<u>Status Report: Stream Velocity, Discharge, and Water-Quality Parameters at the Intersection of the San Bernard River and the Gulf Intracoastal Waterway, near Rivers End, Texas, October 2003 – September 2005</u>

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FY2004/2005 Study of the lower San Bernard River / Cedar Lakes Estuary

Background

In the spring of 2004, the U.S. Geological Survey (USGS) agreed to assist Texas Water Development Board (TWDB) in a study of flow dynamics near the mouth of the San Bernard River. Specifically, the USGS agreed to install and operate multiple gaging stations in and near the lower San Bernard River, proximal to the intersection with the Gulf Intracoastal Waterway (GIWW). Figure 1 shows the study area with the locations of USGS gaging stations (table 1). Data collected at each station would consist of water velocity and tidal stage. After installation of monitoring equipment, a 48-hour synoptic survey would be conducted, whereby multiple discharge measurements would be made at each location and velocity-index ratings would be developed. The ratings would then be used to determine discharge at each location for entire study period.

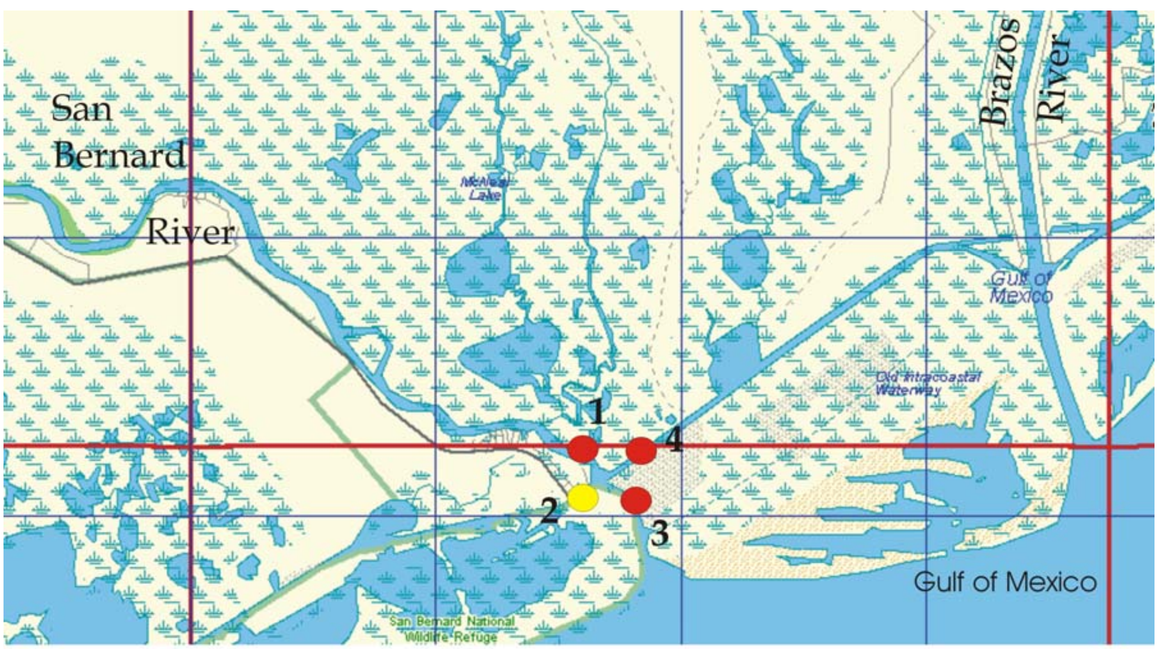

Figure 1. San Bernard River Study Area

USGS Gaging Station

Proposed Gaging Station

Table 1 – USGS Gaging Stations in lower San Bernard River

Site #	USGS Station #	Station Name	Equipment
1	08117730	San Bernard River US of GIWW	ADV w/PT
2	285203095265301	GIWW West of San Bernard River	N/A
3	08117740	San Bernard River DS of GIWW	ADV w/PT
4	285217095263001	GIWW East of San Bernard River	ADV QW Meter

Gaging stations were installed at all four sites (figure 1; table 1) in July 2004. Equipment at each site included Acoustic velocity meters (ADV) with stage sensors, and internal data loggers. Unfortunately, the installation at site 2 (GIWW on the west side of the San Bernard River) was subsequently damaged and data were not collected. Additional efforts to re-establish the station were unsuccessful, as the meter was knocked over each time within days of re-installation. Therefore, velocity and stage data are not available for this station.

In August 2004, a multiprobe water-quality instrument was installed at station 3 (figure 1). This meter measures and records water temperature and specific conductance.

This report is intended to serve as a summary report of the project for the period October 2003 through April 2005. Specifically, in-situ measurements of stage, velocity, water temperature, and specific conductivity are presented, as well as continuous discharge data computed using index-velocity ratings.

Tidal Stage and Water Velocity Data

During the period July 8, 2004 – February 1, 2005, tidal stage and water velocity data were collected at all three USGS stations (1, 3, and 4) in the lower San Bernard River. However, stage data for site 3 appeared unreasonable, most probably due to clogging of the pressure transducer. Therefore, reliable stage data are only available for stations 1 and 4 (figure 1; table 1). Due to their close proximity to one another, stage data collected at stations 1 and 4 should be representative of conditions experienced at station 3. Figure 2 provides a plot of these stage data. Similarly, figure 3 provides a plot of water-velocity data collected at stations 1, 3, and 4 for the same time period.

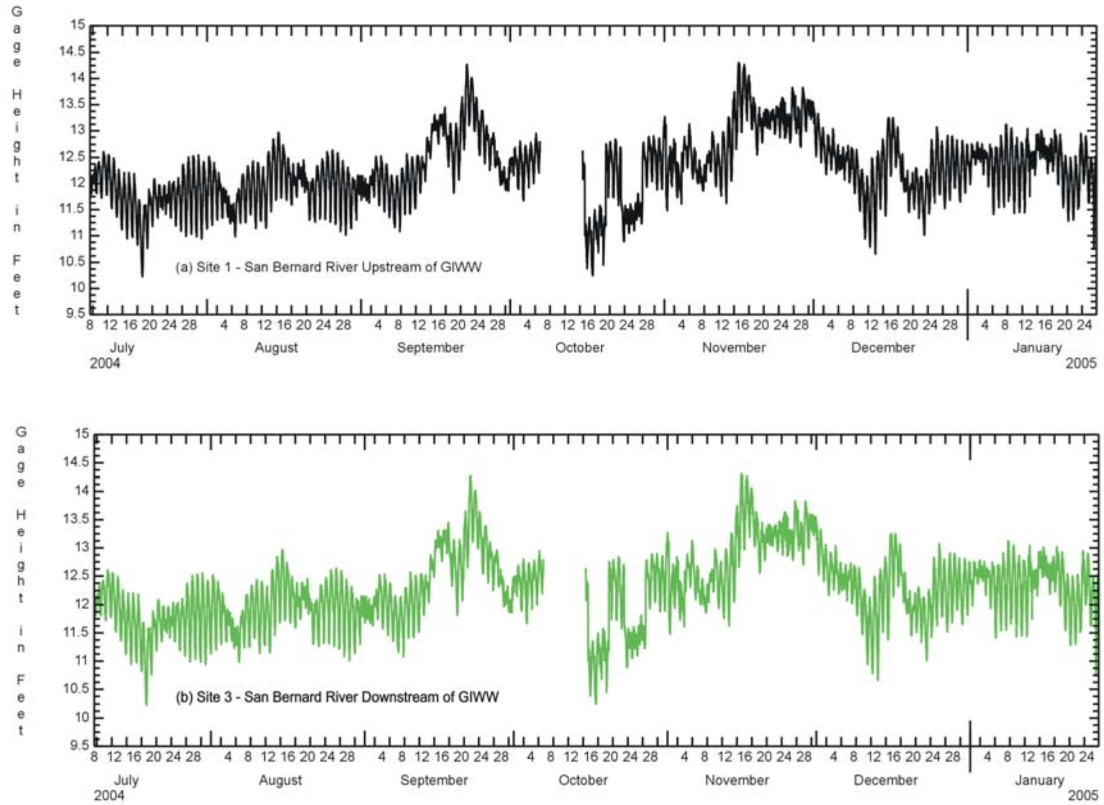

Figure 2 – Tidal stage data for stations 1 and 3 in the lower San Bernard River, July 2004 to February 2005

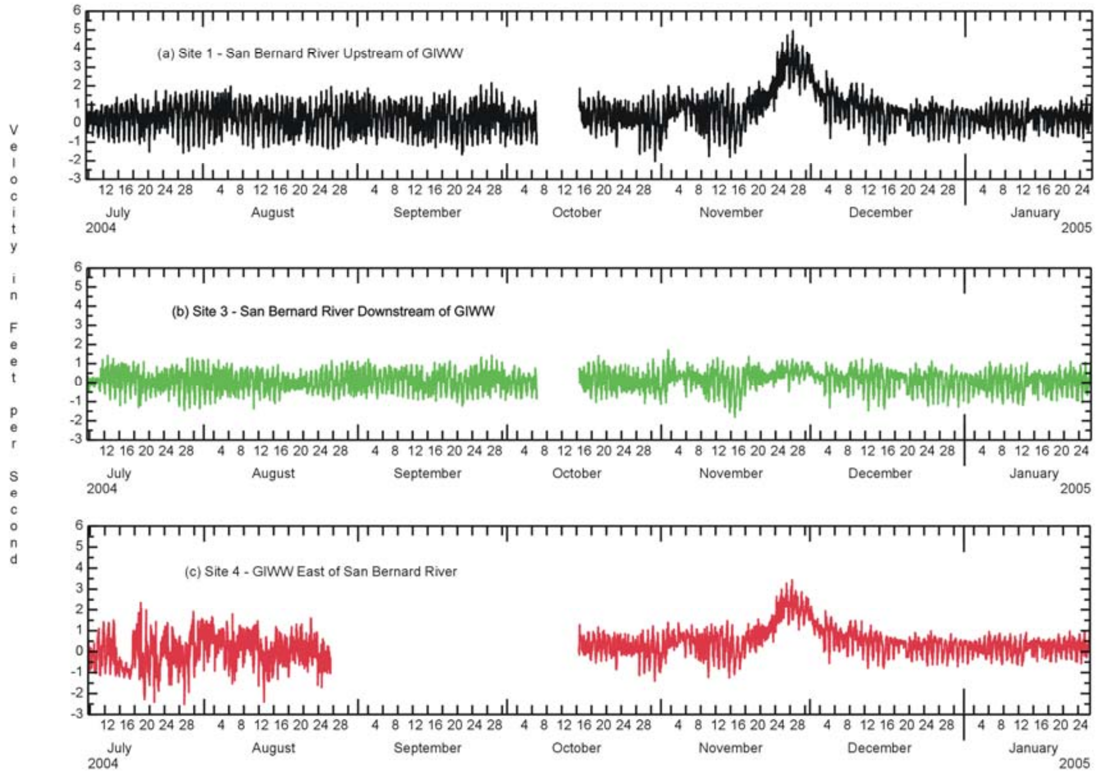

Figure 3 – Water velocity data for three stations in the lower San Bernard River, July 2004 to February 2005

Index-Velocity Ratings

Velocity-index ratings were developed for each site by relating mean channel velocity determined from discharge measurements to concurrent measurements of velocity made by in-situ velocity meters. A second rating is developed that relates water-surface elevation (stage) to channel cross-sectional area. By estimating mean channel velocity from in-situ velocity measurements, and cross-sectional area from stage data, discharge may be computed. This method is discussed by Morlock and others (2002). The index-velocity regression equation of the following form is used;

$$V_m = V_i*B_1 + C$$

where V_m is the mean channel velocity in feet per second, V_i is the instrument (or index) velocity in feet per second, B1 and C are the regression coefficients. The relation between stage and cross-sectional area is empirical and not represented by equations. Table 2 provides the regression coefficients and coefficients of determination for sites 1 3, and 4 using this method.

Table 2 – Regression coefficients and coefficients of determination for index-velocity ratings at three sites in the lower San Bernard River

Site Location	B_1	C	R^2
1	1.36	0	0.95
3	0.68	-0.04	0.97
4	1.04	0.01	0.97

Rating measurements were made during period November 15-17, 2004. Discharge measurements were made using a boat mounted acoustic Doppler current profiler (ADCP).

Computed Discharge

Using instantaneous measurements of velocity (V_i) and stage, mean channel velocity and cross-sectional area are determined. These are then used to compute instantaneous discharge using the equation

$$Q = V_m * A$$

where Q is discharge in cubic feet per second, V_m is mean channel velocity in feet per second, and A is cross-sectional area in square feet. Figure 4 provides graphs of instantaneous discharges computed at sites 1, 3 and 4 during the period July 2004 to February 2005.

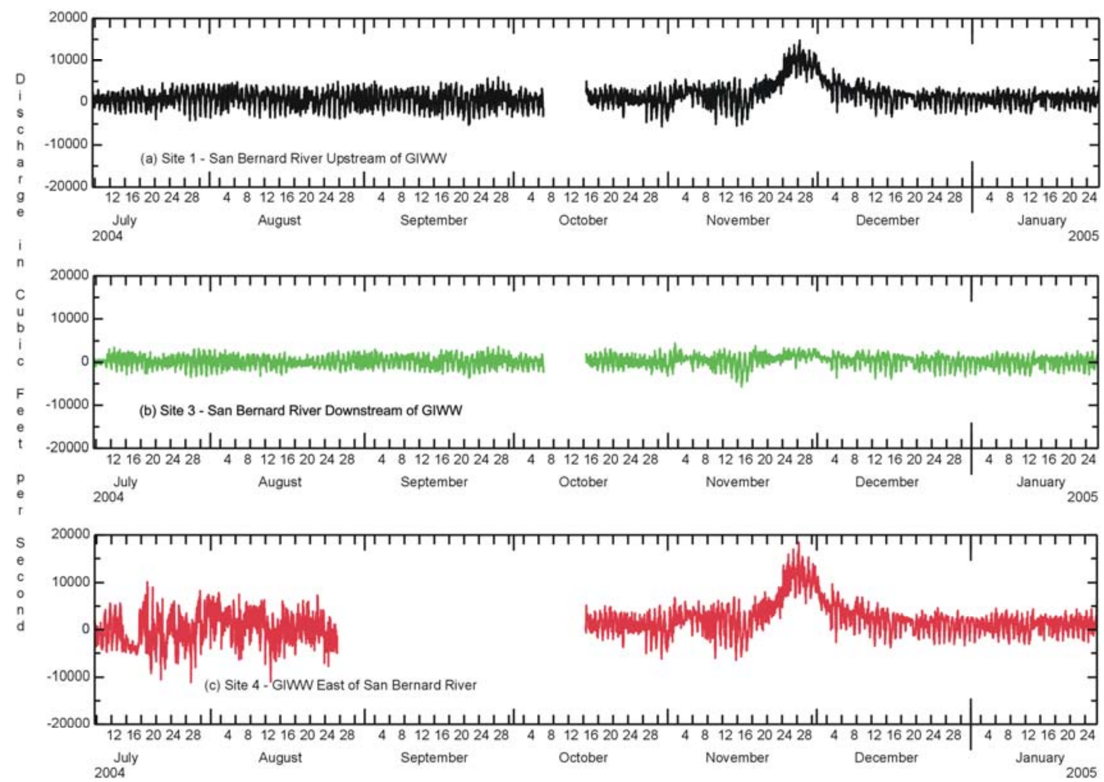

Figure 4 – Instantaneous discharge at three sites in the lower San Bernard River, July 2004 to February 2005

Traditionally, various statistics (such as daily mean) are computed for discharge data as a way of summarizing larger datasets. However, due to the fact that tidal cycles are slightly greater than 24-hours in duration, computation of daily means is inappropriate and can cause aliasing of these data. Therefore, mathematical methods have been developed to theoretically remove the tidal effect from these data and leave the residual discharge values. One such mathematical filter was developed by Godin (1972). Figure 5 is a plot of discharge data for sites 1, 3, and 4 for the period July 2004 to February 2005, which have been processed using the Godin filter.

Comparison of these data shows that, during the study period, the vast majority of water that flows down the San Bernard River (site 1) flows east into the GIWW (site 4). Also, these plots show that magnitude of discharge in the San Bernard River below the GIWW (site 3) is much less than flows at the other two locations.

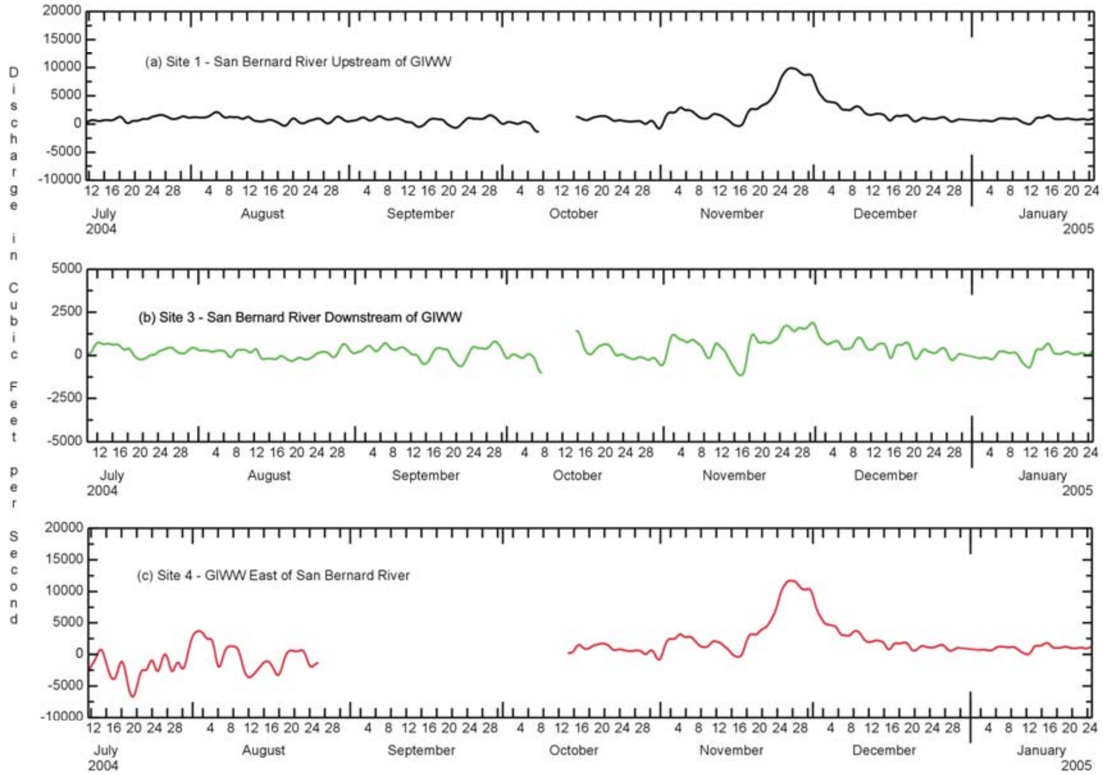

Figure 5 - Discharge data processed using the Godin filter for three sites in the lower San Bernard River, July 2004 to February 2005.

The USGS operates a traditional streamflow gage upstream of the study area, on the San Bernard River near Boling, TX (USGS Station Number 08117500). Figure 6 shows streamflow discharge computed at this upstream station and filtered discharge data at station 1. Comparison of these data shows that during the rise of November 2004, the hydrograph peak attenuated as it moved downstream. In particular, the peak discharge magnitude dropped from approximately 16,000 cfs to approximately 10,000 cfs. However, discharge at the downstream station was also elevated for an extended period of time, as compared with the upstream gage. This would be expected in the lower sections of the San Bernard River, as elevated flows enter storage and are released over longer time periods.

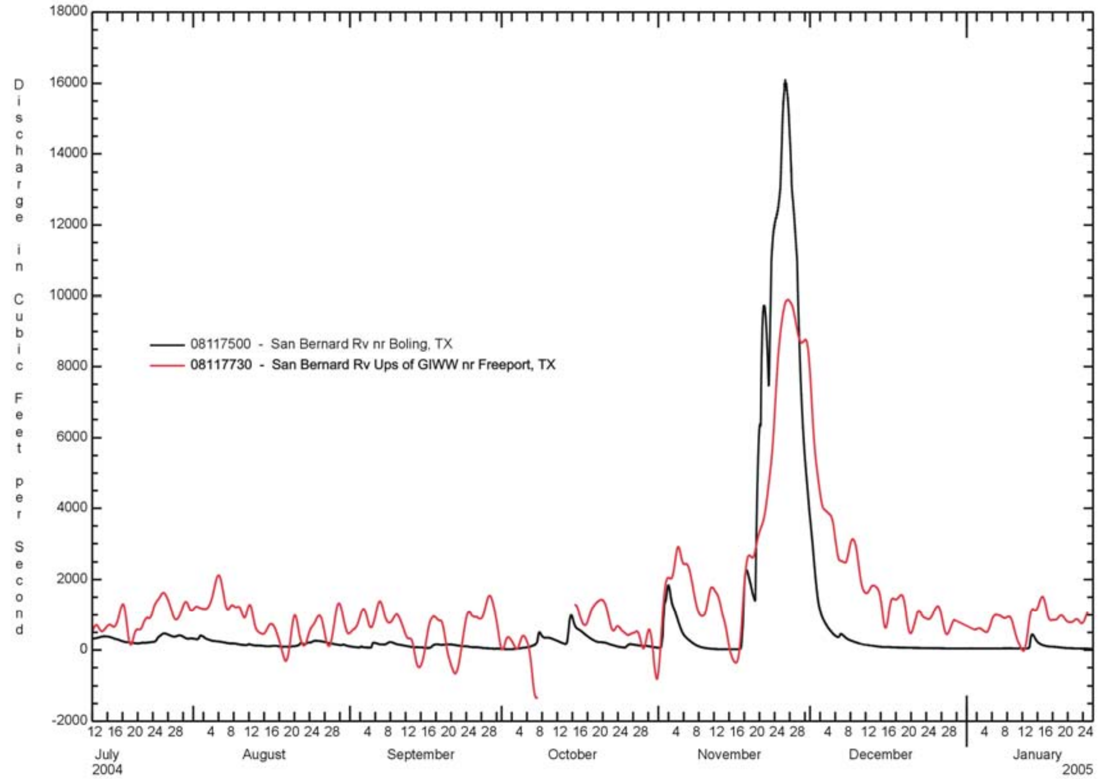

Figure 6 - Streamflow discharge at USGS station 08117500, San Bernard River near Boling, TX and filtered discharge data at USGS station 08117730, San Bernard River upstream of the GIWW, near Freeport, TX, July 2004 to February 2005

Water Temperature and Specific Conductance Data

In August 2004, a multi-probe water-quality meter was installed at station 3. Data collected by this meter were water temperature, in degrees Celsius, and specific conductivity, in microsiemens per centimeter at 25 degrees Celsius (*u*s/cm). Figure 7 provides a plot of these data, along with filtered discharge data at the same location, for the period August 2004 to February 2005. While somewhat subtle, examination of this plot does show that during periods of elevated streamflow (late November – early December), freshwater inflows tend to drown out the saltwater influence and specific conductivities drop well below 1000 *u*s/cm

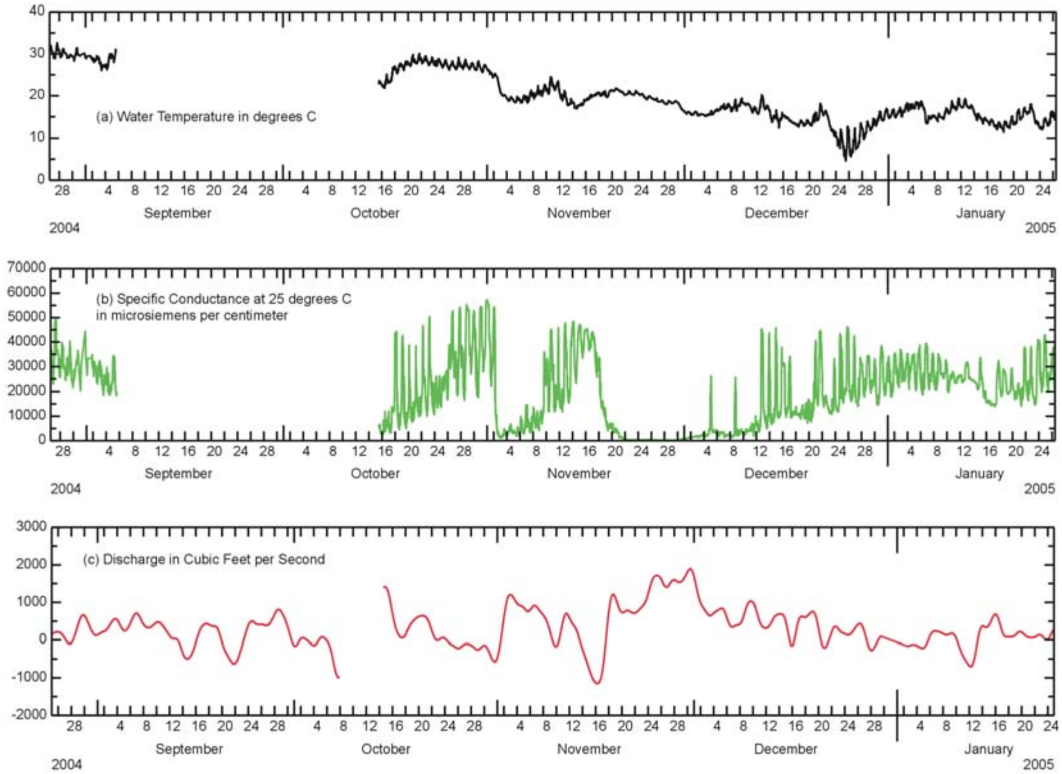

Figure 7 – Water temperature, specific conductivity, and filtered discharge at USGS station 08117740, San Bernard River below the GIWW nr Freeport, TX, August 2004 to February 2005

References

Godin, G., 1982, The analysis of tides, University of Toronto Press, 264 p.

Morlock, Scott E., Nguyen, Hieu T., and Ross, Jerry H., 2002, Feasibility of acoustic Doppler velocity meters for the production of discharge records from U.S. Geological Survey streamflow-gaging stations, U.S. Geological Survey Water Resources Investigations Report 01-4157, 56 p.

<u>ATTACHMENT 1</u> - EXECUTIVE ADMINISTRATOR's Review Comments

1. Figures 2 through 5 are not clear which station is which
2. Figure 5 – the interpolation on the third graph should be removed
3. On all figures, the font in the legends should be increased so as to be legible
4. Labeling the graphs for Sites 1, 3, and 4 should be clear. This is very tiny labeling so that one may determine what is what, but a simple label of "Site 1", etc would be helpful.