Implementing Rural ITS in a Maintenance Environment

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Abstract

When crashes and weather-related events happen in a rural setting, solutions can range from simple to very expensive. Compounding this is remote locations and lack of readily available power and communications. Unfortunately, events in rural areas tend to be less frequent since total vehicle volume is low. When an event does happen, it may be at a higher speed or on a route with no other access. So, when something happens it gains a lot of attention at that time, but after the event focus reverts to normal activity or the next event.

Funding for solutions to these problems are traditionally sought from a safety allocation. Infrequent events on low volume roads are difficult to overcome the benefit/cost requirement. Most systematic evaluations only look at the last few years. Events could be infrequent enough to not show up or occur randomly. With this pattern it is hard to generate enough benefits to warrant a big investment.

With the available toolbox of ITS solutions, Washington County looked to identify possible low-cost solutions to existing system locations. The next step was to determine potential solutions and develop a high-level design and refine the design and level of automation by reviewing current staff operations in response to events.

Lessons Learned include the ability to implement automation in phases, input from maintenance and operation staff is key, and their buy in is essential. Benefits include safety in terms of reduced crashes and staff exposure, staff time and additional services to users.

KEYWORDS:
Safety, Operations, Rural

These Things Happen

Crashes and weather-related events happen every day and no jurisdiction is immune to it. They happen in both urban and rural locations and the effects differ greatly. When they happen in a rural setting, solutions to mitigate or avoid future occurrences can range from simple to very expensive. In rural settings, issues are exacerbated by longer travel distances to remote locations and lack of readily available power and communications. Permanent, long-term solutions are relatively easy to identify, but those involving major reconstruction may not always be possible.

Figure 1: Rural Crashes

Figure 2: Rural Weather Events (Snow, Flooding)

Unfortunately, events in rural areas tend to be less frequent since total vehicle volume is low. When an event does happen, it may be at a higher speed or on a route with no other access. So, when something happens it gains a lot of immediate attention, but after the event focus reverts to normal activity or the next event.

Funding for solutions to these problems is traditionally sought from a safety allocation, which usually requires a positive benefit/cost evaluation to be eligible for safety funding. Infrequent events on low volume roads make it difficult to overcome minimum benefit/cost thresholds. Most systematic evaluations only consider the most recent few years, but events could be infrequent enough to not show up in short term analysis or occur randomly. With this pattern it is hard to generate enough benefits to warrant a big investment. Accordingly, other lower cost solutions need to be developed.

Rural ITS Solutions Toolbox

Transportation agencies have many ITS solutions at their disposal to alleviate safety and operational issues in rural areas. This section describes them and when they might be useful.

Flood Gate Systems

In areas prone to flooding, flood gate systems can prevent travelers from entering flooded roadways and provide efficiency benefits to agency operations and maintenance crews.

Typically, two flood gates are installed to close a section of roadway during flooding events. Physical gates can be more effective at preventing travelers from entering flooded roadways than temporary barricades, which can be moved out of the way or bypassed.

Gates can be manually operated or automatic. The gate arms can be outfitted with sensors that monitor the position of the gates. This gate position information can be transmitted to the agency's central monitoring system and external traveler information dissemination services to notify travelers of roadway closures during flooding.

Intersection Conflict Warning Systems (ICWS)

ICWS are an ITS treatment at unsignalized intersections with stop control on the minor approaches. ICWS deployments are intended to improve safety by reducing number of crashes and crash severity. These systems are typically installed at sites with limited sight distances or gap acceptance issues. They work by detecting vehicles and then alerting motorists on the adjacent intersection approach through activated signs. An example layout of an ICWS at a three-leg intersection is shown in Figure 3**.**

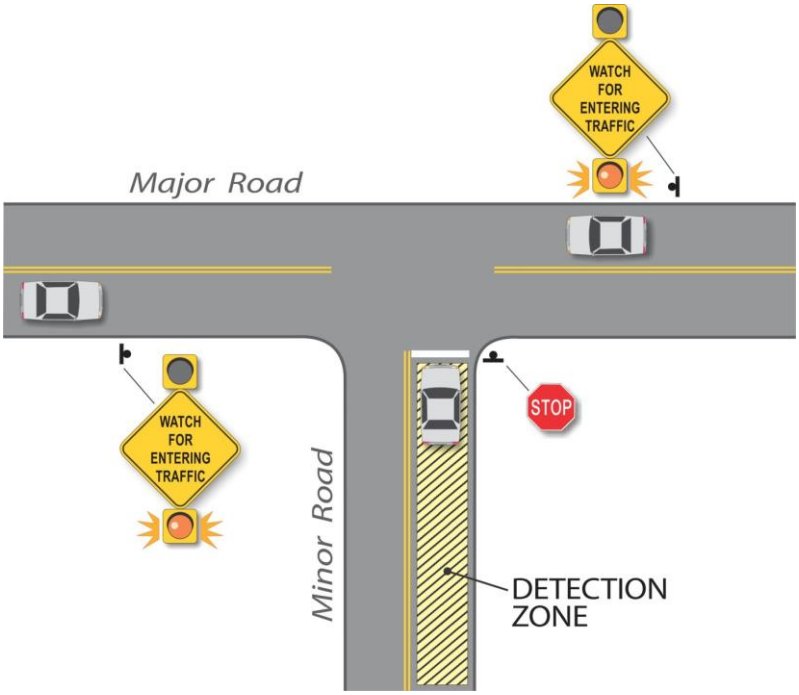

Figure 3: Example Intersection Conflict Warning System Sketch

The Federal Highway Administration (FHWA) ENTERPRISE pooled fund study provides recommendations on ICWS layout based on evaluations of deployments across the United States.[1] Design elements including activated warning signs and locations of vehicle detection are guided by Average Annual Daily Traffic (AADT) on the major road. Design guidance for the ICWS is summarized in Table 1 below.

Table 1: FHWA ICWS Design Guidance

AADT on Major Road	Activated Warning Sign Location	Vehicle Detection Location
Under 3,000	Minor road	Major road
Between 3,000 and 10,000	Major road	Minor road
Over 10,000	Both minor and major roads	Both minor and major roads
AADT so high that warning beacon is activated almost constantly	Both minor and major roads with direction or speed information	Both minor and major roads

Variable Speed Limits (VSL)

VSL are a treatment that is used to provide dynamic speed limits based on congestion or weather conditions. Their purpose is to reduce crashes and crash severity. These systems take data collected by traffic and weather sensors, apply an algorithm, and display a speed limit accordingly. VSL systems can display regulatory speed limits or advisory speeds. When these systems display advisory speeds, they are referred to as variable advisory speed (VAS) systems.

[1] Athey Creek Consultants and USDOT FHWA Office of Safety, 2011. "Design and Evaluation Guidance for Intersection Conflict Warning Systems (ICWS)," ENTERPRISE Transportation Pooled Fund Study TPF-5 (231).

Camera Surveillance

Camera surveillance systems supplement individual ITS solutions by providing operators, maintenance, and responders with a visual of the site. Pan-tilt-zoom (PTZ) cameras are the most common style for modern deployments.

Road Weather Information Systems (RWIS)

RWIS are systems primarily intended to support winter road maintenance activities. Using RWIS information, agencies can dispatch plowing/de-icing efforts more efficiently and obtain information on prevailing weather conditions to proactively manage the transportation system.

FHWA concisely summarizes that "the RWIS collects, transmits, processes, and disseminates weather and road condition information." RWIS are comprised of roadside RWIS stations, communications between stations and a central server, hardware/software, and distribution of weather information to operations and maintenance personnel. Each station may have an array of different types of weather sensors and PTZ cameras, depending on site-specific needs.

Standalone sites are the typical RWIS stations deployed by many state departments of transportation. Traffic signal-integrated stations are simply environmental sensors mounted to existing traffic signal poles.

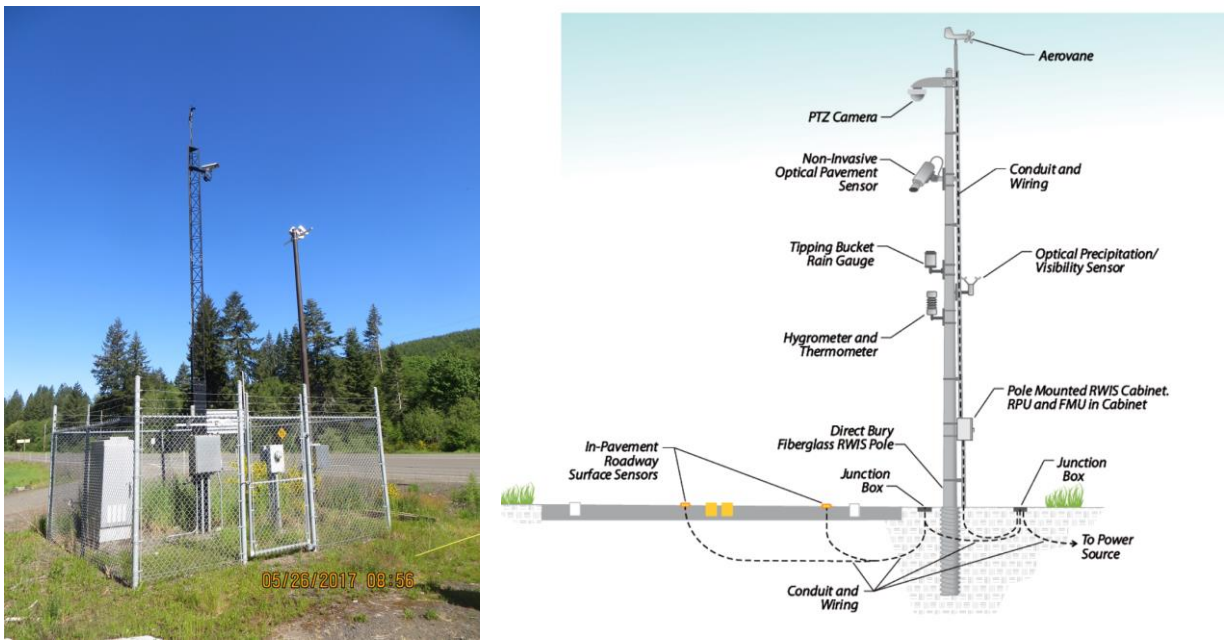

Figure 4: Typical Standalone and Simplified RWIS

Table 2 provides an overview of the features of each type of site. Washington County plans to install both standalone and signal-integrated RWIS stations.

Table 2: Features of Standalone vs. Signal-integrated RWIS Stations

Standalone RWIS Station	Signal-integrated RWIS Station
• Need power and communications infrastructure, a structure (e.g. a tower), and a cabinet • Flexibility to include a wide array of sensors • Often enclosed by a fence to protect site from vandalism	• Benefit from using traffic signal power and communications infrastructure • Number/type of sensors constrained by available space on existing signal poles, conduit capacity, cabinet capacity, and sensor occlusion

Snow Zone Signs

In some jurisdictions, motorists are required to have chains or traction tires in designated "snow zones." Snow zone signs provide status information to motorists of conditions within designated snow zones during severe weather. Snow zone signs are typically used in high elevation areas. The signs use dynamic displays to alert status information to motorists. Figure 5 shows an example of snow zone sign status. Signs can be automated and integrated to agency field equipment monitoring systems. Automated signs can provide efficiency benefits for maintenance activities.

Figure 5: Snow Zone Sign

Speed Feedback Systems

Speed feedback systems are ITS devices that alert drivers of their speed to slow them down. The signs are typically coupled with a warning sign or a regulatory posted speed sign. The speed feedback portion is an LED display that shows the driver's speed. The signs typically include a radar sensor that measures the vehicle's speed.

Dynamic Warning Signs

Dynamic warning signs display messages based on prevailing conditions or supplement a static sign with flashing beacons. These signs are intended to reduce crashes and can be tailored to many site-specific issues like curve warnings, traffic signals ahead, high truck areas, or obstacles ahead that are out of sight.

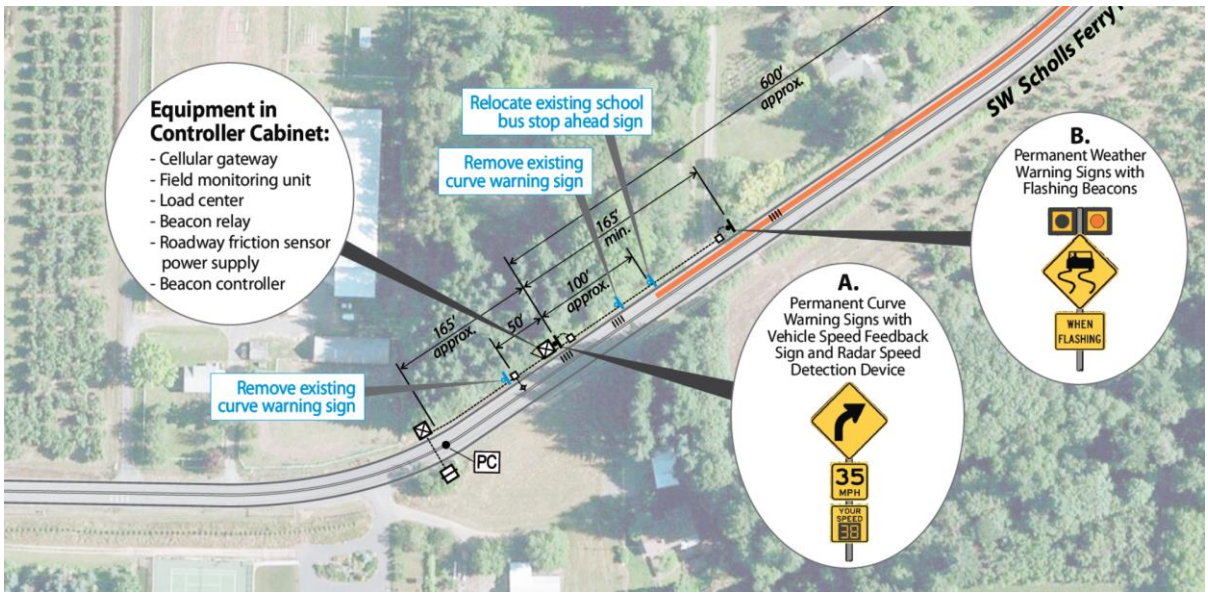

Figure 6: Dynamic Warning Signs

Project Development

With the available toolbox of solutions, Washington County, Oregon looked to identify possible low-cost solutions to existing system locations. With limited resources and funding, the goal was to implement smaller projects over a wide area rather than one big expensive fix. The process for developing each project was identical: identify the location and problem, determine potential solutions, and develop a high-level design. The next step was to refine the design and level of automation by reviewing current staff operations in response to event.

The goal was to fully automate solutions to reduce burden on maintenance and operations staff as well as not overwhelm IT personnel. To demonstrate this process a single example project was chosen to explain the steps in detail. See Figure 7 for conceptual design of an automated floodgate system.

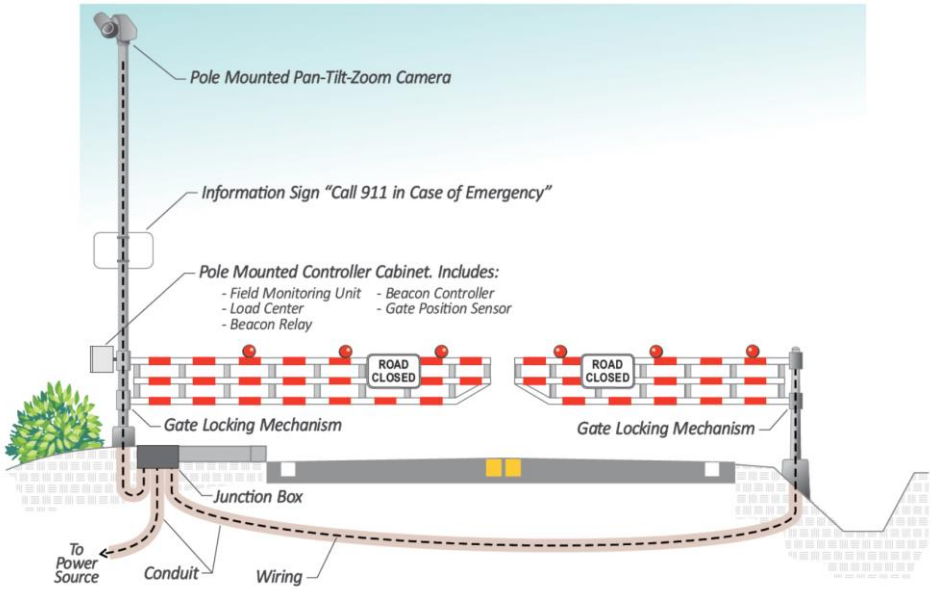

Figure 7: Conceptual Design of Floodgate System

The flooding on Fern Hill Road is managed by Washington County Operations Division, which is a separate division from the ITS/Traffic Group. ITS/Traffic is part of the Engineering and Construction Services Division. The Fern Hill gate project was one of a small group of projects identified by Operations during the ITS plan project list update. Operations would own, and operate the gate system, whereas Traffic would design, construct, and maintain certain electrical and communication components.

Traffic started out by developing a list of questions that Operations could consider internally before setting up meeting to discuss with Operations management, supervisors, and field staff to ascertain and document how they currently monitor rising water levels, close the road, and open the road after the flooding subsided. The focus was on key decision points, what data fed those decisions, and where the critical locations were located in the field.

For example, Traffic learned that Operations uses a nearby rain gauge and water level data to predict when flood levels would occur. With flooding occurring annually, Operations archived a data set that was used to roughly correlate sensor data with conditions at Fern Hill Road. When heavy rains or the possibility of flooding was imminent, Operations began sending field staff to check on the status of the water on Fern Hill Road. This was both a day and night operation.

Figure 8: Floodplain around Fernhill Road

Other information gathered from Operations staff was their interaction with the local EMS providers. In some instances, local fire or sheriff personnel would close the road by moving barricades into place and then Operations would come out to flip down the high-water warning signs on each approach of the closure. In several cases the public would move the barricades when the road looked clear. This was more of a problem at the south end, because water would recede here first, but the road would still be flooded at the North end. The stretch of road that floods is over 2,000 feet long with a dog leg that restricts visibility from end to end.

Some other important information Operations provided were the locations they set up barricades, the location of the low point in the road, and where on the road it first floods and recedes last.

Figure 9: EMS rescues drivers that entered the flooded roadway and were swept downstream

After flood waters recede, Operations would often need to sweep the road to remove gravel, farm debris, and other vegetation debris before opening the road.

Some of the needs that Operations identified were the ability to quickly close the road, the ability to secure or lock the gates to the public, but allow for EMS access if needed. They also expressed the desire to better know the conditions of the road both leading up to and during the flood event.

After meeting with Operations, understanding their work flow and concerns for full automation, the project was able to be scaled and sized to meet several operational objectives, without over complication. Each element of the design took into consideration the value added, potential staff time savings, the service to the public, and the on-going costs to operate.

Field visits were helpful to identify what resources were nearby and potentially available including communications and power. They were also useful to better understand the constructability issues that would be encountered. The field visits were valuable in identifying the deep ditch lines and roadway conflicts at potential locations for permanent gates.

Facilitating discussions in the field between and among stakeholders from Operations, City of Forest Grove, and others involved in the project opened up channels of communication that are often harder to establish if they attempted in the office. The designers/engineers were in the operator's element and information seemed to flow more easily. Items such as parking/staging could be pointed out and areas of skepticism about the project could be addressed directly without putting someone in the awkward position of disagreeing with their supervisor in a group setting. During the field visit, sight lines could be established for locating cameras, and feasible spots located for the gates.

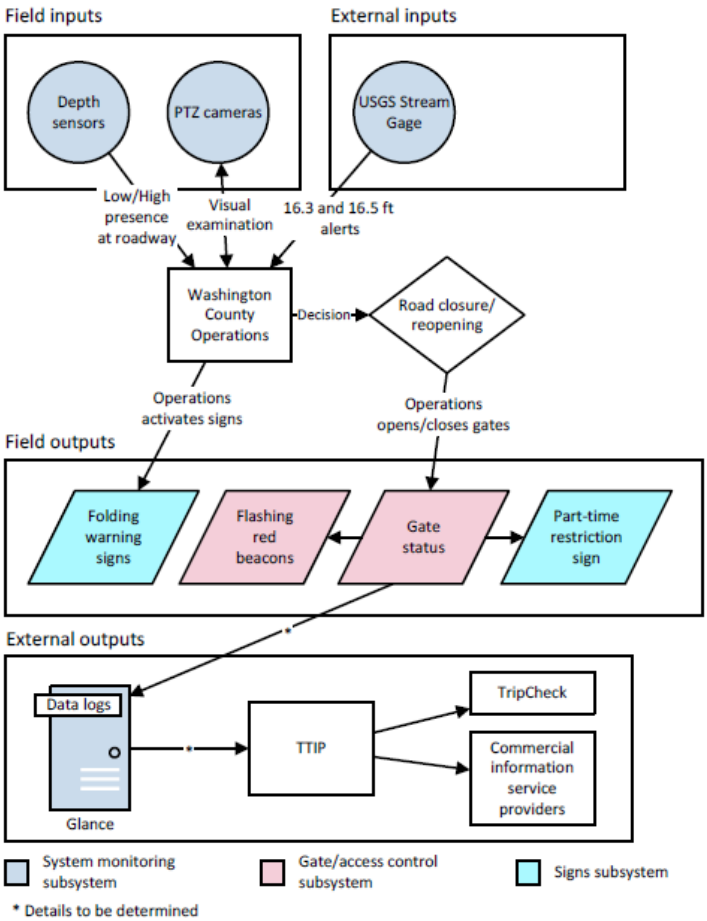

Figure 10: Proposed System Architecture

By talking with maintenance personnel, it was learned they had to go to field to inspect the road before opening it back up to the public. Fully automating the gate did not save a trip to the location. The project then shifted focus to elements that enhance automated detection of flooding onset so a faster response could be facilitated and trips to continually check the water level could be eliminated. The final gate design intentionally does not preclude eventual full automation.

Refinement/Collaboration

Field automation objectives include making a task easier, quicker, and/or more efficient. Adding electronics and instrumentation that requires a lot of maintenance discourages long-term use and further automation. The rural and urban parts of the County are spread out, so any equipment installed needs to be reliable and durable.

Integrating field systems can be a challenge because most systems require a network and Information Technology support to deploy, integrate, and maintain.

The level of institutional support will dictate how the system is designed and deployed. Several vendors provide turnkey systems that are web-based and accessible from any Internet connection. Communication to the field units can be included as part of the capital cost or paid through an annual subscription. These options make it very reasonable to bring automation to a small municipality that doesn't have a lot of resources.

Details such as power, communication, locations for footings, how to lock open/lock closed, elements of automation like how to mount sensors on the gate are determined. Constructability often dictates what stays in the project from the high-level design to the final construction.

Ideas that seemed feasible are winnowed out as the costs become more refined, the ability/inability to construct becomes apparent, and the cost/benefits weighed. The Fern hill Gates started out as a completely automated gate system but in the end a manual closing gate with some automation to help with monitoring and traveler information made the most operational and cost sense. Infrastructure was designed to help facilitate further automation in the future as desired.

Washington County uses a subscription service (Glance GUI) to monitor and operate their systems. This reduces some of the burden on the IT department and allows all systems to monitored from one interface and is available to all maintenance and operations personnel.

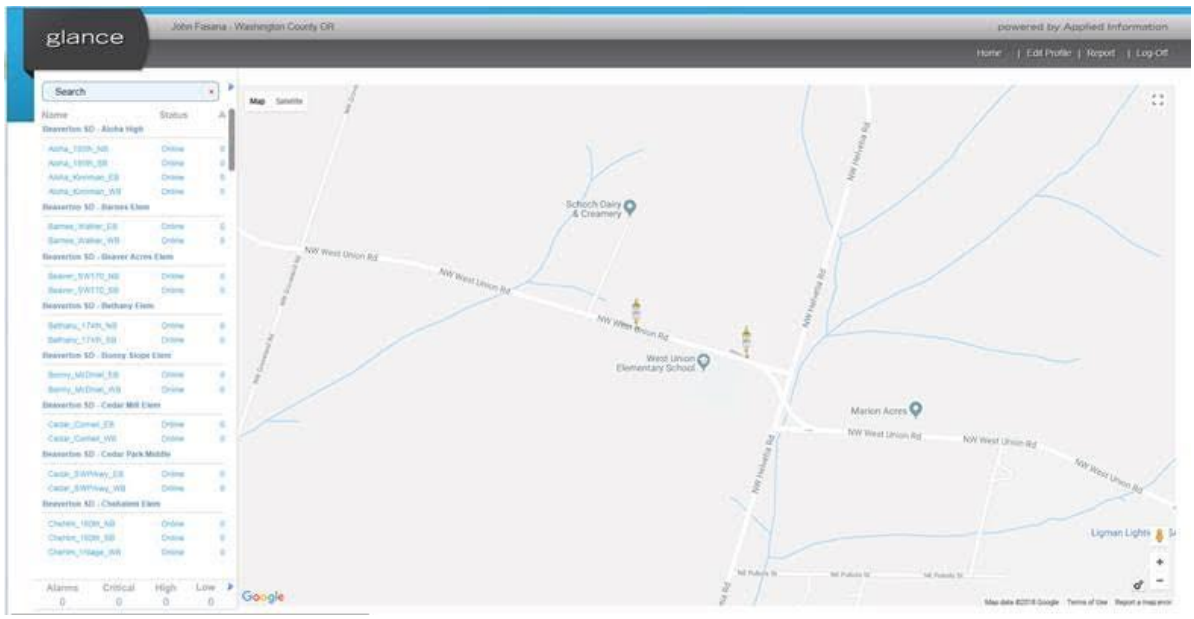

Figure 11: Glance GUI

Figure 12: Fernhill Road Floodgate System in Operation

Key Takeaways

Lessons Learned

- Projects designed for full automation and functionality can be scalable and/or implemented in phases
- Coordinate with resources and gain input from stakeholders
- Obtain buy in from maintenance and operational personnel
    - They will come up with ideas on how to do it better or less costly
    - They will possess information that can make the project successful, like locating equipment in an area that will be accessible during a flood

The point of the project is to help them do their job better.

Benefits

- Safety - Reduction in crashes, less exposure of staff
- Staff time - Save travel time to distant locations like snow zone signs
- Service - Providing information to users that normally would not have