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Village of Grand Ridge GIS Utility Mapping: Effective Decision Making and Cost Benefits

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Abstract

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Village of Grand Ridge GIS Utility Mapping: Effective Decision Making and Cost Benefits

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Abstract

According to Worldpopualtionreview.com, “As of 2018, there are 19,495 incorporated cities, towns and villages in the United States. Of those, 14,768 have populations below 5,000. Only ten have populations above 1 million and none are above 10 million. There are 310 cities considered at least medium cities with populations of 100,000 or more.”[1] According to the U.S Census Bureau stats, “about 80% of the United States population lives in urban areas.”[2] Within these cities or towns are underground utility infrastructures such as water lines and sewer pipes. For years cities have stored in files and boxes these construction plans explaining how, where and when these underground lines and pipes were installed. After years of storage these documents begin to degrade, reducing readability and becoming more cumbersome to store and access. Nonetheless, when issues or new projects arise, these are the documents that need to be referenced. The degradation and accessibility of these documents create many issues for the public works departments of these municipalities. For example, during a watermain break, to shut off the correct water valve, technicians must know how the line was installed. This information may be on archived as-built plans. This project defines the implementation of GIS in the Village of Grand Ridge, Illinois and will reveal that the town has saved money annually in repairs and day to day maintenance.

Introduction

Since the 1600's when settlers began colonizing in the United States, rapidly growing population forced humans to solve various issues within their communities. Over the course of 300 years, settlers organized their communities into municipalities. The twentieth century brought about the rapid installation of indoor plumbing. Underground pipes and structures were constructed to provide clean water and begin moving human waste and dirty water to the local rivers and streams. Then water treatment plants were created. These plants were implanted to clean up rivers and streams to ensure a healthier living environment. Intentional creation of utilities to maintain the environment is one of the many ways humans differ from other living species. Utilities, specifically wastewater and sewage systems, provide communities the ability to remove human waste responsibly, provide clean water and have reliable power in homes. As years pass, municipal utilities grow, alter, and remove infrastructure. The reality of guaranteed upgrades and repairs to utilities demands an overall knowledge of structures and underground lines and is essential to city growth and proactive future planning. Reliable knowledge of utilities infrastructure allows for efficient future planning which can lead to significant cost savings for taxpayers for years to come.

This project will further demonstrate the values and benefits of implementing utility GIS mapping into the Village of Grand Ridge in central Illinois. The absence of these values and benefits—both financial and temporal—have created concerns in nearby cities, such as Ottawa, Chenoa, Marseilles, Naplate and Harvey who have also expressed frustrations in utilities planning and access. The previous Mayor of Chenoa, Chris Wilder, acknowledged, "We don't know where a lot of our structures are. This causes issues when it comes to problem prevention and planning."[3] The purpose of this cost benefit study is to provide the Village of Grand Ridge with more utility knowledge and reduce yearly maintenance costs. The solution to the problem will be solved by locating and mapping all village utilities at and under the surface. And potentially, these benefits can be implemented to surrounding towns, cities, and villages.

Applying utility GIS mapping into the corporate limits of Grand Ridge will increase cost savings, data organization and decision making. The village of Grand Ridge has a population of 600 and the resulting small budget. The unknown locations of their underground utilities pose a threat to city management and city growth. The village currently leans on the knowledge of their public works staff to manage their water utilities. In a water department meeting held at Village Hall on May 12, 2023, mayor Kay Hines said "We've lost a lot of information from losing people over the years."[4] Kay's husband, Bob, was also the mayor of Grand Ridge in the late 1980's through the early 1990's. The solution to this issue in Grand Ridge was to create notecard locations for their structures. The casual transfer of information via notecards and reliance on the previous generation of leaders is how the village has operated since the 1980's and long before.

Figure 1 represents the Village of Grand Ridge. The red polygon displays the current corporate limits of the village. This is the project area for this study for which main breaks, upgrade decisions, and new construction will occur. This project will focus specifically on water utilities as water lines and structures are a large part of overall city "health". To this end, the CEO Water Mandate seeks to mobilize a critical mass of business leaders to address global water challenges, reiterating the following:

Water is essential for human and animal life, for nature and for the economy"[5]*… [emphasizing that] as a resource and commodity, it has a key function in our economic system, for food production, hygiene and health, energy and education. Water also forms biospheres and whole ecosystems such as rivers, lakes, seas, oceans, bays and glaciers and is key for the planet's biodiversity and climate.*[6]

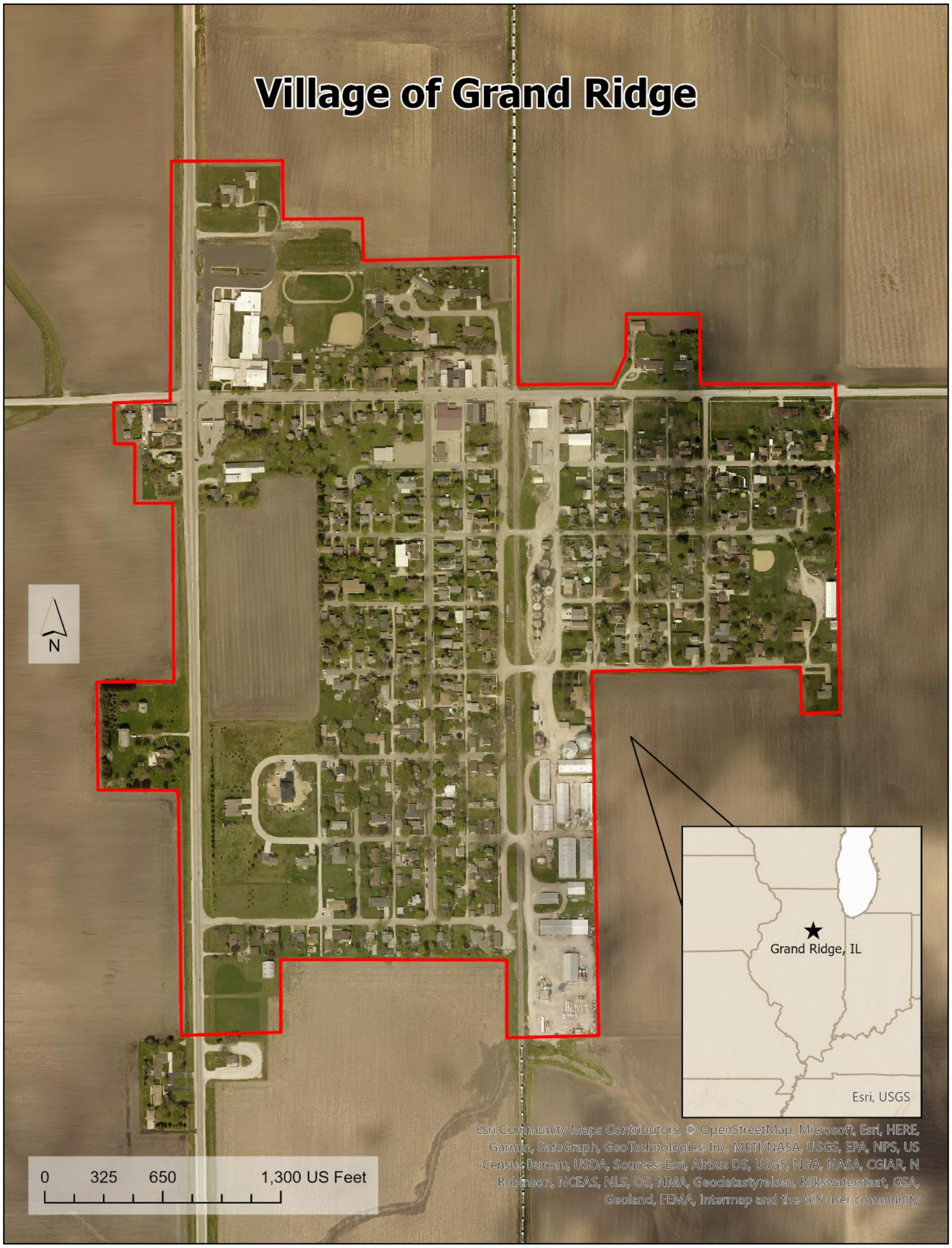


Figure 1, Village of Grand Ridge Corporate Limits

Fresh water for citizens is essential to village growth and development. In the article "How Development of American's Water Infrastructure Has Launched Through History", Dr. David Sedlak, a Malozemoff professor in the Civil & Environmental Engineering department at UC Berkeley states, "Much of the water infrastructure in the United States, Western Europe, and many other places is aging and in serious need of replacement or upgrading, especially to address the effects of a changing climate and new generation of man-made contaminants."[7]

Mapping underground structures and lines gives city workers and officials the ability to make proactive decisions. This can include decisions on drainage, main breaks, sewage backups, etc. Without the knowledge and implementation of GIS mapping, the Village of Grand Ridge would have continued to overspend in infrastructure maintenance costs.

Mayor Hines took an opportunity to discuss recent issues involved with village utilities to begin a cost benefit analysis. The cost benefit analysis provides hard numbers for the mayor and her administration to review yearly. The biggest of the issues came last year. Grand Ridge neighbors a busy highway, Illinois Route 23. Village officials noticed water seeping from the surface on the highway. The problem was eventually solved after a 2-day dig, costing the village $35,000, as officials did not know the location and number of watermain. Mayor Hines shared Grand Ridge's experience during another watermain break resulting in 12 main valve shutoffs. The village workers did not know which valve would shut off the main which resulted in shutting down the village's entire water supply until the break was fixed. Both emergencies would have lessened the time and inconvenience of losing water had utility GIS mapping been in place. The $35,000 spent for three days digging for a broken watermain would have been unnecessary had the GIS mapping been in place which would have resulted in locating the main shutoff in just a few hours. The village could have saved nearly $20,000—a significant amount for a small village on a tight budget. The experience for the community of shutting off twelve main valves and the entire village losing their water supply is not only a massive inconvenience, but also money wasted. Workers being paid by the hour to locate and close the specific valves after spending multiple hours using the aforementioned notecards to find buffalo boxes that should be found within minutes.

Using the database that is corelated with the spatial data can also provide cost savings and more accurate budgeting. One example--spatial data gives village planners the ability to accurately budget for filtering all hydrants that are over 20 years old with a plan for replacements. Mayor Hines spoke about the cost to replace hydrants and fix watermain breaks. Hydrants and water mains break for many reasons, but the most common cause for breaks is structural age. Both water mains and hydrants cost the village approximately $10,000 per fix. These breaks can happen at any time leaving little time for budgeting. Budgeting for these failures is difficult when structures are unknown; this is where spatial mapping can be used to soften the financial shock. When correctly developed, all spatial data contains detailed tables providing information on the feature, for example, hydrants that are collected will contain information like; CityID, InstallDate, LastFlush, GPM, etc. Using GIS and its database, the village can have a solid understanding of when these structures were installed and estimate likely breakage due to their age. GIS data can lead officials to plan proactively for replacing watermains and hydrants before they break. Planning for breaks allows the village to budget and save for specific projects.

Literature Review

Municipalities across the globe experience frustration and hinderances as they grow because they lack full knowledge of their utility's infrastructure. "GIS is used for managing utility data as it provides utility attributes and urban-scale locations using different layers."[8] With constant construction, adding and removing underground infrastructure, knowledge is easily lost in time. The world moves forward making it hard to keep up with years and years of change. For centuries, village and city hall buildings have been the storage unit for old plats, as-builts, and construction drawings.

As stated in "5 Reasons City Governments Are Turning to GPR Technology for Utility Detection", "Cities around the world are coming to understand that what is below ground has a direct impact on what is above ground."[9] If we can understand what is under the surface, we can begin planning for what needs to be above the surface. Getting started is the most important part. "Cities that approach this [technology] 5 to 10 years before they are forced to will really reap dramatic benefits and economic development,"[10] Dallas Innovation Alliance Executive Director Jennifer Sanders said. Not only do these maps allow for quick visualization and data results, they also can be taken to the field.

A 2018 article, "How GIS-Based Maps & Citizen Apps Can Help Cities Work Smarter" illustrates the reality of not having GIS data: "When an entire street was a bank of snow, I'd often have to dig out the entire bank by hand to find a meter,"[11] says Mark Ross, utility locator, GIS Division, Salt Lake City Department of Public Utilities. However, with the new technology, "Now, with my tablet, I can go right to it and uncover it in minutes."[12]

Utility mapping is only the beginning, but all cities must plan their future. In an Unearthlabs.com article, “Urban Mapping with 5 benefits of GIS in Urban planning”, the value of GIS data is clearly stated: “Improved mapping, increased access to vital information, improved communication, increased quality and efficiency for public services and increased support for strategic decision making.”[13]

Cost is always one of the most important factors for city decision making. The decision to incur the initial cost of locating and creating these maps may be hard to swallow; however, once the beginning stages are completed, the benefits are clear. Consider what should be routine maintenance: without accurate mapping and information, Costello, et al says “many utilities cannot be inspected due to the limit of time and budget, which makes the condition of most utilities to remain unknown. Inspection or maintenance activities are mostly performed reactively, i.e. after the utility breakdown instead of in a predictive manner.”[14] GIS data allows for predictive upkeep, allowing these issues to be documented and solved in the field allowing more proactive decision-making.

According to NEXGEN, in-the-field decision-making ranges “From generating digital work orders and locating assets that need repairs to tracking inventory and closing work orders, GIS can help [you] save…time and effort by eliminating the need to generate prints, record inputs, prepare manual reports, review daily PM schedules, plot routes using paper maps, and pick up daily assignments. The implementation of GIS automates routine tasks to help you save thousands of dollars spent on repairs, replacements, and preventive maintenance.”[15]

In the eastern parts of the United States, infrastructure is failing at a rapid rate. According to the US EPA, this trend is unfolding all across the country in part because “in the United States, most municipal sewer systems are at least 60 years old and some are even more than

100 years old."[16] To begin solving these issues, some form of mapping and data collection must be put into place because "poor management of underground utility information can lead to serious consequences."[17] The Pipeline and Hazardous Material Safety Administration (PHMSA) in the United States reported that "25.1% (2678 incidents) of pipeline incidents occurred due to incorrect excavation and operation, causing 163 fatalities, 650 injuries, and approximately USD 650 million in property damage."[18]

Visualizing data is an important part of operating a water system. Along with visualization, creating a database is essential for an effective GIS system. Data will be collected and used frequently. Implementing a database will be important to store and organize data, with the purpose being that "a database management system (DBMS) allows a person to organize, store, and retrieve data from a computer" and the database will be linked with the spatial data that is displayed; thus, the "database, as a collection of information, can be organized so a database management system [that] can access and pull specific information."[19]

In 1960, Charles W. Bachman designed the integrated database system, the "first" DBMS."[20] In "Benefits of Databases", Bachman's work is confirmed as the database benefits are further discussed clarifying the benefits they provide such as, "reduce the amount of time you spend managing data, analyzing data in a variety of ways, promoting a disciplined approach to data management, turning disparate information into a valuable resource and improve the quality and consistency of information."[21] Like a DBMS, a spatial database is also beneficial to a successful GIS system. In 2020, Jessica Kane discusses the benefits of spatial databases, explaining "a spatial database is a database that can store and manipulate data that has a location. It can store points, lines, polygons, etc. and it allows spatial queries by software applications using the database or by a user directly querying the data with SQL. This allows queries such as

'Give me all the gas stations within 1 mile of my location' or 'Give me all the parks within the city boundary'. Other generic terms for spatial databases include geospatial databases, geographic databases, or geodatabases."[22] The ability to run queries gives municipalities flexibility when running data analysis. Further, Kane states "spatial databases have a number of benefits, some of which will be readily apparent to the novice user while others are unlocked as you build more skills in SQL and database design"[23]. She suggests multiple benefits and offers explanations to the importance of database use.

Further explanation in "Easy to Organize and Maintain as the System of Record":

> *databases are designed to organize large amounts of data. All your data will be in one place as the authoritative data source for your organization. You won't have to worry about random GIS files being saved in different places. Can be Used with a Variety of Software: Once your data is in a database, you can access that data from a variety of software applications including Esri's ArcGIS solutions (depending on your license level) and the popular open source desktop GIS application QGIS. In addition to using third-party software applications with your database, you can build your own custom applications (desktop, web or mobile) to view or edit your data - all without having to convert your data to another file format. Multi-user: Multiple people can access and edit the data in the database at the same time, ensuring that your entire team is working off the same data. Permissions & Security: You can set permissions on tables or even individual fields to make sure the right people have read/write access to the right data. Maintain Data Integrity: You won't have to worry about losing one of those files from a shapefile that makes it unusable. Back-ups and Versioned Editing: You can back up your database to make sure you don't lose any data in case of a crash. You can also enable*

> *versioned editing so you can revert to a previous version of your data if needed. Spatial Data Analysis: With some minimal SQL skills, you can do some pretty cool spatial analysis directly with the data (as opposed to using an application). Don't know any SQL? There are plenty of free tutorials online that will help you get the basics in no time. Speed Things Up: You can create spatial indices in your database to optimize spatial queries.*[24]

Creating a DBMS and a spatial database to organize, store and analysis data adds a structured and cost saving benefit within municipalities. Because data is constantly being updated and changed, storing and changing thousands of data points can be extremely difficult. These DBMS's allow for a much easier transition for editing and managing data points.

Secondary research resources include statements by a member of the City of Ottawa, IL public works department: Ottawa has a fully functioning GIS system in place. The Mayor of Grand Ridge, Kay Hines, is quoted throughout. Primary research resources come from published articles of places that show factual evidence to prove the hypothesis. There is no IRB required to complete this project. No sample surveys, questionnaires or templates are used to conduct the project.

Design & Implementation

To conduct this project all water structures and lines in the Village of Grand Ridge were located. Utility data such as hydrants, water valves, buffalo boxes and water lines comprise the spatial data. The data was collected by Advanced Informational Mapping Systems, using a HiPer VR rover that collects centimeter accuracy, as it provides horizontal and vertical spatial data. The data was collected using NAD 1983 (2011) State Plane Illinois East FIPS 1201 (US Feet).

Before data collection was started, a geodatabase was created to store the data. This database contains all details associated with the feature. A feature dataset called, MasterWater will store all spatial and non-spatial data. It's important to use feature datasets to distinguish between other feature classes that also may be within the database. The MasterWater dataset has five feature classes. The 4th (point) features are buffalo boxes, unknown structures, hydrants, and main valves. The 5th (Line) feature class is Water Line. Three non-spatial tables were created to establish relationship classes. Also created are two standalone feature classes, Corporate Limits and Streets. The polygon feature represents the "Corporate Limits" of the Village of Grand Ridge. Including the corporate limits will help distinguish between village owned utilities and private utilities. This will play a large role in future development and data organization. The polyline feature represents the village streets, it is mostly used for street names.

The polyline feature, WaterLines, has the basic data fields. LineID, the primary key, will be used later to relate our non-spatial table. Pipe Size, Year Built, Comments and Material make up the attribute table. A subtype was created to represent Raw Water, Treated Water, Private Water, Abandoned Lines and Service Lines. Adding a relationship class that connects our WaterLines to the Water Line History table will give us a 1:M relationship regarding the water lines. As agreed on with the village board, the village water department superintendent used the structure location notecards to locate most of their structures. When a feature was found, they would use a paint mark to identify the location. Some structures were not found and were shown on the map as an open circle. This indicates to the village that this structure wasn't found. *Figure 2* below represents the way structures are displayed on the map. Every feature that is collected will be represented using a specific line type (line feature) or symbol (point feature). This allows for easier analysis of the data. The buffalo box symbol is a black square; hydrants are orange triangles; and main valves are blue X's. For this specific project, there is only treated water lines.

They will be represented using a blue line. In theory, this blue line may also represent raw water lines, private lines, and service lines.

Figure 2, Water Lines and Structure Displays

Buffalo boxes and valves were a main priority for the village. For years they have struggled to shut off resident water access due to lack of payment. In some cases, they can't shut off the resident's water because the buffalo box couldn't be found. Along with collecting a geographic location for the buffalo boxes, a photo of the exposed structure was also captured for later reference. While in the field collecting spatial data, detailed information is also being collected. *Figure 3* represents a photo that was taken when collecting a buffalo box from a home in Grand Ridge.

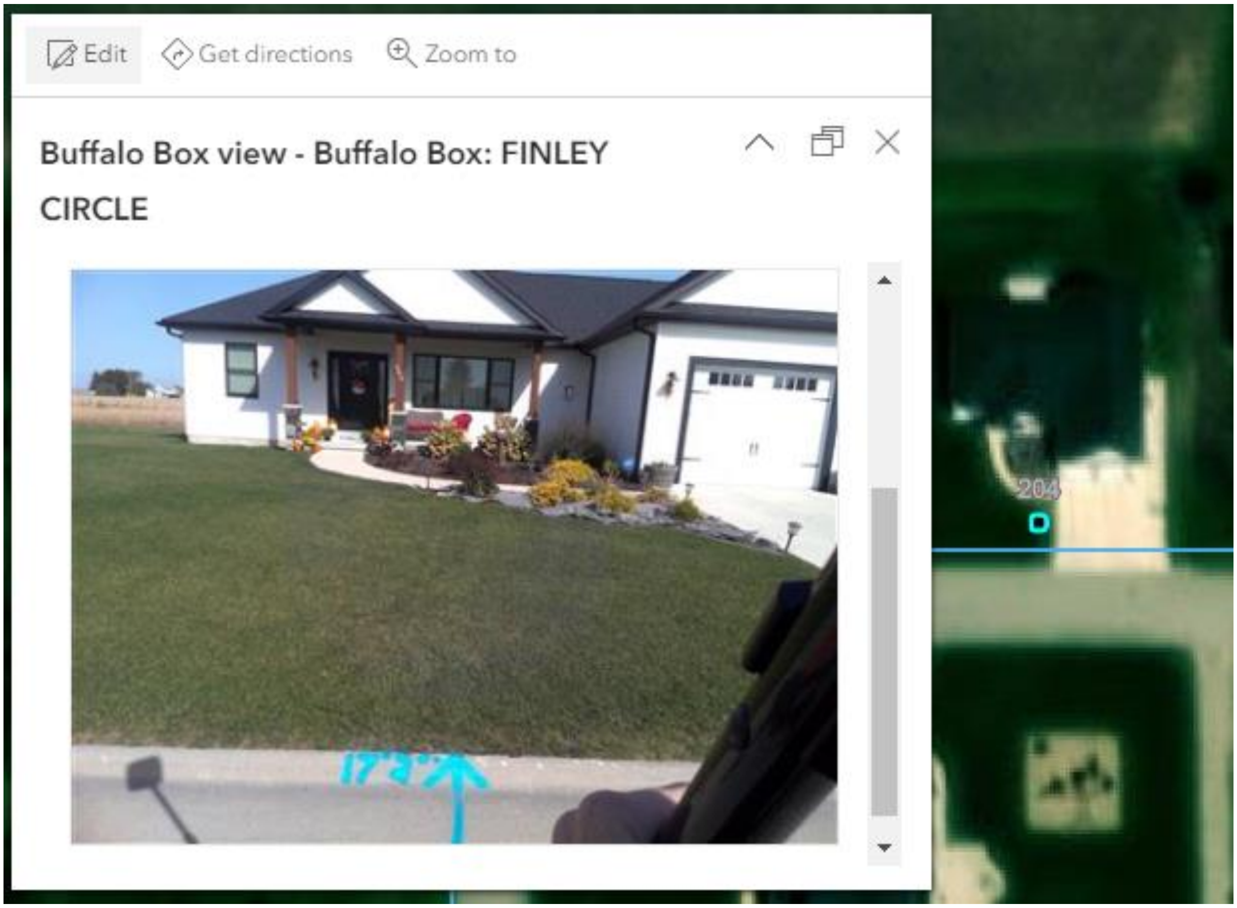


Figure 3, Located Buffalo Box

Each line and structure contain spatial data (coordinate/elevation) and non-spatial data. This information is collected in the field (street name) and using old construction plans (valve size). Water line location was the last step of locating. Once the structures were located and displayed, old maps provided by the village were used to begin configuring water mains. Most of the underground lines were put in before they used tracer wire, so the only way to proceed was to gather knowledge from the village's stored data sources within the village hall. This is an example of gathering institutional knowledge about the water distribution infrastructure from public works personnel. The best way to gather accurate information regarding the lines would be during main breaks or replacements. This data is then displayed in an interactive web map using ESRI ArcGIS Online, organized data that can be accessed anywhere.

When creating large databases, it is important to get everything as accurate and organized as possible. Small input mistakes like misspelled words or incorrect input can result in functionality issues. What makes a geodatabase so effective is the ability to run queries to analyze the data. If data isn't put in correctly, it can't be queried. To increase the accuracy of any database, it is important to use subtypes and domains whenever possible. Having multiple relationship classes can give more detailed and important data. The more information available about a structure or line, the more accurate the analysis. Adding a few more standalone feature classes to display with the utility data can also be beneficial. Identifiers such as city parcels, right-of-way lines, rivers, and parks can all be included in spatial queries. For example, a query can be run to display all water utilities outside the village right-of-way.

Using queries to analyze data can be extremely helpful. Replacing infrastructure and adding new infrastructure requires a lot of information. Typically, you may have to search multiple areas to gather the information that is necessary. For example, if a city is applying for a grant or needing information regarding all sewer lines that cross over water lines in town, the location tool can be utilized. Using the tool allows a query of Input Feature (Sewer Lines > Relationship (Intersect) > Selecting Features (Water Lines). This query populates all sewer lines that cross over a water line. Many cities have policies stating a specific distance away from water and sewer lines; thus this query can aid in future decisions. Another feature that can be added is main repairs. The City of Ottawa collects spatial data points every time there is a main break or repair. This allows the city to keep track of their breaks and how they were fixed. *Figure 5* shows a main repair documented in the City of Ottawa.

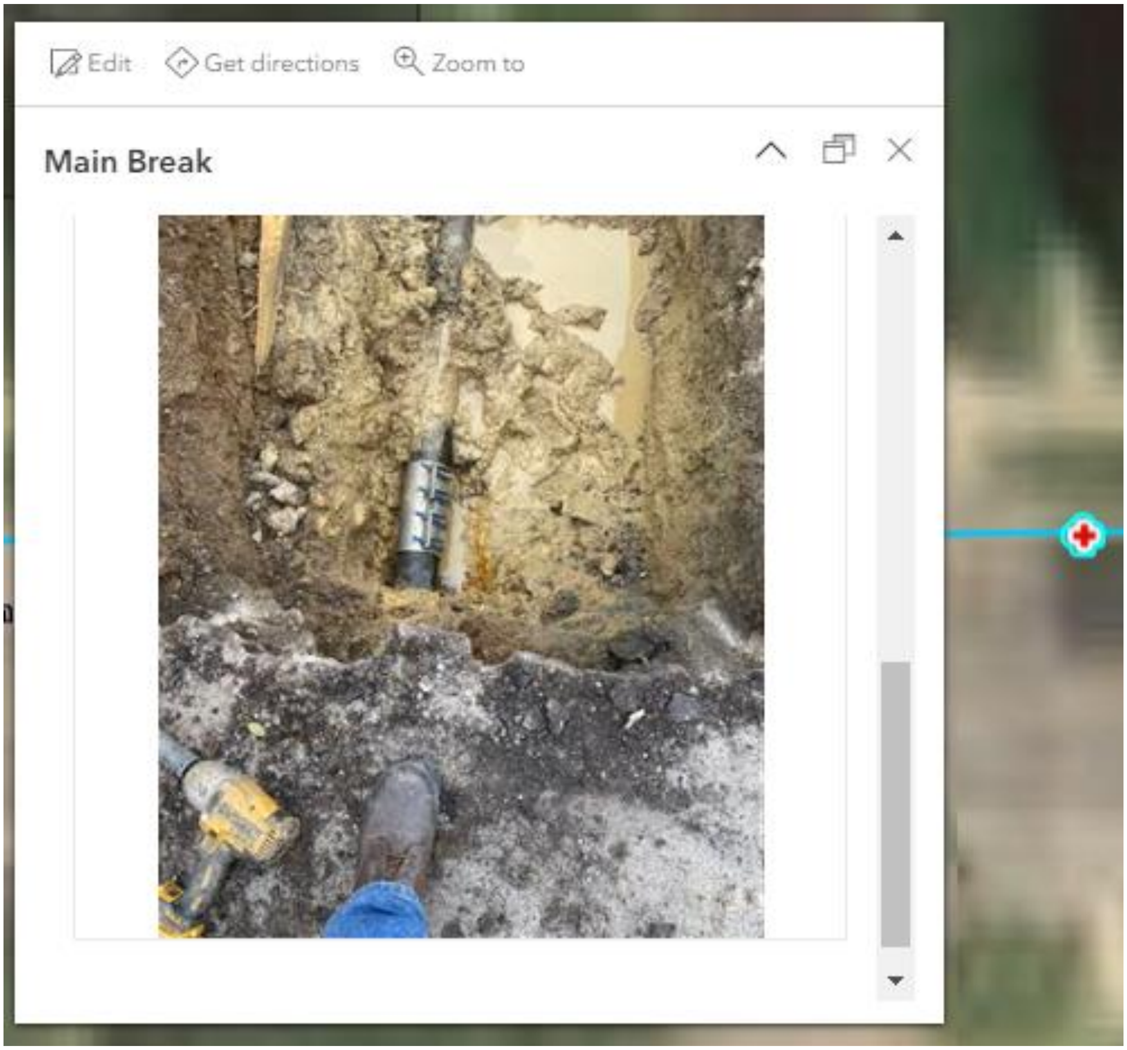
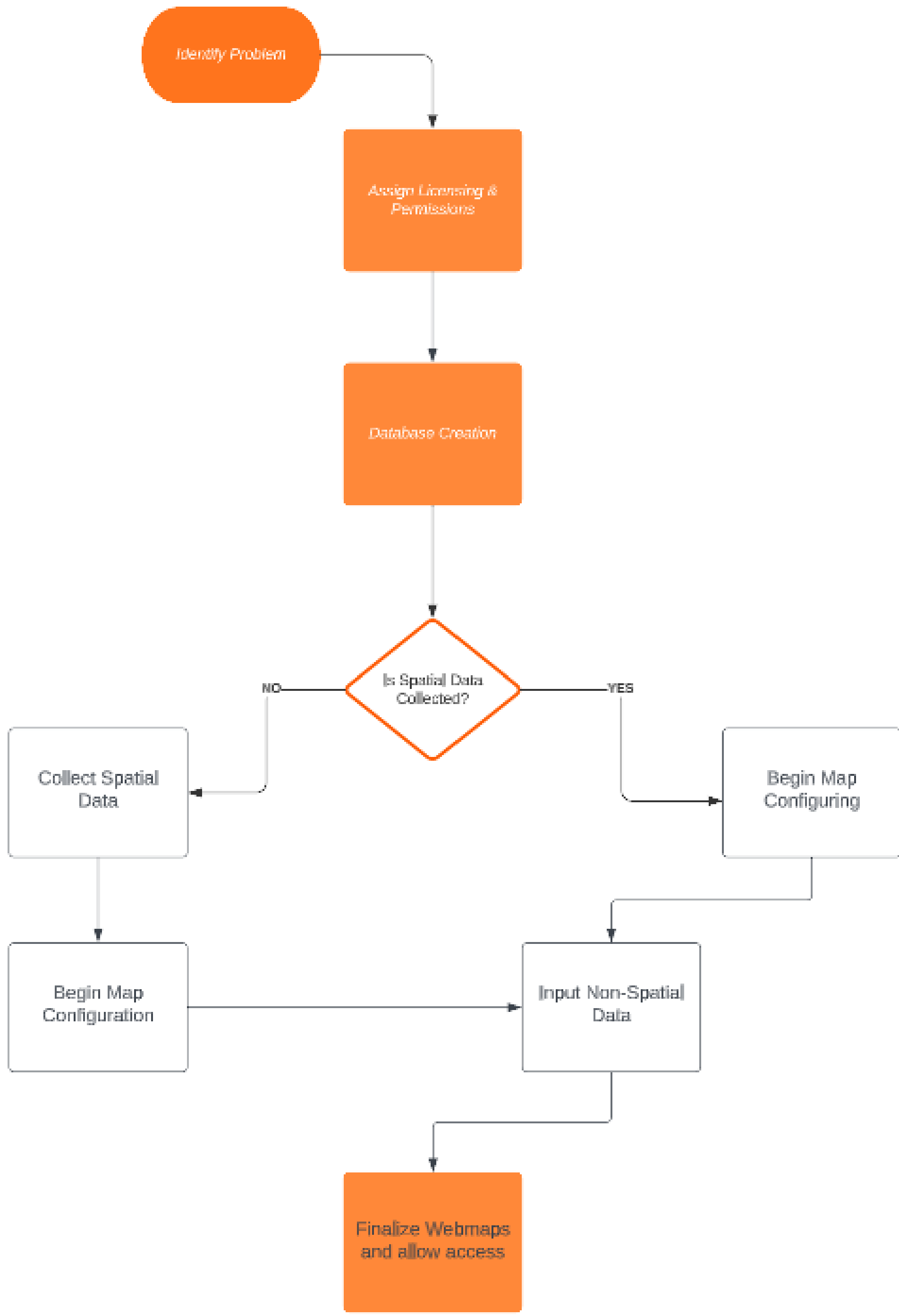


Figure 5, Water Main Repair

Adding a rule to the collection of repairs in the field is necessary. Getting a locate on the line itself means getting in a trench when the line is dug up, unless GIS maps allow for collecting the point at the asphalt. The issue with that collection method is some points are not placed on an actual water line. Running this query displays all the repairs that are not on a water line. All repairs must be attached to an actual line.

Flowchart


Identify Problem
Assign Licensing & Permissions
Database Creation
Is Spatial Data Collected?
NO
YES
Collect Spatial Data
Begin Map Configuring
Begin Map Configuration
Input Non-Spatial Data
Finalize Webmaps and allow access

Cost

With all projects in a municipality, there is always a common question. What will it cost? All municipalities are dealing with budgets. The biggest cost will be locating the spatial data. This requires time in the field. The first step to developing the project is defining the village needs. Where is the village losing the most time and money? Once the need is established, the GIS licensing is purchased. Because Grand Ridge is a relatively small community, they were able to use a ArcGIS Online Creator license with an annual cost of $500. This license allows for map creation and data input. Only the license administrator has permission to operate this license. They also need a Viewer license costing $100 annually. The Viewer license adds another member with a login and password to view the map and its attribute tables. This is the license the village members will be using. After the $600 of licensing is purchased, a database is created. This database allows for organized data to be filtered and queried. Because the village doesn't have an ArcGIS Pro license, all the data is exported and appended into the file geodatabase. This file geodatabase also contains domains, subtypes, and related tables. As the village increasingly depends on the service more, the database files become extremely important. Geodatabase creation and licensing setup takes about 25 hours. The GIS consultant rate is $85 per hour with a down payment to begin the project of $2,725. This costs covers 25 hours, initial setup and licensing. The next step is finding all the structures. With the help of the village, all but nine structures were found. The cost begins when using the HiPer VR rover to collect the coordinate points. Each point is referred to as a standard locate; every point collected is billed at $17. With a total of 360 standard locates--51 Hydrants, 234 Buffalo Boxes, and 75 Water valves--the total cost of data collection was $6,120.

Finally, the structures are imported into the map for configuring. As soon as the points are displayed, a meeting is held to begin watermain implementation. Within older cities and villages, tracer wire on lines is less prevalent. This process will always start with the people who have gathered knowledge over the years. Connecting water structures to finalize the map and adding data to the attribute tables will take some time. When completed, symbology and line types will be configured to allow for a clean visualization. This process takes roughly 50 hours for a small village, resulting in $4,250 in data input and map configuring. The total cost of the project totals $13,095 and is estimated to be completed in 2 months.

Results

To shed light on the benefits of implementing Utility GIS into the Village of Grand Ridge, a discussion was held with the Village Mayor, Kay Hines. Kay has been a resident in the village for 83 years. Eleven of those years she has spent as Mayor. She has always had the village's best interest in mind as a resident and mayor. She knows more about Grand Ridge than the vast majority who now live there. Kay's knowledge is extremely important. Although, like most cities and villages, knowledge held by one person won't last forever. Kay understood this right away and has made it a point to move Grand Ridge into the 21st century. During the interview she said "I want to move us into the 21st century. I want the people after to me to be able to continue growing our village."[25]

Utility infrastructure plays a large role in village and city growth. To grow a municipality must be capable of servicing larger areas. Managing those areas is also essential. Before the implementation of GIS in the village, Grand Ridge officials used notecards to find their water structures. The notecards were organized by street name, then the house address. These cards were created in the 1980's by the water department supervisor. Each card includes directional information. For example, "620 BURLINGTON 171/2 FEET NORTH OF THE NORTH EDGE OF DRIVEWAY, ON EAST SIDE OF THE SIDEWAKK. (NORMAN BAYER)". *Figure 4* provides a photo of an actual card used by village employees.

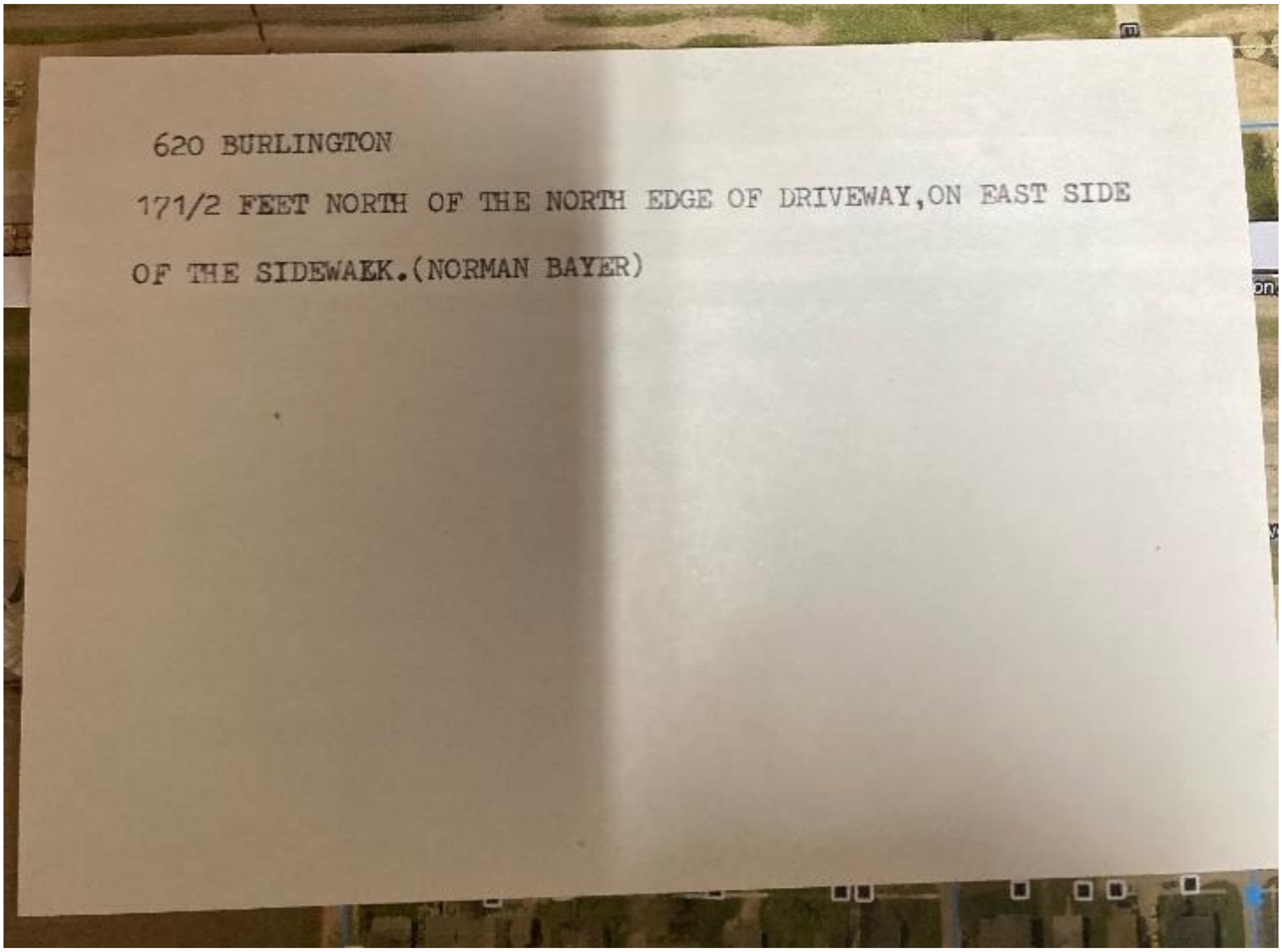


Figure 4, Notecard used for locating

According to Mayor Hines, "I'm guessing 30% of the cards are inaccurate or need updating."[26] The use of notecards can add a sequence of problems, inaccuracy, damaged cards, no real geographic location, time consuming to locate, etc.

In *figure 6* below, the outcome of the project implementation is shown.

Figure 6, Final water utility map

Discussion

Over the past two years, the Village of Grand Ridge has paid roughly $138,000 utility maintenance and repairs. This number is based on the village financial report from the years 2021 and 2022. Depending on the task, the contractor bills anywhere from $115 to $280 dollars per hour. To fix the existing issue, heavy equipment is used to dig up the underground line. In the example referenced initially, the contractor spent two 8-hour days digging. The project cost the village $35,000 dollars. During the dig there was multiple unknown lines discovered. This caused confusion and added more time to the project. Mayor Hines believes, "we could have saved more than 50% of that project cost now that we know where our mains are located."[27] Using the existing GIS presence, the main break could have been found in less than half the time. Time spent locating is only part of the issue with unknown watermain location. To locate unknown lines requires much more digging and time spent using heavy equipment. This also causes more cost to repair the road when completed.

In 2021, a main break resulted in shutting off the entire village's water supply. After attempting to close 12 valves, village officials were left with no choice but to shut off water service to all residents and businesses. This project took roughly four hours with the total cost of the project approximately $11,000. This number could have been cut in half as well. The correct valves would have been located and closed, resulting in less flooding and a quicker repair. And the town would not have been inconvenienced

In 2022 the village was forced to replace a fire hydrant near the Elementary School. This $10,000 expense was unexpected and not in the yearly budget. The hydrant was over 20 years old and was due for replacement. By using the built-in database system connected to the spatial data, the village can now plan and budget for upcoming replacements. A query can be executed to display all hydrants over a specific age. With infrastructure grants and other grants available, Mayor Hines and her administration can now plan years in advance.

These projects are a few examples of large construction repairs that can now be avoided or at least planned for. An estimated 25-35% of the $138,000 spent over the last 2 years could have been saved. That is roughly $35,000 to $50,000 in savings over a 2-year span. Given the $13,000 total cost of the GIS implementation the village will now save thousands of dollars a year and potentially hundreds of thousands over the next decade or two.

Conclusion

In conclusion, the Village of Grand Ridge can now save money for years to come. This cost benefit may not be obvious initially; as with all preventative measures, what does not occur is where the savings are found. Additionally, when problems arise or planning decisions must be made, veteran village staff and administrators will quickly remember the old ways and how ineffective they truly were. Hours after the discussion with Mayor Kay Hines, she sent an email regarding the service: “I know I said at one point the Village really didn’t have the extra funds for the program but the more I think about it, we can’t afford to be without it.”[28] Until the managers and leaders of municipalities truly do a deep drive on cost to operate their utility systems, these municipalities may not understand the money that can be saved. For the Village of Grand Ridge, the entire project cost the village $13,000 to implement. That cost alone was doubled in their three day dig last year--$35,000. If GIS was implemented before that issue, they could’ve saved enough money to pay for this project over 2 times. The village has already begun to realize the savings by reducing the cost in terms of time and real dollars for employees to continuously locate structures and lines for a variety of issues. The one-time $13,000 investment may save thousands of dollars in the next 10-20 years—even accounting for the yearly licensure for software. As the village becomes more comfortable with the system, they can also start utilizing the database queries, running analysis on lines and structure age to make proactive decisions on watermain replacements and structure replacements that can be included in yearly budgeting. This information gives the village time to plan out grants or other funding sources necessary when a large cost is expected.

This GIS implementation has the potential for massive impact on the village for years to come. For years the village has aspired to expand and add more homes and infrastructure. Previously officials relied on resident knowledge of utilities to aid in designing new water structures. A close neighbor to the village, the City of Ottawa, is a prime example of long-term benefits GIS mapping. Brian Roberts, a member of the Ottawa water department, claims "our GIS maps are used daily. When an issue arises, it's the first thing we go to. It's specifically essential during weather events and dark hours. These maps save hours of time in the field and can save cities money for years to come."[29]

Grand Ridge can now utilize their GIS maps and the knowledge stored within, to make extremely educated decisions on infrastructure growth in a timely manner. The Village of Grand Ridge has now begun their transition into the 21st century.

Areas of Further Research

Water utilities are only the tip of the iceberg. All utilities should be located and implemented into GIS maps and databases. The next phase for the Village of Grand Ridge GIS project is adding storm sewers. Along with all the symbology and data collection, using the geodatabase to add sewer to a dataset is vital. A feature dataset called, MasterSewer can be created. This dataset will consist of 2 features to display and store the sewer points and data. This data will have attributes of its own, but will also have multiple related tables. Within our spatial dataset "Sewer Lines" there is multiple attributes. The primary and identifying key is LineID. The other fields include Pipe_Material, Size, Year, Type_Code, HMup, MHdown. The Type_Code field is a subtype field. The subtypes within the field are Combined, Storm, Sanitary, Sanitary Force Main, Storm Lateral, Sanitary Service. The subtype is necessary because it allows for all sewer structures to be the same location but be represented by their structure type. Domains are also created for Pipe_Material and Year_Built. This is helpful to input the most accurate data and reduce issues with querying.

The "Sewer Structures" feature class contains Structure ID (primary), lid elevation, year installed, diameter, and Type_Code. The Type_Code is a subtype feature that contains Combined, Sanitary, Storm, Sanitary clean-out, Storm Inlet Basin, Storm Inlet, Service Connect. This allows for easy distinguishing between structures.

Along with this attribute table, there is a non-spatial table. This table is used for the relationship class. "Inverts" is the table that relates the manhole with its In and Out flow pipes. The flow elevation of these pipes is called "invert elevation". This table will have attributes such as, StructureID, invert direction, manhole lid elevation, LineID, flow in and flow out. To relate the tables, the primary key "ManholeID" from the "storm manhole" entity will be used. This primary code will also be used in relating specific "storm lines" as the project progresses. *Figure 7* gives a visual to a what sewer lines and structures would look like on the map. This example is also from the City of Ottawa.

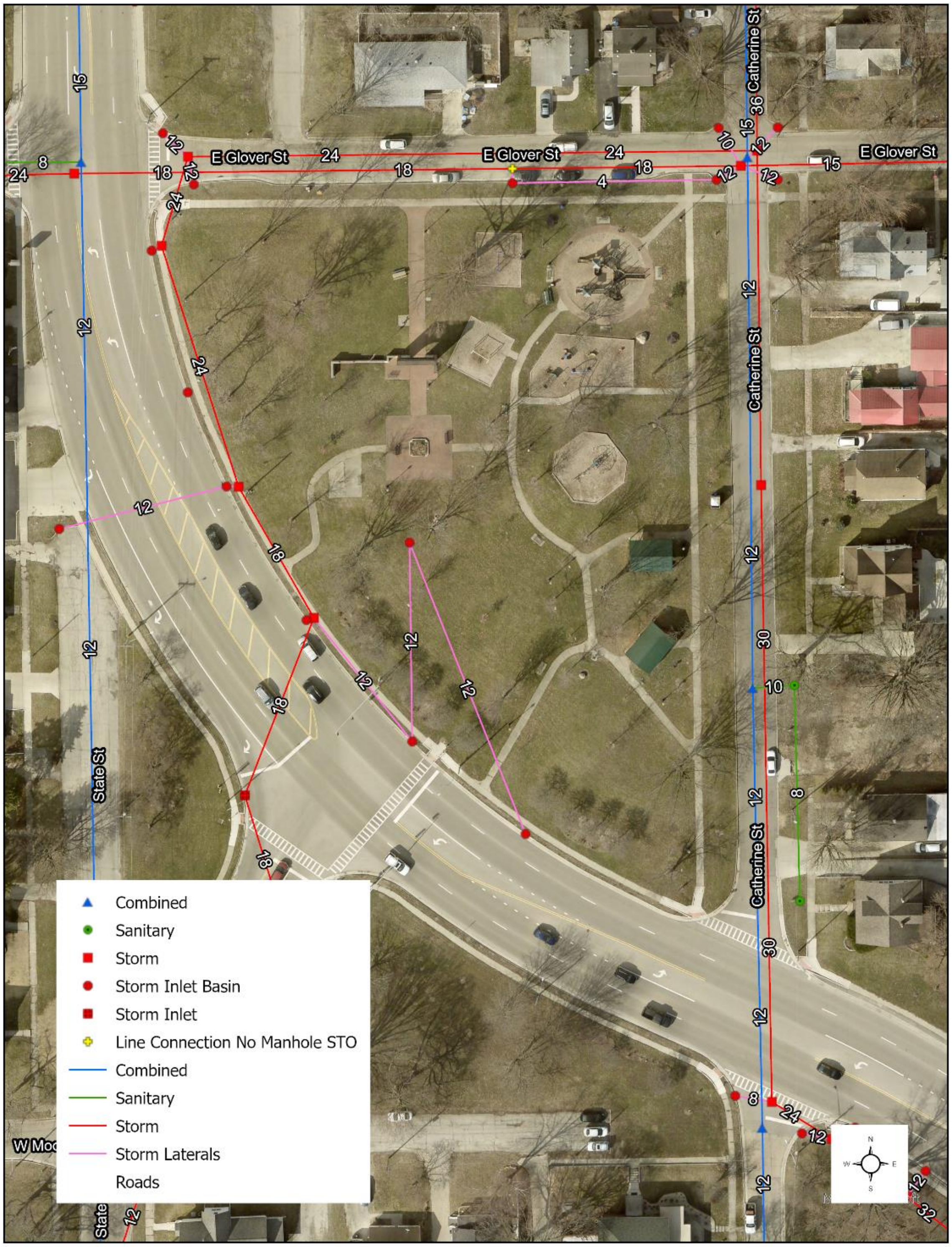


Figure 7, City of Ottawa Sewer Map

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[27] Kay Hines, Village of Grand Ridge Mayor

[28] Kay Hines, Village of Grand Ridge Mayor

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