Project Update: Environmental Analysis and Modeling of the Natuv Aquifer, Western Ramallah, Palestine, Report Submitted to Al-Fallah Foundation

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I. Background

Groundwater is a key source of fresh water for communities around the world. However, the data necessary to protect these resources is often difficult to access, located in various reports and on different computers, and not available in a convenient, centralized location. As a result of inadequate management, groundwater is threatened by pollution from uncontrolled waste disposal and discharge. In resource-constrained communities, where many households rely on private wells and pollution sources are difficult to control, protection of the groundwater supply is especially critical. Yet, as many parts of the world experience rapid urbanization, groundwater resources are becoming more heavily exploited and increasingly exposed to more widespread and diverse sources of contamination, constituting a significant threat to public health (Fig 1).

Figure 1: Water quality in a spring is threatened by adjacent trash disposal near Al Jania.

The myObservatory collaborative data environment is a web-based platform specifically designed to access, manage, and utilize data collected from the environment. It combines Geographic Information System (GIS) tools with data management tools including statistics and charting, archiving, and quality assurance tests. It allows users to curate data collected in the field alongside environmental data from third party sources, and supports collaboration and sharing of results through its multi-user access controls. These features allow different types of environmental data to be collected and stored in a central location over time, allowing users to observe trends and make connections about the world around them.

II. Introduction

Modern management of water resources requires continuous monitoring of hydrological systems. Monitoring should be adaptive and compatible with the development of analytical tools and decision-support systems. It should provide up-to-the-minute information on current conditions and trends. We proposed to form the basis for such a management system for the Natuv drainage basin in the western hills of Ramallah, Palestine. The Natuv Aquifer supplies water to multiple wells and springs, which play a major role in supplying the water needs of local villages. It is threatened by numerous sources of contamination, and there is strong evidence to indicate potential health hazards to local inhabitants and users.

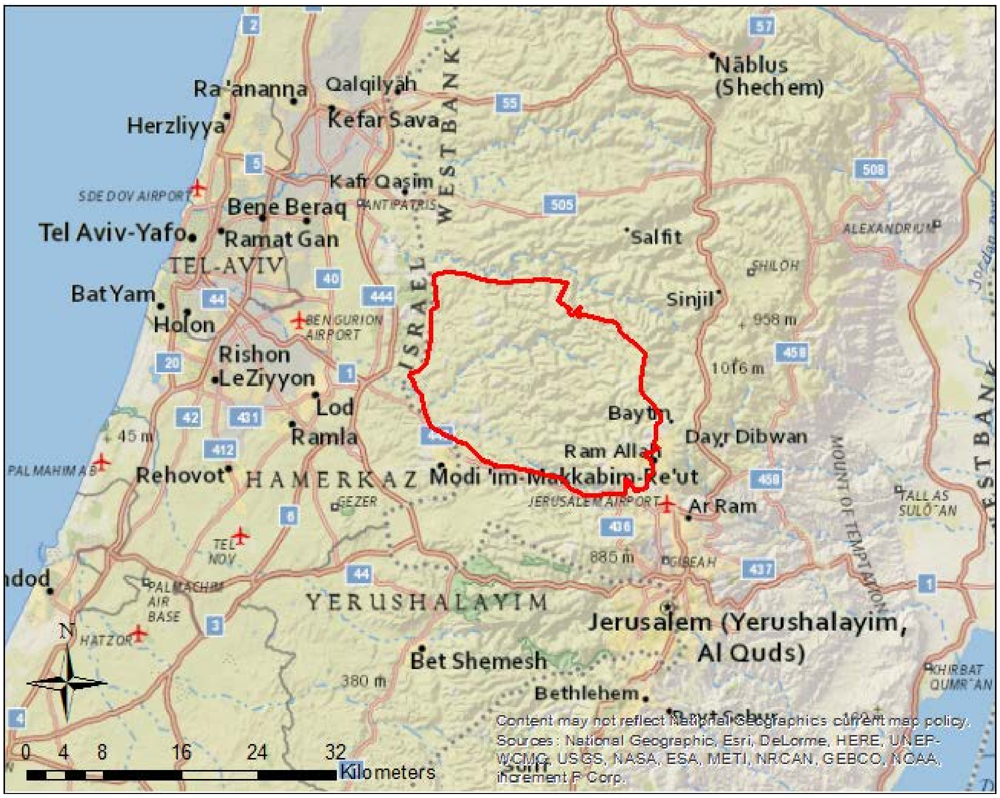

Figure 2: The Natuv drainage basin (outlined in red) extends from Ramallah in the East to the border with Israel in the West. It has a surface area of around 204 square kilometers and is home to around 110 thousand inhabitants.

. The Natuv drainage basin is located in the West Bank, extending from Ramallah in the East to the border with Israel in the West (Fig 2). It drains from the mountains of Western Jerusalem into the coastal plains of the Mediterranean Sea and has a surface area of about 204 km^2. The basin is home to around 110 thousand people (Palestinian Central Bureau of Statistics, 2014), many of whom obtain water from the basin's 130 springs. In addition, the Natuv drainage basin is one of the main sensitive recharge areas within the Western Aquifer Basin (WAB).

This project aims to provide a flexible, accessible, and customizable water monitoring platform, which can be utilized by decision-makers and community members to design and manage groundwater protection efforts. The platform will include an aquifer vulnerability map, which indicates the degree of natural protection of the groundwater supply. This map will be overlaid with customized and updateable information on pollution sources and water quality data to create a dynamic risk map indicating where the risk of current contamination of the water supply is high. Water quality data can be updated as new measurements come in, constituting a growing database of information from which to observe trends, identify areas of acute pollution, and make current predictions of pollutant concentrations throughout the area.

Among other features, users will be able to view water quality data on the map, calculate statistics, interpolations, and charts, and upload geotagged data from mobile devices. Many different users can contribute data to the site, increasing transparency and encouraging participation of community members in the groundwater protection plan. The platform, created using the web-based environmental data management system myObservatory, will be presented to stakeholders including the Palestinian Water Authority, and support will be offered on its use.

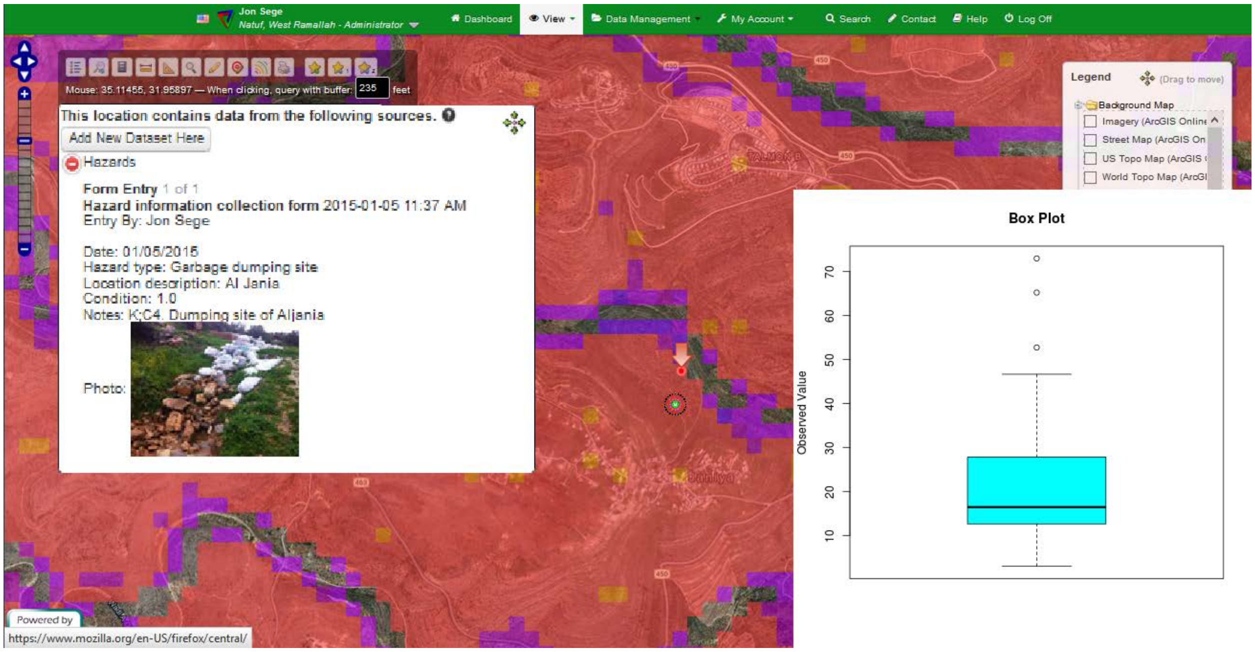

Figure 3: Zooming in on Al Jania (see Fig 1) in the myObservatory map, one sees that there is a hazard (red dot with an arrow) adjacent to the spring (multi-colored circle). Furthermore, one can see that these features are in a more vulnerable area (purple and red background). A photo stored at the hazard location shows the exact condition of the pollution hazard, and a box plot of sodium concentrations at the spring confirms that the dump is having an impact on water quality (note that the measured concentrations (circles) far exceed the expected sodium range (blue box)).

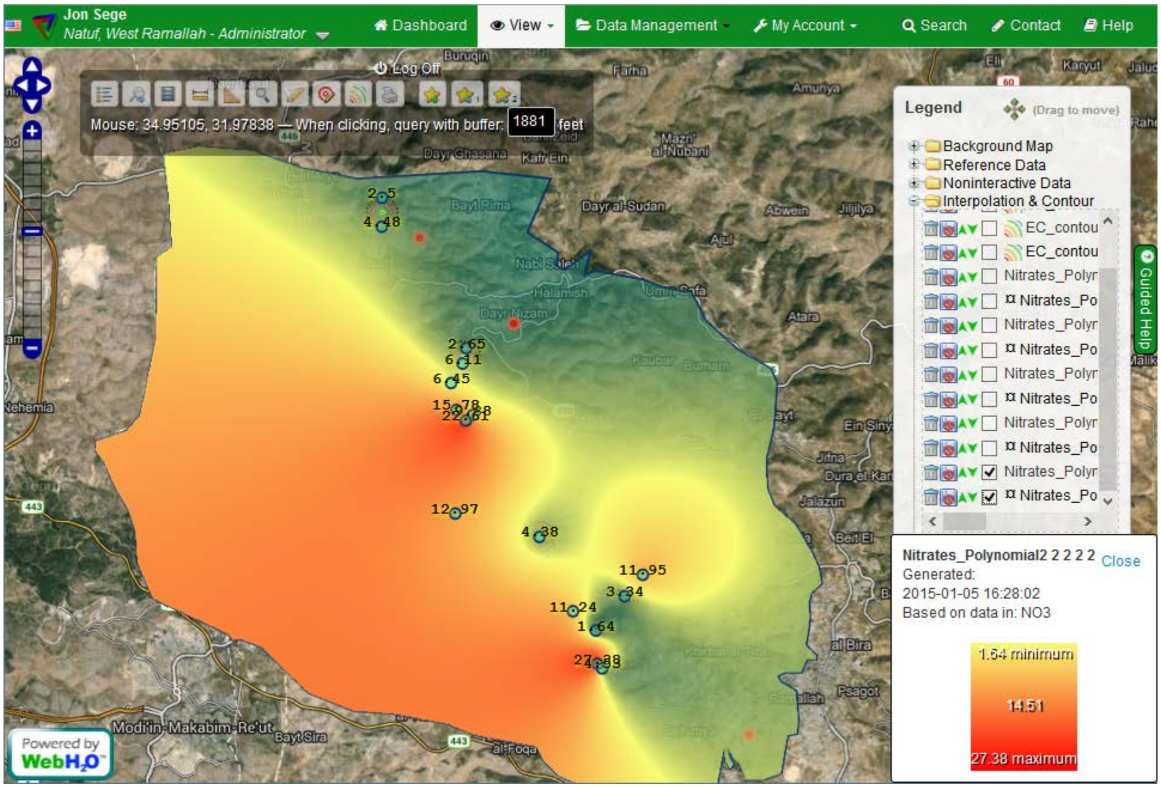

Figure 4: Measurements can be used to make predictions about water quality throughout the study area. In this image, measurements of Nitrate concentrations at 16 locations are interpolated to predict concentrations in areas where no measurements exist. When new measurements are added by users, the interpolation can be updated easily to reflect changing conditions.

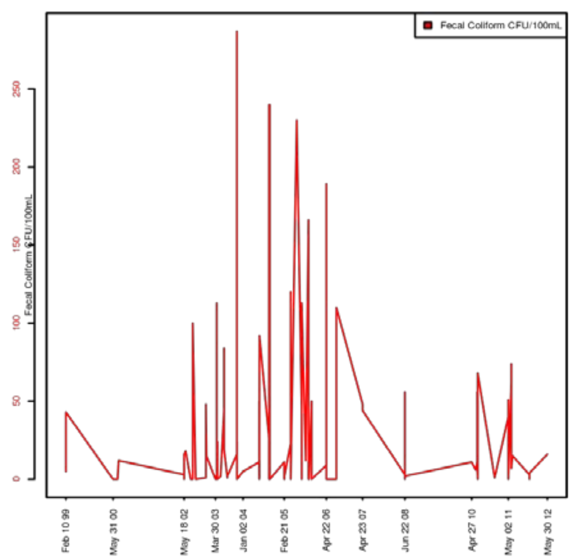

Figure 5: Time series can highlight temporal trends in environmental data. Here, fecal coliform concentrations in springs throughout Natuv basin are plotted over time, revealing distinct spikes in concentration, possibly corresponding to precipitation events or pasturing seasons.

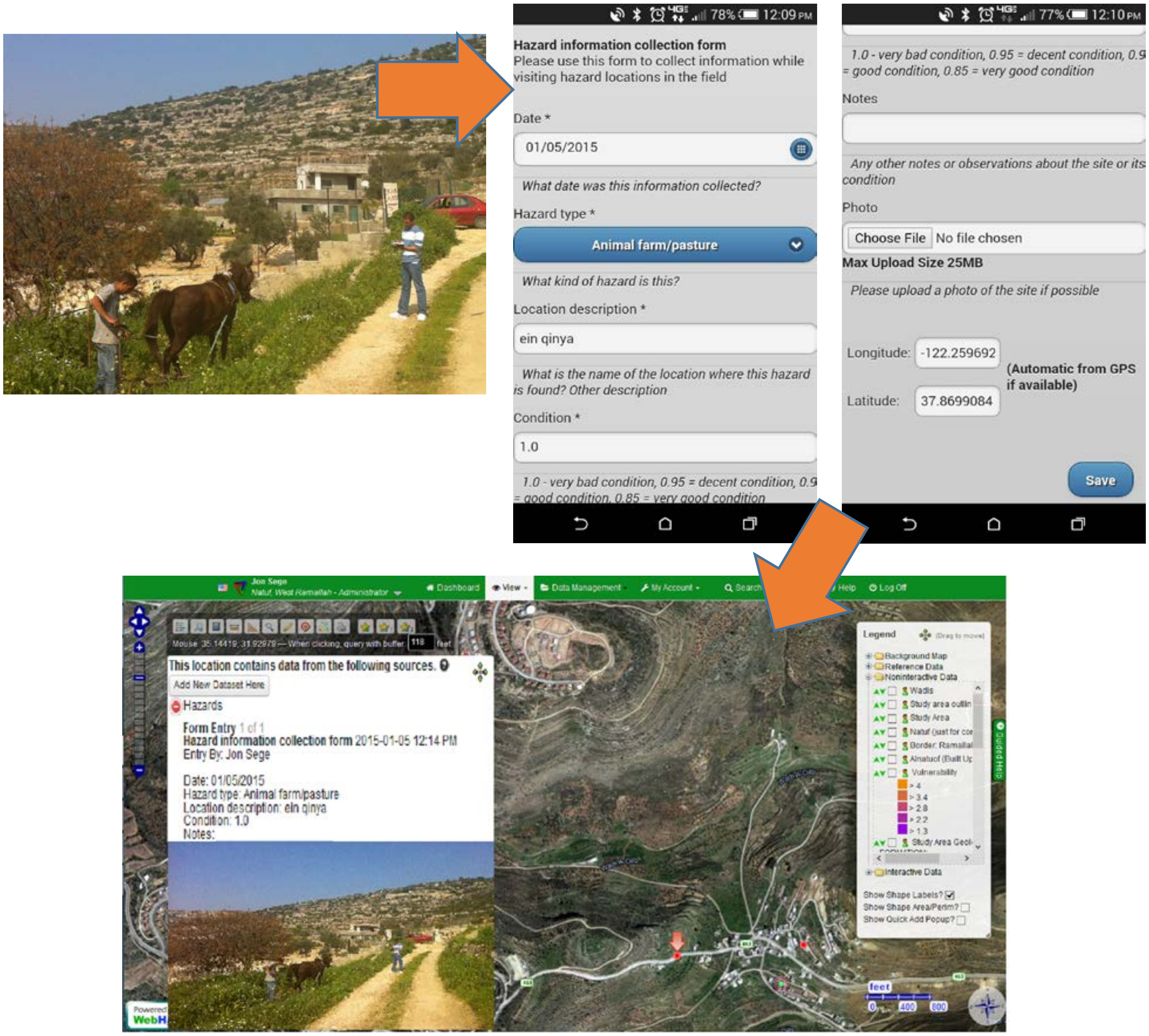

Figure 6: In the field, users can collect information on pollution hazards using a smartphone and upload it directly to the site. The information will be geotagged using coordinates from the smartphone's GPS, and will instantly appear on the map in the location where the user gathered the information. The images above demonstrate the pollution hazard collection form for the Natuv risk map. While at the pollution site, the user fills in prescribed data entry fields to collect all necessary information, and can include notes and pictures taken at the site. The user then submits these data directly to the map, where the information appears as a clickable icon.

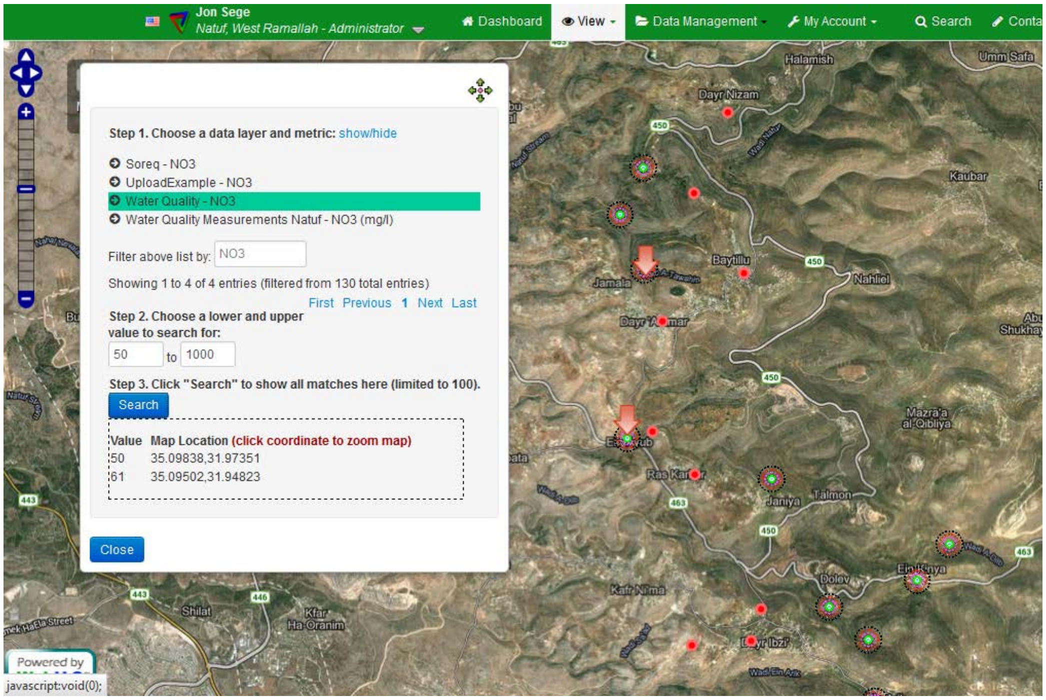

Figure 7: Users can quickly find locations on the map where specified criteria are met. In the image above, springs in Natuv are highlighted where Nitrate has exceeded the WHO guideline value of 50 mg/L. This can be used to quickly identify locations where pollutants exceed threshold values.

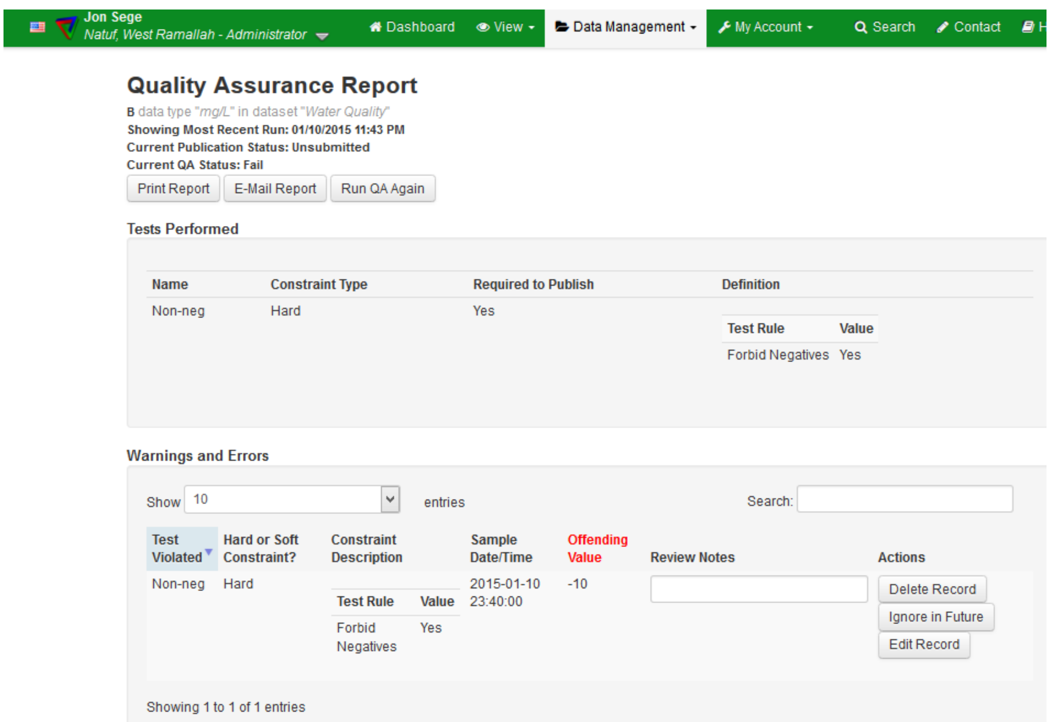

Figure 8: Because data can be submitted from various users, it is important to ensure the quality of all data. MyObservatory's built-in quality assurance tests allow the data manager to find any values that do not meet standards. Here, a measurement of Boron triggers a QA fail because it has been entered as a negative concentration value, which is not physically possible.

III. Project Timeline Summary and Status:

Phase I: Planning and data requirements

Status: Complete. Ended 11/28/2014

Phase I was the planning phase. The team decided the method to create the aquifer vulnerability map. Based on this method, they created a comprehensive list of GIS shapefiles needed for the analysis. They also created a list of pollution hazard sources to include in the study. They then determined what data were already available on these hazards, and what needed to be collected. They created a plan for collecting all necessary data that was not currently available.

The Birzeit team conducted two rounds of water quality data collection in July and October, 2014. They collected samples in the field from all springs in the study area, and had these samples chemically analyzed in a laboratory at Birzeit University. They uploaded this data and all previously collected water quality data to myObservatory. Other features, such as the extent of the study area and the locations of wadis, were also uploaded to myObservatory.

Phase II: Data collection and processing:

Status: In progress. Ends 01/16/2015

In *Phase II*, all of the shapefiles and data identified for the vulnerability study in *Phase I* were collected. All of the shapefiles for the vulnerability study were processed and combined into the final intrinsic vulnerability map in ArcGIS. Data and information on some hazards (trash dumps and clinics) were collected on myObservatory using a custom-made form. Other pollution hazards still need to be added. The vulnerability and hazard maps will be combined to create the final risk map using the raster calculator feature of myObservatory. This feature will allow the risk map to dynamically incorporate new data on pollution hazards as it is uploaded to the site. This map will be validated and/or calibrated based on the water quality data in myObservatory.

Water quality data from the most recent rounds of field sampling undertaken in *Phase I* were analyzed by Professor Ghanem. These results have been synthesized into an initial draft of a paper, which will be reviewed and edited for journal submission.

Phase III: Data presentation and continuity:

Status: Pending. Ends 01/24/2015

In *Phase III*, the map from *Phase II* will be presented to community organizations and government, focused on conveying the information and achieving concrete deliverables and next steps. A plan for continual updating of the hazard map and water quality data will be created, and partners will be identified to collect this information. These partners will agree to the plan and establish commitments, if possible. *Phase III* will be carried out while a member of the Berkeley team is in Ramallah, from January 9th – January 29th.

IV. Next Steps

Once the risk map is fully implemented on my-Observatory, the team will select several communities in the Natuv Basin to characterize in-depth, by collecting detailed and thorough information on pollution hazards and adding these data to my-Observatory. These communities will serve as models to demonstrate the full utility of the system, and will be used to encourage other communities' leaders to become involved in the project. The platform will be demonstrated to the Palestinian Water Authority (PWA), with the aim of expanding its application throughout the west bank. We will work with the PWA and other stakeholders to plan for the sustainable use and maintenance of the system.

V. Conclusion

Rapid urban development presents unique challenges for water resource managers. Adaptable, dynamic, and informative monitoring tools must be created to confront these challenges. This project aims to create and demonstrate the utility of such a tool in the Natuv Basin in Palestine, using the web-based environmental data management system myObservatory. This work will provide a risk assessment platform that accommodates up-to-the-minute information about pollution hazards and water quality data, and adapts to changing conditions. This will allow decision-makers in the area to formulate, execute, and monitor water protection plans using the most current information possible. Furthermore, data can be contributed by members of the community, increasing interest and participation in groundwater protection. As we finalize the risk assessment platform and begin presenting it to the community, we hope to demonstrate that this approach is useful not only for groundwater protection in the Natuv Basin, but to many different types of environmental management problems throughout the world.