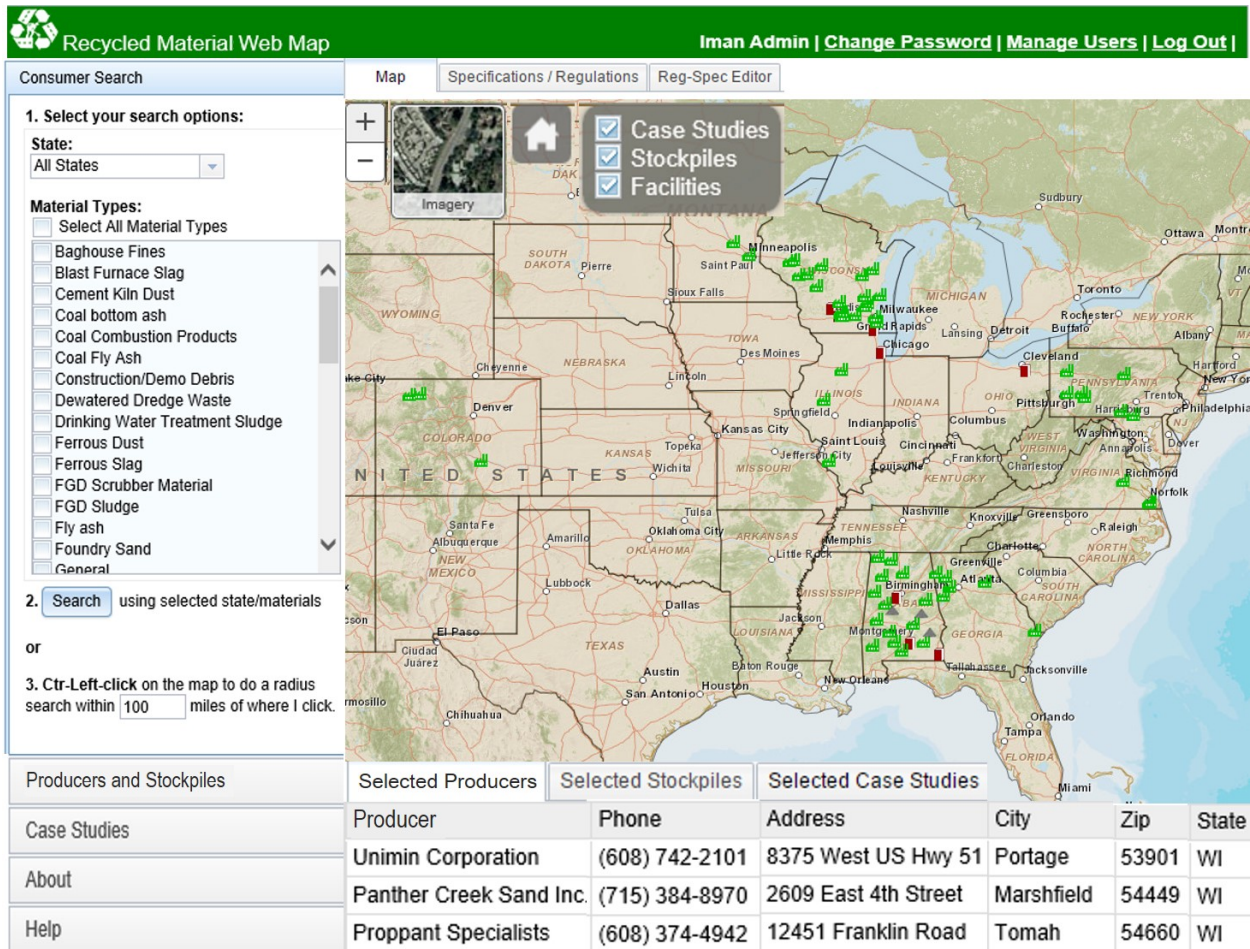
**Figure 2.  Recycled Material Web Map table schema with primary keys underlined, required attributes preceded by a solid dot, and table relationships shown as arrows.**

**Recycled Material Web Map Functionality**

The Recycled Material Web Map was designed as an interactive online tool and supporting website. The website evolves as new producers, stockpiles, and case studies are added. Figure 3 displays the default map view of the website underlain by an ESRI basemap that toggles between street view imagery and aerial imagery (12). Facilities are depicted with factory symbols, stockpiles are shown as triangles, and case studies are represented as rectangles. Users can zoom in and out of the map using the plus or minus buttons located on the top left corner of the map view or by selecting a state from the drop down menu on the search panel. When a state is selected, the map zooms in to the state level, and users can zoom in further to view a project site by using the plus button or the roller ball of the mouse. Across the top of the default screen are tabs that include: Map, which is the default view; Specifications/Regulations, which displays state and federal information; and Reg-Spec Editor, which allows advanced users to enter and maintain specifications and regulations. The side bar to the left of the map screen includes several panels: Consumer Search, Producers and Stockpiles, Case Studies, and Help. The Consumer Search panel allows users to search for stockpiles, producers, specifications and regulations, and case studies. With appropriate login credentials, facility contact information and stockpile data can be entered on the Producers and Stockpiles panel. Case study information and associated project documents can be uploaded using the Case Studies panel. The Help panel includes a user guide and several video tutorials of the major components of the website. The result grid at the bottom of the default map screen displays producers, stockpiles, and case studies that are selected based on the search criteria applied in the Consumer Search panel. The map features a user-friendly interface and is accessible on mobile devices.

There are three user levels associated with the Recycled Materials Web Map: general user, producers or suppliers of recycled material, and advanced users. General users can search for local recycled materials, specifications, and case studies that utilized recycled material in construction projects. Producers can promote material by entering, updating, and maintaining material source information. Additionally, advanced users such as researchers and DOT agencies, can add DOT specifications, environmental regulations, and case studies. The Recycled Material Web Map application was designed to provide specific functionality for each of these three user levels.

**Figure 3. Recycled Material Web Map default map view showing the map area with producers, stockpiles, and case studies on an ESRI basemap (12), the results grid at the bottom of the screen, and a sidebar with multiple panels for searching the site.**

*General User Level*

The general user level is open-access, allowing anyone to view and search the website for recycled material stockpiles, specifications and regulations, and past case studies. There are several ways to search the Recycled Material Web Map. The Consumer Search, as shown in Figure 4(a), allows the user to select a specific state and material type(s) to filter the stockpiles. The stockpiles that meet the search criteria are selected and listed in the grid at the bottom of the main default map screen, as shown at the bottom of Figure 3. Clicking on a stockpile in the grid at the bottom of the default map screen, highlights the stockpile on the map, zooms to that stockpile, and a window pops up on the map that displays available quantity information. In addition, a radius search is available that allows a user to locate their construction project and specify a radius in the search panel to select all of the stockpiles that are within the given distance as shown in Figure 4(b). Users can toggle between selected stockpiles and selected producers in the results grid at the bottom of the map to view producer contact information and available material quantities.
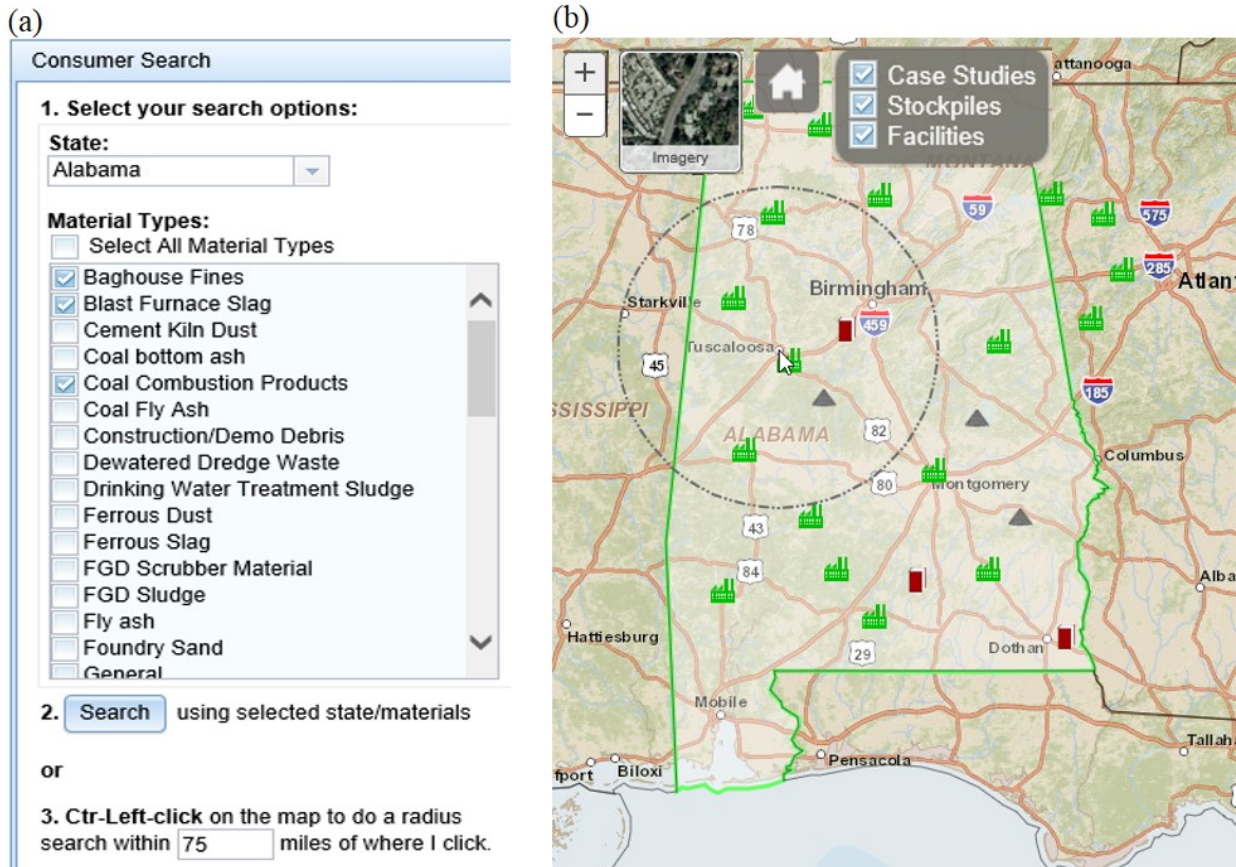
6

**Figure 4(a). Consumer Search panel includes options to search by state and/or material type or search by radius. (b) Radius search selects all producers and stockpiles within a specified radius (12).**

In addition to searching for available stockpiles and viewing producer contact information, general users can also search federal and state DOT specifications and environmental regulations that apply to the beneficial use of recyclable material. The majority of DOTs maintain construction specifications specific to the use of recycled material in roadway construction projects, and the environmental agency of each state regulates the use of recycled material. Any recycled material that is used in construction projects must meet both sets of regulatory requirements, and some practitioners may be unfamiliar with these requirements. Therefore, recycled material specifications and regulations have been collected for national and state entities to provide focused information for users. Specifications and regulations from federal agencies including AASHTO, FHWA, and EPA have been identified and are included in the Recycled Material Web Map database. Also, specifications and regulations for several states including: Wisconsin, Virginia, Pennsylvania, Minnesota, Illinois, and Georgia are included. To search the specifications and regulations, users can filter by state and/or material on the aforementioned consumer search panel or simply click within a state on the map. The specifications/regulations tab automatically updates based on the search results. As shown in Figure 5, links to applicable specifications and regulations are listed on the tab as well as the

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agency, material type(s), and material application(s).  Also, a short description of each specification and regulation appears by hovering over a specification or regulation.  Below the specifications and regulations, additional information that pertains to the search criteria is listed.  Additional information can include fact sheets about the material, design guidance, and links to external websites that may be helpful when designing or constructing with recycled materials.  The specifications, regulations, and additional information connect practitioners with recycled material resources and documents, but engineers and contractors should still perform due



diligence checks.

**Figure 5.  The specifications and regulations tab includes DOT specifications, environmental regulations, and additional information pertaining to the beneficial use of recycled material.**

On the default map view, general users are able to view a map of case study projects that have used recycled materials in past projects.  Case studies are shown as rectangles on the map tab and can be filtered using the same search panel as the stockpiles, producers, and specifications.  Figure 6 shows an example of the information that is attributed to each case study including: a brief synopsis of the project, material(s) used, and additional project documentation such as reports or spreadsheets.

**Figure 6. Case study synopsis window displays key information including project name, materials used, description, and link(s) to project documentation (12).**

*Producer User Level*

The producer user level has all of the capabilities of the general user plus several additional mapping privileges. In order to add and update stockpile or producer information, users must create a log-in to the website. Producers who log-in to the site gain access to the producer and stockpile side panel, allowing users to update producer contact information and stockpile information. A new producer can add facility contact information by clicking the "Add New Producer" button and completing the form that pops up. Returning producers can update the contact information for a facility by clicking the edit button beneath the producer information displayed in the panel as shown in Figure 7. Producers are only able to edit their own facility and stockpile information. Optionally, producers can choose to limit what information they include on the site, such as quantity, cost, or composite material constituents, to protect confidentiality.
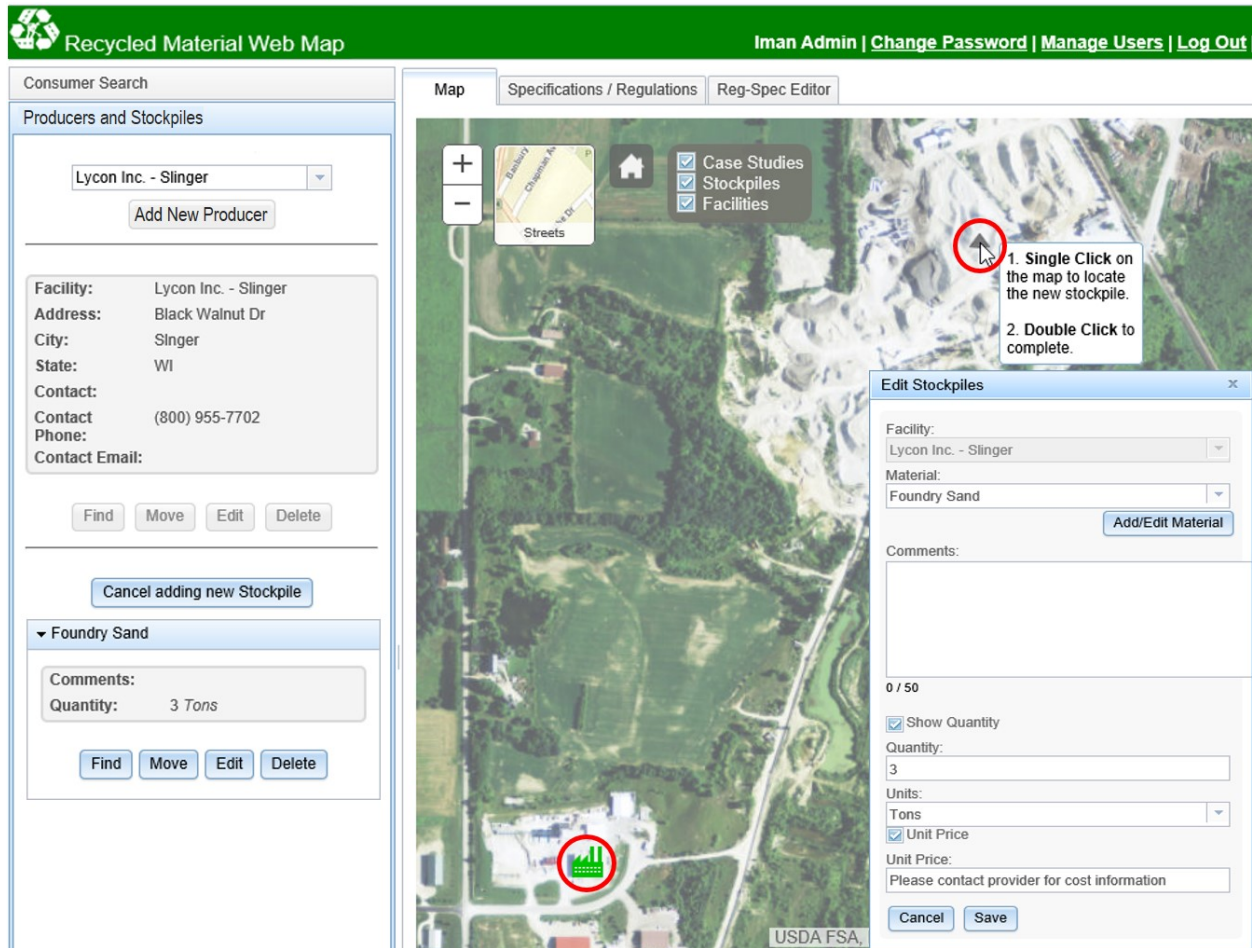
**Figure 7. Example facility and stockpile (circled in this figure) that are added and updated on the Producers and Stockpiles panel. The stockpile details are listed beneath the Producer contact information (12).**

*Advanced User Level: Researcher/Agency*

Researchers and DOT agencies can receive advanced user login credentials. Advanced users have access to the same website features as the general user and producer user levels, but can also add and edit DOT specifications and regulations and add case studies to the map.

Advanced users can use the Reg-Spec Editor tool to add and edit DOT specifications and regulations. To add or edit a specification, the user selects or adds an agency (DOT), group, and



section. The specification group is the title of the regulatory document (e.g. 2007 Road and Bridge Specifications) and the section refers to the subheading of the document that includes the specific specification (e.g. Division II – Materials) as shown in Figure 8(a). Clicking the "Add Reg/Spec" button or double clicking the specific specification in the bottom grid will open the Add/Edit Reg/Spec dialog box as shown in Figure 8(b). Attributes including specification name, number, a brief description, material(s), and application(s) can be added or edited. Materials and applications that are not already listed in the material and application type lists can also be added. Additional information is added in the same way as the specifications and regulations, but this functionality is located on a similar but separate tab.

**Figure 8(a). Example specifications listed by agency, group, and section in the Recycled Material Web Map Reg-Spec Editor. (b) Reg-Spec Editor dialog box for entering and updating specifications, regulations, and additional information.**

In addition to adding specifications and regulations, advanced users can also map case studies and upload documents associated with the project. To add a case study, users can click the "Add New Case Study" button in the Case Studies panel to locate a project on the map and add information into the form as shown in Figure 9. Users are prompted to upload any project

documentation that might include a final report or mix design. For example, Figure 9 displays a case study on the State Highway 60 project north of Madison, Wisconsin that is currently mapped on the website. The case study includes a list of the recycled materials used, a description of the project, and a link to the project report. Hyperlinks can also be added to case studies and can include links to videos or photographs. This information could increase the confidence of other practitioners who are considering using recycled material in construction projects by providing useful examples. The case study information is displayed on the Case Studies panel, and can be edited by any advanced user.

There are web links associated with the Recycled Material Web Map in the regulations, specifications, and case study layers. To avoid "broken links" over time, an automated process routinely checks for changes in the associated page for each link. Hash values created from the source code characters of each page are used in the web page comparisons. If the hash value for a web page link changes, the Recycled Materials Web Map administrator is notified of the discrepancy and will manually verify that the link is still valid.



**Figure 9. Case study data entry form to add and update case study information (12).**

# 3.0 Results

Currently, the Recycled Material Web Map is being populated with producer facility information and stockpile data. A new producer can request login credentials from the login page. Once approved by the system administrator, the new producer can add their facility and stockpile information to the site. Specifications and regulations have been collected and integrated into the website for Wisconsin, Virginia, Pennsylvania, Minnesota, Illinois, Georgia, AASHTO, FHWA, and EPA. Past construction projects that utilized recycled materials are mapped and documented on the case study layer. Additional studies will be added as more researchers and DOTs use the website and report successful exchanges of material.

The Recycled Material Web Map was developed and is hosted at the Center for Advanced Public Safety (CAPS) at The University of Alabama and was funded through a pooled fund supporting the Recycled Material Resource Center (RMRC) at the University of Wisconsin-Madison. CAPS coordinates many GIS research projects and has extensive experience developing and maintaining web-based applications, while the RMRC has extensive domain expertise in the area of recycled material. Due to automated quality controls such as automatic emails and the hyperlink hash comparison process, the website is relatively low maintenance and will evolve mainly based on user input. Because of the autonomous nature of the site, the website can reside on CAPS servers or be migrated to other servers.

The Recycled Material Web Map is flexible and user-defined allowing producers the ability to limit information that is included on the site such as quantity, cost, or composite of material constituents. This flexibility overcomes proprietary issues associated with participation in similar recycled material exchange websites in the past. Also, the specification, regulation, and case study layers are integrated into the website to provide pertinent information to users, thereby increasing traffic to the site and expanding the user base.

The Recycled Material Web Map can be leveraged by both producers and consumers to increase regional sustainability through the use of recycled material. Instead of landfilling recyclable material, producers can offer material and provide key information such as location, company contact, and type of material. By providing consumers a user-friendly map-based interface to find appropriate sources of recycled material closest a project site, the Recycled Material Web Map promotes the use of recycled material and sustainability. Material stockpiles from DOTs participating in the transportation pooled fund are being collected and added to the Recycled Material Web Map. The Recycled Material Web Map is available at http://rmwm.caps.ua.edu.

# 4.0 Conclusions

The Recycled Material Web Map is an all-in-one tool that locates recycled material producers, stockpiles, applicable regulatory information, and case studies using GIS-based data.  This single source website has the potential to promote the use of recycled material in construction applications by connecting consumers to producers and providing location, quantity, cost, and contact information.  The specification and case study layers render additional functionality with the goal of increasing information availability to users.  All users can search stockpiles and producers by state, material type, or within a specified radius.  In addition, users can view applicable beneficial reuse specifications and regulations based on the stockpile location, material type, and material applications.  Producers can add and update contact information, cost, and material volumes.  Advanced users can use the Reg-Spec Editor tool to input DOT specifications, environmental regulations, and additional information concerning recycled materials used in construction applications.  Past construction projects that have effectively used recycled materials can be mapped and documented on the case study layer.  Future work will include adding routing capabilities from selected stockpiles to construction sites and collecting specifications and regulations for additional states.  A continued outreach campaign will ensure a strong user base at all three levels for the Recycled Material Web Map.

# 5.0 ACKNOWLEDGEMENTS

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# RECYCLED MATERIAL WEB MAP



| December 2015 | User Guide |
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The Recycled Material Web Map promotes the use of recycled materials by connecting consumers to producers and providing location, quantity, and contact information. The User Guide will demonstrate the functionality of the website for each user level.

# Recycled Material Web Map

## 1.0 INTRODUCTION

This guide will describe the process of using the Recycled Material Web Map, beginning with the privileges given to the general user, followed by producer/facility privileges, advanced user privileges, and finally administrative privileges. Each section of this User Guide will explain the website components that can be utilized by each user level.

### 1.1 Website Layers

The four layers of the Recycled Material Web Map each provide spatially related information to aid in the use of recycled material in transportation projects. These layers are: producers, stockpiles, specifications/regulations, and case studies.

### 1.1.1 Producer and Stockpile Layers

The producer layer includes contact information for facilities that produce recyclable material. Facility managers can update material type, application, and quantity information in the stockpile layer. Every stockpile is associated with a producer, but producers are not required to have active stockpiles. Both producers and stockpiles can be designated historic if the material is no longer available or after a period of inactivity. To keep the information current on the website, producers can supply a web service that automatically updates the stockpile quantities. If a service is not available, the producer can be automatically contacted by email to confirm that their stockpile quantities are up to date. If the stockpile information is out-of-date (older than nine months), the stockpile(s) will time out and become historic to ensure quality map data.

### 1.1.2 Specifications and Regulations Layer

Department of Transportation specifications and environmental regulations that pertain to the beneficial reuse of industrial byproducts or other recyclable materials were collected for six states (Wisconsin, Virginia, Pennsylvania, Minnesota, Illinois, and Georgia) and three federal agencies (American Association of State Highway and Transportation Officials (AASHTO), Federal Highway Administration (FHWA), and Environmental Protection Agency (EPA)) to

populate the regulation and specification layer. Hyperlinks to the specific sections of these regulatory documents at the state and federal agencies are available on the web map and are searchable by state, material, and application.

### 1.1.3 Case Study Layer

The case study layer locates construction projects that successfully utilized recycled material. In addition to the material type(s) and application(s) used in the project, the additional information stored in the case study layer include a synopsis of the project, pictures, and any other project documentation such as final reports or presentations.

## 1.2 Website User Levels

There are four user levels associated with the Recycled Materials Web Map: general user, producers or suppliers of recycled material, advanced users, and administrators. These are listed in order of increasing privileges. Each classification has privileges that allow users to perform certain tasks. General users can search for local recycled materials, specifications, and case studies that utilized recycled material in construction projects. Producers can promote material by entering, updating, and maintaining material source information. Additionally, advanced users such as researchers and DOT agencies, can add DOT specifications, environmental regulations, and case studies. The Recycled Material Web Map application was designed to provide specific functionality for each of these four user levels.

## 2.0 BASIC FUNCTIONALITY

The Recycled Material Web Map was designed as an interactive online tool and supporting website. The website evolves as new producers, stockpiles, and case studies are added.

## 2.1 Welcome Screen and Login Page

The Recycled Material Web Map is located on a secure server. At the time of this User Guide, the Recycled Material Web Map is located at the following link: http://rmwm.caps.ua.edu. Navigate to this address using a web browser to reach the home page.

## 2.1.1 Welcome Screen

Upon reaching the Recycled Material Web Map home page, a welcome screen will be displayed, as shown in Figure 1.  The user has the option to either continue as a general user to view the site, or can log in and gain access to additional features.



**Figure 1.**  The welcome screen gives a brief overview of the site, and allows the user to enter the site as a General User or log in to access additional features.

## 2.1.2 Login Page

If the "Log In" option is chosen, a Log In window will appear where the user can enter their login credentials as shown in Figure 2.  Log in usernames, passwords, and user privileges are created, edited, and managed by the site administrator.

**Figure 2.** The Log In page allows users to enter login credentials and access additional features of the website.

### 2.1.3 Request a Login

Requesting a producer login from the login page allows for new users to add their facility and stockpile information to the site (producer level) or add specifications, regulations and/or case studies (advanced user). Please contact the site administrator to request login credentials.

### 2.2 Default View

Figure 3 displays the default map view of the website underlain by an ESRI basemap that toggles between street view imagery to aerial imagery. Facilities are depicted with factory symbols, stockpiles are shown as triangles, and case studies are represented as rectangles. Users can zoom in and out of the map using the plus or minus buttons located on the top left corner of the map view or by selecting a state from the drop down menu on the search panel. When a state is selected, the map zooms in to the state level, and users can zoom in further to view a project site by using the plus button or the roller ball of the mouse. Across the top of the default screen are tabs that include: Map, which is the default view; Specifications/Regulations, which displays state and federal information; and Reg-Spec Editor, which allows advanced users to enter and maintain specifications and regulations. The side bar to the left of the map screen includes several panels: Consumer Search, Producers and Stockpiles, Case Studies, and Help. The

Consumer Search panel allows users to search for stockpiles, producers, specifications and regulations, and case studies. With appropriate login credentials, facility contact information and stockpile data can be entered on the Producers and Stockpiles panel. Case study information and associated project documents can be uploaded using the Case Studies panel. The result grid at the bottom of the default map screen displays producers, stockpiles, and case studies that are selected based on the search criteria applied in the Consumer Search panel. The map features a



user-friendly interface and is accessible on mobile devices.

**Figure 3.** Recycled Material Web Map default view showing the map area with producers, stockpiles, and case studies, the results grid at the bottom of the screen, and a sidebar with multiple panels for searching the site.

## 2.3 About and Help Panels

The About panel gives a brief overview of the site and the features available to each user level. It also contains links to the Log In page, the Recycled Materials Resource Center, and the User Guide. Also, the website disclaimer is listed on the About panel. The Help panel includes the User Guide and several video tutorials of the major components of the website.

## 3.0 GENERAL USER LEVEL

The general user level is open-access, allowing anyone to view and search the website for recycled material stockpiles, specifications and regulations, and past case studies.

## 3.1 Search Material Stockpiles and Producers

There are several ways to search the Recycled Material Web Map. The Consumer Search, as shown in Figure 4(a), allows the user to select a specific state and material type(s) to filter the stockpiles. The stockpiles that meet the search criteria are selected and listed in the grid at the bottom of the main default map screen, as shown at the bottom of Figure 3. Clicking on a stockpile in the grid at the bottom of the default map screen, highlights the stockpile on the map, zooms to that stockpile, and a window pops up on the map that displays available quantity information. In addition, a radius search is available that allows a user to locate their construction project and specify a radius in the search panel to select all of the stockpiles that are within the given distance as shown in Figure 4(b). To activate the radius search, enter the desired radius in the third search option in the search panel, and hold the "Ctrl" button on the keyboard and left-click the mouse. The point that is left-clicked will be the center of the radius search. Users can toggle between selected stockpiles and selected producers in the results grid at the bottom of the map view to view producer contact information and available material quantities.
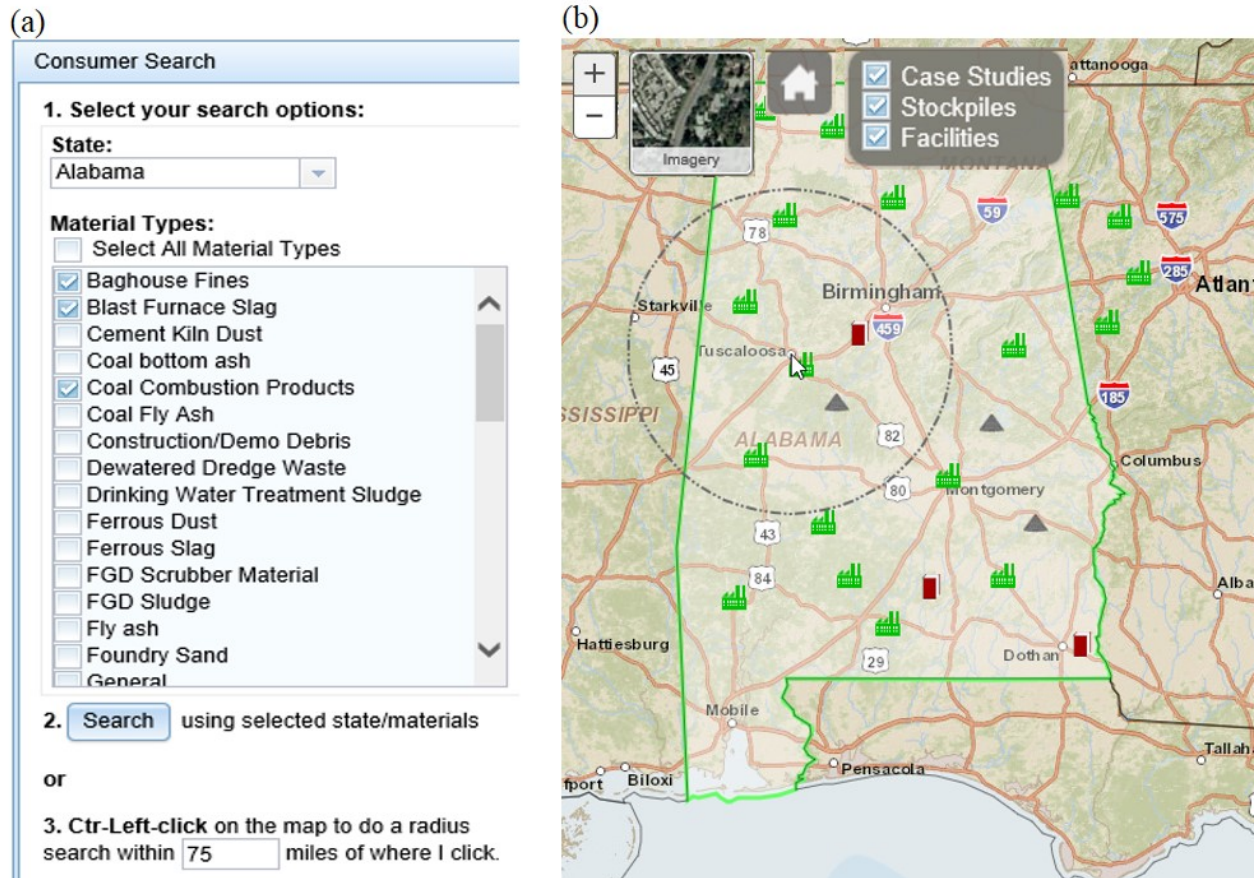
**Figure 4(a)** Consumer search panel includes options to search by state and/or material type or search by radius. **(b)** Radius search selects all producers and stockpiles within a specified radius.

## 3.2 Search Specifications and Regulations

In addition to searching for available stockpiles and viewing producer contact information, general users can also search federal and state DOT specifications and environmental regulations that apply to the beneficial use of recyclable material. Specifications and regulations from federal agencies including AASHTO, FHWA, and EPA have been identified and added to the Recycled Material Web Map database. Also, specifications and regulations have been included for several states including: Wisconsin, Virginia, Pennsylvania, Minnesota, Illinois, and Georgia. To search the specifications and regulations, users can filter by state and/or material on the aforementioned consumer search panel or simply click within a state on the map. The specifications/regulations tab automatically updates based on the search results. As shown in Figure 5, links to applicable specifications and regulations are listed on the tab as well as the agency, material type(s), and material application(s). Also, a short description of each specification and regulation appears by hovering over a specification or regulation. Below the specifications and regulations, additional
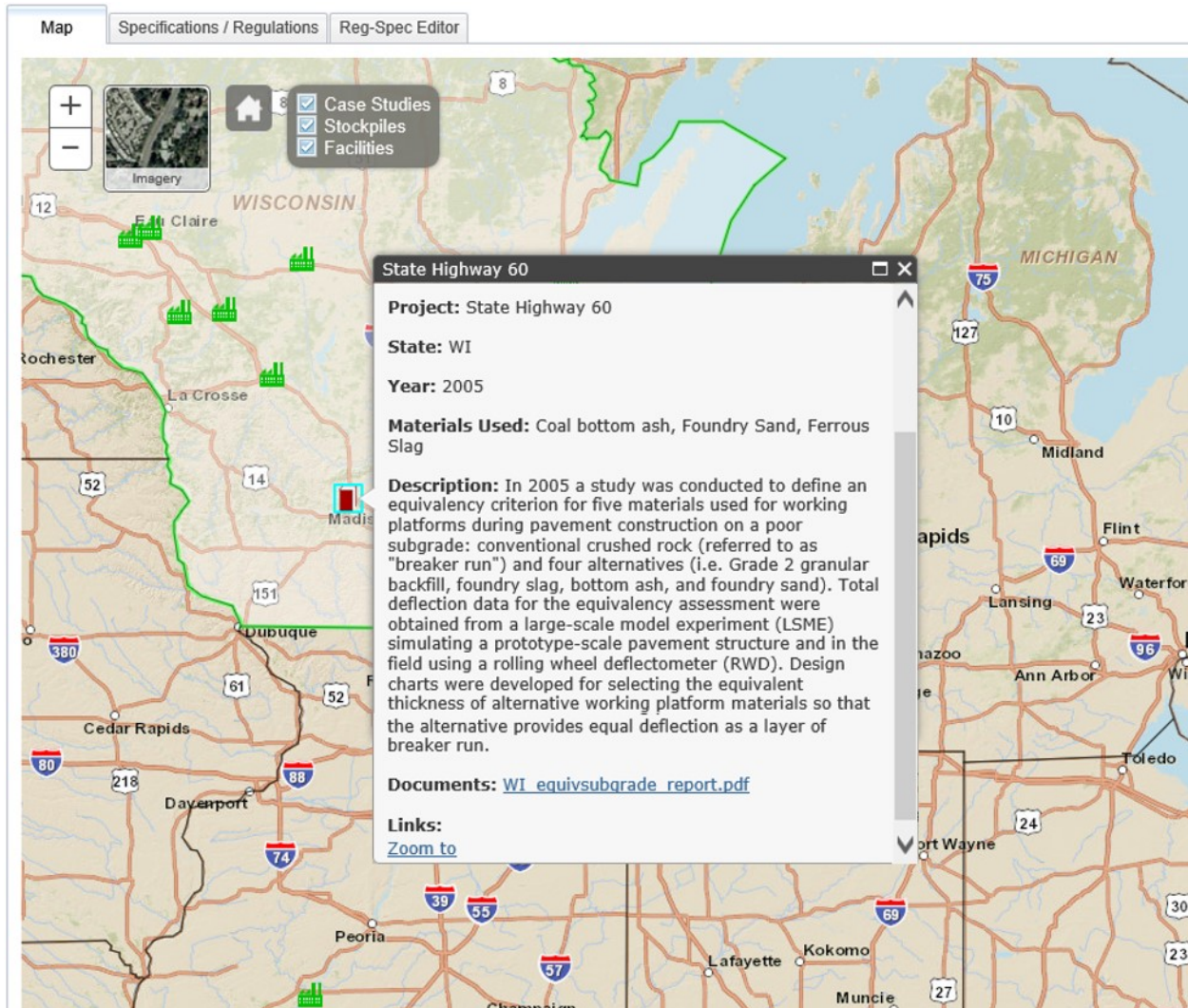
information that pertains to the search criteria is listed. Additional information can include fact sheets about the material, design guidance, and links to external websites that may be helpful when designing or constructing with recycled materials.



**Figure 5.** The specifications and regulations tab includes DOT specifications, environmental regulations, and additional information pertaining to the beneficial use of recycled material.

## 3.3 Search Case Studies

On the default map view, general users are able to view a map of case study projects that have used recycled materials in past projects. Case studies are shown as rectangles on the map tab and can be filtered using the same search panel as the stockpiles, producers, and specifications. Figure 6 shows an example of the information that is attributed to each case study including: a brief synopsis of the project, material(s) used, and additional project documentation such as reports or spreadsheets.

**Figure 6.** Case study synopsis window displays key information including project name, materials used, and a description.
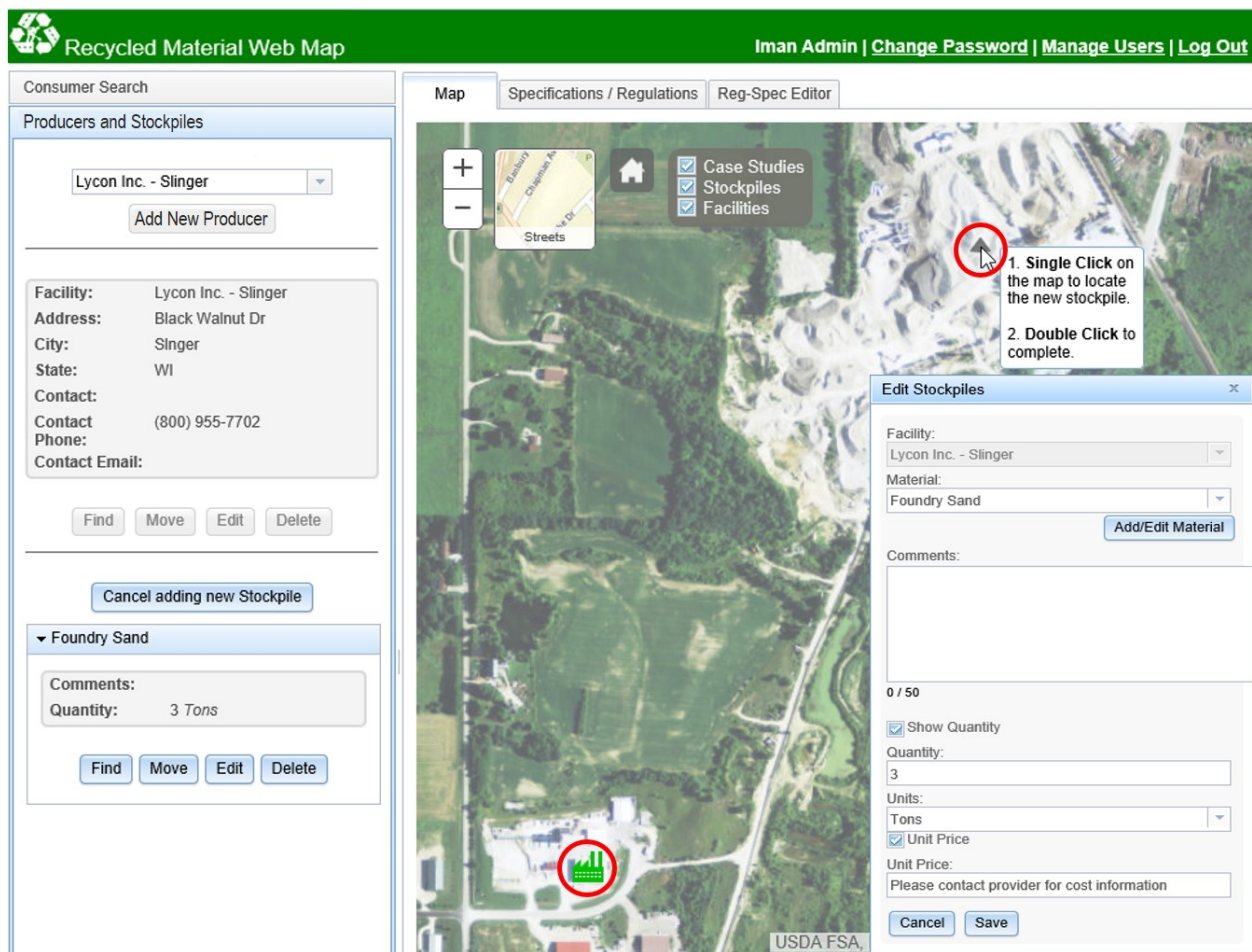
## 4.0 PRODUCER USER LEVEL

### 4.1 Login

The producer user level has all of the capabilities of the general user plus several additional mapping privileges. In order to add and update stockpile or facility information, users must create a log-in to the website. Producers who log-in to the site gain access to the producer and stockpile side panels, allowing users to update producer contact information and stockpile information.

## 4.2 Add/Edit Producer

A new producer can add facility contact information by clicking the "Add New Producer" button.  To locate the facility, single-click the desired location (can continue to single-click until the exact spot is chosen), and then double-click to place the facility.  A window will pop-up where a producer can enter in all applicable contact information.  Optionally, users can click the "cancel adding facility" button on the Producer and Stockpile panel to cancel adding the facility.  Returning producers can update the contact information for a facility by clicking the edit button beneath the producer information displayed in the panel as shown in Figure 7.



**Figure 7.** Example facility and stockpile (circled in this figure) that are added and updated on the Producers and Stockpiles panel.  The stockpile details are listed beneath the Producer contact information.

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## 4.3 Add/Edit Stockpile

Once a producer has added their facility contact information, the facility can be chosen in the producer drop-down menu on the Producer and Stockpile panel. To add a new stockpile, click the "Add new stockpile" button beneath the facility contact information. Single-click the location of the stockpile on the map (can continue to single-click until the correct spot is chosen), then double-click to confirm the location and place the symbol. A pop-up window will appear where producers can enter all of the applicable stockpile information. To cancel adding a stockpile, click the "cancel adding stockpile" button that appears under the facility contact information. Stockpile information should be updated regularly to reflect up-to-date and accurate volumes. To edit stockpile information, click the "Edit" button that appears underneath the stockpile information on the Producer and Stockpile panel. Producers are only able to edit their own facility and stockpile information. Optionally, producers can choose to limit what information they include on the site, such as quantity or composite material constituents, to protect confidentiality.

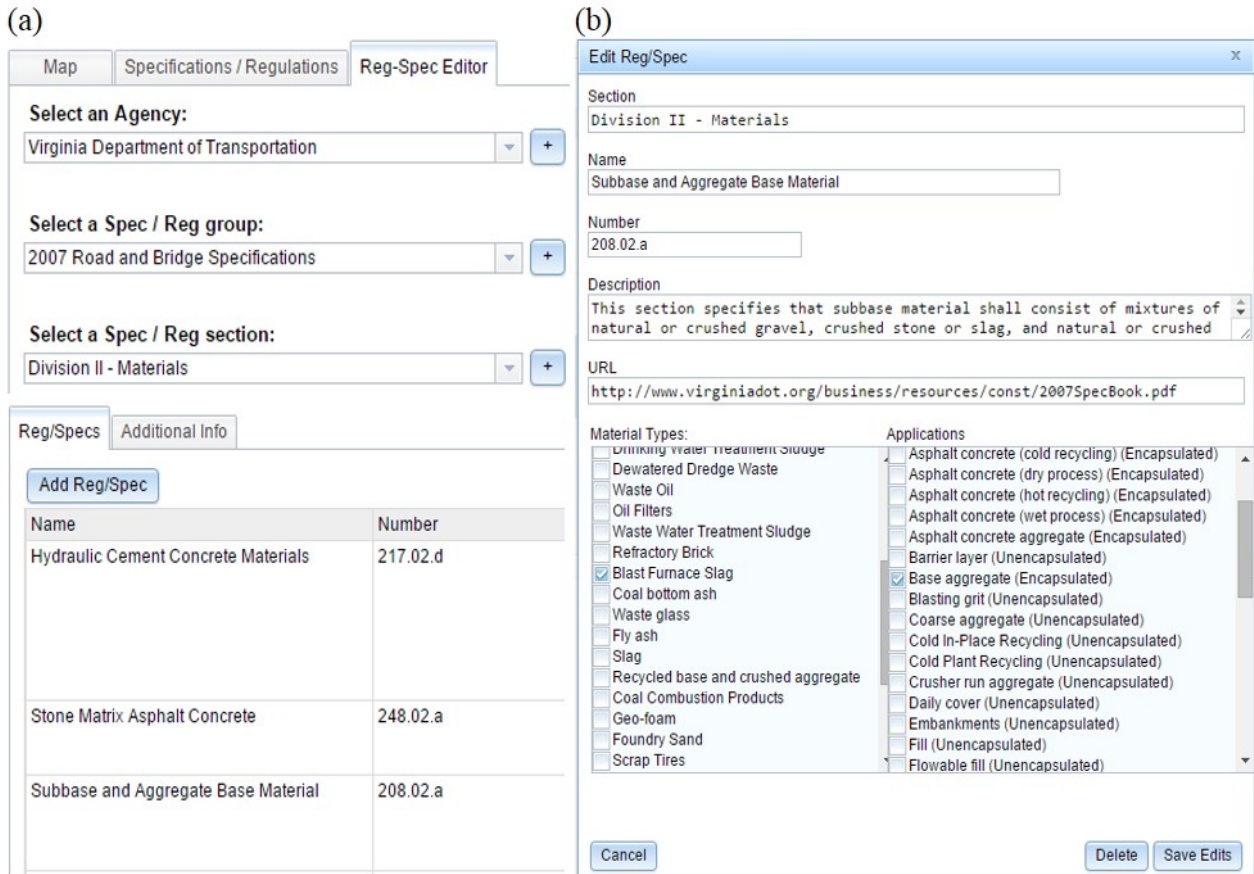## 5.0 ADVANCED USER LEVEL: RESEARCHER/AGENCY

## 5.1 Login

Researchers and DOT agencies can receive advanced user login credentials. Advanced users have access to the same website features as the general user and producer user levels, but can also add and edit DOT specifications and regulations and add case studies to the map. Log-in as an advanced user to gain access to the following features.

## 5.2 Add/Edit Specifications and Regulations

Advanced users can use the Reg-Spec Editor tool to add and edit DOT specifications and regulations. To add or edit a specification, the user selects or adds an agency (DOT), group, and section. The specification group is the title of the regulatory document (e.g. 2007 Road and Bridge Specifications) and the section refers to the subheading of the document that includes the specific specification (e.g. Division II – Materials) as shown in Figure 8(a). Clicking the "Add Reg/Spec" button or double clicking the specific specification in the bottom grid will open the Add/Edit Reg/Spec dialog box as shown in Figure 8(b). Attributes including specification name, number, a brief description, material(s), and application(s) can be added or edited. Materials and

applications that are not already listed in the material and application type lists can also be added. Additional information is added in the same way as the specifications and regulations, but this functionality is located on a similar but separate tab.



**Figure 8(a).** Example specifications listed by agency, group, and section in the Reg-Spec Editor. **(b)** Reg-Spec Editor dialog box for entering and updating specifications, regulations, and additional information.

## 5.3 Add/Edit Case Studies

In addition to adding specifications and regulations, advanced users can also map case studies and upload documents associated with the project. To add a case study, users can click the "Add New Case Study" button in the Case Studies panel to locate a project on the map and add information into the form as shown in Figure 9. To locate a case study, single-click the project location (can continue to single-click until the correct location is chosen), and then double-click to confirm the location and place a symbol. A pop-up window will appear where any applicable information about the project can be entered. Users are prompted to upload any project documentation that might include a final report or mix design. The case study information is

displayed on the Case Studies panel, and can be edited by any advanced user. To edit a case study, click the "edit" button directly under the case study information on the case study panel.
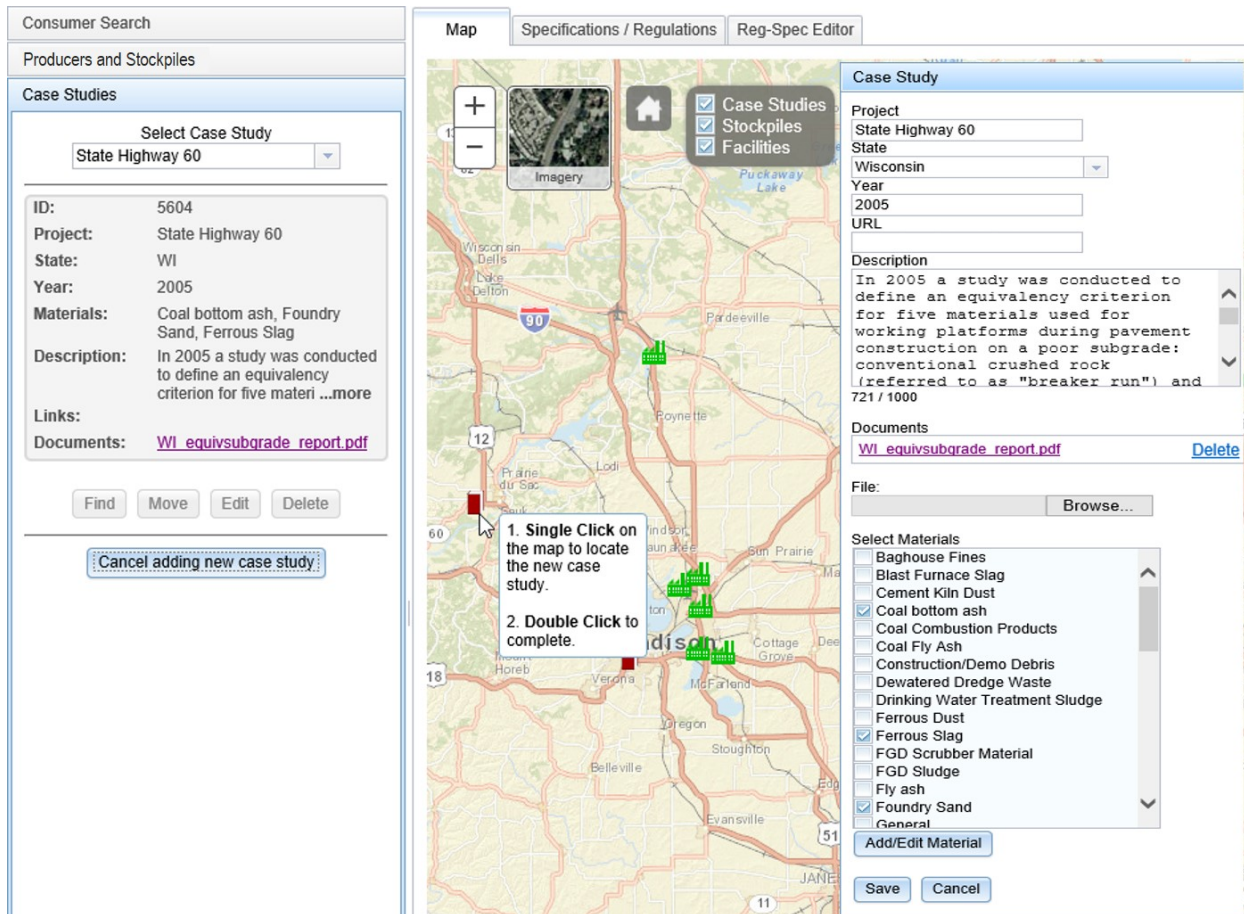


**Figure 9.** Case study data entry form to add and update case study information.

## 6.0 ADMINISTRATOR USER LEVEL

An administrator user has all of the privileges available to a general user, producer, or an advanced user, plus additional management privileges. An administrator will create, delete, and modify user names, passwords, and user levels. A Recycled Material Web Map user must contact the administrator to create a user name and password. In addition to managing login credentials, an administrator will oversee all the data entered into the producer, stockpile, specification/regulation, and case study layers. The administrator has the right to remove any inaccurate or inappropriate information that is added to the site without prior notification.

## 6.1 Create/Edit User Privileges

Administrators can create and edit user privileges through the "Manage Users" button located in the top right corner of the website screen as shown in Figure 10.



**Figure 10.** Header ribbon including the Manage Users button.

Once the "Manage Users" button is selected, a dialog box will open. The administrator can either enter a username to edit privileges of an existing user, or click the "Add New User" button to create a new username and privileges. Figure 11 shows the initial Manage Users
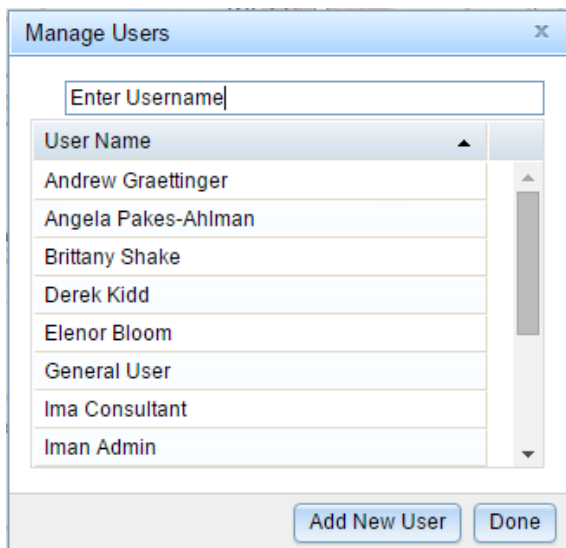


window.

**Figure 11.** Manage Users window

To add users, select the "Add New User" button. A separate pop up window will replace the existing Manage Users window and provide blank fields for new user information to be entered as shown in Figure 12. Multiple roles can be selected for each user. After all of the information has been entered, select the "Add User" button at the bottom of the window to add the user.

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**Figure 12.** Add New User entry window.

User information can be updated by an administrator by clicking on the "Manage Users" button on the header ribbon (Figure 10) which opens the Manage Users window (Figure 11). The Manage Users window displays a full list of users. A user can be selected by searching using the search option ("Enter Username") or by scrolling down the list and clicking directly on the user name. Once a user has been selected, an additional screen will appear containing the user's current information displayed in Figure 13. The administrator may edit any of the fields as necessary, then click the "Update User" button to save the information to the website. Click the "Done" button to close the Manage Users window.
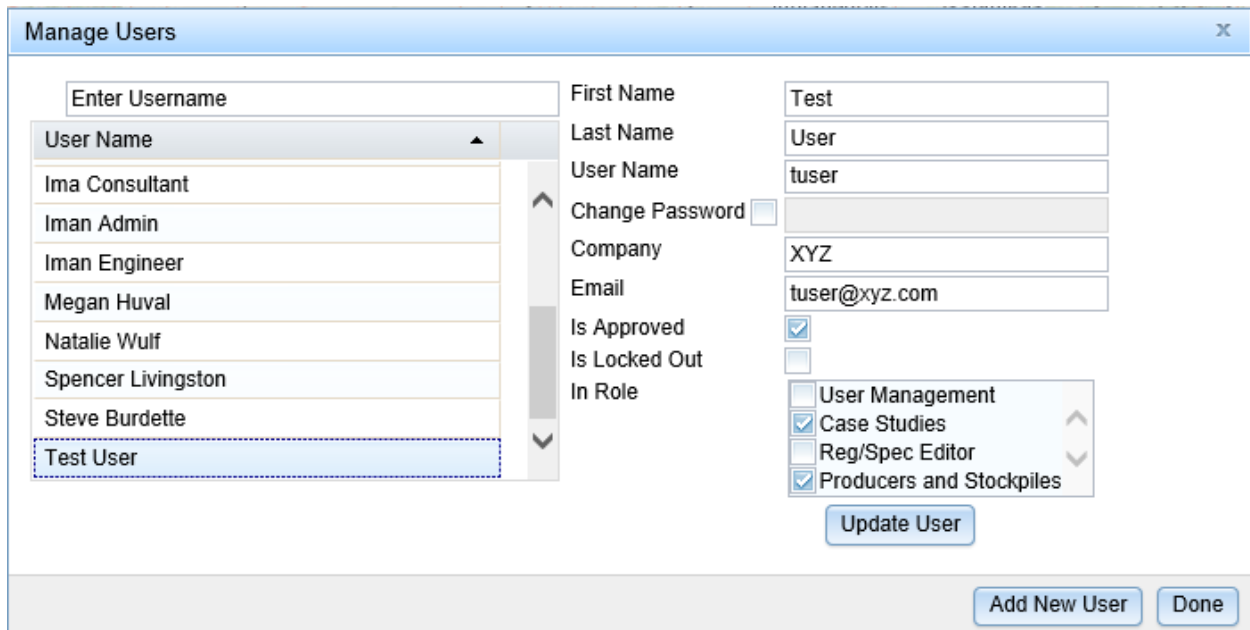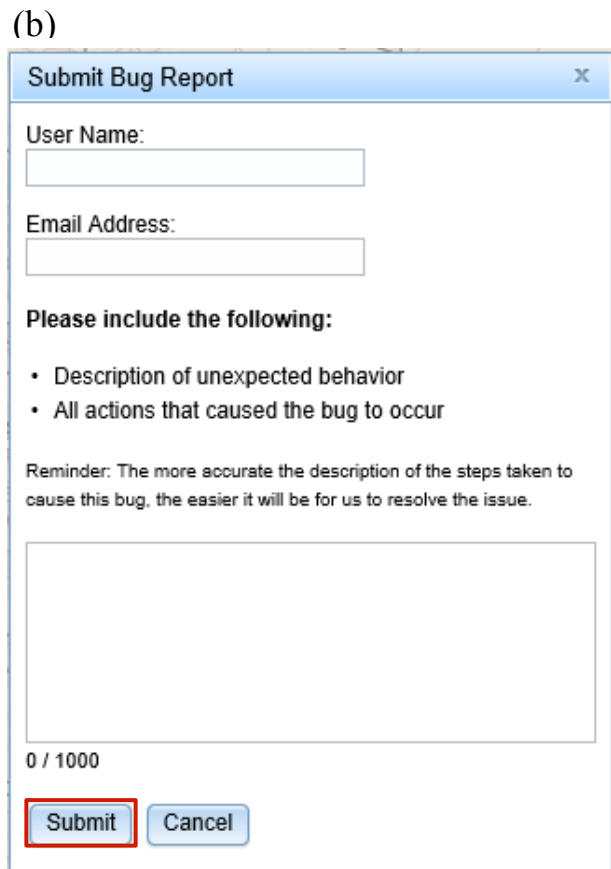
**Figure 13.** Manage Users window to edit existing user information.

## 7.0 ERROR REPORTING

Please contact the site administrator through the Help panel to report an error. The Help panel includes a section entitled "Submit Bug Report" that can be used to notify the site administrator of any unexpected behavior while using the website. To submit a bug report, users should click on the "Submit Bug Report" button as shown in Figure 14(a). A dialog box will open allowing the user to enter contact information and a description of the unexpected behavior. Clicking the "Submit" button on the dialog box will send a notification to the site administrator, and the administrator will begin to resolve the issue. In some cases, the administrator may contact the user directly to request more details about the unexpected behavior of the website.
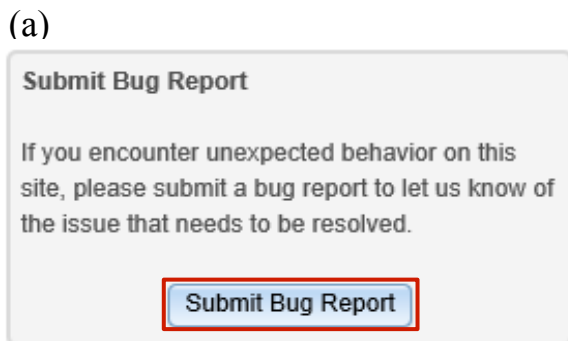
**Figure 14(a).** Submit Bug Report section located on the Help panel. **(b)** The Submit Bug Report dialog box allows users to enter contact information and a description of unexpected website behavior.