OGC Disasters Resilience Pilot User Guide

Using Web Enterprise Suite for Flood, Wildfire and Hurricane Disaster Response

by Compusult Limited

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Publication Date: 2020-04-27

Approval Date: 2019-11-22

Posted Date: 2019-09-09

Reference number of this document: OGC 19-053

Reference URL for this document: http://www.opengis.net/doc/IP/userguide/19-053

Category: User Guide

Editor: Ken Geange, Jason MacDonald, Robert Thomas, Terry Idol

Title: OGC Disasters Resilience Pilot User Guide: Using Web Enterprise Suite for Flood, Wildfire and Hurricane Disaster Response

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Chapter 1. Introduction

Disasters can strike at any time, so being prepared ensures a timely, focused, and organized response. Using tools and data based on open standards enables the exchange of geospatial data between systems, thus providing disaster planners and first responders with a foundation to plan their response.

This User Guide provides guidance for using platforms built on open standards, such as Compusult's Web Enterprise Suite (WES), to provide a timely response to flood, wildfire, and hurricane disasters.

These three disaster scenarios will be discussed with respect to providing the necessary information to specific user groups when they need it.

- During the flood scenario, a disaster response will be planned from the perspective of a City Emergency Operations Center Manager in St. Louis, MO, USA.
- In the case of the wildfire scenario a disaster response will be explored from the perspective of a Kamloops Fire Emergency Operations Center Manager in Kamloops, British Columbia, Canada.
- During the hurricane scenario a disaster response will be explored from the perspective of a State Emergency Operations Center Manager in Puerto Rico.

Throughout these three scenarios, the use of WES will be discussed as a means to gather, analyze, and disseminate information to planners and first responders to inform them about affected areas with respect to incidents such as infrastructure status, road closures, hospital / care facilities, earth observations, such as hotspots or water level, and weather information.

WES, built on open geospatial standards, is a comprehensive suite of tools that can be used to build responses to many disaster scenarios using a wide range of open geospatial data services. The WES Catalog is a key component of the system, and following the Open Geospatial Consortium's (OGC) Catalog Service for the Web (CSW) standard, allows users and user communities to publish metadata about their geospatial assets using open standard based APIs. This allows discovery of those assets by users planning a disaster response. Using a tool such as WES these geospatial assets can be searched, discovered, and organized into a collection specific to a given disaster; in WES this collection is known as a Portfolio. Portfolios also provide the foundation on which other functionality, such as messaging, activities, and tasking are built.

Chapter 2 outlines the basic architectural overview of the WES system, the data providers, catalog providers and data consumers.

Chapter 3 discusses the users and use cases of each scenario.

Chapter 4 discusses the special topics which arose during the pilot, which are not covered in detail in other sections in the user guide.

Chapter 5 presents how a standards-based tool, such as WES, will be used in each of the scenarios.

1.1. Scenarios

The three scenarios that will be explored in this guide are:

1.1.1. Flood

Region: St. Louis, MO, USA
User: City Emergency Operations Center Manager
Use Case: As water levels rise, the manager needs to plan, organize, and dispatch first aid personnel to affected areas, taking into account road closures, current traffic information, increasing water levels, and reported incidents.

1.1.2. Wildfire

Region: Kamloops, BC, Canada
User: Kamloops Fire Emergency Operations Center Manager
Use Case: As the wildfire spreads, the manager needs to plan, organize and dispatch fire fighter response personnel to the highest risk areas, taking into account the current weather conditions and winds, road closures, forest types, population demographics, and reported incidents.

1.1.3. Hurricane

Region: Puerto Rico
User: State Emergency Operations Center Manager
Use Case: In the hours before a hurricane makes landfall, the manager needs to plan an evacuation response with local city departments, using environmental data (weather conditions and forecasts) and geospatial data (Satellite / Sentinel imagery, 2D and 3D maps, planned evacuation routes layers) and then monitor that response through the use of sensor information, infrastructure status, road closures, hospital / care facility capacity, reported incidents, weather information, field collected data.

Chapter 2. Simple Architecture

This section will provide an architectural overview of the tools and data used to plan a response to the flood, wildfire and hurricane disasters scenarios.

Compusult will demonstrate the use of WES and GoMobile to support disaster response during the disaster scenarios. The following WES components will be used during the response:

- **Catalog** - The WES Catalog populated with a repository of services relevant to the specific disaster
- **Portfolios** - Collections of geospatial assets associated with a given disaster
- **GeoPackage** - Data storage for disaster data to be enhanced via GoMobile
- **GoMobile** - A mobile application for display of data in disconnected operations, as well as feature data collection including media (photos and video) that can be synchronized back to the main control center
- **SensorHub** - IoT and sensor integration

The WES components listed above provide the following functionality before, during, and after a disaster scenario:

- **2D Mapping** - Open Street Maps, WMS/WMTS Map Layers, ArcGIS Map Layers, Satellite / Sentinel Imagery
- **3D City, Indoor, Terrain Models** – 3D building models, 3D terrain models, and navigation capabilities, where available
- **Weather Reporting** – Live feed of weather data displayed as a layer on the map
- **Vehicle Tracking / Simulation** – Live feed of data representing service vehicles, fire trucks, ambulances, planes, helicopters, and ships overlaid on the map
- **Evacuation Routes** – Overlaid as a map layer, if available
- **Feature Data Sync of Field Data via GO Mobile** – Allows first responders to gather data on an Android phone or tablet to share with others
- **Collaboration** – Chat, Tasking, Activities and Discussions between users of WES and GoMobile

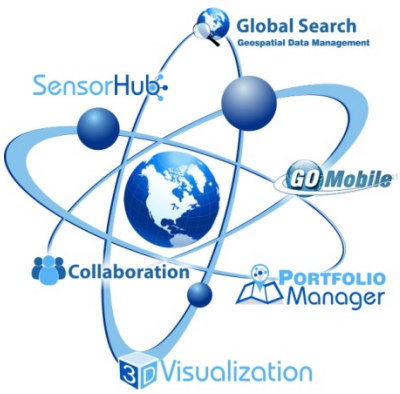

Figure 1. WES Suite

2.1. Data Providers

Various data providers will be used throughout the pilot. These providers include:

Flood (Region: St. Louis, MO, USA)

- U.S. Geological Survey (USGS)
- National Aeronautics and Space Administration (NASA)
- National Oceanic and Atmospheric Administration (NOAA)
- Health Solutions Research, Inc (HSR)
- Data.gov

Wildfire (Region: Okanagan Valley, BC, Canada)

- Government of British Columbia (DataBC)
- Meteorological Service of Canada
- Environment Canada
- National Aeronautics and Space Administration (NASA)

Hurricane (Region: Puerto Rico)

- National Aeronautics and Space Administration (NASA)
- National Oceanic and Atmospheric Administration (NOAA)
- U.S. Geological Survey (USGS)
- Health Solutions Research, Inc (HSR)
- National Hurricane Center
- Data.gov
- European Space Agency (ESA)

2.2. Catalog Providers

The WES Catalog is built on the OGC Catalogue Service-Web (CSW) standard and therefore inherits the ability to harvest various data services. Those services include catalogs that are also built on the standard. Compusult will integrate and collaborate with existing SDIs and catalog providers which will be harvested into the WES Catalog for disaster resilience planning. These include:

1. AmeriGEOSS Data Hub: AmeriGEOSS is a regional Global Earth Observation System of Systems (GEOSS) for continent of North America. It provides discovery and access to data, tools, services and resources for Earth Observations in North American. The Data Hub is made available through the Comprehensive Knowledge Archive Network (CKAN). It currently hosts more than 440K data/services/tools.
2. NextGEOSS: NextGEOSS is a centralized European Earth observation data hub and platform, where the users can connect to access data and deploy applications. The concept revolves around providing the data and ICT resources needed, together with cloud services, seamlessly connected to provide an integrated ecosystem for supporting Earth observation-based

applications and services.

3. GeoPlatform.gov: GeoPlatform.gov is a data portal to find new, trending, and noteworthy items – such as data, web services, press releases, articles, and more. This content changes frequently to keep users up-to-date with current and relevant information about GeoPlatform, its resources, and the GIS community.
4. NASA Common Metadata Repository (CMR): CMR is a comprehensive metadata system for all data and service metadata for NASA's Earth Observation System (EOS) Data and Information System (EOSDIS). It also functions as the International Directory Network (IDN) of CEOS to catalog, maintain, and discover Earth Observation (EO) data of CEOS.
5. FedEO (Federated Earth Observation missions access): FedEO is a large Catalog that is operated by ESA. Together with CWIC, it forms one of the core component aggregate catalogs under CEOS.

Compusult's WES CSW has implemented the auto-harvest capability of the OGC CSW standard so harvesting can be scheduled to automatically run hourly, daily, or weekly to harvest any new records from the source CSW.

2.3. Data Consumers

Standards-based tools such as WES and Go Mobile can be used to analyze and disseminate information to disaster planners and first responders, specifically City and State Emergency Operations Center Managers and Planners.

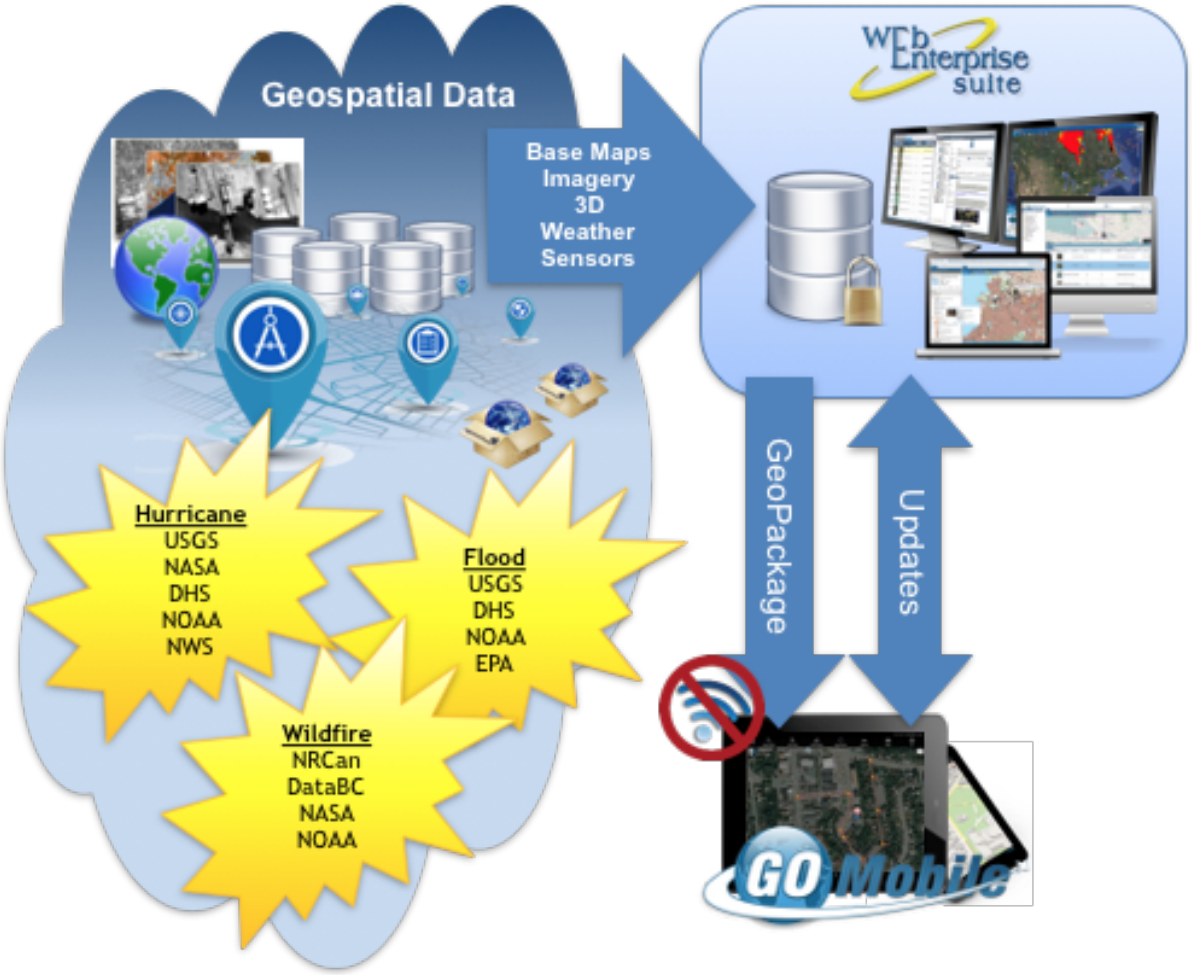

Figure 2. Basic Disaster Scenario Flow

Chapter 3. General Use Cases by User Activity

This pilot focuses on three users and their use cases in three separate scenarios. In the flood scenario, the focus is on a City Emergency Operations Center Manager in St. Louis, MO during a major rainfall which is causing the Mississippi river to rise to a flood level and hours away from flooding the banks of the river. In the wildfire scenario, the focus is on a Kamloops Fire Emergency Operations Center Manager as they plan a response to a wildfire in the Okanogan Valley, BC. In the hurricane scenario, the focus is on a State Emergency Operations Center Manager in Puerto Rico, one week prior to projected landfall of a major hurricane, anticipating flooding in the state.

3.1. Publication of data

A Wildfire Operations Center Manager prepares for an upcoming wildfire event by researching and compiling authoritative data about the terrain, vegetation, land use, current and forecasted weather conditions and other factors that are useful for planning purposes. This data would come from a variety of stakeholders such as provincial and federal government agencies, local officials, social media, and private companies.

A City Emergency Operations Center Manager prepares for an upcoming Flood event by researching and compiling authoritative data about the terrain, city maps, land use, transportation networks, current and forecasted weather conditions, rainfall accumulation data and real-time water levels from sensor data. This data would come from a variety of stakeholders such as federal government agencies, local officials, social media, and private companies.

A State Emergency Operations Center Manager prepares for an upcoming Hurricane event by researching and compiling authoritative data about the terrain, city maps, land use, transportation networks, current and forecasted weather conditions, rainfall accumulation data, real-time water levels from sensor data, and health data. This data would come from a variety of stakeholders such as state and federal government agencies, local officials, social media, and private companies.

The metadata for geospatial data services specific to each scenario noted above are published into the WES Catalog, an OGC-compliant CSW catalog, by a geospatial data administrator as outlined below. These geospatial data services may be sourced from a range of providers as mentioned above, and may be comprised of multiple map layers in a variety of data formats. This catalog of geospatial data assets will provide the foundation from which the disaster response is planned.

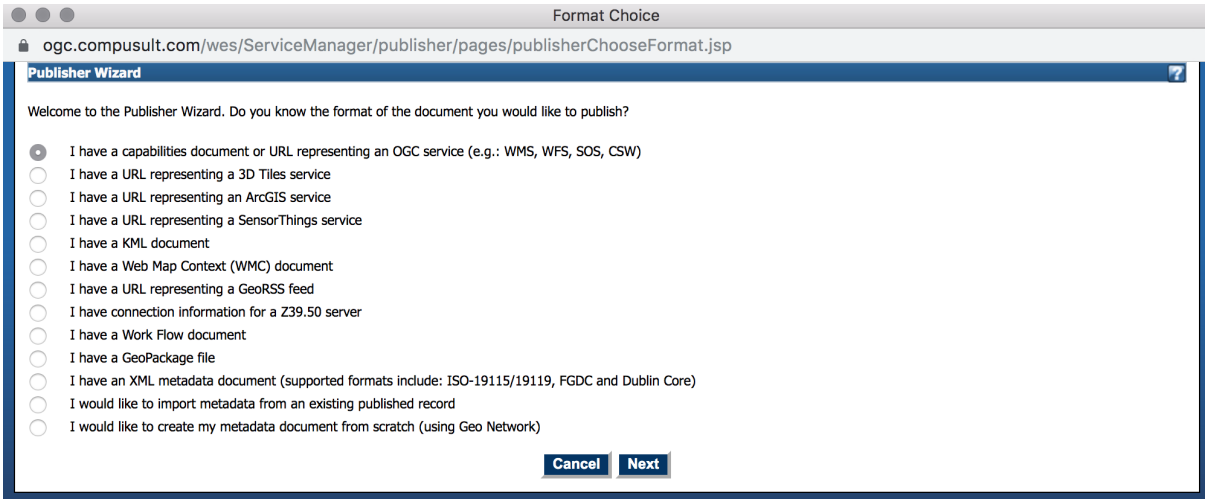

Figure 3. Types of Data Services

OGC CSW-based Catalogs such as WES, support many of the OGC services as shown in Figure 4 below:

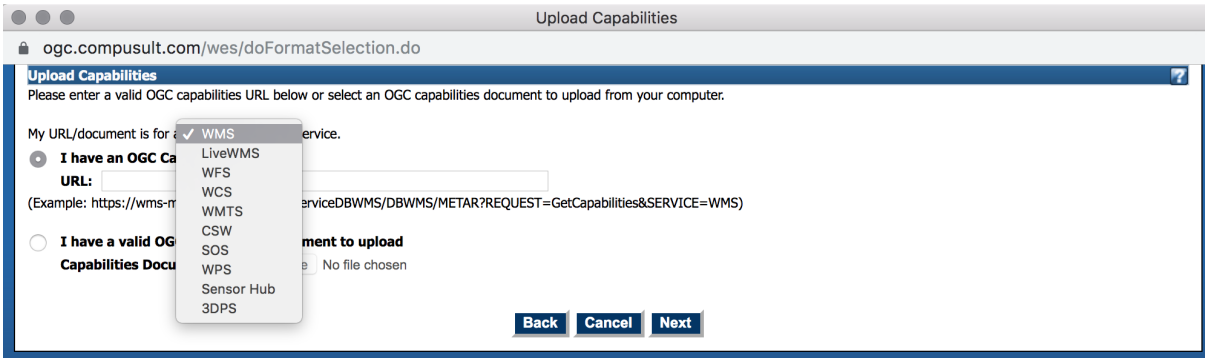

Figure 4. Types of OGC Data Services

Geospatial data administrators publish metadata for the above services into the WES Catalog using the "Publish to Catalog" feature of WES. This feature publishes all metadata for the service into the catalog and optionally downloads the associated geospatial data into WES.

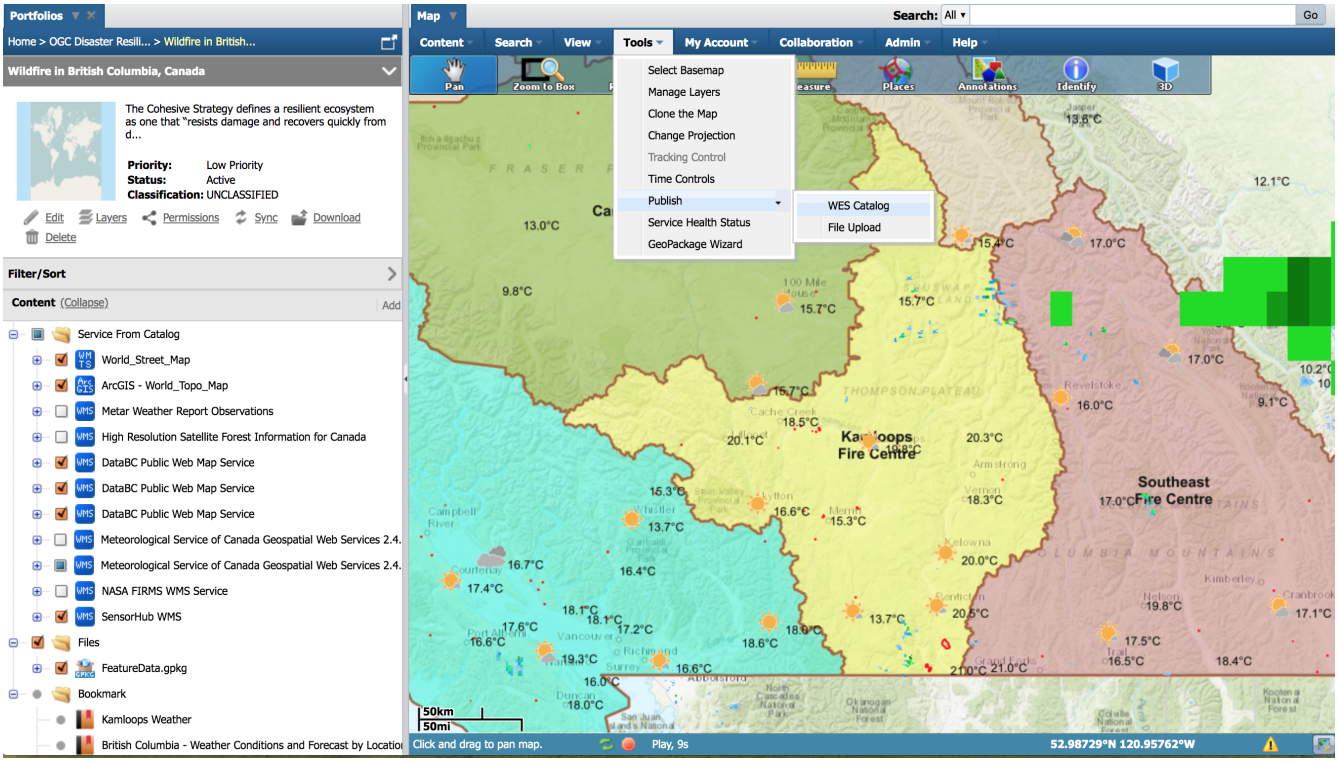

Figure 5. Publish to WES Catalog

During the publication of data, users can select "Automatic Harvesting" which will schedule automatic harvesting of the data service based on a given interval; such as hourly, daily, or weekly.

3.2. Discovery of data

Once metadata for a geospatial service is published into the WES Catalog, users can discover these services in WES by browsing the WES Catalog. Specific criteria can then be specified using the search field as shown in Figure 6 below.

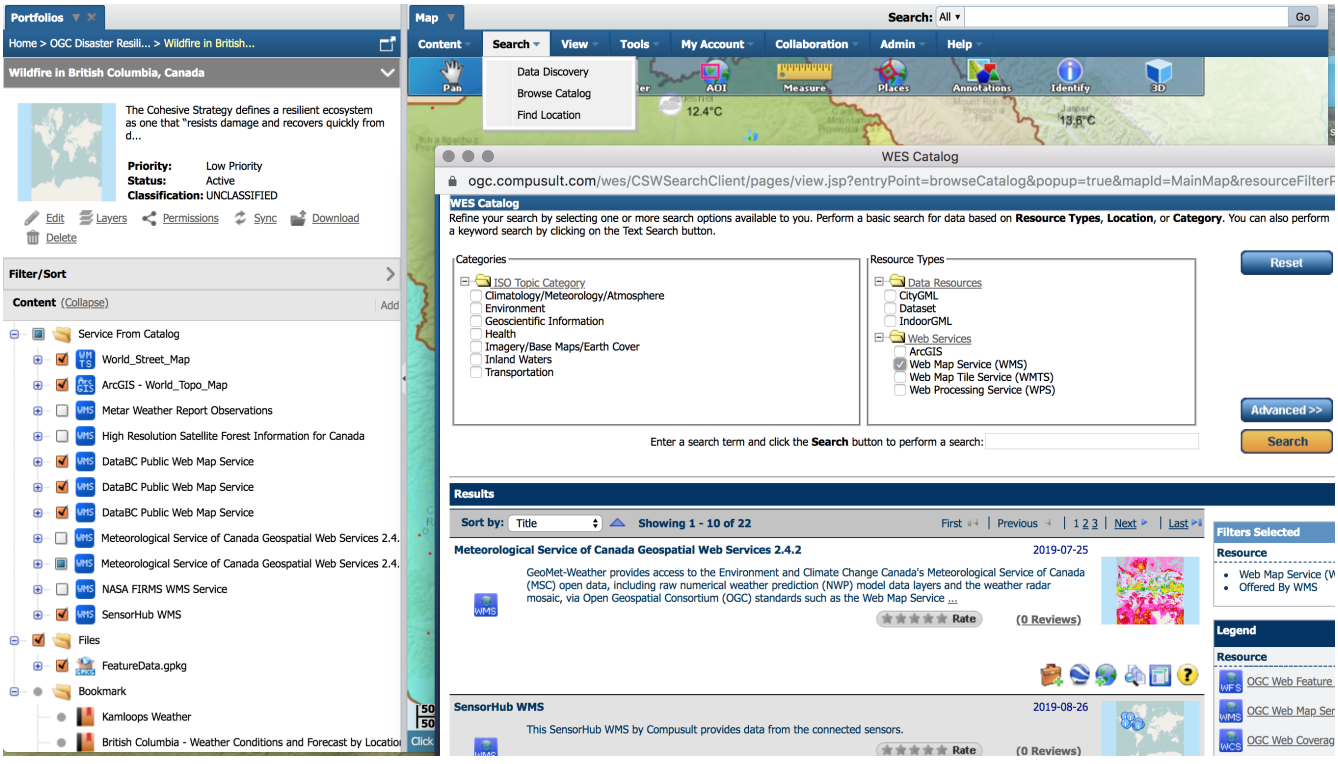

Figure 6. Browse WES Catalog

3.3. Using the data

Once the user discovers relevant map layers they can then add those layers to a WES portfolio for a scenario. These portfolios are dynamic and can be updated to add or remove new geospatial data layers as the scenario unfolds and changes become necessary.

When the data has been added to a portfolio it can be used in WES to view static map layers, view dynamic map layers, and analyzed to make decisions and deliver the appropriate information to planner and first responder. This geospatial data can also be packaged into a GeoPackage, using the GeoPackage Wizard, and downloaded to GoMobile for offline use in a disconnected environment.

Users can also use other collaboration and tasking tools during the disaster's response as discussed in chapter 5 for each scenario.

3.4. Downloading of data

Users can then use the mapping tools outlined in Figure 7 below to add the selected data to a WES portfolio for a scenario. These portfolios are dynamic and can be updated to add or remove new geospatial data layers as the scenario unfolds and changes become necessary.

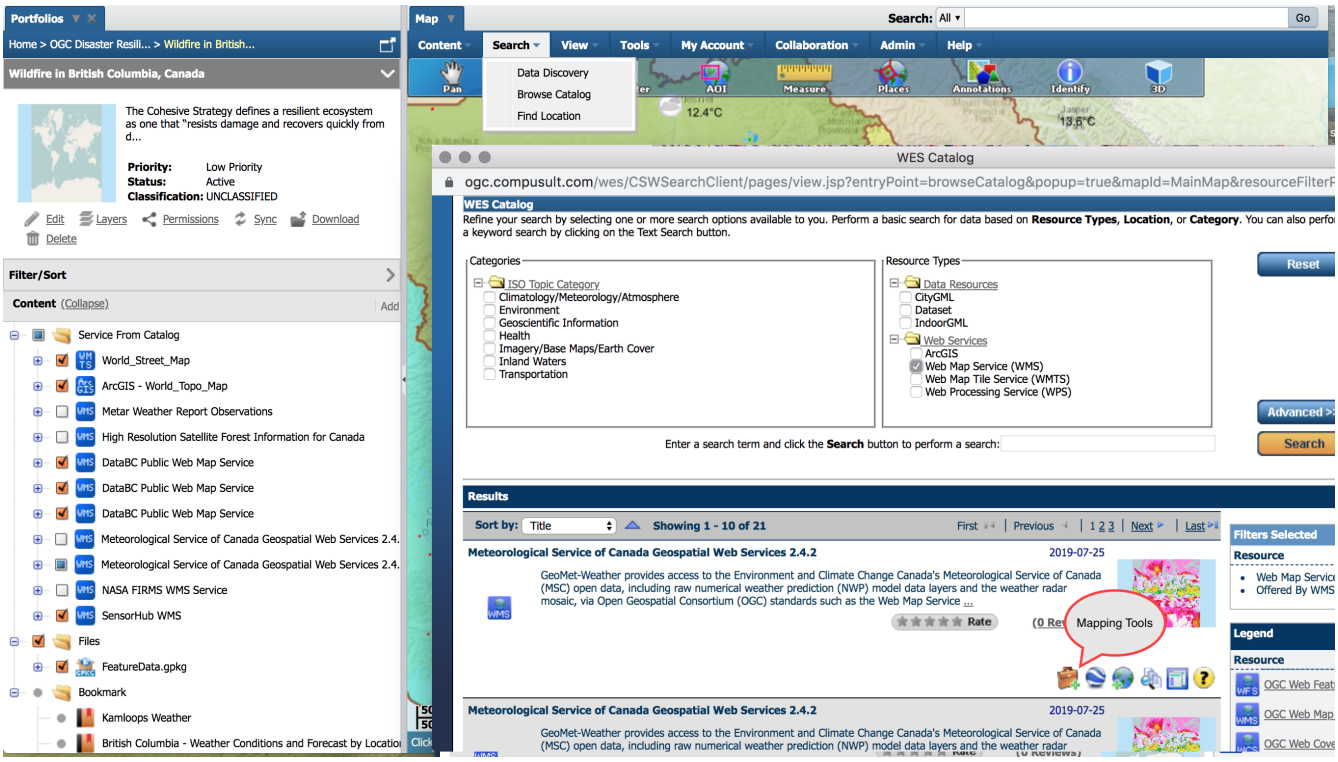

Figure 7. Mapping tools

When the data has been added to a portfolio it can be used in WES to display maps and other dynamic data layers. It can also be packaged into a GeoPackage, using the GeoPackage Wizard, and downloaded to GoMobile for offline use in a disconnected environment.

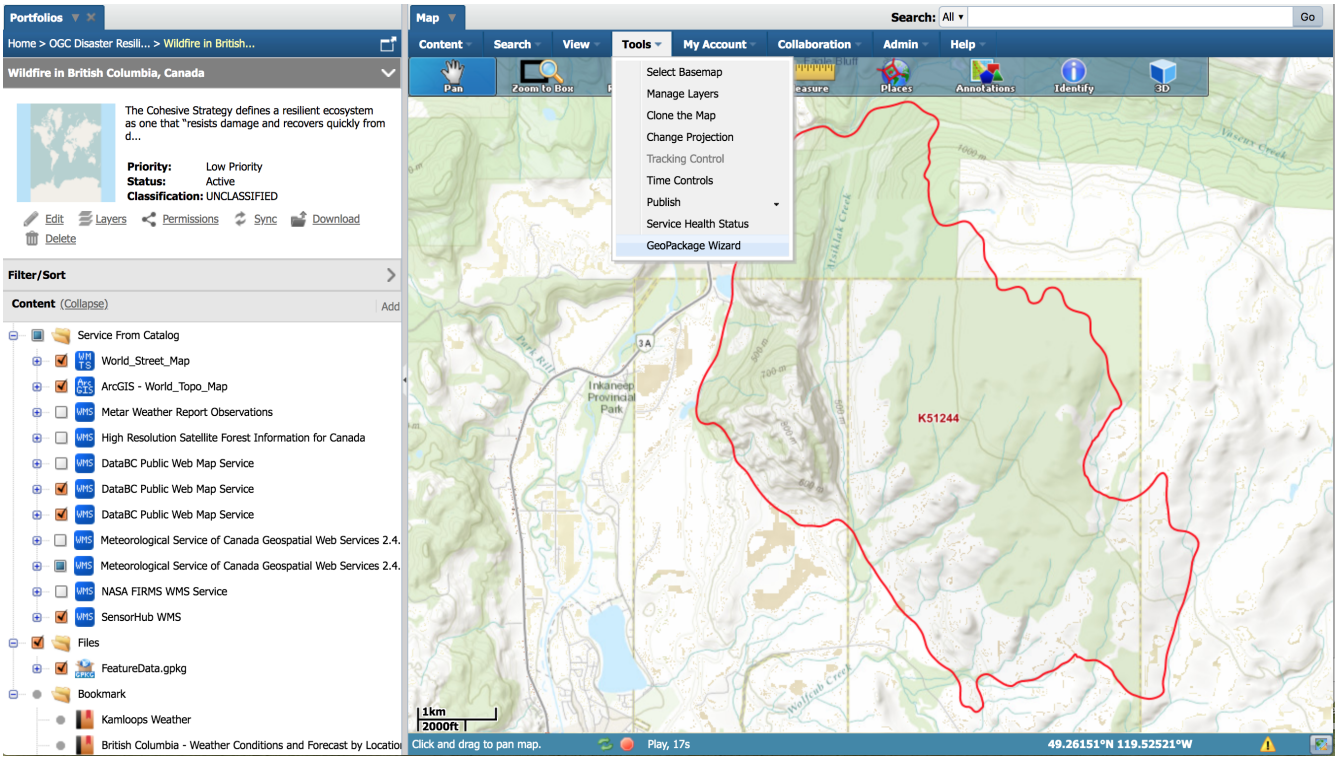

Figure 8. GeoPackage Wizard Menu Selection

Users can customize the GeoPackage by selecting various layers they want added to a GeoPackage before it's generated.

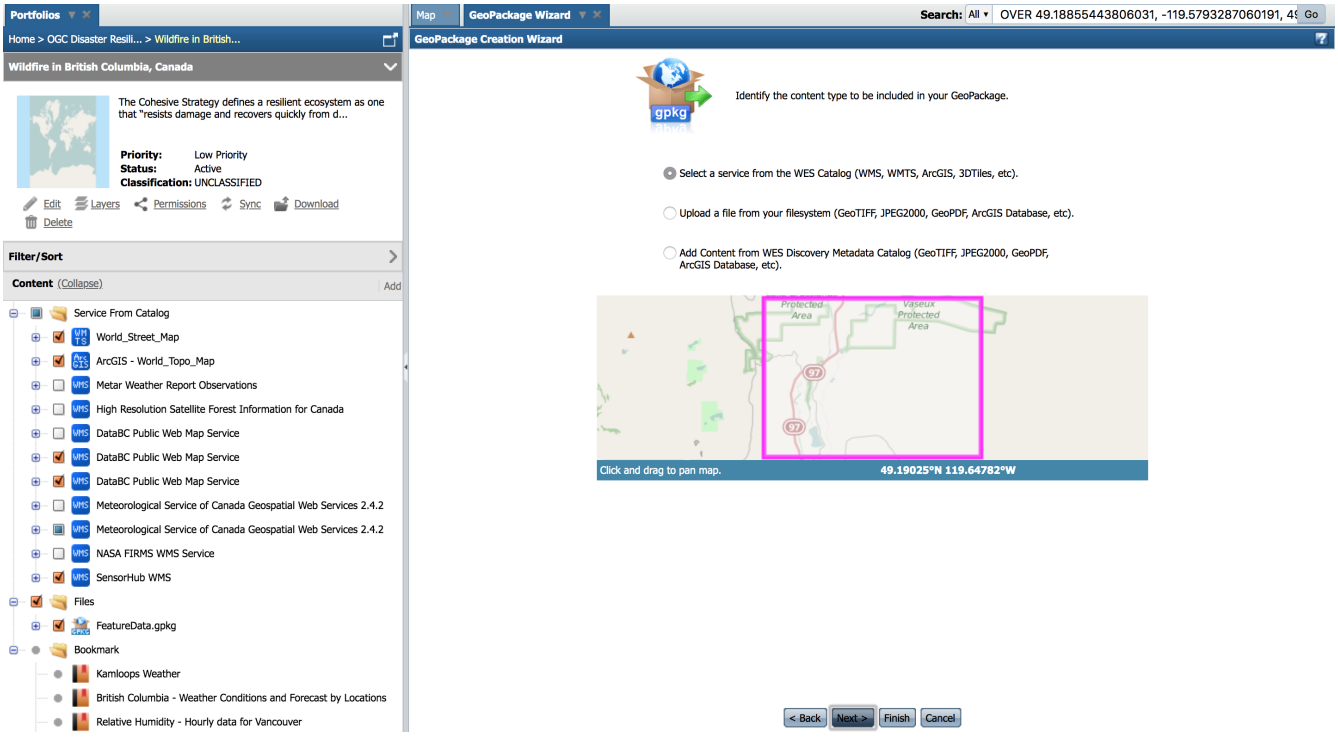

Figure 9. GeoPackage Wizard (selecting content type)

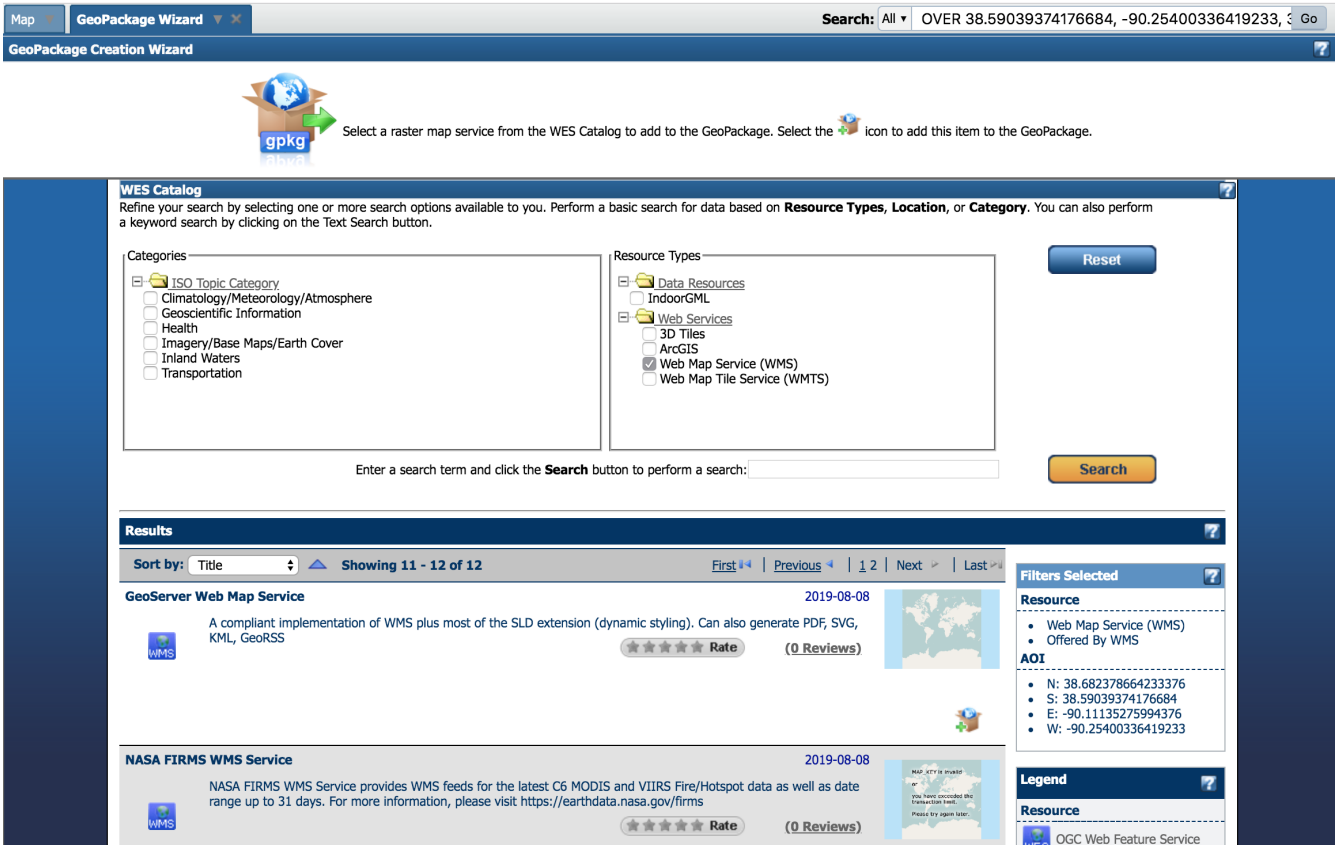

Figure 10. GeoPackage Wizard (selecting service type)

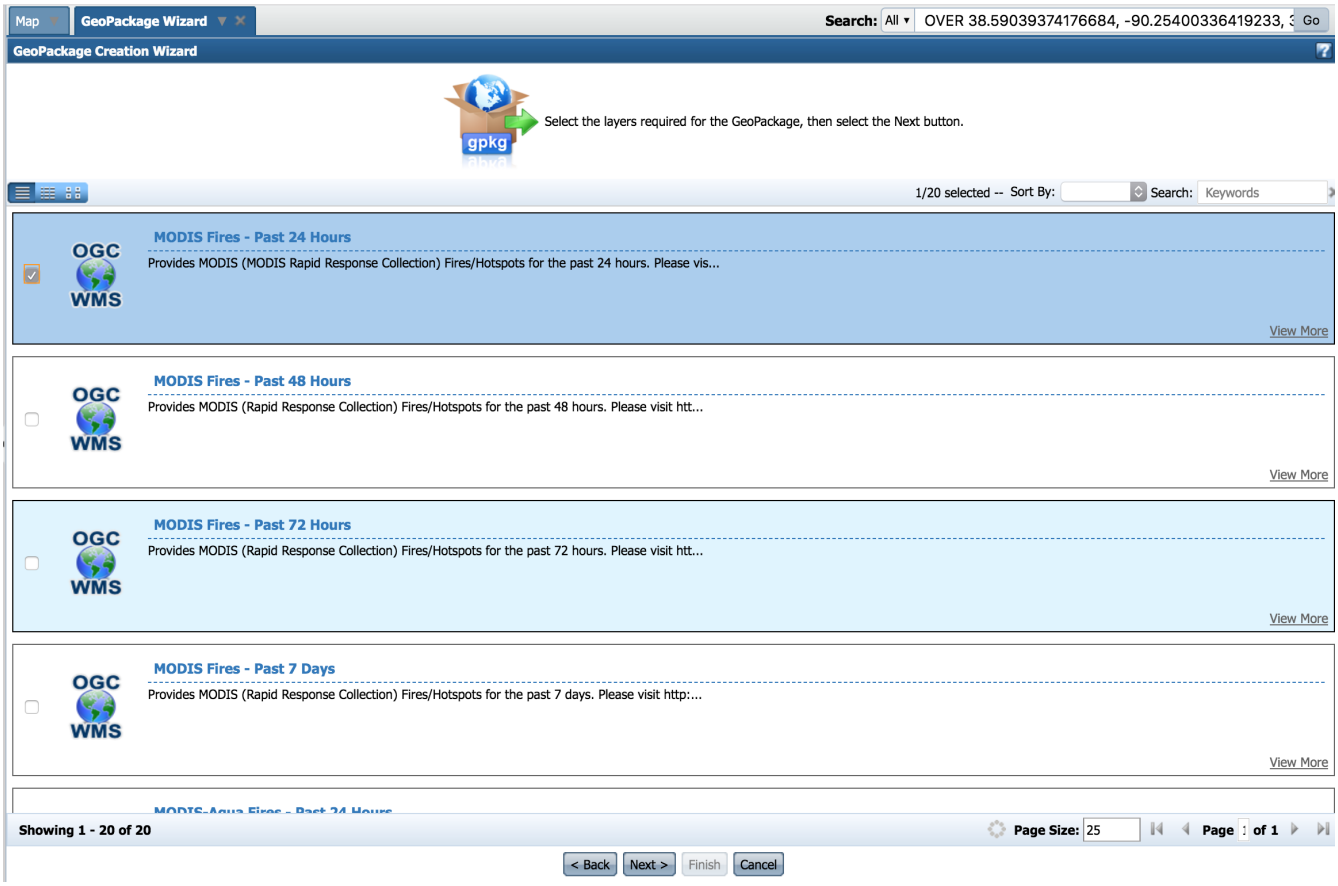

Figure 11. GeoPackage Wizard (selecting map layers)

In the final step, the user specifies the GeoPackage name and description and generates the GeoPackage which can be added to the portfolio and optionally downloaded. This is outlined in Figure 12 below.

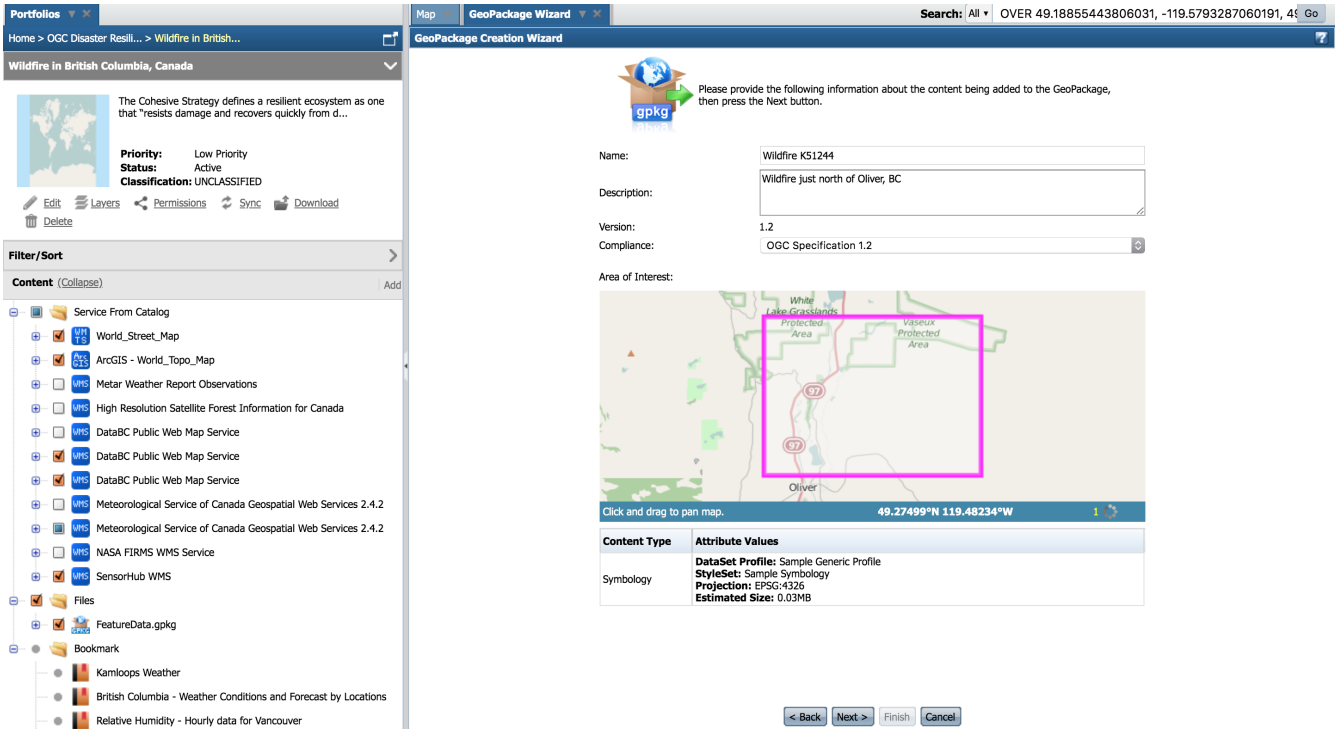

Figure 12. GeoPackage Wizard (setting GeoPackage attributes)

3.5. Displaying of the data with proper symbology

Data can be displayed using predefined symbology sets to provide a consistent map interface based on predefined mapping standards.

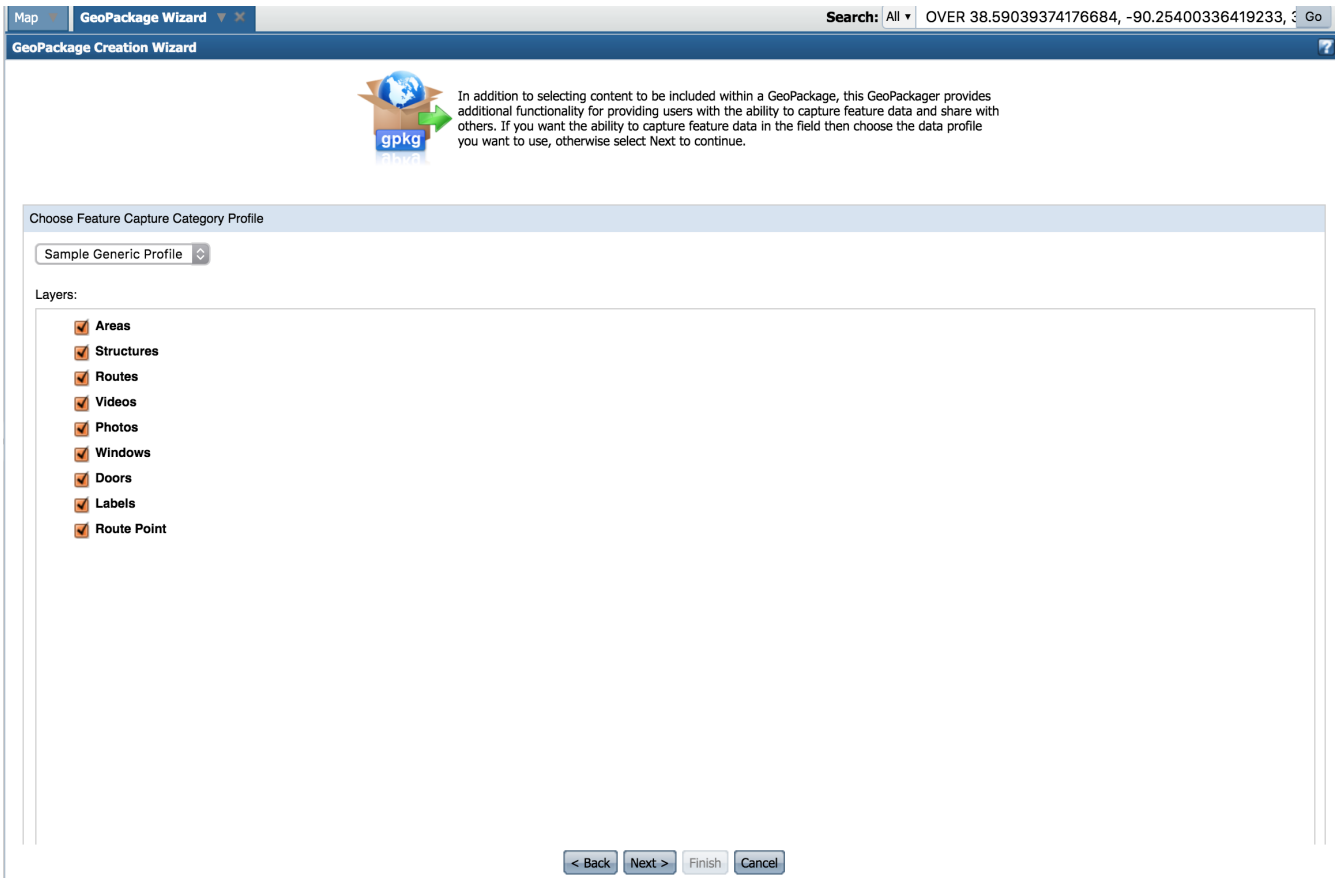

Figure 13. Specifying Symbology

3.6. In-situ Data

While in the field, first responders can use GoMobile to enter details about the current situation on the ground and upload them to WES when they have connectivity. First responders can also communicate with command center using the messaging component of WES and receive and update status information of assigned tasks.

Real-time sensor data based on OGC's SensorThings API will be integrated into WES and can be displayed using the WES SensorHub Dashboard. This can include data from environmental sensors such as water level, wind speed or wind direction sensors or body worn sensors such as first responder heart rate sensors.

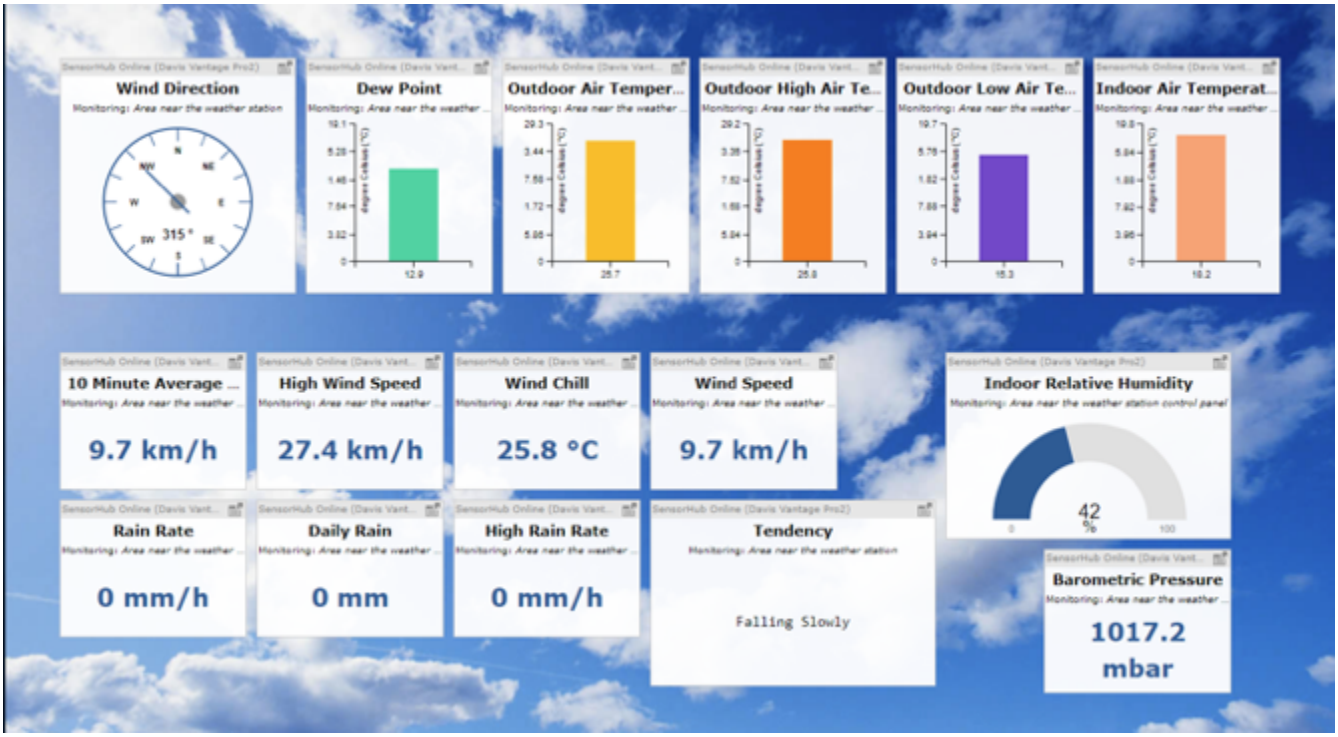

Figure 14. SensorHub Dashboard

Alerts can be configured in the system based on thresholds so that an alert may be sent, via email or SMS text messaging, based on crossing a threshold. For example, an alert can be sent when the wind speed goes above a certain speed or changes direction, or when a firefighter's body temperature or heart rate rises above an acceptable level.

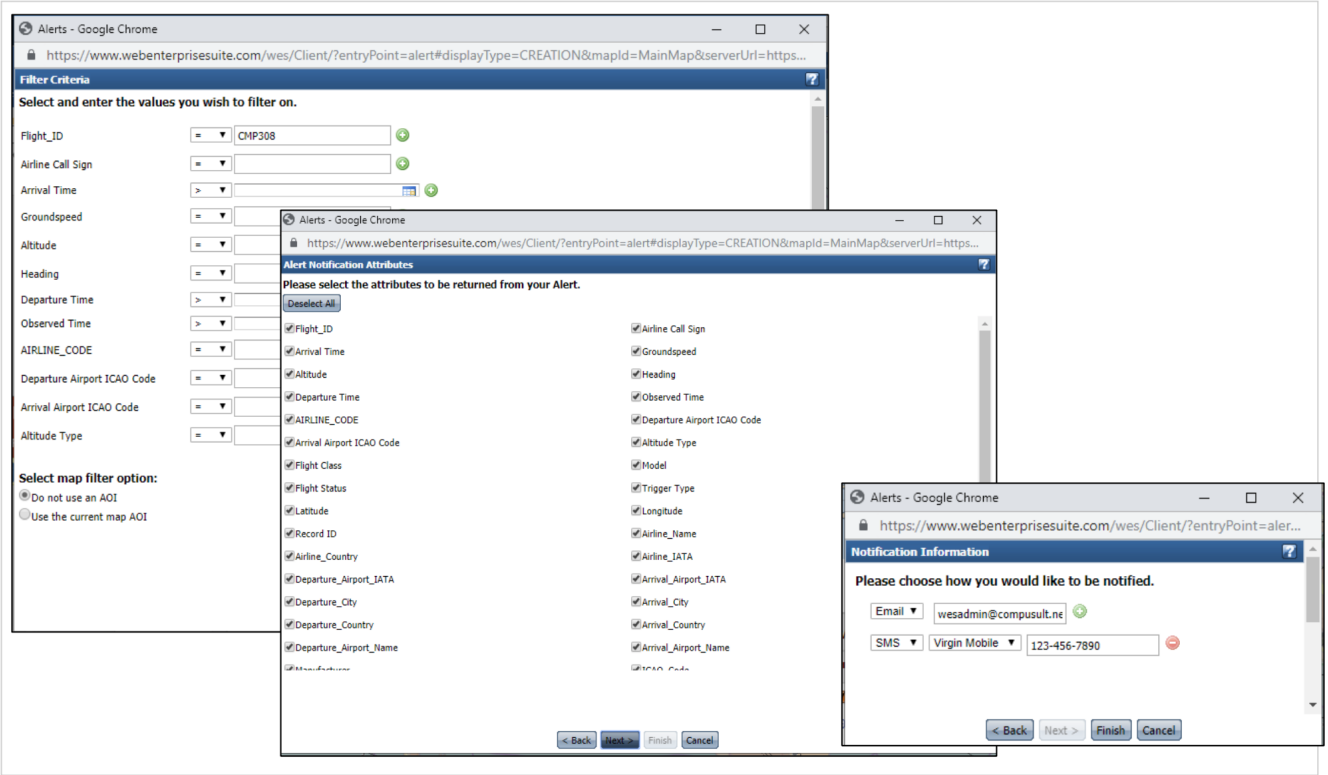

Figure 15. Alert Configuration

3.7. Model Data

3D models can be used to display the terrain, city models or building models in 3D giving the personnel on the ground a 3D perspective and situational awareness that they wouldn't otherwise have with traditional maps. First responders can view water levels in 3D to get real-time and projected information on what areas of a city will be flooded based on water levels.

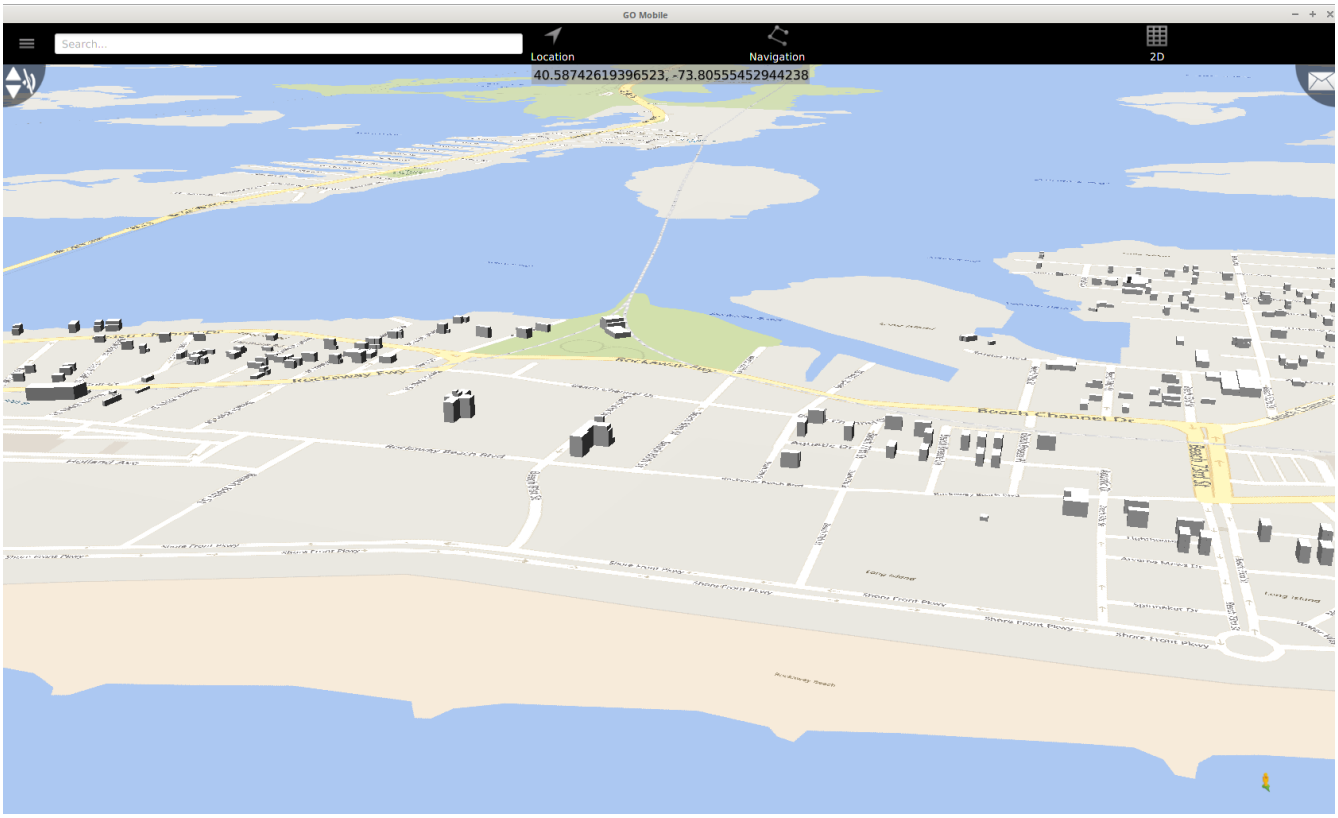

Figure 16. 3D Maps in GoMobile

3D building models can also be viewed, and routes planned into buildings by first responders to rescue civilians trapped in buildings during a disaster.

Figure 17. 3D Building Models in GoMobile

3.8. Remote Sensing Data

Compusult leverages Remote Sensing Data for the base map. In the various scenarios, 3D Terrain maps, land use and land cover data, city maps, is used to help emergency planners gain situational awareness to understand the type of terrain and foliage the response personnel will be entering. This will help them make better decisions when planning the response.

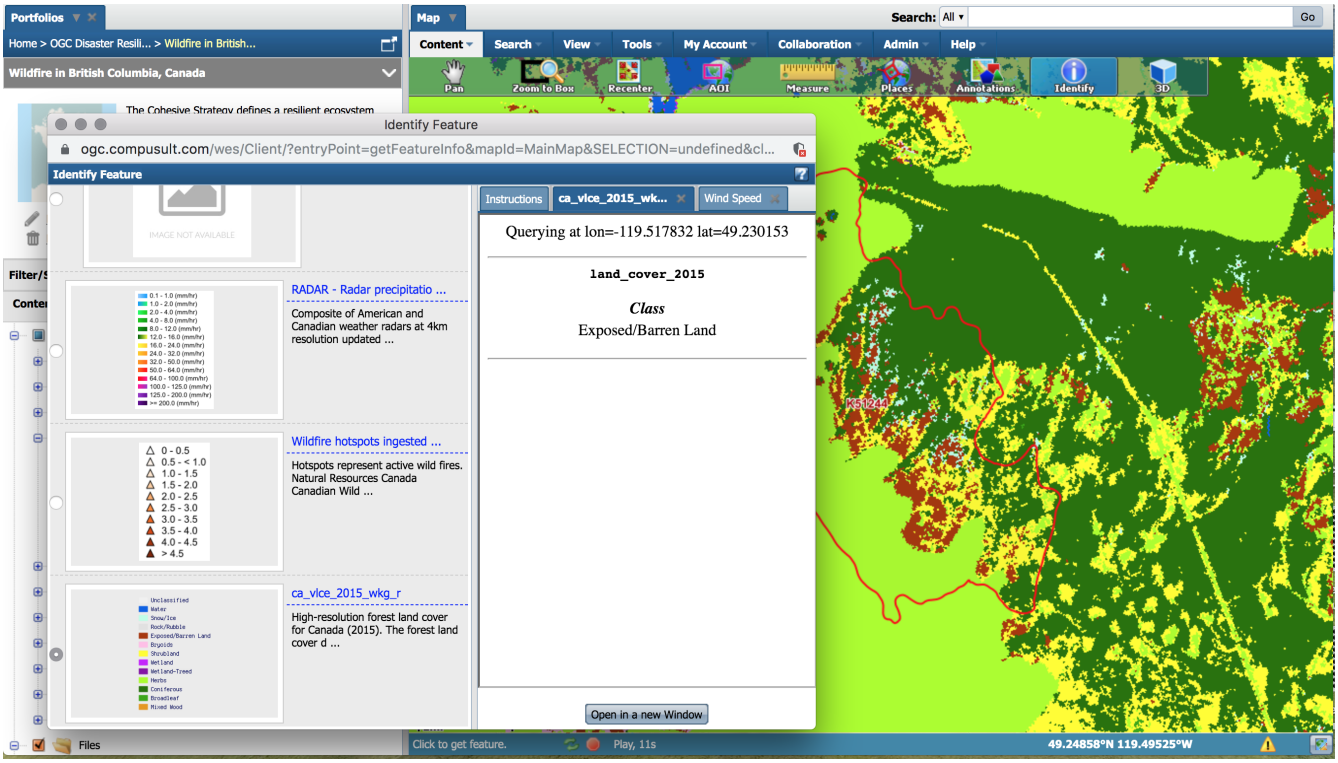

Figure 18. Land Use Mapping

3.9. Collaboration Tools

Collaboration tools such as Messaging, Activities, Chat and Tasks have been implemented in WES to enable exchange of information between command center and first responders in the field. These tools use the open MQTT protocol for communications between Go Mobile and WES.

These tools enable tasks and activities to be planned, scheduled and assigned to first responders and status updates to be posted from Go Mobile to WES.

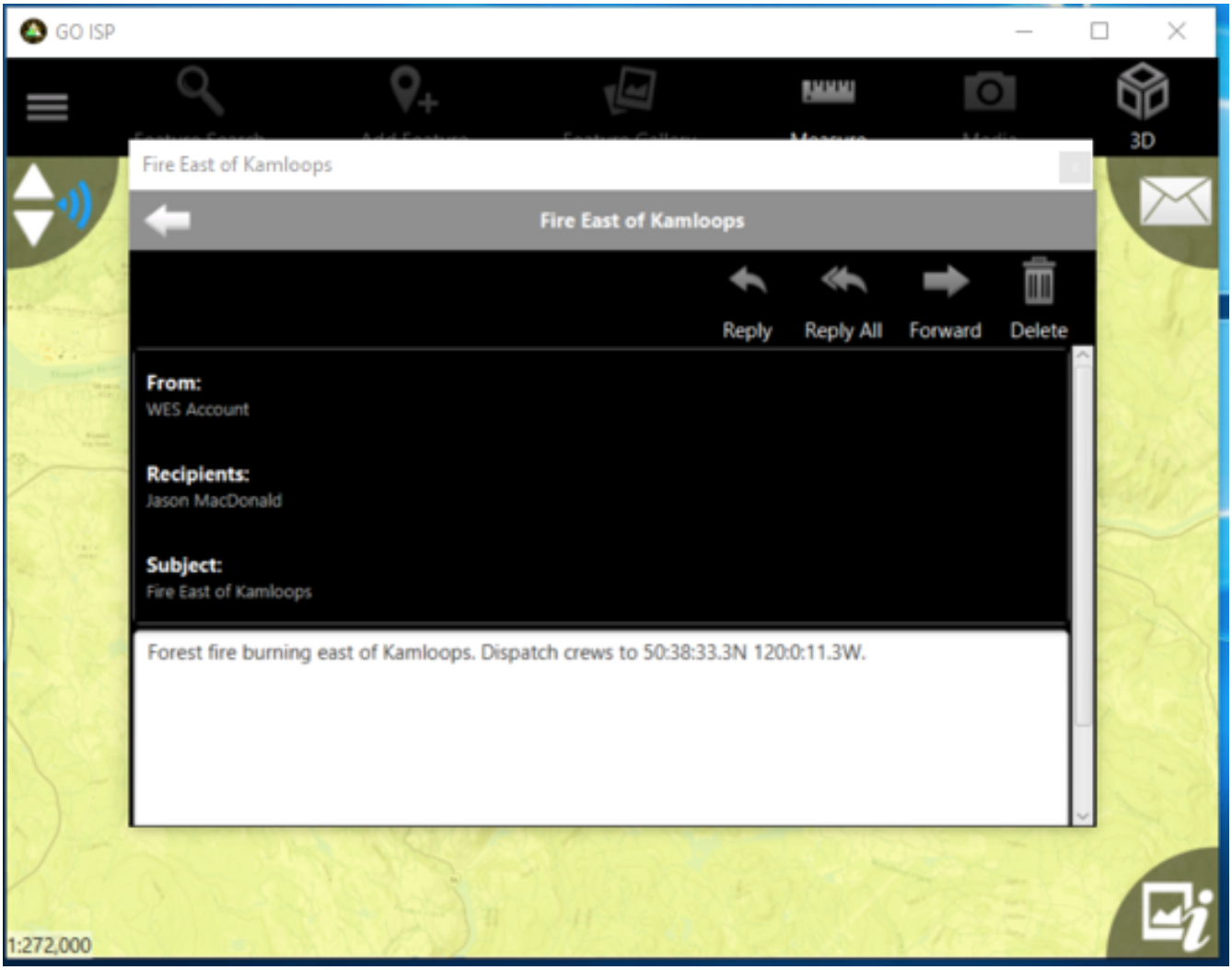

Figure 19. Messaging

3.10. References

- References will go here for this section

Chapter 4. Special Topics

This section will provide a description of any or all of the following special topics:

4.1. Right data for the right user

As demonstrated during the flood, wildfire and hurricane disaster responses outlined in this User Guide, providing the right data to the right users at the right time is critical to the success of the response. In the Flood scenario, providing the City Emergency Operations Center Manager with road closures, current traffic information, water levels, and reported incidents will enable them to plan, organize and dispatch first aid personnel to affected areas in a safe, effective manner. In the Wildfire scenario providing the current weather conditions and winds, road closures, forest types, population demographics and reported incidents will enable the Kamloops Fire Emergency Operations Center Manager to safely and effectively dispatch Wildfire response personnel to the scene. In the hurricane scenario, providing the State Emergency Operations Center Manager with environmental data (weather conditions and forecasts) and geospatial data (Satellite / Sentinel imagery, 2D and 3D maps, planned evacuation routes layers) will enable them to plan an effective response and then monitor that response through the use of sensor information, infrastructure status, road closures, hospital / care facility capacity, reported incidents, weather information, field collected data and crowd sourced data.

WES and Go Mobile will do this by providing a platform that disaster planners and organizers can use to compile geospatial resources for each scenario into a portfolio, and provide viewing, analysis, and dissemination of this geospatial information to first responders in the field.

4.2. Health data

Through collaboration with HSR, Compusult was able to use their health data by ingesting their OGC WMS based health layers into the WES platform. The use of this data was easily added to a standards-based platform such as WES since both HSR and Compusult adhere to the OGC WMS data exchange standards which enabled these two separate systems to work together in a plug and play approach without any extra integration development. This seamless plug and play capability outlines the true value of using Open Geospatial Data standards and Data Exchange standards.

4.3. IoT connectivity

Compusult provided access to sensor data during the pilot by using the open OGC SensorThings and SensorHub technologies. Platforms, such as Compusult’s WES, are able to make use of sensor data from independent sensor data providers who implement the OGC SensorThings API in a plug and play capability.

4.4. Catalog Auto Harvesting

The Catalog component of Compusult’s WES platform has implemented the OGC CSW standard and therefore has inherited the ability to harvest various open and closed standard based data services including OGC services such as CSW Catalogs, WPS services, WMTS services, and WMS services, and

ESRI’s ArcGIS services. Through the implementation of the optional auto-harvest feature WES can offer auto-harvesting of any of these services on a periodical timeframe. Therefore, data services such as other OGC Catalogs can be harvested on an hourly, daily, or weekly basis.

4.5. GeoPackage

One of the most valuable technologies deployed in the pilot was the use of OGC’s standard-based GeoPackages to bundle Geospatial data into packages which can be downloaded to mobile clients for offline and disconnected use. These GeoPackages can contain a wide range of Geospatial data including 2D base maps, 3D terrain and city maps, 3D building layouts and CAD drawings, weather forecasts, feature coordinates, etc. These GeoPackages can then be updated in a disconnected environment and uploaded back to WES when the user is back online where the updates can be viewed.

Chapter 5. Scenarios and Tools Demonstration

This section will provide a detailed description of the scenario(s) and the description of the tools used in the demonstration.

5.1. Flood

According to Webster's dictionary floods are defined as "a rising and overflowing of a body of water especially onto normally dry land".

Flood is one of the most frequent natural disasters in the world. According to the Organization for Economic Cooperation and Development, on average, floods cause over $40 billion in damage worldwide. U.S. alone account 20% of the global loss.

Floods cause more than $40 billion in damage worldwide annually, according to the Organization for Economic Cooperation and Development cite:[OECD2016]. In the U.S., losses average close to $8 billion a year. Significant death tolls have increased in recent decades.

5.1.1. Audience

The flood scenario below outlines the use of WES by a City Emergency Operations Center Manager to plan and provide information to first responders in a disaster response to a flood of the Mississippi River affecting St. Louis, MO.

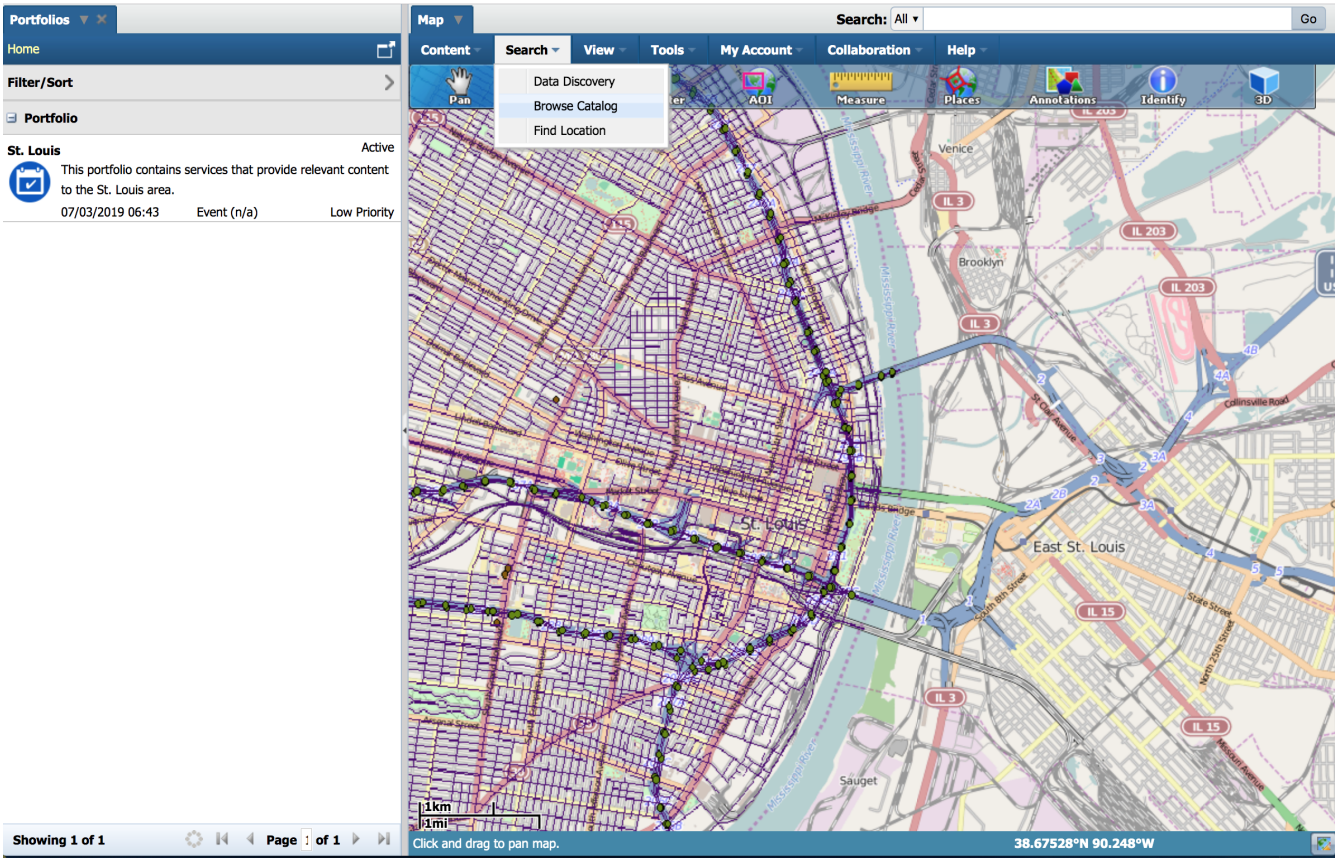

Figure 20. St. Louis, MO Flood Planning

5.1.2. Data Providers

Data for the flood scenario can be harvested from various sources, including:

- USGS
  - STN Real Time and Historical Sensor Data
  - NWIS - National Water Information System
  - DEM - 3DEP 1/3 arc-second DEMs
- NASA
  - LANSE - Near Real-Time Data and Imagery
  - Rainfall Accumulation Analyses Imagery
  - NRT Global Flood Mapping
  - FEMA - RSS Feeds
- NOAA
  - Rainfall Accumulation Analyses
- HSR: Public Health Data
- Data.gov

5.1.3. Publication of data

The data services specific to the flood scenario are harvested into the WES CSW Catalog, an OGC compliant catalog as outlined in chapter 3.

Geospatial Data Administrators publish metadata for the above services into the WES Catalog using the "Publish to Catalog" feature of WES. This publishes all metadata for the service into the catalog and optionally downloads the associated geospatial data into WES.

During the publication of data, users can select "Automatic Harvesting" which will setup automatic harvesting of the data service based on a given interval (hourly, daily, weekly, etc).

5.1.4. Discovery of data

Once metadata for a geospatial service is published into the Catalog users discover these services in WES by browsing the Catalog. Specific criteria can then be searched using the search field.

5.1.5. Downloading of data

Users can then use the mapping tools outlined in chapter 3 to add the selected data to a WES portfolio for a scenario. These portfolios are dynamic and can be updated to add or remove new geospatial data layers as the scenario unfolds and changes become necessary.

When the data has been added to a portfolio it can be used in WES to display maps and other dynamic data layers. It can also be packaged into a GeoPackage, using the GeoPackage Wizard, and downloaded to GoMobile for offline use in a disconnected environment.

5.1.6. In-situ Data

While in the field, flood first responders can use GoMobile to enter details about the current situation and upload them to WES when they have connectivity. First responders can also communicate with command center using the messaging component of WES and receive and update status information of assigned tasks.

Real-time sensor data based on OGC's SensorThings API will be integrated into WES and can be displayed using the WES SensorHub Dashboard. This can include data from environmental sensors such as water level sensors or body worn sensors such as first responder's heart rate sensors.

Alerts can be configured in the system based on thresholds so that an alert may be sent, via email or SMS text messaging, based on crossing a threshold. For example, an alert can be sent when the water level rises above a certain level, or when a first responder's heart rate rises above an acceptable level.

5.1.7. Model Data

3D Terrain models can be used to display 3D building models, the flooded area and the surrounding area in a 3D model giving the personnel on the ground a 3D perspective and situational awareness that they wouldn't otherwise have with traditional maps.

5.1.8. Remote Sensing Data

Compusult leverages Remote Sensing Data for the base map. In the flood scenario, 3D Terrain maps, Land Use, Weather Conditions & Forecast Data, Health Data, Sensor Data and 3D St. Louis city data are all used to help dispatchers gain situational awareness to understand the type of terrain and extent of flooding that response personnel will be dealing with. This will help them make better decisions when planning the response.

5.1.9. Registration of data

The various flood related data services will be registered in the WES Catalog which will enable organization and searching of these geospatial data services.

5.1.10. Collaboration Tools

As discussed in chapter 3 various collaboration tools such as Messaging, Activities, Chat and Tasks have been implemented in WES to enable exchange of information between command center and first responders in the field. These tools use the open MQTT protocol for communications between Go Mobile and WES.

These tools enable tasks and activities to be planned, scheduled and assigned to first responders and status updates to be posted from Go Mobile to WES.

5.2. Wildfire

A wildfire is an unplanned or unwanted natural or person-caused fire which requires suppression action. wildfires burn thousands of acres of land in North America every year, destroying homes

and causing fatalities.

5.2.1. Audience

The wildfire scenario below outlines a disaster response to a wildfire in the Okanagan Valley, BC by a Kamloops Fire Emergency Operations Center Manager who is responsible for planning, organizing and dispatching firefighter response personnel to the highest risk areas while taking into account the current weather conditions and winds, road closures, forest types, population demographics and reported incidents.

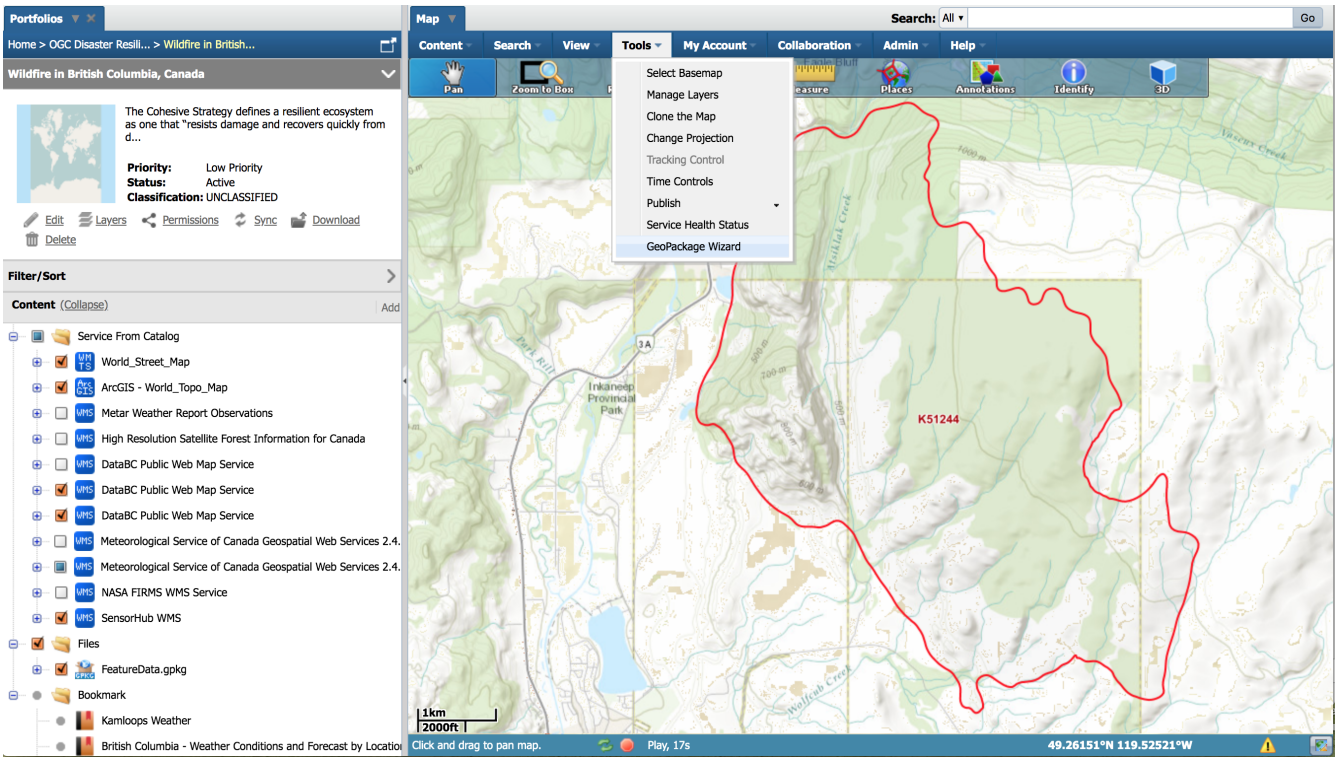

Figure 21. Kamloops, BC Wildfire Planning

5.2.2. Data Providers

Data for the wildfire scenario can be harvested from various sources, including:

- Government of British Columbia (DataBC)
  - Fire Perimeter
  - VRI Vegetation Composite Polygons
  - Fire Centers
- Meteorological Service of Canada
  - Regional Deterministic Prediction System
  - Regional Air Quality Deterministic Prediction System
  - Wildfire Hotspots
  - Weather Radar
  - Current Conditions

- Environment Canada
  - Metar
- NASA
  - FIRMS - Fire Information for Resource Management System

5.2.3. Publication of data

The data services specific to the wildfire scenario are published into the WES CSW Catalog, an OGC compliant catalog as outlined in chapter 3.

5.2.4. Discovery of data

Once metadata for a geospatial service is published into the Catalog users discover these services in WES by browsing the Catalog. Specific criteria can then be specified using the search field.

5.2.5. Downloading of data

Users can then use the mapping tools outlined in chapter 3 to add the selected data to a WES portfolio for a scenario. These portfolios are dynamic and can be updated to add or remove new geospatial data layers as the scenario unfolds and changes become necessary.

When the data has been added to a portfolio it can be used in WES to display maps and other dynamic data layers. It can also be packaged into a GeoPackage, using the GeoPackage Wizard, and downloaded to GoMobile for offline use in a disconnected environment.

Users can customize the GeoPackage by selecting various layers they want added to a GeoPackage before it's generated. As a final step the user specifies the GeoPackage name and description and generates the GeoPackage which can be added to the portfolio and can optionally be downloaded.

5.2.6. In-situ Data

While in the field wildfire first responders can use GoMobile to enter details about the current situation on the ground and upload them to WES when they have connectivity. First responders can also communicate with command center using the messaging component of WES and receive and update status information of assigned tasks.

Real-time sensor data based on OGC's SensorThings API will be integrated into WES and can be displayed using the WES SensorHub Dashboard. This can include data from environmental sensors such as wind speed or direction sensors or body worn sensors such as firefighter heart rate sensors.

Alerts can be configured in the system as described in chapter 3 based on thresholds so that an alert may be sent, via email or SMS text messaging, based on crossing a threshold. For example, an alert can be sent when the wind speed goes above a certain speed or changes direction, or when a firefighter's body temperature or heart rate rises above an acceptable level.

5.2.7. Model Data

3D Terrain models can be used to display the fire perimeter and surrounding area in 3D giving the

personnel on the ground a 3D perspective and situational awareness that they wouldn't otherwise have with traditional maps.

5.2.8. Remote Sensing Data

Compusult leverages Remote Sensing Data for the base map. In the wildfire scenario, 3D Terrain maps, Land Use and Land Cover Data is used to help dispatchers gain situational awareness to understand the type of terrain and foliage the wildfire fighter response personnel will be entering. This will help them make better decisions when planning the response.

5.2.9. Collaboration Tools

As discussed in chapter 3 various collaboration tools such as Messaging, Activities, Chat and Tasks have been implemented in WES to enable exchange of information between command center and first responders in the field. These tools use the open MQTT protocol for communications between Go Mobile and WES.

These tools enable tasks and activities to be planned, scheduled and assigned to first responders and status updates to be posted from Go Mobile to WES.

5.3. Hurricane

Hurricane is one of the major natural hazards around coastal areas. Because of the low-pressure oceanic condition hurricane event cause high precipitation during its landfall Hurricane is one of the most frequent natural disasters in the world. According to the Organization for Economic Cooperation and Development, on average, floods cause over $40 billion in damage worldwide. U.S. alone account 20% of the global loss.

5.3.1. Audience

The hurricane scenario below outlines the use of WES by a State Emergency Operations Center Manager to plan and provide information to first responders in a disaster response to a hurricane making landfall near San Juan, Puerto Rico.

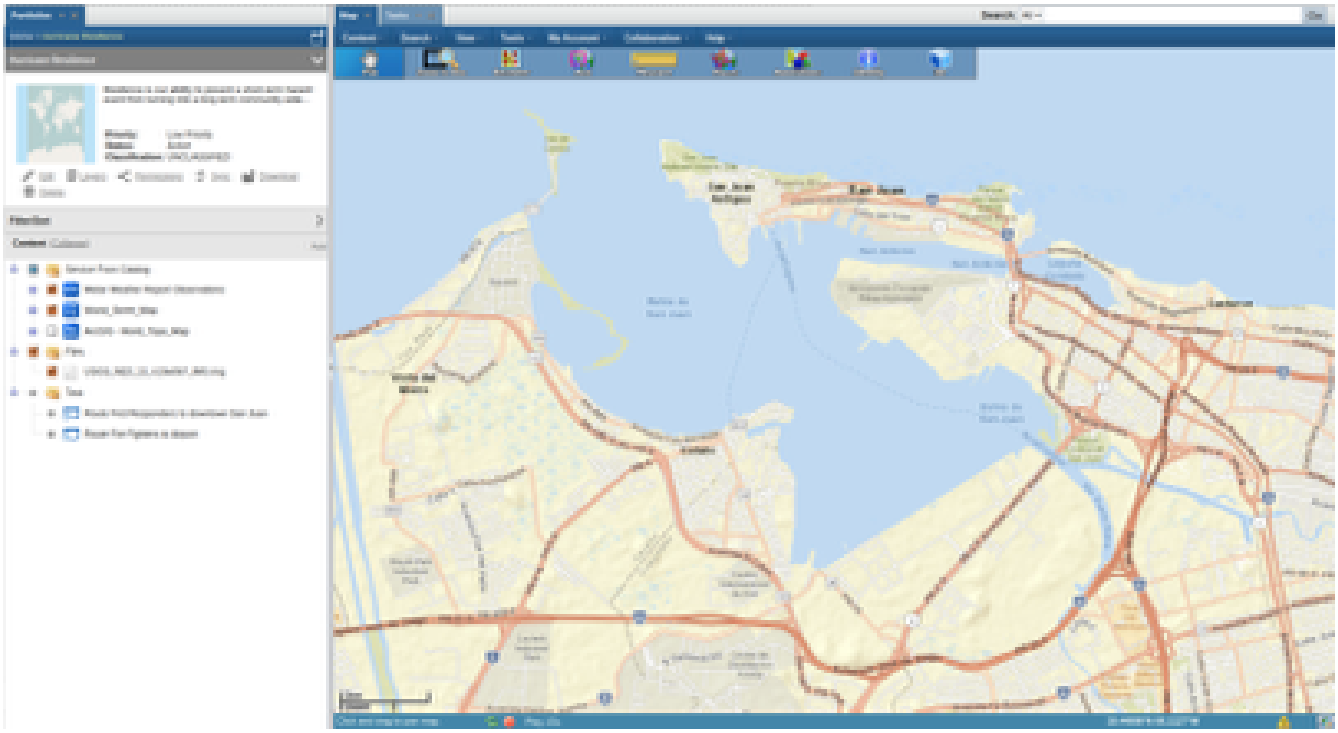

Figure 22. San Juan, Puerto Rico Disaster Planning

5.3.2. Data Providers

Data for the hurricane scenario can be harvested from various sources, including:

- NASA
  - LANSE - Near Real-Time Data and Imagery
  - Moderate Resolution Imaging Spectroradiometer (MODIS) and NASA's Visible Infrared Imaging Radiometer Suite (VIIRS)
  - Rainfall Accumulation Analyses Imagery
  - FEMA - RSS Feeds of OpenFEMA Disaster Declarations Summaries
- NOAA
  - Rainfall Accumulation Analyses
- USGS
  - STN Real Time and Historical Sensor Data
  - NWIS - National Water Information System
  - DEM - 3DEP 1/3 arc-second DEMs
- HSR: Public Health Data
- National Hurricane Center
  - RSS Feeds
- Data.gov
- ESA
  - Sentinel

5.3.3. Publication of data

The data services specific to the hurricane scenario are harvested into the WES CSW Catalog, an OGC compliant catalog as outlined below.

Geospatial Data Administrators harvest metadata for the above services into the WES Catalog using the "Publish to Catalog" feature of WES. This publishes all metadata for the service into the catalog and optionally downloads the associated geospatial data into WES.

5.3.4. Discovery of data

Once metadata for a geospatial service is published into the Catalog users discover these services in WES by browsing the Catalog. Specific criteria can then be searched using the search field.

5.3.5. Downloading of data

Users can then use the mapping tools outlined in chapter 3 to add the selected data to a WES portfolio for a scenario. These portfolios are dynamic and can be updated to add or remove new geospatial data layers as the scenario unfolds and changes become necessary.

When the data has been added to a portfolio it can be used in WES to display maps and other dynamic data layers. It can also be packaged into a GeoPackage, using the GeoPackage Wizard, and downloaded to GoMobile for offline use in a disconnected environment.

5.3.6. In-situ Data

While in the field, hurricane first responders can use GoMobile to enter details about the current situation and upload them to WES when they have connectivity. First responders can also communicate with command center using the messaging component of WES and receive and update status information of assigned tasks.

Real-time sensor data based on OGC's SensorThings API will be integrated into WES and can be displayed using the WES SensorHub Dashboard. This can include data from environmental sensors such as wind speed or water level sensors or body worn sensors such as a first responder heart rate sensor.

Alerts can be configured in the system based on thresholds so that an alert may be sent, via email or SMS text messaging, based on crossing a threshold. For example, an alert can be sent when the wind speed goes above a certain speed or changes direction, or when a first responder's heart rate rises above an acceptable level.

5.3.7. Model Data

3D Terrain models can be used to display the flooded area and surrounding landscape in a 3D model giving the personnel on the ground a 3D perspective and situational awareness that they wouldn't otherwise have with traditional maps.

5.3.8. Remote Sensing Data

Compusult leverages Remote Sensing Data for the base map. In the hurricane scenario, 3D Terrain maps, Land Use, Weather Conditions & Forecast Data, Health Data, Sensor Data and 3D Puerto Rico data are all used to help dispatchers gain situational awareness to understand the type of terrain and extent of flooding that response personnel will be dealing with. This will help them make better decisions when planning the response.

5.3.9. Registration of data

The various flood related data services will be registered in the WES Catalog which will enable organization and searching of these geospatial data services.

5.3.10. Collaboration Tools

As discussed in chapter 3 various collaboration tools such as Messaging, Activities, Chat and Tasks have been implemented in WES to enable exchange of information between command center and first responders in the field. These tools use the open MQTT protocol for communications between Go Mobile and WES.

These tools enable tasks and activities to be planned, scheduled and assigned to first responders and status updates to be posted from Go Mobile to WES.

Chapter 6. Conclusion and Way Forward

Three scenarios, flood, wildfire, and hurricane have been demonstrated by leveraging geospatial Web technologies and OGC open geospatial standards. During the Disasters Resilience Pilot Compusult's WES platform was used to demonstrate the value of interoperability through open geospatial standards. Here are the major findings from the pilot project:

- Available Data - Making objective decisions on resources dissemination is only possible when there are data services available and the data is ready for resource planner to use. There was substantial work involved to research available geospatial resources, learn about the specifics of each resource (update interval, coverage, data format, etc.) and how to ingest them into WES. It is apparent that substantial planning is required to build out a portfolio for each scenario to provide the information needed.
- WES Functionality - While most of the deliverables were able to be met using the standard version of Compusult's WES, there were a few isolated cases where WES needed enhancements to provide some of the desired capability. One such instance was that WFS 2.0 data couldn't be accessed due to limitations of WES.
- Scenario Construction - There are many maps layers provided by the various data sources that were ingested during the development of each scenario. However, with the wealth of data layers it was substantial effort to determine which layers offered the most useful information.
- Mobile Data Synchronization - Depending on the scenario there can be a large volume of data (10s of GB) that must be synced between WES and GoMobile running on the mobile device. Consideration must be given for which type of network is used during this data transfer.
- Data Access - We were unable to access NASA's FIRMS service due to being unable to obtain a map key required to use the service. Also, many of the services we tried to access required ArcGIS authentication which was not provided.

In general WES was able to ingest and deliver data from open geospatial services and provide tools to planners to view and analyze this data and provide collaboration with first responder in the field. As a follow on to this pilot each scenario can be revisited to ensure the most valuable data is being used and that the highest value features are implemented by WES to provide maximum value to each end user for each use case.