Water Plant Membrane Reject Water in an Ocean Outfall

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The city of Hollywood's wastewater treatment plant, serving nearly a quarter million people in southern Broward County, provides secondary treatment utilizing the pure oxygen activated sludge process. The treated effluent is disinfected by chlorination. Up to 51 MGD of chlorinated effluent (42 MGD from the Hollywood WWTP and 9 MGD from Davie/Cooper City on a daily average basis) is then mixed with the reject water from Hollywood's water treatment plant (at 2.3 MGD on an average daily basis). The final effluent is conveyed through a 60-inch pipe about two miles into the Atlantic Ocean and discharged at an ocean depth of 93 feet. A single permit for a total flow rate of 54 MGD is being considered by the city and DEP.

Rather than actual environmental monitoring of the receiving water, EPA's water quality-based approach to toxics control has established requirements that "whole effluent toxicity" be controlled to protect aquatic life when exposure conditions warrant. The whole-effluent approach involves the use of bioassay tests of surrogate species to assess and control the aggregate potential toxicity of effluents. As a result, bioassay tests are often required by EPA or states as a part of an NPDES permit to surface water discharge. If a series of bioassay tests indicate that there is no potential for toxicity at the outfall exposure conditions, there is no requirement for a permit condition.

DEP, in a draft facility permit (replacing the NPDES permit) for the Hollywood WWTP effluent open ocean outfall discharge, requires the city to conduct 96-hour static renewal definitive bioassay on chlorinated effluent at a 30%t concentration. The city has conducted this bioassay monitoring for many years and has consistently demonstrated no potential toxicity. However, the city proposed to add WTP reject water (brine concentrate from the new membrane softening/reverse osmosis process at the WTP) to the WWTP effluent discharge to the outfall. To address the co-mingling of the WTP concentrate with the WWTP effluent, a series of bioassay tests, on three separate occasions, were requested by DEP, taking the seasonal variation into account, to demonstrate reject water would not increase the toxicity of the combined outfall discharge to unacceptable levels. With this demonstration, separate monitoring of the reject water would not be required.

The definitive bioassay tests, including 100% and 30% effluent concentrations, were conducted every two months by a laboratory with a DEP-approved comprehensive CIA plan for bioassay testing. The test results were submitted to DEP. All test species, procedures, and quality assurance criteria used were in accordance with *Methods for Measuring the Acute Toxicity of Effluents to Freshwater and Marine Organisms*, EPA/600/4-90/027, the most current edition. A standard reference toxicant quality assurance test was conducted concurrently with each species used in the toxicity tests and the results submitted with the concomitant monthly operation report.

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Field Work

The special bioassay study for the Hollywood WWTP effluent consisted of three special sampling periods. The objectives of the study were as follows:

- Collect monitoring data for permit;
- Collect reject water, pre-chlorinated effluent, and combined effluent data for DEP evaluation of reject water associated potential toxicity pollution;
- Collect concentration data for metals and major ions;
- Collect effluent samples and perform bioassay tests using *Mysidopsis bahia* and *Menidia beryllina*;
- Evaluate bioassay toxicity of the reject water, pre-chlorinated effluent, and final effluent;
- Confirm that 54 MGD is acceptable as a permitted annual average outfall capacity on the basis of no potential toxicity.

Field testing and collecting effluent samples for definitive bioassay tests and other parameter analyses were conducted on September 22 through 23, 1996, March 2 through 3, 1997, and May 4 and 5, 1997. There were six sampling points, as illustrated in Figure 1. Three of them were at the WWTP and the other three were along the outfall pipeline. These six sampling points are described as follows:

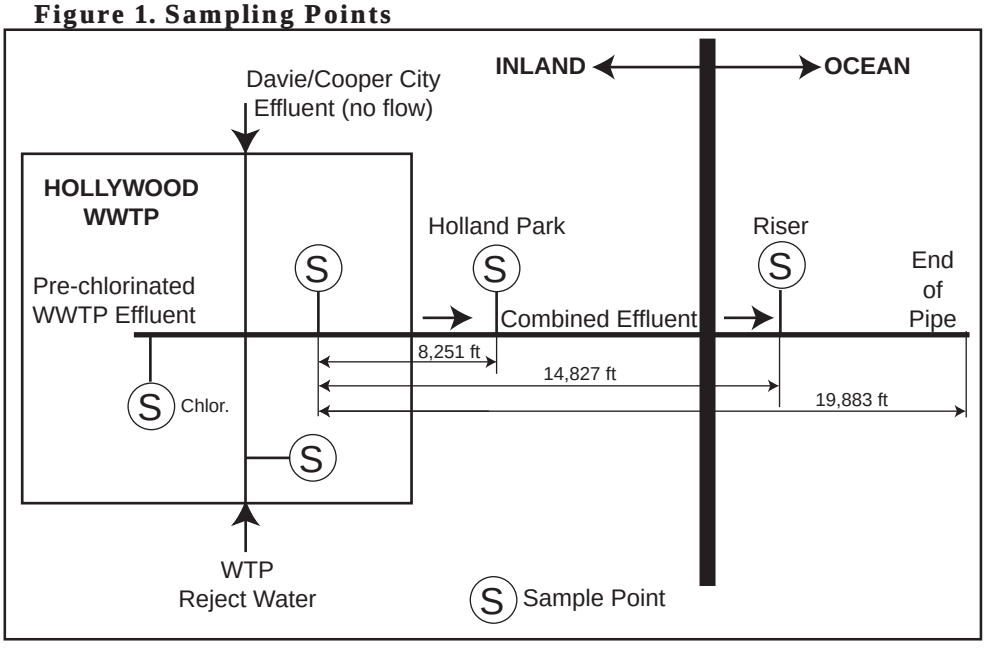
In-plant:

- WTP reject water outlet at the WWTP effluent pump station wet well;
- WTP reject water and effluent WWTP chlorinated;
- Combined WTP reject water and WWTP chlorinated effluent, i.e., the plant NPDES compliance monitoring point (referred as "combined effluent" hereafter).

Outfall pipeline:

- Holland Park, about 8,300 feet from the plant (NPDES bioassay compliance point;

Figure 1. Sampling Points



- A riser in the ocean, 14,800 feet from the plan;
- End-of-pipe, 19,900 feet from the plant.

During the September 1996 field work, effluent samples were collected at all sampling points except the end-of-pipe. During the March 1997 field work, effluent samples were collected at the three in-plant sampling points and at Holland Park. The ocean was too rough to allow collection of samples at the riser and terminus. During the May 1997 sampling effort, all six sampling points were monitored.

Field work involved collecting one grab sample of two gallons every six hours over a 24-hour period at each sampling point, with an additional duplicate sample for the second sampling event. To sample approximately the same effluent water flowing in the outfall pipe, the effluent travel time from the plant to Holland Park and that to the riser and terminus was considered. Depending on effluent flow rate, the travel time from the plant to Holland Park varied from 0.5 to 1.0 hours and that to the riser varied from 0.9 to 1.7 hours. The travel time from the plant to the outfall terminus varied from 1.2 to 2.4 hours.

In addition to effluent samples for the bioassay tests, samples were also collected to measure pH and chlorine residuals on site and to measure major ions: Na, K, Mg, Ca, Cl, $S0_4$, Br, I, $C0_3$, alkalinity, and priority pollutant metals. The intent of these analyses was for correlation with failed bioassay tests. Field tests for chlorine species and pH were conducted at the land-based four sampling points but not at the riser nor the terminus since it was not possible to do the measurements on the boat under the existing weather and sea conditions.

Bioassay Test Results

Definitive bioassay tests were conducted by Marinco Bioassay Laboratory in Sarasota using two organisms: *Mysidopsis bahia* and *Menidia beryllina*. The accompanying tables summarize the bioassay test results in terms of percentage of survival at 24, 48, 72, and 96 hours of exposure at 100% and 30% effluent concentrations. The *Menidia beryllina* tests demonstrated no potential toxicity during any test. For *Mysidopsis bahia*, at the 30% effluent concentration and measured at Holland Park, most of the tests indicated 100% survival (426 of 488). The data with less than 100% survival included three 80%, seven 85%, twelve 90%, and forty 95% survivals out of 488 data. These data strongly support that there is no potential toxicity of these effluents.

To examine the effect of salinity, the bioassay tests at 100% effluent concentration were conducted using non-salinity adjusted samples and salinity adjusted samples to match the control water salinity. To examine the effects of chlorine residuals on bioassay testing, a number of split samples were tested in both the dechlorinated and normal (non-dechlorinated) states. The results are summarized in Table 1 for 100% concentration samples as tested with *Mysidopsis bahia*. Table 2 summarizes the *Mysidopsis bahia* results when tested at 30% effluent.

Menidia beryllina showed no significant toxicity at any effluent or reject water. Salinity-adjusted tests in general yielded higher percentage of survival than non-salinity-adjusted tests. This was most pronounced for the *Mysidopsis bahia*; there were no survivals during these tests after less than 48 hours of exposure in both September 1996 and March 1997 tests, and only one survival in May 1997 tests when salinity was not adjusted. When salinity was adjusted to match the control water salinity, up to 70% survival was observed even after 96 hours of exposure. Salinity is a coarse measurement of the specific ions, which are important to maintain homeostatic conditions in the test species. The specific chemical analysis data indicate that the ionic balance of the reject water is quite different from typical salt water and important ratios of specific ions are also quite different. Therefore, ionic imbalance is the probable cause of the mortality in the Mysids.

Table 1. Summary Of 100% Effluent Bioassay Tests (no salinity adjustment).

			% survival of Mysid Shrimps			
Water Type	*Percent*	*Salinity*	*24 hr*	*48 hr*	*72 hr*	*96 hr*
Reject	100	7.3	50	0	0	0
Combined Effluent - Pre-Chlor	100	7.4	92	76	70	67
Combined Effluent - Post Chlor	100	7.3	93	83	80	73

Table 2. SUMMARY OF BIOASSAY TESTS (assumes 30% effluent)

			% survival of Mysid Shrimps			
Water Type	*Percent*	*Salinity*	*24 hr*	*48 hr*	*72 hr*	*96 hr*
Reject	30	21.0	67	46	37	36
Combined Effluent - Pre-Chlor	30	21.1	98	97	96	95
Combined Effluent - Post Chlor	30	20.8	98	97	96	96

Results also indicated that salinity had more pronounced effect on *Mysidopsis bahia* than *Menidia beryllina*. For all of the tests for *Mysidopsis bahia*, salinity adjusting significantly improved the survival. However, salinity adjusting had no significant effects on *Menidia beryllina*, as there was no mortality. Future bioassay monitoring should be conducted with the salinity of the test solution addressed to the salinity of the control (20%±2%). The *Menidia beryllina* had high survival rates on all tests and had no indication of potential toxicity.

The WTP reject water was examined using salinity adjusted to the minimum salinity required for survival of the test organisms and to approximately 20 ppt to control salinity. Menindia beryllina showed no indication of potential toxicity at either salinity. For the *Mysidopsis bahia*, the low salinity at 100% effluent concentration displayed higher mortality than the 100% concentration with the salinity adjusted to the control water. The *Mysidopsis bahia* mortality in the lower salinity water often occurred between 24 and 48 hours. A fast acting toxicant such as free chlorine residual or a pesticide would cause mortality by the end of the first 24 hours. Therefore, this pattern of mortality suggests an ion imbalance condition. All tests results indicate no potential toxicity at 30% concentration with salinity adjustment. The salinity adjustment would, to a large degree, restore the ionic balance the test organisms are adapted to.

The *Mysidopsis bahia* tests with the three different effluent waters: pure WTP reject water, pre-chlorinated WWTP effluent, and combined effluent (i.e., the combined WTP reject water and chlorinated WWTP effluent) indicated that the pure WTP reject water yielded the lowest percentages of survival. The survival percentages for the combined effluent were nearly the same as those for the prechlorinated WWTP effluent that was not combined with the WTP reject water. Therefore, while the pure WTP reject water had some toxicity, when combined with the WWTP effluent, its impact on the potential toxicity of the commingled effluents was insignificant.

The *Menidia beryllina* tests indicated that there was no significant differences in survival percentages for the three different effluents as the *Menidia beryllina* had nearly 100% survival.

The combined effluent was sampled at four locations along the outfall pipe: plant, Holland Park, the riser in the ocean, and the outfall terminus. Both of the *Mysidopsis bahia* and *Menidia*

beryllina tests indicated that there were no significant differences in the survival percentage for the four sites.

Conclusions

Menidia beryllina showed no toxicity from the reject water. The results indicate that while the WTP reject water (100%) was toxic to *Mysidopsis bahia*, when combined with the WWTP effluent, its impact on the potential toxicity of the commingled effluent was insignificant. All of the tests indicate the combined effluents are not toxic to either of the species tested when salinity is adjusted. The lack of demonstrated potential toxicity concerns allowed DEP to issue a permit to the city of Hollywood for the disposal of the combined effluent of 54 MGD.

Extensive conventional bioassay testing at 30% effluent concentration indicates that there is no potential toxicity for the pre-chlorinated WWTP effluent, WTP reject water, dechlorinated combined effluent at the plant, chlorinated combined effluent at Holland Park, the riser, and the terminus. Based on these results, the continued use of the Holland Park sampling point and 30% effluent for bioassay monitoring is recommended. Biomonitoring of the reject water separately is not necessary. The Holland Park bioassay data at 30% indicates no reasonable potential and further bioassay testing should be monitoring only. *Mysidopsis bahia* is the most sensitive species and future testing should focus on this species until an indigenous species is developed. To minimize low salinity effects which produce false implications of potential toxicity, the samples should be salinity adjusted to 20%±2% before testing.