IRRIGATION TRAINING AND RESEARCH CENTER
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Bottom Mounted Doppler Flow Meter for Canals

A critical need exists for advanced water flow measurement technology that is relatively easy to use, applicable to various hydraulic conditions and very accurate. In recent years, Doppler technology, similar to that used by meteorologists to track weather patterns, has been developed and expanded to provide for such requirements. Acoustic pulses sent and received by transducers at a fixed frequency collide with particles in the water, allowing for a determination of velocity. The flow rate for an open channel is then calculated using an algorithm based on the measured velocities and the depth of the channel. An example of a unit with this type of technology is the Acoustic Doppler Flow Meter Velocity Profiler™ (ADFM) by MGD Technologies Inc., of San Diego.

Operation

Doppler units, such as in Figure 1, are installed in the center of the bottom of the channel. Four ceramic Doppler frequency transducers send very short acoustic pulses at a fixed frequency. These pulses collide with material in the water and are received by the unit. The frequency shift of each pulse allows for a calculation of the velocity of the water and with the use of a proprietary algorithm, provide the velocity profile for the channel in that specific area.

The velocity pattern is then established over the entire depth of flow. An ultrasonic sensor in the center of the unit measures the depth of the water in the channel. Integrating the velocity pattern over the cross sectional area of the flow determines the flow rate for the channel. The Doppler method of flow measurement has proven to be very accurate; the ADFM model in particular typically maintains an accuracy within ± 2% of the actual flow. Figure 1 illustrates the dimensions of a Doppler unit. Four round ceramic transducers measure velocity, two at each end of the unit, with a fifth in the center for measuring depth.

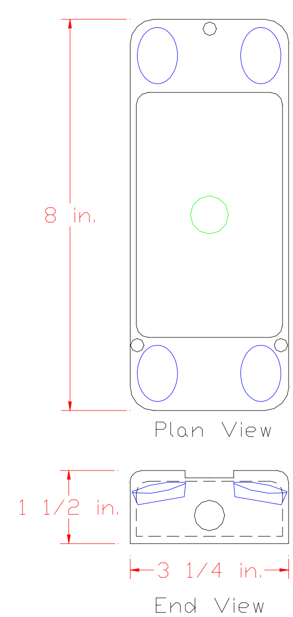

Figure 1. Doppler Unit

The Doppler unit may be attached to a mounting arm which can be easily constructed for any type of situation and then lowered into the channel. An example of a mounting arm is illustrated in Figure 2. The mounting arm may be moved to a variety of depths depending upon the number of adjustable holes created in the frame.

Figure 3. Doppler Unit at Head of Delta Mendota Canal Prior to Installation

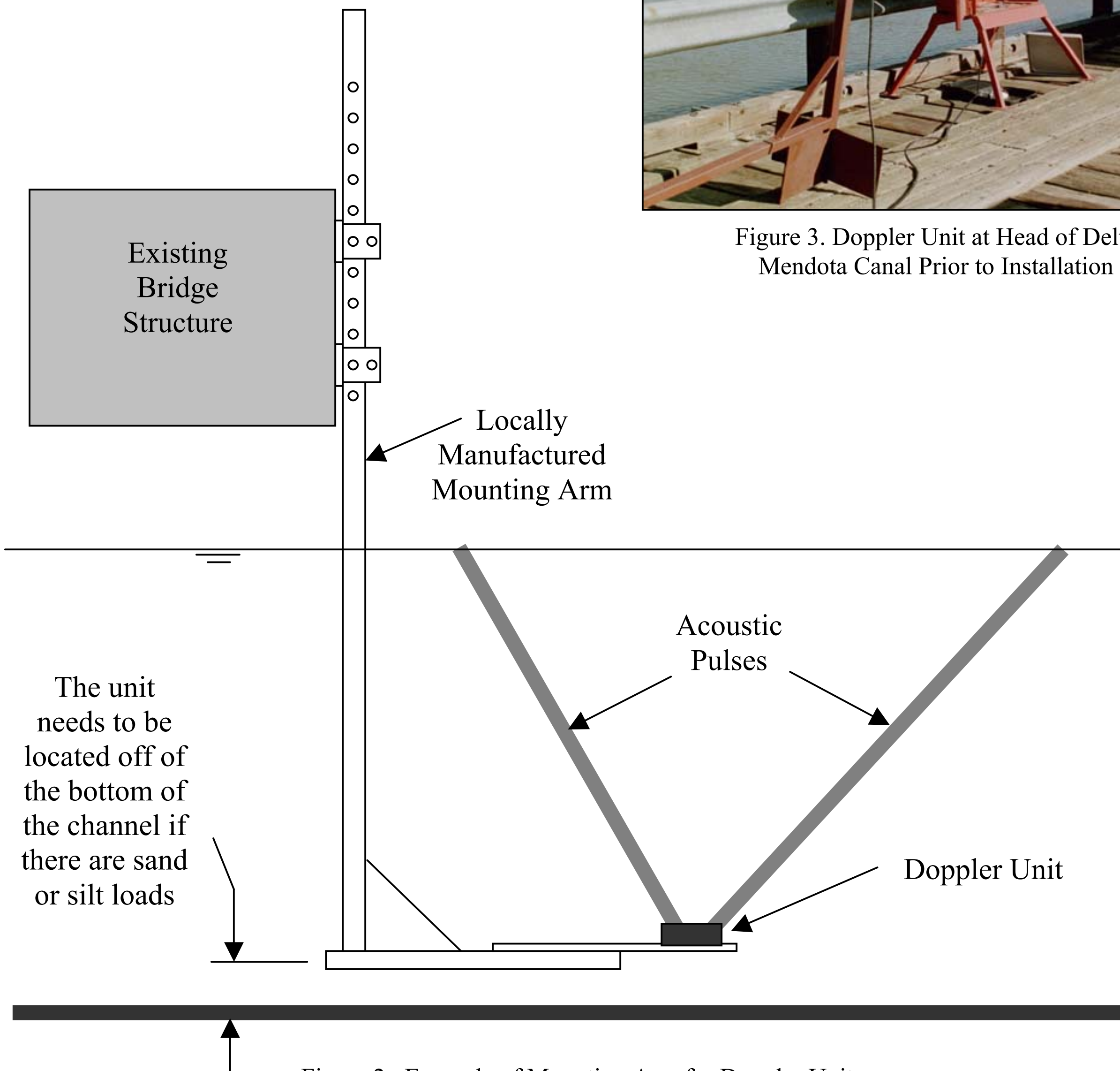

Figure 2. Example of Mounting Arm for Doppler Unit

Comparison

The Irrigation Training and Research Center (ITRC) at California Polytechnic State University, San Luis Obispo, working under a technical services agreement with the United States Bureau of Reclamation Mid-Pacific Region is currently evaluating new flow measurement technologies. To demonstrate the operation of this technology, ITRC utilized the ADFM Velocity Profiler™ on the Delta Mendota Canal to gauge the flow rate at the entrance. Figure 3 shows the unit used for this measurement.

At the Tracy Pumping Plant in Tracy, California (Figure 4) six pumps lift water from the Delta into the canal with a capacity of 750-1,000 cfs each at an average lift of fifteen feet. The total flow rate capacity of the canal is approximately 4,000 cfs.

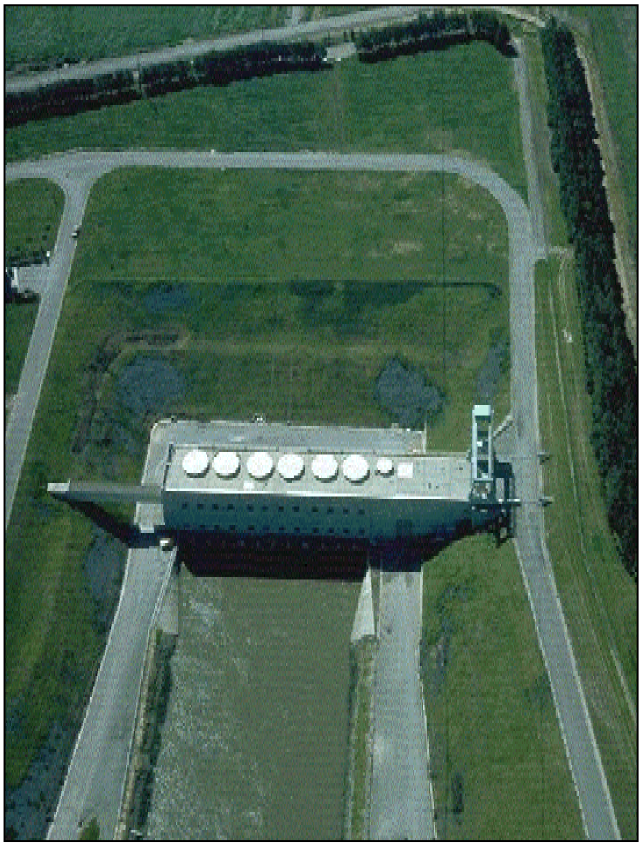

Figure 4. Tracy Pumping Plant

However, since the Delta is connected to the Pacific Ocean, the tide height affects the combined pump curve (Figure 5) and as a result, the flow rate into the canal varies. Figure 6 illustrates that the ADFM indicated a flow rate corresponding to tide height fluctuations measured by the Center for Operational Oceanographic Products and Services at Station #9414290 in San Francisco Bay.

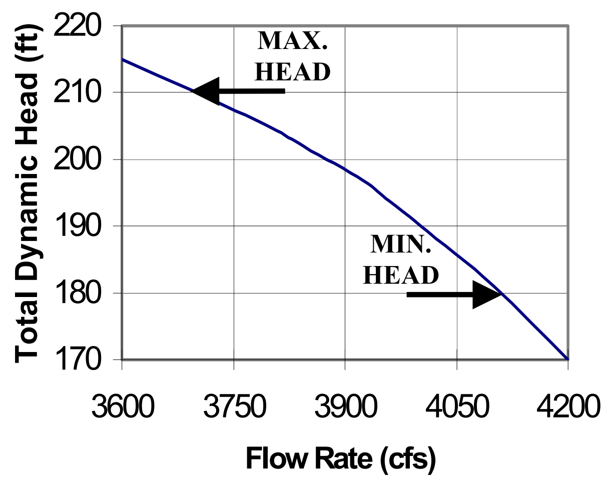

Figure 5. Combined Pump Curve for the Tracy Pumping Plant

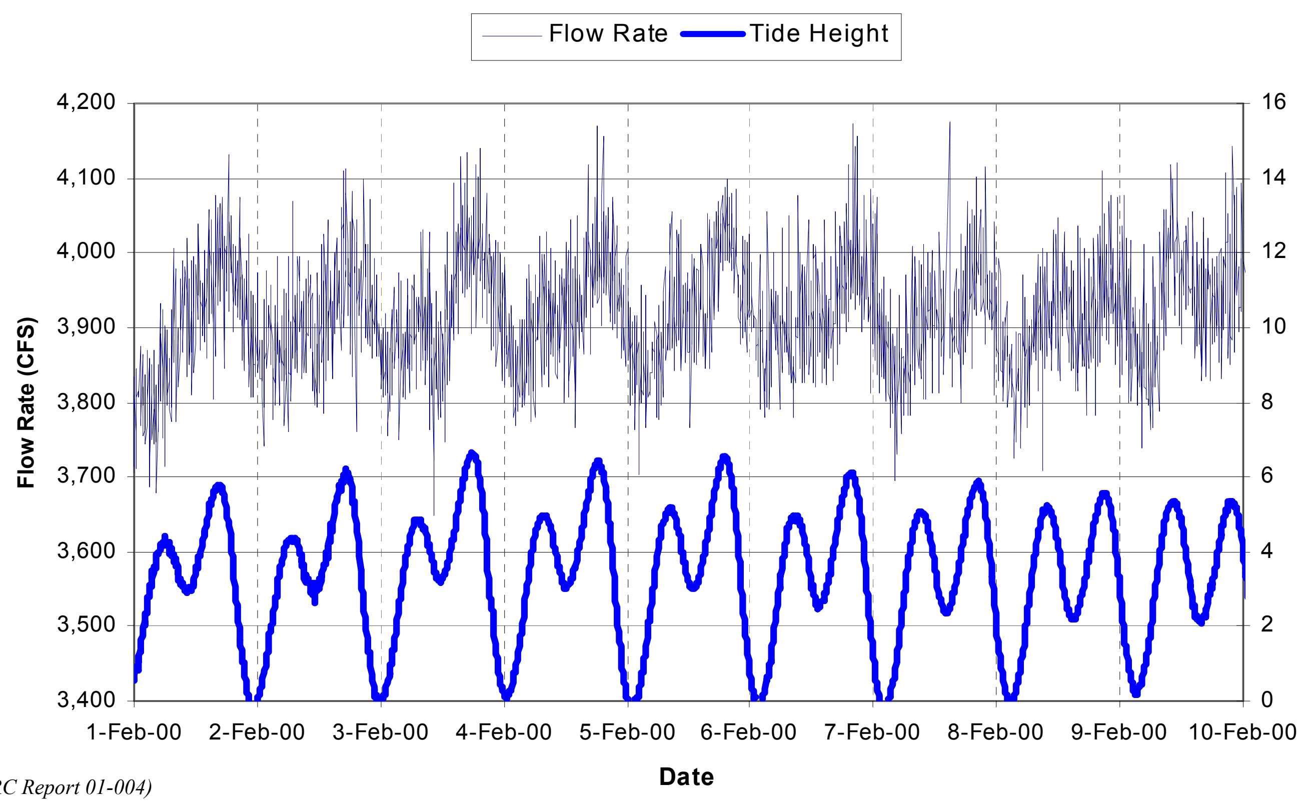

Figure 6. Flow Rate at the Head of the Delta Mendota Canal and Tide Height in San Francisco Bay

Benefits

Researchers and irrigation districts have employed the use of the ADFM for several reasons. The ADFM provides:

- ✓ Fast installation
- ✓ No head loss required
- ✓ Operates with biomass and algae conditions
- ✓ Possible placement in almost any open channel
- ✓ Operates under unsteady velocity distributions
- ✓ Accurate - typically within ± 2% of actual flow
- ✓ Performs well in non-ideal hydraulic conditions
- ✓ No calibration required
- ✓ With an added interface, meter can be integrated with a Supervisory Control And Data Acquisition System (SCADA)

Cost

Base cost for the ADFM is approximately $16,000. Components to connect the unit to a SCADA system will cost an additional $4,000. This can make the unit expensive for small channel installations (less than 150 cfs).

Use

Projects where the ADFM unit has been utilized (2/05/01):

- ✓ Glenn-Colusa Irrigation District - Currently, 3 units are installed in an existing structure in the main canal to measure up to 3,000 cfs.

- ✓ West Stanislaus Irrigation District - Installed an ADFM unit in the main canal served by multiple pumps which turn on and off frequently and was able to accurately measure the flow rates under unsteady conditions.

- ✓ Salt River Project in Arizona - Tested the ADFM in series with the Replogle Flume, measuring a flow rate within ± 0.5% of the flume.

For Further Information

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