BENEFITS OF THE SOUTH SAN JOAQUIN IRRIGATION DISTRICT'S PILOT PRESSURE IRRIGATION PROJECT

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ABSTRACT

The SSJID board commissioned Stantec Consulting as a partner in developing an irrigation program that could improve delivery efficiency and service. A portion of one of the District's nine divisions – 3,800 acres in Division 9 – was chosen as the site for building, testing, and optimizing a pilot pressure irrigation project. The vision for the system included the following fundamental capabilities:

- Pressurization – pumping water from a 56-acre-foot pond to individual farms through 19 miles of pressurized pipeline
- Calculated use – letting farmers choose the time, volume, and flow rate of deliveries
- Automated/mobile access – developing a web-based tool that allows farmers to schedule deliveries from a computer, smart phone, or iPad based on current and past weather forecasts, previous water usage and historical evapotranspiration rates, and orchard moisture sensors.

This paper will focus on the realized benefits for the SSJID and the Division 9 farmers including but not limited to: improved service to crops, volumetric billing compliance, improved irrigation flexibility(duration, frequency, flow rate), water conservation, reduction in farmer energy costs, reduced groundwater pumping, improved air quality, improved yields, reduction in labor inputs, automatic delivery information for billing, increased pumping efficiency, increased District enrollment, protection of water rights, improved flood delivery service and efficiency, intelligent irrigation scheduling, and improved management of flows through a regulating reservoir.

INTRODUCTION

The South San Joaquin Irrigation District (SSJID) has historically delivered water to farmers through 400 miles of gravity-based canals and pipelines. Farmers drew from the network of laterals at scheduled times via flood irrigation or private pumps used for sprinkler or drip systems.

While the system works well for flood irrigation, the combination of flood and sprinkler usage on a single system becomes problematic. As a result, some customers did not buy water from the SSJID, opting instead to draw from their private, salinity stricken wells.

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The SSJID board commissioned Stantec Consulting as a partner in developing an irrigation program that could improve delivery efficiency and service. A portion of one of the district's nine divisions – 3,800 acres in Division 9 – was chosen as the site for building, testing, and optimizing a pilot pressure irrigation project.

The newly completed pressurized irrigation system is among the most water-efficient in the agricultural industry. Designed to be an industry model for water efficiency and provide area growers with individualized, automated irrigation access through the use of online and mobile technology, the new system was designed and constructed over a three-year period. Design of the new system was developed and implemented as a cooperative effort between Stantec Consulting and the SSJID.

The project consists of a 19-mile network of pipelines with flexible pressurization (currently set at 60 psi), a 56-acre-foot water storage basin, a 1,225-hp pumping station containing seven vertical turbine pumps capable of pumping a total of 23,500 gal/min (52.4 ft^3/s), and a total of 55 solar-powered Field Telemetry Units or FTU's controlling 77 customer connections. The FTUs consist of a PV panel, a flow control valve and meter, and a radio based supervisory control that communicates with data acquisition (SCADA) system in the pump control room.

With the new system, irrigation water is distributed to the customers across 3,800 acres of California's Central Valley through an automated channel. Using an online system similar to an airline ticketing platform, growers in the District's Division 9 are able to log-in and schedule water deliveries. Additional information on current and past weather forecasts, previous water usage, historical evapotranspiration rates, and real-time moisture sensor readings are also available on the website. Each farmer selects from available delivery dates and receives alerts via email and text message before and after delivery to confirm volume and flow rate data. To promote efficient water usage, moisture sensors placed in the ground on each grower's property will help indicate optimal ordering times when orchards are at their greatest need. This paper will focus on the realized benefits of the Division 9 Pressure System Project.

IRRIGATION SERVICE

An irrigation service study was conducted in 2012 by Davids Engineering in conjunction with the District's On-Farm Conservation Program to assess the current service quality the District is providing to its customers. Survey results related to irrigation water availability, flow rate, and duration are detailed below. As a comparison, customers of the pressure system are now receiving irrigation water at the exact time, flow rate, pressure, and duration they desire. In addition, the reduced number of customers using the gravity system has allowed the flood runs to be accomplished faster and more efficiently, with less stress on the previously overloaded gravity system and reduced long term maintenance costs.

Availability

Figure 1 shows the percent of surveyed SSJID farmers for each irrigation application method who irrigate based on surface water availability. With the Division 9 pressure system, zero farmers irrigate based on surface water availability; the farmers irrigate when their crops need it.

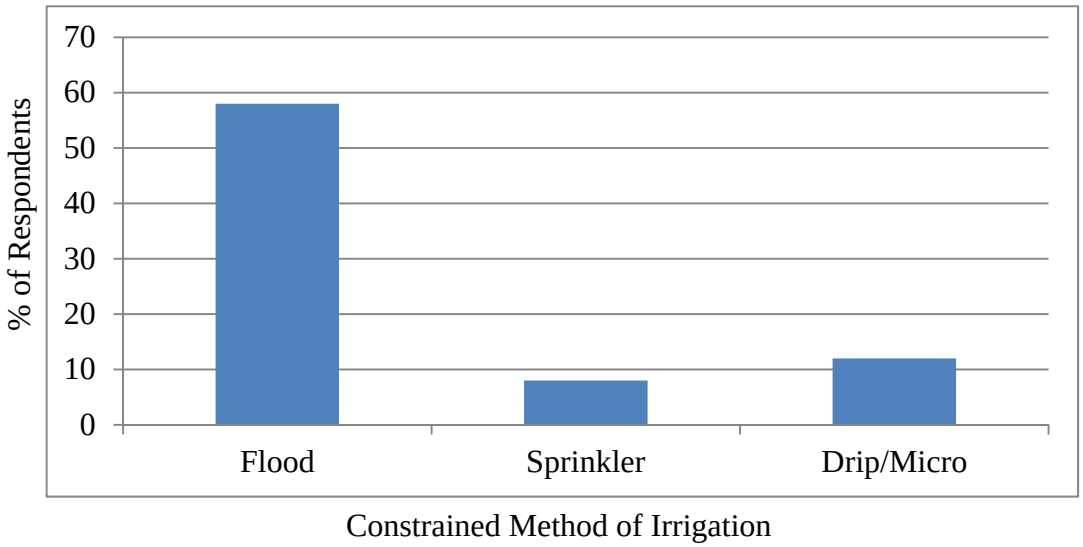

Figure 1. Percent of surveyed SSJID farmers for each irrigation application method who irrigate based on surface water availability.

Flow Rate

Figure 2 shows the percent of surveyed SSJID farmers for each irrigation application method who determine flow rate based on District infrastructure system flow constraints and/or District infrastructure turnout system capacity. With the Division 9 pressure system, zero farmers determine flow rate based on District infrastructure system flow constraints and/or District turnout system capacity; the farmers irrigate at the exact flow rate they desire.

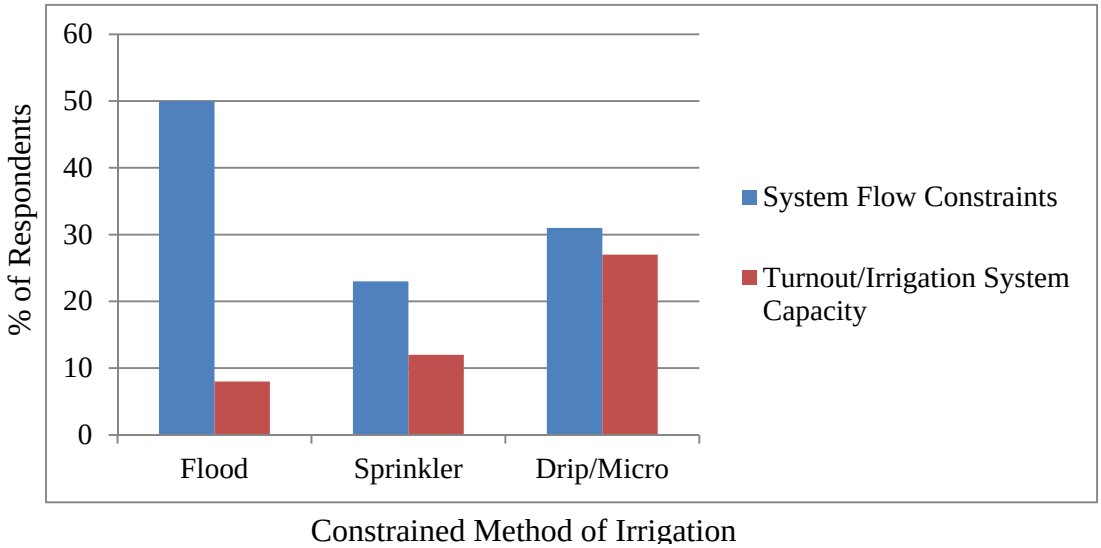

Figure 2. Percent of surveyed SSJID farmers for each irrigation application method who determine flow rate based on infrastructure limitations.

Duration

Figure 3 shows the percent of surveyed SSJID farmers for each irrigation application method who determine irrigation duration based on infrastructure constraints. With the Division 9 pressure system, zero farmers determine irrigation duration based on District infrastructure delivery system constraints; the farmers irrigate for the exact duration they desire.

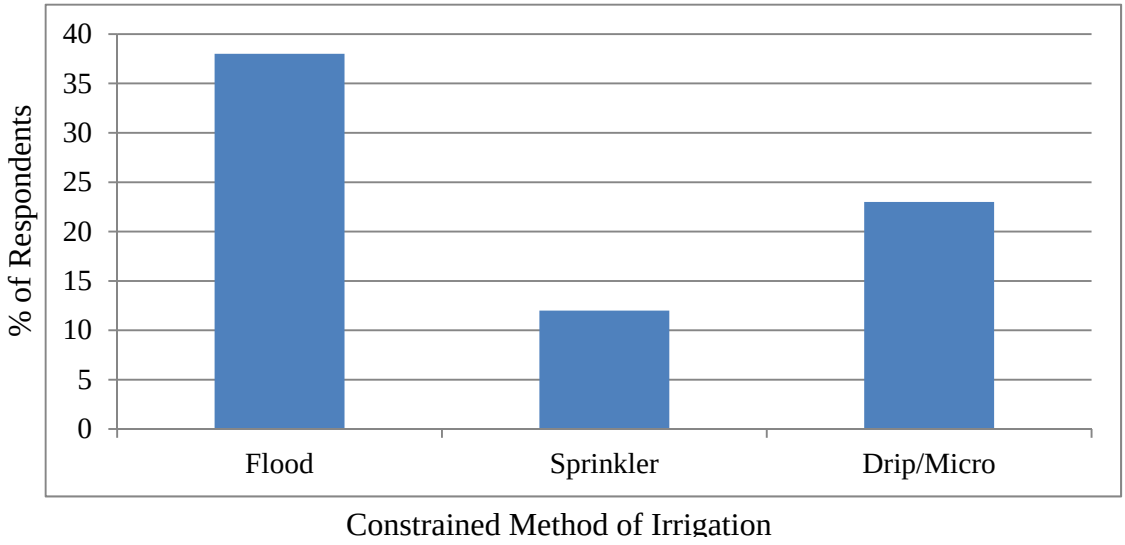

Figure 3. Percent of SSJID farmers for each irrigation application method who determine irrigation duration based on infrastructure constraints.

WATER CONSERVATION ACT COMPLIANCE

A growing population and competing demands for limited water resources prompted California to pass the Water Conservation Act. In addition to a 20% reduction in per-capita urban consumption by 2020, the law requires agricultural suppliers to “implement efficient water management practices” and volumetric pricing. With a statewide assessment of water use under way, the SSJID Board of Directors realized the issue posed a potential threat and approved the Division 9 pressure system upgrade to demonstrate the District is proactively addressing California’s conservation goals. The Division 9 system efficiently manages water delivered by reducing water needs by up to 30%(Dunbar, 2012) and accounts for water use through magnetic flow meters at each customer connection.

VOLUMETRIC BILLING

The farmers in the SSJID service area have historically been charged a flat rate of $24/acre for irrigation water. To come into compliance with the Water Conservation Act, the SSJID is required to bill water deliveries volumetrically. A typical 40 acre orchard

has numerous valve structures used to flood irrigate the land. This poses a very difficult and expensive challenge for the District to comply with due to the thousands of exit points off of the gravity system. With the Division 9 pressure system, each customer has one connection point, with a magnetic flow meter to measure and transmit water deliveries; historic data are automatically stored on the District's server for uploading into the District's billing software.

RELIABILITY AND ACCESS TO DISTRICT'S WATER SUPPLY

The District's fixed, 10-day delivery schedule does not provide an optimal water supply at the frequency needed to maximize yield of crops. The Division 9 pressure system's East Basin Pump Station doubles as a regulating reservoir, storing and pumping irrigation water to 77 customer connections on an on-demand basis.

CONVERSION FROM FLOOD TO SPRINKLER IRRIGATION

The introduction of the Division 9 pressure system induced a demand to convert from flood irrigation to sprinkler/drip application methods. Of the 77 customer connections in the system, 18 have installed sprinkler or drip systems immediately after the pressure system was available to serve their land. The increased use of sprinkler/drip increases the irrigation efficiency of the farming operation and contributes to the goal of maximizing beneficial use of the District's water rights.

RENEWABLE ENERGY

The abundant sunlight in the Central Valley of California is one of the reasons why agriculture is so successful. The Division 9 pressure system taps this readily available solar energy to meet the power demands of all of the customer connections. The solar system powers the solenoids of the flow control valve, magnetic flow meter, moisture sensors, process logic controller, and radio communications to operate the turnouts and provide real time information on flow rate, crop moisture conditions, turnout pressure, control and battery component status, and delivery details(start time, end time, total hours irrigated, average flow rate, total water delivered).

WATER CONSERVATION

The Division 9 pressure system includes a number of conservation features that contribute to the District's water savings. These measures include drip and sprinkler conversions, a tail water recovery system, intelligent irrigation scheduling, and soil moisture monitoring.

From a conservation perspective, delivering the right amount of water(and nothing more) to the District's irrigation customers through 400 miles of gravity based pipelines spanning approximately 72,000 acres is very problematic and often times causes spills to the drain. During drought years, when water conservation is paramount, infrastructure that allows precise and accurate water deliveries that match a farmer's actual water needs

is a crucial asset to ensure that the water needs of all of the District's customers can be met. Frank Avila, SSJID's telemetry and SCADA manager, reports that the new pressure system reduced spills to the drains in Division 9 by 5,000 acre-ft in the 2012 irrigation year.

The ten year average water supply (2002-2011) to the Division 9 pressure system customer base has been 7,528 acre-feet. The summation of water deliveries (calculated via magnetic flow meters at each customer connection) through the pressure system for the first year amounted to 4,695 ac-ft. Thus, a 2,833 acre-ft conservation has been achieved.

On a water delivered per acre basis, the savings are magnified because 50% of the customers of the pressure system were using their own wells prior to the pressure irrigation system being constructed. With the introduction of the Division 9 pressure system, the District was able to re-enroll these farmers and get them to reduce ground water pumping and use higher quality surface water. Prior to the pressure system, 19,924 acre-ft of water was delivered to Division 9 to support 3,151 acres, or 6.32 ft of water per acre. Water deliveries for the pressure system customer connection for the 2012 irrigation year amounted to 4,695 acre-ft to support 2,389 acres, or 1.96 ft of water per acre. In addition to the Division 9 water conservation Davids Engineering found that SSJID's On-Farm Conservation Program is also producing water savings using many of the same measures featured in the Division 9 project.

Table 1. Water conservation results from SSJID's On-Farm Conservation Program (Davids, 2012).

Conservation Measure	Fields Evaluated	% of Fields Evaluated for each Conservation Measure	Acres	% of Acres Evaluated for each Conservation Measure	True Point Deliveries, ac-ft (March - October)		Preliminary Conservation Estimate	
					2010	2011	ac-ft	inches
Drip Conversion	8	53%	379	54%	1093	719	374	11.8
Sprinkler Conversion	4	80%	220	90%	472	373	99	5.4
Tail water Recovery	0	NA	0	NA	NA	NA	NA	NA
Grower Proposed	1	11%	25	10%	100	101	-1	-0.6
Irrigation Scheduling	7	30%	278	30%	996	721	275	11.9
Soil Moisture Monitoring	47	61%	1,497	58%	5,242	4,695	547	4.4
Totals	67	51%	2,399	45%	7,902	6,608	1,294	6.5

FARMER OPERATING COSTS

A case study was conducted at the end of the 2012 irrigation season on three customer pressure system turnouts that previously elected to not take District water and use their own wells to pump water from the groundwater aquifer. When the current diesel fuel costs and their historical records of run time hours are compared to the $30/acre-ft the District charges for delivered pressurized water, the farmers at these three locations are experiencing between 34 – 67% reductions in costs for pressurized irrigation water. These numbers do not factor in costs the farmers historically incurred to maintain their personal pumps and the increased labor costs of a manual irrigation operation compared to the fully automatic pressurized water the District now supplies.

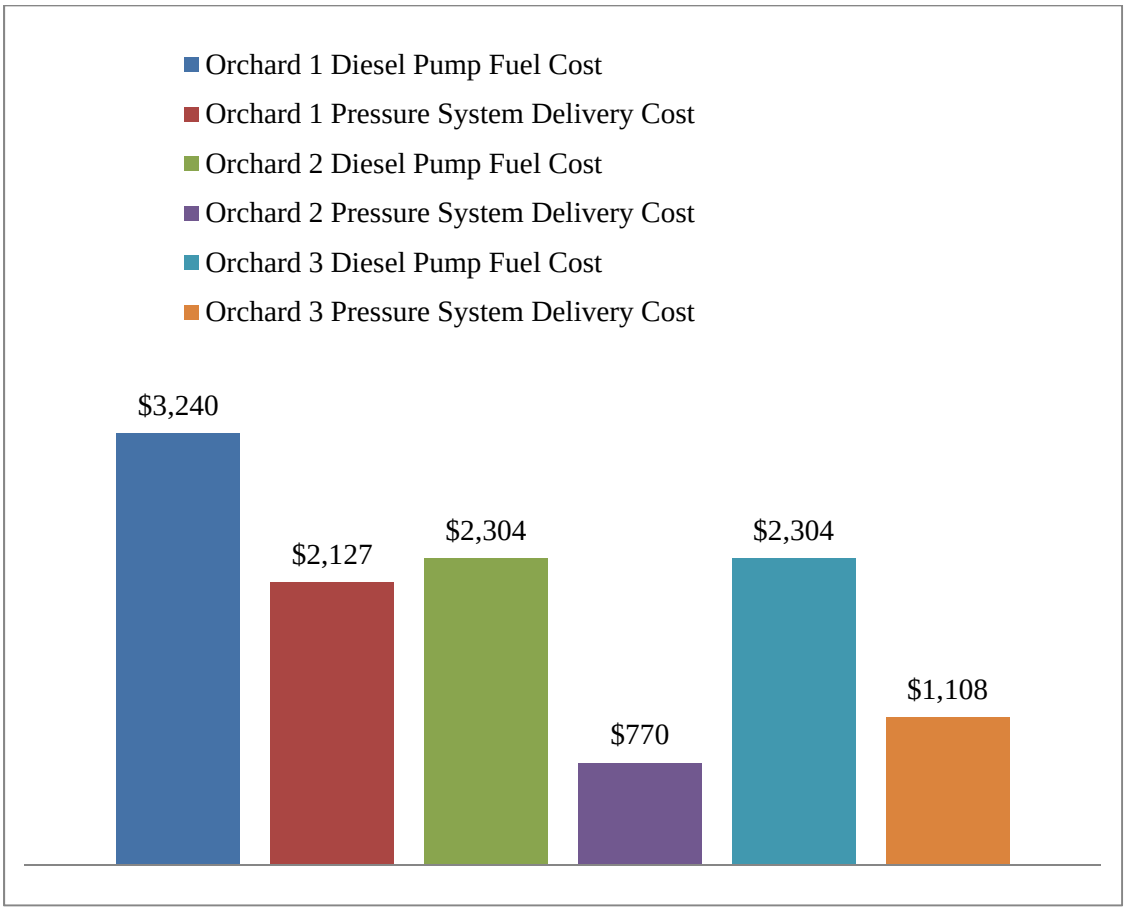

Figure 4. Comparison of farmer fuel cost to pump water from private well to meet irrigation demands vs. SSJID supplied pressurized water for a peak summer month.

Table 2. Farmer savings from pressurized system compared to energy costs to pump from private well.

	Farmer Savings (%)
Orchard 1	**34%**
Orchard 2	**67%**
Orchard 3	**52%**

GROUNDWATER PUMPING AND AIR QUALITY

The irrigation service component of this project was conceived because growers in this immediate area were coming into our office and complaining that the groundwater was getting too salty to apply to permanent crops and the cost of running pumps was chewing up profits," SSJID General Manager Jeff Shields said(Campbell, 2012). The Division 9 pressure system has reduced the acreage pumping from the ground water aquifer by 50% according to the Division 9 Manager Michael Donahue. Groundwater pumping in the Division 9 area was primarily conducted using diesel driven pumps. The reduction in diesel emissions has improved the air quality, and the high quality surface water has improved crop (primarily almond and walnut orchards) health.

FERTILIZER APPLICATION

Farmers participating in the pressure system to a large extent are using direct injection of fertilizer at their filter stations and delivering chemicals directly to the root zone area; reducing the deposition of fertilizer in the local surface and ground water.

IRRIGATION SCHEDULING AND ACCOUNT MANAGEMENT

To provide a manageable pressure system for both the SSJID and the customers, a user-friendly software interface to replace the practice of phoning in delivery orders was crucial. Since creating an interactive tool required a two-way conversation, sizeable portions of early community meetings were devoted to gathering insight into the features, capabilities, and information farmers felt would be helpful for scheduling deliveries online. Through a web-based interface entitled "The Division 9 Irrigation Information Center", each farmer has been assigned a unique platform to service all of their irrigation related needs. Tools at the farmers fingertips to plan their irrigations includes national weather service alerts for the area (including frost and wind alerts), weather forecasts, Doppler radar imaging, customizable and exportable/printable charts on past weather (rainfall, wind, temperature, humidity, evapotranspiration rates), water deliveries (time start, time end, total hours irrigated, average flow rate, and total water delivered), and moisture sensor information. After the farmer has analyzed all of the information, an irrigation can be completed with only three selections. Via an airline ticketing type calendar, a farmer selects a date, followed by the number of hours of irrigation desired. The web site immediately queries system capacity for the requested date, times, and flow

rate, and displays available times for the requested day (order time options are normally available on the hour every hour). If there are times unavailable for the requested day, the system gives all time options 48 hours before and after the requested day for the farmer to select. After the farmer selects the optimal time, text and email alerts notify the farmer (24 hours and 1 hour prior to irrigation, and an irrigation delivery summary after the order has completed). Full account management is available through the web site to keep the customers apprised of their records on file at the District.

NEXT GENERATION OF FARMERS

While it's a stark departure from the way that agriculture has been approached in the area for decades, younger generations that are set to take over operations at some point are more likely to pick up and embrace the new technology. It is something that SSJID Engineering Department Manager Sam Bologna said he has already seen playing itself out. "We had a father out here with his son that will more than likely take over the operation and he's already up to speed on the system – we expected that would be the case with the younger generations that are savvier with technology," Bologna said(Campbell, 2012).

YIELDS

Although it will take many years of data to figure the increase in yield due to the Division 9 pressure system project, evidence from other case studies leads the District to believe that farmers will see an increase in yield of up to 30% according to the General Manager of the SSJID, Jeff Shields.

PESTS AND DISEASE

With increased control of irrigation timing, duration, and application rate, there has been a marked decrease in pests and disease associated with water delivery.

PUMPING EFFICIENCY

A major benefit from the Division 9 pressure system project has been the consolidation of pumping operations. Historically, farmers used private motors and pumps that were diesel driven and provided much less water per unit of energy input. With the construction of the Division 9 East Basin Pump Station, seven 480V variable frequency drive vertical turbine pumps deliver water in a much more efficient manner. The pump station has two 50 hp pumps for low flow operation, one 125 hp pump, and four 250 hp pumps with a combined pumping capacity of 23,500 gpm.

CONCLUSION

The clear winner for this design innovation is the community of farmers that make up Division 9 of SSJID. For the first time, these farmers get water exactly when they need it at the pressure and flow rate they desire. Since the valves are automatic and the web based interface allow management through an Internet connection (smart phone and iPad compatible), farmers can concentrate on other aspects of their farming operation. Since gravity water was often not available when farmers needed it, groundwater pumping had become commonplace. Due to the new surface water based pressure system, there has been a considerable reduction in the pumping of salinity stricken groundwater, and the trees in Division 9 are already benefiting. With less groundwater pumping, air quality throughout Division 9 has improved due to the reduced use of diesel powered well pumps. With a pressure system available, farmers can reduce flood irrigation and utilize drip, micro, and solid state sprinklers to irrigate their land which improves crop yield, conserves water by up to 30%, and reduces erosion and deposition of fertilizer into local surface and groundwater. Finally, the system complies with new State regulations on volume based billing.

ACKNOWLEDGEMENTS

Sam Bologna, SSJID
Frank Avila, SSJID
Lloyd Wayman, SSJID
Jerry Donahue, SSJID
Michael Donahue, SSJID
Bere Lindley, SSJID
Jeff Shields, SSJID
Dawn Driesen, SSJID
Julie Vrieling, SSJID
Michael O’Leary, SSJID
John Holbrook, SSJID
Ralph Roos, SSJID
Dale Kuil, SSJID
Robert Holmes, SSJID
Dave Kamper, SSJID
Forrest Killingsworth, SSJID
The farmers of Division 9
Natural Resources Conservation Service
Bureau of Reclamation

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