

GPS Mapping Irrigation Systems for Better Communication and Management

Author: Jacob A. Young, Registered Landscape Architect

Affiliations ASLA & APA, jyoung@civilsolutionsgroup.net

Abstract: GIS and GPS technologies are still fairly new and are not widely used in the irrigation industry. These technologies can provide detailed mapping solutions, which many related industries have already begun to benefit from. Current research from recent surveys of landscape professionals shows their current solution to mapping irrigation systems is inadequate and there is an apparent need for better application of technology. Applying GIS and GPS technologies when designing, building and mapping irrigation systems will aid in the management of irrigation systems and promote water conservation.

Key Words: irrigation mapping, irrigation management, water conservation, GPS, GIS, irrigation “as built”, irrigation documentation, and landscape mapping.

Introduction:

Beautiful landscapes and green open spaces are a valuable asset in a world where growth and resource management are an ever growing concern. Knowledge of the newest and most advanced technology is often the key to success in any field, especially the irrigation and landscape maintenance fields in today’s economy. The combination of educated management, skilled employees and using advanced tools make it possible to do better irrigation construction, maintenance, and communication.

Geographic Information Systems (GIS) and Global Positioning Systems (GPS) technologies are creating new methodologies and tools for documenting, mapping and managing today’s landscapes more effectively than ever. Routine maintenance and conservation become more straightforward and easy to achieve in a timely and cost-effective manner. Related industries have been harnessing the power of GIS and GPS for a number of years and their examples provide valuable insight to the irrigation industry.

Looking under the hood at GIS/GPS Technology:

Geographic Information Systems is essentially computer modeling of the earth's surface. Various map types, boundaries, built improvements (roads, water lines, etc) and limitless other elements of our environment can be modeled with this technology. A GIS map is an interactive computer generated image consisting of: layers, features/surfaces, values, locations, data, map projection and map display.

Layers are essentially single maps or specific data layered on top of each other (such as rivers, cities, and political boundaries).

Features represent the data layers and are made up of points, lines and polygons. A surface often consists of elevation data such as topography or an aerial image. With features or surfaces each point, line, polygon or raster square has values or data assigned to them. What makes GIS different than historic maps is that various components of any map can be combined, separated or even analyzed with the click of a button.

A projection represents the manner in which the data is draped over the earth's surface or projected. GIS has become the vehicle for understanding complex systems such as city infrastructure, large plant ecosystems, and thousands of other systems (Ormsby, 2010).

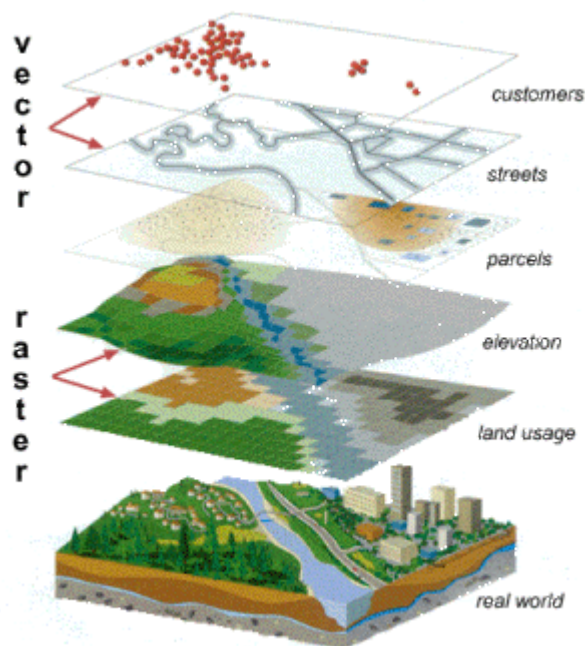


Figure 1 Diagram of GIS Layers (GIS, 2011).

The source of GPS signals is a network of satellites orbiting the globe twice a day. Through triangulation, satellites send signals to a GPS receiver which then determines the location of the user. With three satellites a 2D latitude and longitude point is determined, but with four satellites a 3D

elevation point can be determined. The greater number of satellites connecting to your receiver the stronger the signal or more accurate the data (to a degree). The signal lets the receiver or GPS device know its exact location (or point), tracking speed, direction and other useful information. Depending on the type of GPS hand-held equipment used; the accuracy of data can be between 30 feet to less than 1 foot. Other factors can also affect GPS accuracy in the landscape industry including: location of satellites at time of mapping, building height, user distance from building(s), tree canopy and location, and type of GPS mapping device used.

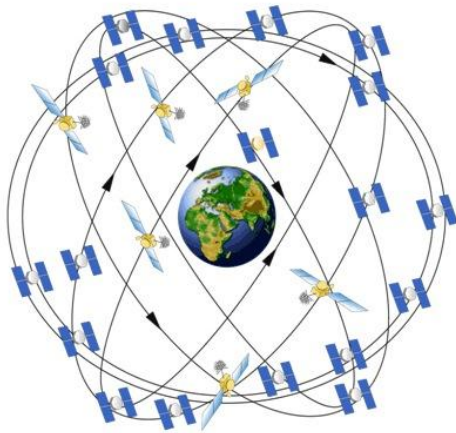


Figure 2 GPS Satellite Constellation (Delaware and High, 2011)

GIS/GPS Technology in Related Industries:

The City of Nashua New Hampshire is in the process of acquiring a water company which serves approximately 120,000 people. The city is planning and preparing for the future by using GIS to manage the water system. Nashua relies on GIS, *“technology to plan future improvements to their water delivery systems, quickly spot leaks, and uncover hard-to-find fire hydrants. They use it to track the dates when old pipes last received any maintenance. They rely on GIS to target which pipes or valves may next need a visit from the city or district maintenance staff”* (Rafter, 2011). GIS is helping Nashua conserve water through fixing leaks faster and maximizing the systems efficiency this also applies to smaller systems of water such as irrigation systems.

The city manages its water system by doing an in-depth inventory of assets. The inventory of assets helps in the day to day management, but is crucial when senior employees with long-term institutional knowledge of the system retire and that information could be lost. If the system has been mapped correctly and the knowledge of the supervisor is in the data and maps then as management changes over time this important institutional knowledge is available to the next generation of management and workers (Rafter, 2011).



Figure 3 Water Provider Systems Mapped (Rafter, 2011)

“Better maintenance is another important benefit of GIS technology, Brennan says. GIS allows utilities to better track past maintenance work. It also allows them to be more proactive when it comes to maintaining the health of their systems. Staffers may discover that water pipes are breaking across the city. Through the use of GIS and computerized maintenance management systems, staffers can target areas of the water system that should be repaired next to avoid future breaks. It’s usually cheaper to maintain a pipe than it is to repair one that’s already broken” (Rafter, 2011).

GIS technology allows professionals to see the system as a whole or zoom in on specific details. This same approach of managing large water districts or water providers is beneficial to irrigation maintenance companies, property managers, and agencies which are responsible for managing irrigation systems and water. **Knowing where your irrigation lines and parts are located is the first step in managing a system proactively.** Similarly institutional information of irrigation systems and property can be mapped and made available for all those involved in the long-term maintenance (Rafter, 2011).

Maricopa County Arizona has a population of more than four million. The growth patterns have largely been sprawling development and the county maintains more than 650 miles of road. The county was over burdened with tracking and managing the cleaning and sweeping of streets.

“To lower costs and improve business processes, the county decided to install GPS units on sweeper trucks that broadcast data when brooms are lowered for sweeping... As the sweeper truck drives down the street, the rotating brushes sweep road debris into the vacuum and off the street. Information is transmitted at 30-second intervals, providing the speed and location of the sweeper. The automated process replaces manual inspection and provides verification of work completed against work invoiced, ensures that speed limits are enforced, and provides support in litigation.” (Akuoko 2011).

The GPS/GIS technology is now allowing the county to track: sweeping vehicles assigned to routes, identification of driver on vehicle per day, speed threshold, virtual inspection, and comparison of bills assessed (Akuoko, 2011).

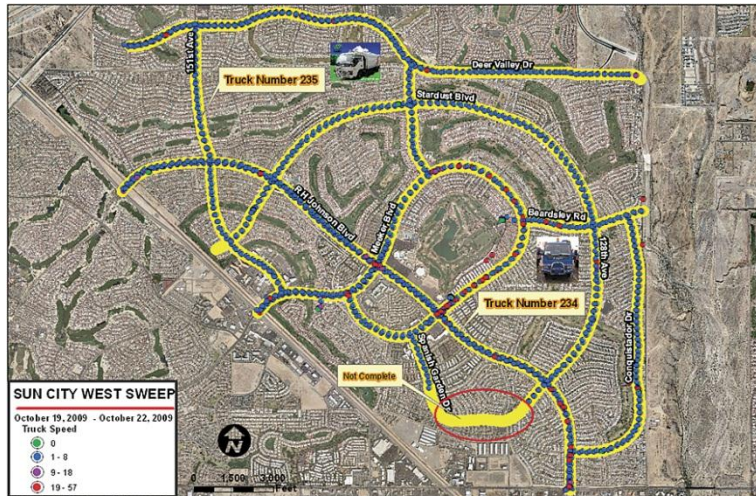


Figure 4 Map of Streets Swept (Akuoko, 2011)

“The objective of this program is to provide the tools necessary to effectively manage the sweeping contract with 100 percent accountability while reducing inspection costs” (Akuoko, 2011). The collection of GIS data while running sweeping vehicles makes it possible for the county managers to analyze and improve the maintenance of a large network of streets. **Likewise mapping and tracking large irrigation systems can also assist in creating greater accountability and effectiveness.**

Surveying the Field of Irrigation Mapping:

Irrigation mapping is the documentation or creation of “as built” diagrams or drawings of previously installed irrigation systems. In 2010 a survey was conducted of 37 irrigation/landscape professionals relating to irrigation mapping or documentation. The survey is the beginning of understanding how companies and organizations are documenting and mapping irrigation systems. The survey was conducted in December of 2010 (Benson, 2010). At this point in time limited research data is available in how irrigation professionals as a whole document previously installed irrigation systems.

As GIS/GPS technology evolves the application and use of the technology in the landscape and irrigation industries will also advance. The diagrams below show the results of the 2010 survey.

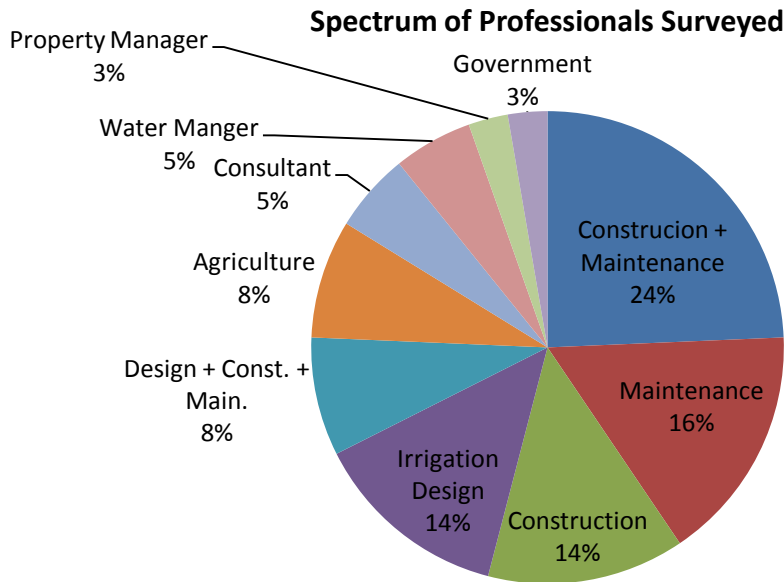


Figure 5 (Benson, 2010)

Does your Company Currently Create Irrigation Maps?

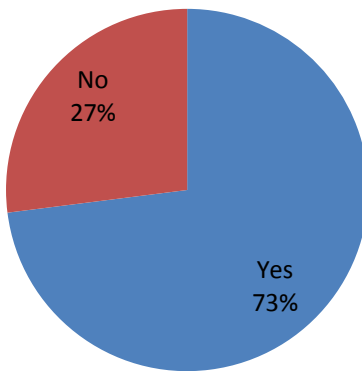


Figure 6 (Benson, 2010)

Are You Required To Create "As Built" Drawings?

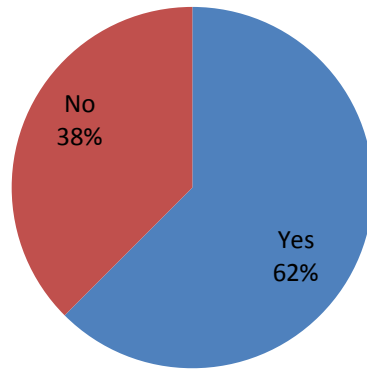


Figure 7 (Benson, 2010)

The majority of the group (73%) regularly creates irrigation maps as part of their work, but only 62% are required to create irrigation maps per mandate or specification. Most organizations involved with irrigation understand that it is essential to have maps or as built of irrigation systems to communicate the tasks of maintenance and repairs with employees.

The study shows that the majority of **landscape professionals still use old methods for creating irrigation maps** such as hand drawing or measuring in the field and then drawing on CAD. The problems with hand drawn irrigation plans is that often they are not drawn to scale, parts shown on plan do not show or correspond to the site, they are hard to read because of handwriting, and overall less effective.

The methodologies for creating irrigation maps will improve and advance in the coming decade as irrigation professionals have more educational opportunities and technology advances. From the 1980s to the 1990s the architecture and design industry underwent a major change as the technology of CAD (computer aided drafting/design) developed and became the prevailing method for designing buildings. Likewise technology advancement can assist irrigation professionals in managing the systems and water through accurate mapping.

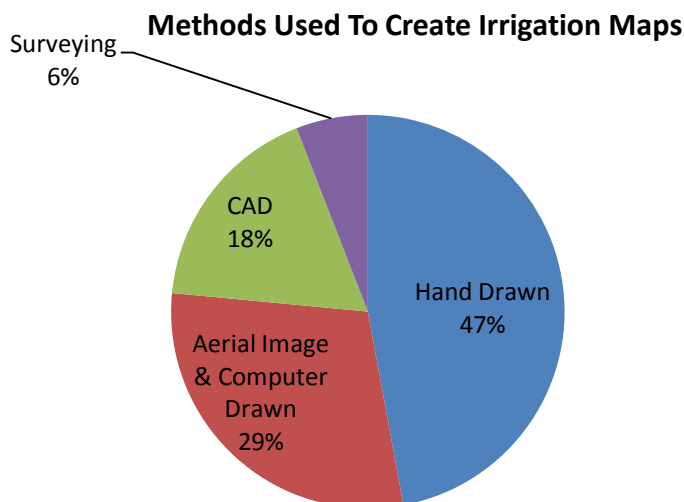


Figure 8 (Benson, 2010)

Do You Currently Use GPS Technology?

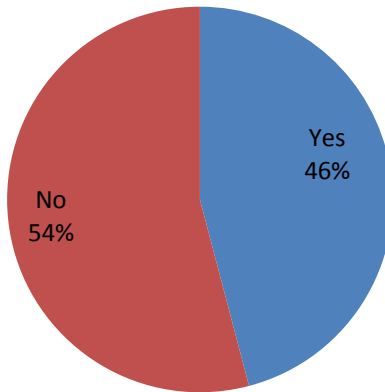


Figure 9 (Benson, 2010)

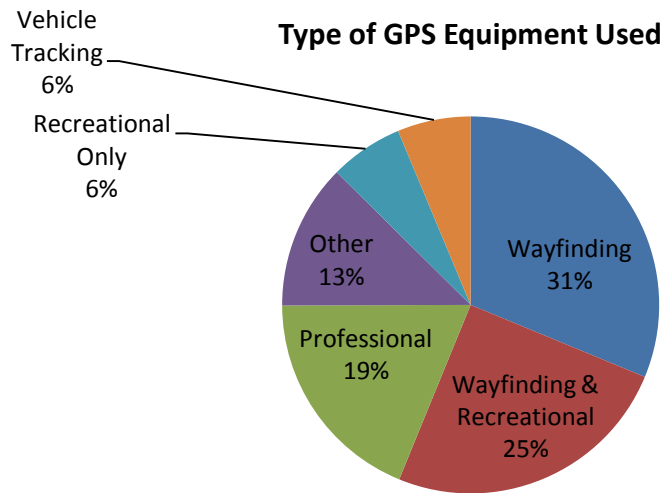


Figure 10 (Benson, 2010)

Figure 9 shows that less than half of the survey group was currently using GPS technology. This number will increase as technology and understanding increases. Figure 10 shows that many irrigation/landscape professionals are using common day to day applications of GPS. These applications include finding addresses, mapping points with basic recreational GPS devices. Only a few are using professional GPS equipment. With professional equipment you can collect GPS data for creating specific maps (such as irrigation valves, lines, trees and etc). The data is then imported into a GIS type program and a useable map is generated. Recreational GPS devices mostly track basic points, distances, and speed. Professional GPS equipment has higher accuracy and greater durability.

A group of 10 irrigation/landscape companies were surveyed in 2011. These irrigation/landscape companies have started using GPS technology for less than six months to map and document irrigation systems and landscapes. Prior to 2011 the majority of the companies involved in the study used hand measuring or survey equipment to get field measurements. Most of the map creation was done by hand, while some of the companies were using CAD for drawing (Benson, 2011).

The companies selected were spread out geographically including the following regions: Alberta, California, Texas, Utah, Ohio, Washington DC, Florida and elsewhere. In the irrigation industry work practices can vary according to climate and region. GPS mapping for irrigation systems was relevant and valuable no matter the geographic location.

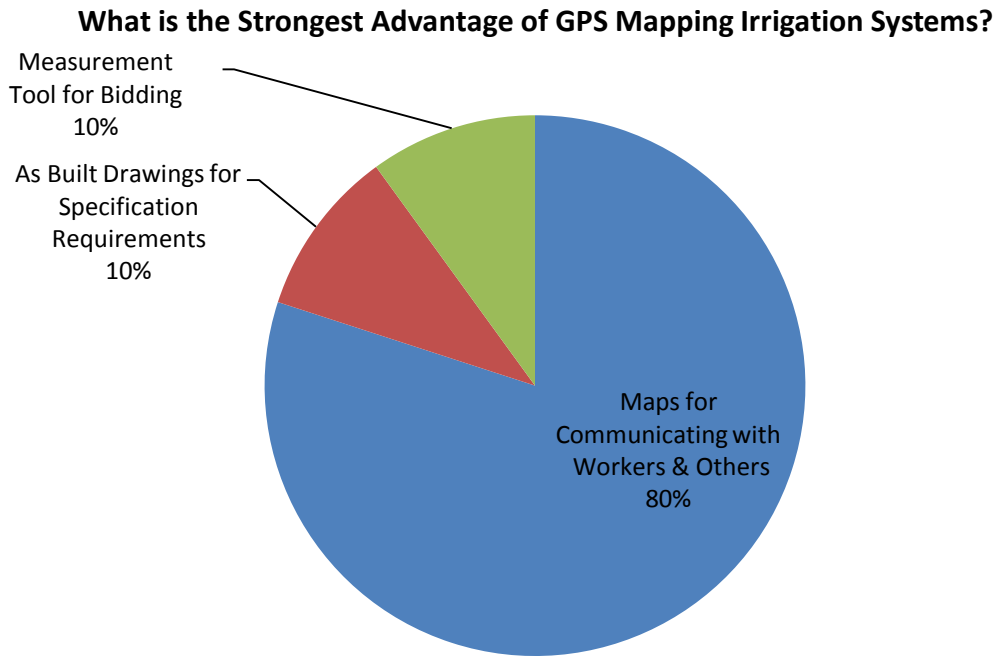


Figure 11 (Benson, 2011)

The question was asked “What are the strongest advantages of GPS mapping irrigation systems?” The provided answers included: Water Conservation, Measuring Tool for Bidding, Communication Maps for Workers and Others, Irrigation System Management, and Additional Source for Increased Revenue. **The greatest of value offered from irrigation maps is the communication tool between employees, managers and customers which provides a more effective service (figure 11).**

What Level of Employee is Trusted for GPS Mapping Irrigation Systems?

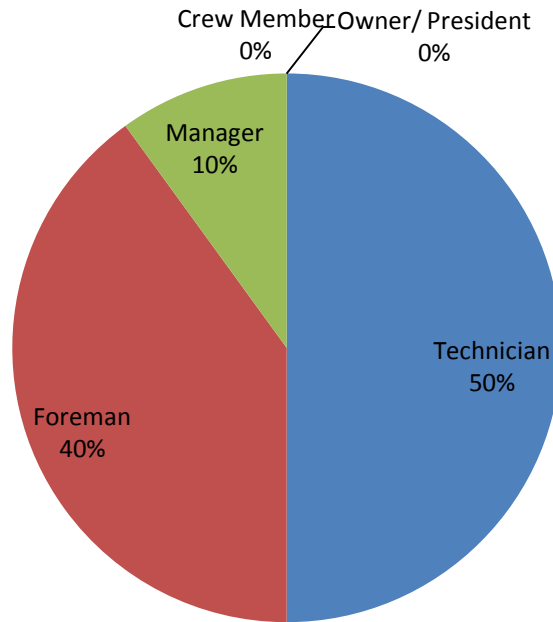


Figure 12 (Benson, 2011)

Historically GIS/GPS mapping has been done by professionals with higher education degrees in Geographic Information Systems or professionals who have received months of training. This advanced education was necessary to understand the science, run the applications and analyze the data. Technology used to create GIS maps for professional work is becoming more user friendly (even for non GIS professionals). As shown in figure 12 **trained foreman and technicians are doing the GPS mapping (not GIS professionals or upper management)**. Depending of the needs of each individual company, and the importance of their GIS maps, the employee's knowledge level and training time will differ. This is an important achievement for the irrigation/landscape industry to bring the cost level down and allow more organizations to offer this service.

Basic Steps to Irrigation Mapping:

There are many strategies to mapping and documenting irrigation systems. There are also various options for software such as generic GPS mapping or more industry specific. Some basic steps for irrigation mapping may include:

1. Prepare hand-held GPS for field. While it's not necessary, you may want to load aerial images, base map, setting parameters or projections.

2. Stand over parts and equipment in the field and take points or collect data. Common parts mapped include: controllers, backflow, shut of valve, remote control valves, main lines, lateral, spigots and other misc. landscape items (such as fire hydrants, trees, and electrical boxes). **It is recommended to add information regarding part sizes, manufacturer, model number, and condition of parts** (if it needs repairs or maintenance). **This information will be valuable when doing repairs or maintenance is needed later on.** Mapping in areas with buildings or extensive tree canopy can be challenging, you may have to move away from buildings/trees and take the points (to be adjusted on the desktop). While mapping you can turn on valves to map water coverage, to better understand the efficiency of the irrigation system and learn what is needed to improve water conservation.
3. The last part to irrigation mapping is loading the data onto the computer and creating maps. Maps can be large and complex or simple in nature. It is beneficial to have a site background such as a drawing of the site (if it's new) or an aerial image (if available). **Quality map creation usually requires some basic editing** (correcting exact location of part) or cleaning up maps to be readable. GPS technology is not perfect and like other professional work it requires adaptation at times.

Figure 13 shows one valve and its spray heads which were GPS mapped. This one valve and heads took approximately 5-7 minutes to map in the field. Measuring the distances in the field and drawing the same valve and heads in CAD or by hand would take two to three times longer. When mapping much larger or complex systems; such as 20-100 valves, multiple main lines, multiple clocks, and multiple points of connection is when GPS mapping becomes an incredibly valuable time saver.

Conclusion:

GIS and GPS technology is invaluable and is ever growing in its simplicity to use. The technology has been proven in related industries such as large water system providers and infrastructure management as shown in the examples from New Hampshire and Arizona. Currently the majority of irrigation companies are creating irrigation maps, but many are doing it with obsolete technologies or methodologies. Irrigation mapping techniques will improve as technology evolves and irrigation professionals are trained how to use them.

In the past GIS/GPS mapping methods required advanced education and a few weeks or months of training to learn how to collect data and create maps. Now irrigation mapping is becoming user friendly with easy to use systems and GPS technology designed for technicians. **Irrigation professionals should consider GPS mapping systems to improve service performance for their customers and manage irrigation systems for water conservation.**

The advantages of GPS mapping irrigation systems include:

- Accurate location of irrigation parts and system mapped
- Ability to find previously mapped parts and system (i.e. buried valve boxes)
- Ability to map or track parts that need maintenance or repair
- Maps can be customized according to points, features and layers (such as valves, lines, etc)
- Areas or parts can be mapped for bidding purposes
- Photos of parts can be geo-tagged (to add location of where the photo was taken on-site)
- Coverage of water distribution by heads can be mapped to show efficiency
- Maps and data of irrigation systems can be created for communicating work procedures to employees



Figure 13 Irrigation Head & Valve Map (Young, 2011)

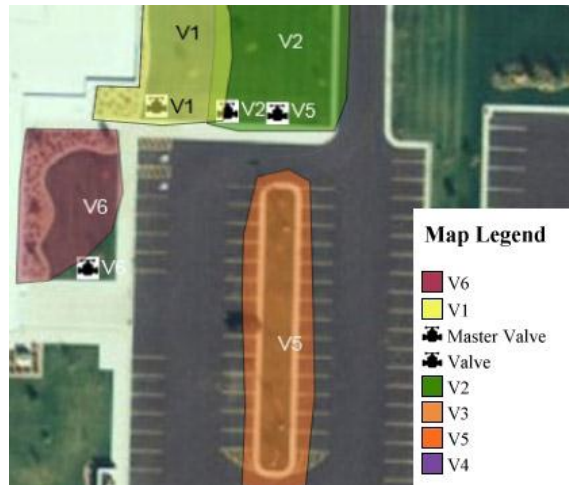


Figure 14 Irrigation Valve Coverage Map (Benson, 2011)

Irrigation maps hold the greatest value for irrigation professionals in offering better communication among employees, managers, and customers. If irrigation systems are mapped and documented it will offer organizations faster repairs, documentation of repairs, planning for improvements and create an overall better understanding of the systems. The GPS mapping and GIS management of irrigation systems **will conserve water through more timely repairs and the ability to plan for improvements**. As landscape and irrigation professionals learn and use this technology it will enhance their service to customers and assist them in creating beautiful landscapes that are sustainable and lasting.

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