EXHIBIT G

APPENDIX L

AQUATIC BIOASSAYS CONSULTING LABORATORIES REPORT

Draft Response to Item 9 of the Notice of Violation Letter from the Central Coast Regional Water Quality Control Board to the Carpinteria Sanitary District, December 10, 2013

Prepared by:
Daniel Hennessy, Anchor QEA, LLC
Scott Johnson, Aquatic Bioassay & Consulting Laboratories, Inc.

ANCHOR QEA

aquatic bioassay & consulting laboratories, inc

Summary of Qualifications for Dan Hennessy

Mr. Dan Hennessy is a Managing Scientist for Anchor QEA in Bellingham, Washington. He has led and supported a wide range of environmental assessment and restoration projects. With 20 years of professional experience, he has worked on a diversity of environmental projects and contributed at all levels, including as a project manager, technical advisor, aquatic toxicology laboratory manager, and field team leader. This experience provides a pragmatic knowledge base to efficiently assess complex issues, including human and ecological risks from complex exposure pathways, and the selection of appropriate interpretative criteria. His primary areas of expertise are aquatic ecology, toxicology, and ecological and human health risk assessment. Mr. Hennessy's work experience has included significant contributions to state and federal remedial investigation/feasibility studies, aquatic and terrestrial ecological risk assessments, human health risk assessments, sediment and water quality studies and criteria development, biological monitoring, habitat analysis, natural resource damage assessments, and discharge permit evaluations.

Education

University of Washington, M.S., Fisheries Science, 1998
Western Washington University, B.S., Environmental Science, 1992
University of California, Irvine, B.A., Social Science, 1990

Professional Memberships and Registrations

Member, Society of Environmental Toxicology and Chemistry, 1994 to present
Member, Association for Environmental Health & Sciences, 2007 to present
40-hour HAZWOPER Training and current 8-hour Refresher Course, 2013

Summary of Qualifications for Scott Johnson

Mr. Scott Johnson is the Laboratory Director for Aquatic Bioassay & Consulting Laboratories (Aquatic Bioassay) in Ventura, California. Mr. Johnson joined Aquatic Bioassay in 2001 and currently manages the freshwater bioassessment and marine monitoring programs for several of the largest municipal, state, and private agencies in the State of California. His career has focused on the effects of anthropogenic contaminants and habitat conditions on the composition and integrity of biological communities, the development and implementation of both distributed and centralized environmental database systems, and laboratory management. Mr. Johnson began his career with the City of Los Angeles, where he managed the biology laboratories and was responsible for the regulatory permits pertaining to the Los Angeles River, Santa Monica Bay, and Los Angeles Harbor. He joined EcoAnalysis, Inc., an environmental analysis and database company in 1994, advancing to President in 1998. He has numerous scientific papers and presentations to his credit.

Education

California State University, Long Beach, M.S., Biology, 1988
California State University, Long Beach, B.S., Biology (minor in Chemistry), 1981
University of Uppsala, Sweden, Limnology studies, 1978 to 1979

Professional Memberships and Registrations

Board, Southern California Chapter of the Society of Environmental Toxicologists and Chemists, 2010 to 2013
Board, Southwestern Association of Freshwater Invertebrate Taxonomists, 2007 to 2011
Member, Technical Advisory Committee for the Southern California Stormwater Monitoring Coalition, 2006 to present

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Daniel Hennessy, Anchor QEA, LLC

Scott Johnson, Aquatic Bioassay & Consulting Laboratories, Inc.

Introduction

The following evaluation partially addresses the information request in the notice of violation letter from the Central Coast Regional Water Quality Control Board (CCRWQCB) to Craig Murray (Carpinteria Sanitary District; CSD) dated December 10, 2013. The letter is regarding three self-reported deviations of CSD National Pollutant Discharge Elimination System (NPDES) permit provisions. Specifically addressed herein is Item 9 of the letter, Impacts of Discharge. Included in this evaluation are an assessment of potential short and long-term impacts of the discharge events on public health and animal and plant communities (including sensitive and/or endangered species in the Pacific Ocean located downstream of the CSD outfall), and on the overall ecosystem downstream of the discharges. Supporting evaluations and sampling and analysis activities are described.

Three reported discharge events are addressed, an October 3, 2012, loss of disinfection and two chlorine residual effluent limit excursions, one on January 3, 2013, and the other on January 7, 2013. The potential for effluent exposure to aquatic life and people is a function of the effluent concentration and rate of discharge to the receiving water. The fate and transport of effluent in the receiving water is a function of the chemical and physical conditions of the receiving environment. Effluent that has not been disinfected has the potential to contain pathogens that are at sufficient concentrations to be harmful to human health through water contact recreation or shellfish harvesting. Effluent that contains excess residual chlorine has the potential to pose adverse acute effects on aquatic biota, including threatened or endangered species. The CSD NPDES permit specifies concentrations of pathogenic bacteria and residual chlorine limits under different exposure and sampling regimes, and these are the primary basis for determining potential impacts to people and aquatic life. The permit also specifies the application of the minimum initial dilution factor. Review of the technical basis for the effluent limits and the dilution factor provided in the CSD NPDES permit were beyond the scope of this review and they were applied per the permit.

This evaluation applied conservative assumptions to compare available data from the three discharge events to CSD NPDES permit requirements. Recognizing the high energy environment of the beach where the CSD outfall is located, the distribution of effluent beyond the initial dilution zone was also evaluated using a simple mixing model. Overall, impacts to aquatic biota from the chlorine residual events, including threatened or

endangered species, is unlikely. Likewise, it is unlikely that the loss of disinfection event posed any threat to people involved in water contact recreation or shellfish harvesting. Uncertainties associated with the data, assumptions, and evaluation are detailed at the end of this discussion in the Risk Characterization and Uncertainty Evaluation section.

Problem Formulation

The problem formulation includes a review of discharge event information, the determination of likely ecological receptors and human uses in the area of discharge, and summarizes diffuser and receiving water characteristics. The methods used to evaluate potential impacts of the discharges follow established environmental risk assessment steps including:

- Effects assessment including a review of permit conditions and relevant water quality benchmarks established for the protection of aquatic life and human health
- Exposure assessment including an evaluation of discharge event duration and magnitude, and fate and transport considerations
- Risk characterization and discussion of uncertainties

Discharge Event Information

The discharge occurred from the CSD outfall diffuser, which is located approximately 1,000 feet offshore in approximately 30 feet of water. The CSD outfall is regulated under NPDES permit CA0047364. The outfall diffuser section is approximately 93 feet long, with diffuser ports located every 6 feet. Post-event monitoring data were not collected by CSD for the loss of disinfection incident. The three events addressed in the letter and reviewed herein are one loss of disinfection event on October 3, 2012, and two similar short duration chlorine residual events on January 3, 2013 and January 7, 2013. Details related to these three incidents were provided by CSD for the purposes of this analysis.

For the October 3, 2012 loss of disinfection, the event lasted for 5 hours 37 minutes with total estimated flow of 231,076 gallons[1]. During this period, the effluent flow rate ranged from approximately 400 gallons per minute (gpm) to 1,700 gpm. In support of the evaluation of the loss of disinfection event, on January 6, 2014, CSD staff collected samples of ocean

[1] The event flow was initially estimated by CSD to be 281,250 gallons. The actual amount, 231,076 gallons, was subsequently calculated by Carollo Engineers.

water and un-disinfected secondary effluent. The CSD certified laboratory then conducted multi-tube fermentation bacteriological analyses for total and fecal coliform most probable number (MPN) on plant effluent before chlorination, plant effluent after chlorination, ocean water, and effluent-spiked ocean water at a 93:1 dilution(see Attachment 1). These results were used in lieu of post-event monitoring data and indicate the MPN counts that could be expected for the event in plant effluent (160,000 coliform MPN/100 milliliters [mL] and 92,000 fecal MPN/100 mL, respectively) and under the permit-established dilution factor of 93:1 (490 coliform MPN/100 mL and 330 fecal MPN/100 mL).

One chlorine residual event occurred on January 3, 2013, with a 26-minute duration starting at 8:26 a.m. and a total estimated flow of 22,610 gallons. A second chlorine residual event occurred on January 7, 2013, with a 2-minute duration starting at 7:27 a.m. and a total estimated flow of 2,060 gallons. Total chlorine concentrations measured in the first and second events were 10.4 milligrams per liter (mg/L) and 7.8 mg/L, respectively.

Ecological and Human Receptors

Beneficial uses of the Pacific Ocean around the outfall include water contact recreation, marine habitat, shellfish harvesting, wildlife habitat, migration of aquatic organisms, and spawning, reproduction, and/or early development. For the purpose of this assessment, water quality objectives specified in the CSD NPDES permit were applied to evaluate potential impacts to the above listed beneficial uses.

An appropriate and required literature search of the California Department of Fish and Wildlife (CDFW) Natural Diversity Database (CNDDB[2]) was conducted. The following quadrangles were queried for known sensitive Elements of Occurrence of natural communities, plants, and animals using the commercial computer application RAREFIND 3: Carpinteria (3411945) and Santa Barbara (3411946). This information is often helpful in determining which elements might be present and should be looked for, or perhaps are at least expected to occur. This list was further refined to reflect one species, the Southern California distinct population segment (DPS) of steelhead (*Oncorhynchus mykiss irideus*), that is expected to be present in the habitat of the outfalls (located approximately 1,000 feet

[2] California Natural Diversity Data Base (CNDDB). 2014. Rarefind data output for the Cambria USGS 7.5-minute quadrangle, January, 2014. California Department of Fish and Wildlife. Sacramento, California. Accessed online January 16, 2014, from the following link: https://map.dfg.ca.gov/rarefind/view/RareFind.aspx

offshore in approximately 30 feet of water). The Southern California DPS of steelhead is a federally endangered species and a CDFW Species of Special Concern. Shorebirds and wetland or dune species were not included due to the location of the outfalls 500 feet offshore. The tidewater goby was not considered because it lives in lagoon, estuary, and brackish marsh shallow water areas.

For the purpose of this evaluation, only chlorine exposure was considered for aquatic life. Bacterial loading from secondary effluent is unlikely to have an impact on aquatic biota. Further, there are no interpretative criteria for pathogen exposure to aquatic life. The water quality objectives in the Ocean Plan (2012)[3] are intended to be protective of marine communities, including vertebrate, invertebrate, and plant species. Therefore, the Ocean Plan water quality objectives for total chlorine residual applying to intermittent discharges not exceeding 2 hours was applied to characterize potential risk to aquatic life from the chlorine residual events. For the purpose of evaluating potential impacts on listed species, the receptor evaluated was individual steelhead. As discussed below in the Exposure and Effects Assessment section, toxicity data applied by EPA (1985)[4] to develop the aquatic life criteria for chlorine were used to develop an acute benchmark for steelhead.

Humans potentially exposed are those involved in water contact recreation and shellfish harvesting. Chlorine discharges at the levels observed are well below the conservative EPA dermal screening levels for residential tap water of 240 mg/L.[5] Therefore, chlorine was not considered a risk to people. For the purpose of this evaluation, only potential effects from exposure to total coliform and fecal coliform bacteria were considered for people.

Diffuser and Receiving Water

The outfall diffuser section is a 93-foot section with diffuser pipes spaced 6 feet apart along the entire diffuser length. The dilution zone is defined as the region in which the rapid, initial mixing occurs and provides the basis for determining the minimum initial dilution ratio of seawater to effluent achieved during the initial mixing phase in the dilution zone. The minimum initial dilution ratio is calculated under an assumption that no current flows

[3] State Water Resources Control Board. 2012. Water Quality Control Plan, Ocean Waters of California.
[4] U.S. Environmental Protection Agency (EPA). 1985. Ambient Water Quality Criteria for Chlorine – 1984. EPA 440/5-84-030. January, 1985.
[5] http://www.epa.gov/region9/superfund/prg/

across the discharge structure. Waves and currents in the vicinity of the discharge structure will significantly dilute effluent beyond the minimum initial dilution ratio. The CSD permit applies a dilution ratio of 93:1 to the discharge to determine effluent limitations derived from Ocean Plan water quality objectives.

To better understand the fate and transport of the effluent plume a simple point discharge effluent mixing model developed by the U.S. Army Corps of Engineers (USACE) was applied. The calculation follows the dilution volume method for confined disposal facility (CDF) effluent discharges in USACE (1998)[6]. This method was selected because it is a relatively simple model that is consistent with a point effluent discharge into a tidal receiving water.

Exposure and Effects Assessment

Chlorine

Discharges of chlorine are common because it is used to disinfect effluents. In salt water, the addition of chlorine results in a solution that contains free chlorine and chlorine-produced oxidants including hypochlorous acid (HOCl) and hypochlorite ion (OCl-). Because saltwater contains bromide, hypobromous acid (HOBr), hypobromous ion (OBr-), and bromamines are also produced. The term *chlorine-produced oxidants* is used to refer to the sum of these oxidants in salt water and is measured by the methods for total chlorine residual (EPA 1985).

Per the permit, water quality objectives for total chlorine residual applying to intermittent discharges not exceeding 2 hours shall be determined using the following equation:

$$\text{Log } y = -0.43 (\log x) + 1.8$$

where:

y = the water quality objective (in micrograms per liter [µg/L]) to apply when chlorine is being discharged

x = the duration of uninterrupted chlorine discharge in minutes

[6] U.S. Army Corps of Engineers (USACE). 1998. Evaluation of Dredged Material Proposed for Discharge in Water of the U.S. – Testing Manual, Appendix C.

The applicable effluent limitation must then be determined using Equation No. 1 from the Ocean Plan (2012) as follows:

$$Ce = Co + Dm\ (Co - Cs)$$

where:

Ce	=	the effluent concentration limit, in µg/L
Co	=	the concentration (water quality objective) to be met at the completion of initial dilution, in µg/L
Cs	=	background seawater concentration, in µg/L
Dm	=	minimum probable initial dilution expressed as parts seawater per part wastewater; the minimum probable initial dilution applying to the discharger is 93:1, therefore, Dm = 93

For the purpose of evaluating potential effects on individuals from the Southern California DPS of steelhead, the National Ambient Water Quality Criteria for Chlorine (EPA 1985) was reviewed for acute toxicity data for species of the genus *Oncorhynchus*. The saltwater genus mean acute value (GMAV) for *Oncorhynchus* (0.047 mg/L) was used as a conservative benchmark to evaluate potential impacts on individual steelhead. Other Pacific Ocean fish and invertebrate species data used by EPA (1985) had higher GMAV. This benchmark is applied per EPA methods and represents a 1-hour average concentration. Marine plant toxicity benchmarks reported by EPA (1976)[7] ranged from 0.075 to 0.330 mg/L and are all above the GMAV value for *Oncorhynchus*. Therefore, the selected value is also protective of marine plant species.

For the January 3, 2013, 8:26 a.m. chlorine residual event, which had a duration of 19 minutes, the calculated water quality objective for total chlorine residual is 1.7 mg/L. The measured total chlorine concentration in the effluent discharge was 10.4 mg/L. The effluent concentration at the edge of the zone of initial dilution is 0.11 mg/L.

[7] Gentile, J.H., J. Cardin, M. Johnson, and S. Sosnowski. 1976. Power plants, chlorine, and estuaries. EPA-600/3-76-055.

For the January 7, 2013, 7:24 a.m. chlorine residual event, which had a duration of 2 minutes, the calculated water quality objective for total chlorine residual is 4.4 mg/L. The measured total chlorine concentration in the effluent discharge was 7.8 mg/L. The concentration at the edge of the dilution zone is 0.084 mg/L.

For both chlorine residual events, the concentrations were substantially below the water quality objective, and therefore short- or long-term impacts to aquatic life from these events are unlikely.

Bacterial

Bacterial discharges may adversely impact water contact recreation and shellfish harvesting beneficial uses, and therefore potential impacts are mitigated by CSD by applying chlorine as a disinfectant. The CSD permit limit for total coliform is 2,300 MPN/100 mL as a daily maximum, or 23 MPN/100 mL as a weekly median. The Ocean Plan (2012) receiving water standards are a single maximum total coliform of 10,000 MPN/100 mL, and fecal coliform of 400 MPN/100 mL. The 30-day geometric mean standard is total coliform of 1,000 MPN/ 100 mL, and fecal coliform of 200 MPN/100 mL.

Using samples collected on January 6, 2014, the CSD laboratory tested total coliform and fecal coliform in plant effluent before chlorination and under the permit-established dilution factor of 93:1. During the loss of chlorination event, the effluent flowed through the 80,000-gallon serpentine chlorine contact tank prior to entering the ocean outfall pipe. Therefore, some level of disinfection likely continued due to mixing within the reactor for a period of time after failure of the chemical feed pump. As such, the laboratory test using untreated effluent diluted with ocean water at the permit-established dilution factor of 93:1 is the most appropriate measure of bacterial concentrations released from the outfall diffuser to the initial dilution zone during the Loss of Disinfection event. The test assumes no chlorination, but appropriately dilutes the effluent to conservatively estimate bacterial concentrations. Applying the dilution factor to the100 percent effluent test result would likely overestimate exposure because coliform colony-forming units decrease with time in seawater[8]. In the 93:1 ocean water-to-effluent dilution test, the total coliform were 490 MPN/100 mL, and fecal

[8] Dawe, L.L and W.R. Penrose. 1978. "Bactericidal" Property of Seawater: Death or Debilitation? Applied and Environmental Microbiology 35(5):829-833.

coliform were 330 MPN/100 ml. In the 100 percent effluent MPN tests, the total coliform were 160,000 MPN/100 mL, and fecal coliform were 92,000 MPN/100 mL.

Risk Characterization and Uncertainty Evaluation

Chlorine

It is unlikely that concentrations outside the zone of initial dilution were above the intermittent discharge permit limit for chlorine. For the January 3, 2013, 7:24 a.m. chlorine residual event, which had a duration of 2 minutes, the estimated concentration at the edge of the dilution zone is 0.084 mg/L. This value is well below the calculated permit limit for total chlorine residual for this event (4.4 mg/L). For the January 7, 2013, 8:26 a.m. chlorine residual event, which had a duration of 19 minutes, the estimated concentration at the edge of the zone of initial dilution is 0.11 mg/L. This value is well below the calculated permit limit for total chlorine residual for this event (1.7 mg/L).

Because of the potential for individuals of the Southern California DPS of steelhead to be present near the outfall, and the exceedance of the acute toxicity benchmark at the edge of the initial dilution zone, the exposure to steelhead was evaluated using the simple mixing model assuming a tidal current velocity of 0.1 foot/second and a 25-foot water column mixing depth (Tables 1 and 2). For the January 3, 2013 event, the effluent residual chlorine concentration at the edge of the zone of initial dilution, 0.084 mg/L, would reach a concentration of 0.047 mg/L (the steelhead acute toxicity benchmark) in approximately 15 seconds and at a distance of approximately 2 feet from the point of discharge. For the January 7, 2013 event, the effluent residual chlorine concentration at the edge of the zone of initial dilution, 0.11 mg/L, would reach a concentration of 0.047 mg/L (the steelhead acute toxicity benchmark) in approximately 24 seconds and at a distance of approximately 2 feet from the point of discharge. Given that the 2-minute and 19-minute durations of the chlorine residual events are less than the acute toxicity benchmark 1-hour averaging time, no adverse impact on individuals of the Southern California DPS of steelhead would be expected from either of the chlorine residual events.

Bacterial

Because bacterial samples were not available for the October 3, 2012, Loss of Disinfection event, the CSD laboratory conducted multi-tube fermentation tests using untreated effluent in a 93:1 ocean water-to-effluent dilution test to estimate conditions in the initial dilution

zone. In this test the total coliform were 490 MPN/100 mL, and fecal coliform were 330 MPN/100 ml. Under this set of test conditions, the CSD permit limit for total coliform (2,300 MPN/100 mL as a daily maximum) was not exceeded, nor were the Ocean Plan (2012) receiving water standards for a single maximum total coliform of 10,000 MPN/100 mL or fecal coliform of 400 MPN/100 mL.

Because there is uncertainty associated with the actual bacterial concentrations at the edge of the zone of dilution during the event, the worst case 100 percent effluent MPN tests were evaluated using the mixing model (Table 3). The effluent concentration at the edge of the zone of initial dilution, 990 MPN/100 mL, would reach a concentration of 400 MPN/ 100 mL (the fecal coliform single maximum concentration) in approximately 20 seconds and at a distance of approximately 2 feet from the point of discharge. Given the relatively small area this represents, no adverse impacts to human direct contact recreation or shellfish harvesting would be expected from the loss of disinfection event.

Summary

Three discharge events were evaluated for potential impacts to people and aquatic biota, including sensitive and/or endangered species: an October 3, 2012, loss of disinfection and two reported chlorine residual effluent limit excursions, one on January 3, 2013, and the other on January 7, 2013. Under reasonable maximum exposure scenarios, none of the events resulted in an exceedance of applicable water quality limits and no adverse impacts to human direct contact recreation or shellfish harvesting or aquatic life would be expected.

Steelhead, the single endangered species that could have potentially been near the outfall during the discharge events, was evaluated using data from EPA (1985) aquatic life criteria for chlorine. Based on the duration of the residual chlorine events and conservative plume dilution model, no adverse impact on individuals of the Southern California DPS of steelhead would be expected from either of the two chlorine residual events.

Tables

Table 1

Estimate of Plume Mixing Characteristics for January 3, 2013 Chlorine Residual Event

Parameter	Variable	Units	Value	Basis
Effluent Concentration Back-Calculated to Achieve 150-foot Mixing Zone				
Effluent Concentration	C_0	***Parts/L***	***0.11***	***Chlorine concentration estimated in effluent (10.4 mg/L, 93:1 dilution)***
Assumptions				
Discharge Rate	V_p	cfs	2.64	Event duration was 19 minutes. Estimated flow during event was 22,610 gallons. There are 0.133 cubic feet in 1 gallon.
Average Tidal Current	V_w	ft/sec	0.100	Assumed tidal current in location of discharge
Aquatic Life Protective Concentration	C_c	mg/L	0.047	Based on *Oncorhynchus* acute value from EPA (1985) Aquatic Life Criteria for Chlorine
Assumed Water Column Mixing Depth	d	ft	25	Mixing depth could occur to the water depth of up to 42 feet
Assumed Turbulent Dissipation Parameter	λ	unitless	0.005	Recommended in USACE (1998) for estuary system
Estimate of Concentration with a 150-foot Mixing Zone				
Time to reach 150 ft	t	sec	1,500	$t = 150\ ft / V_w$
Mixing Zone Width at 150 ft	L	ft	713	$L = (t * \lambda / 0.094)^{3/2}$
Mixing Volume at 150 ft	V_a	cfs	1,782	$V_a = V_w * d * L$
Mixed Concentration at 150 ft	C_m	mg/L	0.0002	$C_m = C_0 * V_p / (V_a + V_p)$
Estimate of Mixing Zone Required to Meet Water Quality Criteria				
Mixing Factor Required to Achieve Effluent Limit	D	unitless	1.4	$D = (C_0 - C_c) / C_c$. Assumes background concentration is zero
Mixing Volume to Achieve Mixing	V_a	cfs	4	$V_a = V_p * D$
Mixing Zone Width Required to Achieve Mixing	L	ft	1	$L = V_a / (d * V_w)$
Time to Spread to Achieve Mixing Zone Width	t	sec	24	$t = (1/\lambda) * (0.094 * L^{2/3})$. Assumes a point discharge with an initial width of 0 feet
Length of Mixing Zone Required to Meet Aquatic Life Protective Concentration	X	ft	2.4	$X = V_w * t$

Notes:

Calculation based on the Dilution Volume Method for CDF Effluent Discharges in USACE (1998).

Table 2
Estimate of Plume Mixing Characteristics for January 7, 2013 Chlorine Residual Event

Parameter	Variable	Units	Value	Basis
Effluent Concentration Back-Calculated to Achieve 150-foot Mixing Zone				
Effluent Concentration	***C_0***	***Parts/L***	***0.08***	***Chlorine concentration estimated in effluent (7.8 mg/L, 93:1 dilution)***
Assumptions				
Discharge Rate	V_p	cfs	2.28	Event duration was 2 minutes. Estimated flow during event was 2,060 gallons. There are 0.133 cubic feet in 1 gallon.
Average Tidal Current	V_w	ft/sec	0.100	Assumed tidal current in location of discharge
Aquatic Life Protective Concentration	C_c	mg/L	0.047	Based on *Oncorhynchus* acute value from EPA (1985) Aquatic Life Criteria for Chlorine
Assumed Water Column Mixing Depth	d	ft	25	Mixing depth could occur to the water depth of up to 42 feet
Assumed Turbulent Dissipation Parameter	λ	unitless	0.005	Recommended in USACE (1998) for estuary system
Estimate of Concentration with a 150-foot Mixing Zone				
Time to reach 150 ft	t	sec	1,500	$t = 150\ ft / V_w$
Mixing Zone Width at 150 ft	L	ft	713	$L = (t * \lambda / 0.094)^{3/2}$
Mixing Volume at 150 ft	V_a	cfs	1,782	$V_a = V_w * d * L$
Mixed Concentration at 150 ft	**C_m**	**mg/L**	**0.0001**	**$C_m = C_0 * V_p / (V_a + V_p)$**
Estimate of Mixing Zone Required to Meet Water Quality Criteria				
Mixing Factor Required to Achieve Effluent Limit	D	unitless	0.8	$D = (C_0 - C_c) / C_c$. Assumes background concentration is zero
Mixing Volume to Achieve Mixing	V_a	cfs	2	$V_a = V_p * D$
Mixing Zone Width Required to Achieve Mixing	L	ft	1	$L = V_a / (d * V_w)$
Time to Spread to Achieve Mixing Zone Width	t	sec	15	$t = (1/\lambda) * (0.094 * L^{2/3})$. Assumes a point discharge with an initial width of 0 feet
Length of Mixing Zone Required to Meet Aquatic Life Protective Concentration	**X**	**ft**	**1.5**	**$X = V_w * t$**

Notes:
Calculation based on the Dilution Volume Method for CDF Effluent Discharges in USACE (1998).

Table 3
Estimate of Plume Mixing Characteristics for October 3, 2012 Loss of Disinfection Event

Parameter	Variable	Units	Value	Basis
Effluent Concentration Back-Calculated to Achieve 150-foot Mixing Zone				
Effluent Concentration	C_0	***MPN/L***	***9,892.5***	***Fecal coliform bacteria estimated concentration in effluent (92,000 MPN/100 mL, 93:1 dilution)***
Assumptions				
Discharge Rate	V_p	cfs	1.52	Event duration was 5 hours 37 minutes. Estimated flow during event was 231,076 gallons. There are 0.133 cubic feet in 1 gallon.
Average Tidal Current	V_w	ft/sec	0.100	Assumed tidal current in location of discharge
Effluent Limit	C_c	*MPN/L*	4,000	Ocean plan single sample maximum 400 MPN/100 mL
Assumed Water Column Mixing Depth	d	ft	25	Mixing depth could occur to the water depth of up to 42 feet
Assumed Turbulent Dissipation Parameter	λ	unitless	0.005	Recommended in USACE (1998) for estuary system
Estimate of Concentration with a 150-foot Mixing Zone				
Time to reach 150 ft	t	sec	1,500	$t = 150\ ft / V_w$
Mixing Zone Width at 150 ft	L	ft	713	$L = (t * \lambda / 0.094)^{3/2}$
Mixing Volume at 150 ft	V_a	cfs	1,782	$V_a = V_w * d * L$
Mixed Concentration at 150 ft	C_m	***MPN/L***	**8.4318**	$C_m = C_0 * V_p / (V_a + V_p)$
Estimate of Mixing Zone Required to Meet Water Quality Criteria				
Mixing Factor Required to Achieve Effluent Limit	D	unitless	1.5	$D = (C_0 - C_c) / C_c$. Assumes background concentration is zero
Mixing Volume to Achieve Mixing	V_a	cfs	2	$V_a = V_p * D$
Mixing Zone Width Required to Achieve Mixing	L	ft	1	$L = V_a / (d * V_w)$
Time to Spread to Achieve Mixing Zone Width	t	sec	17	$t = (1/\lambda) * (0.094 * L^{2/3})$. Assumes a point discharge with an initial width of 0 feet
Length of Mixing Zone Required to Meet Effluent Limit	X	ft	1.7	$X = V_w * t$

Notes:
Calculation based on the Dilution Volume Method for CDF Effluent Discharges in USACE (1998).

Attachment 1

Effluent and Ocean Sample Bacteriological Test Results

CSD Laboratory
Total & Fecal Coliform (MTF)

Form 9921BE-0

LTB Solution # R-376

BGB Solution # R-126

EC Solution # R-243

Phos. Buffer # R-415

Sampling Point:

Plant Effluent After Chlorination

Date & Time Collected: 1-6-14/10:25

Sample collected By: FR

Results:

Coliform MPN/100 ML: 2.0

Fecal MPN/100 ML: 1.8

Dilutions In	10					1					0.1					0.01				
Portions In ML	10	10	10	10	10	1.0	1.0	1.0	1.0	1.0	10	10	10	10	10	1.0	1.0	1.0	1.0	1.0
Persumptive 24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
48	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Confirmed 24		+			-															
48					-															
Fecal Coliform 24		-			-															
Date:	1-6-14	Date:	1-7-14	Date:	1-8-14	Date:	1-9-14	Date:	1-10-14
Time:	1:20	Time:	2:30	Time:	1:45	Time:	1:15	Time:	1:10
Started By:	FR	Read By:	FR	Read By:	FR	Read By:	FR	Read By:	FR

Remarks: Ocean Study 2014

All test done by "Standard Method" (20th Ed.) SM9221B/SM9221C,E

CSD Laboratory
Total & Fecal Coliform (MTF)

Form 9921BE-0

LTB Solution # R-376 ***BGB Solution #*** R-126 ***EC Solution #*** R-243 ***Phos. Buffer #*** R-415	Sampling Point: ***Plant Effluent Before Chlorination*** Date & Time Collected: 1-6-14 / 10:20 Sample collected By: FH	Results: Coliform MPN/100 ML 160,000 Fecal MPN/100 ML 92,000

Dilutions In		10					1					0.1					0.01					0.001				
Portions In ML		10	10	10	10	10	1.0	1.0	1.0	1.0	1.0	10	10	10	10	10	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Persumptive	24	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	−	−	+	−	+	−	−	+	−
	48																	+	+		+		+	−		+
Confirmed	24	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+
	48																									
Fecal Coliform	24	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+	−
Date:		1-6-14					Date: 1-7-14					Date: 1-8-14					Date:					Date: 1-9-14				
Time:		1:20					Time: 1:00					Time: 1:00					Time:					Time: 1:25				
Started By:		FH					Read By: FH					Read By: FH					Read By:					Read By: FH				

Remarks: Ocean Study 2014.

All test done by "Standard Method" (20th Ed.) SM9221B/SM9221C,E

CSD Laboratory
Total & Fecal Coliform (MTF)

Form 9921BE-0

LTB Solution # R-376

BGB Solution # R-126

EC Solution # R-243

Phos. Buffer # R-415

Sampling Point:

OCEAN

Date & Time Collected: 1-6-14 / 10:30

Sample collected By: BT

Results:

Coliform MPN/100 ML: 23

Fecal MPN/100 ML: 13

Dilutions In	10					1					0.1					0.01				
Portions In ML	10	10	10	10	10	1.0	1.0	1.0	1.0	1.0	10	10	10	10	10	1.0	1.0	1.0	1.0	1.0
Persumptive 24	+	+	+	+	+	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
48						−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
Confirmed 24	+	+	+	+	+															
48																				
Fecal Coliform 24	−	+	+	+	+															
Date:	1-6-14		Date: 1-7-14			Date:			Date:			Date: 1-8-14								
Time:	1:00		Time: 2:15			Time:			Time:			Time: 1:40								
Started By:	FK		Read By: FK			Read By:			Read By:			Read By: FK								

Remarks: Ocean Study 2014

All test done by "Standard Method" (20th Ed.) SM9221B/SM9221C,E

CSD Laboratory
Total & Fecal Coliform (MTF)

Form 9921BE-0

LTB Solution # R-376
BGB Solution # R-126
EC Solution # R-243
Phos. Buffer # R-415

Sampling Point: ***OCEAN (*SPIKED)***
Date & Time Collected: 1-6-14 / 10:30
Sample collected By: BT

Results:
Coliform MPN/100 ML: 490
Fecal MPN/100 ML: 330

Dilutions In	10					1					0.1					0.01					0.001				
Portions In ML	10	10	10	10	10	1.0	1.0	1.0	1.0	1.0	10	10	10	10	10	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Persumptive 24	+	+	+	+	+	+	+	+	+	+	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
48											+	−	−	+	−	−	−	−	−	−	−	−	−	−	−
Confirmed 24	+	+	+	+	+	+	+	+	+	+	+			−											
48														+											
Fecal Coliform 24	+	+	+	+	+	+	+	+	+	+	+			−											
Date:	1-6-14		Date:	1-7-14		Date:	1-8-14		Date:	1-9-14		Date:	1-10-14												
Time:	1:00		Time:	1:45		Time:	1:20		Time:	1:15		Time:	1:10												
Started By:	FR		Read By:	FR		Read By:	FR		Read By:	FR		Read By:	FR												

Remarks: Ocean Study 2014. * Ocean sample spiked with plant effluent before chlorination (93:1).

All test done by "Standard Method" (20th Ed.) SM9221B/SM9221C,E