Investigation of Interactive Maps Using Power BI

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Abstract

The Committee to Honor America's Veterans (CHAV) Memorial advisory board in Sunset Beach, NC requested an interactive map application to locate bricks on the floor of their memorial. The application was created using four applications: Adobe Photoshop, Adobe Illustrator, Synoptic Design, and Power BI. Power BI was compared to ArcGIS and MapInfo Pro to demonstrate why it was the better choice for this project. The user requirements, methods, testing, and application maintenance are documented throughout this paper. The Software Development Life Cycle was followed in completion of this project. The project was completed successfully, with all but one of the user requirements fulfilled to satisfaction.

Acknowledgements

I would like to give a huge thank you to Kenneth McMillan and Ben Yerby from the National Drug Court Resource Center for UNCW. Kenneth graciously walked me through created the shape file in Synoptic Design and setting up the map in Power BI. Ben provided the blueprint of the map, which I would not have been able to complete this project without. I would also like to give thanks to Darren Bouley for taking the time to fly his drone over the memorial and take pictures of the map free of charge. I am thankful for Dr. Ron Vetter, my committee chair, who lent his time and effort whenever I needed project advice. Finally, I would like to thank Jack Lenz and the CHAV memorial committee for showing me the memorial and being a pleasure to work with.

Table of Contents

I. Introduction.

The Committee to Honor America's Veterans (CHAV) Memorial advisory board in Sunset Beach Town Park, Sunset Beach, NC requested the creation of a software application that could determine the exact location of a memorial brick on the floor of the veteran's memorial. The memorial floor is circular and consists of 1400 bricks with about 1500 honorees. There are blank bricks, and the brick population is expected to increase by 40-50 bricks per year (see Appendix A). There is currently a Microsoft Excel spreadsheet with a grid-reference map to each brick, honoree information, and location on the memorial floor (see Appendix B).

The CHAV memorial committee sent a list of requirements for this application. These requirements entailed that the interactive map should be able to run on any operating system or device. It should be self-explanatory so that users of any skill level can follow along. It should not stop operating because of input errors and it should use software that can be updated in the future to run on newer platforms. The application should also include instructions for an administrator to be able to add/delete/edit the spreadsheet information and to expand upon the visualization if desired. Lastly, the application should include detailed instruction so that if something goes wrong the entire application can be easily re-built from scratch. This includes trouble-shooting instruction and disabling features.

To create this interactive map, two applications were utilized: Synoptic Design and Power BI. Synoptic Design, a Microsoft Power BI application, was used to render the specific map image and to assign keys to each square on the map. Once this is completed, the map image and assigned keys were directly exported to Power BI. In Power BI, the keys were assigned to each grid-reference location with honoree information on them. A filter was added to the map so that a specific honoree could be searched for, and the associated brick highlighted once found.

Map styling, colors, and fonts of the data, title, and instructions were then chosen as the final touches to the application. The later sections of this paper contain detailed instructions accompanied by images of each step of the process, implementation, maintenance, and testing phases to fulfill documentation requirements.

The main goal of this project, besides creating the interactive map for the memorial, was to discuss the benefits of using Synoptic Design and Power BI in comparison to other data visualization mapping tools. Different components of Power BI were compared to the same components of ArcGIS, MapInfo Pro, and QGIS to defend the argument that Power BI is a more simple and more effective tool to create this type of visualization. Lastly, this project emphasized the scope of Power BI to communicate a finite solution to a common problem.

II. Review and Analysis.

In this section, the features of Power BI were compared to the features of different data visualization mapping tools. Specifically, Power BI pro was compared to ArcGIS pro and MapInfo Pro in terms of affordability, specific features, ease of use, and adaptability. This comparison shows why the combination of Synoptic Design and Power BI was the superior choice for this project and why more users should utilize Power BI for data visualization. The table below shows a comparison of each mapping tool based on the previously mentioned criteria:

	Power BI Pro	ArcGIS Pro	MapInfo Pro
Price	$120/year *	$100/year	$880/year
Feature Set	Share workspaces, create shape maps, map customization, use map templates, easily publish to the web	Visualize 2D, 3D, and 4D data, share within organization, use data from more than one source, edit data, publishing capabilities	Visualize location data, simulate predictive outcomes, powerful spatial processing capabilities
Ease of Use	Beginner/Intermediate	Advanced	Intermediate/Advanced
Adaptability	Requires add-ons and hard to manipulate data within application	Can use data from multiple sources and can manipulate data within application	Requires add-ons for customization – drone operators and python console

*Power BI Pro only allows for monthly payments of $9.99/month (changed to yearly for comparison purposes).

Table 1. Comparison of visual mapping tools by price, feature, ease of use, and adaptability *(ArcGIS pro*. 2D, 3D & 4D GIS Mapping Software, 2022; Microsoft, 2022; Precisely 2021).

The prices of the applications were analyzed by personal accounts, not by business accounts. By looking solely at price point, ArcGIS Pro would be the cheapest option for creating an interactive map *(ArcGIS pro*. 2D, 3D & 4D GIS Mapping Software, 2022; Microsoft, 2022; Precisely 2021). However, because UNCW already pays for a Power BI license in this scenario,

using this application was free. For those organizations that already have a Power BI license, this route is recommended to reduce the cost of both creation and maintenance of an interactive map.

Regarding diversity, all three applications have a wide range of features. It was difficult to compare these features directly because the sales material for each was very different. The features for the Power BI Pro application are more specific for data visualization than they are for mapping. ArcGIS Pro and MapInfo Pro have more capabilities for visualizing geo-spatial data. Because of this, more background knowledge and a deeper skillset within the applications are required to successfully use them in comparison to Power BI Pro. This gives them higher ease of use ratings since they are more complicated programs. Power BI Pro and MapInfo Pro both require add-ons, which makes the basis of these programs a lot simpler than ArcGIS. Power BI Pro should be considered the least adaptable in terms of data manipulation compared to ArcGIS Pro and MapInfo Pro. This is because data cannot be manipulated in the tables within Power BI. It must be re-uploaded and refreshed unlike the other programs *(ArcGIS pro*. 2D, 3D & 4D GIS Mapping Software, 2022; Microsoft, 2022; Precisely 2021)**.**

The principal motive for this project was to create a more streamlined and documented interactive map to help organizations with little tech experience achieve their desired visualization goals within a low budget. In comparison with the other programs, it was clear that Power BI Pro was the best choice for this project, especially with the short time frame to complete it in. Power BI was the easiest to learn how to use, the cheapest for this organization, had all the required features, and fit the adaptability criteria.

III. System Applications

There were four applications used to create this project. The first application was Adobe Photoshop, which was used to stitch together two close-up drone photos of the memorial to create one high resolution photo. The next application used was Adobe Illustrator, which allowed for the creation of the blueprint layout of the memorial from the stitched together photo (see Methods section for explanation). This layout was then uploaded into Synoptic Design, an add-on application to Microsoft Power BI, which was used to create an original shape file. Synoptic Design allows images to be presented with assigned meanings to specific areas. This was necessary because the shape of the memorial was unique and could not be found in a pre-made Power BI template. Once all the bricks were labeled in Synoptic Design, the shape file was uploaded into Power BI, where the Excel sheet with grid-reference locations of each brick was connected. Power BI was used to manipulate the aesthetic features of the data, such as adding a search bar to find an honoree or making a specific brick highlight accordingly (see Appendix C for an example).

IV. User Requirements

The requirements for this project were provided by the CHAV memorial committee members. In the primary requirements, they required that the map be user friendly and self-explanatory for all levels of sophistication. This means that the application should have clear instructions for input requirements for the user to follow. This also means that the application should be resilient to user input errors. They also required that the application be accessible by desktop, tablet, smartphone, or laptop on multiple forms of operational system (iOS or Android). This entailed that the program should not be affected by future software updates (this requirement may not be sustainable, as programs often update). The last requirement for the program was that it should be visually appealing to the user. Regarding the documentation, they desired instruction to be able to add, delete, and edit the database information for proper maintenance. They also wanted documentation of instructions to re-build the entire application from start to finish in case the system crashes or updates in a way that the administrator needs to re-create the application. This includes trouble shooting procedures. It should be noted that this process is not specific to a location, so any other memorial or campus can utilize these instructions to create an interactive map of their own.

After the baseline requirements were met, a link to the application was sent to the committee to test. After looking at the map, the committee wanted to add some visual enhancements. This meant to black out the pillars and the center of the monument where there were no bricks. The colors of the map were changed to grey and dark blue and key reference points ("Ocean" and "Street" labels) were added for orientation. Instructions were also added above the search box for the user to easily follow along and understand how to find a brick. Lastly, the data was updated

to include the most recently added bricks and any corrections to bricks that were listed under the wrong grid-reference point were fixed.

After the second round of testing, more requirements were added. The memorial committee wanted the application to be put in a smaller window so that it would fit the screen of an iPhone or iPad. They also wanted the title of the application to read “CHAV Sunset Beach Veteran’s Memorial Brick Locator” and for the instructions to be more specific. The Harley Davidson blocks were left out of the initial map in Synoptic Design, so they wanted to include this in the final product so that they could be searched for. Lastly, the “Filter” and “Focus mode” icons were displayed in the bottom of the screen, so those were to be removed to avoid confusing the user.

V. Project Plan/Milestones

The completed project consisted of a Power BI web page published via Power BI. This allowed the application to be accessible from any source. The page enables a user to determine the exact location of the chosen memorial brick and display it on the map of the memorial (highlighted) for easy finding. The first major project milestone was getting the blueprint layout of the map into Synoptic Design to assign panel names to each brick. This step took the most amount of time, because after each brick was clicked on, it had to be re-named to match the name in the spreadsheet. The second major milestone was importing the Synoptic Design shape file into Power BI and connecting it to the database table of all the bricks. This table stored each brick and its grid-reference as well as the last names and initials of the honorees. The next milestone was the testing process. This involved publishing the application and sending the memorial committee the link to the application to test. They were asked to give additional comments and requests based on what they liked and disliked about the map. The final milestone was completing the documentation of the project, which included an explanation of the methods used to complete the project, how the application was implemented, tested, and how to maintain the application and the database. This documentation also contains a comparison of the current methods used to other system applications, and how this project could be expanded on in the future. This was completed in an easy-to-follow format so that even those with basic computer skills would be able to understand the process and adjust if needed (see Appendix D for use case and Appendix E for Gantt chart).

VI. Methodology and Design

To complete this project, a high-resolution photo of the memorial from an aerial view was necessary. Darren Bouley, a friend of the members of the CHAV committee, graciously lent his time, drone, and operational skills to take this photo. The first time that Bouley took the photos, there was a large shadow overcasting onto the memorial from the oak tree next to it (as seen in Figure 1). This would not work because the lines of the bricks needed to be visible to create the blueprint layout. Bouley went to take the pictures again early in the morning so that there wouldn't be any shadows. Unfortunately, the photo encapsulating the entire memorial was not high-resolution enough to put directly into Synoptic Design and the oak tree was also blocking part of the memorial (as seen in Figure 2). He lowered the drone and took two separate high-resolution photos to be photoshopped together. If re-creating this project, it would be recommended to take photos in the morning with the drone approximately 20ft in the air for best results. Ben Yerby, an Integrated Marketing Communication Specialist for the National Drug Court Resource Center for UNCW, was then able to stitch together the two close-up, high-resolution photos by their axes using Adobe Photoshop.

Figure 1. Drone photo with oak tree shadow.

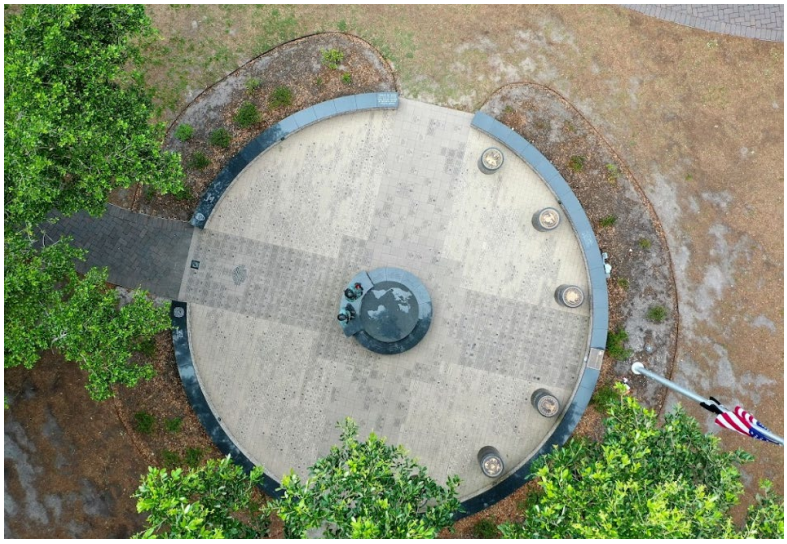


Figure 2. Drone photo that was taken from too far away with oak tree blocking the memorial.

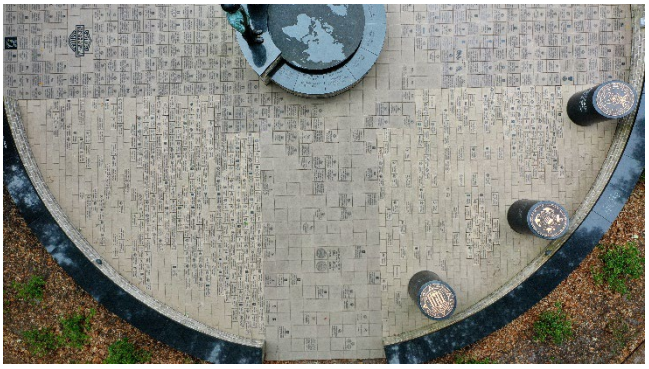


Figure 3. The west side of the memorial aerial photo.

Figure 4. The east side of the memorial aerial photo.

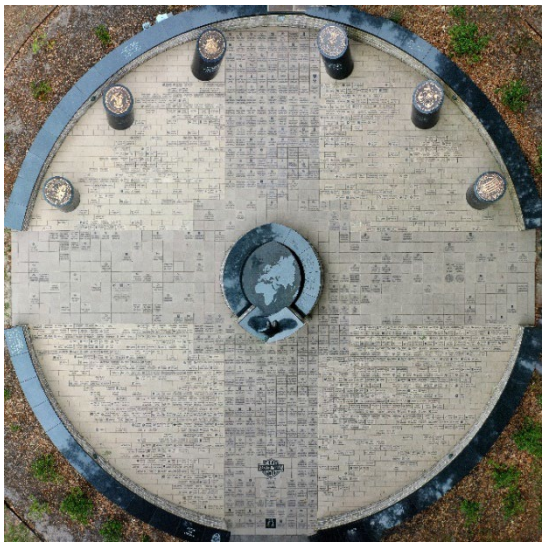


Figure 5. The stitched together west and east side photos.

After Mr. Yerby finished stitching the photos together, he imported the large photo of the entire map into an application called Adobe Illustrator. In Illustrator, he was able to create a blueprint layout of the map by replicating the bricks as squares and rectangles on a layer on top of the photo, kind of like tracing.

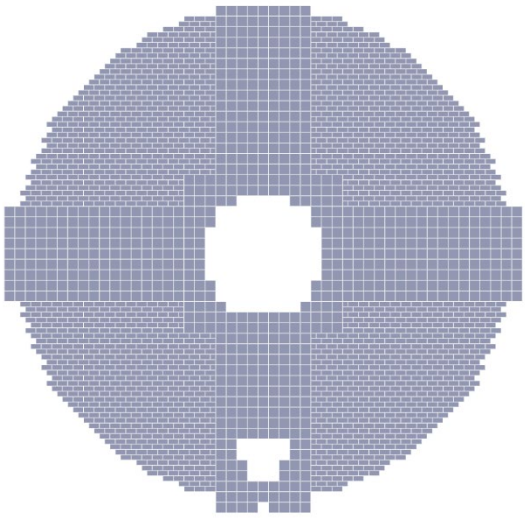


Figure 6. Blueprint layout of memorial created in Adobe Illustrator.

The blueprint of the memorial layout was then imported into Synoptic Design. This was done by navigating to https://synoptic.design/, clicking "Browse," and selecting the blueprint from the location in which it was stored.

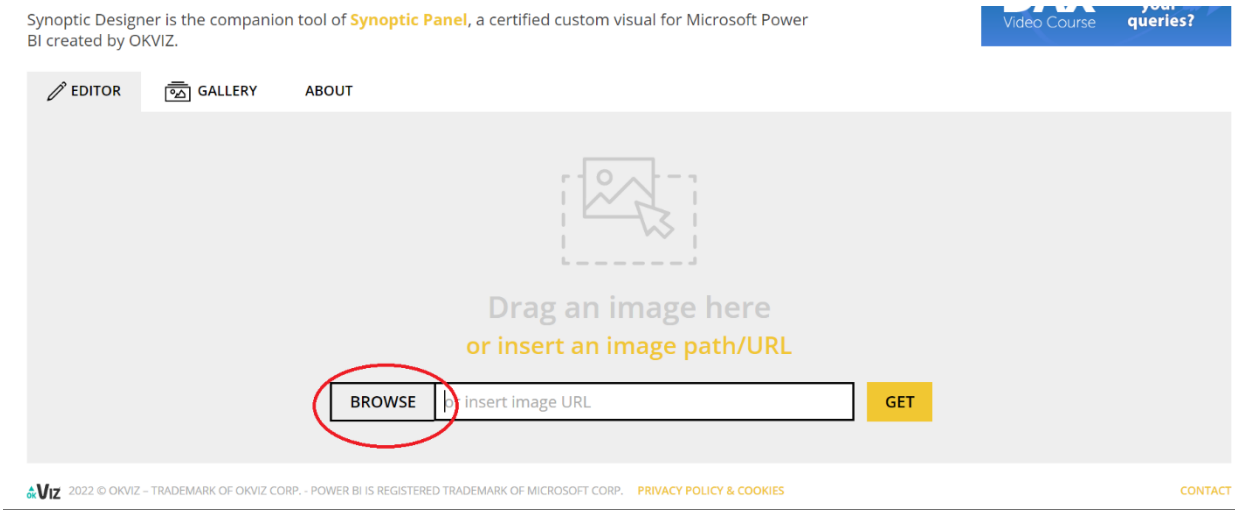


Figure 7. Synoptic Design home page.

In Synoptic Design, there are four main functions used to navigate and manipulate the image. The cross symbol is used to free-draw areas, the wand symbol is used to detect pre-determined areas, the cursor symbol is used to click on existing areas to re-name, and the glove is used to move the map without effecting the panel areas created.

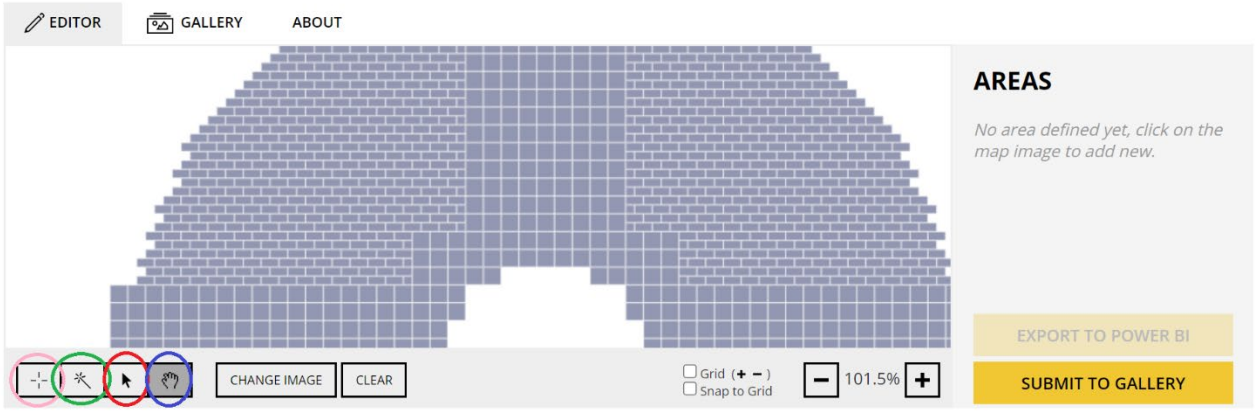


Figure 8. Functions of Synoptic Design from left to right: cross function, wand function, cursor function, glove function.

The wand function was used to tap on each square of the layout. This created a panel for each square, or brick, of the memorial. Once every brick had a corresponding square, the cursor was used to click on each square and rename it in the area section to its corresponding name on the Brick Map Excel sheet provided by the memorial committee. Once every square was filled out, the squares that were not used (the pillars) were deleted with the trash can icon. This was done to make a more realistic shape file of the actual memorial. This step was completed after the entire layout was filled in because it was easier to tell which squares were not used in the Excel sheet after everything was labeled.

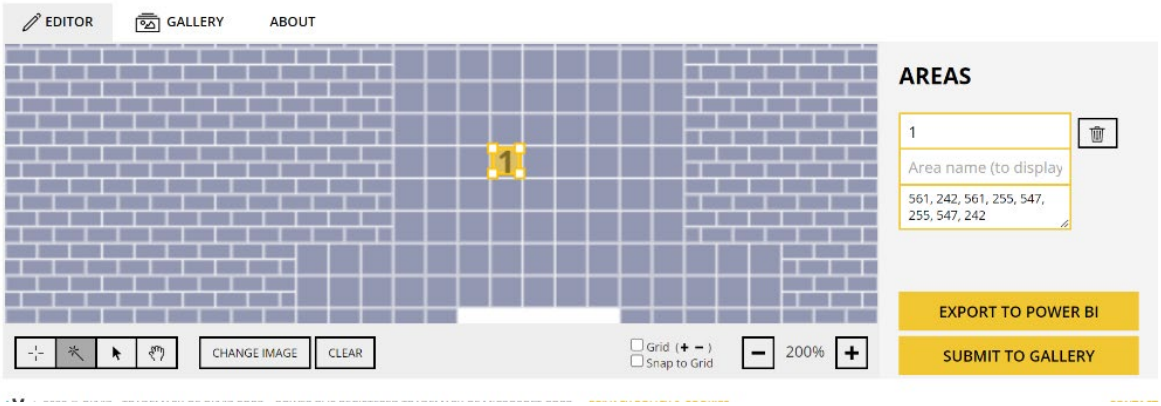


Figure 9. Using the wand function to create panels.

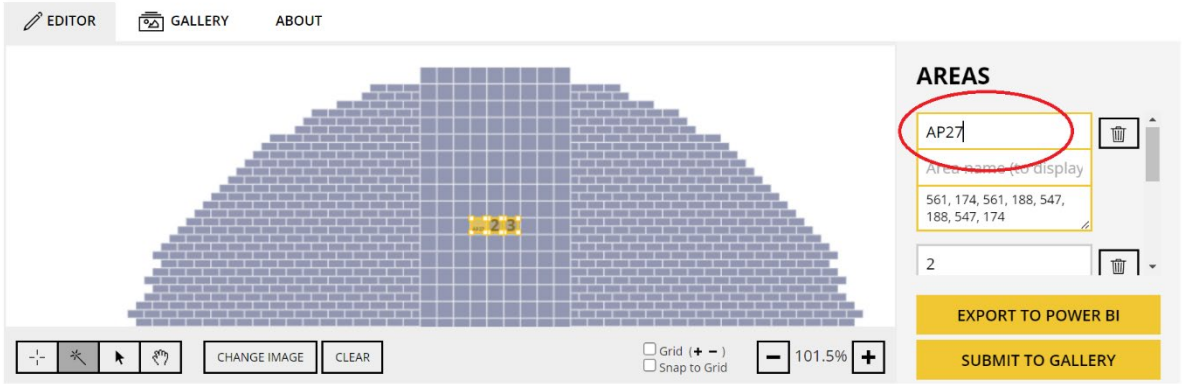


Figure 10. Using the cursor function to click on panel and then rename to corresponding brick.

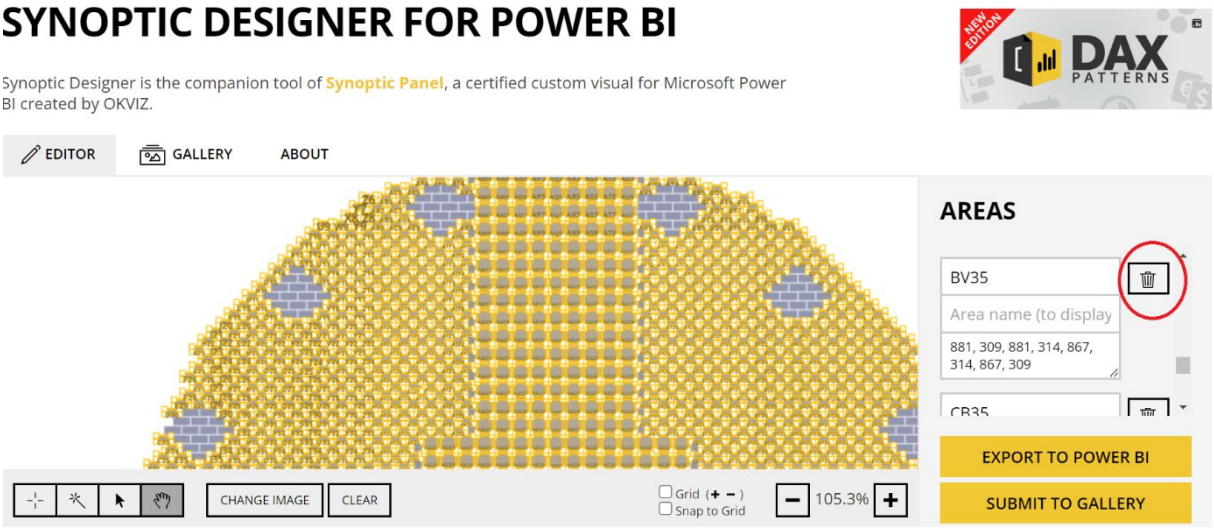


Figure 11. Pillar bricks were removed by using the trash can icon.

After all the bricks were labeled and the pillars were removed, the Synoptic Design image was ready to export to Power BI. This was done by clicking the "EXPORT TO POWER BI" button, right clicking on the image, and saving it as a .SVG file. After the image was saved, the Power BI desktop application was opened. On the main screen, the three dots on the right-hand side by all the visuals (as seen in Figure 12) were selected and the "Get more visuals button" was clicked.

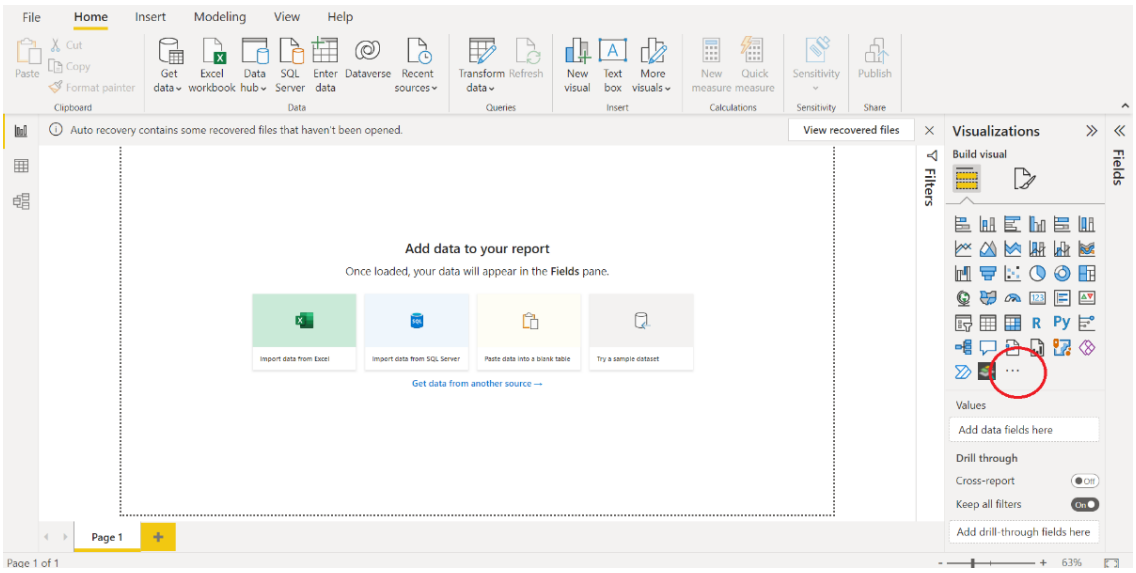


Figure 12. Button clicked to get more visuals.

In the search bar, "Synoptic Panel" was typed in and the icon in Figure 13 was selected. The Synoptic Panel Microsoft visual tool must be installed to import the custom visual made in Synoptic Design into Power BI. To add this tool, the icon was clicked and then the "add" button on the following page was also clicked.

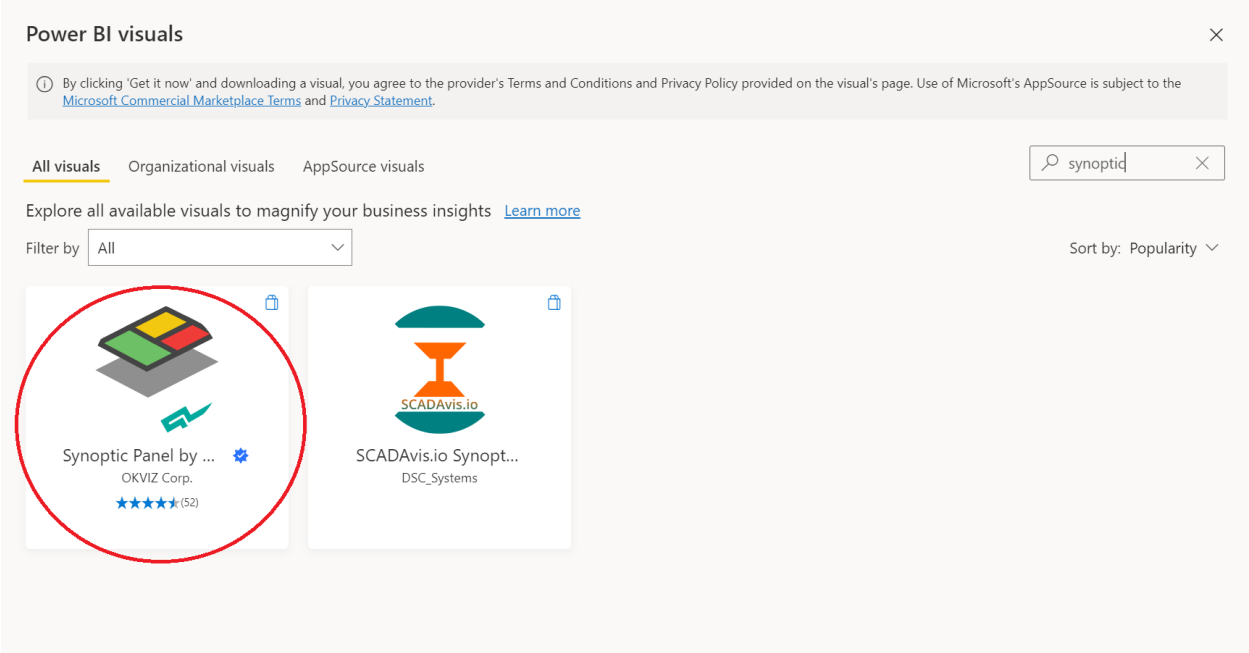


Figure 13. Adding Synoptic Panel add-on to Power BI.

Once the Synoptic Panel add-on was implemented, the data and the custom visual could be imported. The first step was to press the “Import data from Excel” icon on the home page.

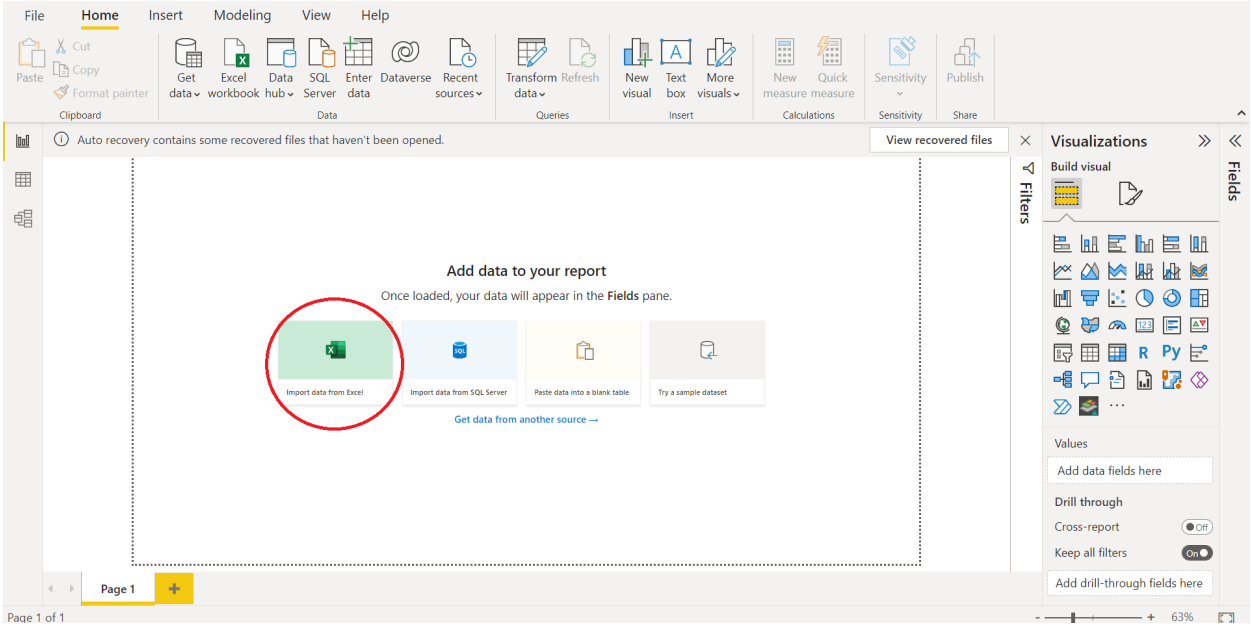
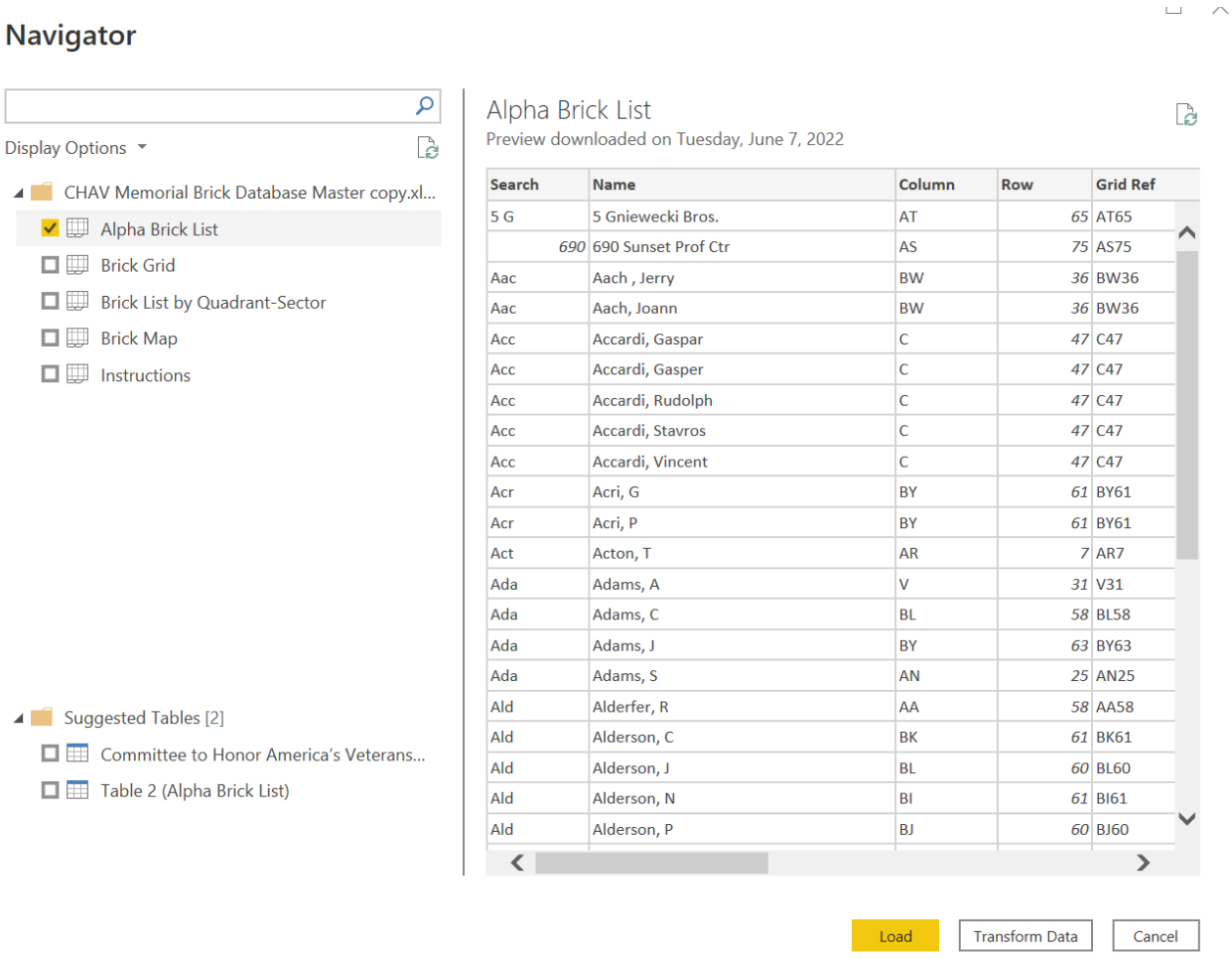


Figure 14. Import data from Excel.

The CHAV Memorial Brick Database Master copy was imported from its location on the desktop. The Alpha Brick List was checked off from the list of sheets in the master Excel sheet and the yellow “Load” button was selected to import the table.



Search	Name	Column	Row	Grid Ref
5 G	5 Gniewecki Bros.	AT	65	AT65
690	690 Sunset Prof Ctr	AS	75	AS75
Aac	Aach , Jerry	BW	36	BW36
Aac	Aach, Joann	BW	36	BW36
Acc	Accardi, Gaspar	C	47	C47
Acc	Accardi, Gasper	C	47	C47
Acc	Accardi, Rudolph	C	47	C47
Acc	Accardi, Stavros	C	47	C47
Acc	Accardi, Vincent	C	47	C47
Acr	Acri, G	BY	61	BY61
Acr	Acri, P	BY	61	BY61
Act	Acton, T	AR	7	AR7
Ada	Adams, A	V	31	V31
Ada	Adams, C	BL	58	BL58
Ada	Adams, J	BY	63	BY63
Ada	Adams, S	AN	25	AN25
Ald	Alderfer, R	AA	58	AA58
Ald	Alderson, C	BK	61	BK61
Ald	Alderson, J	BL	60	BL60
Ald	Alderson, N	BI	61	BI61
Ald	Alderson, P	BJ	60	BJ60

Figure 15. Selecting the Alpha Brick List to load into the Power BI project database.

Once the data was loaded into Power BI, the visual was added. To add the custom visual that was made in Synoptic Design, the OKVIZ icon was selected.

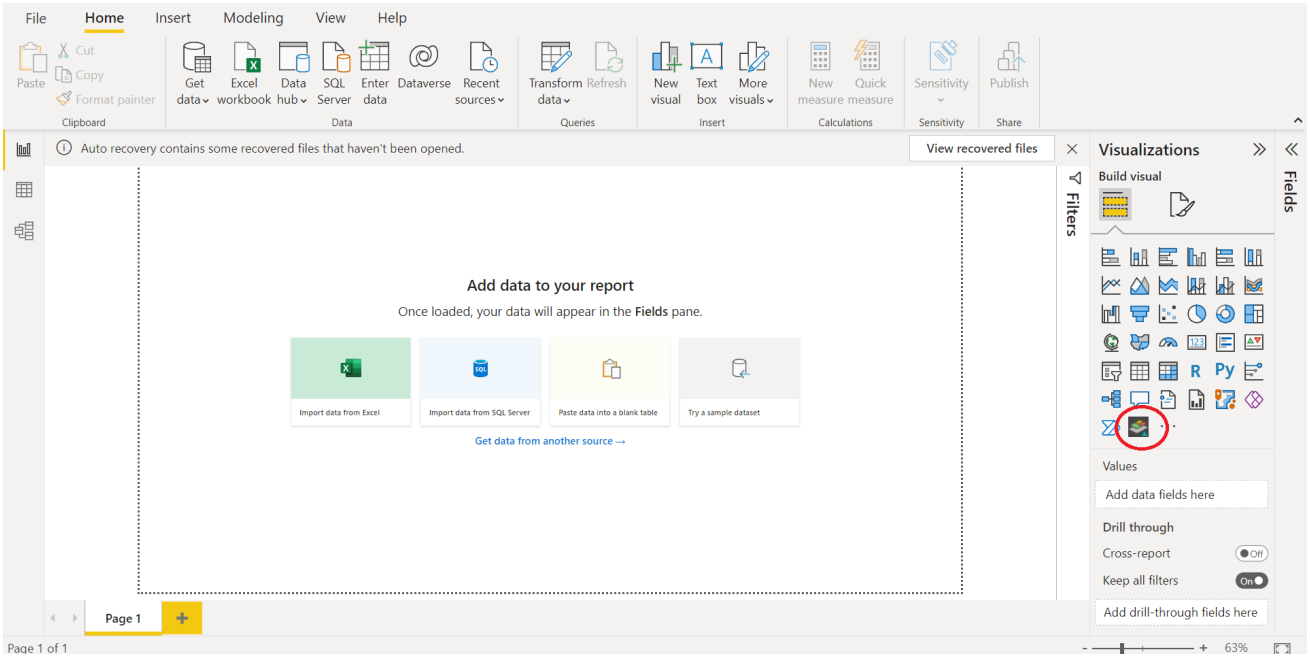


Figure 16. Selecting the OKVIZ icon to import the custom visual from Synoptic Design.

Next, the "Grid Reference" column from the table was dragged into the measurements field of the visual.

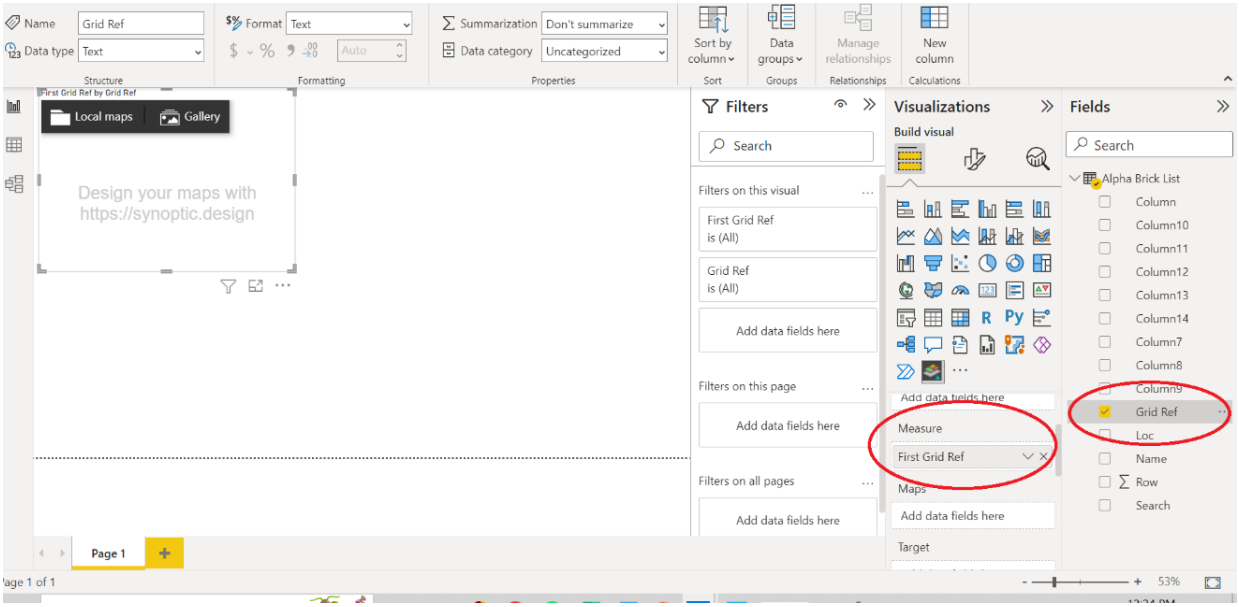


Figure 17. Adding the Grid Reference column to the measurement field.

Adding the Grid Reference to the measurement field made the “Local maps” and “Gallery” buttons appear on the visual. The “Local maps” button was selected and the .SVG file saved from Synoptic Design was imported from its stored location.

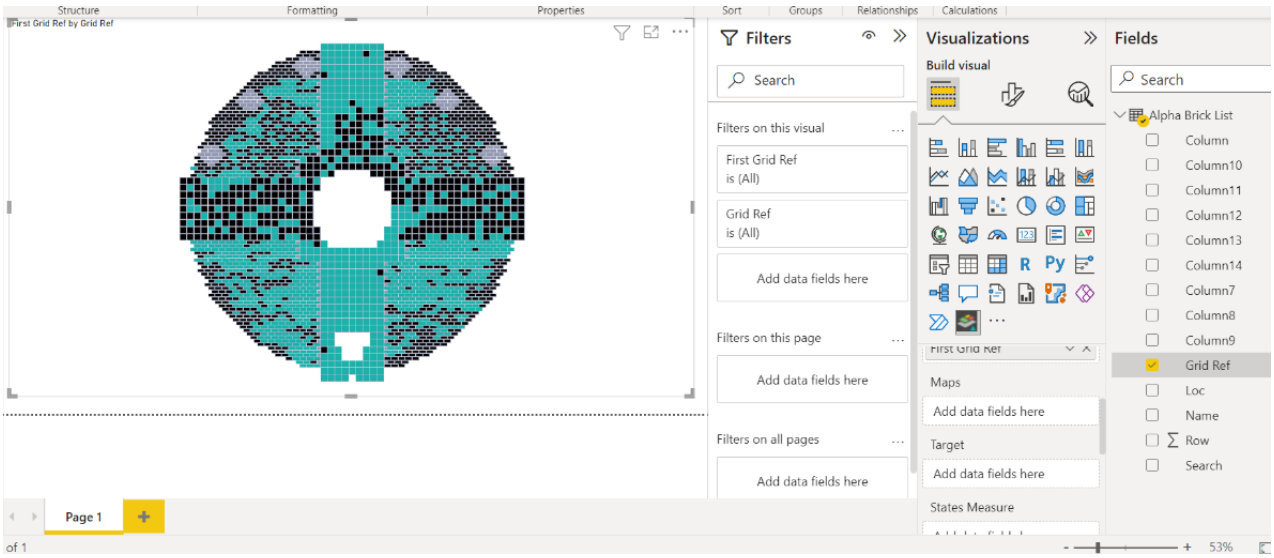


Figure 18. Default map that appears after importing .SVG saved from Synoptic Design.

The next step was to get the map to display the names in connection with the grid reference so that the map would display the correct name for the correct brick. To do so, the “Grid Reference”, “Name”, and “Location” columns were dragged into the “Tooltips” field. The order of these fields could unfortunately not be changed because the OKViz custom visual does not yet have a custom Tooltip feature to do so.

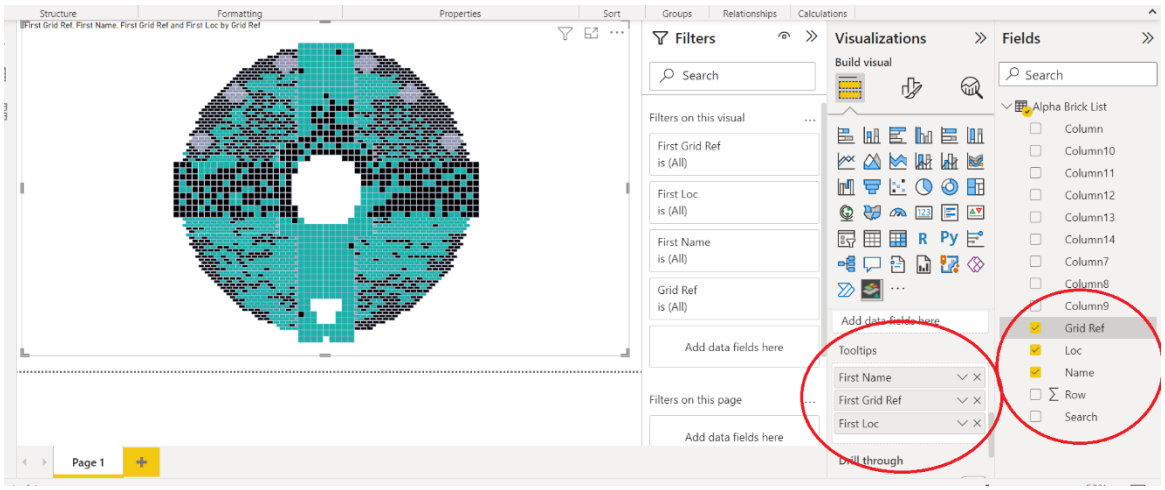


Figure 19. Dragging the "Grid Reference", "Location", and "Name" columns into the "Tooltip" field.

The "Grid Reference" column was also dragged in the same way into the "Category" field to make the distinction between available and unavailable (taken) bricks. The color of the bricks was then changed to clarify the distinction between the available and unavailable bricks. This was done by clicking on the paintbrush icon underneath "Visualizations" and navigating to "Data Colors." It was decided that the available bricks would be grey, and the unavailable bricks would be navy blue.

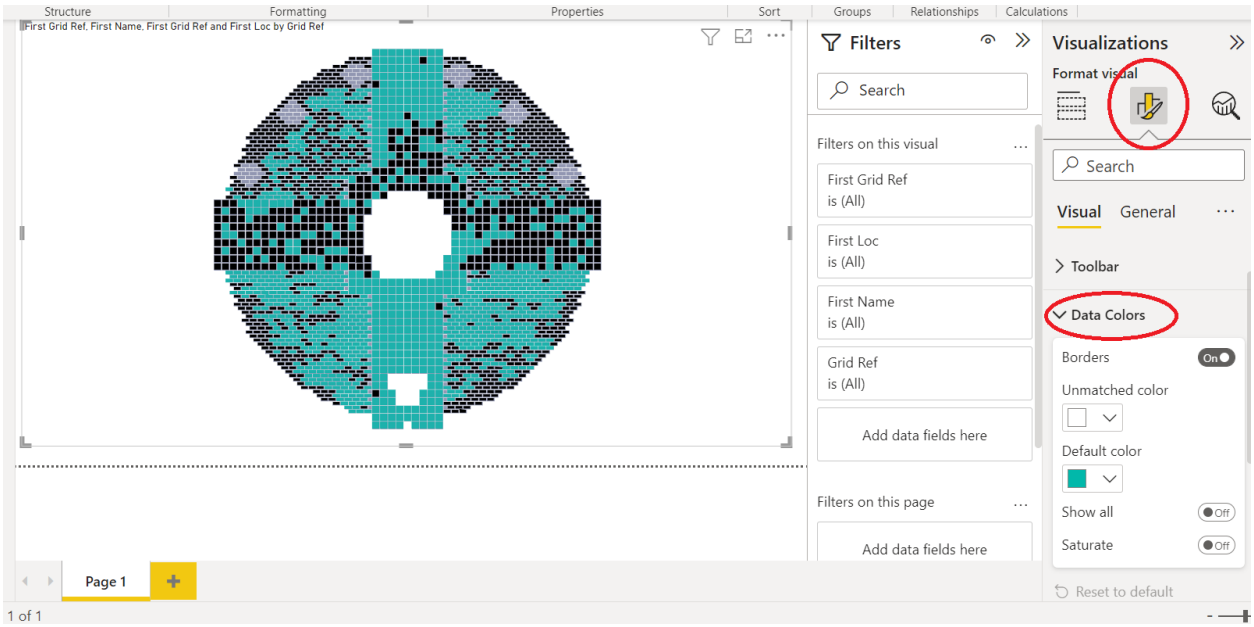


Figure 20. Changing the color of the data in the visualization.

The title of the map was added by clicking the "General" button under the paintbrush icon underneath "Visualizations." The map was labeled "CHAV Sunset Beach Veteran's Memorial Brick Locator" and the font was changed to Times New Roman.

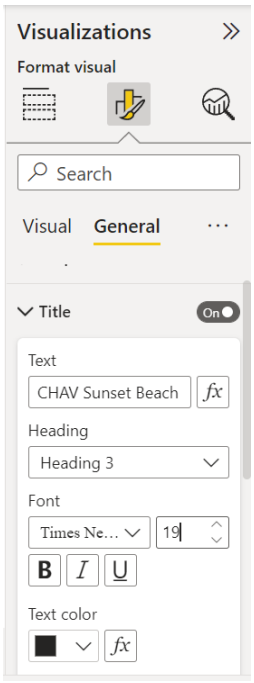


Figure 21. Changing the title and title font of the brick map locator.

To add the search bar to type in an honoree's name and have the brick display, the slicer icon was selected underneath "Visualizations."

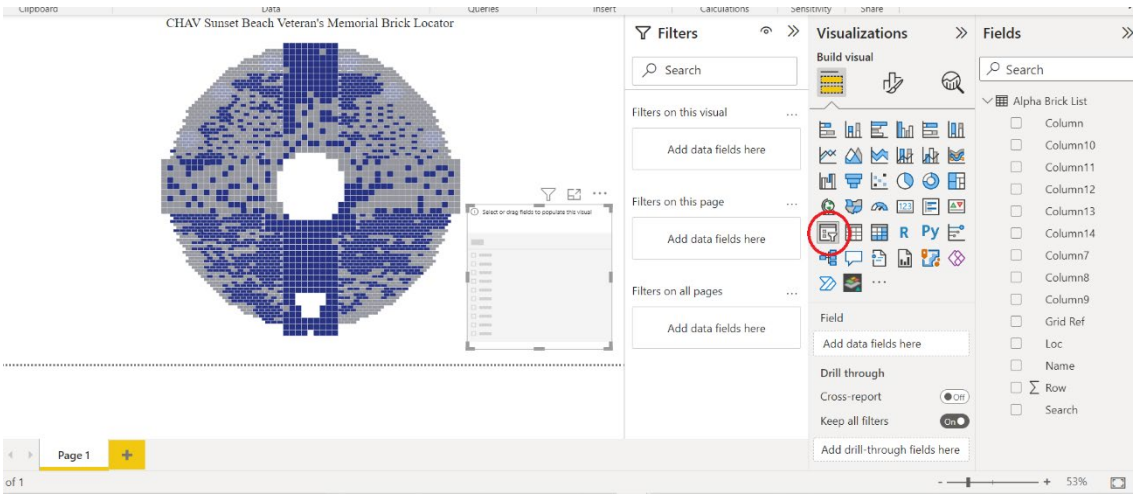


Figure 22. Selecting the slicer icon to create search bar for the user to search for an honoree.

The "Name" column was then dragged into the "Field" field underneath "Visualizations" in the same way the Tooltips were added in Figure 19. The three dots at the top of the slicer

visualization were then selected and “Search” was clicked to add a search bar to the visualization.

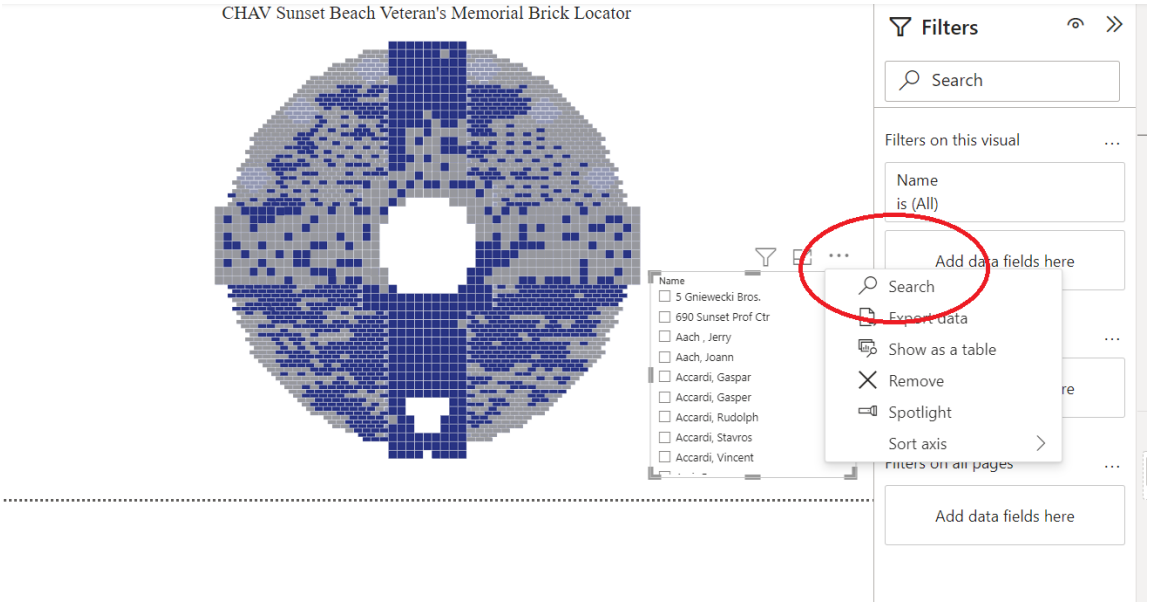


Figure 23. Adding the search bar to the slicer search visualization for the user.

The last step to completing the application was to add text boxes for the instructions and location markers (for orientation). The “Insert” tab at the top of the Power BI window was selected and “Text Box” was clicked to add a text box. This step was repeated for each text box.

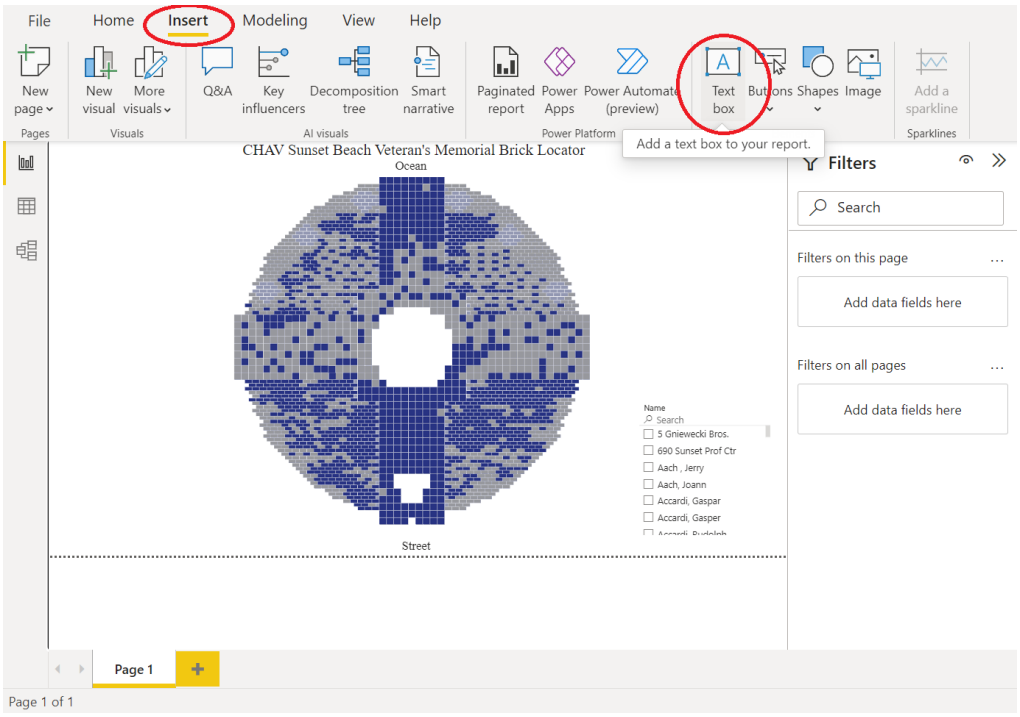


Figure 24. How to add the text box for location orientation and instructions.

After the textboxes were added, the map was reduced in size so that it would fit on an iPhone or iPad (tablet) screen. This was completed by clicking on the map visual and pinching the trackpad on the computer. The map was then re-centered underneath the orientation markers and the title, so that nothing was blocking the view of the map. Lastly, the “Filter”, “Focus mode”, and “More options” buttons had to be removed from the user window. To do this, the three dots under “Visualizations” and next to “General” were clicked and “More options” was selected. From this menu, “Report settings” on the bottom left was chosen and “Hide the visual header in reading view” was checked off.

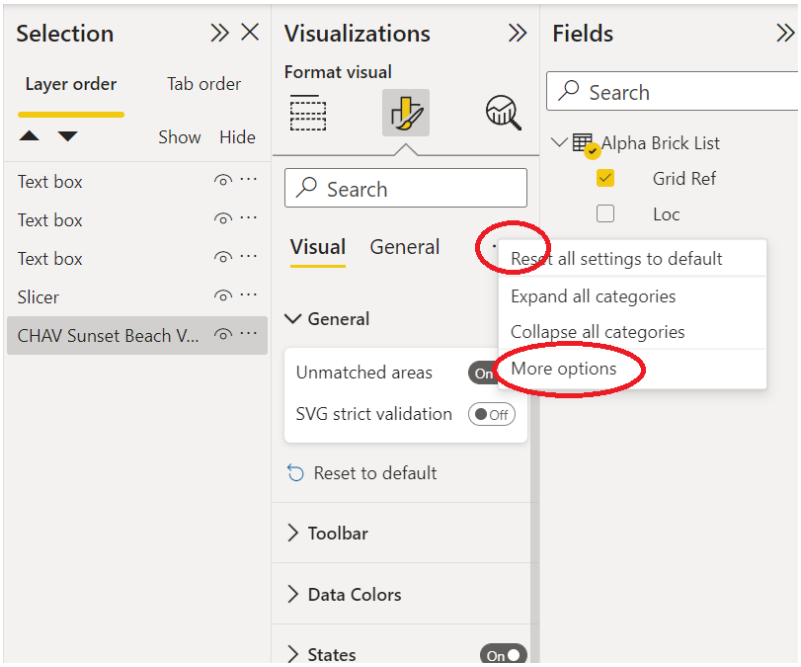


Figure 25. Selecting more options from the "Visualizations" menu.

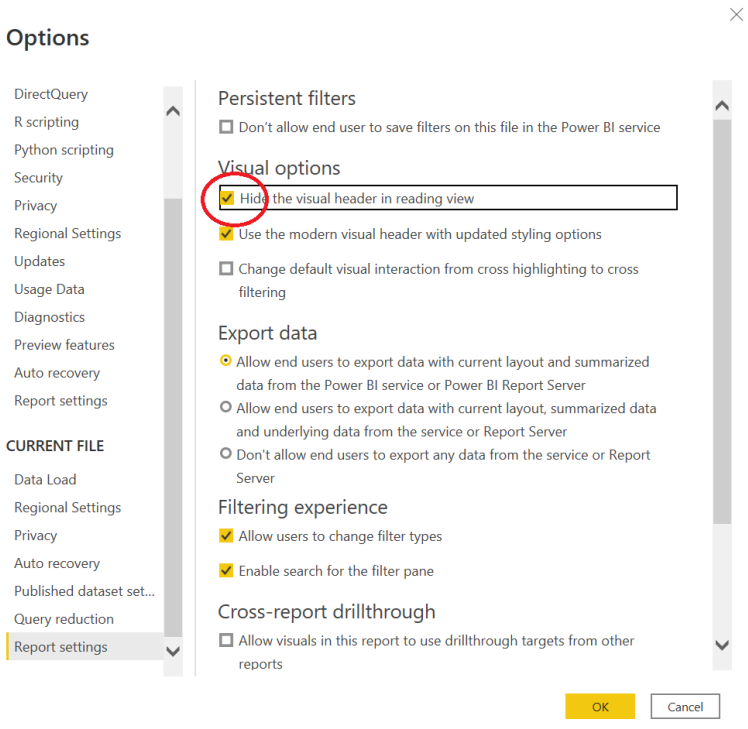


Figure 26. Selecting the "Report settings" and hiding the visual header.

This was the final step of completing the project, besides refreshing the data for maintenance.

The final product can be found at:

https://app.powerbi.com/view?r=eyJrIjoiZTU3ZjllOGMtYmRjOC00NDczLTg1MmEtODkzYjY1MzVmODVhIiwidCI6IjIyMTM2NzgxLTk3NTMtNGM3NS1hZjI4LTY4YTA3ODg3MWViZiIsImMiOjF9

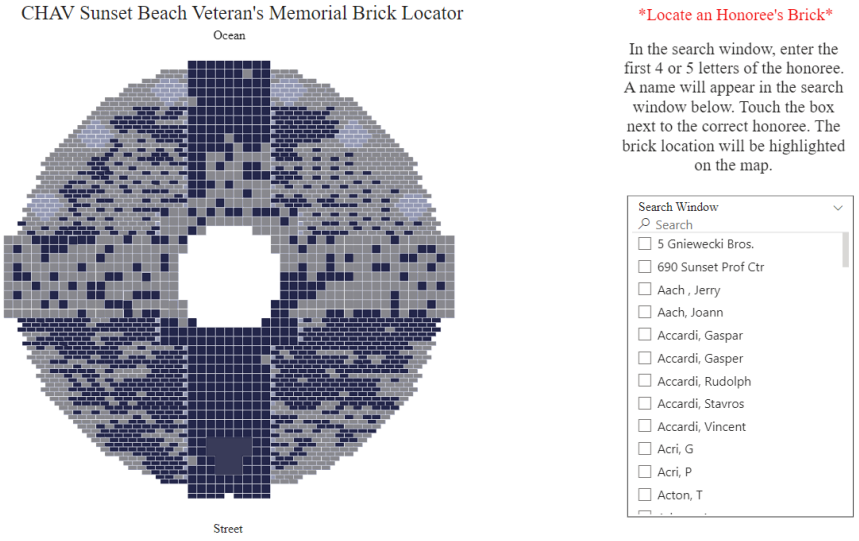


Figure 27. Final Power BI application of the brick locator system.

VII. Housing the Application

Once the project was completed in Power BI, it was saved as a Power BI template. The template was then emailed as an attachment to Dr. Ron Vetter, who has the rights to publish publicly through UNCW. Dr. Vetter imported the template to his Power BI Desktop application and published it to his workspace. It should be noted that the Power BI template should be saved as a .pbix file, otherwise the import will not work correctly. He was then able to publicly publish from the workspace. Once published, Power BI provided a link as well as an HTML tag to allow the application to be embedded in a web page. The link and the HTML code were sent to the memorial committee to be added to the CHAV memorial web page (https://sbvets.org/the-memorial.html). This tag will be added to the "Brick Locator Map" button on the website to take users directly to the brick locator system.

VIII. Testing

The link to publish was provided to members of the memorial committee for testing. This allowed for the users to engage with the application prior to the release on the memorial website to get a feel for the operation and aesthetic. The link was provided after the baseline requirements were given. The purpose of this was to allow the users to try the most simplistic model of the application, assess the improvements they wanted to be made, and provide reasonable feedback. Once the first round of testing was completed, another set of requirements was given by the memorial committee. These were mostly aesthetic requirements made to add appeal and avoid confusing the user. For example, when looking at the application in the published link, the orientation labels were blocking the top and bottom row of bricks. To fix this, the font of the labels was decreased, and the text boxes were minimized to avoid getting in the way. The font of the labels was also changed to Times New Roman, so that they all matched. A few other visual updates that are described in the Methods section above were also adjusted. After these updates were made, the link was sent to more committee members for approval. The final requirements and documents were finalized. Overall, there were very few aesthetic errors found during the testing phase.

A test had to be done to ensure that each name from the database was connected to the correct panel. Each name was checked off in the search box of the application to make sure a brick was displaying on the map. Thirty names did not display a highlighted brick when checked off in the search box. To fix this, these names were cross-referenced with the original Brick Map and Alpha Brick List spreadsheets to find the correct grid-reference location. This was corrected and the database was refreshed so that all the names were found on the map when searched for.

In the future, it would also be wise to hover over all the unused bricks (grey bricks) and ensure that the grid-reference area shown matched the grid-reference on the Grid Map spreadsheet. This would ensure that all the bricks on the map were correctly labeled. However, time did not allow for this test to take place.

The last test completed was a cross-browser test. This test was done to ensure that the application would work on all operating systems and devices. LambdaTest (lambdatest.com/) was used to perform this test. This website simulates the application on different browsers and devices and allows the user to interact with it. The results of this test secured that the application would work on any phone, tablet, web browser, and operating system to meet that requirement.

IX. Maintenance

One of the main requirements of this project was to ensure that there be a way to update the application as bricks are added or removed from the memorial. There were two ways this could be done. The first way was for the memorial committee to update the Excel spreadsheet semi-annually and send that to Dr. Ron Vetter at UNCW. Dr. Vetter, or someone on the UNCW map committee overseeing part of this project, would then refresh the data in Power BI with the updated Excel sheet. Once the data was refreshed, the application would be refreshed publicly so that the changes made would be shown. The second, and more expensive, option would be for the memorial committee to pay for their own Power BI Pro license at $10 a month and update the Excel sheet themselves. Although this would ensure that the database would be updated and could be updated at any point in time, it was far more expensive. Therefore, it was decided that the committee would send the updated Excel sheet to Dr. Vetter every quarter, with the commitment to update the application.

To update the data, all the columns in the new spreadsheet must match the columns in the old spreadsheet. This was because the features in Power BI are reliant on the naming conventions of the old spreadsheet. Changing this would ultimately change the entire visual and make things more difficult to update. After ensuring that the columns were the same, the Excel sheet was saved to a location on the local machine. In the Power BI desktop app, the “Power Query Editor” button was selected along the top ribbon of the home screen.

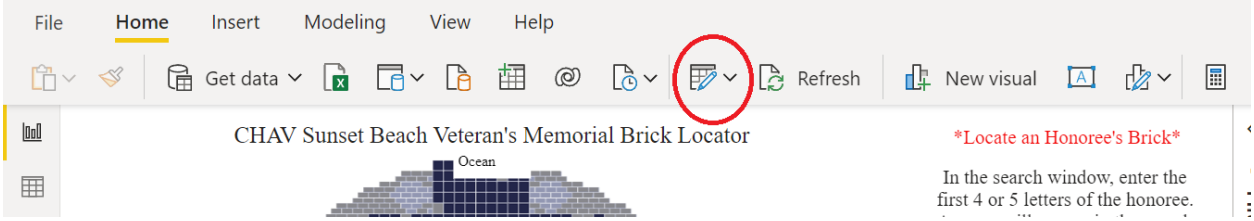


Figure 28. Selecting the "Power Query Editor" button to refresh the data.

From the "Power Query Editor" screen the gear icon next to the "Source" button on the bottom right was selected.

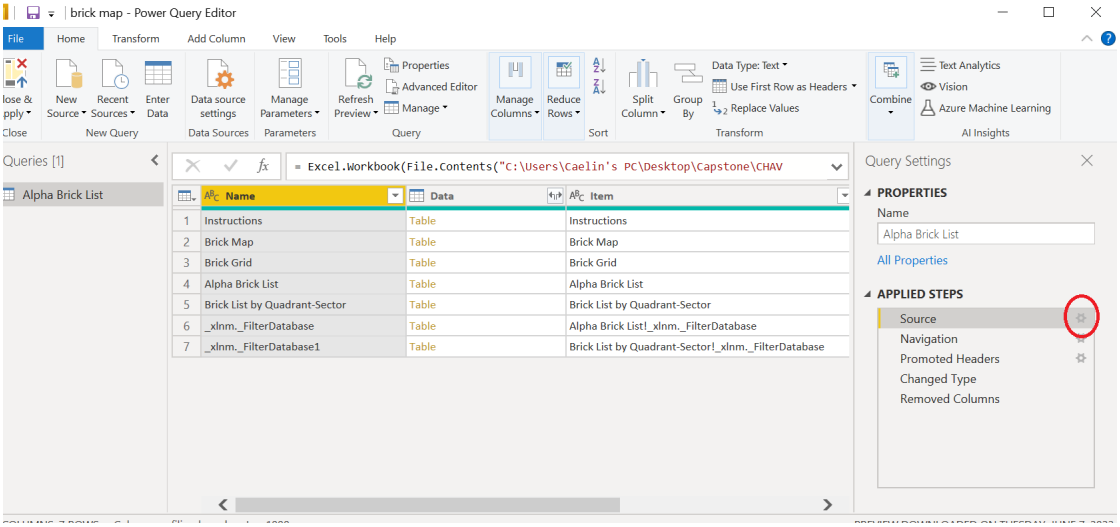


Figure 29. Selecting the gear icon next to the "Source" button in the "Power Query Editor".

This displayed the location for the new file path of the updated Excel sheet to be pasted in.

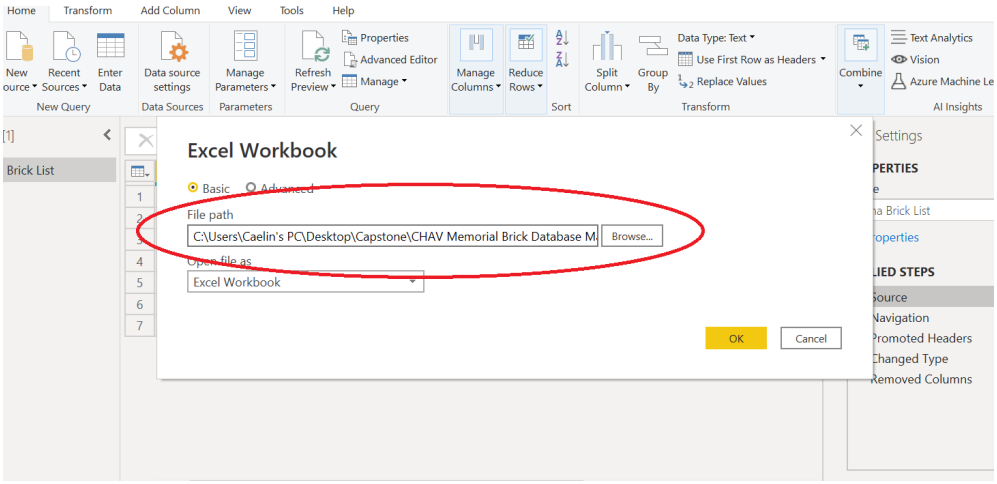


Figure 30. File path location to be pasted to refresh the data.

The last step in this process was to hit the refresh button on the home screen of the Power BI desktop. The application was then re-published as it was done the first time and the data was updated accordingly.

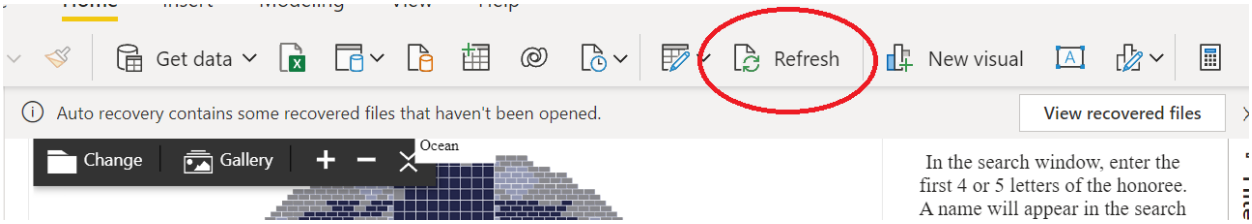


Figure 31. Button hit to refresh the data with the updated spreadsheet.

X. Discussion

This project was successfully completed with all, but one requirement met. The requirement that was not met was the re-ordering of columns in the tooltip. Because this was a visual requirement and was not vital to the map's functionality, the client was satisfied with the result of the interactive map. This project progressed with very little limitations. However, it was difficult to get a high-resolution photo for Synoptic Design. This made Synoptic Design the most time-consuming part of the project, but this was to be expected when the project was started. To make this task more efficient, having more than one person working on assigning the panels would be most effective. This was not because one person was incapable of completing it, but because it was tiresome work and having more than one set of eyes would have helped. The most difficult decision that was made over the course of this project was to determine how the map would be maintained in the future. Ultimately, the decision was based on financial limitation, so nothing could have been done differently.

The software development life cycle (SDLC) describes the different phases that were followed in the completion of this project. These phases include user involvement and requirement gathering throughout process, an iterative approach in terms of project updates, and quality testing (Leau et al., 2022). It was important to continuously gather user requirements to ensure that the project was meeting the user's expectations. The iterative approach involved several rounds of displaying the progress of the application to the user and receiving feedback. This allowed for the project to be flexible. Testing was one of the most important phases of this project. It was necessary for the user to try the application and make sure that they understood it and all its features.

To enhance this project in the future, the application could include augmented reality. Augmented reality is a feature that displays digital information on top of scenery or objects to make for a more immersive user experience (Berryman 2012). This would work by allowing users to open the camera on their phone and point it towards the memorial floor. The name of each honoree in relation to the brick would pop up on the camera so that the brick location could be found more easily. However, adding this feature would not be feasible with the features of Power BI, so another system application would be required, and the methods and timeline of the project would be more extensive. This could add confusion for the users and ultimately be a more expensive project. Another feature that could be added in the future is a button to purchase a brick on an open brick's tooltip. This would allow the user to quickly purchase and see exactly where their brick would be on the map. This also may not be feasible due to the lack of tooltip customization, so would need to investigate this idea further.

After researching the features of Power BI Pro, ArcGIS Pro, and MapInfo Pro it was obvious that Power BI was the superior program for this specific project. However, that would not be true if the map had been more complex. Learning about each program and choosing the best fit was beneficial in that it tied together research and decision-making skills.

Overall, this project was a great way to learn the fundamentals of a real-world project. The most beneficial portion, in my opinion, was gathering user requirements and communicating with the user to meet the expectations. Also, having a distinct timeline enforced my time management skills and lent practice in completing a project within a deadline. Although this project was not necessary very technical, it enforced my project management and SDLC skills learned from the Computer Science and Information Systems Master's program at UNCW.

XI. Literature Cited

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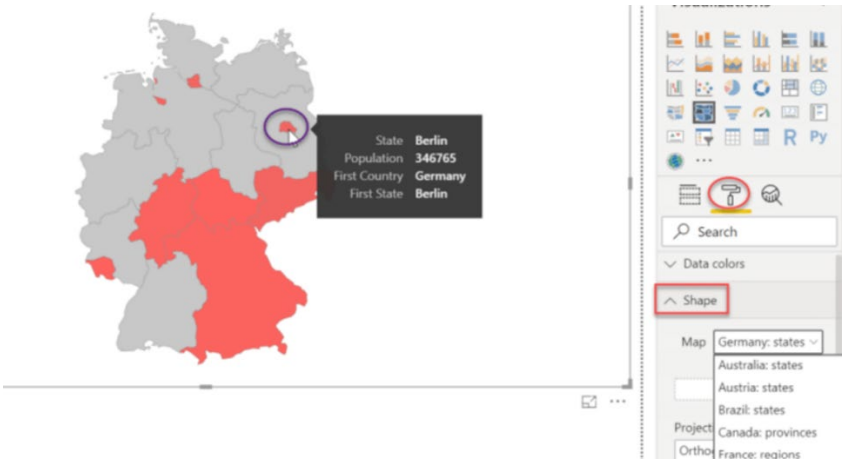
XII. Appendices

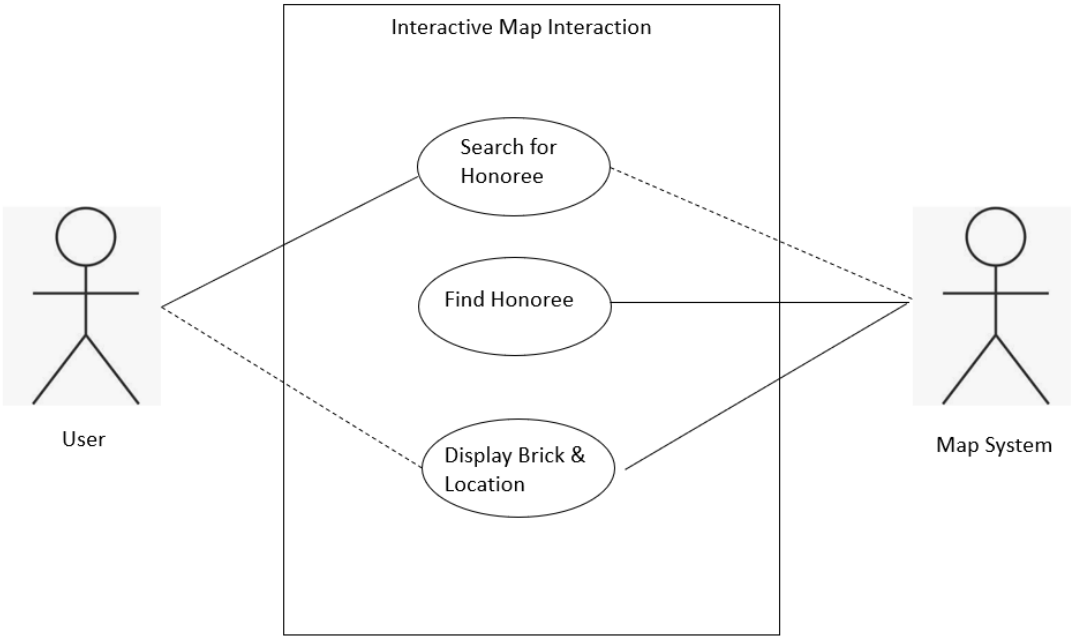
Appendix A. Photo of the memorial location in Sunset Beach, NC (see page 5).

	A	B	C	D	E	F	G
1	**Search**	**Name**	**C**	**R**	**Grid Ref**	**Loc**	
2	5 G	5 Gniewecki Bros.	AT	65	AT65	S1	
3	690	690 Sunset Prof Ctr	AS	75	AS75	S1	
4	Aac	Aach , Jerry	BW	36	BW36	Q3	
5	Aac	Aach, Joann	BW	36	BW36	Q3	
6	Acc	Accardi, Gaspar	C	47	C47	S2	
7	Acc	Accardi, Gasper	C	47	C47	S2	
8	Acc	Accardi, Rudolph	C	47	C47	S2	
9	Acc	Accardi, Stavros	C	47	C47	S2	
10	Acc	Accardi, Vincent	C	47	C47	S2	
11	Acr	Acri, G	BY	61	BY61	Q4	
12	Acr	Acri, P	BY	61	BY61	Q4	
13	Act	Acton, T	AR	7	AR7	S3	
14	Ada	Adams, A	V	31	V31	Q2	
15	Ada	Adams, C	BL	58	BL58	Q4	
16	Ada	Adams, J	BY	63	BY63	Q4	
17	Ada	Adams, S	AN	25	AN25	S3	
18	Ald	Alderfer, R	AA	58	AA58	Q1	
19	Ald	Alderson, C	BK	61	BK61	Q4	
20	Ald	Alderson, J	BL	60	BL60	Q4	
21	Ald	Alderson, N	BL	61	BL61	Q4	

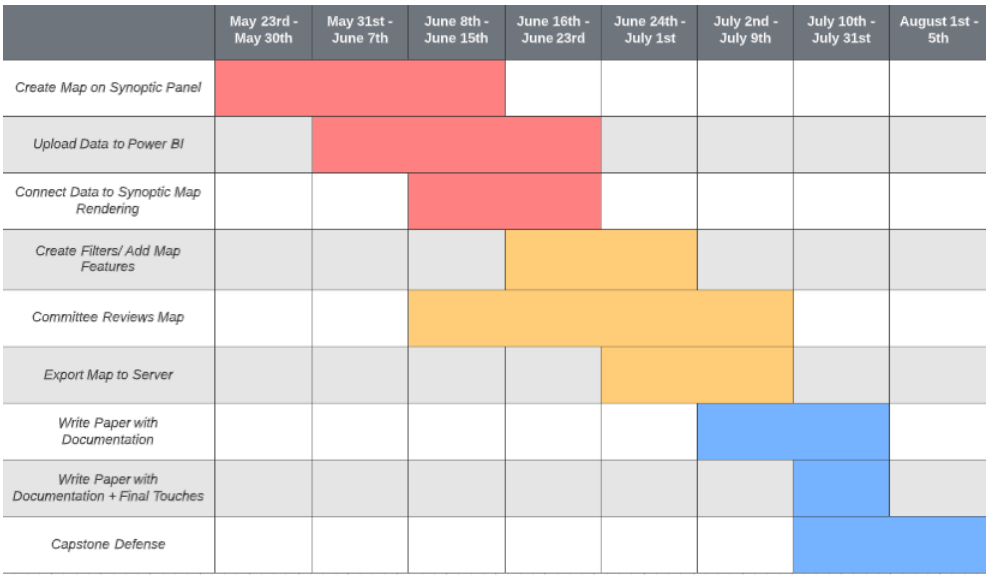
Appendix B. Example of spreadsheet with name and grid-reference location (see page 5).



Appendix C. Example map with search bar and highlight option (see page 9).



Appendix D. Use case demonstrating how users will interact with the map (see page 12).



Appendix E. Timeline of Capstone Project Milestones (see page 12).