Note on Regional Board Staff Concerns Regarding Rainfall Effects on Impingement Sample Outliers per RWQCB Staff Report 27 March 09

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On pages 14-15 of the 27 March RWQCB Staff Report, staff express concern that the "heavy rainfall may not be the underlying cause of the outlier impingement." They raise three concerns with respect to the heavy rainfall explanation, the first two of which relate to the timing of rainfall relative to the impingement sample dates, and a third regarding the causal mechanism of the outlier impingement.

Before addressing staff's concerns directly, it is important to note that analysis of impingement data for the EPS is complicated by the apparently low signal to noise ratio reflected in the data. That is, the impingement counts are generally small, and consequently, the signal we are trying to resolve (the flow-proportional relationship) is obscured by the variability of the data (noise) that is on the same order of size as the signal or greater; i.e., it appears that impingement at the EPS flows occurring during the 2004-2005 sampling period is so low that a strong correlation between flow and impingement was not observed. This outcome does not undermine the generally-accepted principle that impingement and flow are positively correlated (flow-proportional). Nor is it inconsistent with the long-established "direct" and "significant" relationship between flow and impingement at the EPS intake, as reported in its 1980 impingement and entrainment study. The implication here is that when two outliers (5% of the samples) occur when operational conditions are in the mid-low range, then it is reasonable to look for other causal agents (other than the EPS flow rate) that cause these outliers.

In response to the first two concerns, we begin by overlaying the time history of the rainfall on the impingement sampling in Figure 1 below.

Staff Concern #1. No similar impingement was associated with October 2004 rains.

Response #1. This is because the rains of October 2004 were the first rains to end the dry season. Antecedent Moisture Conditions (AMC) were extremely dry; in the Agua Hedionda Creek Watershed, the AMC number was "0.0". Because of the dry conditions, much of the October rainfall was absorbed and retained by the soil. The precipitation, therefore, did not lead to discharges of runoff from the Agua Hedionda Creek into the Agua Hedionda Lagoon, as would have occurred during the sampling period.

The October rains were also short in duration. Specifically, the largest October rain event, which preceded impingement sampling on October 27, 2004, was limited to a single day of precipitation (see Figure 1). The corresponding flow volumes in Agua Hedionda Creek were not nearly as large as those recorded during the two five-day rain events that preceded impingement sampling on the outlier days (i.e., January 12 and February 05, 2005). These outlier dates were each preceded by at least five days of continuous, record-setting rainfall totals—events with probabilities of recurrence in a given year of only 0.025% and 0.17%, respectively.[1].

The extreme precipitation of the January and February 2005 events fell on soils that had already been heavily saturated from the antecedent rainfall that began in October of 2004. By the time these five-day rain events began, the AMC number of the watershed soils had increased to 3.[2] These conditions resulted in five days of continuous, record-setting discharges into the Lagoon (probability of occurrence of 0.12%)[3]—water discharges that directly corresponded with the outlier impingement samples.

In sum, it is reasonable to conclude that the October rains did not markedly affect impingent levels because (a) the precipitation was absorbed by the dry soil and (b) the volume of rainwater was much less than that which preceded the outlier impingement samples.

Staff Concern #2. The next three highest days of impingement (July 14, 2004; August 11, 2004; April 13, 2005) were not associated with rainfall.

Response #2. A comparison of the next three highest impingement days is inappropriate because the amount of biomass impinged at the intake on the next three highest days was minor in relation to the amount observed on the outlier days. The biomass impinged on January 12, 2005 is nearly an order of magnitude greater than the impingement of any of the next three highest days, and the biomass impinged on February 23 was 2.4 to 2.6 times greater than that observed on these other three days. Furthermore, the biomass impinged on July 14, 2004, August 11, 2004 and April 13, 2005 is not significantly greater than the amount impinged on the next 5 highest days.

Inspection of Figure 1, however, shows that relatively higher impingement counts were observed in the midst of rainfall events, suggesting a relationship between rainfall events and impingement. In fact, rainfall occurred during or immediately before 7 of the 10 highest impingement samples.

Staff Concern #3 No clear mechanistic explanation is given as to how heavy rainfall is causing relatively higher impingement. Staff advances their own theory that the higher impingement samples are related in part or entirely to EPS intake operations and not to heavy rainfall, owing to operations during extreme low (minus) tides.

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[1] *See* "Statement Addressing Regional Board Staff Concerns regarding the Biological Data," Dr. Scott Jenkins, March 19, 2004 (Attachment 9-B, page 4).
[2] *See* "Frequencies for Storm Events of January and February 2005," Dr. Howard Chang, March 19, 2009 (Attachment 9-A, page 3).
[3] *See* "Frequencies for Storm Events of January and February 2005," Dr. Howard Chang, March 19, 2009 (Attachment 9-A, page 1).

Response #3. The extreme rains that preceded the outlier samples may have affected lagoon species in a number of different ways. Although some possible explanations are discussed in Attachment 9 to the Minimization Plan, it is clear that such theories require additional scientific investigation.

Despite the absence of specific evidence on this point, Staff speculates that the relatively higher impingement must have been due to tidally enhanced flow through the EPS intake screens rather than caused by the extreme rains. This speculation is unsupported by the tidal data. Figure 2 responds to staff's theory that operation of the intake during minus tides results in higher impingement levels by comparing (a) the time history of daily high and low water levels in the lagoon (green and red, respectively) against (b) the impingement history (blue). While Figure 2 confirms that the January 12, 2005 outlier did, in fact, occur during an extreme minus tide while EPS was consuming 560 gpm, the figure also indicates, however, that operation of the intake during minus tides did not frequently result in relatively high impingement levels. The data for December 15, 2004 illustrate this point. Although the EPS pumped close to its maximum capacity at 710 gpm during a nearly comparable minus tide, the observed impingement on that day was only 2,570.5 g—more than 40 times less than the impingement value recorded on January 12, 2005. Moreover, of the ten days characterized by the highest impingement levels, January 12, 2005 was the *only* day that also corresponded with extreme minus tides.

On the other sampling days (including the outlier event recorded on February 23, 2005), daily low water levels remained within a narrow range[4] of the long-term mean lower-low water level. This fact further undermines the Staff's hypothesis that the relatively high impingement was caused by tidal influences as opposed to rain. The data simply do not reflect any systematic relationship between extreme minus tides and high impingement values, but a clear relationship is shown to the extreme rain events.

It is worth noting that extreme minus tides occur concurrently with extreme high water levels (green trace in Figure 2). This is due to the extreme spring/neap cycle of the declination tides (typically occurring December-February each year). While intake velocities may increase during extreme low water levels, velocities subsequently decline during the extreme high water portion of the diurnal tide cycle. Therefore, whatever effect extreme spring tides may have on intake velocities, the net effect is nil over the course of a complete tidal day.

Extreme spring tides produce very large daily tidal ranges, as compared against the impingement sampling in Figure 3. Inspection of Figure 3 indicates that the tidal range (purple) was relatively high on those days when relatively higher levels of impingement were observed. For instance, the tidal range reached 9.15 ft on January 12, 2005—an outlier day in terms of impingement. Relatively higher impingement was recorded on other days of relatively high tidal range, i.e., when the tidal range exceeded the mean diurnal range of 5.37 ft. It is possible that the strong lagoon inlet currents associated with large tidal ranges cause advection of additional numbers of nearshore species into the

[4] couple tenths of a foot

lagoon. To the extent this is true, the relatively high impingement observed on those days may have more to do with local fish abundance than with EPS intake operations.

REFERENCES

Chang, H., 2009 “Frequencies for Storm Events of January and February 2005,” Dr. Howard Chang, March 19, 2009.

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NOAA, 2009, “Verified Water Level Data” http://tidesandcurrents.noaa.gov/

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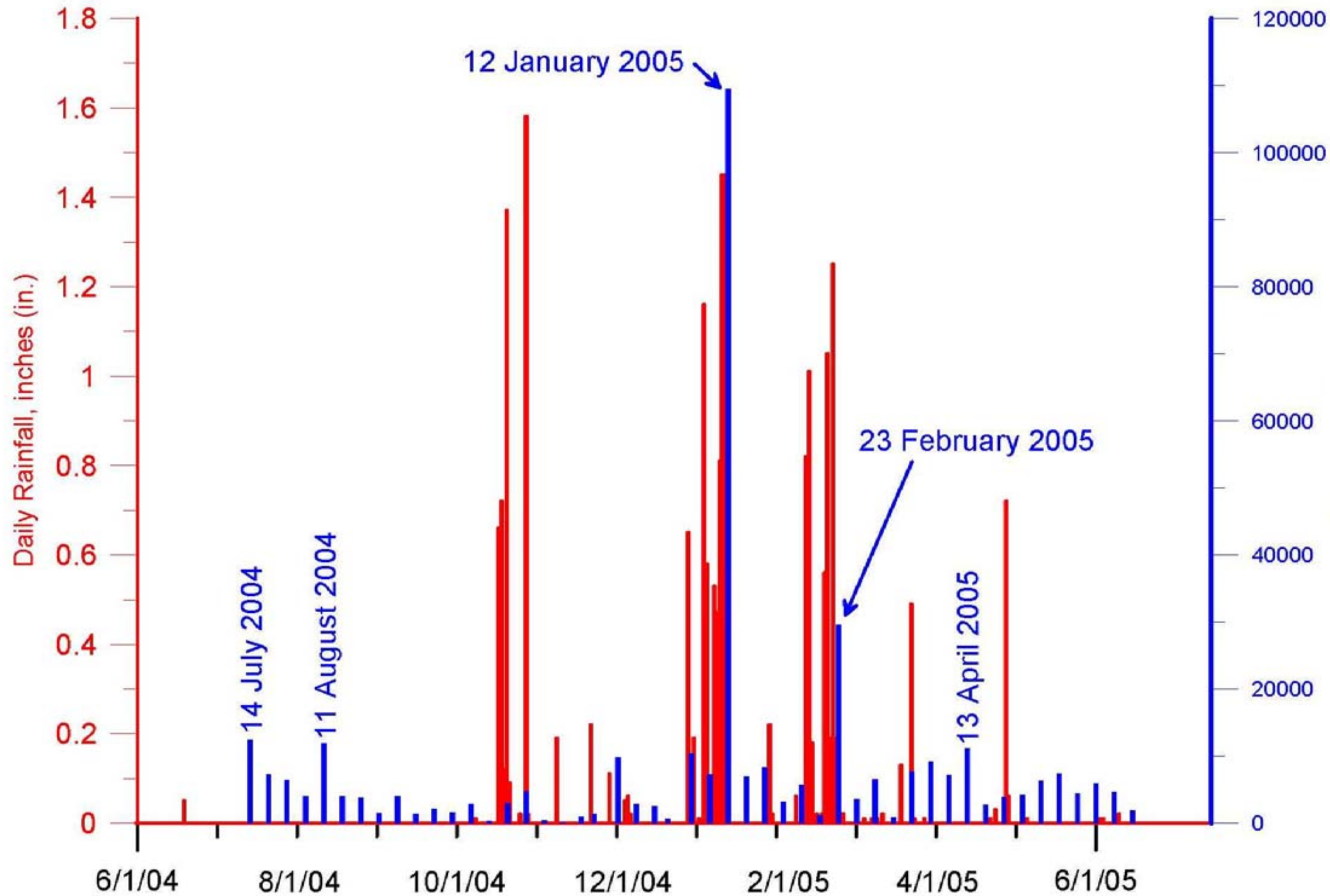

Figure 1. Rainfall in Aqua Hediona Cr. watershed (red) and impingement at Encina Power Station intake (blue) during the Entrainment Impingement Study, 1 June 04 through 15 July 05. Rainfall data from NOAA/NCDC rain gauge #031777, Carlsbad Airport, CA. Impingement data provided by Tenera Environmental, per file: <Impingement data(1002460_1_OC).XLS>.)

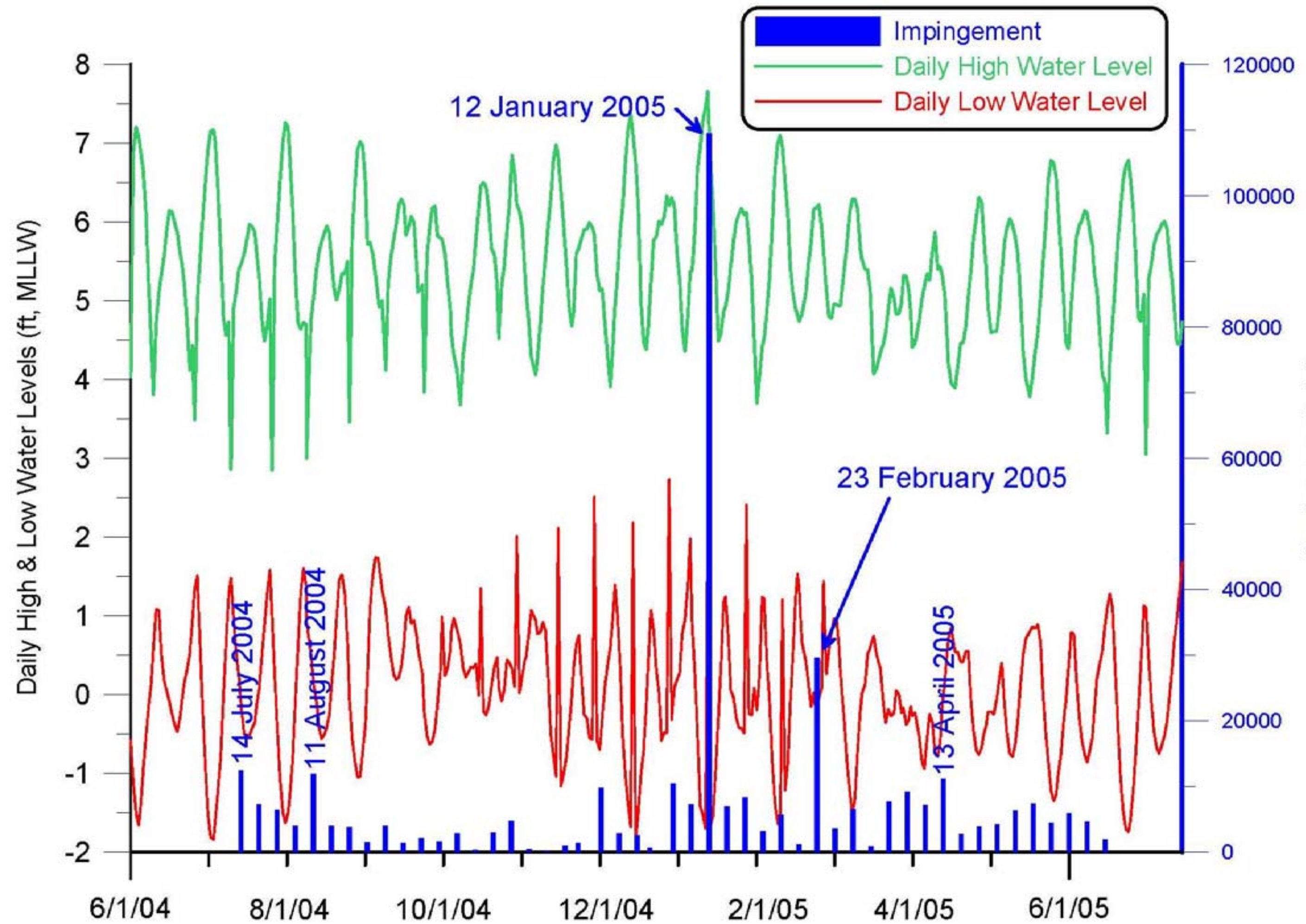

Figure 2. Comparison of daily high & low water levels (green, red) vs. impingement at Encina Power Station intake (blue) during the Entrainment Impingement Study, 1 June 04 through 15 July 05. Tide data from NOAA tide gauge #941 0230, Scripps Pier, La Jolla, CA (http://tidesandcurrents.noaa.gov/). Impingement data provided by Tenera Environmental, per file: <Impingement data(1002460_1_OC).XLS>.)

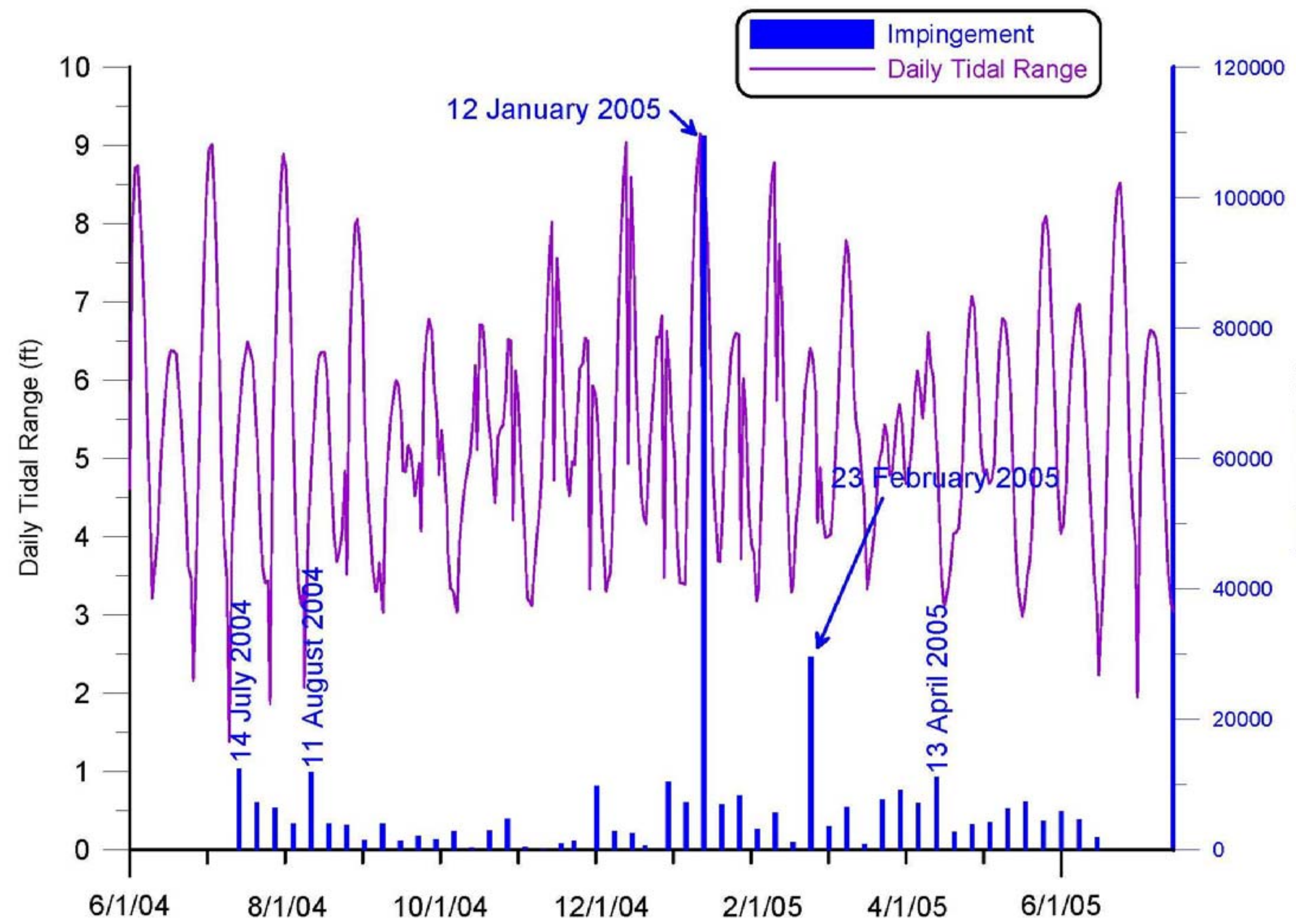

Figure 3. Comparison of daily tidal range (violet) vs. impingement at Encina Power Station intake (blue) during the Entrainment Impingement Study, 1 June 04 through 15 July 05. Tide data from NOAA tide gauge #941 0230, Scripps Pier, La Jolla, CA (http://tidesandcurrents.noaa.gov/). Impingement data provided by Tenera Environmental, per file: <Impingement data(1002460_1_OC).XLS>.)