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Application Note

Using SCADA and acoustic flow meters to tame a once dormant river:

A case study in the Lower Owens River Restoration Project.

*This Application Note is made possible courtesy of **Ronald Nauman,** President, HydroScientific West and **Steven Keef,** Chief Hydrographer, Los Angeles Department of Water and Power*

Abstract

In 1913 it was thought to be the demise of the Owens River when it was diverted to feed a thirsty growing urban population in Los Angeles, CA. The Owens River sustained a complex riparian habitat and provided a constant flow of run-off from the snow pack in the High Sierras of Eastern California which also provided irrigation water for an agricultural community in the Owens Valley. A few years after the diversion began and the Los Angeles Aqueduct was completed the river lay dormant. Litigation that commenced in the early 1970's was a catalyst which began a long litigious exercise with the objective of local and state governments along with a handful of environmental groups to mitigate and ensure this ecological lifeline for the Owens valley was restored. In 2005 an adjudicator in Inyo County made it official the Owens River will flow again to some semblance of its past.

Thus began the Lower Owens River Project (LORP) with the objective to move and maintain a 40 ft^3/s (cubic feet per second) flow rate with at least 200 ft^3/s "flushing" cycles designed to re-invigorate the dormant riverbed. This paper will briefly describe the SCADA technologies, flow instrumentation and sensor hardware used to maintain and control in real-time a once dormant river. This document will highlight the electronic hardware integrated with a combination of gates for flow augmentation, and an elaborate pumping mechanism to return water to the LA aqueduct or to the Owens Lake Dust Mitigation Project to ensure this flow rate will be maintained along a 62 mile stretch of the Owens River in the Owens Valley.

Introduction

After approximately 93 years of remaining dormant, dry, and to a greater extent lifeless, a decision had been made to move water through the Lower Owens River which starting at the point where it had been diverted at the upper end of its reach with the Los Angeles Aqueduct. The objectives to the decision were many, but some specific are:

- Restore the pre-existing riparian habitat.
- Development of a plan for indigenous threatened and endangered (T & E) species of fish, wildlife and plants, and other biodiversity
- Create new recreational opportunities such as fishing, birding, hiking, etc.
- Identify, manage and audit the 4 areas that will benefit from this endeavor which are irrigation, ranching, recreation, and ultimately water export from the southern end.

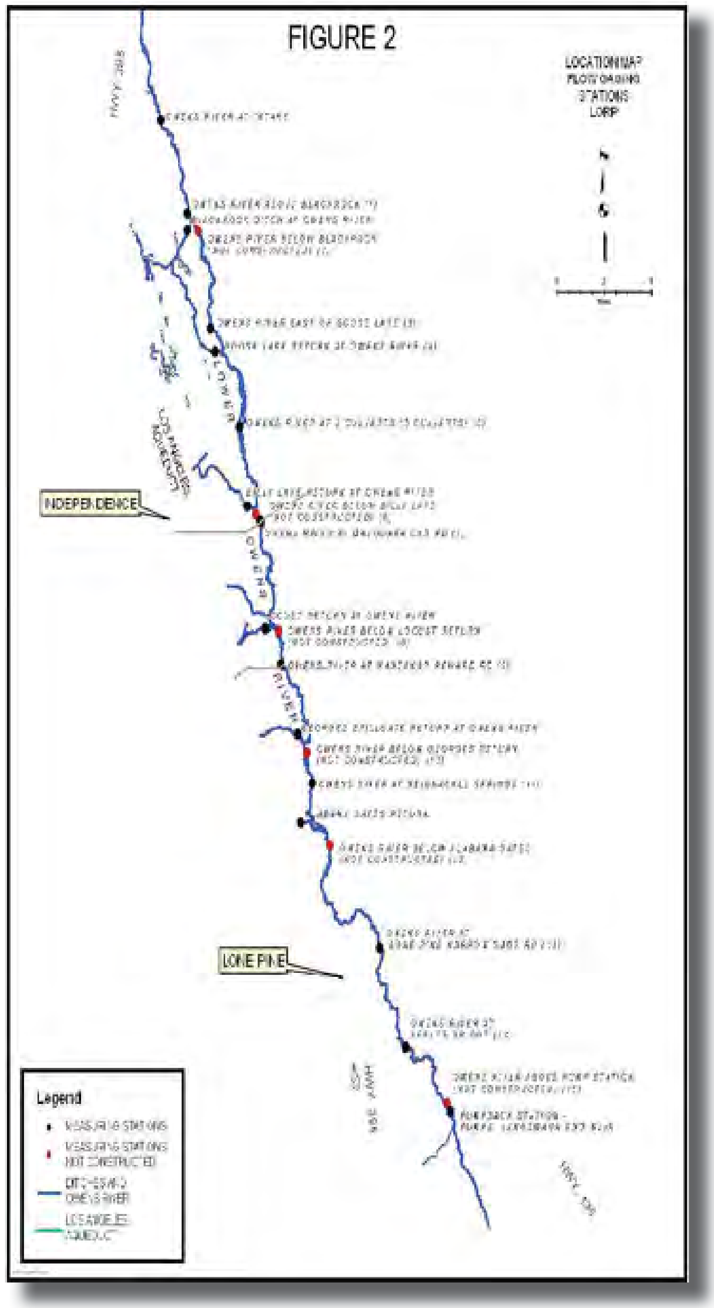
Specifically, the decision also mandated not just the task of returning flows to the parched river, but measuring and monitoring flow rates along its 62 mile stretch. In addition, the monitoring of 9 reaches was specifically to be implemented using a "real time" technology, and, make it available on public domain. The results near term for this project will show that the monitoring and implementation of real time data to the public is practical, real, but at a substantial cost and resources in the early stages. With the growing concern over environmental issues and sustaining our most valuable natural resource, water, this project will pave the way and become a litmus test for what will be a trend for decades to come which may well entail restoring rivers, lakes and ground water aquifers for use to supplement very inefficient methods of irrigation for agriculture and urban sustenance of water. With a 25 million dollar budget and the green light from the City of Los Angeles, the project began in fall/2005.

River Sections or Reaches that require flow monitoring

In the early stages of the project flow values from the intake are approximately 60 ft^3/s rate which will hopefully allow the system to equilibrate at 40 ft^3/s while the water snakes its way through the 62 mile river section until it reaches the Owens River Pumpback Station, where at that point the water will be pumped to the Los Angeles aqueduct or the Owens Lake Dust Control project. Because of the potential for losing and gaining reaches within the river channel, specific sites had to be located to accommodate flow instrumentation. Some sites will make use of existing man made structures and others will be installed new. With this combination it is hoped it will meet and exceed the real time flow monitoring and control needs, and allowing the flexibility to utilize the existing infrastructure of laterals and the Los Angeles Aqueduct to augment the system on the reaches to sustain the 40 ft^3/s rate. Figure 2 shows the geographic location of each monitoring site along the river between the intake and the pumping plant at the tail end of the system.

The instrument site selection by the Los Angeles Department of Water and Power consisted of the following criteria:

1. Based on data collected during the 1993 flow study for losing and gaining reaches
2. Use existing man made structures
    a. culverts
    b. bridges
3. Natural lined Cross Sections
    a. Site locations required sections of hundreds of feet of a straight channel, which at times was very difficult to locate. This ensures a more uniform or homogenous flow condition for the flow instrument.
    b. No boulders, trees protruding from the canal bottom or sides, or desert scrub would be conducive for laminar flow conditions
    c. Because these conditions were hard to find it was determined by The Department of Water and Power that some modifications had to be made with minimal intrusion to the natural landscape
        i. 4 natural site sections rocked and formed to create a uniform



geometry, and lined with a 160 millimeter geo-textile lining to inhibit biological growth and minimize friction which will result in a more laminar flow.
ii. Concrete trapezoidal sections installed at intake, and a concrete box weir installed at Pumpback station
iii. Culverts installed at 4 locations
iv. 2 each Langemann Gates to control flow to the delta at Pumpback Station

Instrumentation Selection

Many factors were considered in choosing an instrument that would precisely measure a parameter such as water level or velocity or a combination of both to compute discharge. In any site evaluation it is imperative that an understanding of level/stage or velocity values be known or has a level of predictability before choosing an instrument. This can be determined prior to an installation by:

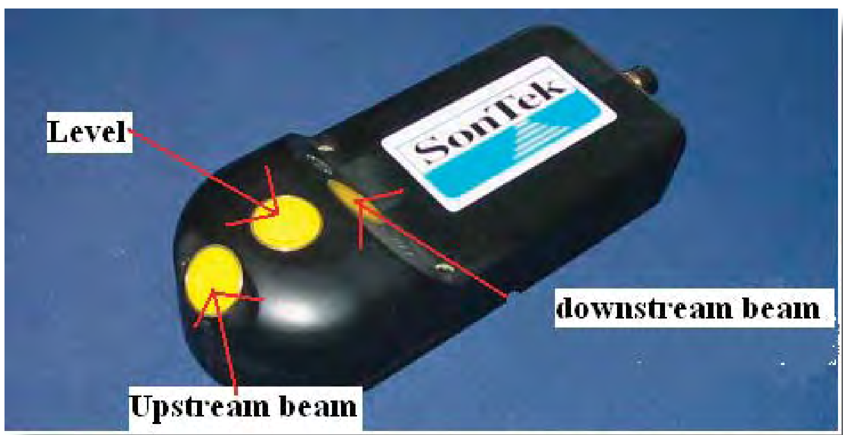


Figure (3)

1. Analyzing historical stage/discharge data compiled by the user, if available
2. Analyzing historical area ratings from the site, if available

In the instance of the Lower Owens River Project this scenario was not a luxury as the river had not seen any water since 1913. So how do we know what the conditions are going to be like at some of the site selection points? How is the river going to behave once flows are ramped up to 40 ft^3/s? How much change is going to occur at the measuring stations with velocity or level? How many of the sites will see a backwater effect from miles of decomposing vegetation?

Since none of these questions had answers The Los Angeles Department of Water & Power determined an acoustic method would be the favorable solution for the following reasons:

1. Measure both velocity and level acoustically
2. Low maintenance
3. Low power
4. The hardware should interface with SCADA, data loggers, etc.
5. Easy installation of the hardware
6. Can be deployed autonomously for indefinite periods of time
7. No instrument calibration
8. Most important, can measure velocity and level and compute flow in very low and high water conditions (inches to several feet of water)

After evaluating these factors the Los Angeles Department of Water and Power chose the Argonaut SW ADVM (acoustic Doppler velocity meter) manufactured by SonTek/YSI Figure (3)

Instrument Deployment Locations

In determining the measuring sites the same principles were used as on any other site selection exercise for any hydraulic monitoring project sampling for physical parameters such as level or velocity. The criteria used were:

1. Is there existing infrastructure to mount, maintain, and periodically conduct site calibration measurements?

2. What modifications and alterations are allowed to the natural habitat, if any?
3. Can I get to the site easy?
4. What is available for power?
5. How can I control existing or future conditions at the site to minimize the changes in the cross sectional area? Sediment transport and/or biological growth?
6. What kind of flow conditions might we expect at the site? Is it at a bend or curve?
7. Can we move data easily from the site if required?
8. Is the correct installation method within our budget?

By adhering to the above criteria it was concluded that the use of existing culverts was one method where installation and construction costs could be kept to a minimum. In addition, the cross sectional area should not change substantially and remain defined for a longer period of time. 4 sites with 2 culverts each were selected in the initial planning stage. All of the culvert sites had substantial bio growth as standing and flood waters were drawn to most of the culvert sites.

These site conditions were typical of most of the culvert sites. As previously noted earlier in this paper that because of the natural conditions of the dormant river bed and environmental regulations that do not allow for removal of vegetation it is not conducive to predicting or affirming what kind of flow conditions may exist at these sites once a flow rate of 40 ft^3/s is established in the system. Thus it is believed the correct technology for flow instrumentation was selected.

Other site selections included a concrete lined trapezoidal shaped flume. It was constructed at the intake which included a structure for the Langemann gate, and an Argonaut SW mounted in the apron further downstream.

The other method used to control site conditions and maintain a uniform cross sectional geometry was by installing a fabricated 160 mil Geo-Textile Liner manufactured by Teranap in Irving, TX. Department of Water and Power personnel installation crews were trained briefly on-site on the installation procedures by Teranap personnel. Once the demonstration period and training was completed DWP installation crews were skilled and proficient enough to install the liner at the remaining sites. Once the liners were installed elevations were shot to ensure cross sectional geometries were uniform and instrument elevations were consistent and updated as referenced to the site benchmark.

Installation of the liner material could be considered relatively simple in nature. The mechanics of hauling and rolling out the pre-cut rolls specific to the site is very difficult if improper or undersized heavy equipment is not available. In installing a geotextile liner the site preparation is paramount to ensure uniformity, as well as reduce the possibility of the liner buckling upstream or downstream at the leading or trailing edge of the material.

SCADA and Radio Hardware and Software

The SCADA hardware selected for each of the monitoring sites and back at the operations headquarters in Bishop, CA is manufactured by Rugid Computer. The Aqueduct Division of the Los Angeles Department of Water and Power has standardized the complete SCADA system in the Owens Valley using a combination of Rugid Computers RUG 3's, Rug 5's, and RUG 9's. There are over 100 remote monitoring and control sites plus several radio repeater sites that the department polls real time. The main reason the Department of Water and Power have standardized on this platform include:

1. Can withstand extreme temperatures (-40 to 85 C)
2. small, lightweight, and consumes little energy (50mW to 5W)
3. 12 bit resolution on 6 analog inputs
4. 4 digital outputs
5. has peer to peer and store and forward communication features
6. Setup of RTU is relatively easy compared to other hardware
7. Open architecture
8. Built in LCD display
9. Integrated Watchdog timer

Remote Site Enclosure

Concrete Box Weir

Each site is collecting flow and level values from the Argonaut SW that has an averaging interval of 300 seconds sampling every 900 seconds. Polling of the sites from the master PLC is every 5 minutes. Data is moved through a combination of 950 MHz radios (Motorola) or spread spectrum radios (~ 900 MHz) (Microwave Data Systems).

HydroScientific West was the integrator chosen for this task. All site hardware was built in its warehouse in Poway, CA and shipped to Bishop, CA, where installation occurred over several months. Currently there are 16 stations interfaced directly with the SonTek Argonauts. Some culvert stations employ 2 Argonauts.

The HMI (human machine interface) was designed and built by Los Angeles Department of Water and Power personnel. Using the existing Intellution Human Machine Interface (HMI) allowed the developers to enhance existing displays and easily add remote stations as needed. Real time data from the sites can be viewed at http://wsoweb.ladwp.com/Aqueduct/realtime/realtimeindex.htm.

Part of the MOU (memorandum of understanding) between Inyo County, Sierra Club et al mandated use of current technology to present real time flow data to the public at large. The HMI software allows this on a web based server and provides the Department of Water and Power the ability to archive all time series data from the Argonauts and water quality sondes deployed in the reaches of the Lower Owens River Basin.

Short and Long Term Issues to maintain accurate flow data

The Lower Owens River has been modified in places to accommodate very accurate flow instrumentation. State of the art data platforms are monitoring the in-situ instrumentation, and high speed radios are moving data across the Owens Valley using repeaters on the Sierra's and White Mountain Range. However, present and past real time data is not reflecting actual hydraulic conditions at the sites. What is happening?

We have tamed this river to flow from point A to point B, however it is in a state of flux due to natural conditions that are changing instantaneously due to decomposing vegetation, and moving sediment and debris, canals geomorphic conditions that due not allow the river to move in a laminar or homogenous fashion. This is reality between the intake and the pumping plant at the end of the river.

Velocity Indexing is going to be an integral function of this project for years to come. It would not be unusual to witness more than a couple of shifts in the existing rating curves at these sites. Department of Water and Power personnel are currently conducting instantaneous discharge measurements on a weekly basis at every site on the system, and using the FloPAK software from SonTek/YSI they are using linear regression tools in the software to calculate new equations and build newer geometry files when required. The Reinhackle site is reflecting a change of 20% - 30% of computed flow, sometimes daily.

The losses throughout the system can be attributed to evaporation and seepage mostly. When flow values at the intake are not substantial to maintain a 40 ft^3/s (cubic feet per second) in between reaches and throughout the system flows are augmented by additional water deliveries through diversions from the Los Angeles Aqueduct.

In addition the final draft of the project mandated 2 each 200 ft^3/s flushing cycles for 24 hour duration to occur next fall and a year thereafter. Nobody can really forecast how the system will react during the 1st flushing cycle. Department of Water and Power personnel will closely monitor the event, and when practical they will conduct discharge measurements to verify flows and how the river would behave during a flood event. In addition, biologists will be an integral part of this exercise to determine the relevance and positive or negative results to a controlled high flow event.

Conclusion

The purpose of this paper was to highlight the significance of major components of the SCADA system that is monitoring and controlling the Lower Owens River Project deployed flow instrumentation and gates. Due to legal circumstances that initiated the project and requirements, it was essential that the Los Angeles Department of Water and Power designed, purchased, and tested a SCADA system with off the shelf components interfaced with robust flow instrumentation that would provide real time data from remote sites with confidence that accurate data will be made available to the public without interruption. Many public and private entities are monitoring on line data from the 16 sites along the 62 mile stretch to ensure restoration of the river riparian habitat.

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