Tool for Developing Integrated Strategies for Decontamination and Waste Management-20291

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ABSTRACT

Management of waste from chemical, biological, and radiological incidents is complicated by the fact that decontamination decisions have a profound impact on the characteristics of resulting waste streams. Wide-area biological and radiological incidents could produce massive quantities of waste that may need to be treated on-site and sent for subsequent disposal as non-contaminated materials, or else be directly disposed of as contaminated materials. The EPA has developed the Waste Estimation Support Tool (WEST) for characterizing and quantifying biological and radiological waste that may be generated from decontamination efforts. This paper focuses on the WEST's uses for radiological incidents.

WEST combines Geographic Information System (GIS)-based analysis of externally-supplied plume data, infrastructure databases derived from the Federal Emergency Management Agency's (FEMA's) Hazus tool [1], and satellite imagery surface recognition algorithms to combine the composition and square footage of the buildings in the plume with estimates of the materials between the buildings in the plume. The resulting GIS datafiles are then imported into a Microsoft Access database application, where they are combined with information about the nature and concentration of contaminants, and then subjected to decontamination strategies for different contaminated surfaces. The tool provides estimates of the type and quantities of potential wastes resulting from simulated decontamination and/or demolition activities and includes estimates of the remaining contamination levels including residual contamination contained within each waste stream. Estimates are presented at several levels of detail, allowing users to obtain needed data at the desired resolution. These include estimates for the total affected area, estimates by contamination zone, estimates by decontamination method(s), and estimates by building type (occupancy classification).

EPA is currently developing the next version of WEST which will include several substantial enhancements. The most significant improvement for the next version of WEST will include the ability for users to develop contamination scenarios and waste estimates based on previously developed, readily available, and geographically specific infrastructure data. Instead of using WEST's default infrastructure data based on FEMA's Hazus tool, users will be able to import their own building data specific to the geographically affected area. This capability may substantially decrease uncertainties in the resulting waste estimates because the results will be based on actual building data (numbers of each type, square footage, building height, etc.). Two other significant enhancements will be the ability to generate waste estimates for vehicles and biomass. In addition to building debris and building decontamination waste, vehicles and biomass will likely constitute a significant percentage of the total waste which may result from wide area contamination events.

This presentation will present the most recent version of WEST, which includes such considerations as affected biomass (e.g., trees), vehicles, and the ability to replace the default Hazus infrastructure databases with custom infrastructure databases.

INTRODUCTION

EPA is designated as the coordinating Agency, under the National Response Framework (NRF), to prepare for, respond to, and recover from a threat to public health, welfare, or the environment caused by actual or potential oil and hazardous materials incidents, including chemical, biological, and radiological substances, whether accidentally or intentionally released. Recovery from a radiological incident, of all potential threats, could possibly be the costliest and most time consuming [2]. Response and recovery is largely a function of decontamination and waste management strategies, policies, timelines, available resources, and public sentiment [3]. Effective decision-making in the waste management areas can offer significant cost reductions [4]. Historically, these factors have been decoupled from each other. Through a series of recent national-level exercises and planning activities, it has become apparent that to minimize the economic, environmental, and public health impacts of such an incident, factors such as decontamination, waste management, sampling must be simultaneously considered using a "system-of-systems" approach, where decisions in one area (e.g., decontamination) profoundly affect decisions in another area (e.g., waste management). Decision makers must also account for the topographic, geographic, and geometric properties of the impacted area as these considerations will largely influence the magnitude and characteristics of waste generated by decontamination activities. These considerations are especially significant for urban areas where factors such as infrastructure density, construction materials, and abundance of vegetation vary greatly. Vehicles also pose a particularly challenging situation, since vehicle contamination is highly dependent on the state of the vehicle (e.g., on, off, windows open, windows closed, etc) at the time the plume passed over the vehicle [5]. Based on the previous incidents in Chernobyl and Fukushima, there is no "one size fits all" solution when considering decontamination and demolition approaches. Each approach is just as unique as the geographic location itself.

The EPA's Homeland Security Research Program (HSRP) has developed the Waste Estimation Support Tool (WEST) to help decision makers and planners better understand the impact these mechanisms have on waste management considerations. To scope out the waste and debris management issues resulting from a radiological or biological response and recovery effort, it is critical to understand not only the quantity, characteristics, and level of contamination of the waste and debris but also the implications of response and cleanup approaches regarding the quantity and rate of waste generation. Based on user feedback and continuing interest in adding to the capabilities of the WEST tool to epitomize the "system-of-systems" approach, several significant changes and enhancements are planned for future releases. Some of these improvements are specifically directed at key non-conventional "niche" waste streams that may offer opportunities for significant cost savings (i.e., biomass) or are problematic for various reasons (i.e., vehicles). For radiological incidents, WEST currently uses an approach to combine:

- Externally supplied Geographic Information System (GIS) shape files describing the affected area in terms of radionuclide deposition per unit area; WEST currently utilizes three geographic study regions, with Zone 1 representing the area with the highest levels of contamination, Zone 2 representing the area with a moderate level of contamination, and Zone 3 representing the area with the lowest level of contamination;
- Queries of infrastructure databases, based on FEMA's Hazus software to identify what types and sizes of buildings fall inside the contaminated areas as well as describing the materials of construction and building contents;
- A description of the contaminants in terms of deposition activity and contaminating radionuclides for each of the Zones 1, 2, and 3; and

- A “decontamination strategy” dataset that describes decontamination approaches for different types of materials (e.g., asphalt, concrete, etc.) and locations inside and outside buildings (e.g., roofs, interior floors, etc.).

This approach allows for an estimate of the quantity, characteristics, and level of post-decontamination residual contamination of radiological waste as a function of demolition/decontamination decisions that are specific to the geographic features of that location (i.e., outdoor and indoor characteristics and surface area).

New features that have been added include:

- Infrastructure and international support: custom infrastructure and Outside Continental United States (OCONUS) support; and
- Additional waste factors: inclusion of waste factors that can significantly add to the waste stream, such as vegetation, and vehicles.

SYSTEM ARCHITECTURE

The Microsoft Access-based WEST application includes two primary components (Figure 1):

Presentation Tier: A single Microsoft Access Visual Basic for Applications (VBA)-based desktop database file (.accdb) to interface with the user, manage data sets (e.g., import surface classification files and GIS tool files), and generate and display results. The VBA framework manages user interactivity and submit parameters to the Access database network layer.

Data Tier: Multiple Microsoft Access Database files (.accdb) to support data storage and computations, as well as storing specification of key attributes, storing user inputs, and facilitating communication with the Presentation Tier.

An additional **Business Logic Tier** contains data validation functions and helper utilities. The business logic implemented between the Presentation Tier and Data Tier will ensure that data are validated, formatted correctly, and stored correctly.

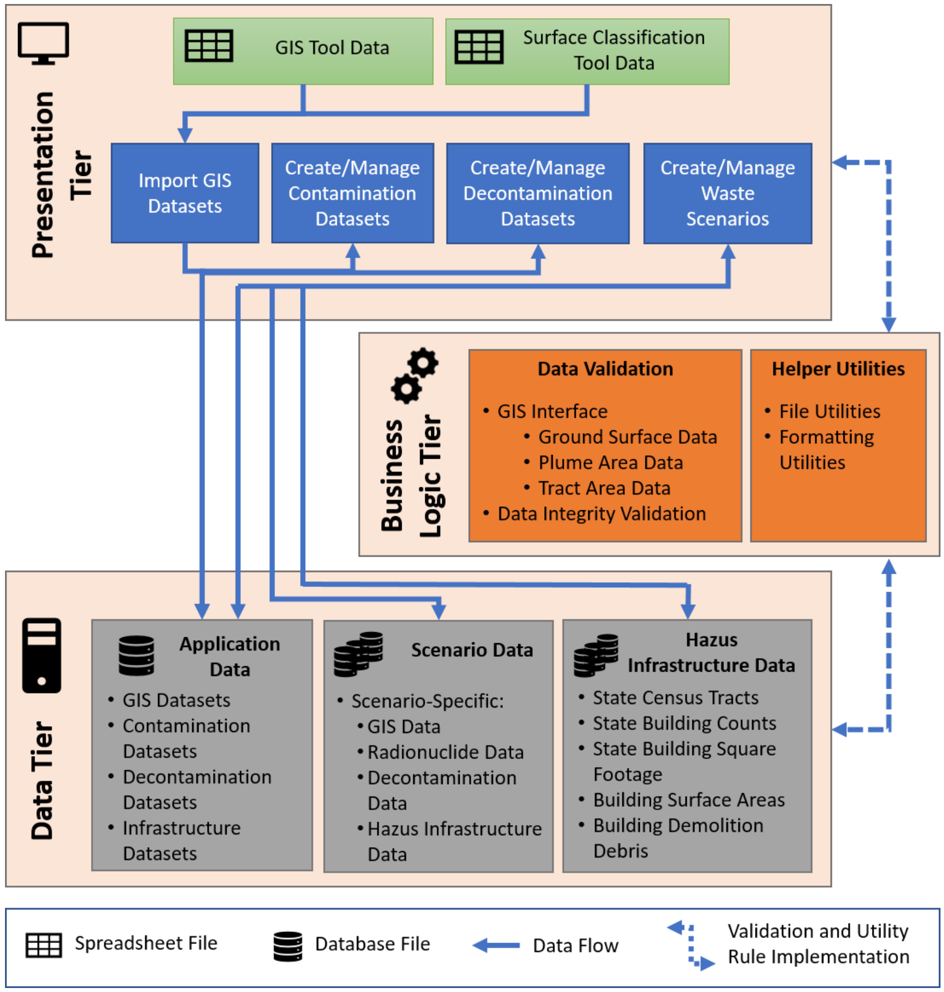

Figure 1. WEST Components and Data Flows

Data Sources

WEST uses a combination of EPA-derived, national level, and publicly available data to operate. These datasets represent surface contamination, environmental conditions, infrastructure, and geographical information. The information these data represent can change drastically from one location to another. Previously published case studies [2] have shown that minute changes in occupancy type, density, and surface media can have significant implications for the volume and characteristics of waste; therefore, it is crucial that these data be complete and representative as much as possible. Furthermore, no model or data provided therein can account for every single variable found in the field. It is crucial that these datasets be customizable when more representative data are provided by more informed sources (i.e., states, locals). The new version 6.0 release of WEST, due in March 2020, has this functionality and is described later in this paper.

A diagram showing the systems approach to specific waste management is shown in Figure 2. This diagram describes how current and future versions of WEST will operate and how datasets will interact. The following section will further describe these enhancements and their role in waste management.

Version 6.0 of WEST uses (or will use in future versions) the following datasets: 1) plume or deposition maps, 2) infrastructure, 3) outdoor surface media, 4) vehicles, 5) vegetation, 6) decontamination, 7) site analysis/logistics*, and 8) resource demand*. Note that features marked with an asterisk (*) are currently under development. A consolidated list of WEST data sources is shown in Table 1. Note that the default WEST data sources are primarily from publicly available data sets or those that are included with Esri's ArcGIS software [6]. There may be other government or commercial data sources that may have higher quality data, which can be used in WEST. These higher resolution data sets, however, may have restricted distribution.

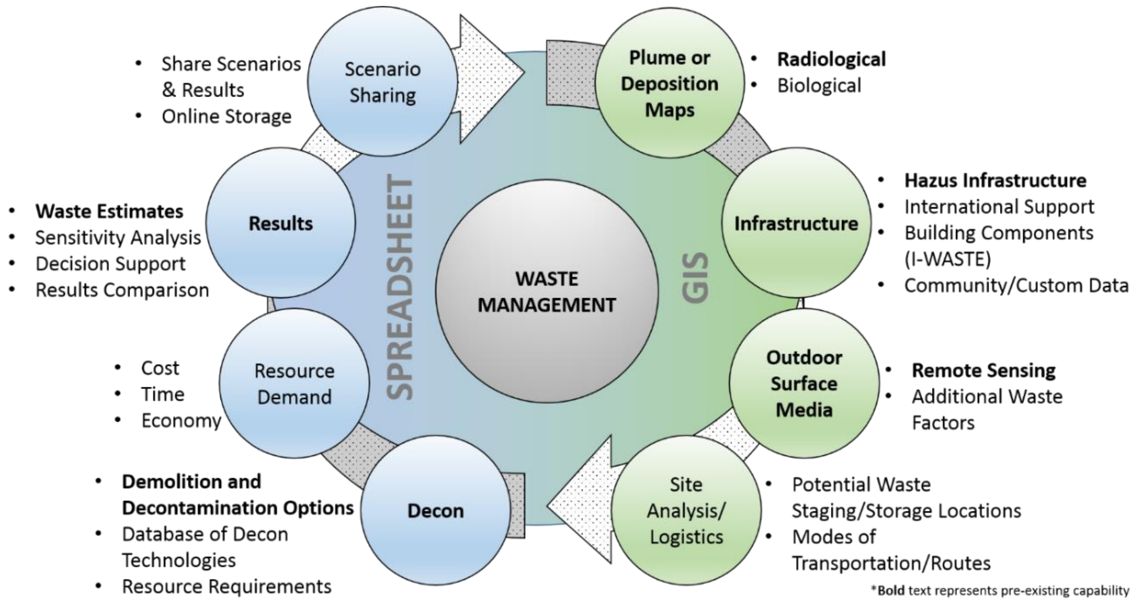

Figure 2. A Systems Approach to Waste Management (Bold Text in Bullets and Outer Circles in Figure Represent Features in Current Version of WEST)

TABLE 1. WEST Data Sources

Dataset	Purpose	Data Structure	Source(s)
Plume or Deposition Map	For simulating surface contamination extent and level	Dynamic*	Dispersion modeling
Decontamination	Metrics on decontamination technologies	Static	EPA, Department of Defense (DoD), Department of Homeland Security (DHS), Japan Atomic Energy Agency (JAEA), International Atomic Energy Agency (IAEA)
Resource demand	For estimating the cost and duration of a given decontamination approach	Static	EPA, Department of Energy (DOE), DHS, DoD
Surface media	Distribution of surface media for a given area	Dynamic/static	Remote sensing, custom
Vehicles	Number of vehicles and types	Dynamic/static	FEMA, Department of Transportation (DOT), LandScan [7], state, local, remote sensing
Vegetation	Tree/shrub count, species type, surface area	Dynamic/static	FEMA, US Department of Agriculture (USDA), state, local, remote sensing
Infrastructure	Information on building types, construction material, counts, and surface area	Static	DHS, Hazus, state, local, custom

* For the purposes of this document, a dynamic dataset is one that is dynamically generated according to some modeled or constantly changing phenomenon. A static dataset is one that is derived from a direct measurement or well-established principle.

New Features

A variety of new features have been added to WEST 6.0. These new features will allow for more representative waste estimates and will feature the latest decontamination technologies. A complete list of new features and an explanation of their methodology is below:

USE OF CUSTOM INFRASTRUCTURE

By default, WEST uses building infrastructure data that is incorporated into the Hazus databases.

Those data are resolved at the US Census tract level and include building counts, square footage, and occupancy type. Furthermore, each occupancy type is comprised of a distribution of construction types which are also included in the Hazus databases.

Should a user desire to develop a WEST waste estimate based on their own building inventory information instead of the default data, WEST can accommodate a custom infrastructure data set based on a predefined schema used by WEST to process the default building information. Instead of defining the area of interest as the Census tract, users must supply an alternative identifier (numeric or text based) upon which their custom infrastructure data is resolved. This unique identifier is subsequently referred to as a “tract” but is not equated to any single US Census tract. This enables infrastructure sets from outside the continental United States (OCONUS) to be used, enabling WEST to be used in international settings. Figure 3 presents an example of a custom infrastructure dataset which has been imported into WEST.

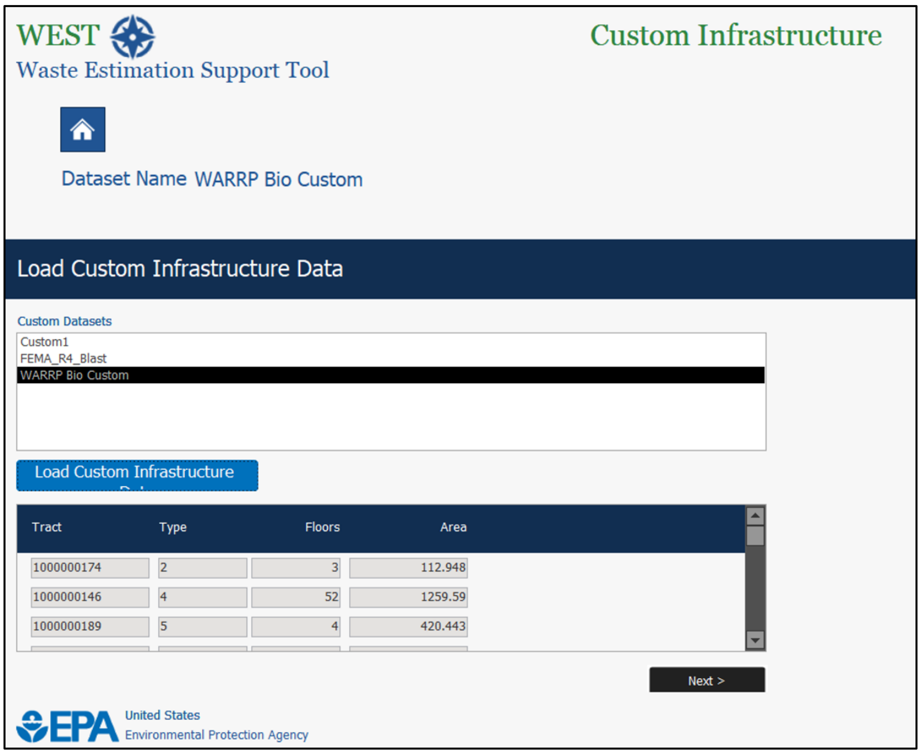

Figure 3. Imported Custom Infrastructure Data

After the custom data are loaded into WEST, users must then specify how their building types correspond to specific occupancy classes (Figure 4).

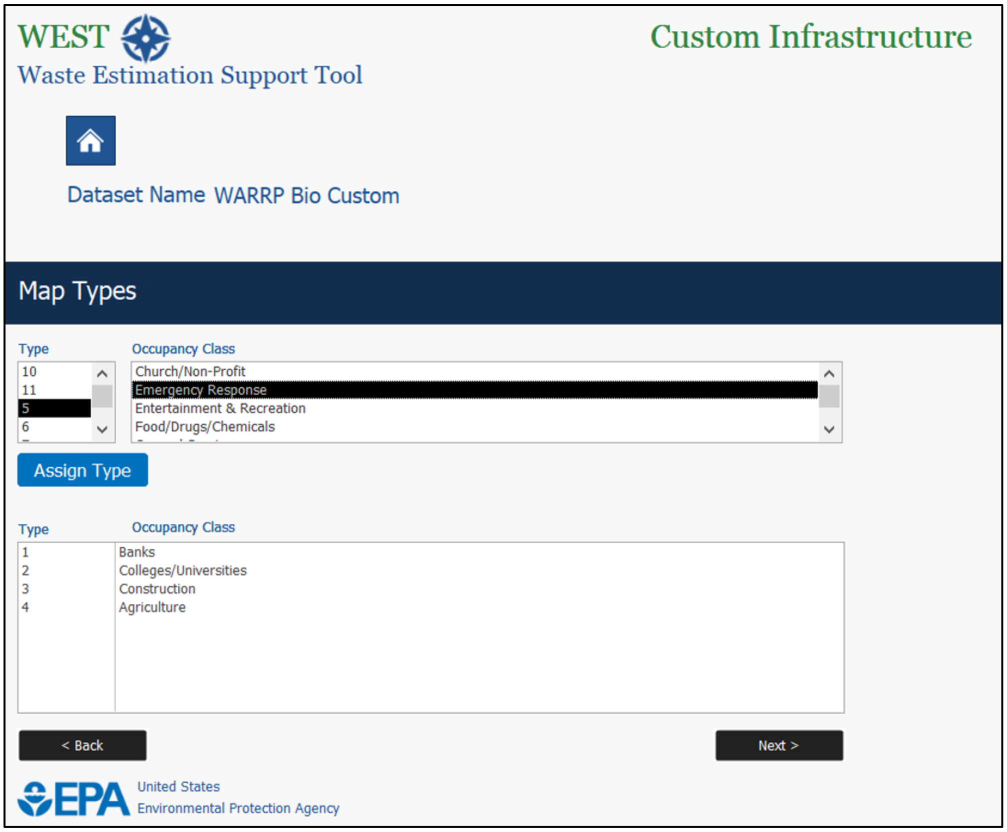

Figure 4. Custom Infrastructure Type-to-Occupancy Class Mapping

WEST uses the same occupancy classifications as Hazus and includes thirty-three unique classifications. The building occupancy classification mapping must be performed so that WEST can calculate the distribution of building construction types for each occupancy type. WEST uses a national default mapping scheme and those values can be modified by the user if desired. Once the mapping is complete, waste results are generated using the same methodology in WEST as is done for non-custom infrastructure datasets.

ESTIMATION OF VEHICLES

WEST provides estimates of the number of vehicles, mass, and volume for light cars, medium trucks, and heavy trucks. Figure 5 shows an example of the waste results screen for vehicles.

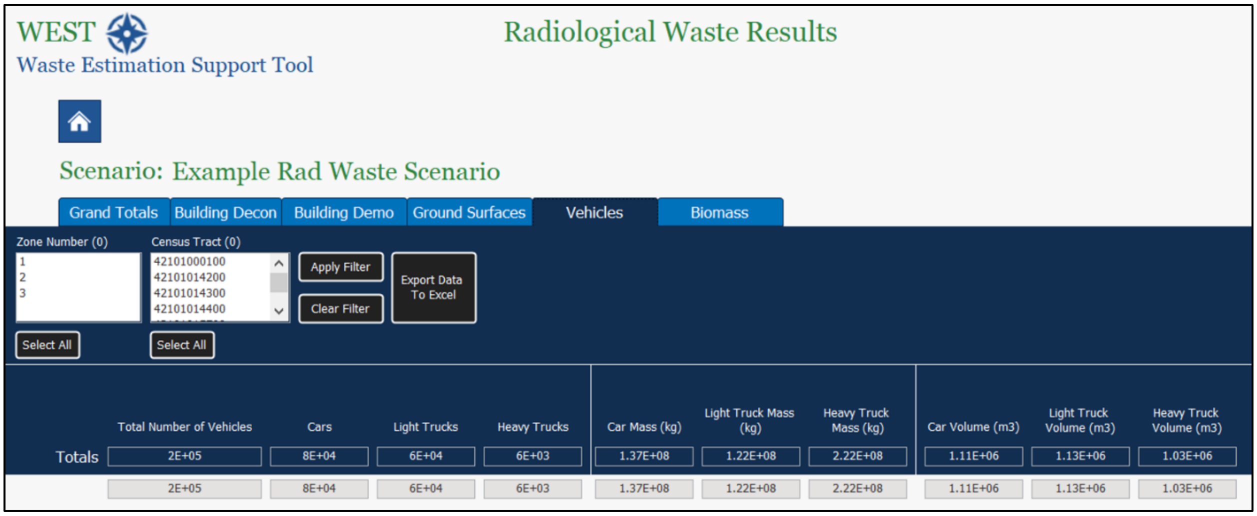

Figure 5. Vehicle Waste Estimates

As for building waste estimates, vehicle estimates can be viewed for each zone, tract, or combination of zone and tract.

ESTIMATION OF BIOMASS AND VEGETATION

WEST also provides estimates of biomass segregated by trunks/stems, branches, and foliage. The estimates are based on the number of stems per acre, distributed by height, and utilizing a custom calculation model to estimate the amount of truck/stem mass and volume and branch and foliage mass and volume. Currently, the biomass estimate is based on an aggregated average that is state-specific for most states and is not seasonally based. For states where data are not available, adjacent states' data are used. Figure 6 shows an example of the waste results screen for biomass.

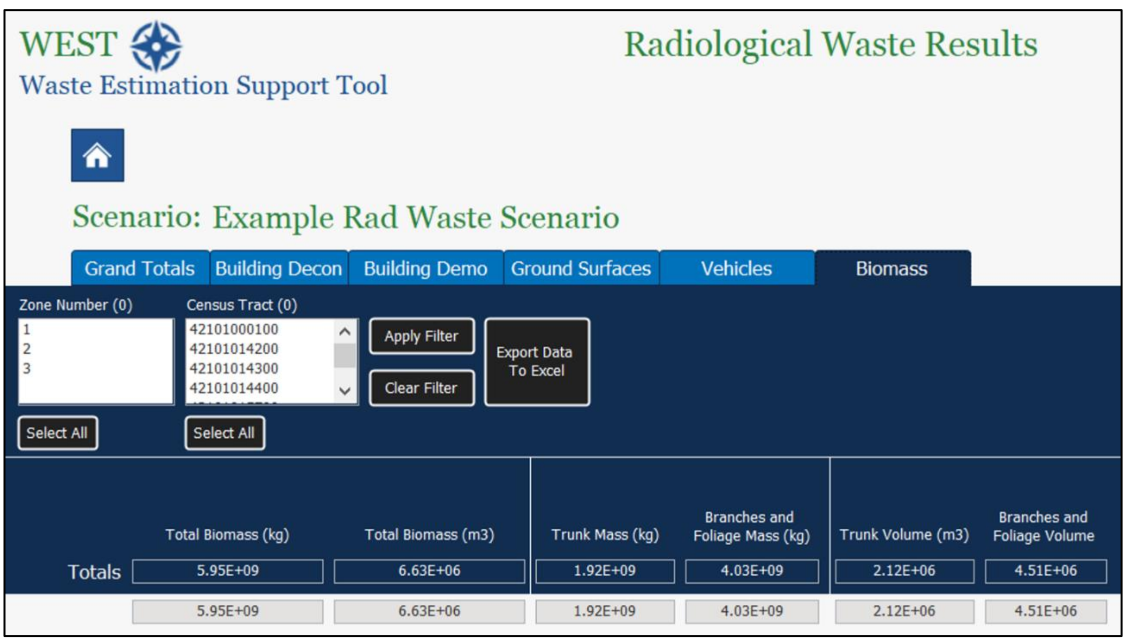

Figure 6. Biomass Waste Estimates

CONCLUSIONS

Planning for and managing a response to chemical, biological, or radiological contamination incident is an extremely complex undertaking, with multiple coupled considerations that must be assessed simultaneously to achieve an optimal response from a cost, time, and resource perspective. WEST is intended to help planners and emergency managers analyze and visualize these coupled decisions. The new version of WEST improves upon the previous version by including important non-conventional waste streams such as vehicles and biomass, and by allowing higher resolution infrastructure databases to be used in place of the low-resolution FEMA Hazus infrastructure databases. This new version of WEST is intended to provide advanced GIS-oriented features to users without requiring significant GIS expertise.

DISCLAIMER

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