Statement Addressing Regional Board Staff Concerns regarding the Biological Data Used to Support Poseidon's Impingement and Entrainment Assessment

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3/19/09

PURPOSE OF STATEMENT

Poseidon asked me to address certain questions raised by staff in staff's April 4, 2008 technical report. Specifically, staff state therein:

> "This sampling set is likely to be skewed because it does not account for annual variability and the data were collected during a year that was atypical with regards to rainfall."

I examined these concerns prior to my testimony before the Board at the April 9, 2008 meeting. I submitted a written statement to the Board on 26 January 2009 that memorializes that testimony. Since that time, new information has come to my attention that allows me to perform a more in-depth analysis of these concerns. The statement below presents that new analysis and elaborates on relevant sections of my 26 January 2009 statement.

QUALIFICATIONS

I earned a B.S. in Chemistry at Yale University and a Ph.D. in Physical Oceanography at University of California, Scripps Institution of Oceanography. I am presently a Principal Engineer at the Scripps Institution of Oceanography where I have been employed since the age 16. I have 30 years experience in coastal process and have published research in the Journal of Geology that is specifically relevant to this statement (see, Inman, D. L. & S. A. Jenkins, 1999, "Climate change and the episodicity of sediment flux of small California rivers," *Jour. Geology*, v. 107, p. 251–270). That research discovered a relation between climate cycles and rainfall, stream flow and sediment flux of small California rivers. In addition, I have provided consulting services in wetlands tidal hydraulics and restoration, beach erosion, as well as more generally hydrodynamics, aerodynamics and pollution dispersion in nearshore waters, harbors and estuaries (services include field measurements and numerical modeling). I have authored 23 peer reviewed publications, 47 conference proceedings and technical publications and 60 technical reports. A true and correct copy of my Curriculum Vitae is attached. The opinions expressed here are based on my education and experience including 29 years of studying tidal exchange and sediment transport in the Agua Hedionda Lagoon.

ROLE ON THIS PROJECT

I performed hydrodynamic modeling for Poseidon Resources of the brine dispersion and dilution from the Carlsbad Desalination Plant and tidal transport analysis of the effect the

CDP might have on Agua Hedionda Lagoon water quality, sand influx into the Lagoon and historic variations of water levels in the Lagoon over multi-decadal climate cycles.

SUMMARY STATEMENT

Staff is correct that the year in which the Impingement & Entrainment data were collected was an above-average year for rainfall in the relevant vicinity. This turns out to be a benefit of the field program – not a problem. The field program captured not only typical lagoon conditions and variability, but also two events that were atypical and which have a very low probability of occurring in any given year. This enabled me to examine whether such events skewed the results of the overall program. Such was not the case. The lagoon rebounds quickly from depressed salinities associated with extreme events. Lagoon salinity does not appear to have been depressed on a persistent basis by these extreme events. While infrequent extreme events depress salinity more than typical rainfall-runoff conditions, the effect is transient.

I have examined the relevant characteristics of rainfall-runoff affecting Agua Hedionda Lagoon during the period of the field studies, June 2004-May 2005. The timing of this study was ideal (even fortuitous) because it spanned the full range of natural hydrologic variability, and yet average, long-term water quality properties in the lagoon remained normal during the June 2004-May 2005 study period. The lagoon recovers rapidly from extreme hydrologic impacts associated with rainfall and runoff because it holds a large volume of seawater to dilute the storm water, and, has excellent tidal flushing that limits the residence time of storm water. Over the year-long period of sampling, the rainfall and runoff were neither intense enough nor persistent enough to alter the predominately salt water environment of Agua Hedionda Lagoon on other than a transient and short-term basis. I have concluded that the rainfall-runoff did not skew the results as staff were concerned, but rather provided a comprehensive data base that captured a range of conditions, including some that are not likely to re-occur in most years.

DISCUSSION

The sampling set used for Poseidon's Impingement and Entrainment Assessment is not likely to be skewed because the data were collected during a year that was atypical with regards to rainfall. While two extreme events appear to present a different condition than typically occurs in the lagoon, the effects are isolated to those events, and do not affect the utility of the remaining data set for long-range planning, and characterization of typical conditions. As discussed more fully below, the 2004-2005 rainy season provided a robust picture of impacts arising from hydrologic variability without upsetting the predominately salt water environment of Agua Hedionda Lagoon that is representative of its long-term state. The Regional Board can be confident that the sample set was robust and comprehensive and included extreme hydrologic events.

1. The physical data indicate that the 2005 rainy season altered the predominantly salt water environment of Agua Hedionda Lagoon only on a transient basis. Ninety-

five percent of the time during this period, lagoon salinity exceeded 32 parts per thousand (ppt), whereas average ocean salinity is 33.5 ppt.

Agua Hedionda Lagoon is a salt water environment populated by salt water tolerant species. The watershed draining to Agua Hedionda Lagoon consists of 18,800 acres upstream from the lagoon, which drains to the lagoon principally via the Agua Hedionda Creek. (See Figure 1). The physical data show that this watershed is too small for runoff from it to persistently alter the predominantly salt water environment of Agua Hedionda Lagoon, even in a relatively wet year such as the period from June 2004 to June 2005 when the sampling for the impingement and entrainment study was done. (See Figure 2). As a point of reference, annual rainfall totals in the Agua Hedionda Creek watershed (as measured by the NOAA/NCDC rain gage #03177 at Carlsbad Airport) average 9.05 inches. In contrast, 19.19 inches of rain fell during the Impingement & Entrainment Study according to the same gage.[1]

Tetra Tech (2007) prepared a comprehensive report on the Agua Hedionda Watershed water quality for the City of Vista, and Table 3 and Figure 7 of that report provide flow rate measurements for Agua Hedionda Creek for 2005-2007. Unfortunately, Tetra Tech (2007) provides no flow rate data during the first half of the impingement and entrainment study in 2004, and there were some heavy rainfall events occurring in October 2004. (See Figure 2). The missing flow rate data can be estimated from rainfall data by establishing a quantitative relationship (hydrographic rating function) between rainfall and creek discharge using the body of data that does exist for 2005-2007. Figure 3a compares the Tetra Tech (2007) daily discharge rates for Agua Hedionda Creek (shown as black crosses) against the daily rainfall (red bars) measured by NOAA/NCDC rain gage #03177 at Carlsbad Airport (cf. NWS, 2009). Note each rainfall event produces a corresponding peak discharge event in the creek, except during a portion of the winter of 2006 when no flow data was collected. Figure 3b indicates that the relation between rainfall and creek discharge rate can be expressed as a second order polynomial (hydrographic rating curve) having a coefficient of determination, R-squared = 0.80, (indicating a reasonably good fit). The polynomial can then be applied to the rainfall during the first half of the impingement/entrainment to fill in the missing creek discharge data, as shown in Figure 4. Here, the creek discharge calculated from the hydrographic rating curve (red) tends to over estimate measured creek discharge rates (black), and consequently errs on the side of caution with respect to not underestimating storm water impacts on the lagoon water quality.

Now, consider how the storm water discharge from Figure 4 is diluted in the volume of sea water in the lagoon. On average, the lagoon exchanges 1,700 acre ft. of seawater with the ocean each day through tidal flushing, and stores an average of 3,450 acre ft. of seawater. (Elwany, 2005; Jenkins and Wasyl, 2006.) Because of tidal flushing, storm water would remain in the lagoon for only 2.6 days, based on the residence time of the lagoon water mass as determined by Elwany, (2005) and Jenkins and Wasyl, (2006) using two independent methods. Applying these dilution volumes and residence times to

[1] The NOAA/NCDC rain gage #03177 at the Carlsbad Airport is the closest gage to the project site that is located inside Agua Hedionda Creek watershed.

the creek discharges in Figure 4 (using the tidal hydraulics model detailed in Jenkins and Wasyl, 2006), produces the time series of lagoon salinity throughout the impingement and entrainment study shown by the green/red/cyan trace in Figure 5. Although the dilution analysis in Figure 5 is based on the assumption of a well mixed lagoon, the predicted lagoon salinity in green/red/cyan compares closely with unpublished near-surface salinity measurements (Tenera Environmental, 2009) shown as blue triangles. The lowest predicted salinity (red) in Figure 5 is 20.4 ppt and the lowest measured salinity (blue) is 20.1 ppt. However the green portions of the curve predict a number of other events of salinity depression in the lagoon when salinity measurements were not taken. Regardless, a histogram analysis in Figure 6 of the salinity variation in Figure 5 indicates that 95 % of the time, lagoon salinity exceeded 32 ppt throughout the year-long impingement and entrainment study, while average ocean salinity is 33.52 ppt (Jenkins and Wasyl, 2001, 2006). From this, I conclude that rainfall events during 2004-2005 were neither intense enough nor persistent enough to significantly alter the predominantly salt water environment of Agua Hedionda Lagoon.

2. The June 2004-May 2005 impingement study data include two extremely high weekly samples that contained some fresh water species. These samples are statistically anomalous because they were immediately preceded by extreme storms producing 5-day rain totals among the highest found anywhere in the period of record of the Agua Hedionda Creek watershed, with a probability of occurrence of 0.025% to 0.17%. This range compares to a probability of occurrence of 0.12% for these storms that was calculated by Dr. Howard Chang using HEC-1 hydrographic modeling of the Agua Hedionda Cr. watershed.

The two anomalous weekly impingement samples were taken on 12 January 2005 and 23 February 2005. One sample contained 109.5 kg and the other contained 29.5 kg. In comparison, the average impingement excluding these outliers was only 4.7 kg. Among the fish collected on these dates were catfish and possibly other fresh water species. Both samples were preceded by extreme event storms, each producing five continuous days of rainfall shown as cyan bars in Figure 2. The five-day rain totals preceding the 12 January 2005 samples were the highest 5-day rain totals found anywhere in the period of record of the Agua Hedionda Creek watershed, totaling 4.01 inches with a probability of occurrence of 0.025%. The 23 February 2005 samples were preceded by 5-day rainfall totals that are the eighth highest in the period of record, 3.24 inches with a probability of occurrence of 0.17%. So rare were these two events that a four-decade log-scale was required to render them visible in the histogram of the period of record of the NOAA/NCDC rain gage #03177 at Carlsbad Airport in Figure 7.

The salinity depression in the lagoon caused by these two 5-day storms is shown in cyan in Figure 6. Although these two storms produced the lowest salinity observed during the impingement and entrainment study, these salinity depressions were short-lived. This affirms the value of using the impingement and entrainment study database to identify and quantify both the magnitude and duration of the reaction of the lagoon habitat to the full range of natural hydrologic variability, while still providing a long-term baseline in response to the average hydrologic state.

REFERENCES

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Jenkins, S. A**.** and J. Wasyl, 2006, "Coastal Processes Effects of Reduced Intake Flows at Agua Hedionda Lagoon," submitted to Poseidon Resources, 34pp.

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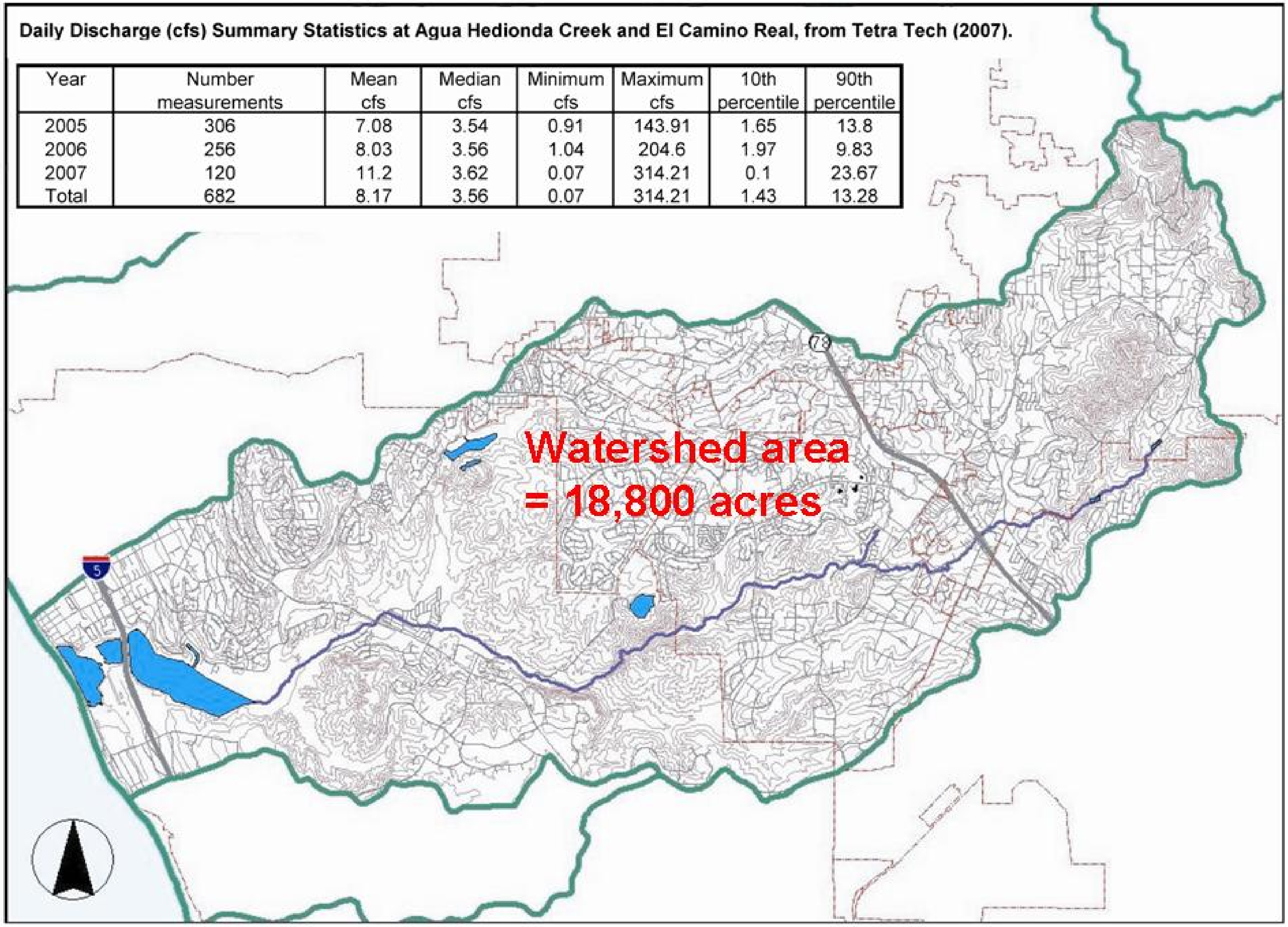

Daily Discharge (cfs) Summary Statistics at Agua Hedionda Creek and El Camino Real, from Tetra Tech (2007).

Year	Number measurements	Mean cfs	Median cfs	Minimum cfs	Maximum cfs	10th percentile	90th percentile
2005	306	7.08	3.54	0.91	143.91	1.65	13.8
2006	256	8.03	3.56	1.04	204.6	1.97	9.83
2007	120	11.2	3.62	0.07	314.21	0.1	23.67
Total	682	8.17	3.56	0.07	314.21	1.43	13.28

Figure 1. Flow Statistics of Agua Hedionda Creek Watershed, 2005-2007.

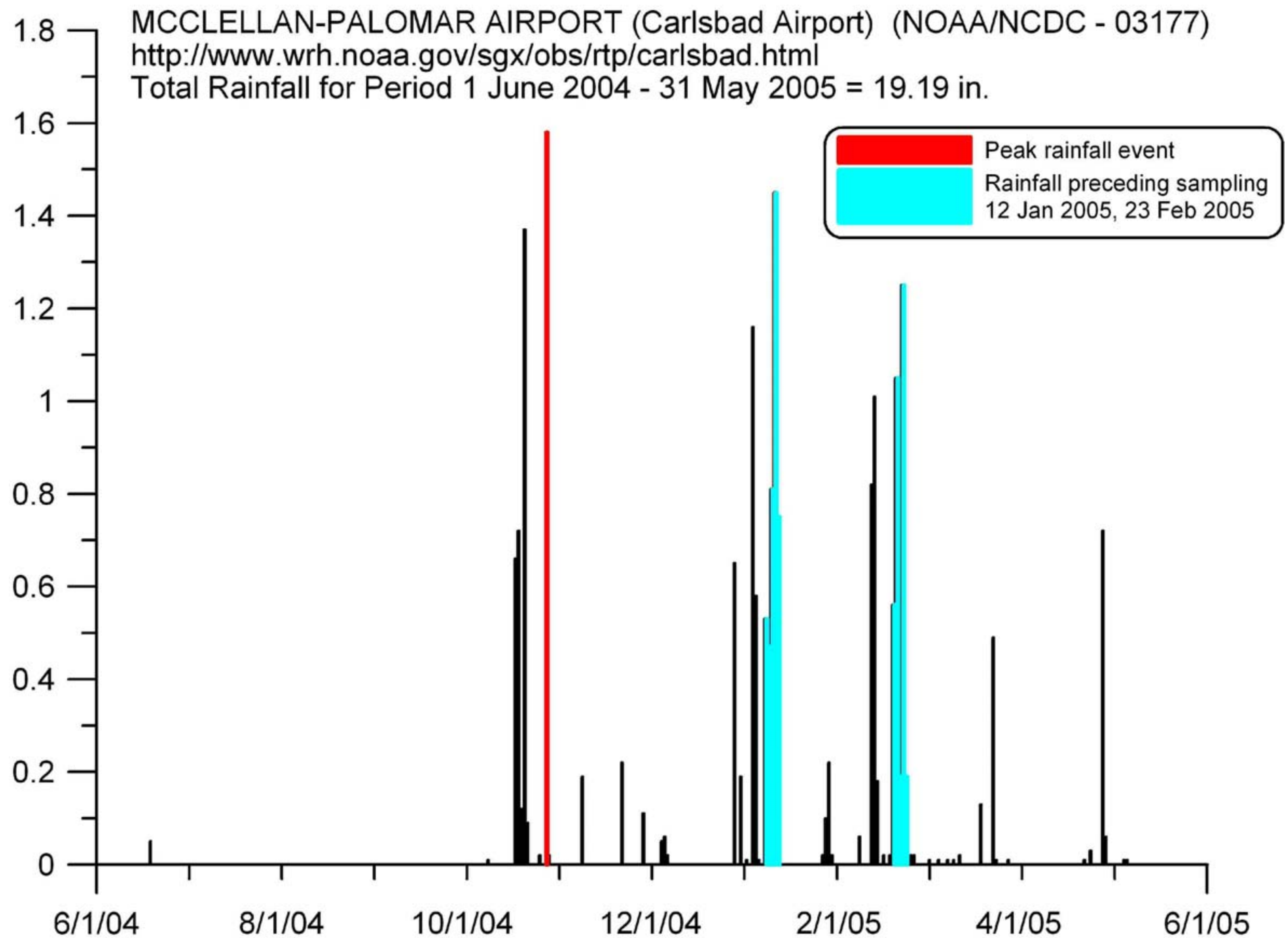

Figure 2. Rainfall history during entrainment / impingement study: 1 June 2004 - 31 May 2005. NOAA/NCDC rain gauge #03177, Carlsbad Airport, CA.

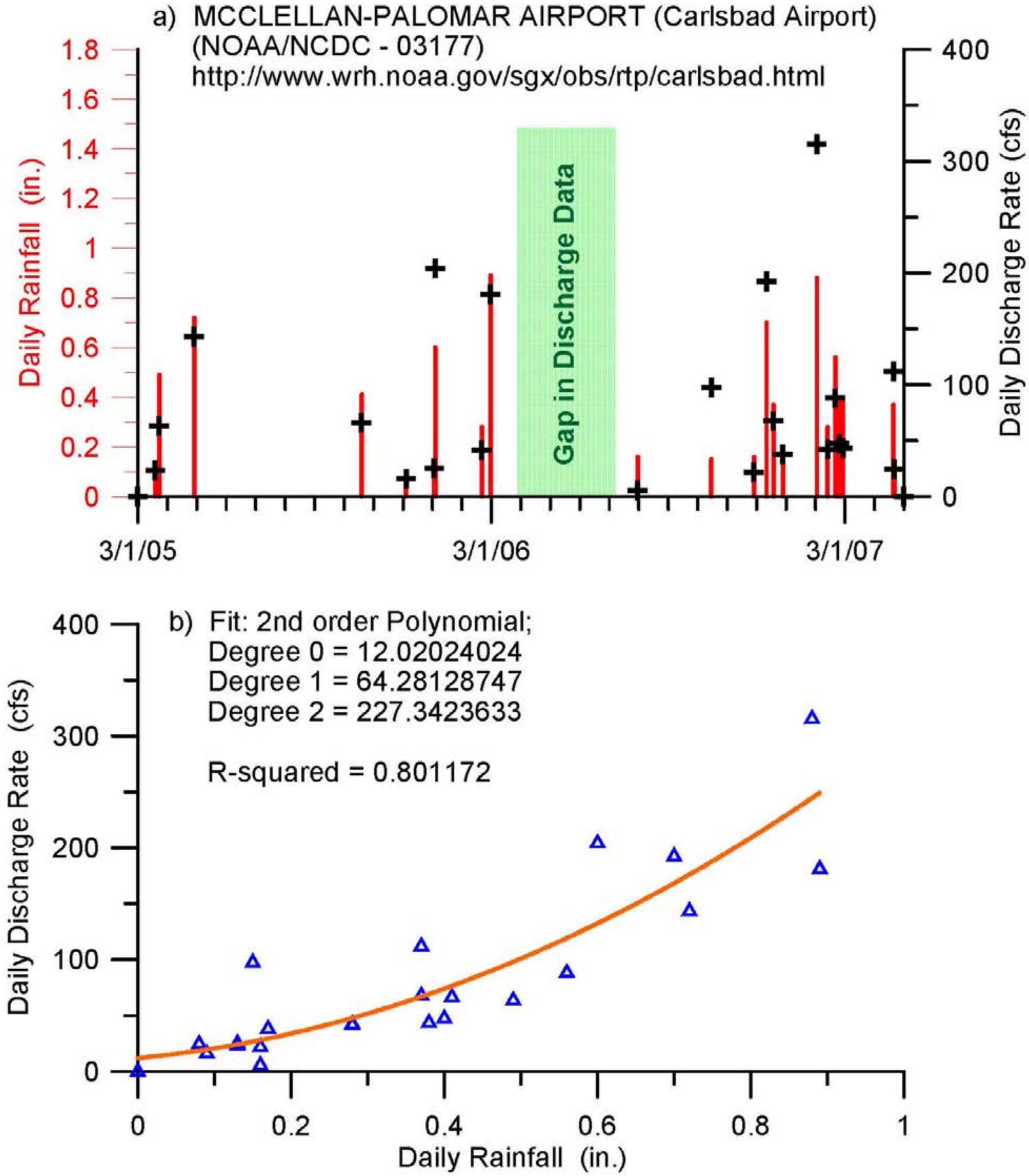

Figure 3. Relation between rainfall and discharge rate of Agua Hedionda Creek: a) Rainfall (red bars) & daily discharge Agua Hedionda Cr. (black crosses from Tetra Tech, 2007). b) Hydrographic rating curve (red) from 2nd order polynomial fit to flow rate vs rainfall data (blue diamonds).

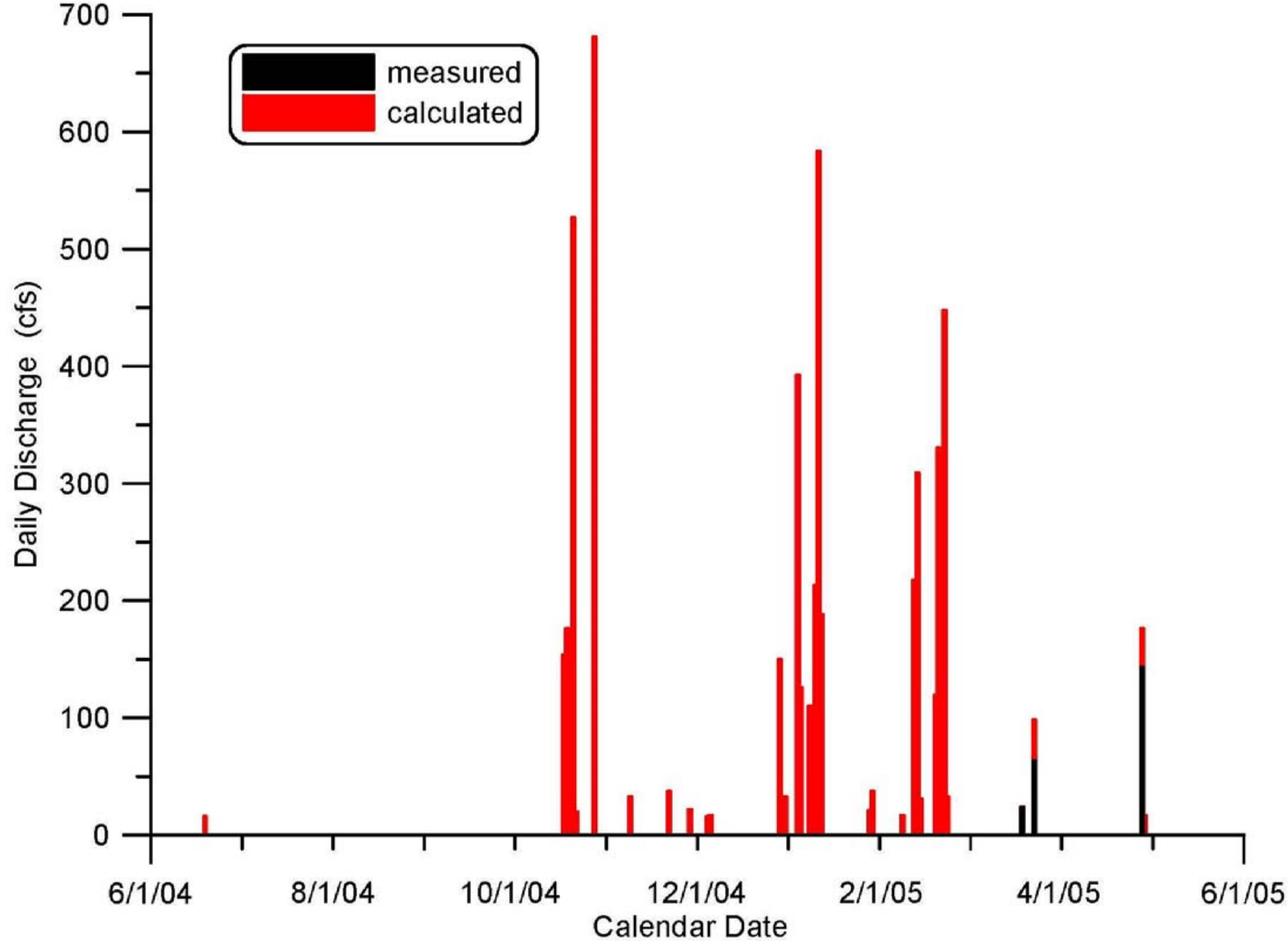

Figure 4. Daily discharge flow rates from Agua Hedionda Creek during the entrainment/impingement study: 1 June 04 - 1 June 05; measured data (black), from Tetra Tech, (2007), values calculated from hydrographic rating curve (red) .

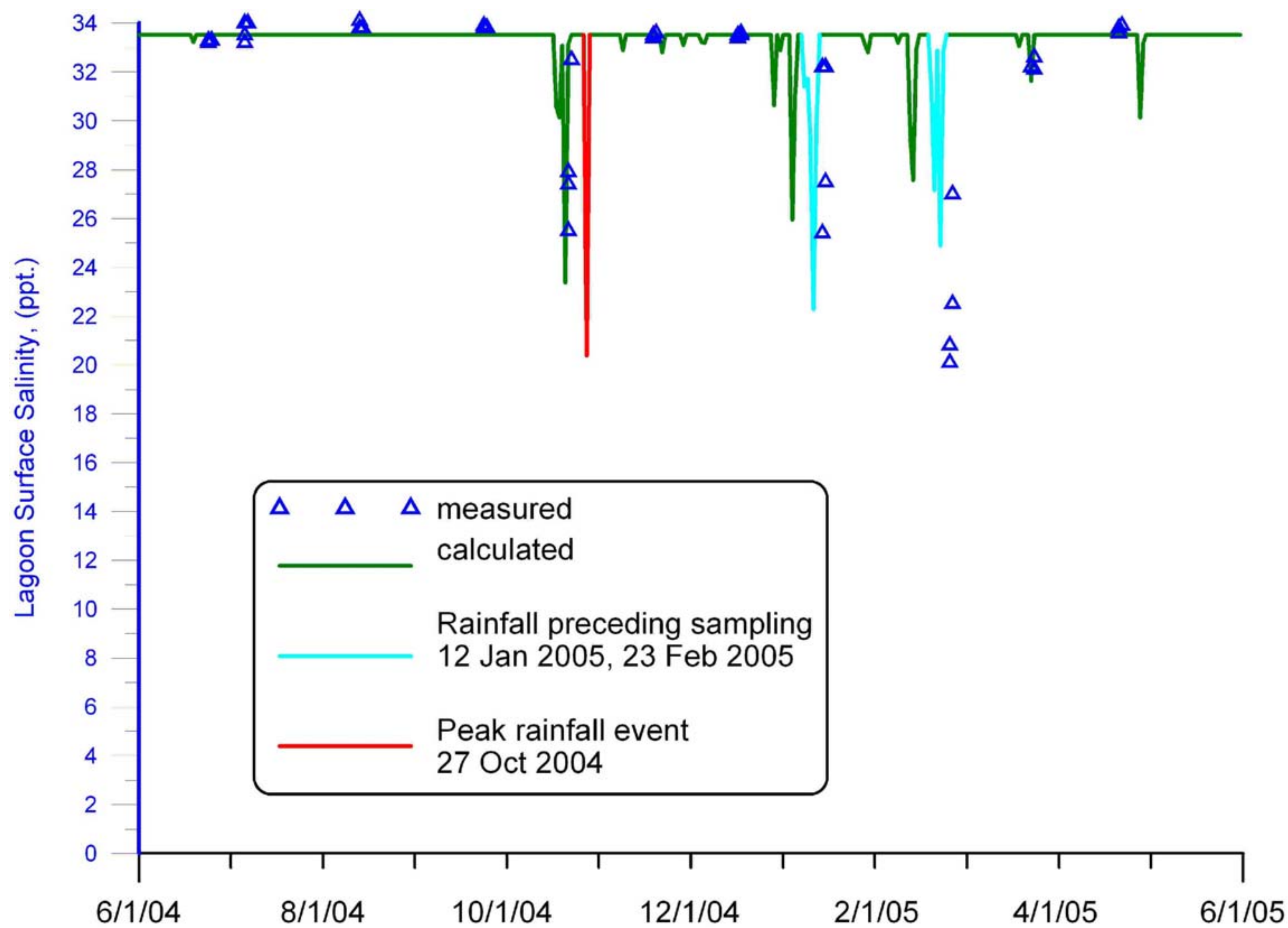

Figure 5. Salinity in Agua Hedionda Lagoon during entrainment/impingement study: 1 June 04 - 1 June 05. Measured values (blue diamonds), from unpublished data due to Tenera Environmental vs. calculated salinity (green, red, cyan) from hydrographic rating curve applied to measurements of tidal prism and storage volume after Elwany et al., [2005], and Jenkins and Wasyl [2006].

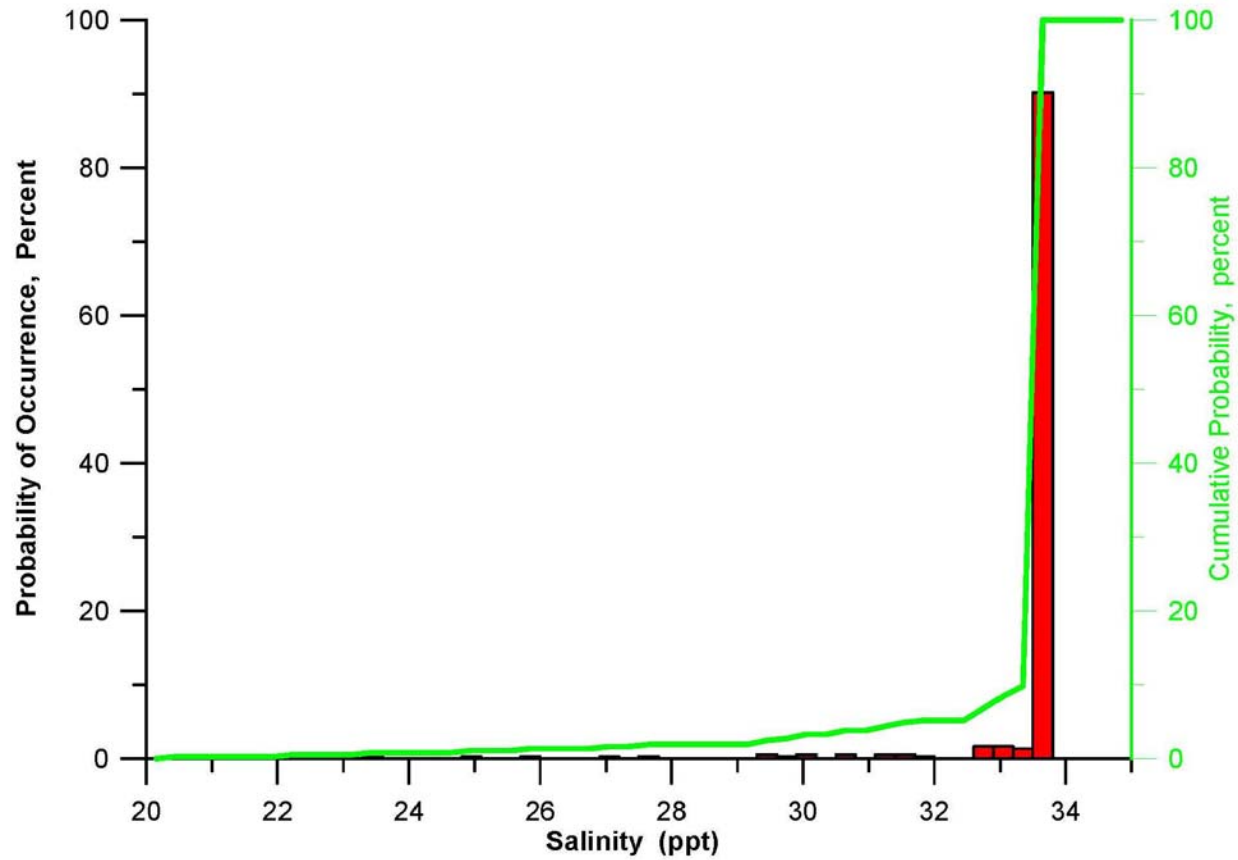

Figure 6. Histogram of salinity in Agua Hedionda Lagoon during the entrainment impingement study, 1 June 2004 - 31 May 2005. Probabilities of occurrence based on the red curve in Figure 5.

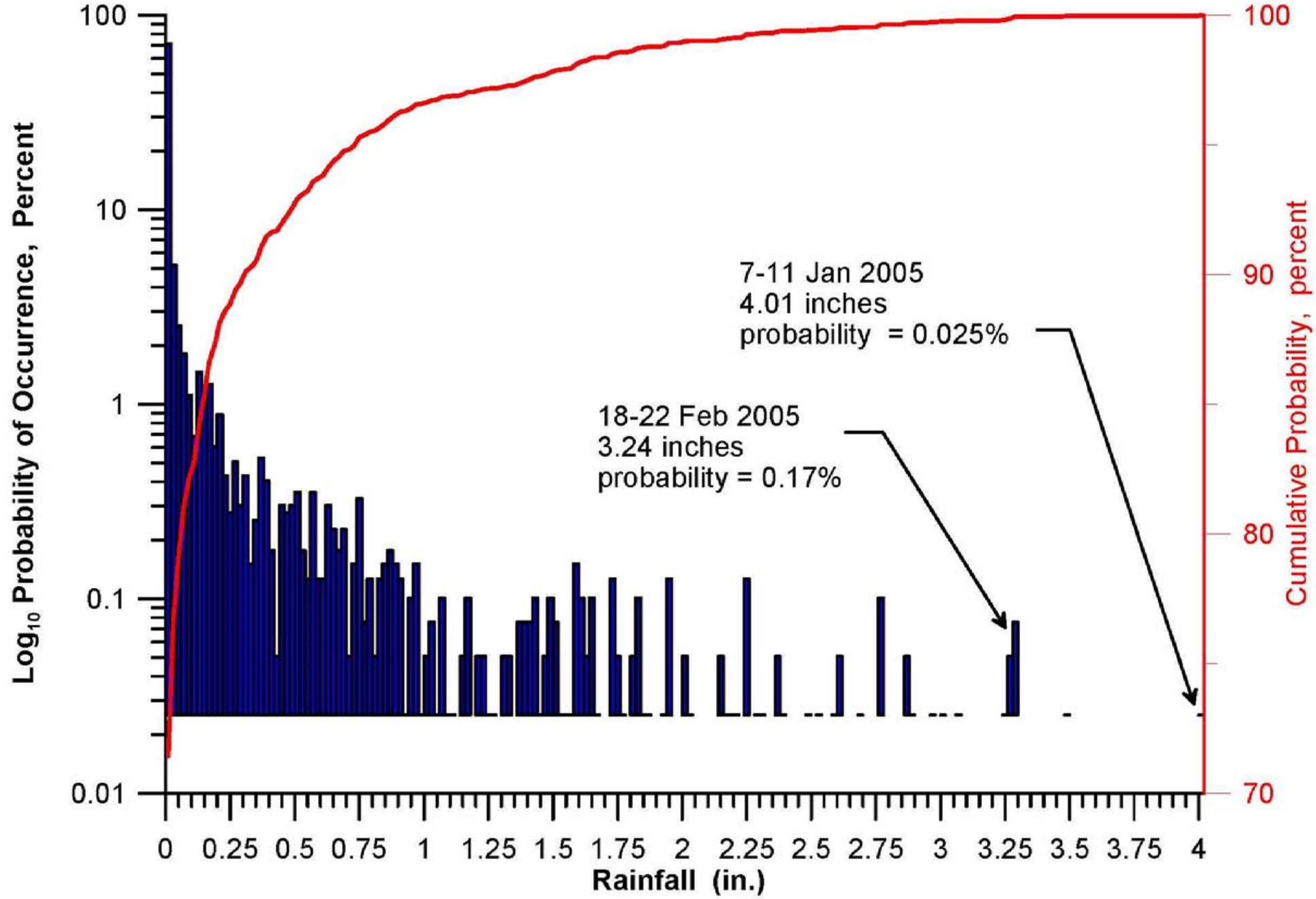

Figure 7. Histogram of 5-day rainfall totals measured in Agua Hedionda Cr. watershed during the period of record, 23 May 1998 - 8 Mar 2009. http://www.wrh.noaa.gov/sgx/obs/rtp/carlsbad.html