Public Hearing (5/18/11)
ASBS Special Protections
Deadline: 5/20/11 by 12 noon

THE CITY OF SAN DIEGO

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May 20, 2011

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Jeanine Townsend, Clerk to the Board
State Water Resources Control Board
1001 I Street, 24th Floor
Sacramento, CA 95814

Subject: Comment Letter – Areas of Special Biological Significance (ASBS) Special Protections

Dear Ms. Townsend:

The City of San Diego, Transportation & Storm Water Department (City) appreciates the opportunity to provide supplemental comments on draft Area of Special Biological Significance (ASBS) Special Protections document, included as Appendix 1 of the Draft Program Environmental Report (PEIR). We are incorporating our March 14, 2011 comments by reference (Attachment 1). We are asking that these draft regulations be returned to the State Water Resources Control Board (State Board) Ocean Standards Unit for review and inclusion of the findings from the Bight '08 ASBS special study (Attachment 2). This study was performed under the direction of Ocean Standards Unit with their consultant Southern California Coastal Water Research Project (SCCWRP), with the participation from the southern California dischargers.

In September 2007, the Ocean Standards Unit requested the southern California ASBS dischargers participate in a Bight '08 regional ASBS assessment study. The purpose of the study was two-fold: 1.) determine the range of natural water quality near reference drainage location; and, 2.) assess how water quality near ASBS discharges compares to natural water quality near reference drainage locations. This special study was funded by the State Board and the dischargers at a cost of approximately $1,000,000 for sample collection, data analysis, and labor to develop an approach based on best available science to protect the ASBS. Over a period of 2 ½ years multiple coordination meetings were conducted to determine the study design, monitoring protocols, and data analysis to provide the stakeholders with a scientifically valid study that would be used to assess the impacts of storm water runoff on the ASBS receiving waters.

In February 2011, the State Board and SCCWRP finalized the study. The major finding of the study was that ASBS receiving water quality during storm events that receive discharges from storm drain systems was not significantly different from water quality at reference sites. In

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addition there was no toxicity associated with storm events at any of the ASBS discharge sites. Although the study is scientifically valid and defensible, the Special Protections appears to disregard the results by requiring best management practices to treat "end of pipe" storm drain system discharges to California Ocean Plan standards. This end of pipe treatment requirement disregards the mixing that occurs in the ocean receiving waters that has been demonstrated by the Bight '08 study to reduce constituent concentrations identified in the California Ocean Plan to levels similar to those found at reference sites. In addition, the Bight '08 study included assessments of the rocky intertidal and subtidal biological communities as integral components assessing impacts to the ASBS beneficial uses. To date, draft reports of these assessments have not yet been produced and the results of this critical component of the ASBS assessment have been completely disregarded in the Special Protections.

Although the City has consistently worked in good faith to protect the beneficial uses of our waters, the Draft ASBS Special Protections and Draft PEIR disregarded all of our research and analysis. At a time when federal, state, and local governments need to collaborate to achieve the goals of our citizens, we have concerns regarding future partnering opportunities with the State Board if valid findings and results are disregarded or key components are not considered in the formulation of water quality regulations. In a time when the governor is calling for dramatic cuts to balance the state's budget, it would seem reasonable that a state agency would work cooperatively with other agencies to achieve common goals.

As stated in our March 14, 2011 comments, we do not support the numerous inconsistencies in the draft regulations which impose end of pipe treatment solutions that are not substantiated by the weight of evidence from the scientific studies to date. If you have any questions regarding this matter, please contact Ruth Kolb at (858) 541-4328 or Edith Gutierrez at (858) 541-4361.

Sincerely,

Kris McFadden
Deputy Director

KM\rk

Enclosures:
1. Comment Letter-ASBS Special Protections, dated March 14, 2011
2. Southern California Bight 2008 Regional Monitoring Program: II Area of Special Biological Significance

cc:
Almis Udrys, Office of the Mayor
Garth K. Sturdevan, Interim Director
Ruth Kolb, Program Manager
Drew Kleis, Program Manager
Edith Gutierrez, Associate Planner

THE CITY OF SAN DIEGO

March 14, 2011

Electronic Delivery to commentletters@waterboards.ca.gov

Jeanine Townsend, Clerk to the Board
State Water Resources Control Board,
1001 I Street, 24th Floor
Sacramento, CA 95814

Subject: **Comment Letter – Areas of Special Biological Significance (ASBS) Special Protections**

Dear Ms. Townsend:

The City of San Diego, Transportation & Storm Water Department (City) appreciates the opportunity to provide comments on this important issue. The City is committed to protecting the beneficial uses of our waters using the best available science and cost-effective approaches.

Since 2005, the City has been actively participating in ASBS workshops and meetings, and has funded efforts through the Bight '08 program and other initiatives to develop an approach based on best available science to protect the ASBS. We continue to conduct studies to better understand the specific conditions of the La Jolla ASBS. Based on these studies, we developed the Proposition 50 ASBS Watershed Management Plan (WMP) in collaboration with Scripps Institute of Oceanography (SIO), University of California San Diego. We initiated projects in accordance with the State Water Regional Control Board State Board (SWRCB) approved WMP, which uses a "weight of evidence" approach to identify and prioritize Water Quality projects.

This weight of evidence approach was based on key findings from studies conducted by SIO and the City, and findings and special studies conducted by the cities of Newport Beach and Laguna Beach. All of these scientific studies indicated that a weight of evidence approach utilizes the most cost effective resources available to protect and preserve the ASBS' beneficial uses. This approach is consistent with SWRCB policies, empirical results of state-funded studies, the Bight '08 program, and with discussions documented in SWRCB workshops over the last several years.

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We would like to point out that the Draft ASBS Special Protections does not take this approach. The Special Protections focuses on meeting California Ocean Plan objectives prior to mixing with the receiving waters without an initial dilution zone as allowed in the Ocean Plan on Page 26. In addition, the City submitted comments to the SWRCB on March 15, 2010, in response to the Notice of Preparation of the Statewide Draft Environmental Impact Report (DEIR) regarding ASBS, which have not been addressed or incorporated into the DEIR (Section S.5.3) nor the ASBS Special Protections (Appendix 1 of the DEIR). Our comments appear to have been completely disregarded, and approving this document as written will cause the City to expend funds in the ASBS without consideration of other water quality concerns in our jurisdiction.

The City is requesting the following inconsistencies in the Draft ASBS Special Protections (Appendix 1 of the DEIR) be addressed to meet the SWRCB goals:

1. The basis for the compliance targets in the Special Protections does not reflect the results of the recent monitoring studies conducted by ASBS responsible parties and the SWRCB, and is not based on the best available science. The two regulatory thresholds described in the Special Protections (i.e., end of pipe water quality must meet Ocean Plan (Table B) water quality objectives, and receiving water quality must be less than the 85th percentile of reference conditions) are not supported by the studies conducted to date. Additional studies are needed to properly define natural water quality, and the potential impacts to the ASBS from storm drain effluent. The requirement to meet Ocean Plan water quality objectives in end of pipe effluent prior to the mixing zone is completely unsubstantiated by the studies conducted to date. Site-specific studies are needed to properly define natural water quality and to understand the potential impacts of storm water runoff on the beneficial uses of the ASBS.

2. The requirement to meet Ocean Plan (Table B) water quality objectives at the end of the pipe prior to mixing with the ocean receiving water (Section 2.d of the Special Protections) is in conflict with the Ocean Plan. Under Implementation Provisions for Table B (Section III.C.2 of the California Ocean Plan), it states that "*effluent limitations shall be imposed in a manner prescribed by the SWRCB such that the concentrations set forth below as water quality objectives shall not be exceeded in the receiving water upon completion of initial dilution...*", where initial dilution is defined as "*the rapid and irreversible turbulent mixing of wastewater with ocean water around the point of discharge.*" Applying Ocean Plan standards to end of pipe effluent from storm drains is inconsistent with the California Ocean Plan, does not address the beneficial uses of the receiving waters, and will impose a significant financial burden on the responsible parties without a clear benefit to the biota in the ASBS.

3. Monitoring and Best Management Practices (BMP) Implementation guidelines proposed in the Draft ASBS Special Protections represent an unfunded mandate for responsible parties, and will impose a significant financial burden on municipalities and other entities in the region.

4. Special Protections Provision A.1.b. states, "*discharges composed of storm water runoff shall not alter natural ocean water quality in the ASBS.*" However, authors of the Summary of Findings of the State Board approved Natural Water Quality Committee (Appendix 8 of the DEIR) state in their conclusions that "*it is too early to tell if there are impacts of waste discharge to marine species and communities.*" Furthermore, they acknowledge that "*In order to avoid significant expenditures that do little to protect ASBS, an assessment of existing and potential anthropogenic influences on each ASBS should be conducted.*" In addition, they state that "*Further work needs to occur for quantitatively defining natural water quality.*" The City agrees with the findings of the SWRCB's appointed Natural Water Quality Committee, and recommends conducting further studies to identify controllable anthropogenic impacts to the ASBS before compliance targets are established.

5. The four-year timeline to meet reduction goals as defined in the Draft ASBS Special Protections conflicts with the Proposition 13 grants' authorized Watershed Management Plans, which have implementation schedules. These approved plans set a timeline for a phased and tiered approach that addresses sources and implements cost effective pilot projects to reduce impacts. Additionally, the four-year timeline is not consistent with the time required to site, design, permit (CEQA, Coastal Commission permitting, etc.), and implement structural treatment solutions to ultimately meet the Ocean Plan's water quality goals. The EIR does not address the potential impacts from the installation of structural BMPs that would be required to meet the reduction goals.

6. The immediate exemption of dry weather non-point sources is inconsistent with the recent NPDES Permit requirements. For example, dry weather flow prohibition shall be addressed through a program that can cost effectively identify the sources of these flows, and prioritize actions to practically achieve this goal over the long-term. Other uncontrollable sources include aerial deposition, naturally occurring groundwater, and US Environmental Protection Agency and the California Department of Pesticide Regulation authorized pesticides. The immediate exemption of dry weather flows (even if treated) is also unreasonable since potential impacts of dry weather flows have not been determined.

7. The majority of discharges to the La Jolla ASBS identified by the SWRCB were from private properties, such as weep holes in structural foundations that are not connected to the City's storm drain system. These pipes discharge directly onto the beach and are not under the authority of the City.

8. The monitoring and regulatory compliance targets for ASBS are inconsistent with other regulatory requirements that affect the ASBS, such as the Marine Life Protection Act (MLPA). Duplicative monitoring and BMP implementation to support multi-agency regulations is an inefficient use of our limited resources. The City supports coordination of monitoring and efforts among the agencies responsible for maintaining the health of the ASBS to ensure that the beneficial uses are protected with a cost effective and coordinated approach.

9. The ecological analysis comment (Page 302) was based only on grassy swales; therefore, is underestimated. It is unacceptable to base compliance conditions on the review of a grant application cost, and not all requirements to meet water quality objectives. We recommend performing a complete analysis, considering at a minumin the WMPs components approved by the SWRCB.

10. The City recognizes the importance of protecting the ASBS beneficial uses and supports collecting additional data to comply with the recommendations in Appendix 8 to further define water quality.

We do not support the numerous inconsistencies in these draft regulations that impose end of pipe treatment solutions that are not substantiated by the weight of evidence from the scientific studies to date. This proposed approach will require high capital costs with maintenance solutions that will result in the expenditure of limited public funds on efforts that will likely result in a low return on investments in meeting the ASBS protection goal when applied to all outfalls. Continued public support for these programs will require demonstration that public monies are being used cost-effectively with proven benefits.

The four-year timeline to meet reduction goals defined in the Draft ASBS Special Protections conflicts with the State approved WMP. These approved plans set a timeline for a phased and tiered approach that addresses sources and implements pilot projects in the initial phase to reduce impacts cost effectively using a weight of evidence approach. Based on numerous policy inconsistencies, proposed time lines, exclusion of studies, and CEQA concerns, the City recommends that timelines be extended, which will also allow for integration with the Marine Life Protection Act requirements, and the completion of natural water quality studies.

The Federal Clean Water Act (CWA) requires the development of an Ocean Plan; however, there are no requirements regarding the development of Areas of Special Biological Significance. Therefore, the Draft ASBS Special Protections regulations may constitute an unfunded mandate that will require the State to reimburse the City and other municipalities to comply with these requirements.

The City is not advocating inaction, but is instead asking for consistency in regulations and a reasonable timeline through the best available science and prioritization to improve water quality of our ASBS. If you have additional questions, please contact Ruth Kolb at (858) 541-4328 or Edith Gutierrez at (858) 541-4361.

Sincerely,

Kris McFadden
Deputy Director

KM\rk

cc: Ruth Kolb, Program Manager
Edith Gutierrez, City Associate Planner
Drew Kleis, City Program Manager
Fritz Ortlieb, Deputy City Attorney
Brent Eidson, Water Policy Advisor

Areas of Special Biological Significance

BIGHT'08

Southern California Bight
2008 Regional Monitoring
Program
Vol. II

Southern California Bight 2008 Regional Monitoring Program: II. Areas of Special Biological Significance

February 2011

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Robert Stein (City of Newport Beach)
Alicia Thompson (US Navy)
John Ugoretz (US Navy)
Jennifer Voccola (City of Malibu).

FOREWORD

The Southern California Bight 2008 Regional Monitoring Program (Bight'08) is part of an effort to provide an integrated assessment of environmental condition through cooperative regional-scale monitoring. The Bight'08 program is a continuation of regional surveys conducted in 1994, 1998 and 2003, and represents the joint efforts of more than 90 participating organizations. The Bight'08 program consists of several elements including: Sediment Toxicity, Sediment Chemistry, Areas of Special Biological Significance (ASBS), Demersal Fishes and Megabenthic Invertebrates, Benthic Macrofauna, Offshore Water Quality, Rocky Reefs, Shoreline Microbiology, and Bioaccumulation. Bight'08 workplans, quality assurance plans, as well as the data described in this report and assessment reports for other elements are available at www.sccwrp.org.

The proper citation for this report is: Schiff, K.C., B. Luk, D. Gregorio and S. Gruber. 2011. Southern California Bight 2008 Regional Monitoring Program: II. Areas of Special Biological Significance. Southern California Coastal Water Research Project. Costa Mesa, CA.

ACKNOWLEDGEMENTS

This project was only possible with the collaboration of the ASBS Planning Committee of Southern California Bight Regional Marine Monitoring Program. Sampling was performed by ABC Laboratories, AMEC Environmental, Mactech Environmental, and Weston Solutions. Laboratory analysis was performed by ABC Laboratories, CRG Marine Laboratories, Nautilus Environmental, and Weston Solutions. Partial funding was provided by the State of California Water Resources Control Board Surface Water Ambient Monitoring Program.

EXECUTIVE SUMMARY

Over 280 km of shoreline have been designated as marine water quality protected areas, termed Areas of Special Biological Significance (ASBS), in southern California, USA. While the standard for water quality protection in an ASBS is "natural water quality", there are at least 271 documented coastal discharges that potentially threaten this important ecological resource. The goal of this study was to assess the water quality status of ASBS by answering two questions: 1) What is the range of natural water quality near reference drainage locations? and 2) How does water quality near ASBS discharges compare to the natural water quality near reference drainage locations? The sample design focused exclusively on receiving water (not effluents) and wet weather, which are the locations and times where natural and anthropogenic contributions can mix making pollutants difficult to identify and control. Sixteen locations encompassing 35 site-events were sampled immediately prior to (<48 hours), then immediately following (<24 hours) storm events ranging from 0.1 to 9.8 cm rainfall. Geometric mean concentrations of total suspended solids (TSS), nutrients (ammonia, nitrate, nitrite, total nitrogen, total phosphorus), total and dissolved trace metals (arsenic, cadmium, chromium, copper, nickel, lead, silver, and zinc), and polycyclic aromatic hydrocarbons (PAH) from post-storm samples were similar at reference drainage and ASBS discharge sites. The average concentration difference between post-storm geometric mean concentrations at reference drainage vs. ASBS discharge sites across all parameters (except chlorinated hydrocarbons) was 3%. Concentrations of chlorinated hydrocarbons were almost entirely nondetectable and no post-storm sample exhibited significant toxicity to the purple sea urchin *Strongylocentrotus purpuratus*. In addition, there was no consistent increase from pre- to post-storm concentrations at either reference drainage or ASBS discharge locations. Most post-storm concentrations did not correlate well with storm parameters (i.e., rainfall quantity, antecedent dry period) or stormwater tracers (i.e., salinity, dissolved organic carbon), decreasing the utility of these tools for predicting impacts. A reference based threshold was used as a proxy for distinguishing differences from natural water quality. The reference based threshold included a two-step process: 1) was the individual chemical post-storm discharge concentration greater than the 85th percentile of the reference drainage site post-storm concentrations; and then 2) was the individual post-storm discharge concentration greater than the pre-storm concentration for the same storm event. While the concentrations near ASBS discharges were on average similar to reference site concentrations, there were some individual ASBS discharge sites that were greater than the reference site based threshold. Cumulatively across all ASBS, the constituents that were most frequently greater than the reference site based threshold were nutrients and general constituents, followed by dissolved or total trace metals.

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I. INTRODUCTION

Coastal municipalities and other agencies subjected to nearshore water quality regulation face a difficult task. The public demands equal access to the shoreline and, at the same time, mandates protection of water quality to maintain the integrity of marine ecosystems. Public access, especially in highly populated urban centers is almost always to the detriment of coastal marine life. This is routinely observed in terms of habitat loss (Boesch *et al.* 2001), harvesting of seafood and other marine resources (Cohen 1997), and the introduction of pollutants (Daskalakis and O'Connor 1995, Schiff *et al.* 2000). Almost by definition, natural water quality is in the absence of coastal development and public access (Halpern *et al.* 2008).

Southern California epitomizes this conundrum. Approximately 17.5 million people live within an hour's automobile drive to the beach and is home to the sprawling urban centers of Los Angeles and San Diego, two of the nation's eight largest cities (US Census Bureau 2009). Over 1.5 billion gallons of treated wastewater are discharged to the ocean every day (Lyon and Stein 2009). In a typical rainy season, over double this volume is discharged via surface runoff (Ackerman and Schiff 2003). Surface runoff following storm events will carry the accumulated anthropogenic pollutants from urban activities such as residential application of fertilizers and pesticides (Schiff and Sutula 2004), trace metals from brake and tire wear (Davis *et al.* 2001), and atmospheric fallout from mobile and non-mobile sources (Sabin *et al.* 2006). Exacerbating these potential threats to the environment, sanitary and stormwater systems are separate in southern California. Therefore, stormwater runoff receives virtually no treatment prior to entering the ocean (Lyon and Stein 2009).

The dilemma between water quality protection and urbanization reaches a climax in southern California at areas of special biological significance (ASBS). The ASBS are marine water quality protected areas whose standard is "no discharge of waste" and maintenance of "natural water quality" (SWRCB 2005). Over 2800 km of shoreline in southern California are designated as ASBS. While state regulatory agencies have been effective at minimizing point source discharges, there are at least 271 storm drain outfalls (SCCWRP 2003). These storm drains can discharge urban runoff, but also natural runoff from undeveloped portions of their respective watersheds. Nutrients, trace metals, and some organic constituents found in urban runoff are also natural components of the ecosystem (Yoon and Stein 2008). The dichotomy between natural versus anthropogenic inputs ultimately clashes because the state regulatory structure does not numerically define natural water quality.

In order to address the dilemma between water quality protected areas and development in the coastal zone, the goal of this study was to assess the water quality in southern California ASBS. Specifically, the study was designed to answer two questions: 1) what is the range of natural water quality near reference drainage locations? and 2) how does water quality near ASBS discharges compare to the natural water quality at reference drainage locations? These two questions address the primary lack of information faced by both ASBS dischargers and regulators that stymies management actions, if they are necessary. The first question aims to quantify what is meant by "natural water quality" by visiting locations presumptively free of anthropogenic contributions. The second question compares the natural water quality levels derived from the first question to water quality near ASBS discharges to determine the level of existing water quality protection.

II. METHODS

There are 34 ASBS in California, 14 of which occur in southern California (Figure 1). The majority (78%) of ASBS shoreline in southern California surrounds the offshore Channel Islands, but a significant fraction (35 km) occur along the six mainland ASBS.

This study had two primary design elements. The first design element was a focus on receiving water. All samples were collected in receiving waters near reference drainage or ASBS discharges; no effluent discharge samples were collected as part of this study. The second design element was a focus on wet weather. Dry weather was not addressed in this study.

Sampling

Sixteen sites were selected for wet weather sampling in this study (Table 1). Six of the sampling locations were reference drainage sites (representing natural water quality) and 10 were ASBS discharge sites. Reference site selection followed five criteria: 1) the site must be an open beach with breaking waves (i.e., no embayments); 2) the beach must have drainage from a watershed that produces flowing surface waters during storm events; 3) the reference watershed should be similar in size to the watersheds that discharge to ASBS; 4) the watershed must be comprised of primarily (>90%) open space; and 5) neither the shoreline nor any segment within the contributing watershed can be on the State's 2006 list of impaired waterbodies (e.g., §303d list). All but one of the reference drainage sites was located within an ASBS.

A total of 35 site-events were sampled (Table 1). Twelve site-events were sampled near reference drainage locations, and another 23 site-events were sampled near ASBS discharge locations. Up to three storm events were sampled per site. A storm was defined as any wet weather event that resulted in surface flow across the beach into the ocean receiving water. Rainfall during sampled events ranged from 0.1 to 9.8 cm. Pre-storm samples were collected prior to (<48 hours) rainfall, and post-storm samples were collected immediately following (<24 hours) rainfall, with most post-storm samples collected less than 6 hours after rainfall cessation. Approximately 89% of all post-storm samples also had a pre-storm sample collected. Samples were collected in the ocean at the initial mixing location in the receiving water. Both pre- and post-storm samples were collected by direct filling of pre-cleaned sample containers just below the water surface.

Laboratory Analysis

All water samples were analyzed for 93 parameters: 1) general constituents including total suspended solids (TSS), dissolved organic carbon (DOC), and salinity; 2) nutrients including nitrate (NO3-N), nitrite (NO2-N), ammonia (NH3-N), total nitrogen (TN), total phosphorus (TP), and ortho-phophate (PO4-P); 3) dissolved and total trace metals (arsenic, cadmium, chromium, copper, nickel, lead, silver, zinc); 3) chlorinated hydrocarbons including total PCB (sum of congeners 18, 28, 37, 44, 49, 52, 66, 70, 74, 77, 81, 87, 99, 101, 105, 110, 114, 118, 119, 123, 126, 128, 138, 149, 151, 153, 156, 157, 158, 167, 168, 169, 170, 177, 180, 183, 187, 189, 194, 201, 206) and total DDT (sum of o,p'- and p,p'-DDT, DDE, and DDD); 4) total polycyclic aromatic hydrocarbons (28 PAHs); and 5) short-term chronic toxicity. All sample analysis followed standard methods and/or EPA approved procedures (APHA 2006). Trace metals were prepared for analysis using ammonium pyrrolidine dithiocarbamate (APDC), a chelation method that concentrates trace metals and removes matrix interferences (USEPA 1996). Toxicity of the receiving water was evaluated by performing an egg fertilization test using the endemic purple sea urchin *Strongylocentrotus purpuratus* (USEPA 1995).

The project focused on performance-based measures of quality assurance. In general, laboratory data quality was quite good: no laboratory blank samples greater than the method detection limit; 96% success meeting data quality objectives (DQOs) for precision using laboratory duplicates; 91% success meeting DQOs for accuracy using spiked samples. The lowest accuracy success rate was for cadmium (12 of 15 batches) and zinc (8 of 16 batches) where the requirement of 75 to 125% recovery from seawater was not met. This was due, in part, to the APDC chelation method that has lower affinities for extracting cadmium and zinc.

Data Analysis

Data analysis followed four steps. The first step was determining the validity of reference drainage site selection. This was achieved by examining the data for known anthropogenic contamination (i.e., chlorinated hydrocarbons such as DDTs and PCBs), testing for outlier samples in the reference drainage data set, and the presence of toxicity. The second data analysis step compared the average concentration of post-storm ambient concentrations at reference drainage sites to ASBS discharge sites. Differences between these concentrations were evaluated using a studentized T-test. The third data analysis step examined potential relationships among parameters looking for explanatory variables that derive differences both within reference drainage sites and between reference drainage and ASBS discharge sites. Rainfall quantity, antecedent dry period, TSS and DOC concentrations were correlated with all of the post-storm chemical concentrations and with the relative change in concentration between pre- and post-storm concentrations after log-transformation for data normalization. For the final data analysis, a reference based threshold was used as a proxy for distinguishing differences from natural water quality. The reference based threshold included a two-step process: 1) was the individual chemical post-storm discharge concentration greater than the 85th percentile of the reference drainage site post-storm concentrations; and then 2) was the individual post-storm discharge concentration greater than the pre-storm concentration for the same storm event. For ASBS discharge sites that did not have a matching pre-storm concentration, the pre-storm concentration from the previous storm at that site for which data was available was used.

III. RESULTS

Post-storm reference drainage site concentrations were similar to post-storm ASBS discharge site concentrations (Figure 2). For 13 parameters (including TSS, nutrients, total PAH and total trace metals), none were significantly different between reference drainage and discharge sites following storm events ($p < 0.05$). Of the minor differences between reference drainage and ASBS discharge site results, post-storm geometric mean concentrations were greater for nine of 13 constituents at reference drainage sites. No detectable concentrations of total DDT or total PCB were observed at reference drainage sites. However, detectable quantities of chlorinated hydrocarbons (p,p'-DDE), while extremely rare, did occur at certain ASBS discharge sites. The average difference between geometric mean concentrations at reference drainage vs. ASBS discharge sites across all parameters (except chlorinated hydrocarbons) was 3%; no parameter differed by more than a factor of 70%.

In general, there was no consistent increase or decrease in concentrations pre- to post-storm at reference drainage or ASBS discharge sites (Figure 3). Pre:Post-storm concentration ratios were not significantly different between reference drainage and ASBS discharge sites for any of the trace metals. Nearly every trace metal, whether from reference drainage or ASBS discharge sites, encompassed unity within its interquartile distribution indicating that pre- and post-storm concentrations were similar. The only exception was copper that, despite having similar reference drainage and discharge site concentrations, had roughly 75% of their respective distributions greater than unity. This would indicate that receiving water concentrations of copper increased following storm events.

Most relationships of discharge post-storm concentrations with storm characteristics were poor (Table 2). Correlation coefficients with storm size ranged from -0.2 to 0.25 across all constituents, none of which were significant. Correlation coefficients with antecedent dry days were marginally better, ranging from -0.45 to 0.34 across all constituents; only salinity and total P were statistically significant. Other potential explanatory variables such as salinity, TSS, or DOC concentrations provided limited insight. Salinity was negatively correlated with most of the total trace metals; cadmium, chromium, and copper were statistically significant. In contrast, TSS was positively correlated with most of the total trace metals; arsenic, chromium, lead and nickel were statistically significant. Despite the statistically significant correlation for a subset of metals for both salinity and TSS, no correlation explained more than 45% of the variability in parameter concentrations observed in ASBS receiving waters. In fact, roughly one-third of the parameters had correlation coefficients less than 0.30.

Differences from natural water quality were relatively infrequent at ASBS discharge sites (Table 3, Figure 4). ASBS 25 (Northwest Santa Catalina Island) had the greatest proportion of analyses that were greater than reference site based thresholds (35% of all analyses). ASBS 29 (La Jolla) had the smallest proportion of analyses that were greater than reference site based thresholds (5% of all analyses). Cumulatively across all ASBS, 15% of all analyses were greater than reference site based thresholds. Nutrients (24% of all analyses) and general constituents (23% of all analyses) were greater than reference site based thresholds most frequently (Table 3, Figure 5). For both total and dissolved metals, approximately 19% of all samples were greater than reference site based thresholds. Total PAH were greater than reference site based thresholds least frequently (2% of all analyses).

Significant toxicity was not observed during this study. Sea urchin fertilization in all post-storm samples ranged from 88 to 100% of laboratory control responses, indicating a lack of statistically significant effect in both the reference drainage and ASBS discharge samples. However, samples from ASBS 25, the site that differed most from natural water quality, had no toxicity data.

IV. DISCUSSION

Based on the data collected during this study, ASBS in southern California are consistently protective of natural water quality following storm events. On average, the range of post-storm pollutant concentrations in receiving waters sampled near ASBS discharge sites were not significantly different from post-storm concentrations at reference drainage sites, which included stormwater inputs free of (or minimally influenced by) anthropogenic sources. No conservative tracer could be used to track natural constituents such as salinity, TSS, or DOC, in large part because pollutant concentrations were so low. Furthermore, synthetic anthropogenic contaminants such as total DDT or total PCB were not detectable across the wide variety of reference drainage sample locations in ASBS, and were rarely detectable at discharge sites in ASBS. Moreover, no post-storm samples collected near ASBS discharges exhibited toxicity.

Although ASBS on average were maintaining natural water quality, there were some individual ASBS sites that appeared to have anthropogenic contributions. ASBS 25 (Catalina Island) had an unusually large proportion of analyses that were greater than reference site based thresholds. This is not wholly unexpected as this site is subject to pollutant inputs via stormwater runoff from a developed community as well as a vessel mooring field. ASBS 21 (San Nicolas Island), 32 (Newport Coast), and 33 (Heisler Park), all of which receive discharges from municipal and/or industrial (military) stormwater runoff, were the next three water quality protected areas to exceed reference site based thresholds. While no stormwater discharge information was collected just upstream of the ASBS during our storm events, other studies have identified pollutants such as nutrients and trace metals widespread in municipal (Tiefenthaler *et al.* 2008) and industrial (Lee *et al.* 2007) stormwater. Trace metals and nutrients were also two groups of constituents that had the greatest proportion of samples greater than the reference site based thresholds in this study.

The reference drainage sites in this study were used to as a proxy for establishing natural water quality thresholds. The algorithm selected for this natural water quality threshold, while not arbitrary, is not an exclusive approach to utilizing the reference drainage site information. In this case, the 85th percentile of the reference site distribution was selected as a primary threshold. Because of the similarities to the reference site data, approximately 15 percent of the ASBS discharge data distribution also exceeded this threshold. As a test of sensitivity, differing reference thresholds were used to assess the ASBS discharge site information. Regardless of whether the thresholds were empirically based (i.e., 95th percentile) or statistically based (i.e., 95th prediction interval), a concomitant decrease in ASBS discharge site difference from natural water quality followed (i.e., 5%). This once again emphasizes that, despite a few samples with high magnitude concentrations that exceeded reference site maxima, the reference and discharge data were similar in their distribution.

Turbulent mixing and advection associated with breaking waves likely plays a large role in reducing concentrations in coastal stormwater plumes. Mixing and advection were the primary forces associated with shoreline dilution of dye and bacteria near flowing storm drains in Santa Monica Bay (Clarke *et al.* 2007). In these examples, dilution factors of 10^3 to 10^6 were observed at distances of 25 m from the discharge mixing zone during dry weather. While the increased flows from dry to wet weather could overwhelm nearshore mixing and advection, wave energy also increases during storm events. Similarly detailed studies at the shoreline during wet weather have not been conducted.

The data in this study represent some of the first near-shore seawater concentrations at reference drainage sites located on the Pacific coast of the United States that are influenced by stormwater inputs. The concentrations were generally low overall with many parameters very close to, or less than, method detection limits (i.e., DDTs, PCBs, PAHs). The trace metal concentrations measured in these nearshore waters were in the same range as concentrations measured from reference freshwater streams in the southern California coastal range (Yoon and Stein 2008). However, the trace metal concentrations measured in this study were greater than typical open ocean concentrations cited by the State of California as reference conditions (Klapow and Lewis 1979) suggesting that these open ocean concentrations are not representative of near-coastal conditions.

Despite this new source of information, many data gaps remain in regards to natural water quality and these data gaps limit our ability to definitively assess water quality in ASBS. The data gaps fall into five categories. First, the reference data set that was used to derive natural water quality is limited. While this study produced one of the most complete data sets to date on ambient seawater concentrations near reference drainages during wet weather, it was only comprised of 12 site-events. Undoubtedly, this is insufficient to capture the wide range of natural conditions associated with watershed size and composition, storm size and intensity, or receiving water dynamics associated with waves and currents. Without a good grasp of natural water quality following storm events, it will be uncertain whether those ASBS discharges that were similar to reference drainage conditions actually lacked measurable anthropogenic enhancements. The second data gap is associated with those ASBS discharges that were dissimilar from reference drainage sites. While it appeared clear, even from our limited reference data set, that some ASBS discharge sites contained anthropogenic contributions, the thresholds we evaluated are not currently regulatory compliance measures. Additional information on the magnitude and duration of anthropogenic contributions is crucial before state regulators or regulated ASBS managers can rank or prioritize discharges for remediation. The third data gap addresses sources of anthropogenic inputs to ASBS discharges. Sites that appeared dissimilar from natural water quality may be attributable to non-anthropogenic site-specific causes (i.e., marine mammal defecation of nutrients). This gap is best addressed through follow-on site-specific investigations. The fourth data gap addresses all of the non-sampled ASBS discharges. Only 10 ASBS discharges were targeted in this study and, while these may have been the largest and perceived greatest risk to the ASBS, they are only a small fraction of the 271 discharges to the southern California ASBS. The last data gap to evaluate for natural water quality is non-water quality threats. Risks posed by poaching, trampling, or invasive species are equally, or perhaps even more, threatening to the health of ASBS. To compliment this chemical and toxicity testing effort, the State of California and stakeholders are currently addressing this data gap by conducting intertidal and subtidal biological surveys of ASBS.

Table 1. Reference drainage and ASBS discharge sites, and their respective sampling effort, collected immediately prior to and immediately following storm events in southern California.

ASBS Number	ASBS Name	SiteName	Latitude	Longitude	Reference or Discharge	Number Pre-Storm Samples	Number Post-Storm Samples
ASBS 21	San Nicolas Island	Barge Landing	33.21967	-119.44728	Discharge	2	2
ASBS 21	San Nicolas Island	Cissy Cove	33.21448	-119.48459	Discharge	1	1
ASBS 21	San Nicolas Island	Reference Site	37.26600	-119.49828	Reference	2	2
ASBS 21	San Nicolas Island	Reverse Osmosis site	33.24281	-119.44433	Discharge	1	1
ASBS 24	Malibu	Solstice Beach	34.03255	-118.74216	Reference	1	1
ASBS 24	Malibu	Arroyo Sequit	34.04441	-118.93393	Reference	1	1
ASBS 24	Malibu	Broad Beach	34.03339	-118.85090	Discharge	3	3
ASBS 24	Malibu	Nicholas Canyon	34.04172	-118.91574	Reference	3	3
ASBS 24	Malibu	Westward Beach	34.01030	-118.81721	Discharge	2	2
ASBS 25	Santa Catalina Island	Two Harbors Pier	33.44194	-118.49821	Discharge	1	2
-	-	Italian gardens	33.41011	-118.38176	Reference	1	2
ASBS 29	San Diego	Avienda de la Playa	32.85466	-117.25899	Discharge	3	3
ASBS 31	La Jolla	San Diego Marine Life Refuge	32.86632	-117.25469	Discharge	1	3
ASBS 32	NewportCoast/CrystalCove	NewportCoast/CrystalCove	33.58867	-117.86759	Discharge	3	3
ASBS 33	Heisler Park	El Moro Canyon	33.56033	-117.82205	Reference	3	3
ASBS 33	Heisler Park	Heisler Park	33.54301	-117.78958	Discharge	3	3
					Discharge	20	23
					Reference	11	12
					Total	31	35

Table 2. Correlation coefficients between storm characteristics: rainfall quantity, antecedent dry days (Ant Dry); or conservative tracers: total suspended solids (TSS), salinity, dissolved organic carbon (DOC) and chemical parameters of interest. Bold numbers are statistically significant at p <0.05.

	Rainfall	Ant Dry	Salinity	TSS	DOC
Salinity	0.20	**-0.43**			
TSS	0.19	0.23	0.02		
DOC	0.08	-0.11	**0.50**	0.05	
Ammonia-N	0.08	0.29	-0.34	-0.11	0.26
Nitrate-N	-0.05	0.05	0.00	-0.08	**0.41**
Total N	-0.20	0.22	-0.07	0.15	0.09
Total P	-0.07	**0.34**	0.03	0.07	-0.21
Arsenic	-0.04	-0.04	0.13	**0.46**	0.17
Cadmium	-0.01	-0.01	**-0.34**	-0.09	0.03
Chromium	0.25	0.25	**-0.34**	**0.67**	0.21
Copper	0.07	0.07	0.02	0.27	0.24
Lead	0.13	0.13	-0.06	**0.37**	0.15
Nickel	0.14	0.14	-0.19	**0.55**	0.32
Zinc	0.02	0.02	**-0.44**	0.31	-0.10
Total PAH	0.16	0.16	-0.03	**0.03**	0.11

Table 3. Reference site based threshold exceedence frequency near discharges into Areas of Special Biological Significance (ASBS) following storm events in southern California.

	Reference Site Based Threshold		Discharge Site Comparison		
Parameter	85th Percentile of Reference Data	Units	Total No. Post-Storm Samples	Pct Samples > Reference 85th Percentile	Pct of Samples > Reference 85th Percentile and greater than Pre-Storm Concentration
Total Suspended Solids	16.5	mg/L	23	35	22
Dissolved Organic Carbon	0.80	mg/L	21	24	19
Ammonia-N	0.03	mg/L	23	30	26
Nitrate-N	0.05	mg/L	23	26	13
Nitrite-N	0.01	mg/L	23	0	0
Total Nitrogen	4.0	mg/L	21	10	5
Total Phosphorus	0.10	mg/L	23	9	9
Arsenic-Dissolved	1.48	ug/L	19	32	32
Arsenic-Total	1.9	ug/L	23	13	4
Cadmium-Dissolved	0.05	ug/L	19	21	16
Cadmium-Total	0.14	ug/L	23	26	17
Chromium-Dissolved	0.21	ug/L	19	5	5
Chromium-Total	1.6	ug/L	23	17	13
Copper-Dissolved	0.45	ug/L	19	47	42
Copper-Total	2.2	ug/L	23	26	26
Iron-Dissolved	1.7	ug/L	19	11	11
Iron-Total	813	ug/L	23	13	13
Lead-Dissolved	0.02	ug/L	19	26	21
Lead-Total	1.1	ug/L	23	13	17
Nickel-Dissolved	0.32	ug/L	19	32	26
Nickel-Total	1.5	ug/L	23	17	17
Silver-Dissolved	ND	ug/L	19	0	0
Silver-Total	0.0	ug/L	23	13	9
Zinc-Dissolved	2.88	ug/L	19	5	5
Zinc-Total	8.6	ug/L	23	30	30
TotalPAH	19.6	ug/L	23	9	9

Figure 1. Map of Areas of Special Biological Significance (ASBS) in Southern California.

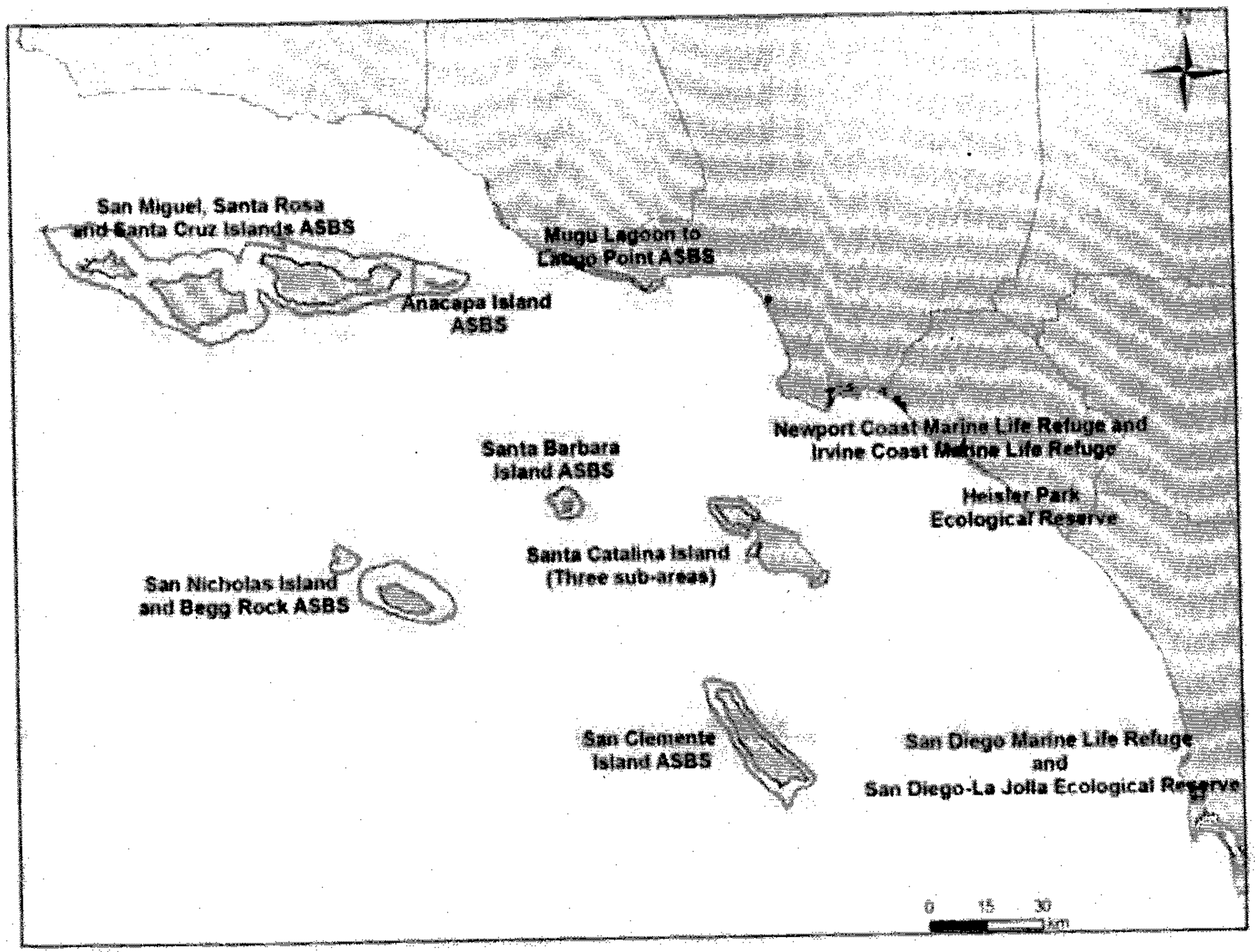


Figure 2. Comparison of geometric mean (± 95% confidence interval) concentrations in ambient near-shore receiving waters following storm events at reference drainage and ASBS discharge sites. Total suspended solids (TSS) and nutrients in mg/L; Total Polycyclic Aromatic Hydrocarbons (Total PAHs), and total trace metals in µg/L.

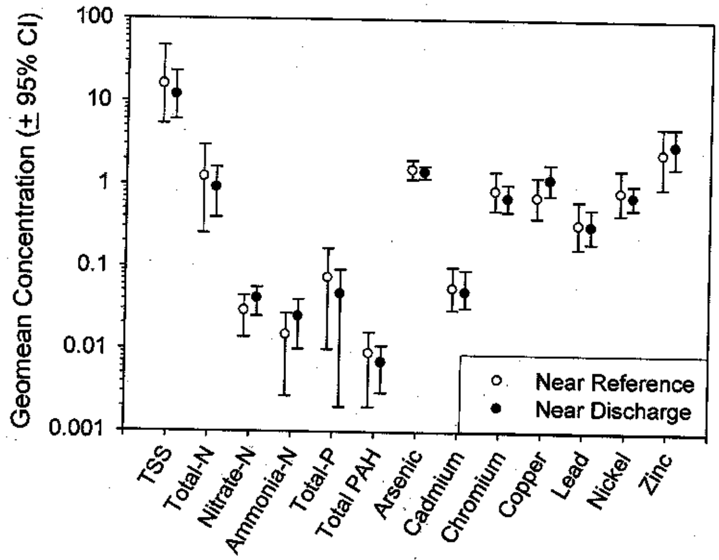


Figure 3. Distribution of post-storm relative to pre-storm trace metal concentrations in ambient near-coastal waters at reference drainage (in white) and ASBS discharge (in grey) sites. Box plots include the 5th, 25th, 50th, 75th, and 95th percentile of the data distribution.

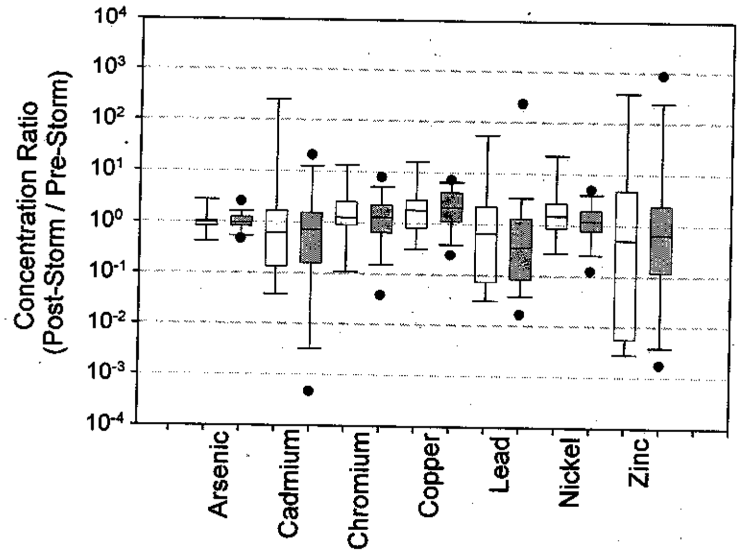


Figure 4. Frequency of reference site based threshold exceedences for all parameters during all storm events at each Area of Special Biological Significance (ASBS) in southern California. Number above bar is total sample size.

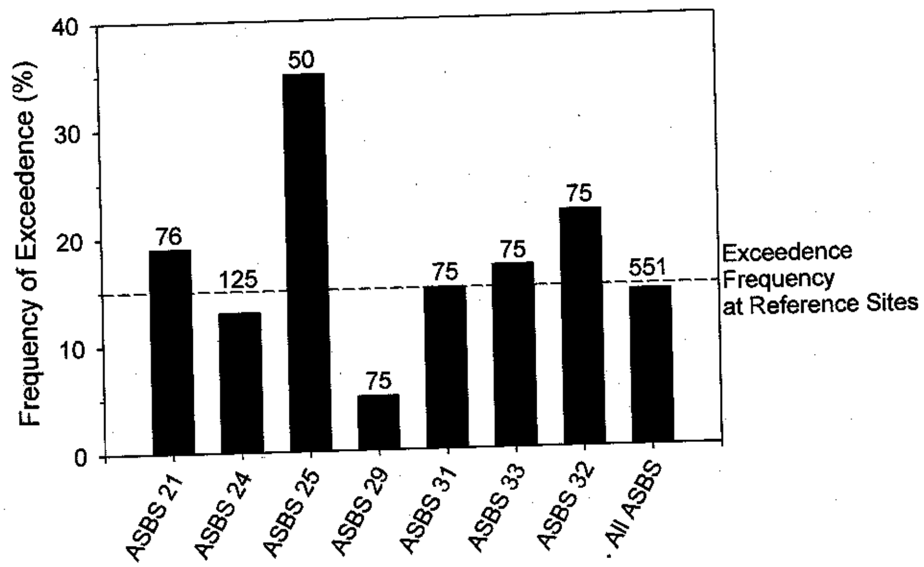
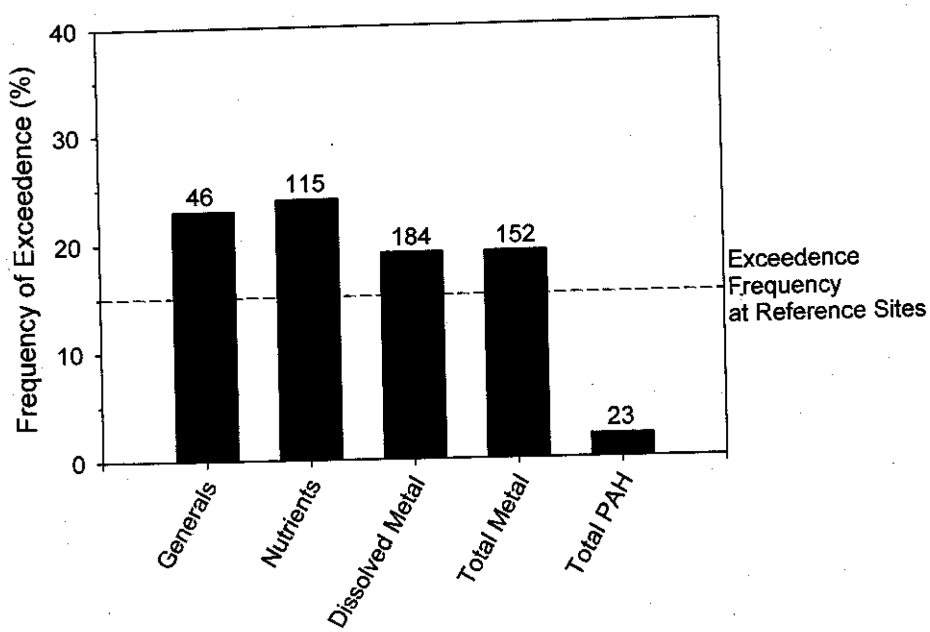


Figure 5. Frequency of reference site based threshold exceedences by parameter group for all storm events and all Areas of Special Biological Significance (ASBS) in southern California. Number above bar is total sample size.



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APPENDIX A: PARTICIPANTS IN THE BIGHT'08 REGIONAL MONITORING PROGRAM

Organization	Coastal Ecology	Microbiology	Water Quality	Rocky Reefs	Areas of Special Biological Significance	Coastal Wetlands and Estuaries	Bioaccumulation
AMEC Incorporated					X		
Aquatic Bioassay and Consulting Laboratories	X		X		X		
Associated Laboratories		X					
California Polytechnic University			X				
California State Parks					X	X	
California State University Channel Islands						X	
California State University Long Beach	X						
California Dept. of Fish and Game	X					X	X
California Department of Public Health			X				
Camp Pendleton Marine Corps Base						X	
Channel Islands National Marine Sanctuary	X						
Chevron USA Products Company	X						
City of Carlsbad						X	
City of Coronado						X	
City of Del Mar						X	
City of El Cajon						X	
City of Encinitas		X				X	
City of Escondido						X	
City of Imperial Beach						X	
City of La Mesa						X	
City of Laguna Beach					X		
City of Lemon Grove						X	

Organization	Coastal Ecology	Microbiology	Water Quality	Rocky Reefs	Areas of Special Biological Significance	Coastal Wetlands and Estuaries	Bioaccumulation
City of Long Beach			X				
City of Los Angeles Environmental Monitoring Division	X	X	X			X	
City of Poway						X	
City of San Marcos						X	
City of Santee						X	
City of Solana Beach						X	
City of Vista						X	
City of Chula Vista						X	
City of Malibu					X		
City of Newport Beach					X	X	
City of Oceanside			X			X	
City of Oxnard	X		X				X
City of San Diego	X	X	X		X		X
City of Ventura			X			X	
Coastal Conservancy			X			X	
CRG Marine Laboratories	X		X		X		X
Encina Wastewater Authority	X	X	X				
Jet Propulsion Laboratory			X				
Los Angeles County Dept. of Beaches & Harbors	X						
Los Angeles County Dept. of Health Services		X					
Los Angeles County Dept. of Public Works		X			X		
Los Angeles County Sanitation Districts	X	X	X	X			X
Los Angeles Department of Water and Power	X						
Los Angeles Regional Water Quality Control Board					X	X	X
Loyola Marymount University		X					X
Marine Pollution Studies Laboratory - Granite	X						

Organization	Coastal Ecology	Microbiology	Water Quality	Rocky Reefs	Areas of Special Biological Significance	Coastal Wetlands and Estuaries	Bioaccumulation
Canyon							
Marine Pollution Studies Laboratory - Rancho Cordova	X						X
Marine Biological Consultants	X						
Monterey Bay Aquarium Research Institute			X				
Natural History Museum of Los Angeles County	X						
National City						X	
National Parks Service				X			
Nautilus Environmental	X				X		
NES Energy, Inc.	X						
National Oceanic and Atmospheric Administration	X	X	X			X	
NRG Energy, Inc.	X						
Orange County Environmental Health Division		X					
Orange County Public Facilities and Resources					X	X	
Orange County Sanitation District	X	X	X				X
Port of Long Beach	X						
Port of Los Angeles	X		X	X			
Port of San Diego	X						
Reliant Corporation	X					X	X
Resource Conservation District						X	
Riverside County Flood Control District			X				
San Bernardino Flood Control District			X				
San Diego County						X	
San Diego County Dept. of Environmental Health						X	

Organization	Coastal Ecology	Microbiology	Water Quality	Rocky Reefs	Areas of Special Biological Significance	Coastal Wetlands and Estuaries	Bioaccumulation
San Diego Regional Water Quality Control Board					X	X	
San Diego State University				X			
San Elijo Joint Powers Authority	X						
San Elijo Lagoon Conservancy						X	
San Francisco Estuary Institute							X
Santa Ana Regional Water Quality Control Board			X			X	
Santa Ana River Watershed Management Authority						X	
Santa Monica Bay Restoration Commission						X	
Scripps Institution of Oceanography			X				
Sea Ventures							
South Orange County Water Authority							
Southern California Coastal Water Research Project	X	X	X	X	X	X	X
Stanford University		X					
State Water Resources Control Board	X	X	X	X	X	X	X
Tijuana Estuary National Estuarine Research Reserve						X	
University of California, Los Angeles		X	X				
University of California, San Diego				X	X		
University of California, Santa Barbara		X	X	X		X	
University of California, Santa Cruz					X		
University of South Carolina						X	
University of Southern California			X		X		
US EPA Region IX						X	X

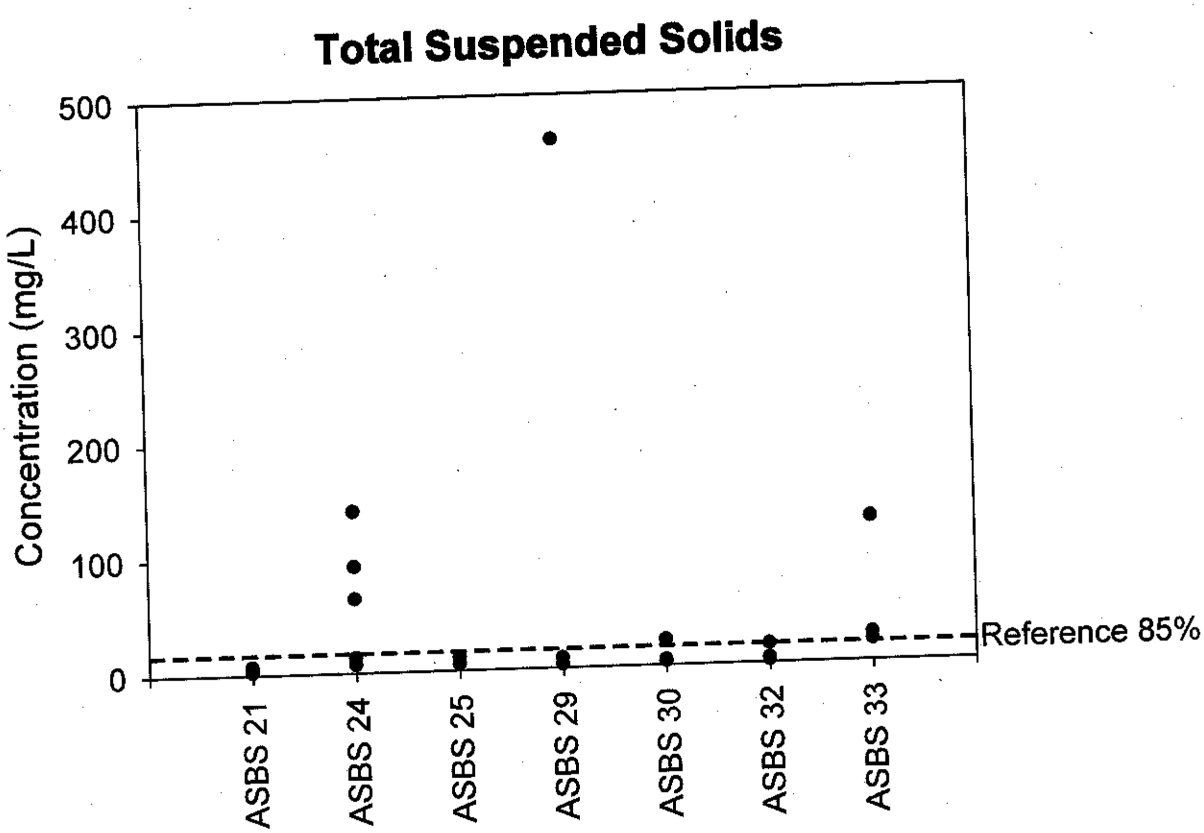
Organization	Coastal Ecology	Microbiology	Water Quality	Rocky Reefs	Areas of Special Biological Significance	Coastal Wetlands and Estuaries	Bioaccumulation
US EPA Office of Research and Development	X						
US Fish and Wildlife Service						X	
US Geological Survey	X						
US Navy					X		
Vantuna Research Group, Occidental College	X			X	X		
Ventura County Public Health Laboratory		X					
Ventura County Watershed Protection Division			X			X	
Weston Solutions	X	X	X		X	X	

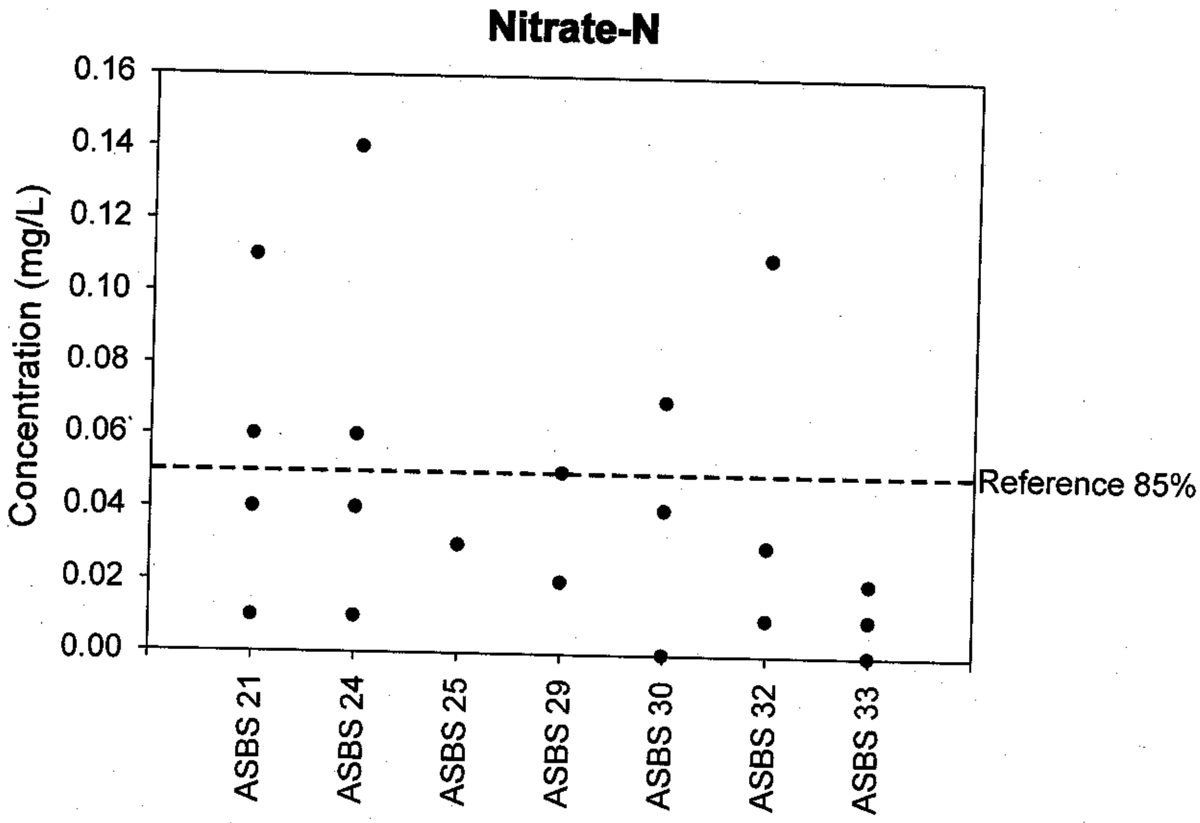
APPENDIX B: SUMMARY TABLES OF REFERENCE AND DISCHARGE SITE PRE- AND POST-STORM CONCENTRATIONS

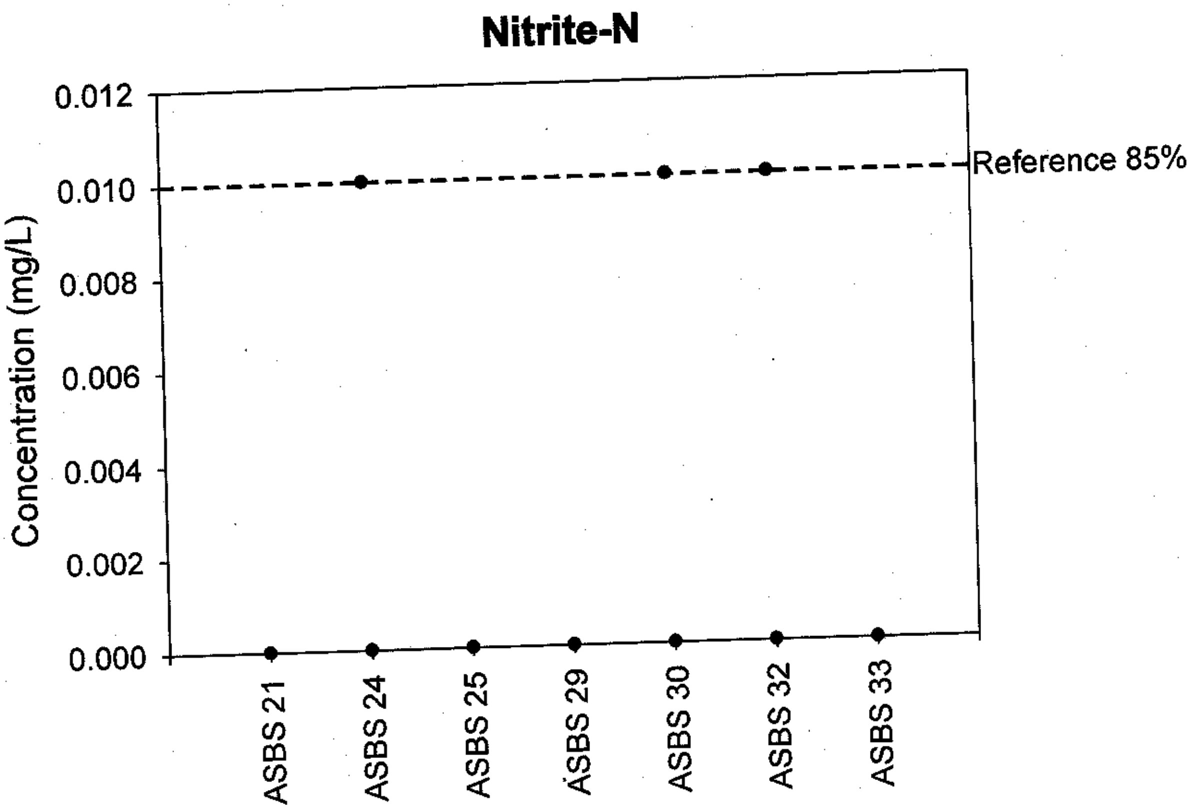
Reference Sample Summary Concentrations													
			Reference Pre-Storm					Reference Post-Storm					
Parameter	Units	Detection Limit	%ND	Min	Max	GeoMean	(+) 95% CI	%ND	Min	Max	GeoMean	(+) 95% CI
Ammonia-N	mg/L	0.03	55	0.00	0.04	0.01	(0.003, 0.03)	58	0.00	0.05	0.01	(0.003, 0.03)
Arsenic-Dissolved	ug/L	0.01	0	1.10	1.58	1.34	(1.23, 1.45)	0	0.41	1.53	1.25	(0.94, 1.65)
Arsenic-Total	ug/L	0.01	0	1.16	5.02	1.64	(1.25, 2.17)	0	0.53	4.53	1.53	(1.17, 2.0)
Cadmium-Dissolved	ug/L	0.005	11	0.00	0.04	0.02	(0.01, 0.03)	0	0.02	0.12	0.04	(0.02, 0.06)
Cadmium-Total	ug/L	0.005	9	0.00	0.92	0.09	(0, 0.23)	0	0.02	0.47	0.06	(0.03, 0.10)
Chromium-Dissolved	ug/L	0.025	0	0.14	0.23	0.17	(0.15, 0.19)	0	0.14	0.30	0.18	(0.16, 0.22)
Chromium-Total	ug/L	0.025	0	0.04	16.93	0.46	(0.17, 1.27)	0	0.29	8.34	0.85	(0.49, 1.47)
Copper-Dissolved	ug/L	0.01	0	0.02	0.73	0.16	(0.07, 0.35)	0	0.08	0.99	0.23	(0.13, 0.42)
Copper-Total	ug/L	0.01	0	0.05	6.08	0.46	(0.21, 1.04)	0	0.27	5.88	0.71	(0.4, 1.26)
DOC	mg/L	0.10	60	0.00	1.40	0.23	(0.01, 0.53)	45	0.00	3.60	0.55	(0.07, 1.26)
Iron-Dissolved	ug/L	0.50	78	0.00	0.80	0.12	(0, 0.33)	20	0.00	8.91	1.15	(0.32, 2.49)
Iron-Total	ug/L	0.50	0	1.00	10680	77	(15, 403)	0	18	7874	259	(105, 635)
Lead-Dissolved	ug/L	0.005	11	0.00	0.05	0.02	(0.01, 0.03)	10	0.00	0.06	0.02	(0.01, 0.03)
Lead-Total	ug/L	0.005	0	0.02	6.93	0.13	(0.05, 0.38)	0	0.07	7.02	0.33	(0.17, 0.65)
Nickel-Dissolved	ug/L	0.005	0	0.17	0.40	0.23	(0.19, 0.27)	0	0.15	0.49	0.25	(0.20, 0.31)
Nickel-Total	ug/L	0.005	9	0.00	19	0.79	(0.02, 2.15)	0	0.25	15	0.84	(0.45, 1.56)
Nitrate-N	mg/L	0.01	27	0.00	0.08	0.03	(0.01, 0.05)	83	0.00	0.07	0.03	(0.01, 0.04)
Nitrite-N	mg/L	0.01	91	0.00	0.01	0.001	(0, 0.003)	67	0.00	0.01	0.003	(0, 0.01)
Silver-Dissolved	ug/L	0.02	100	--	--	--	–	100	–	--	–	–
Silver-Total	ug/L	0.02	64	0.00	0.18	0.03	(0, 0.06)	86	0.00	0.06	0.01	(0, 0.02)
TN	mg/L	2.00	55	0.00	1.86	0.22	(0, 0.55)	42	0.00	11.00	1.23	(0.26, 3.0)
TotalPAH*	ng/L	1.00	18	0.00	318	33	(0, 91)	25	0.00	32	9	(2, 16)
TP-Total	mg/L	0.02	45	0.00	0.33	0.07	(0.01, 0.14)	50	0.00	0.59	0.07	(0, 0.17)
TSS	mg/L	0.50	9	0.00	1472	10	(2, 44)	0	2.30	1692	16	(5, 47)
Zinc-Dissolved	ug/L	0.005	44	0.00	5.55	0.71	(0, 2.05)	40	0.00	5.62	0.92	(0.13, 2.27)
Zinc-Total	ug/L	0.005	18	0.00	29	3.08	(0.97, 7.47)	21	0.00	19	2.43	(0.95, 5.03)

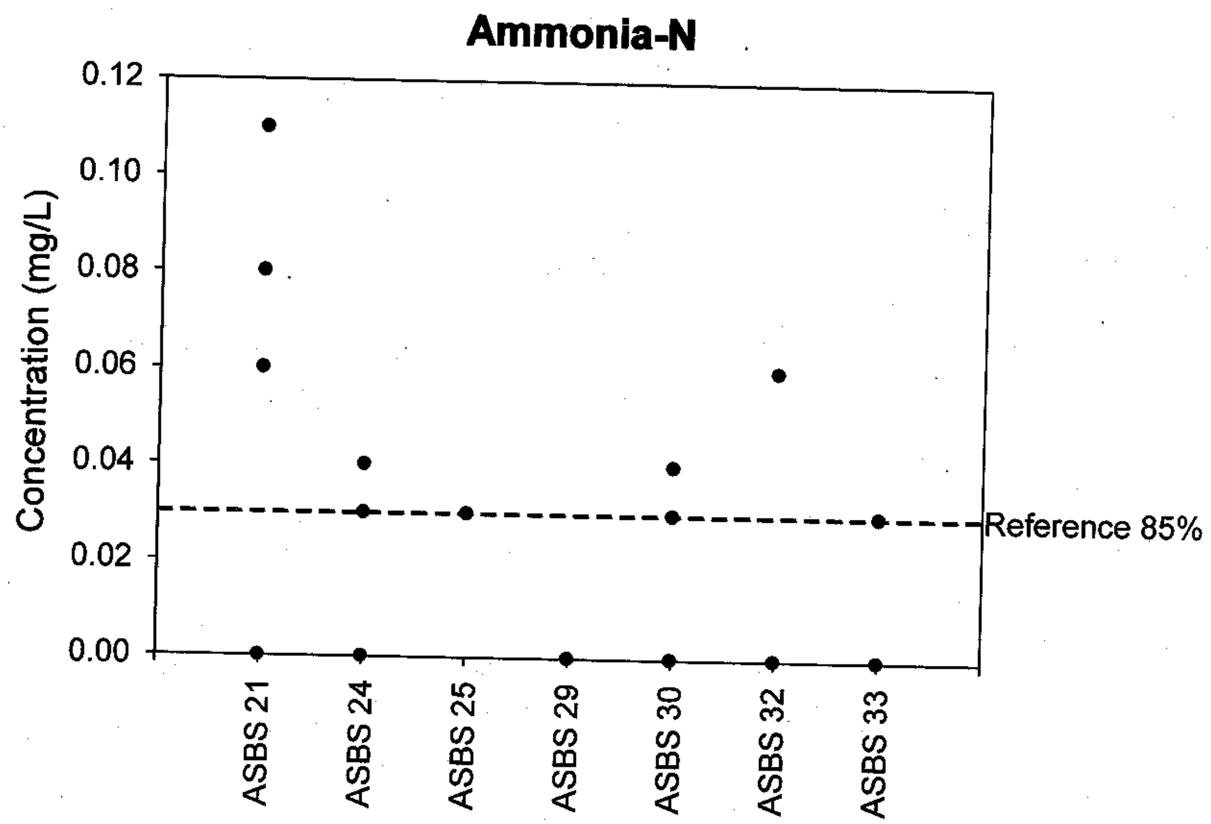
ASBS Discharge Sample Summary Concentrations													
			Discharge Pre-Storm					Discharge Post-Storm					
Parameter	Units	Detection Limit	%ND	Min	Max	GeoMean	(±) 95% CI	%ND	Min	Max	GeoMean	(±) 95% CI
Ammonia-N	mg/L	0.03	60	0.00	0.06	0.02	(0.01,0.03)	48	0.00	0.11	0.02	(0.01,0.04)
Arsenic-Dissolved	ug/L	0.01	0	0.89	1.58	1.29	(1.18,1.40)	0	0.47	1.82	1.29	(1.10,1.50)
Arsenic-Total	ug/L	0.01	0	0.98	3.16	1.53	(1.34,1.78)	0	0.57	3.37	1.44	(1.21,1.70)
Cadmium-Dissolved	ug/L	0.005	13	0.00	0.85	0.08	(0.00,0.17)	5	0.00	1.18	0.08	(0.00,0.17)
Cadmium-Total	ug/L	0.005	5	0.00	0.31	0.07	(0.04,.010)	0	0.01	1.07	0.05	(0.03,0.09)
Chromium-Dissolved	ug/L	0.025	0	0.12	0.20	0.16	(0.15,0.17)	0	0.12	0.21	0.17	(0.16,0.18)
Chromium-Total	ug/L	0.025	0	0.06	5.53	0.41	(0.24,0.72)	0	0.16	5.48	0.70	(0.48,1.03)
Copper-Dissolved	ug/L	0.01	0	0.05	1.06	0.24	(0.16,0.36)	0	0.08	3.16	0.36	(0.22,0.60)
Copper-Total	ug/L	0.01	0	0.16	5.41	0.58	(0.39,0.86)	0	0.26	10.09	1.17	(0.76,1.80)
DOC	mg/L	0.10	56	0.00	1.40	0.28	(0.10,0.50)	48	0.00	3.60	0.39	(0.14,0.07)
Iron-Dissolved	ug/L	0.50	38	0.00	3.90	0.64	(0.27,1.12)	26	0.00	4.10	0.68	(0.47,0.90)
Iron-Total	ug/L	0.50	0	6.40	2415	80	(33,195)	0	46	3863	187	(108,322)
Lead-Dissolved	ug/L	0.005	13	0.00	4.50	0.02	(0.01,0.03)	26	0.00	0.09	0.02	(0.01,0.30)
Lead-Total	ug/L	0.005	0	0.02	2.08	0.14	(0.07,0.26)	0	0.05	3.10	0.32	(0.20,0.52)
Nickel-Dissolved	ug/L	0.005	0	0.16	0.55	0.24	(0.20,0.29)	0	0.15	2.17	0.28	(0.21,0.37)
Nickel-Total	ug/L	0.005	0	0.20	4.78	0.53	(0.34,0.83)	0	0.24	4.31	0.73	(0.52,1.03)
Nitrate-N	mg/L	0.01	32	0.00	396	0.38	(0.00,1.60)	9	0.00	0.14	0.04	(0.03,0.06)
Nitrite-N	mg/L	0.01	100	--	--	--	--	83	0.00	0.01	0.002	(0.00,0.004)
Silver-Dissolved	ug/L	0.02	100	--	--	--	--	100	--	--	--	–
Silver-Total	ug/L	0.02	80	0.00	0.06	0.01	(0.00,0.01)	87	0.00	0.06	0.01	(0.00,0.02)
Total CHC	ng/L	1.00	100	--	--	--	--	100	--	--	--	–
Total PAH	ng/L	1.00	24	0.00	121	11	(0.00,23)	30	0.00	32	7	(3,11)
Total PCB	ng/L	1.00	100	--	--	--	--	100	--	--	--	–
Total-N	mg/L	2.00	47	0.00	555	0.99	(0.00,3.0)	38	0.00	5.99	0.91	(0.40,1.62)
Total-P	mg/L	0.02	35	0.00	0.46	0.08	(0.03,0.14)	57	0.00	0.59	0.05	(0.002,0.09)
TSS	mg/L	0.50	5	0.00	104	5	(2,11)	0	1.70	460	12	(6,23)
Zinc-Dissolved	ug/L	0.005	50	0.00	10.35	0.92	(0.26,1.93)	58	0.00	5.15	0.61	(0.20,1.17)
Zinc-Total	ug/L	0.005	10	0.00	12	3	(2,5)	13	0.00	16	3.02	(2,5)

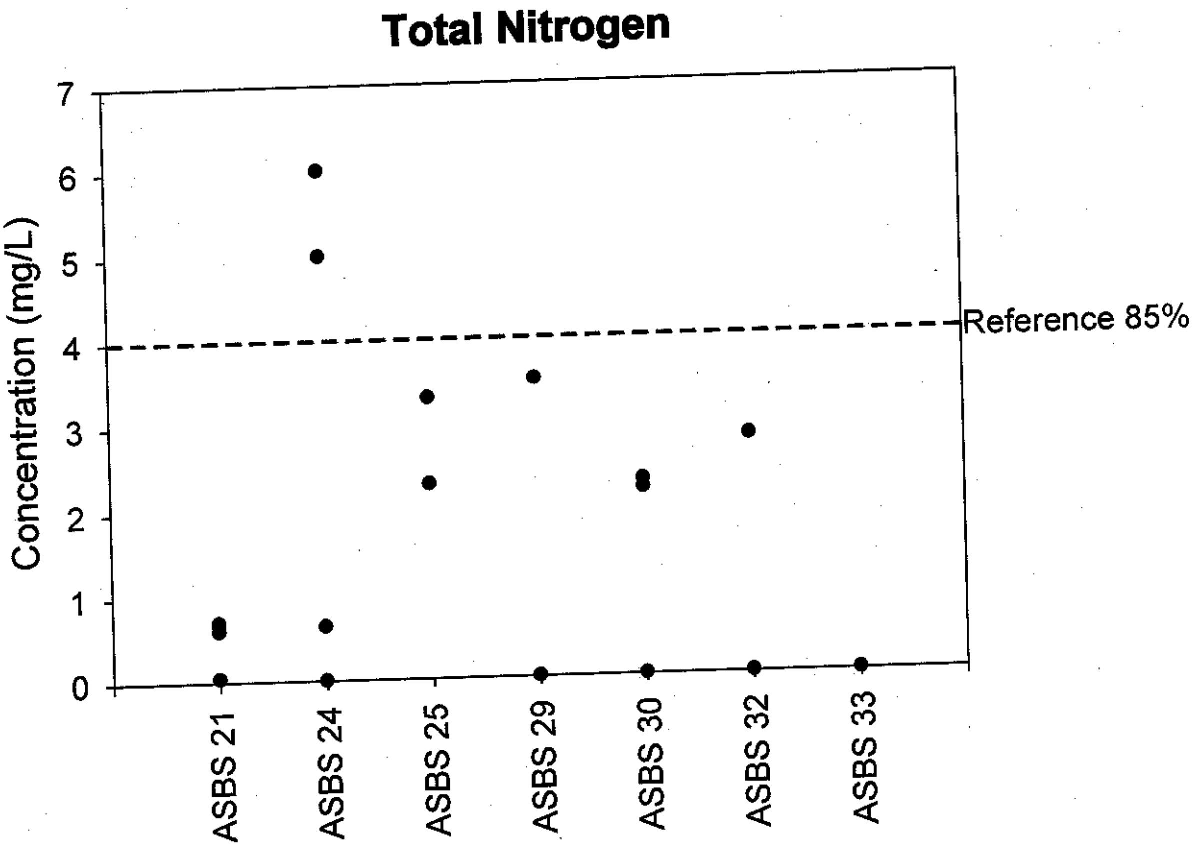
APPENDIX C: INDIVIDUAL GRAPHS OF POST-STORM DISCHARGE CONCENTRATIONS BY ASBS

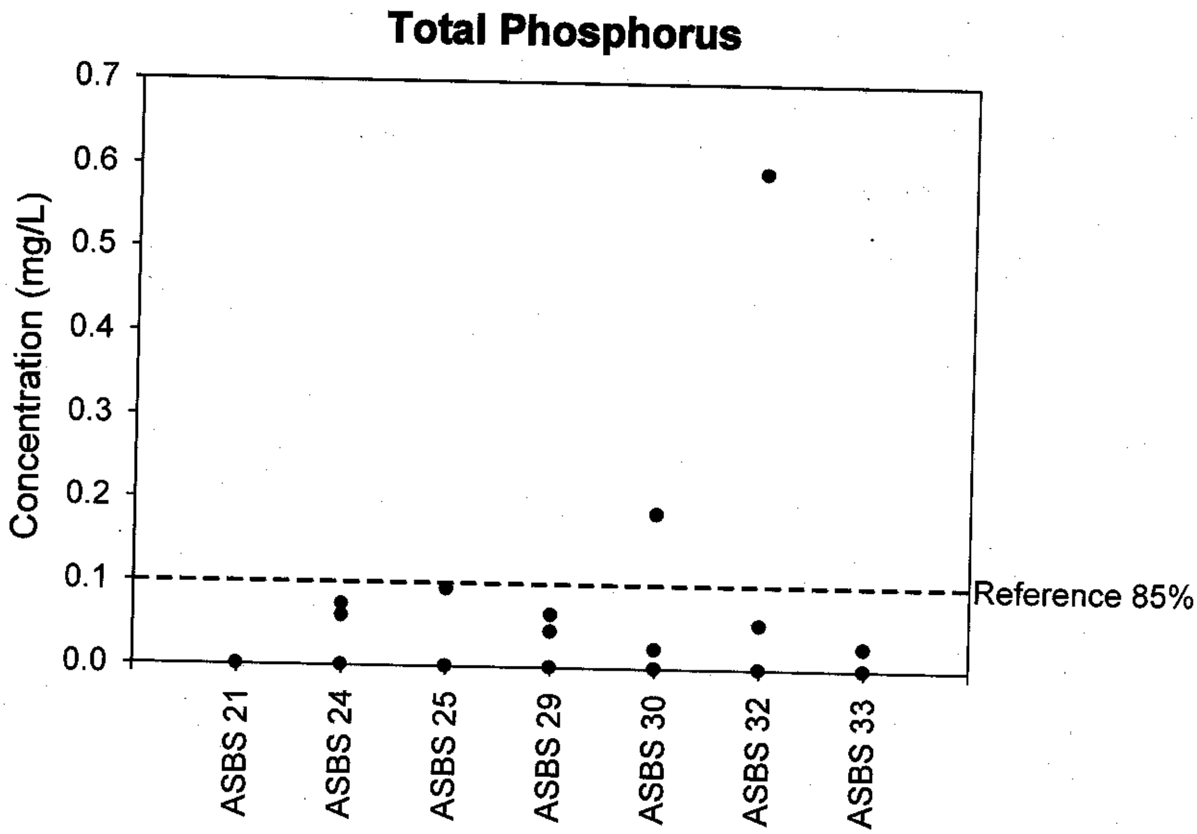



Nitrate-N
Concentration (mg/L)
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Reference 85%
ASBS 21
ASBS 24
ASBS 25
ASBS 29
ASBS 30
ASBS 32
ASBS 33

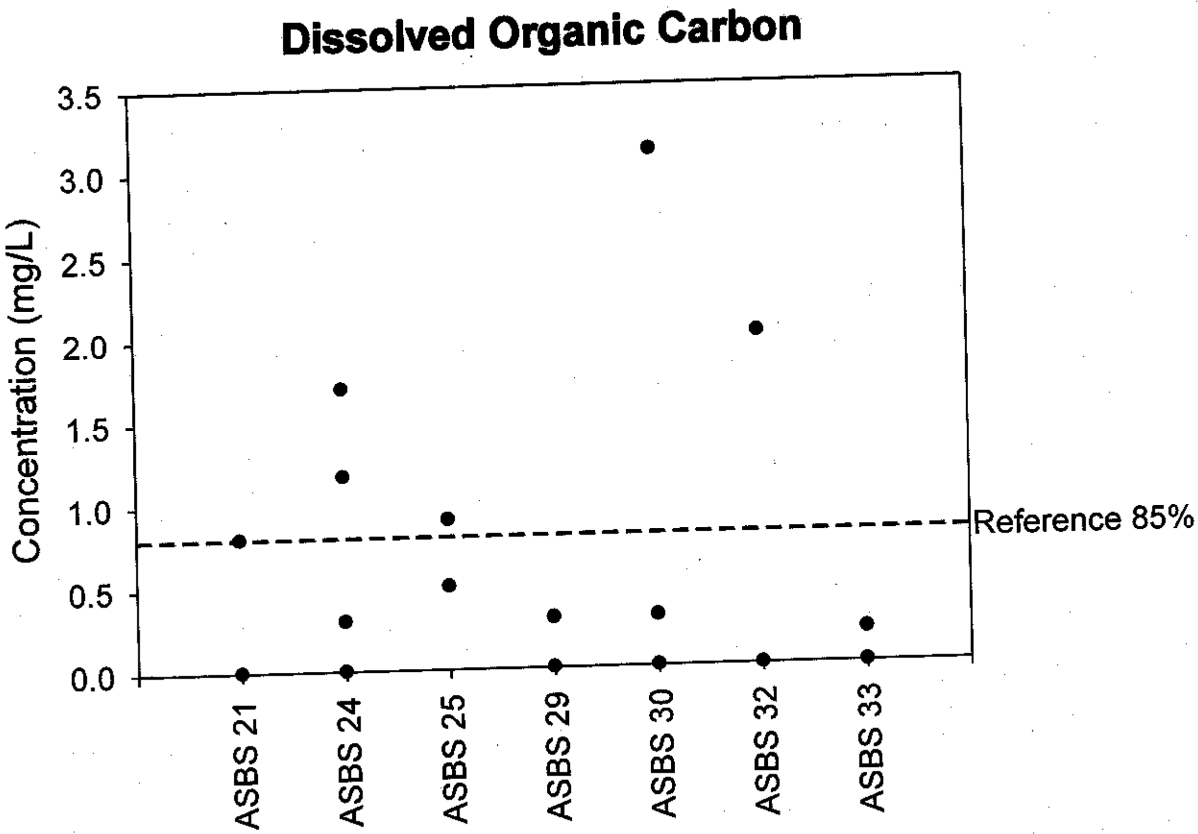

Nitrite-N
Concentration (mg/L)
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Reference 85%
ASBS 21
ASBS 24
ASBS 25
ASBS 29
ASBS 30
ASBS 32
ASBS 33


Ammonia-N
Concentration (mg/L)
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Reference 85%
ASBS 21
ASBS 24
ASBS 25
ASBS 29
ASBS 30
ASBS 32
ASBS 33

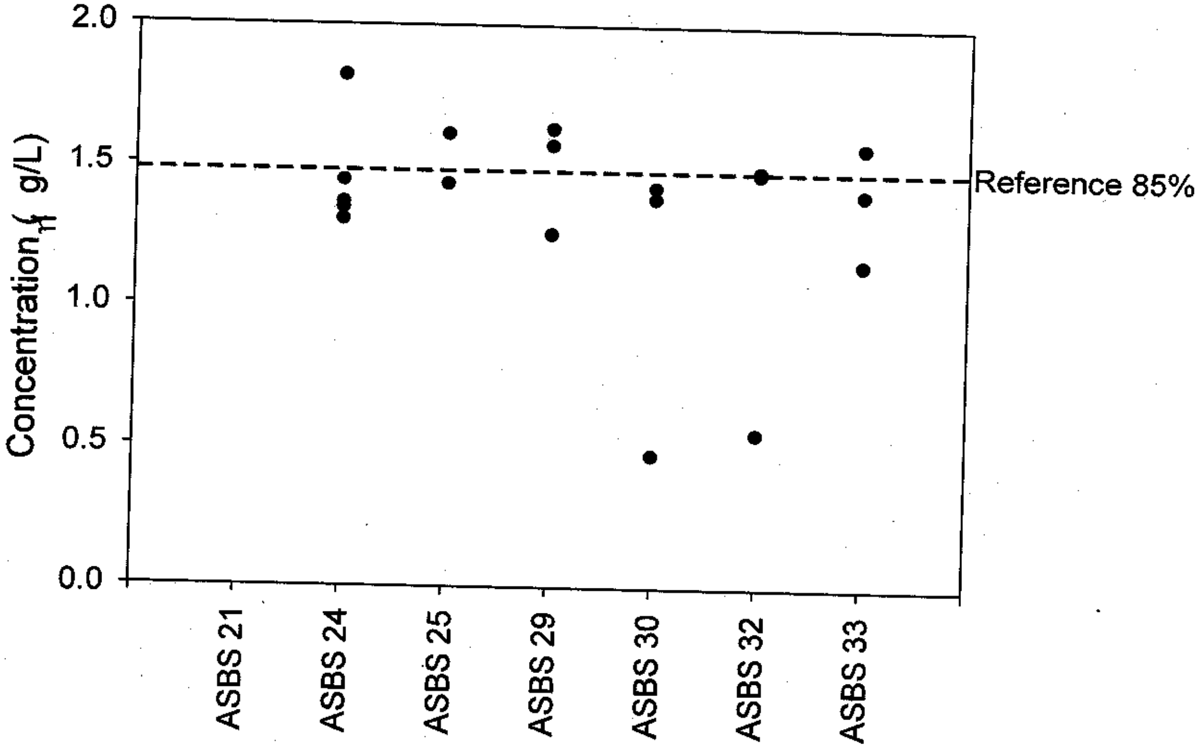

Total Nitrogen
Concentration (mg/L)
0
1
2
3
4
5
6
7
Reference 85%
ASBS 21
ASBS 24
ASBS 25
ASBS 29
ASBS 30
ASBS 32
ASBS 33

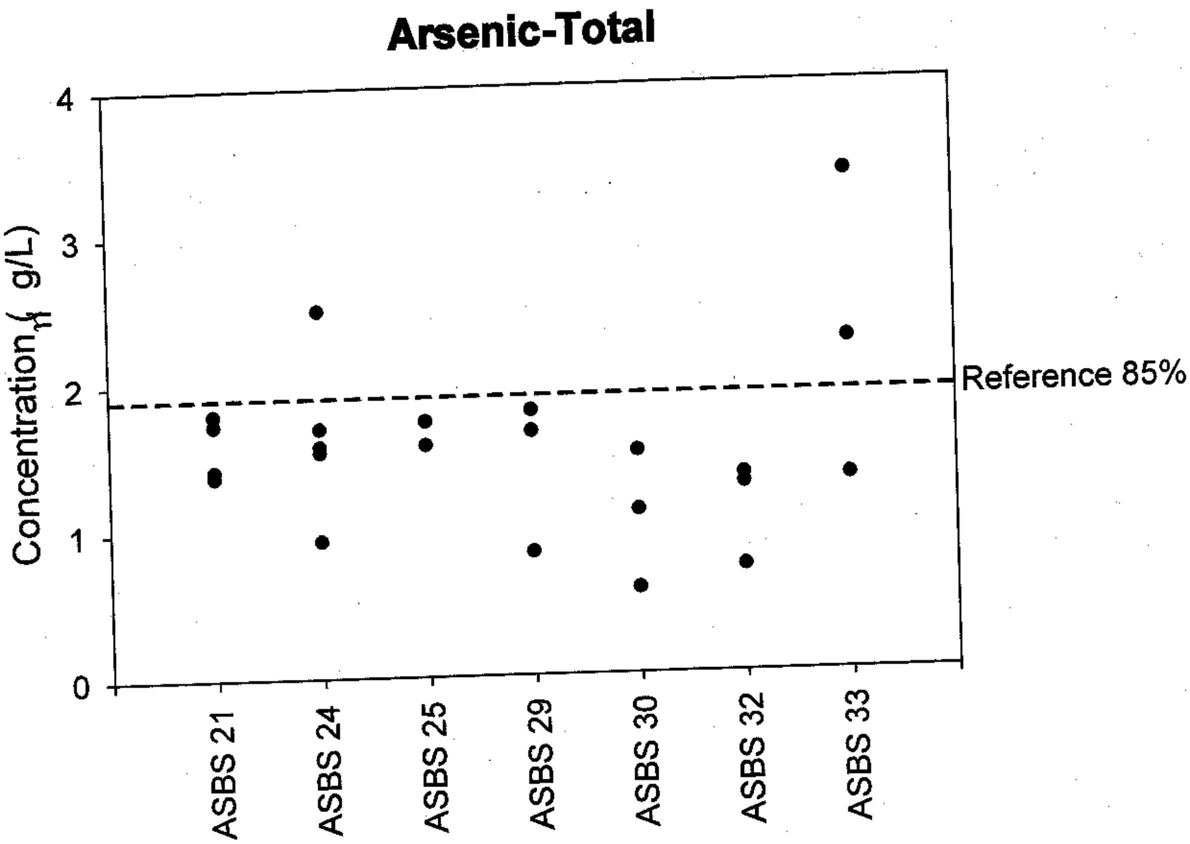


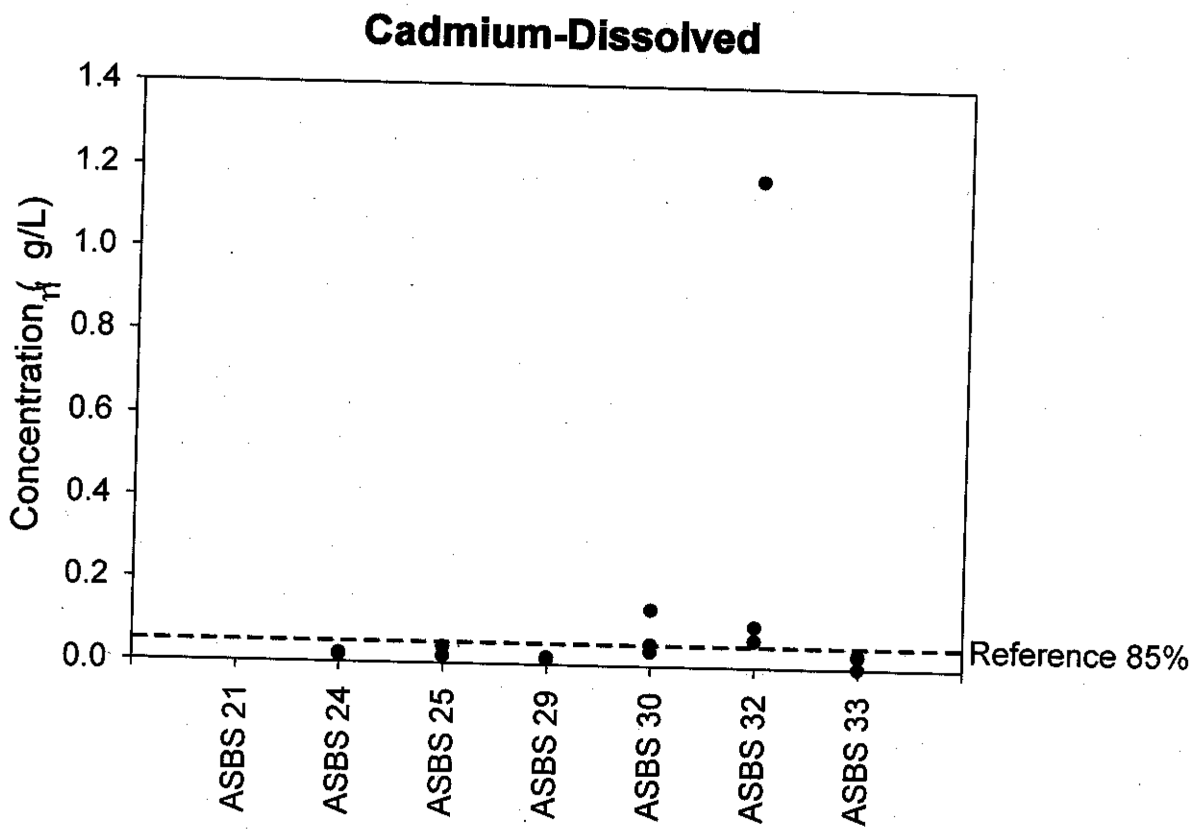
Total Phosphorus
Concentration (mg/L)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Reference 85%
ASBS 21
ASBS 24
ASBS 25
ASBS 29
ASBS 30
ASBS 32
ASBS 33


Dissolved Organic Carbon
Concentration (mg/L)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Reference 85%
ASBS 21
ASBS 24
ASBS 25
ASBS 29
ASBS 30
ASBS 32
ASBS 33

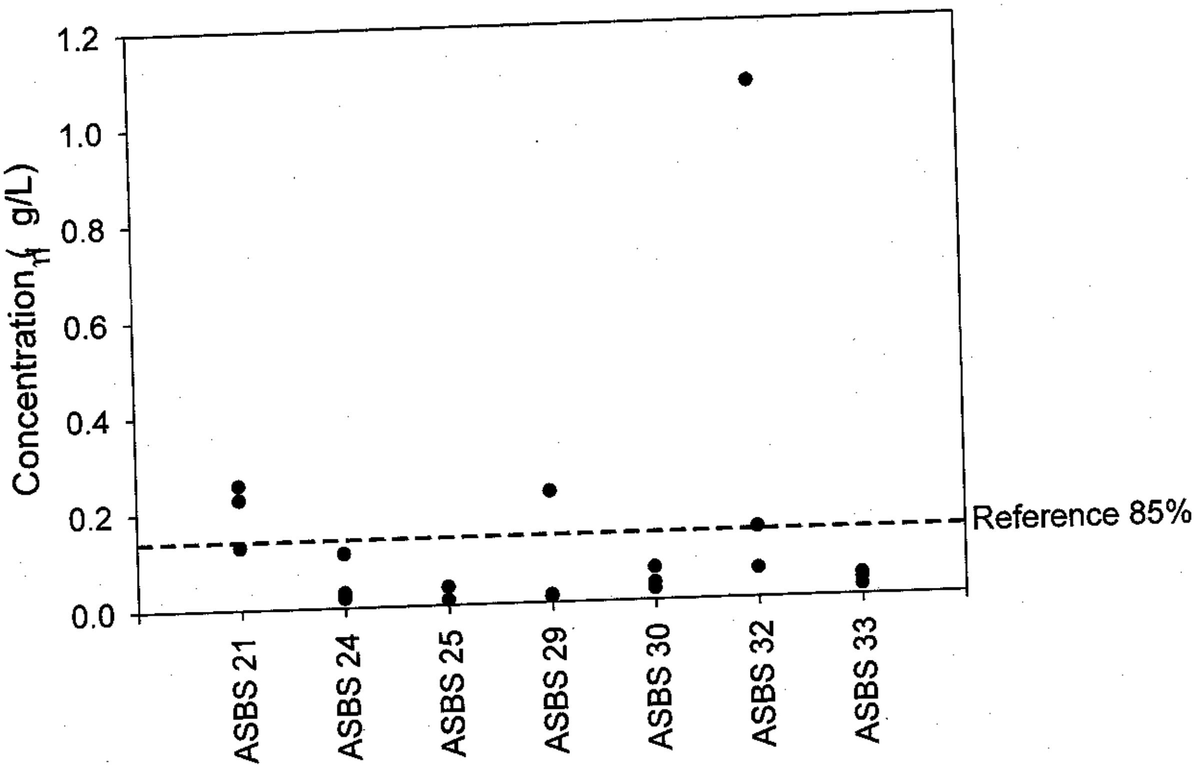
Arsenic-Dissolved

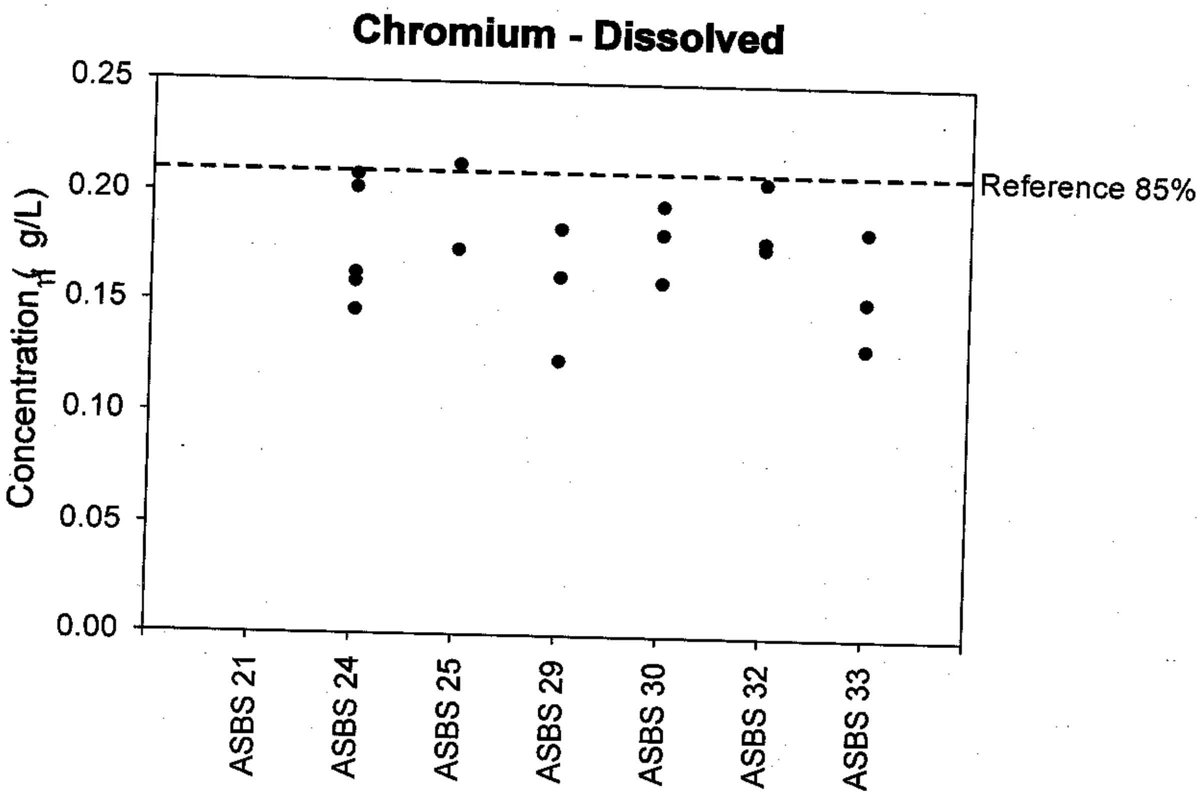



Arsenic-Total
Concentration (µg/L)
0
1
2
3
4
Reference 85%
ASBS 21
ASBS 24
ASBS 25
ASBS 29
ASBS 30
ASBS 32
ASBS 33

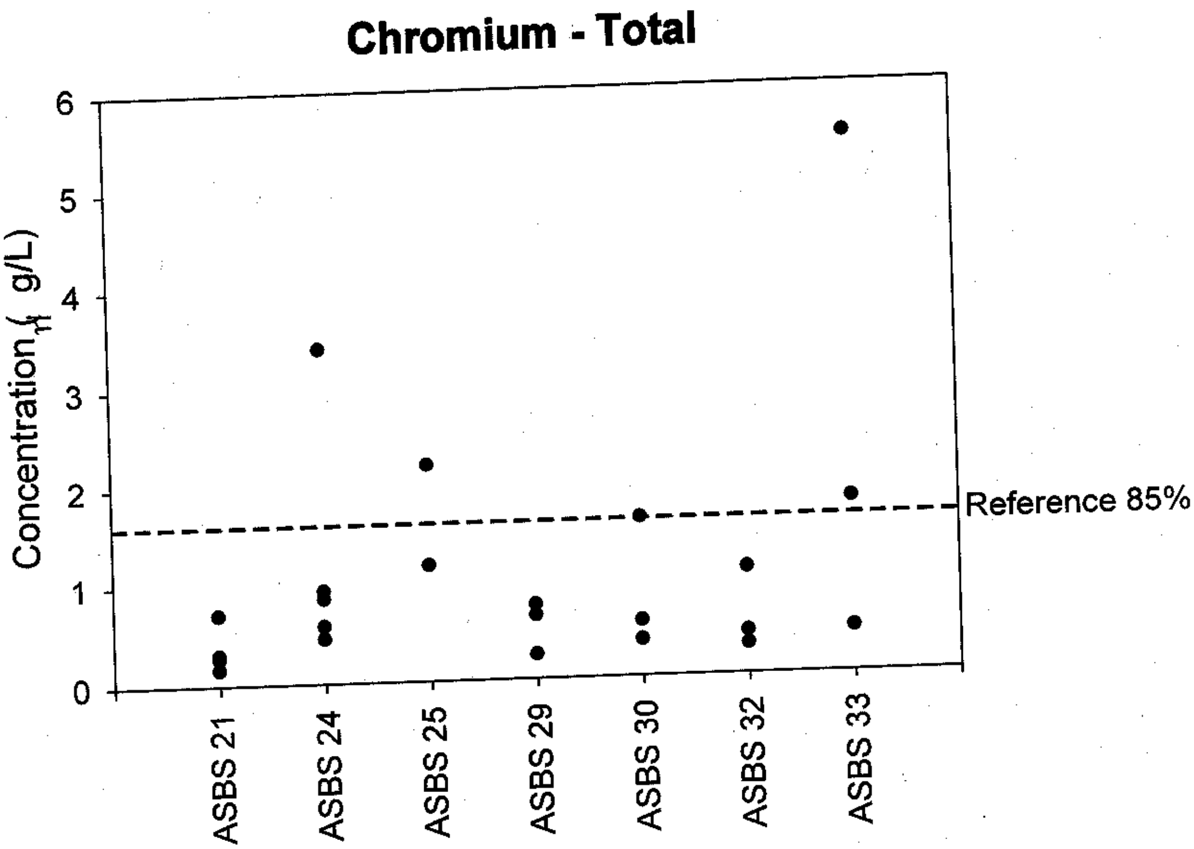

Cadmium-Dissolved
Concentration (µg/L)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Reference 85%
ASBS 21
ASBS 24
ASBS 25
ASBS 29
ASBS 30
ASBS 32
ASBS 33

Cadmium-Total

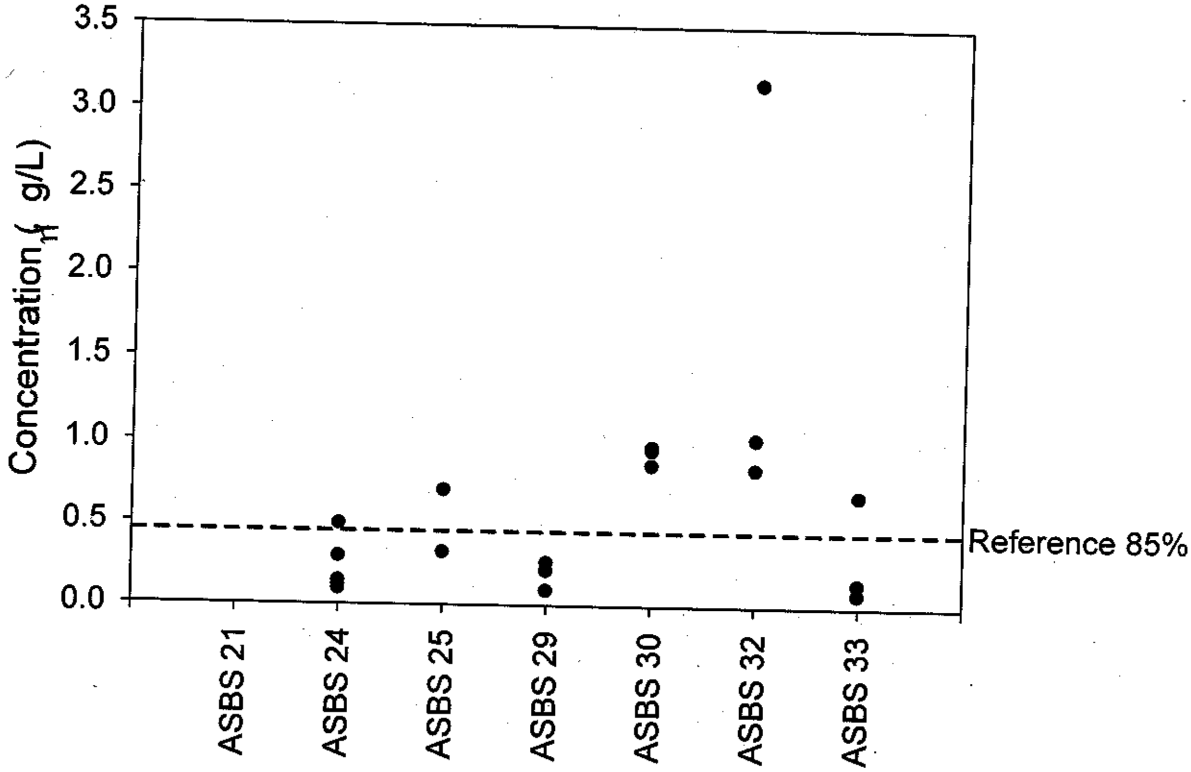


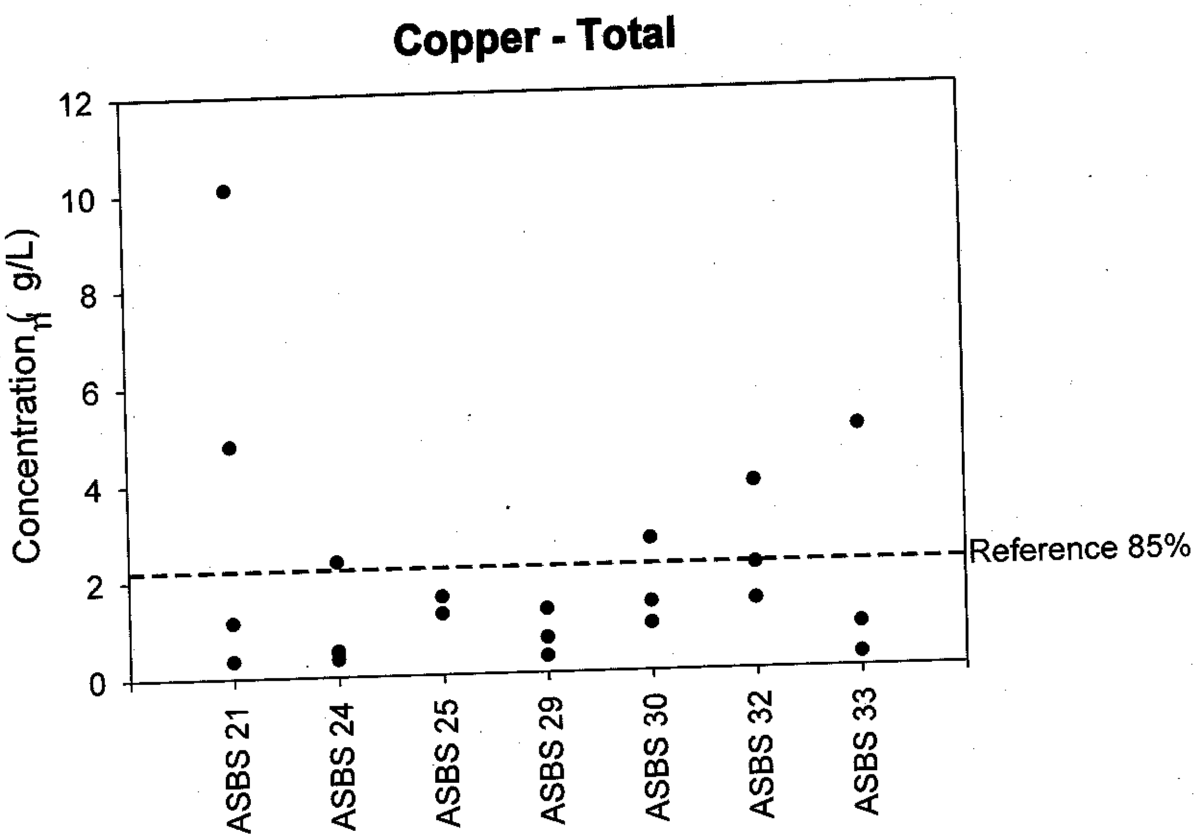


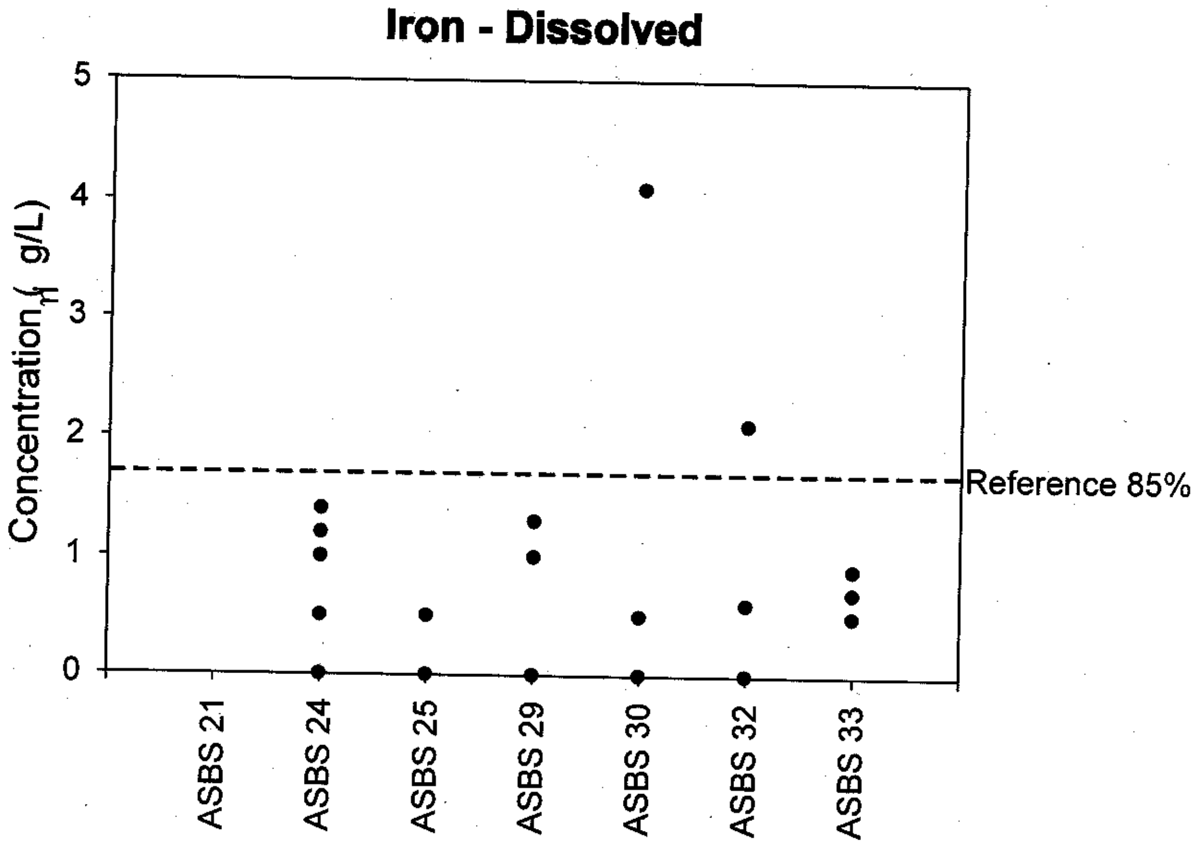
Chromium - Dissolved
Concentration (g/L)
0.25
0.20
0.15
0.10
0.05
0.00
Reference 85%
ASBS 21
ASBS 24
ASBS 25
ASBS 29
ASBS 30
ASBS 32
ASBS 33


Chromium - Total
Concentration (µg/L)
0
1
2
3
4
5
6
Reference 85%
ASBS 21
ASBS 24
ASBS 25
ASBS 29
ASBS 30
ASBS 32
ASBS 33

Copper - Dissolved

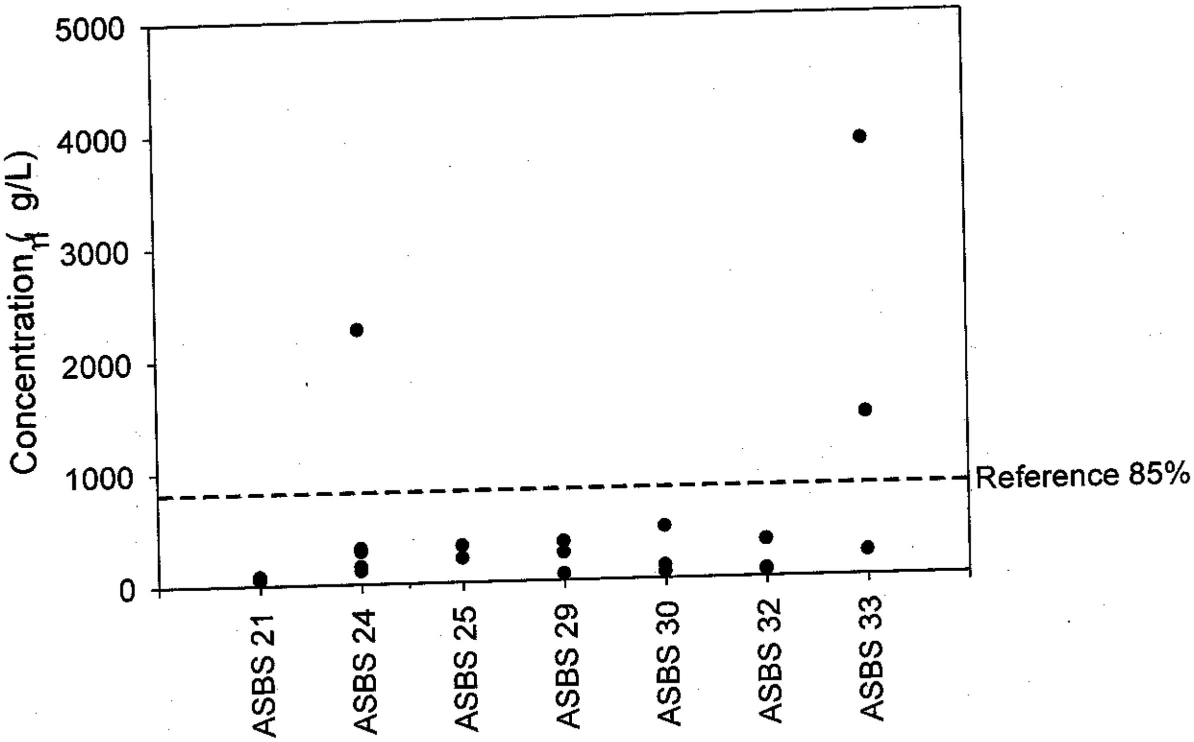



Copper - Total
Concentration (µg/L)
12
10
8
6
4
2
0
Reference 85%
ASBS 21
ASBS 24
ASBS 25
ASBS 29
ASBS 30
ASBS 32
ASBS 33

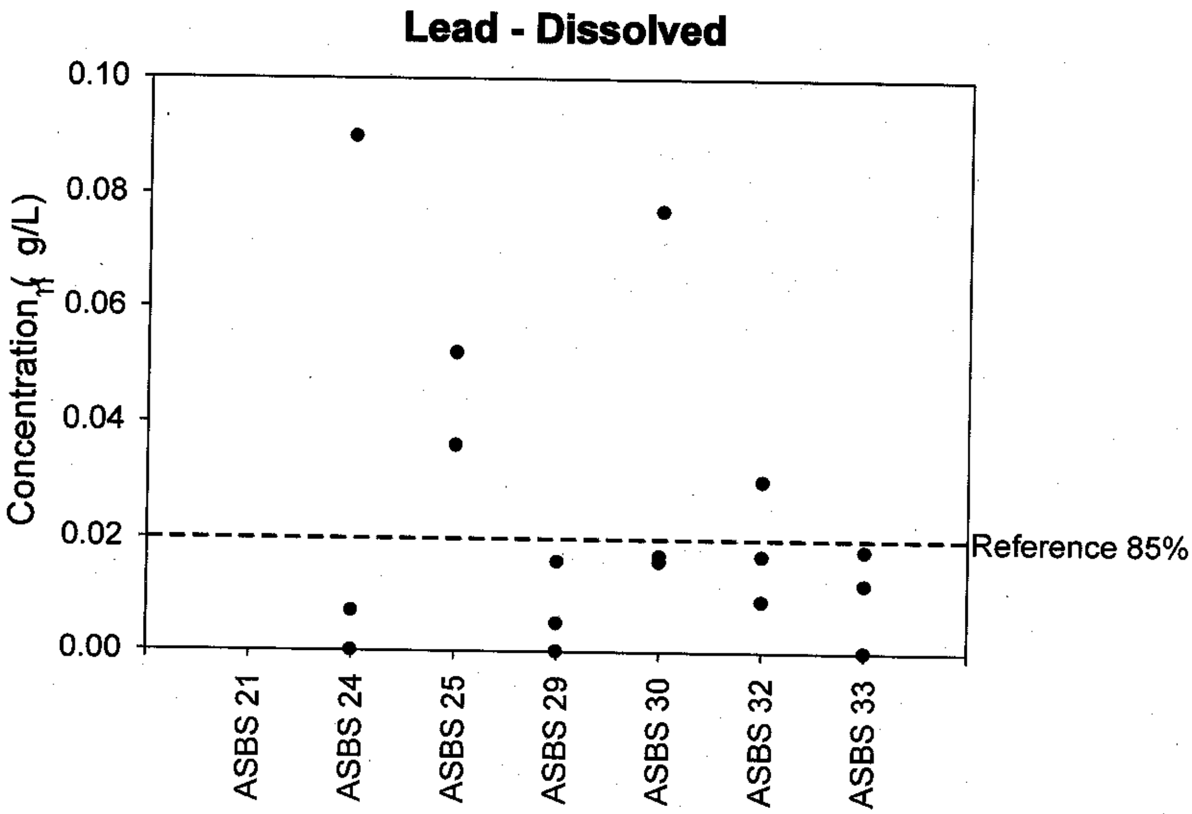


Iron - Dissolved
Concentration (µg/L)
5
4
3
2
1
0
Reference 85%
ASBS 21
ASBS 24
ASBS 25
ASBS 29
ASBS 30
ASBS 32
ASBS 33

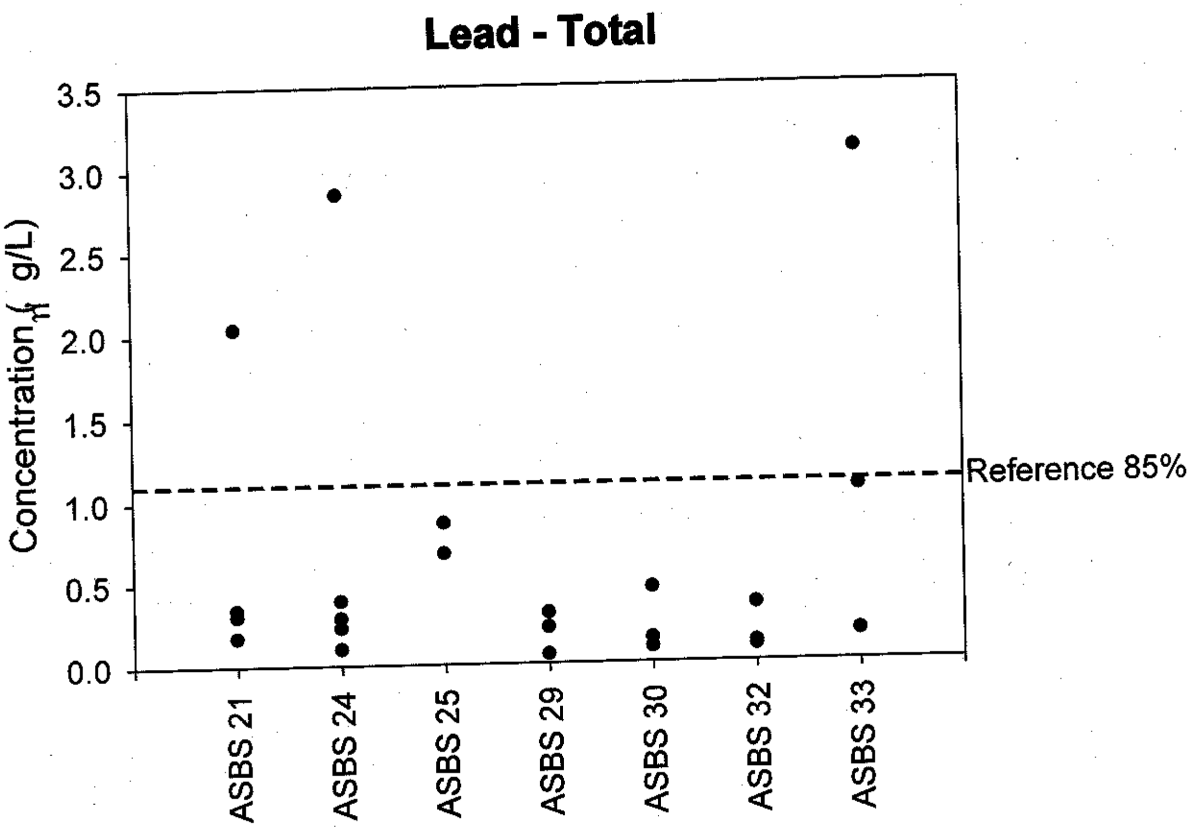
Iron - Total



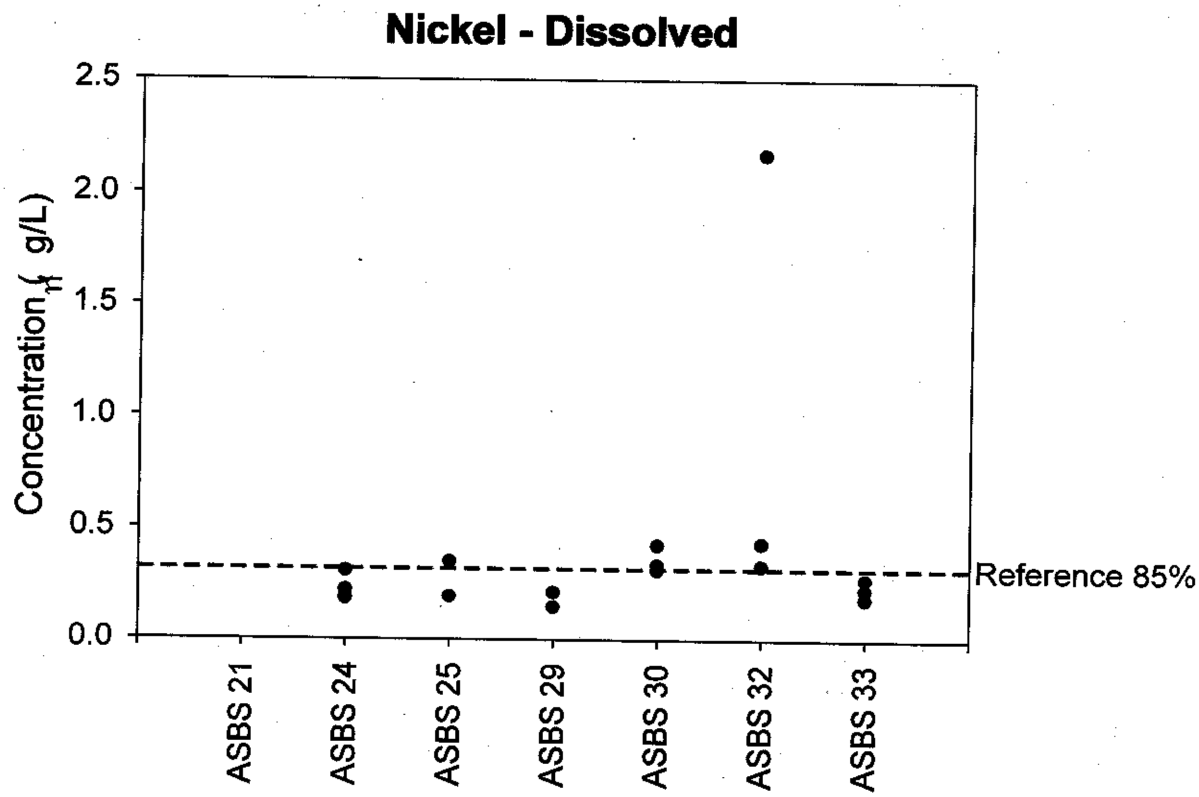
5000
4000
3000
2000
1000
0
Concentration (µg/L)
Reference 85%
ASBS 21
ASBS 24
ASBS 25
ASBS 29
ASBS 30
ASBS 32
ASBS 33



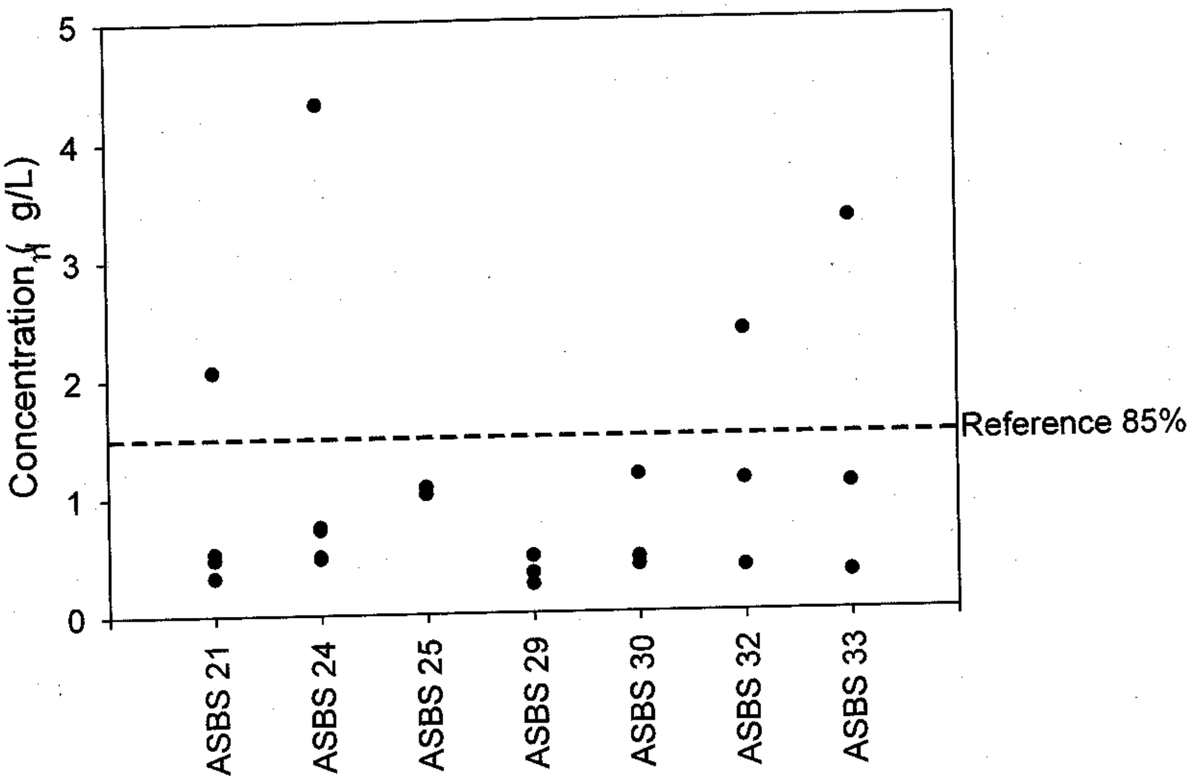
Lead - Dissolved
0.10
0.08
0.06
0.04
0.02
0.00
Concentration (g/L)
Reference 85%
ASBS 21
ASBS 24
ASBS 25
ASBS 29
ASBS 30
ASBS 32
ASBS 33

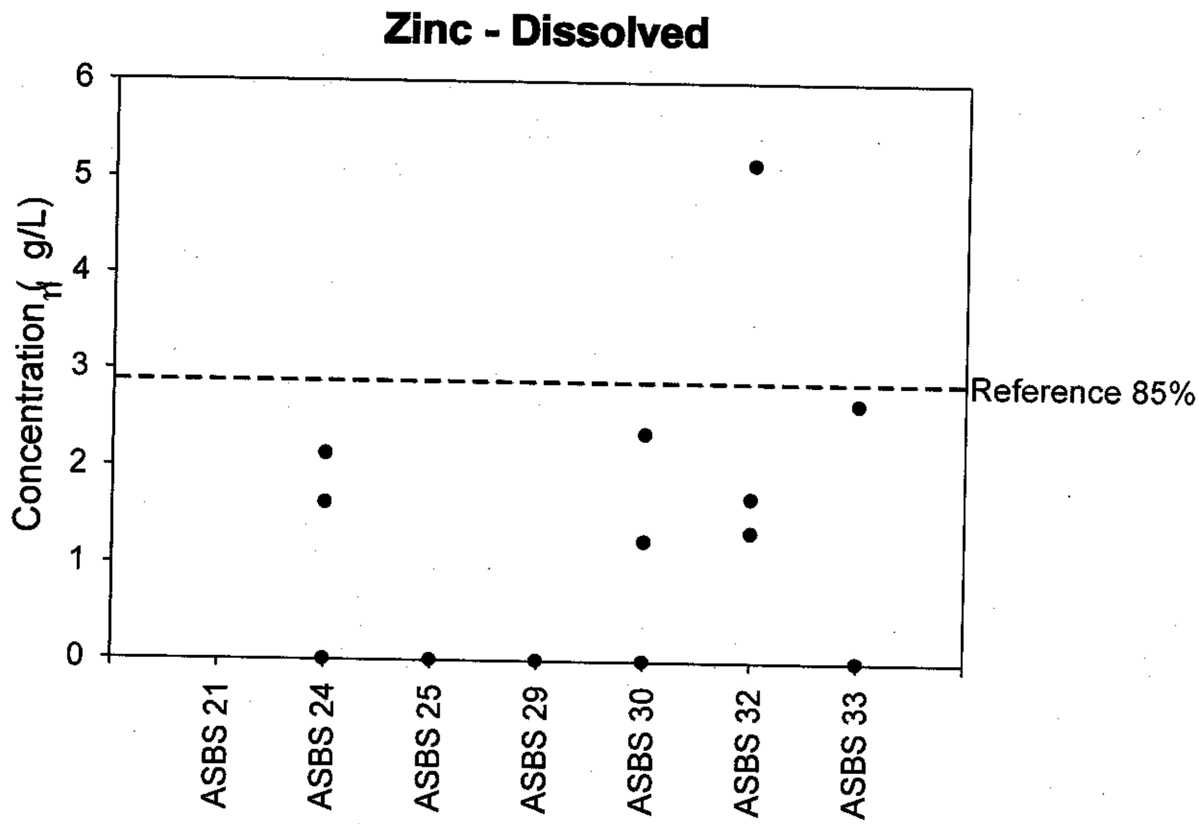


Lead - Total
Concentration (µg/L)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Reference 85%
ASBS 21
ASBS 24
ASBS 25
ASBS 29
ASBS 30
ASBS 32
ASBS 33

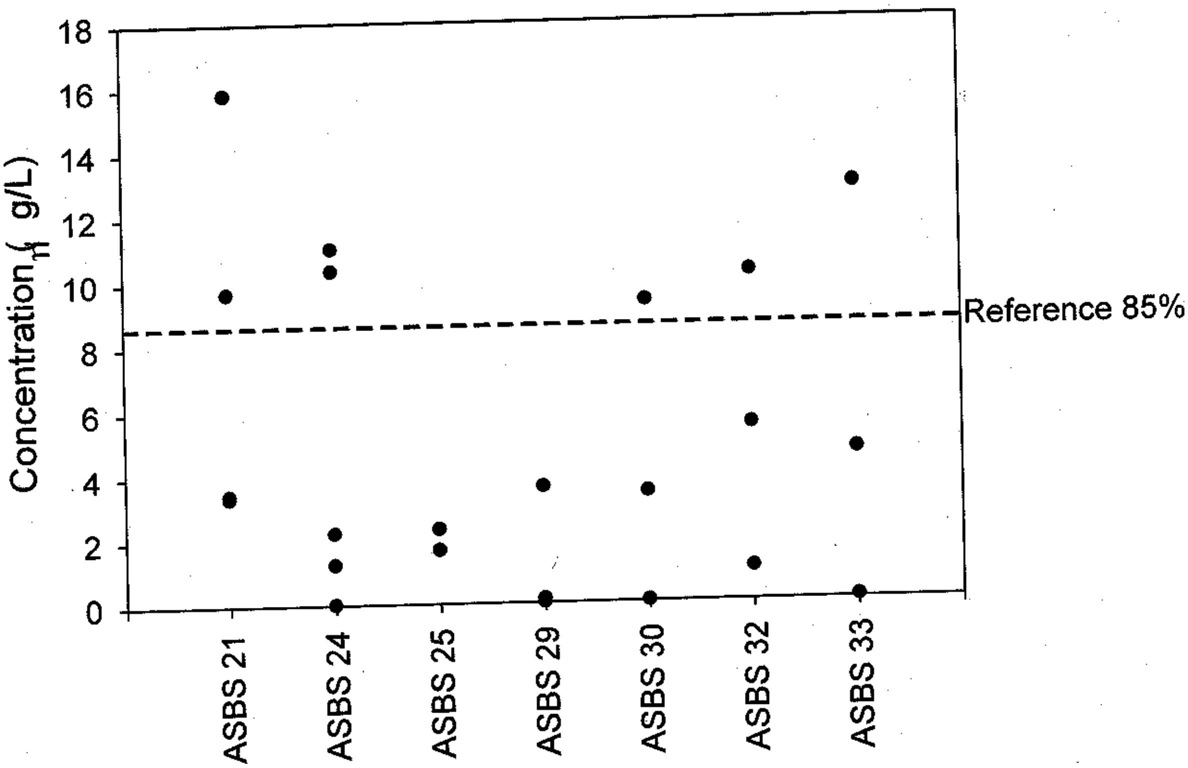

Nickel - Dissolved
2.5
2.0
1.5
1.0
0.5
0.0
Concentration (µg/L)
Reference 85%
ASBS 21
ASBS 24
ASBS 25
ASBS 29
ASBS 30
ASBS 32
ASBS 33

Nickel - Total

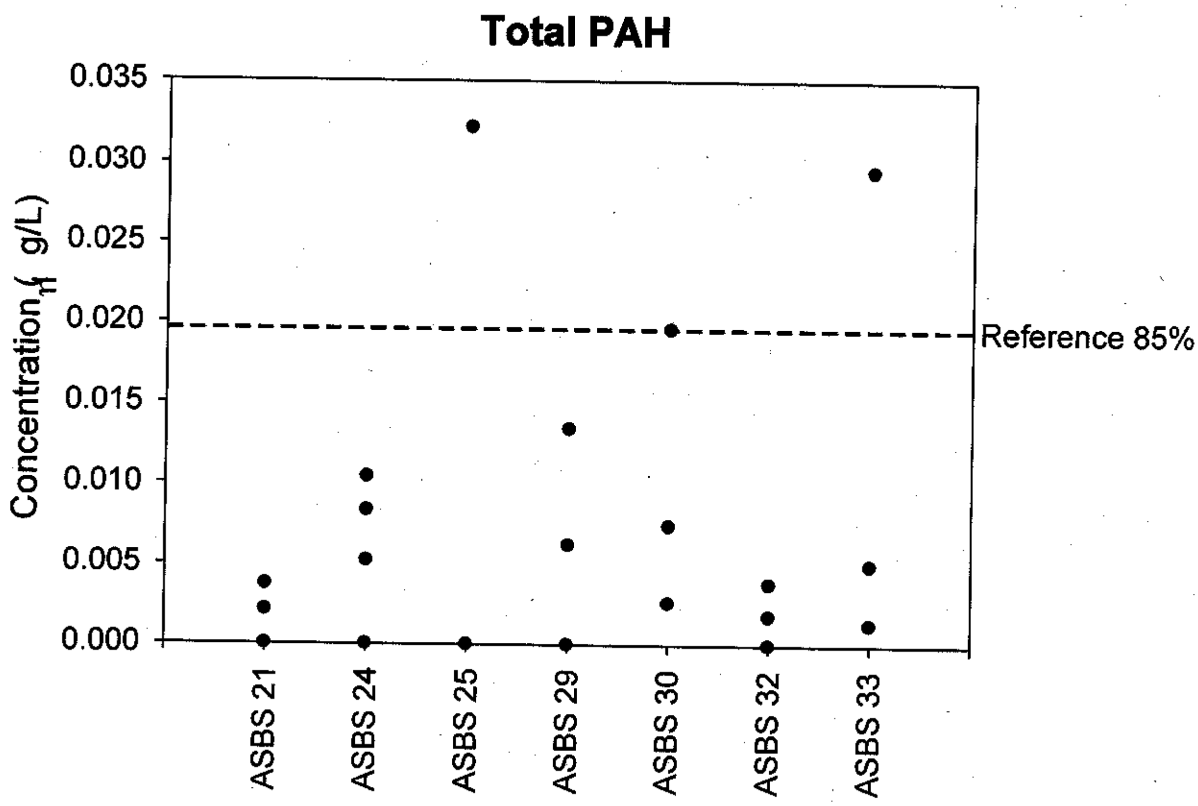



Zinc - Dissolved
6
5
4
3
2
1
0
Concentration (µ g/L)
Reference 85%
ASBS 21
ASBS 24
ASBS 25
ASBS 29
ASBS 30
ASBS 32
ASBS 33

Zinc - Total



18
16
14
12
10
8
6
4
2
0
Concentration (µg/L)
Reference 85%
ASBS 21
ASBS 24
ASBS 25
ASBS 29
ASBS 30
ASBS 32
ASBS 33


Total PAH
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
Concentration (µg/L)
Reference 85%
ASBS 21
ASBS 24
ASBS 25
ASBS 29
ASBS 30
ASBS 32
ASBS 33