Use of Remote Technology in the Surface Water Environmental Monitoring Program at SRS Reducing Measurements in the Field- 13336

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ABSTRACT

There are a wide range of sensor and remote technology applications available for use in environmental monitoring programs. Each application has its own set of limitations and can be challenging when attempting to utilize it under diverse environmental field conditions. The Savannah River Site Environmental Monitoring Program has implemented several remote sensing and surface water flow technologies that have increased the quality of the data while reducing the number of field measurements. Implementation of this technology reduced the field time for personnel that commute across the Savannah River Site (SRS) over a span of 310 square miles.

The wireless surface water flow technology allows for immediate notification of changing field conditions or equipment failure thus reducing data-loss or erroneous field data and improving data-quality. This wireless flow technology uses the stage-to-flow methodology coupled with implementation of a robust highly accurate Acoustic Doppler Profiler system for measuring discharge under various field conditions. Savings for implementation of the wireless flow application and Flowlink® technology equates to approximately 1175 hours annually for the radiological liquid effluent and surveillance programs.

The SonTek RiverSuveyor and Flowtracker technologies are utilized for calibration of the wireless flow monitoring devices in the site streams and validation of effluent flows at the SRS. Implementation of similar wireless devices is also planned in the National Pollutant Discharge Elimination System (NPDES) Stormwater Monitoring Program. SRS personnel have been developing a unique flow actuator device. This device activates an ISCO™ automated sampler under flowing conditions at stormwater outfall locations across the site. This technology is unique in that it was designed to be used under field conditions with rapid changes in flow and sedimentation where traditional actuators have been unsuccessful in tripping the automated sampler. In addition, automated rain gauges will be tied into this technology for immediate notification of rain at stormwater locations further enhancing the automation of environmental data collection. These technological improvements at SRS have led to data-quality improvements while reducing the field technician time in the field and costs for maintaining the traditional environmental monitoring applications.

INTRODUCTION

The SRS Environmental Monitoring Program is designed to characterize and quantify contaminants and the effects to the public and any impacts to the environment. A key component of the program is the liquid effluent and surveillance characterization of radiological and non-radiological constituents and the accompanying volumes which are obtained from the flow rates of the each effluent or surveillance stream. This portion of the SRS Environmental Monitoring Program has advanced with the implementation of wireless flow technology and improvements in field equipment used in obtaining area-velocity flow measurements.

BACKGROUND

The SRS borders the Savannah River and covers about 310 square miles in the South Carolina counties of Aiken, Allendale, and Barnwell. Continuous effluent and surveillance monitoring is performed at each radiological effluent outfall and downstream surveillance sampling locations in order to detect and quantify levels of radioactivity in effluents transported to the Savannah River. The five primary streams at SRS that deposit into the Savannah River are Upper Three Runs, Fourmile Branch, Pen Branch, Steel Creek, and Lower Three Runs (Figure 1). The frequency and types of analyses performed on each sample are based on potential quantity and types of radionuclides likely to be present at each sampling location. SRS monitors nonradioactive liquid discharges to surface waters through the National Pollutant Discharge Elimination System (NPDES), as mandated by the Clean Water Act. The NPDES Permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States. The NPDES permit program is administered by the State of South Carolina. NPDES stormwater locations are shown in Figure 2.

Radionuclide and nonradionuclide inventories require accurate discharge volumes determined from the flow rates of each effluent or surveillance sampling point.

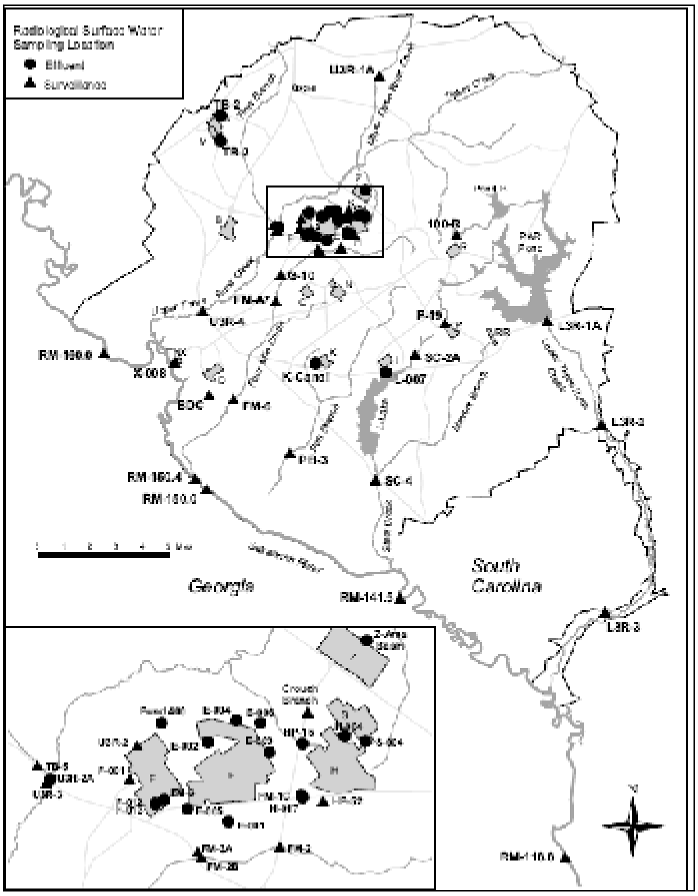

Figure 1. Radiological Surface Water Sampling Locations

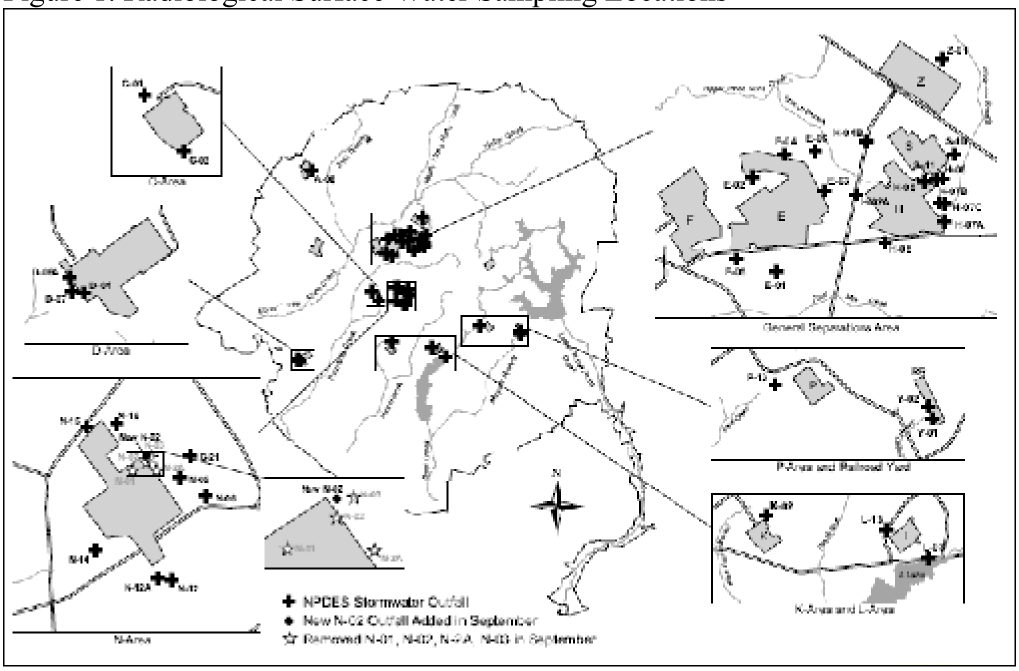

Figure 2. NPDES Stormwater Outfall Locations

ENVIRONMENTAL MONITORING SURFACE WATER SAMPLING EQUIPMENT

Each environmental monitoring liquid effluent and surveillance location consists of the following:
an ISCO™ ultrasonic flowmeter and sensor, either an automated composite sampler or automated sequential sampler, battery power that is connected to one or more solar panels with a trickle charger, 3/8 vinyl and Teflon® sample tubing, polyvinyl chloride pipe for holding the sample tubing, and a stainless steel strainer for holding the end of the sample tubing in the surface water (Figure 3). Each NPDES stormwater location consists of either an automated ISCO™ sequential sampler or a stormwater sampler kit for collection of a grab sample, manual rain gauge, battery power, 3/8 vinyl and Teflon® sample tubing, and a stainless steel strainer.

Figure 3. Typical Liquid Surveillance Sampling Location

FLOW MONITORING IN SRS SURFACE WATER

Most SRS liquid effluent locations utilize the stage-to-flow methodology coupled with either standard measurement devices or datapoints established for a pipe. Datapoints are determined from either known volumes of facility releases or area velocity measurements quantified near each pipe. The stage is measured at each liquid effluent location every fifteen minutes from an ultrasonic flow sensor and quality control checked against a staff gauge. The flow for the primary measurement devices is determined using the following equation:

$$Q = CLH^n$$

where:

Q= Flow Rate

C= Constant for Structure

L = Width of the Crest
H = Height of Water over Crest
n = varies with structure

SRS stream surveillance locations are also setup using the stage-to-flow methodology. Flow-rates for the streams are based on flow equations established uniquely for each location that are determined from numerous area-velocity and stage measurements where each measurement is taken at one cross sectional area of each stream at a particular stage of the stream. The stage is measured at each liquid surveillance location every fifteen minutes from an ultrasonic flow sensor that is calibrated to the flow equation that is established at that stream and quality control checked against a staff gauge.

The process for performing area-velocity measurements involves dividing the stream into rectangles and measuring the velocity at each rectangular section using a velocity meter. The total discharge flow is then determined from a summation of each subsection flow (Figure 4).

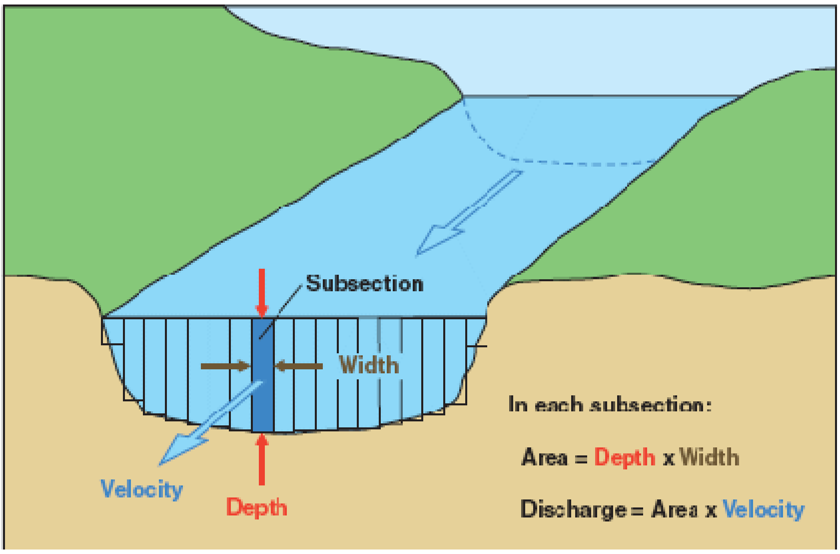

Figure 4. USGS Area Veolcity Methodology

For both the liquid effluent and surveillance programs, the ultrasonic flowmeter internally stores the fifteen minute flow and level readings.

TECHNOLOGY UPGRADES AND BENEFITS

Wireless Flow Implementation

Implementation of cellular wireless flow technology was established at all liquid effluent and surveillance locations during 2012. This technology utilizes a Teledyne ISCO™

interface module with a cellular modem to push the data out from the flowmeter over the network to the ISCO™ Flowlink® software on a DMZ server as shown in Figure 5. The frequency to push the data can be modified and when implemented was set-up for a data push every four hours.

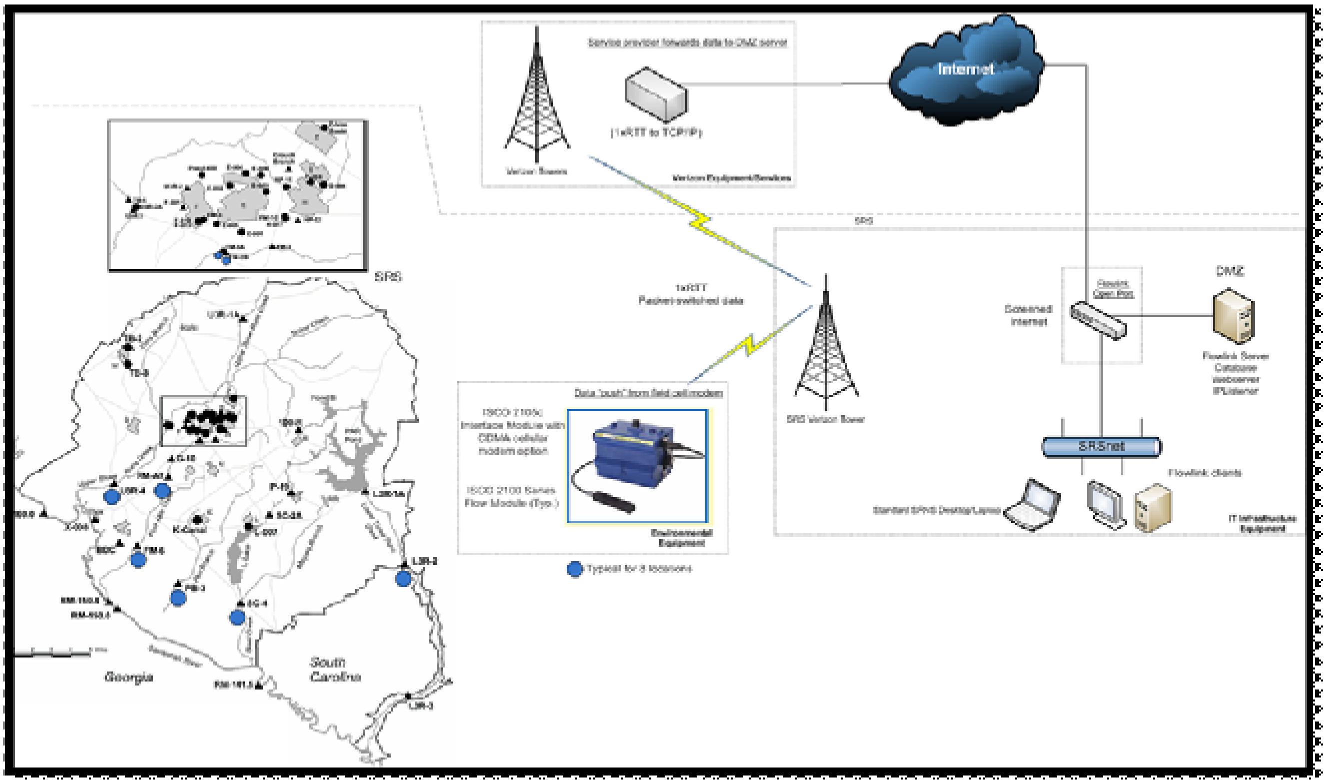

Figure 5. Wireless flow uploading process.

Prior to implementation of the technology the field personnel would manually download the flow data from each field flowmeter using a Rapid Transfer Device (RTD) ™ that was connected to each flowmeter and upon return to the office downloaded from the RTD™ to a PC where the data would be accessed via the Flowlink® software on the PC. The new technology places the software on the server for multiple users to access and has a secured weblink. The savings benefits equates to approximately 685 traveling hours annually and 430 downloading and processing hours annually for both the liquid effluent and surveillance programs.

Another benefit to the wireless implementation is the Flowlink® software application allows the user to set limits or conditions for notification via a text or pager for any of the field parameters that are set-up in the software for each particular location. In this case, the field parameters of flow, level, or power can be set-up where any significant change in those conditions arise, the field personnel would get an immediate text page. This application has been found to be useful in notification of battery loss or sensor problems for remote locations at SRS that are on a monthly sampling collection frequency. In the past, there have been field problems at remote locations where either data loss resulted in extra back calculations performed by the technical oversight person or several troubleshooting trips to the field caused an inefficient use of maintenance time. The improvements were quantified based on real field data and it was determined that approximately 60 hours of maintenance troubleshooting and travel time would be saved per year with this new technology.

The total savings for both the liquid effluent and surveillance programs equates to 1175 hours annually.

FlowTracker Technology and Implementation

Prior to 2012, SRS had been utilizing an electromagnetic velocity meter for field area-velocity measurements. This device measures velocity in one direction, has no easy way to perform calibrations without shipping to the vendor, and displays the velocity as a continuous digital display. This technology is outdated and depends heavily on human judgement for determination of the average velocity from a continual changing digital display.

During 2011, SRS acquired new field instruments that utilize Doppler technology from one of the leading high-resolution velocity sensors that are currently being utilized by United States Geological Survey. The SonTek FlowTracker-Acoustic Doppler Velocimeter® and RiverSurveyor® technology were both purchased for performing field area-velocity measurements and replacement of the electromagnetic technology.

The FlowTracker provides the following benefits: 2D or 3D velocity measurements, built-in calibrations which are performed during each field use, simple operation and assistance on the handheld for Quality Control warnings of erroneous readings, an accuracy of 1% of measured velocity, internal total discharge performed in the device and can be downloaded onto software for formal reporting, and internal calculations of total statistical and standard ISO uncertainty in the results.

The Doppler principle states that if a source of sound is moving relative to the receiver, the frequency of the sound at the receiver is shifted from the transmit frequency [1].

$$F_{doppler} = -F_{source}\,(V/C)$$

where:

$F_{doppler}$ = change in received frequency (Doppler shift)
F_{source} = frequency of transmitted sound
V = velocity of source relative to receiver
C = speed of sound

A simplification of the FlowTracker technology is provided as follows. The FlowTracker measures velocity by the transmitter generating a short pulse of sound at a known frequency, the sound travels through the water along the transmitter beam axis and as the pulse passes through the sampling volume, sound is reflected in all directions by particulate matter where some portion of the reflected energy travels back along the receiver beam axes and is sampled by the acoustic receivers; the change in the frequency for each receiver (Doppler shift) is proportional to the velocity of the particles (Figure 6) [1].

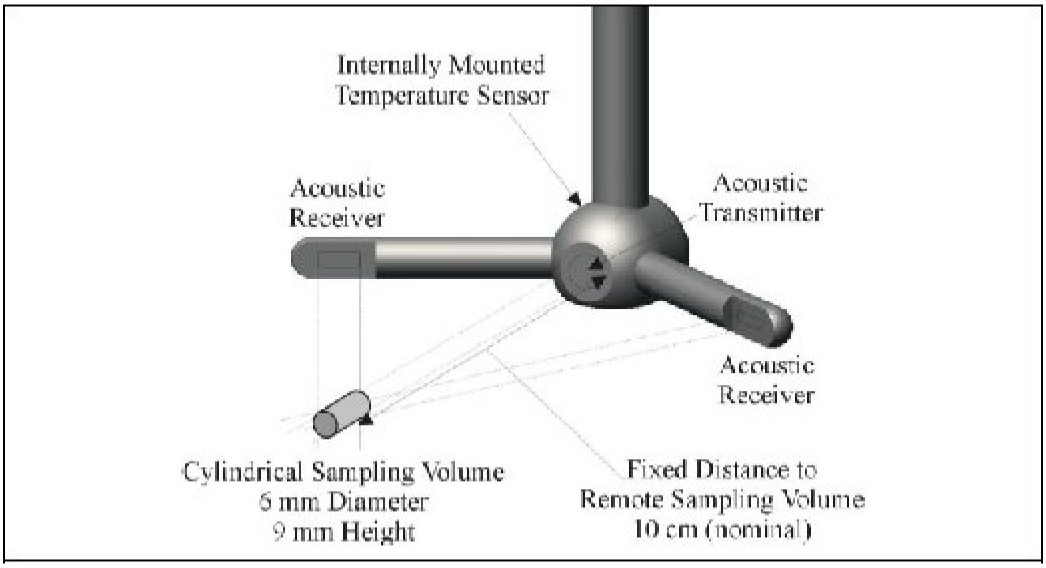

Figure 6. FlowTracker 2D Side Looking Probe and Sampling Volume [1]

FlowTracker operation uses a technique called pulse-coherent processing where two pulses of sound separated by a time lag where each receiver measures the phase of the return signal from each pulse, and the change in phase divided by the lag time is proportional to the velocity.

One benefit to this technology that has not already been mentioned is that when the sensor is placed near underwater obstacles, it performs boundary adjustments automatically to adapt for the interferences.

This technology was implemented at SRS during 2012 and was found to be a tremendous benefit to the overall technology in obtaining discharge volumes and has been utilized to validate liquid effluent rating tables. An example of one of the discharge reports for the Lower Three Runs stream location is provided in Figure 7.

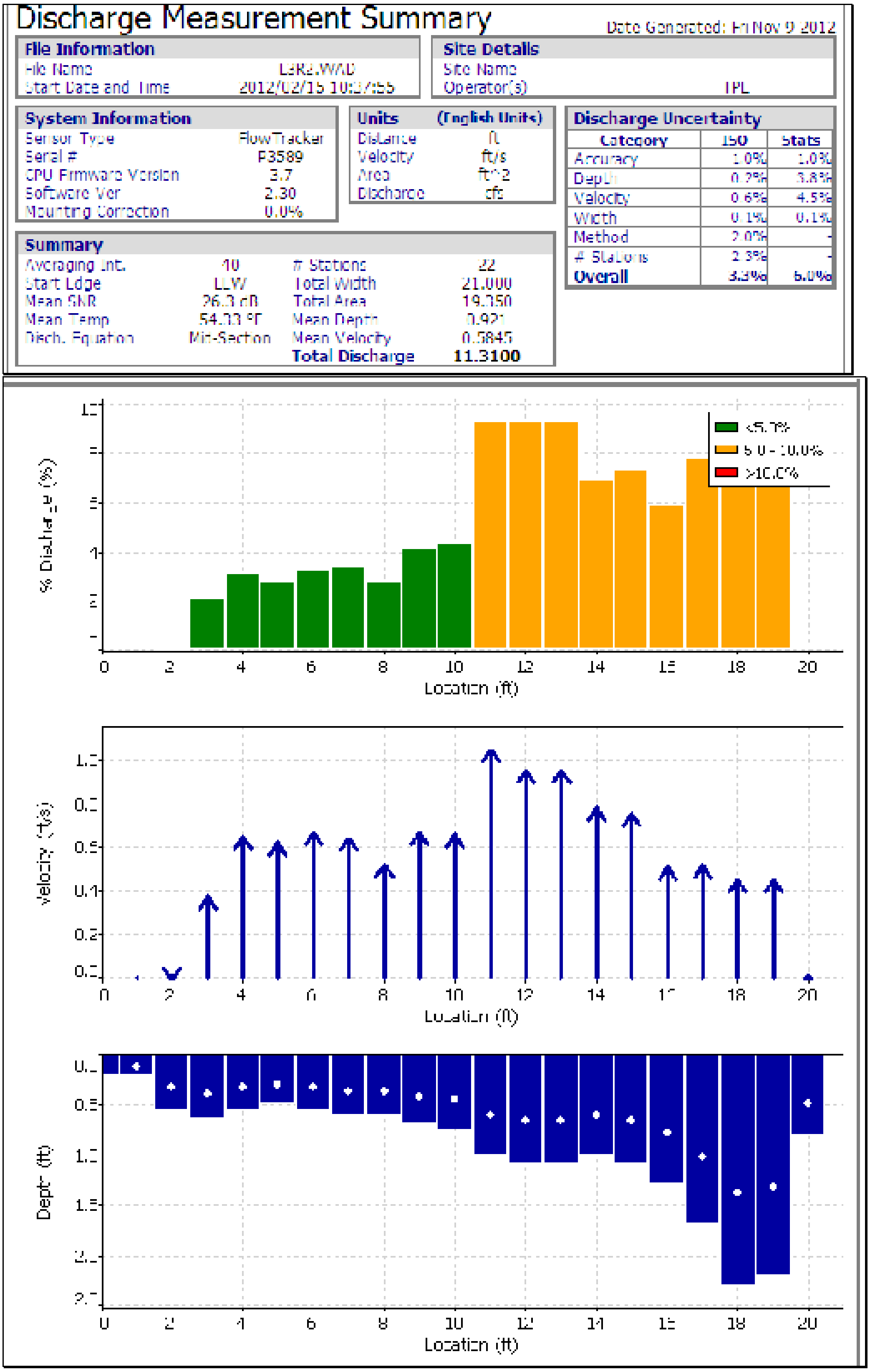
Discharge Measurement Summary
File Information
Site Details
Operator(s)
System Information
Sensor Type FlowTracker
Serial # P3589
CPU Firmware Version 3.7
Software Ver 2.30
Mounting Correction 0.0%
Units (English Units)
Distance ft
Velocity ft/s
Area ft^2
Discharge cfs
Discharge Uncertainty
Category ISO Stats
Accuracy 1.0% 1.0%
Velocity
Width
Method
Overall 3.3%
Summary
Averaging Int. 40
Start Edge LEW
Mean SNR
Stations 22
Total Width 21.000
Total Area 19.350
Mean Velocity 0.5845
Total Discharge 11.3100
<5.0%
5.0 - 10.0%
>10.0%
% Discharge (%)
Location (ft)
Location (ft)
Depth (ft)
Location (ft)

Figure 7. Discharge Measurement Summary Report for Lower Three Runs Stream Location.

In the future it will be utilized for updating flow equations on ultrasonic flow meters at liquid surveillance stream locations.

RiverSurveyor Technology Application and Implementation at Two Field Locations

During 2011, the SonTek RiverSurveyor® was purchased for measuring area-velocity measurements in streams of depth of 1 feet or greater as a safety and technology improvement measure.

The SonTek RiverSurveyor® (Figure 8) is a robust and highly accurate Acoustic Doppler Profiler (ADP) system designed to measure 3-dimensional water currents, depths, and bathymetry from a moving or stationary vessel [2]. SRS purchased the S5 Shallow range system (Figure 9) model since it has the depth range (0.3 to 5 meters) appropriate for usage in the SRS streams. The RiverSurveyor has a multiple acoustic frequencies with a deterministic microcontroller that automatically distributes the appropriate acoustics and pulse schemes as you cross the stream [2].

Figure 8: Sontek RiverSurveyor System

Figure 9: RiverSurveyor S5 Shallow Range System

The S5 model provides four beams for velocity measures, and one cantered vertical acoustic beam (echo sounder) for providing depth data.

Other components to the system are a GPS option, temperature sensor, compass, hydroboard, internal discharge calculations performed on the system, power and communications module, and supplemental software for data processing and reporting.

The system employs a moving boat method which consists of the three components: the Start Edge, the Transect, and the End Edge (Figures 10 and 12).

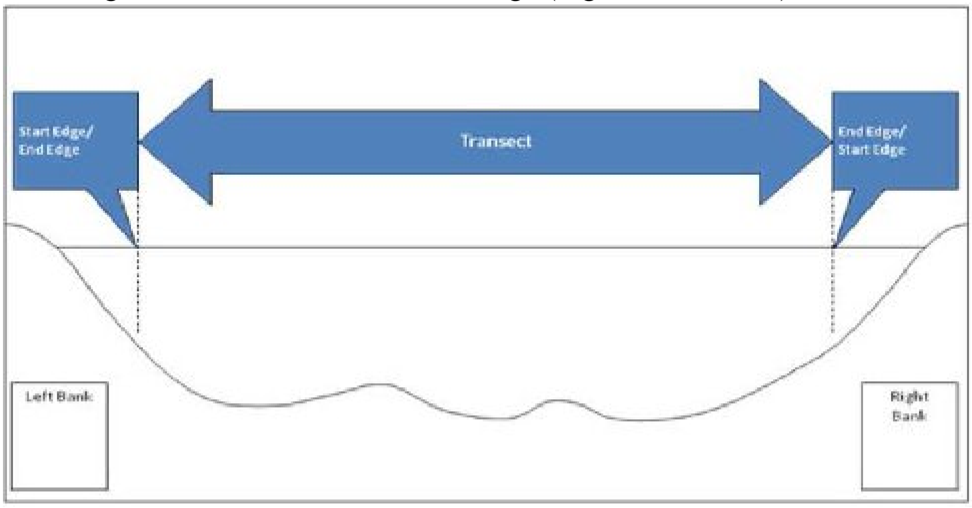

Figure 10: RiverSurveyor Measurement Sections

The Start Edge, End Edge, and top and bottom sections are all estimated using industry recommended and approved calculations [2]. The top section is the mounting depth of the Acoustic Doppler Profiler plus a blanking distance. The technique applied for estimating the unmeasured top and bottom sections is known as Velocity Profile Extrapolation [2]. The Start and End Edges are calculated from a mean velocity profile and mean depth determined by holding the boat stationary at each edge and extrapolating based on either a constant sloped bank or vertical wall. The remaining section of the stream is measured using the RiverSurveyor Acoustic Doppler Profiler.

Prior to implementing this technology, there were several locations where entry into the stream to obtain area-velocity measurements was not feasible due to safety concerns over alligators (Figure 11). This technology removes the need for field technicians to physically enter streams in obtaining area-velocity measurements.


Figure 11. EM Field Location Where Alligators Are Problematic

During the summer of 2012, a location on a steel bridge upstream of the ultrasonic flowmeter was setup for obtaining area velocity measurements with the RiverSurveyor moving boat methodology at the primary location where alligators were consistently problematic on Lower Three Runs (Figure 12).


Figure 12. Lower Three Runs RiverSurveyor Application

A total of 13 measurements indicated that the ultrasonic flowmeter and RiverSurveyor agreed within 10%. A summary of the measurements are summarized in the Table 1 below.

Table 1. Lower Three Runs -1A Flow Comparison					
	RiverSurveyor			Ultrasonic	
Date	# Measurements	Average Flow (CFS)	Average Flow (GPM)	Flowmeter (GPM)	% Difference
7/25/2012	5	6.24	2802	2772	1.06%
10/4/2012	3	8.76	3931	3639	7.72%
10/11/2012	5	7.30	3274	3465	5.67%

FUTURE TECHNOLOGY UPGRADES

Technology upgrades are planned for the NPDES Stormwater Program during Calendar Year 2013. These include implementation of wireless technology for notifications of rain and flow events at stormwater outfalls. SRS has developed a unique stormwater actuator device (Figure13) for activation of an automated ISCO™ Sampler during initial flow conditions each stormwater outfall. This device consists of an automatic float switch, drain cover on each end and top, and screen wire for prevention of debris that could hinder the operation of the automatic float switch. This device was tested and proven successful at several stormwater outfalls during 2012.

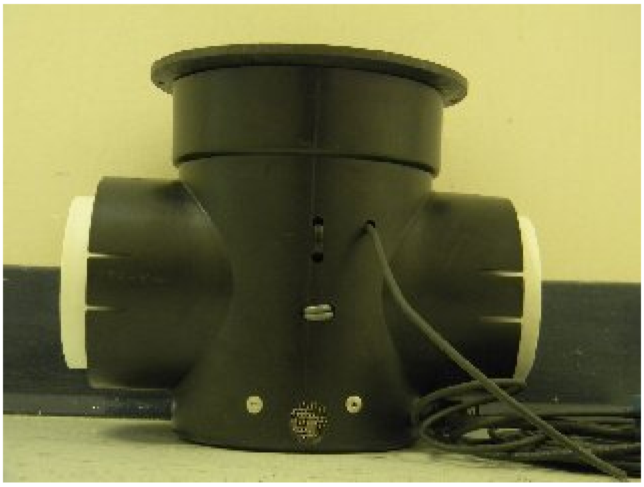

Figure 13. SRS Stormwater Actuator Device

During 2013, the plans are to couple the stormwater actuator device with an ISCO™ wireless interface module that would provide immediate notification of initial flow or rain through a text page at each stormwater outfall. In addition, real time data for the rain amount and flowrates would be available on the Flowlink® software currently utilized for the wireless flow data for the radiological liquid effluent and surveillance program.

CONCLUSIONS

The Savannah River Site Environmental Monitoring Program is implementing technology improvements in quality, safety, and efficiency necessitated at SRS under a reduced labor force under budgetary constraints. Smart deployment and delivery of emerging technology improves capacity and performance with potentially minimal budget impact. Evolving wireless technology reduces safety risks during field evolutions and maximizes efficiency by decreasing interface time associated with traditional methods for retrieving field data. The FlowLink® wireless application saved approximately 1175 manhours annually and coupled with the RiverSurveyor technology has improved the safety posture for the site. Continuous improvements at the site allow SRS to move forward with focusing on new missions for SRS.

REFERENCES

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2. RiverSurveyor S5/M9 System Manual Firmware Version 1.0, SonTek YSI incorporated, San Diego, CA (2010).

ACKNOWLEDGEMENTS

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