DRAINAGE AREA MANAGEMENT PLAN (DAMP)

Exhibit 11.II San Diego Region Dry Weather Monitoring Program

July 1, 2003

A COOPERATIVE PROJECT OF THE COUNTY OF ORANGE, THE CITIES OF ORANGE COUNTY AND THE ORANGE COUNTY FLOOD CONTROL DISTRICT

Exhibit 11.II

San Diego Region

Dry Season Water Quality Monitoring Program

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3.0 Future Dry Weather Monitoring

The Permittees' Dry Weather Monitoring Program under the San Diego Regional Water Quality Control Board's Order No. R9-2002-0001 consists of three main elements:

- A set of **randomly located stations** intended to characterize the average area-wide conditions in urban runoff

- A set of rotating **targeted stations** intended to provide additional information about specific sites thought to have a high potential for contaminated runoff and to provide coverage of the entire MS4 system over the period of the permit term

- A set of **criteria** that will trigger focused IC/ID (illegal connection and illicit discharge) studies by the Permittees when the monitoring data indicate the presence of a problem.

It is important to recognize that the Permittees' overall Stormwater Management Program includes a wide range of elements that involve activities such as public education, inspections, and a variety of best management practices (BMPs). The Dry Weather Monitoring Program described in this section will provide important feedback on the ultimate effects of such actions on stormdrain water quality. Combined with special studies and focused BMP evaluations, the Dry Weather Monitoring Program will enhance the Program's ability to continually adapt its management approach as knowledge improves.

3.1 Objectives and Program Overview

The objectives of the Dry Weather Monitoring Program, as stated in the permit, are to:

- Assess compliance with Order No. R9-2002-0001

- Detect and eliminate illicit discharges and illegal connections to the MS4 system (by identifying sites that will be the subject of follow-up source identification investigations conducted by the Permittees)

- Characterize urban runoff within the MS4 system with respect to water quality constituents that may cause or contribute to exceedances of receiving water quality objectives when discharged to receiving waters.

These objectives translate into six fundamental questions that form the basis for specific design elements of the Dry Weather Monitoring Program:

1. What are the average background characteristics of urban dry weather runoff in the region?

2. What are the trends in these background characteristics over time?

3. What are the characteristics of urban dry weather runoff at specific locations that may present higher risk?

4. What are the trends in runoff characteristics at these locations?

5. Which sites exceed the overall regional average by a substantial amount in one or more constituents?

6. Which sites exhibit substantial changes in their characteristics over time that could be indicative of worsening or improving conditions?

The randomly located sites will address Questions 1 and 2. The targeted sites will address Questions 3 and 4. Data from all sites will be used to address Questions 5 and 6, using the criteria established to trigger follow-up IC/ID studies by the Permittees. The goal of these studies will be to seek out reasons for exceedances and, if feasible, correct the problems. Data from the IC/ID studies can be combined with monitoring data to help link particular land uses to specific patterns of contamination. **Figures 3-1** and **3-2** present maps of the random and targeted station locations, respectively. **Figures 3-1** and **3-2** also demonstrate that each Permittee has at least one site in each major drainage area in its jurisdiction (major drainage areas are defined as the major watersheds listed in **Table 3-1**), in accordance with permit section E.4.b.2.

Three aspects of the dry weather program deserve to be emphasized:

- First, the initial year of monitoring will have a stronger emphasis on characterizing average background conditions through the use of the random sites. As the estimates of background conditions stabilize, some of this monitoring effort may be shifted to targeted sampling focused on specific potential problems.

- Second, the list of targeted sites will be updated each year as potential problems are identified and/or resolved. This will enable the Permittees to meet the permit requirement to "provide adequate coverage of the entire MS4 system" (E.4.b.3) over the course of the full permit term.

- Third, monitoring data will be evaluated from a variety of perspectives (see Section 3.3) and decisions about whether to initiate follow-up investigations will be based on professional judgment. Thus, there are no automatic triggers built into the program.

3.2 Dry Weather Monitoring Program Elements

The dry weather monitoring program will address the six questions listed above with a two-part sampling design. The first part consists of 30 randomly selected sites intended to address questions about regional background conditions (Questions 1 and 2). The second part consists of 18 non-random, targeted sites intended to address questions about specific locations (Questions 3 and 4). Data from both sets of sites will be used to address questions about which sites should be evaluated more extensively by the Permittees because they exhibit higher values of pollutants or substantial changes in such values over time (Questions 5 and 6). The set of targeted sites will be updated each year to ensure that monitoring results in the coverage of the entire MS4 system over the course of the permit period.

The Dry Weather Monitoring Program will sample each of the 30 random sites three times and each of the 18 targeted sites five times during the five-month dry season. Laboratory analyses for metals, coliforms, pesticides, and oil and grease will be carried out for all samples, in addition to the on-site analyses conducted at each site. While this level of sampling and laboratory analysis exceeds the permit requirements, we believe it is warranted for three reasons:

- First, past experience has shown that problematic discharges can be intermittent in nature and there is a much greater likelihood of identifying such discharges if sampling occurs at a greater frequency

- Second, not all potential problems can be identified by the set of on-site analyses; thus, performing laboratory analyses at each site at each sampling event will maximize the program's ability to detect potential problems

- Third, interpreting monitoring results, putting them into context, and assessing their relative severity can be more effectively accomplished with this more intensive sampling and analysis approach.

Thus, the monitoring design described below reflects the fundamental philosophy that the program will produce more usable information by concentrating monitoring resources on a given set of sites, and sampling and analyzing them more intensively, than would be achieved by monitoring a larger number of sites less intensively. We also emphasize that the cumulative number of sites monitored will increase each year as effort is shifted from random to targeted sites and as monitoring rotates to new sets of targeted sites each year.

3.2.1 Random Site Sampling

The goal of the random sampling element is to characterize concentrations and trends in the average conditions of urban runoff. A related goal is to help identify those sites that are candidates for follow-up source identification efforts. This section describes the site selection protocol, identifies the sites chosen for random sampling, and describes field sampling and laboratory analysis.

3.2.1.1 Random Site Selection

Figure 3-3 outlines the steps involved in selecting sites for the random sampling element of the Program.

There are two primary considerations in selecting sites for the random element of the program. The first is defining the pool of potential sites to be drawn from and the second is ensuring that the random selection is not overly weighted toward one geographic area at the expense of others. These two issues are discussed more fully in the following paragraphs.

The primary goal of the Dry Weather Monitoring Program is to provide focus and support to an illicit connection and illegal discharge (IC/ID) effort, which means that the program should concentrate on urban runoff to the greatest extent possible. This can best be achieved by attempting to remove extraneous influences by including only enclosed pipes in the pool of potential sites. Open channels run the risk of including fecal contamination from birds and other wildlife, while enclosed pipes are more likely to reflect the influence of urban runoff. In addition, including only pipes that collect runoff from predominantly urbanized land uses (as opposed to open space areas) will also help ensure that monitoring focuses on the impacts of urban runoff. However, in order to achieve the most efficient "coverage" opportunities with the least number of tests, it may be necessary to occasionally collect some samples from open channels.

The County's database of facilities contains 148 major named drains in the south County that are designated as enclosed pipes draining urbanized land uses. Of these, 64 pipes discharge either to an open channel or to the ocean where sampling is more feasible. However, it is known that not all stormwater pipes are included in the County's database. This does not represent a problem for the random site selection if the undocumented pipes are spread throughout the study area and are not significantly different in character from the documented pipes. We have no reason to believe that the undocumented pipes fail these two criteria.

The other major consideration in selecting sites is to avoid a geographic overweighting of random sites in a small portion of the study area. This was achieved by creating geographic strata based on watersheds (**Figure 3-1**) and allocating random sites to each stratum based on their relative proportions of urbanized land. Urbanized land uses included:

- Commercial
- Education and religion
- Industrial
- Recreational
- Residential
- Transportation, communication, utility.

More specifically, strata were defined based on watershed boundaries (see **Table 3-1** for a list of watersheds and **Figure 3-1** for their locations). The area of total urbanized land uses in each watershed was then calculated based on GIS maps produced by the County's Geomatics Division. The relative proportion of the total urbanized land uses appearing in each stratum was then used to divide the total pool of 30 random sites among the strata (see **Table 3-1** for the number of random sites per watershed). For example, if a stratum contained 10% of the study area's total area of urbanized land uses, it would be allocated 10%, or 3, of the sites. Once the proportional allocation was determined, the specified number of random sites per stratum was selected from the pool of potential sites. One additional site was selected per watershed as an alternate site to be used when a primary site is found to be dry, with the exception of watersheds H (Los Trancos) and I (Laguna Canyon), which had only one suitable pipe apiece. **Table 3-2** lists the random sites and **Figure 3-1** illustrates their distribution throughout the study area.

3.2.1.2 Random Sampling and Laboratory Analysis

Monitoring will be conducted three times during the dry season (May through September) at each site. Monitoring will begin in May and subsequent monitoring carried out in July and September, depending on logistical constraints that may shift the monitoring time somewhat. Monitoring at each site will consist of:

- Field observations
- Field screening analyses
- Analytical laboratory analyses.

If flow or ponded runoff is observed at a site and there have been at least seventy-two (72) hours of dry weather, field observations will include general information such as time since last rain, quantity of last rain, site descriptions (i.e., conveyance type, dominant watershed land uses), temperature (air and water), and visual observations (e.g., odor, color, clarity, floatables, deposits/stains, vegetation condition, structural condition, and biology). Flow estimates will be made at each site where there is flowing water, based on the width of the water surface, the approximate depth of water, and the approximate flow velocity. The flow measurements may contribute to pollutant mass loading estimates and to identifying substantial changes in discharge that bear further investigation. Digital photographs may be taken to document unusual conditions that may have a bearing on the interpretation of the other monitoring data.

If flow or ponded runoff is observed at a site and there have been at least seventy-two (72) hours of dry weather, a grab sample will collected for an on-site analysis (field screening) of the parameters specified in permit Section E.4.d.1.d:

- Turbidity
- pH, specific conductance, dissolved oxygen, water temperature
- Reactive Phosphorous
- Nitrate Nitrogen
- Ammonia Nitrogen
- Phenol
- Surfactants (MBAS)
- Total hardness (from Section e.4.d.1.e).

If flow or ponded runoff is observed at a site and there have been at least seventy-two (72) hours of dry weather, a grab sample will be collected for laboratory analysis of the parameters specified in permit Section E.4.d.1.e:

- Oil and grease
- Diazinon and chlorpyrifos
- Cadmium (dissolved)
- Copper (dissolved)
- Lead (dissolved)
- Zinc (dissolved)
- Fecal coliform bacteria
- Enterococcus bacteria
- Total coliform bacteria
- Total suspended solids (TSS)
- Total chlorine (not specified in permit).

If a designated site is dry (i.e., no flowing water or ponded runoff), then all applicable observations will be recorded and sampling will be attempted at the alternate site for that watershed. **Table 3-3** lists the analytical methods that will be used for each parameter.

In accordance with permit Section E.4.d.6, monitoring staff will use a global positioning system (GPS) unit to record the coordinates of each site on the first sampling event. These coordinates will then be compared to those in the County's GIS system to verify the accuracy of the database and update it if necessary.

3.2.1.3. Random Data Analysis

There are three components to the analysis of data from the random sites. These are intended to help provide the basis for determining which sites are candidates for follow-up source identification studies to be carried out by the Permittees (see Section 3.3). These include:

- Calculation of a regional tolerance interval based on data from all 30 random sites, which will help answer Question 5: Which sites exceed the overall regional average by a substantial amount in one or more constituents?

- Comparison of each site's data values with relevant guidance levels, which will help answer Question 3: What are the characteristics of urban dry weather runoff at specific locations that may present higher risk?

- Calculation of a site-specific control chart for each individual random site, which will help answer Question 6: Which sites exhibit substantial changes in their characteristics over time that could be indicative of worsening or improving conditions?

Tolerance intervals are a quantitative, rigorous method for incorporating and addressing the presence of variability in background conditions when a monitoring program searches for data values that are significantly different from background (see the technical appendix for additional detail). A tolerance interval bound is simply the upper or lower confidence-interval bound of a quantile of the background data distribution (see **Figure 3-4**). Tolerance intervals will be calculated as described in the technical appendix and applied as described in Section 3.3 to help identify candidate sites for further follow-up investigations by the Permittees. The tolerance interval will be derived after the first sampling period and will then be recalculated each time the random sites are sampled throughout the duration of the program, in order to ensure that decisions are being made with the best data possible. As additional data lead to better estimates of variance, the tolerance interval will continue to become more precise over time. We investigated the possibility of accelerating this process by developing a regional tolerance interval with existing data, but found this was not feasible because existing data were not collected with a random sampling design.

Where guidelines and/or standards are available, data will be compared to these (**Table 3-4**), although it should be noted that any standards in **Table 3-4** have been developed for receiving waters and not for the storm drain system. Information about the degree and persistence of exceedances will be used to help identify which sites are candidates for follow-up source identification efforts (see Section 3.3).

Control charts provide a means of tracking data at each individual site and identifying when new data values deviate substantially (either upward or downward) from previous experience (see Appendix 1 for technical detail). A control chart can be used to establish a bound or threshold, based on previous monitoring data, as illustrated in **Figure 3-5**. Control charts will be calculated as described in Appendix 1 and applied as described in Section 3.3 to help identify candidate sites for further follow-up investigations by the Permittees. The site-by-site control charts will be recalculated each time the random sites are sampled throughout the duration of the program in order to ensure that decisions are being made with the best data possible. As additional data lead to better estimates of variance, the control charts will continue to become more reliable over time. We investigated the possibility of accelerating this process by developing site-specific control charts with existing data, but found this was not feasible because appropriate grab sampling data were not available from these sites.

The results of these three analyses will be combined with professional judgment to identify those sites that are candidates for further source identification efforts by the Permittees (see Section 3.3 for more detail).

3.2.2 Targeted Site Sampling

The primary goals of the targeted sampling element are to, first, characterize concentrations and trends at particular sites that are thought to have a high potential for polluted runoff and receiving water impacts, and, second, help provide coverage of the entire MS4 system. A related goal is to help identify those sites that are candidates for follow-up IC/ID efforts. This section describes the site selection protocol, identifies the sites chosen for targeted sampling, and describes field sampling and laboratory analysis.

3.2.2.1 Targeted Site Selection

Sites for the targeted, or non-random, portion of the Dry Weather Monitoring Program were selected by combining information from three sources:

- A review of the County's PNIR (Pollution Notification and Incident Response) database
- County staff's knowledge about the sorts of locations and land uses with a high potential for polluted runoff
- Input from the Permittees.

The County's PNIR database provides a record of spills and other incidents extending back to 1991. As in the development of the 99-04 monitoring plan, the database was queried for reaches of County channels impacted three or more times from January 1991 to the present, and specific Thomas Brothers coordinates, not associated with any particular channel, impacted 10 or more times in the same period. In addition, County staff have noted that concrete companies, waste transfer stations, food warehouses where transfer operations take place, and concentrations of automobile repair facilities are correlated with elevated pollutant levels. Of these, only the automobile repair facilities occur to any degree in the south County.

The Permittees also provided suggestions about sites they felt were areas of particular concern, based on inspections, spills, land use type, and other past experience. These sites were also added to the list of potential sampling locations (**Table 3-5**).

Table 3-5 presents the final list of the targeted sites and **Figure 3-2** illustrates their distribution throughout the study area.

As discussed in more detail below (Section 3.2.3), the list of targeted sites will be updated each year, with the twin goals of addressing high-priority potential problems first and achieving coverage of the entire MS4 system over the course of the full permit term.

3.2.2.2 Targeted Sampling and Laboratory Analysis

Sampling and laboratory analysis will be conducted as described for the random sites (see Section 3.2.1.2).

3.2.2.3 Targeted Data Analysis

There are three components to the analysis of data from the targeted sites. As with the random sites, these are intended primarily to help provide the basis for determining which sites are candidates for follow-up source identification studies to be carried out by the Permittees (see Section 3.3). These include:

- Comparison of each site's data values with the regional tolerance interval calculated from the random sites, which will help answer Question 5: Which sites exceed the overall regional average by a substantial amount in one or more constituents?

- Comparison of each site's data values with relevant guidance levels, which will help answer Question 3: What are the characteristics of urban dry weather runoff at specific locations that may present higher risk?

- Calculation of a site-specific control chart for each individual targeted site, which will help answer Question 6: Which sites exhibit substantial changes in their characteristics over time that could be indicative of worsening or improving conditions?

Methods for comparing data values to guidelines and/or standards, and for constructing control charts, are the same as described above (Section 3.2.1.3) for the random site data analysis.

The results of these three analyses will be combined with professional judgment to identify those sites that are candidates for further source identification efforts by the Permittees (see Section 3.3 for more detail).

<u>3.2.3 Periodic reevaluation</u>

Each year's monitoring results will be used to reevaluate the two main aspects of the Program's design, the random and the targeted monitoring elements.

First, the first year's data from the random sites will be used to assess the need for continued measurement of background conditions at the original level of sampling intensity. If the tolerance interval bounds are effective and stable, then it may be feasible to reduce the random sampling effort and allocate these monitoring resources to higher-priority issues. Any decision to cut back the random, or background, portion of the Program must take into account the need to monitor for longer-term trends in background conditions. Once the current background conditions are established, one sampling event per year may serve to track trends, especially if the south County data can be combined with data from the remainder of Orange County and from other Counties as part of any Stormwater Monitoring Coalition (SMC) regional monitoring effort.

The Southern California Stormwater Monitoring Coalition (SMC) is a partnership of the lead municipal stormwater Permittees and RWQCBs in southern California, and the Southern California Coastal Water Research Project (SCCWRP). The SMC has endorsed regional cooperation and has agreed to collaboratively fund research that will improve stormwater monitoring efforts. The SMC has developed a research agenda to direct its activities and more information on both the SMC and the research agenda can be found at: ftp://ftp.sccwrp.org/pub/download/PDFs/358_stormwater_workplan.pdf.

Second, the list of targeted sites will be reevaluated each year to determine whether an individual site requires further monitoring by the County or whether monitoring can be shifted to another targeted site that has yet to be monitored. Monitoring will be discontinued at a particular site when:

- Multiple sampling events find no evidence of elevated values compared to the regional tolerance interval

- An IC/ID effort, led by the relevant Permittee, is underway and does not require further County monitoring data from the targeted site

- An IC/ID effort has found the source of elevated values.

In such cases, the Program will identify additional priority sites and shift monitoring effort to those.

3.3 Criteria for Source Identification Studies

When sampling data from the County's routine dry weather program exceed certain criteria, then this will trigger a consideration of whether follow-up investigations by the Permittees are warranted, in accordance with permit conditions E.4.d.4 and E.4.d.5. These criteria are designed to identify sites that:

- Exceed the overall regional average by a substantial amount in one or more constituents

- Exhibit substantial changes in their characteristics over time that could be indicative of worsening or improving conditions. (It may be informative to continue monitoring where conditions are improving in order to gain information that could be useful elsewhere.)

These criteria correspond to questions 5 and 6 in Section 3.1 and will help to focus follow-up investigations on those sites that may pose the greatest potential risk to receiving waters. Because the Dry Weather Monitoring Program's primary focus is prioritizing IC/ID detection and elimination studies, the threshold levels for the tolerance intervals and the control charts will be set at levels that will be high enough to focus follow-up sampling on those instances that are clearly beyond average conditions and therefore represent the highest-priority problems.

The tolerance interval will initially be set at the 90^{th} percentile (or the .90 quantile), with allowance made for sampling variability around that estimate (see Appendix 1).

The control chart threshold will be set at 3.9 standard deviations beyond the mean. Given the large number of comparisons to be performed each year (approximately 1000, resulting from the large number of parameters being measured at all 60 sites), false positives will unavoidably occur. As Appendix 1 explains, numerical simulations estimate that the false positive rate at this threshold will be 0.05, which is equivalent to about 50 false positive results per year. While this appears to be a substantial number, it represents a reasonable starting point for three reasons:

- It is analogous to setting the α level at 0.05, a common procedure in statistical tests

- A single exceedance of the threshold by a single parameter will not necessarily trigger a follow-up IC/ID investigation. With the exception of values that are clearly extreme, the guidance levels will be considered in the context of the tolerance level and control chart results, and then assessed with professional judgment.

- The control chart results will not be used in isolation to initiate a follow-up investigation; they will be combined with results of comparisons to the regional tolerance interval and to any relevant guidance levels, and then assessed with professional judgment.

The flowchart in **Figure 3-6** illustrates the steps involved in establishing the criteria that would trigger a consideration of follow-up investigations:

- The **random sites** will be used to establish a tolerance interval for each monitored pollutant. The tolerance interval will be applied to data from the entire region and will be used to identify sites that exceed the overall regional average for a particular pollutant.

- Data from **all sites** (both random and targeted) will be used to establish site-specific control charts for each pollutant. The control charts will be applied to data on a site by site basis to identify sites whose characteristics change substantially over time.

- Data that exceed either a tolerance interval or a control chart bound will be confirmed with data from the next sampling event. If this second sample does not confirm the exceedance, then routine sampling will continue.

- If exceedances of either tolerance intervals or control chart bounds are confirmed, then these data will be further evaluated by comparison to guidance levels and with professional judgment. Only after passing through these two additional steps will follow-up source identification efforts be initiated.

- Professional judgment will be based on knowledge of and past experience with past contamination patterns. For example, extreme pH values are evidence of a problem, as are oil sheens and the presence of dead animals, and a dissolved oxygen value of < 1 ppm on a sunny day. In addition, elevated nutrients can be evidence of agricultural activity, high pH values of concrete waste, and extremely turbid water of a grading violation. A finding of elevated copper levels is indicative of printed circuit board operations, especially when combined with low pH and the presence of soluble cyanide. Elevated bacteria levels, combined with ammonia, MBAS, COD, BOD, turbidity, and odor suggest a sewage spill. The findings of the IC/ID studies will be used to refine the screening process as the program develops.

- At any time, if extreme data values warrant it, the tolerance interval and control chart steps may be bypassed to consider whether source identification studies should be initiated as soon as is feasible.

When the County has identified a site that meets the criteria in **Figure 3-6**, it will notify the appropriate City representative that follow-up IC/ID efforts should be initiated. However, if the monitoring program finds extreme conditions that represent a clear and immediate risk to human health or receiving water quality, or that provide unambiguous evidence of a substantial upstream problem, then this routine procedure will be bypassed and the relevant inspector for that City notified immediately. In both kinds of instances, if the monitored site is near a jurisdictional boundary and the upstream drainage network for the site extends into a neighboring jurisdiction, both the jurisdiction containing the site as well as the jurisdiction containing the upstream portion of the drainage network will be notified.

The County plans to deliver monitoring data to the cities as soon as it is received from the contract laboratory and processed through a set of quality control checks. In most cases, this will be accomplished within 45 days of the sampling data. In addition, the County will carry out the procedure described in Section 3.3 after each sampling event and notify the relevant city of any sites that require follow-up IC/ID investigations within 21 days of receipt of the data from the laboratory.

Table 3-1 Major watersheds in the south County and the number of random sites allocated per watershed.

Watershed name	Percent of total urbanized area	Number of random sites
H: Los Trancos	.03	1
I: Laguna Canyon	.04	1
J: Aliso Creek	.25	7
K: Salt Creek	.05	2
L: San Juan Creek	.50	15
: Prima & Segunda Deshecha	.13	4

Table 3-2 List of random sites selected in each watershed.

Watershed	Drain Name	Numeric Designation
H: Los Trancos	H00P01	H00P01
I: Laguna Canyon	Cleo Street Storm Drain	I00P02
J: Aliso Creek	J00P02	J00P02
	Munger Creek Channel	J01P02
	Muirlands Storm Drain	J01P05
	J01P26	J01P26
	J01P33	J01P33
	Niguel Storm Drain	J03P01
	J07P02	J07P02
	J02P05 *	J02P05
K. Salt Creek	K01P02	K01P02
	K01P04	K01P04
	K01P08	K01P08
	K01P09	K01P09
	K01P07 *	K01P07
L: San Juan Creek	L02P20	L02P20
	L02P25	L02P25
	L02P28	L02P28
	L02P29	L02P29
	L02P32	L02P32
	L02P45	L02P45
	Ladera 1	L02P50
	Ladera 2	L02P55
	L03P04	L03P04
	L03P05	L03P05
	L03P10	L03P10
	L03P11	L03P11
	L11P02 *	L11P02
M: Prima & Segunda Deshecha	Capistrano Palisades Storm Drain	M00P01
	Capistrano Bay Storm Drain	M00P03
	Talega Valley 1	M03P01
	Talega Valley 2	M02XXX
	Calle Real Storm Drain *	M00P05

An asterisk (*) indicates the alternate site for that watershed. There were no suitable alternate sites available for the Los Trancos and Laguna Canyon watersheds.

Table 3-3 Analytical methods used for field screening and laboratory analyses.

Parameter	Method	HACH Method	Standard Method	EPA Method
Field screening analyses				
Turbidity	Turbidimeter - Nephelometric Method			
pH, specific conductance, dissolved oxygen and water	Multi-parameter probe			
Reactive Phosphorous		8048 - Ascorbic Acid		
Nitrate Nitrogen		8039 - Cadmium Reduction		
Ammonia Nitrogen		10031 - Salicylate		
Phenol		8047 - 4-Aminoantipyrine		
Surfactants (MBAS)		8028 - Crystal Violet		
Total hardness		8213 - Digital Titrator with EDTA		
Laboratory analyses				
Oil and grease			5520B	1664
Diazinon and chlorpyrifos (GCMS)				525.2
Cadmium (dissolved)			3125B	200.8
Copper (dissolved)		8506 - Bicinchoninate Method	3125B	200.8
Lead (dissolved)			3125B	200.8
Zinc (dissolved)			3125B	200.8
Fecal coliform bacteria			9222D	
Enterococcus bacteria			9230C	
Total coliform bacteria			9222B	9132
Total chlorine		8167 - DPD Method		
Total suspended solids (TSS)			2540D	160.2

Table 3-4 Guidance levels for field screening and laboratory analytical parameters.

Analyte	Guidance Levels	Source / Notes
Field screening		
Turbidity (NTU)	Best professional judgment	WQOs relevant to inland surface waters are not available. Base judgment on channel type and bottom, time since last rain, background levels, and visual observation (e.g. unusual colors).
pH	<6.5 or >9.0	Basin Plan, w/ allowance for elevated pH due to excessive photosynthesis. Elevated pH is especially problematic in combination with high ammonia
Conductivity (µmhos/cm) or TDS (mg/L)	5000 µmhos/ cm conductivity or ~3500 mg/L TDS	Professional judgment. EC may be highly elevated in some regions due to high-TDS groundwater exfiltration to surface water, mineral dissolution and seawater intrusion. Normal source ID and discharge elimination work is not effective in these situations. Conversion factor for EC to TDS is approximately 0.7.
Temperature (F or C)	Best professional judgment	Base judgment on season, air temperature, channel type, shade, etc.
Reactive Phosphorous (orthophosphate-P) (mg/L)	2.0	USEPA Multi-sector General Permit
Nitrate-Nitrogen (mg/L)	10.0	Basin Plan, and drinking water standards
Ammonia-Nitrogen (mg/L)	1.0	Staff and Permittee experience, may also consider unionized ammonia fraction.
Phenol		
Surfactants (MBAS) (mg/L)	1.0	Basin Plan, w/ allowance based on relevant field experience and possible field reagent interferences.

Analyte	Guidance Levels	Source / Notes
Laboratory		
Oil and Grease (mg/L)	15	USEPA Multi-sector General Permit. If a petroleum sheen is observed, the sample should be collected from the water surface.
Diazinon (µg/L)	0.5	Acute LC50 for aquatic invertebrates range from 0.2 µg/L for *Gammarus fasciatus* to 4.0 µg/L for *Hyallela azteca*
Chlorpyrifos (µg/L)	0.5	Acute LC50 is 9 µg/L rainbow trout, higher for other fish, decreased survival and growth for fathead minnow at 30-day chronic exposure of 2 µg/L.
Dissolved cadmium, copper, lead, zinc	California Toxics Rule	Use CTR table, 1-hour criteria, adjusted for hardness, to determine appropriate action level for individual samples.
Fecal Coliform (MPN or CFU/ 100 mls)	31,000 MPN or CFU/100 mls	The 75th percentile of all data collected during the Aliso directive monitoring program between May 1 and September 30, 2001 and 2002.
Enterococcus (MPN or CFU/ 100 mls)	20,000 CFU/100 mls	The 75th percentile of all data collected during the Aliso directive monitoring program between May 1 and September 30, 2001 and 2002.
Total Coliform (MPN or CFU/ 100 mls)	160,000 MPN or CFU/100 mls	The 75th percentile of all data collected during the Aliso directive monitoring program between May 1 and September 30, 2001 and 2002. However, this is an underestimate because the upper detection limit was 160,000 and many values were above the detection limit.
Total suspended solids	Best professional judgment	

Table 3-5 List of targeted sites selected in each jurisdiction and watershed.

Jurisdiction	Targeted Sites
Aliso Viejo	J01P28
	J01P27
Dana Point	
Laguna Beach	N. Main Beach Stormdrain #13
Laguna Hills	
Laguna Niguel	J03P01
	J03TBN-Golden Lantern/Moulton
	J04 @ J03
	K01S02
	K01P08
	K01P09
Laguna Woods	
Lake Forest	J01P08
Mission Viejo	
San Clemente	M00P06
San Juan Capistrano	L01 @ SJC City Line
	L02 @ SJC City Line
	L05 @ SJC City Line
	L05 U/S I-5
	L05 @ Del Obispo West
	L05 @ L01
	L01TBN1 & 2 - D/S L05 @ L01
Rancho Santa Margarita	
County of Orange	L11P01

TO BE COMPLETED

Figure 3-1 Map of watersheds and cities and random site locations.

TO BE COMPLETED

Figure 3-2 Map of watersheds and cities and targeted site locations.

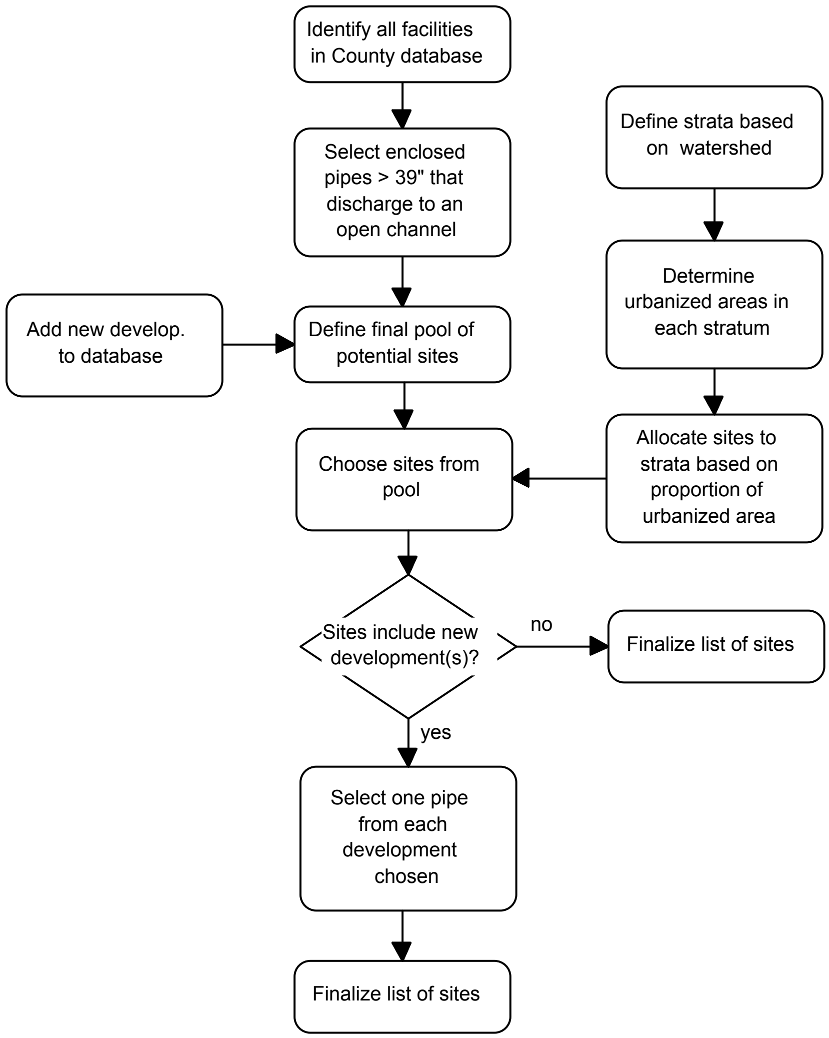


Figure 3-3 Flowchart of the random site selection protocol.

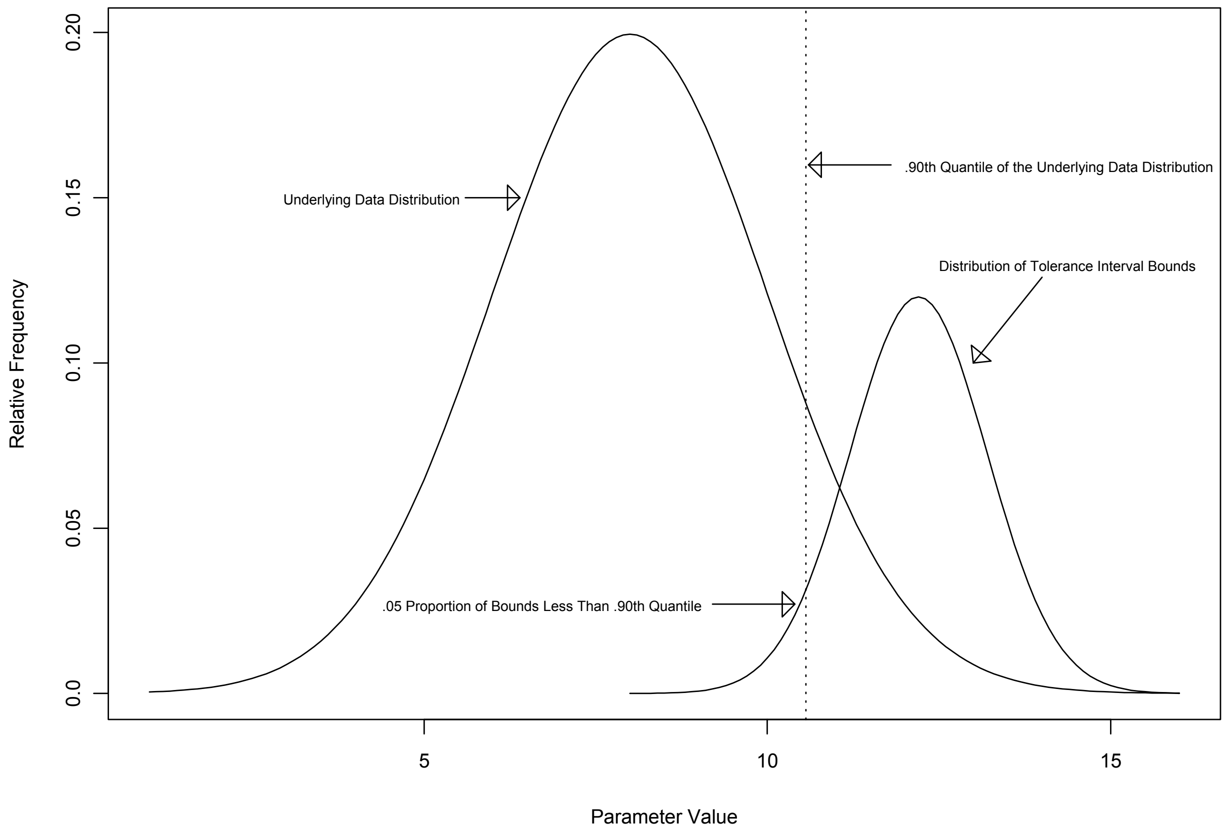


Figure 3-4 Example of the tolerance interval approach.

Illustration of a $p=0.90$, $\alpha=0.05$ tolerance interval. The tolerance interval bounds are computed so that the bounds will only fall below the actual 90th quantile *0.05* proportion of the time.

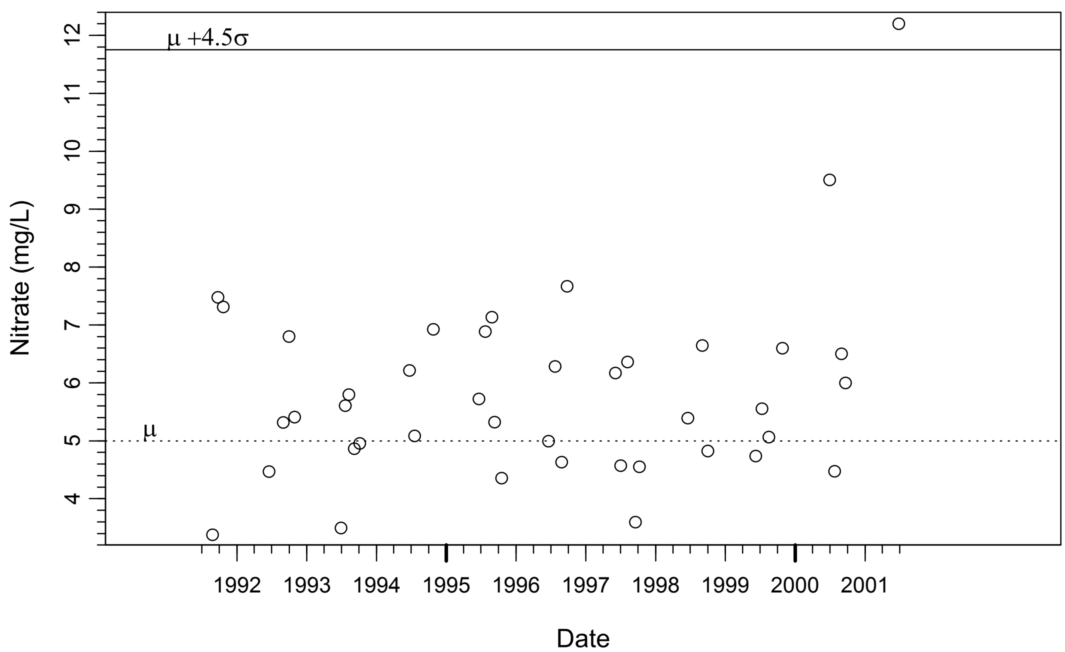


Figure 3-5 Example of the control chart approach

In this example, points occurring above the solid horizontal line (the control limit) are considered outliers of concern. The point on the last date would be flagged as an outlier. In this example, the mean (μ) is *5.0* and the standard deviation (σ) is *1.5*.

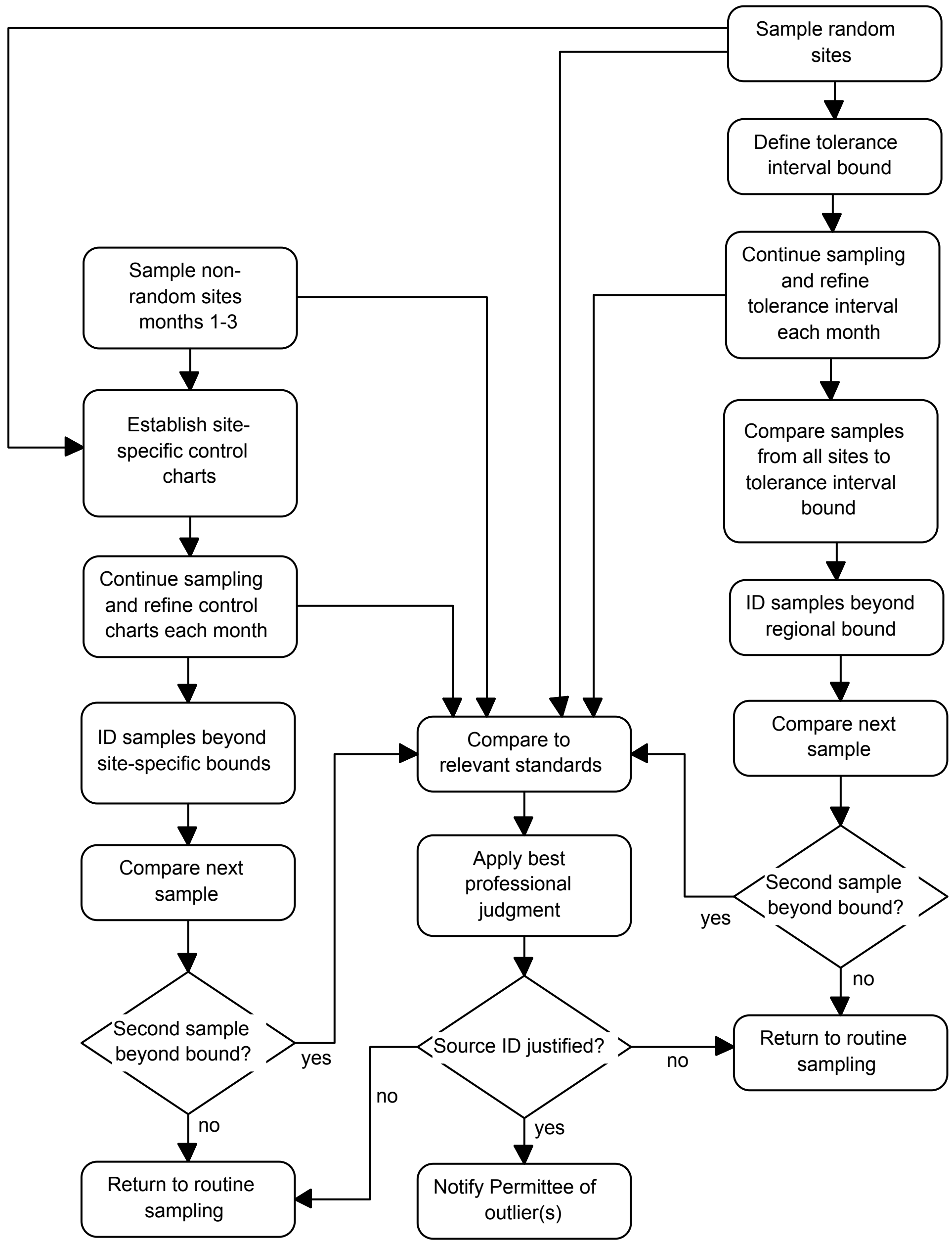


Figure 3-6. Criteria that would trigger follow-up IC/ID investigations by individual Permittees.

Technical Appendix to San Diego Dry Season Monitoring Program

A.0 Data Analysis Methods

A.1 Tolerance Intervals - Comparing Parameter Levels With Background

It will be useful to find unusual parameter measurements indicating potential problems at a location. Before we can define "unusual," we need to know what constitutes "usual" or background parameter levels. Thirty sites have been randomly selected for the purpose of defining the County background, or reference, distribution of parameter values for the County as a whole. Measurements taken at other selected locations can then be compared to these background levels, and measurements with a relatively low probability of being part of the reference population distribution will be flagged for further study.

The reference parameter measurements will cover a range of values, and some sort of comparison with this range is appropriate. Direct comparison with the maximum or minimum reference measurement does not take into account the uncertainty from sampling error. A better comparison would be with a quantile toward the tail of the reference distribution (Splitstone 1991,Kilgour & Somers 1998). A quantile of a distribution is the measurement value that exceeds a selected proportion of the data. Instead of directly estimating a quantile, we can take into account sampling error by instead using the confidence interval bound of the quantile. The $1-\alpha$ confidence interval of the p^{th} quantile of a distribution is called a *p*, α *tolerance interval* (Hahn & Meeker 1991,Vardeman 1992). Given the definition of a confidence interval, a computed tolerance interval bound is expected to cover the true quantile of the population distribution $1-\alpha$ proportion of the time.

The choice of *p* to use for the tolerance intervals depends on the desired sensitivity of the comparison with background levels. If one wants to flag only the very worst measurements, the *p=0.95* or *p=0.99* could be used (for parameters problematic at high values). The resulting quantiles will be toward the extreme edge of the reference distribution. On the other hand, if one wants to be more cautious and flag more values that might potentially be a problem, then lower values of *p* could be used. The value chosen for the tolerance interval α can also affect the sensitivity of the comparison with reference. However, it is more convenient to keep α constant at *0.05* and vary *p* to obtain the desired level of sensitivity.

The choice of computational method for tolerance intervals depends on the sampling design and whether parametric assumptions can be met. The most common type of tolerance interval assumes that the data observations are independent and are normally distributed. Here, an upper *p,* α tolerance interval bound (b_U) is computed as

$$b_U = \bar{x} + k_{p,\alpha} s \,, \qquad (1.1)$$

and a lower bound (b_L) is computed as

$$b_L = \bar{x} - k_{p,\alpha,n} s \,. \qquad (1.2)$$

The $\bar{x}$ is the estimated parameter mean, s is the estimated standard deviation, and $k_{p,\alpha,n}$ is a factor that depends on the chosen p, α, and sample size n. The $k_{p,\alpha,n}$ values can be obtained from tables in Hahn & Meeker (1991) and Gilbert (1987), or can be directly computed as follows (Portugal 1992).

The upper bound b_U will be used when the parameter of interest is problematic at higher values, e.g., metals or bacterial concentrations. On the other hand, b_L would be used for parameters potentially harmful at lower concentrations, for example, pH and dissolved oxygen. In practice, if the concentration of a parameter harmful at high levels exceeds the computed b_U for that parameter, then the parameter would be flagged as being high compared with the background levels in the County. Similarly, parameters harmful at lower levels will be flagged when measurements are below b_L .

If the data do not appear to originate from a normal distribution (and cannot be transformed to normality), non-parametric tolerance intervals can be computed (Woodward & Frawley 1980,Hahn & Meeker 1991). The non-parametric methods still assume that the observations are independent.

The assumption of independence will only hold when computing tolerance intervals from a single survey. When more than one survey within a year is used, the replicate values at a location will tend to be correlated, and when more than one year is used, the data from the same location will be correlated over time, and the data within each year will tend to be correlated.

The lack of independence among the observations will provide tolerance interval bounds that cover the true quantile of the reference distribution at a lower rate than that specified by the chosen nominal α value. At this point, there are two options, which are:

1. Compute tolerance interval bounds only for single surveys, where the data are independent. These bounds would be compared to the parameter values from the same survey only.

2. Use all the data and choose a suitable method of computation. Since the same 30 locations are revisited each year, the statistical model will correspond to a crossed year by location ANOVA model. If there is a year-to-year trend in the data, then years can be considered a covariate and the mixed ANOVA method proposed by Vangel (1994) can be used. If there is no year-to-year trend in the data, the random crossed model developed by Smith (2001) can be used. An advantage of the Smith (2001) method is that the computed bounds can be applied to surveys and years where no random data are available.

The second option has the advantage of being based on more data, which in turn may provide better estimates of tolerance interval bounds. However, the simplicity of the first option is attractive. Another advantage of the first option is the availability of nonparametric methods for this situation. The methods in the second option are parametric, assuming the data within the years are from a normal distribution. Nonparametric analogues for these statistical model have not been developed at this time. At the very least, the first option will be used for the first survey in the first year. This will allow for immediate identification of outlier locations.

If after multiple years of monitoring, it becomes evident that the parameter levels at the randomly chosen locations are not trending over time, then sampling of the random locations can be discontinued or performed less frequently. In this case, the Smith (2001) method can be used to compute tolerance interval bounds that can be applied to years and surveys where no random samples are taken.

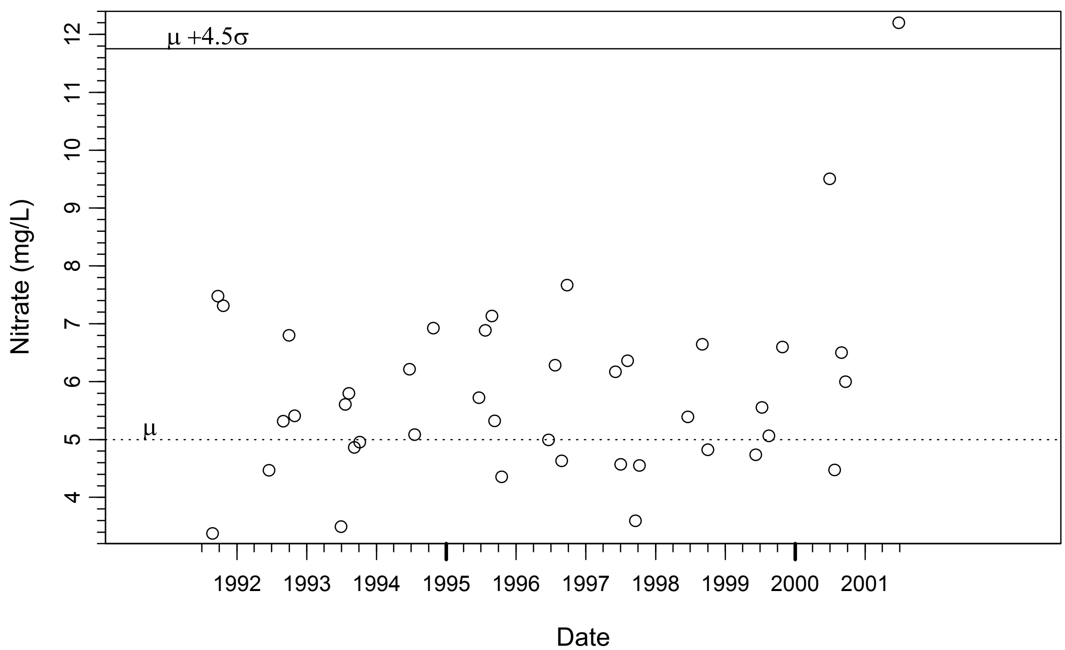
A.2 Control Charts – Detecting Parameter Changes Over Time at a Location

Measurements will also be obtained at the targeted sites, which are fixed locations of interest because of their elevated potential for contamination. It will be useful to observe the parameter values over time at both these targeted sites and the random sites and detect when significant changes from previously observed parameter levels have taken place. Such information will be useful for detecting the presence of new or slowly increasing inputs. For this purpose, Shewart and CUSUM control charts will be used to monitor each location over time.

A.2.1 Shewart control charts

A Shewart control chart (Shewart 1931,Gibbons 1994) is simply a plot of time (x-axis) vs. the concentration of a parameter of interest (y-axis). On the plot, a horizontal line is drawn at the control limit set at $\mu + Z\sigma$, where μ is the mean and σ is the standard deviation of the parameter. Z is a quantile from the standard normal distribution, used to control the sensitivity of the chart to outlier values and to control the rate of false positive indications of outlier status. Values above the horizontal line will be flagged as unusually high values deserving of further attention. Figure 1 shows an example of a Shewart control chart with *Z=4.5*, which means that data values more than 4.5 standard deviations above the mean will be flagged. If we are concerned with low values of a parameter, the control limit of the control chart can be set at $\mu - Z\sigma$ and measurements below this limit will be flagged.

Figure 1. Example of a Shewart control chart.



Points occurring above the solid horizontal line (the control limit) are considered outliers of concern. The point on the last date would be flagged as an outlier. In this example, the mean (μ) is *5.0* and the standard deviation (σ) is *1.5*.

The μ and σ values are usually estimated from historical data. The locations in the present monitoring design lack such historical data. Thus, the data from the first year will be used to compute initial estimates of μ and σ, and control charts will not be used until the second year of monitoring. Subsequent observations will be compared with the control limit and then be used to re-estimate the means and standard deviations and update the control limit for future observations.

The more measurements compared with the control limit, the higher the probability that some data values might occur outside the control limit by chance alone (false positives). To adjust for the multiple tests, a higher value of Z is used. However, if too high a Z value is used, the rate of finding the true outliers (false negatives) becomes too low. To provide balanced rates of false positives and false negatives, confirmation samples will be obtained and analyzed when a value is found outside the control limit. If the confirmation sample measurement is also outside the control limit, then the value is considered outside the control limit (Gibbons 1994). The confirmation samples should be obtained on a sampling date after the date of the original sample.

Simulations were performed to estimate appropriate Z values for the Shewart charts with the proposed design.

Table 1. Recommended Z values for dry weather monitoring.

Time Period	# Tests/Facility	False Positive Rate	Z
After first year	4800	0.05	3.9
		0.01	5.0

Table 1 provides Z values to use for the control charts. Z values for two false positive rates are given. Using the higher false positive rate (0.05) will make for more sensitive tests, but require more confirmation samples. If time or monetary resources for large numbers of confirmation samples are limited, the lower false positive rate (0.01) should be used.

The total numbers of tests were computed as follows. A monitoring program of five years is assumed. There will be no tests the first year as data are gathered to estimate μ and σ. Thirty random locations will be sampled three times a year and thirty targeted locations will be sampled five times per year, and 17 parameters will be measured. Some of the measured parameters will correlated, so 5 sets of intercorrelated variables are assumed. These five sets are treated as five independent variables since the computations assume that the parameters are independent. Given these numbers, there will be (4 years of tests) x [(5 observations/year for targeted locations) x (30 targeted locations) + (3 observations/year for random locations)] x (30 random locations)] x (5 parameter sets) = 4800 separate tests.

CUSUM control charts

CUSUM control charts are charts with time on the x-axis and standardized parameter measurements on the y-axis. An index summarizing cumulative inputs above a chosen level is superimposed in the chart. CUSUM control charts are sensitive to smaller, gradual changes in parameter values at a single location (Gibbons 1994). At a location, for each sampling period, the cumulative sum S_i is computed as

$$S_i = \max(0, z_i - k + S_{i-1}), \qquad (1.3)$$

where i is the index of the current time period, k is a factor selected to be approximately one half the size of a difference worth detecting, and

$$z_i = \frac{x_i - \mu}{\sigma}. \qquad (1.4)$$

In (1.4), x_i is the parameter measurement at time i, μ is the presumed mean and σ is the presumed standard deviation of the population of parameter values over time at the location. The μ and σ will need to be estimated from the first year's data and the estimates updated as more values become available. Formula (1.3) pertains to parameters that are harmful as values increase. When harm is associated with decreasing values, instead use

$$S_i = \min(0, k - z_i - S_{i-1}) .$$

When S_i reaches a preset value h, the parameter is considered outside the CUSUM control limit, and flagged as a parameter that has changing over time. When using the CUSUM control charts, the recommended values are h=5 and k=1 (Gibbons 1994).

F**igure 2** shows an example of a CUSUM control chart.

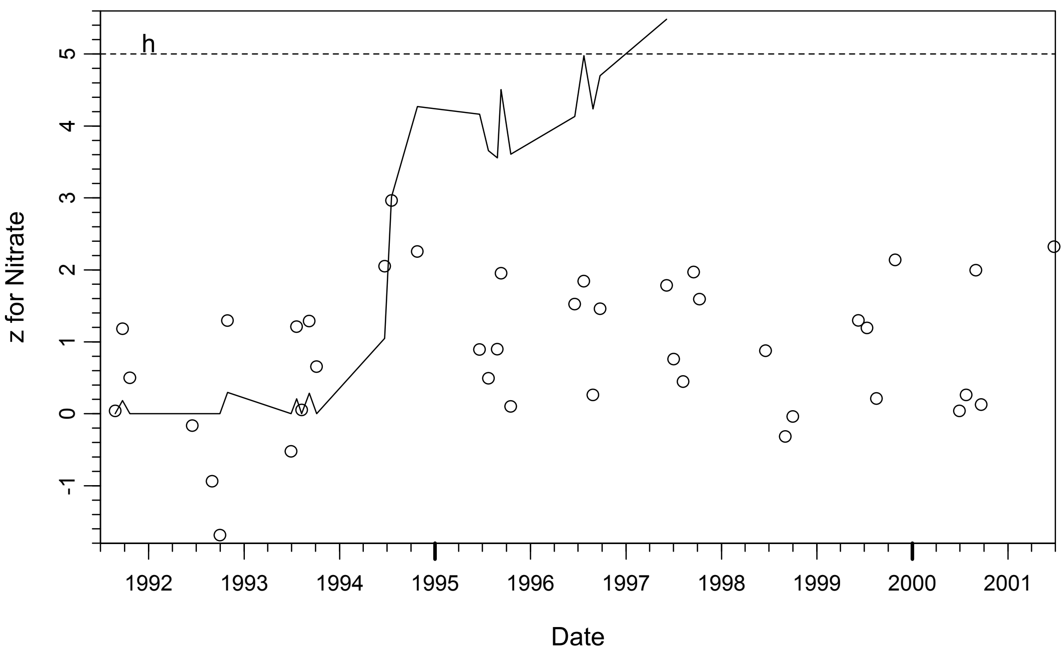


Figure 2. Example of a CUSUM control chart. The solid line is S_i in (1.3). The example is based on a simulation where k=1 and the mean value of Nitrate increased by *1.08* standard deviations in 1994.

Using both Shewart and CUSUM control charts allows for more comprehensive monitoring where sudden changes are detected with the Shewart chart and cumulative smaller changes are detected with the CUSUM chart. Both control charts could be expressed in a single plot, but would require that the y axis of both charts be converted to either the z_i or the original measurement scale.

Control chart issues

Both methods assume the data are normally distributed. If the raw data measurements do not appear to be normally distributed, then the data should be transformed to approximate normality if possible. Most often, this can be accomplished with a log or square root transform with the present type of data. The method of Box and Cox (1964) is helpful in finding a suitable transformation.

Since historical data are not available at the sampling locations, the required means and standard deviations need to be estimated as data become available from the monitoring program. Outlier data points should not be included in the mean and standard deviation estimates, since the outliers can inflate the standard deviation and decrease sensitivity for detecting future outliers. The parameter values outside the Shewart control limit are obviously outliers, but outlier detection methods could also be used, e.g., Dixon (1953), Davies and Gather (1993).

The methods also assume there is no trend over time in the parameter data used to estimate the mean and standard deviation. When a linear trend is found, the data can be detrended first as (Gibbons 1994)

$$x_i^* = x_i - \beta t \, , \qquad (1.5)$$

where x_i^* is the detrended value, x_i is the original parameter value, t is the year index (starting with 1,2, ..) and β is the slope from a linear regression of x_i vs. year index. The mean and standard deviations are computed from x^*, but the original x values are compared with the resulting control limits.

The estimates of mean and standard deviation also assume that the data measurements are independent with a fixed underlying mean and variance. This assumption will not strictly be met where the underlying parameter mean varies from year to year. The effect of this violation of assumptions will cause the variance to be underestimated, which in turn leads to more conservative control limits (in the direction of greater environmental protection).

Intercorrelated subsets of the measured parameters will tend to occur outside the control limits at the same time. When this happens, it may not be necessary to make confirmatory measurements for all the measured parameters in the subset. If it is confirmed that the one of the parameters is outside the control limit, it would reasonable to assume that the other parameters in the subset are also outside the control limit. This approach could reduce the number of confirmatory reanalyses required.

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