# Stormwater Runoff Water Quality Science/Engineering Newsletter
# Devoted to Urban/Rural Stormwater Runoff
# Water Quality Management Issues

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Volume 6 Number 1
January 6, 2003

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This issue of the Newsletter is devoted to two issues; US EPA recent announcement of **updated water quality criteria** and a discussion of the overall approach for developing a **nonpoint source water quality monitoring program.**

**Updated US EPA Water Quality Criteria**

According to the January 2, 2003, US EPA *Water Quality Standards News*, "*The US EPA published, in the federal register at 67 FR 79091, a revision of fifteen of its national recommended water quality criteria for protecting human health. This revision is a partial update based on EPA's new methodology for deriving human health criteria. The fifteen criteria included in this notice are: chlorobenzene, cyanide; 1,2-dichlorobenzene; 1,4-dichlorobenzene; 1,1-dichloroethylene;1,3-dichloropropene; endrin; ethylbenzene; hexachlorocyclopentadiene; lindane; thallium; toluene; 1,2-transdichloroethylene;1,2,4-trichlorobenzene;and vinyl chloride*." The Agency has posted the recommended updated water quality criteria at,

http://www.epa.gov/fedrgstr/EPA-WATER/2002/December/Day-27/w32770.htm

"*The US EPA will accept scientific views on the fifteen criteria published in this notice until February 25, 2003.*"

The federal register notice also announced the availability of an updated national recommended water quality criteria compilation (EPA Document # EPA-822-R-02-047) which is now posted on EPA's website, http://www.epa.gov/waterscience/pc/revcom.pdf. "*This compilation is presented as a summary table containing EPA's water quality criteria for approximately 150 pollutants. The recommended water quality criteria contained in this document provide guidance for states and tribes authorized to establish water quality standards under the CWA to protect human health and aquatic life. Under the CWA, states and authorized tribes are to establish water quality standards to protect designated uses. Such standards are used in implementing a number of environmental programs, including setting discharge limits in National Pollutant Discharge Elimination System (NPDES) permits. The national recommended water quality criteria presented in the table include: previously published criteria that are unchanged, criteria that have been recalculated from earlier criteria (63 FR68354, 12/10/1998) and newly calculated criteria based on peer-reviewed assessments and data. The updated compilation partially revised 83 national recommended water quality criteria for protecting human health. The fifteen criteria that EPA published in the December 27 federal register notice are not part of the November 2002 updated criteria compilation.*"

The US EPA criteria are important to developing technically valid, cost-effective stormwater runoff water quality management programs, since they serve as the basis of state standards which become the regulatory limits for nonpoint source discharges/runoff. Exceedance of these standards leads to a 303(d) listing and a TMDL to control the exceedance of the standard. As

discussed in previous Stormwater Newsletters (volumes 1-1, 2-2, and 3-4, available from www.gfredlee.com), the US EPA criteria and state standards based on these criteria, when mechanically applied to nonpoint source runoff/discharges such as from agricultural runoff and "point source" discharges such as urban stormwater runoff, tend to over-regulate the control of constituents for which there are criteria/standards. The US EPA criteria are based on worst case or near worst case assumed situations of the most toxic/available forms of the potential pollutant and extended exposure. Many of the potential pollutants in agricultural and urban stormwater runoff are in nontoxic/non-available forms. Therefore, the regulated community should evaluate whether the exceedance of a US EPA criterion and state standard based on this criterion is an "administrative" exceedance or represents a real significant impairment of the water quality of the waterbody for which control programs must be implemented to protect the designated beneficial uses of a waterbody into which the discharge/runoff occurs.

The key to technically valid, cost-effective water quality management programs is a reliable water quality monitoring program. During the past year, Drs. G. Fred Lee and Anne Jones-Lee have been developing guidance to NPS water quality monitoring programs for the California Central Valley Regional Water Quality Control Board. This effort was conducted under a contract between the CA State Water Resources Control Board and the California Water Institute (CWI) located at CA State University, Fresno. Drs. G. F. Lee and A. Jones-Lee developed this NPS monitoring guidance as employees of the CWI. In December 2002 they completed a report, (Lee, G. F., and Jones-Lee, A "Issues in Developing a Nonpoint Source Water Quality Monitoring Program for Evaluation of the Water Quality - Beneficial Use Impacts of Stormwater Runoff and Discharges from Irrigated Agriculture in the Central Valley, CA," CWI report TP 02-07). This is about a 100-page report that provides information on the approach that should be used to establish a technically valid water quality monitoring program for CA Central Valley agriculture stormwater runoff/tailwater and subsurface drain water discharges. While the focus of the report is guidance for developing water quality monitoring programs for NPS – irrigated agriculture runoff/discharges, most of the report provides guidance to water quality monitoring programs as part of technically valid, cost-effective NPS water quality management programs. The Executive Summary for this report is presented below. The complete report is available from www.gfredlee.com or from gfredlee@aol.com. Questions or comments on this NPS water quality monitoring guidance are welcome.

Drs . G. F. Lee and A. Jones-Lee have also recently developed CWI reports on:

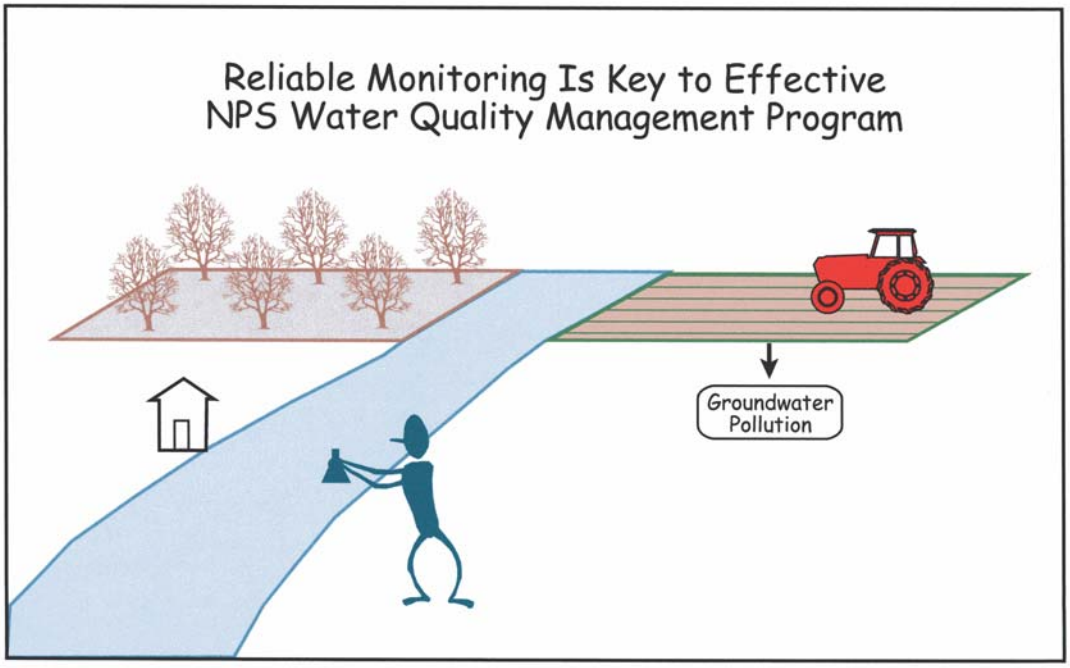
- developing BMPs for CA Central Valley agriculture stormwater runoff/discharges,
- controlling excessive bioaccumulation of organochlorine legacy pesticides (such as DDT, chlordane, dieldrin, and toxaphene), PCBs, and dioxins/furans in CA Central Valley aquatic life/fish that are a threat to those who use fish and other aquatic life as food, and
- developing a TMDL to control aquatic life toxicity caused by the OP pesticides, diazinon and chlorpyrifos, in city of Stockton, CA, stormwater runoff.

Future issues of this Newsletter will present information on these topics.

CALIFORNIA WATER INSTITUTE

**Executive Summary from Report TP 02-07**

# Issues in Developing a Nonpoint Source Water Quality Monitoring Program for Evaluation of the Water Quality - Beneficial Use Impacts of Stormwater Runoff and Discharges from Irrigated Agriculture in the Central Valley, CA

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Sacramento, California
December 2002

## Executive Summary

As part of the Central Valley Regional Water Quality Control Board's (CVRWQCB's) implementation of the State Water Resources Control Board's (SWRCB, 2000, 2001a) Plan for California's Nonpoint Source Pollution Control Program (NPS Program Plan), there is need to develop a nonpoint source water quality monitoring program for the Central Valley of California. Presented herein is guidance on the development of this monitoring program. Particular attention is given to assessing the potential impacts of irrigated agricultural stormwater runoff and irrigation tailwater and subsurface drain water discharges, as they may impact the beneficial uses of Central Valley waterbodies.

In addition to monitoring for the purpose of assessing the impacts of constituents in irrigated agricultural stormwater runoff and tailwater/subsurface drain water discharges on receiving water quality, consideration is given to monitoring the discharges of managed wetlands in the Central Valley. There are substantial acreages of wetlands devoted to federal and state refuges, as well as private duck clubs, that, at times, discharge waters from the areas to the State's waters. These waters can have a significant concentration of potential pollutants that can cause violations of water quality objectives and/or impairment of the beneficial uses of the State's waters.

Further, in connection with the potential renewal of waivers from waste discharge requirements (WDRs) for discharges from irrigated agricultural lands in the Central Valley, there is need to develop a water quality monitoring program to determine whether constituents in irrigated agricultural stormwater runoff, tailwater and subsurface drain water cause violations of water quality objectives and/or impair the beneficial uses of the State's waters. The Central Valley Regional Water Quality Control Board staff has been working with the agricultural community to develop a Phase I water quality monitoring program that will provide information that can be used by the CVRWQCB to determine if WDR waivers for irrigated agriculture in the Central Valley should be renewed. This Phase I monitoring program is recognized to be an initial monitoring program that will need to be expanded to determine if constituents in irrigated agricultural stormwater runoff, tailwater and subsurface drain water impair the beneficial uses of the State's waters.

**Scope of Agricultural Waiver Monitoring Program.** CVRWQCB Resolution No. 5-01-236, "Control of Discharges from Irrigated Lands," adopted on September 7, 2001, defines that the agricultural waiver monitoring program is to cover the *basin*, *drain* and *field* level runoff/discharge monitoring. A preliminary draft Phase I agricultural waiver monitoring program (see Appendix A) focuses on the *drain* level, where the CVRWQCB staff have developed a "strawman" monitoring program that included 56 sites to be monitored about monthly for toxicity, sediment and constituents on the 303(d) list, including organophosphate pesticides (diazinon/chlorpyrifos), selenium, salt, boron, nutrients, dissolved oxygen, biochemical oxygen demand and temperature. The agricultural community has proposed a revised Phase I agricultural waiver monitoring program that includes 29 sites. At this time (early December 2002) the Phase I monitoring program is still under development.

This report presents guidance on issues that need to be considered in developing a comprehensive agricultural waiver water quality monitoring program to evaluate the water quality impacts of irrigated agricultural stormwater runoff and tailwater/drain water discharges, which includes the components that need to be covered to achieve the requirements of CVRWQCB Resolution No. 5-01-236.

The comprehensive agricultural waiver monitoring program and the nonpoint source water quality monitoring program for agriculturally derived constituents have the same overall objective, with the result that the water quality monitoring program guidance presented herein has applicability to both programs.

The first step in developing a comprehensive nonpoint source water quality monitoring program is to clearly define the objectives of the program. Once the objectives of the monitoring program have been defined, there is need to determine the desired reliability of defining the water quality impacts of irrigated agricultural stormwater runoff and discharges. With information on the variability of irrigated agricultural runoff/discharges from various types of irrigated agricultural settings, it is possible to begin to develop a water quality monitoring program that will achieve the objectives of the program.

**Waterbodies of Concern.** In the early 1990s, the CVRWQCB (1992) (see Appendix C) developed a list of Central Valley waterbodies that are considered to be dominated by irrigated agricultural runoff/discharges. The 1992 CVRWQCB-listed waterbodies were categorized into:

- Natural waterbodies dominated by agricultural drainage water
- Natural waterbodies dominated by agricultural supply water
- Constructed facilities designed to carry agricultural flows or drainage
- Constructed facilities designed to carry irrigation water and may, at times, carry recycled return flows
- Natural dry washes that have been altered and now carry agricultural supply water or return flows during time periods

The CVRWQCB September 7, 2001, Resolution defines that the waterbodies of primary concern are those dominated by agricultural drainage and constructed waterbodies used for conveying or holding agricultural drainage.

**Monitoring Site Selection.** A list of initial NPS water quality monitoring sites has been developed based on the information available from monitoring programs that have been conducted in the Sacramento and San Joaquin River watersheds. The selection of a specific site for monitoring of a waterbody should be based on an understanding of the plumbing and hydrology of the waterbody's watershed upstream of where the monitoring is proposed. As information is gained on the role of agriculturally derived discharges/runoff of potential pollutants to these waterbodies, additional waterbodies will be added to the list of recommended waterbodies for NPS water quality monitoring. As the NPS water quality monitoring program

develops, particular reference needs to be given to what, if anything, is representative of the watershed upstream of the monitoring point that would cause this waterbody either to be different from other waterbodies or to be representative of a group of waterbodies with similar irrigated agricultural and other land use activities in the watershed.

A similar approach needs to be followed for all of the agricultural drains and agriculturally dominated waterbodies in the CVRWQCB (1992) report. Each watershed upstream of the sampling point should be characterized based on the agricultural activities conducted within the watershed – i.e., crops produced, chemicals used and other factors that could influence the concentrations of constituents in the stormwater runoff or agricultural irrigation water discharges. The constructed agricultural drains and agriculturally dominated waterbodies should be prioritized with respect to their potential representativeness and importance in impacting the beneficial uses of the waters of the State. This prioritization would be used to determine which waterbodies are monitored based on the funding available.

**Organizing a Water Quality Monitoring Program.** The development of a comprehensive nonpoint source water quality monitoring program involves consideration of each of the following:

- Clearly establish the objectives of the monitoring program.
- Understand the nature of "water quality," water quality concerns, beneficial uses, and their assessment for the waterbodies of concern.
- Select the parameters to be measured and justify potential significance of each parameter selected.
- Examine previous studies to understand variability in each area of the waterbody to be monitored.
- List factors that can influence results of the monitoring program and how they may influence the results.
- Determine the level of confidence at which the objective is to be achieved.
- For each area of each waterbody to be monitored, determine the number and location of samples to be collected.
- If no data are available from previous studies or if existing data are inadequate to define variability and other characteristics needed to establish a reliable monitoring program, conduct a pilot study of representative areas to define the characteristics of the area that are needed to develop a reliable water quality monitoring program.
- If the purpose of the monitoring program is to determine changes in water quality characteristics, select the magnitude of change that is to be detected and design the monitoring program accordingly.
- Select sampling techniques and methods of analysis to meet the objectives and level of confidence desired.
- Verify that analytical methods are appropriate for each area of the waterbody and at various seasons.
- Conduct studies to evaluate precision of sampling and analytical procedures and technique, reliability of preservation, and variability of the system.

- Critically examine the relationship between present and past studies.
- Determine how the data will be analyzed, with respect to compliance with Basin Plan objectives, using existing data or synthetic data that is expected to be representative of the site.
- Screen/evaluate data as they are collected.
- Analyze, interpret and store data, and report on the results of the analysis and interpretation.

Information on each of these areas is presented in this report.

One of the most important steps in developing a credible monitoring program to assess the impact of constituents derived from a particular source on the beneficial uses of receiving waters is an explicit statement of the objectives of the monitoring program. The agricultural waiver policy and the CVRWQCB and staff have identified a number of objectives that need to be met in developing a water quality monitoring program to evaluate the impact of constituents in irrigated agricultural stormwater runoff, tailwater and subsurface drain water on receiving water beneficial uses. These include violations of Basin Plan water quality objectives (WQOs), which also include California Toxics Rule criteria and the CA Department of Health Services drinking water Maximum Contaminant Levels (MCLs).

Of particular concern, relative to the waiver conditions adopted in 1982, was whether the amount of sediment derived from irrigation return water caused Basin Plan turbidity objectives to be exceeded. Further of concern was whether the discharge contained constituents in sufficient concentrations to be toxic to fish and wildlife. It is anticipated that future reviews of agricultural drainage will contemplate a far wider range of constituents and impacts. In terms of the current understanding of agriculturally derived constituents that are potential threats to the State's waters' beneficial uses, there continues to be concern about agricultural runoff/discharges containing constituents, such as pesticides, which are toxic to humans and/or aquatic and terrestrial life, through excessive bioaccumulation. The legacy pesticides, such as DDT, chlordane, dieldrin and toxaphene, were extensively used in Central Valley agriculture and have been found in agricultural runoff/discharge waters and in edible aquatic life at concentrations which are a threat to human health and/or higher-trophic-level aquatic and terrestrial life through consumption of the aquatic organisms.

In order to reliably monitor stormwater runoff-associated constituents and their potential impacts, it is necessary to base the monitoring program on when the constituents of potential concern are applied to the agricultural areas and during stormwater runoff events or other times when there would be expected transport of the constituent of concern from the areas where it was applied. This event-based, episodic monitoring requires a significantly different approach and resources than the traditional monitoring, involving periodic (i.e., monthly) sampling at a fixed location, such as that proposed by the CVRWQCB staff in their draft Phase I Water Quality Monitoring Program for Discharges from Irrigated Lands (Appendix A).

The appropriate approach to take in developing a reliable monitoring program for runoff/discharges from irrigated lands is to first define the constituents that are potentially present in the runoff/discharges that could occur at sufficient concentrations to impair the beneficial uses of the receiving waters for the runoff. Next it is necessary to gain an understanding of when, where and how various chemicals, or sources of potential pollutants, use/apply/release the constituents of concern. Further, there is need to understand, for each constituent defined as a potential pollutant, how that constituent potentially impacts the beneficial uses of a downstream waterbody. With this information, it will be possible to develop a reliable water quality monitoring program to assess whether irrigated agricultural runoff/ discharges adversely impact the beneficial uses of the State's waters. Without this critical review and implementation of this approach, the water quality monitoring program can be of limited value in reliably achieving the objectives of the nonpoint source water quality monitoring program, as well as the agricultural waiver monitoring program, since it has not been properly designed to meet the objectives of these programs.

Another significant problem with the spring 2002 proposed CVRWQCB irrigated agriculture Phase I water quality monitoring program is that many of the monitoring stations represent agriculturally dominated waterbody discharge points near where the constructed or natural drain/creek discharges to the State's mainstem rivers. This sampling does not provide the upstream information on specific sources or practices that can cause excessive concentrations of the constituents at the monitoring point. It is inappropriate to assume that there are no upstream water quality problems caused by irrigated agricultural runoff/discharges just because monitoring at the drain discharge point did not detect a problem. Since upstream tributaries can be important fish and other aquatic life reproduction/development areas, and since chemicals used in one part of a watershed can cause localized water quality impacts, it is important to evaluate whether waters from other tributaries which may not have the chemical at critical concentrations or at any concentration are diluting the concentrations at the downstream monitoring point sufficiently so that the interpretation of the data at that location leads to an erroneous conclusion that there are no upstream water quality problems due to the use of that chemical in a part of the watershed.

**Accounting for Variability.** Since the measurements of irrigated agricultural runoff/discharge-derived constituent concentrations at any particular time and location have a certain amount of variability associated with them, a monitoring program should evaluate the magnitude of the variability about any particular measurement, as well as for measurements made of different systems or at different times. This then introduces the need to evaluate the variability for each system monitored, and then establish, as part of the monitoring program goals, the amount and type of monitoring that is needed to achieve a certain prescribed degree of reliability of the measured concentrations of potential pollutants and associated water quality impacts associated with a particular discharge/runoff. Addressing these issues should involve appropriate statistical techniques, where, *a priori*, a degree of reliability in detecting concentrations and water quality impacts is established.

Because of the year-to-year variability in rainfall runoff and agricultural practices, the initial phase of the NPS monitoring program should be conducted for three to five years. Normally this period of time is needed to begin to establish the range of conditions that are encountered in NPS runoff.

**Review of Existing Data.** Before finalizing a monitoring program, a systematic effort should be made to collect and carefully review all existing data pertaining to the area of the study. The data collected in previous studies, even though inadequate to achieve the objectives of the present study, can still be of significant value to present and future studies in helping to guide the development of future monitoring programs.

**List Factors that Can Influence Results of the Study.** Water quality characteristics in particular waterbody types tend to behave according to certain fairly well-defined principles of physics, chemistry and biology. While the details of many of the processes that control the concentrations in runoff/discharge waters may not be fully understood, there is considerable knowledge about them and how they influence the manifestation of "water quality," which should be used to develop a more efficient monitoring program. Understanding these processes should allow a better assessment to be made of the significance of changes in concentration and distribution of contaminants between sampling dates, and whether changes in concentrations measured are related to a natural driving force or result from man's activities and hence are potentially controllable. For each sampling point, an estimate should be made of the expected range of concentrations of the parameters being measured and, most importantly, the factors influencing these concentrations. This information should be used to guide the development of the monitoring program, to be certain that it covers the conditions that are likely to be encountered in the monitoring program.

**Parameters of Concern.** This report presents a discussion of the water quality parameters of potential concern in irrigated agricultural stormwater runoff and tailwater discharges. Reasons for the water quality concern and regulatory limits are discussed. The parameters include pH, color, taste and odors, total suspended solids, turbidity, nitrate, nitrite, ammonia, total Kjeldahl nitrogen, biostimulatory substances, phosphorus, boron, total and fecal coliforms, *E. coli*, dissolved oxygen, biochemical oxygen demand, temperature, organophosphate pesticides, organochlorine pesticides, herbicides, other potentially toxic chemicals, unknown-caused toxicity, sediment toxicity, PCBs, dioxins, furans, total organic carbon, dissolved organic carbon, heavy metals (Cu, Zn, Pb, Cd, Ni, Cr), mercury and selenium.

In addition to evaluating the impact of irrigated agricultural stormwater runoff and tailwater releases on surface water quality, there is also need to evaluate the impact on groundwater quality. This is especially true in light of the fact that there is a potential of causing even greater groundwater quality problems than are occurring now, as a result of trying to minimize surface water quality problems associated with irrigated agriculture's ponding of waters to minimize discharges to surface waters.

In addition to considering the chemicals that are added to/used on irrigated agricultural lands (such as pesticides, fertilizers, soil amendments, etc.), there is also need to consider the chemicals that are released from these lands that are generated on these lands. The monitoring program should include measurements of transformation products of added chemicals, such as nitrate that is formed from the nitrification of ammonia that is added as a fertilizer to the agricultural lands. Total organic carbon (TOC), dissolved organic carbon (DOC), total dissolved solids/electrical conductivity (TDS/EC), total suspended solids (TSS), nitrogen and phosphorus compounds and turbidity should be monitored as part of assessing the potential for constituents generated on or from irrigated agricultural lands to be present at concentrations that could impair the beneficial uses of the receiving waters for runoff/discharges from these lands. Boron, selenium, and other constituents which are present in the soils of the area and are mobilized by agricultural practices so that they occur at potentially significant concentrations in runoff/ discharge waters should be included in the monitoring program. The US EPA standard three-species aquatic life toxicity tests should be conducted to determine if toxicity is present in the runoff/discharge waters from agricultural lands.

There is considerable interest in assessing whether the aquatic organism assemblages in a waterbody potentially impacted by agricultural runoff/discharges are altered by constituents in these discharges. Reliably assessing the impacts of agricultural runoff/discharges on aquatic organism assemblages within the Central Valley is difficult because of a lack of suitable reference sites, where the numbers and types of organisms present at these sites can be compared to those with similar habitat characteristics that are potentially influenced by agricultural runoff/discharges. Considerable work needs to be done learning how to collect and utilize benthic organism assemblage information in Central Valley waterbodies, in order to be able to reliably interpret whether the cause of an apparently altered organism assemblage is due to agricultural discharges or other factors. A component of this situation is whether the sediments in a waterbody are toxic to benthic and epibenthic organisms because of agricultural discharges of constituents that cause sediments to become toxic. While pesticides that tend to strongly sorb on sediments (such as the pyrethroids) are of concern because of their potential to cause sediment toxicity, agricultural discharges of nutrients which develop into algae that die, settle and become part of the sediments can be an important source of sediment toxicity due to the release of ammonia from the decay of organic nitrogen in the algal cells.

Since a number of the parameters of particular concern (such as TSS, TOC and nutrients) in irrigated agricultural discharges/runoff do not have water quality objectives that establish specific numeric limits, there is need for the CVRWQCB to establish an approach for interpretation of the data with respect to exceeding narrative water quality objectives, in order to be able to interpret the results of the NPS water quality monitoring program with respect to assessing impairment of the receiving waters for irrigated agricultural discharges/runoff. This could result in the need for a significantly different monitoring program than the minimum initial NPS monitoring program recommended herein, in order to develop the information needed to interpret narrative water quality objectives with respect to impairment of beneficial uses of the waters.

For example, with respect to nutrients, the current CVRWQCB Basin Plan does not have specific numeric concentrations of nitrogen and phosphorus that are considered excessive with respect to impairing the beneficial uses of a waterbody due to excessive growths of algae and/or other aquatic plants. The Basin Plan has a narrative objective for "biostimulatory substances," which requires a subjective assessment of excessive growths of aquatic plants and/or their impacts on the beneficial uses of a waterbody. Monitoring for nitrogen and phosphorus compounds' concentrations in agricultural drains or agriculturally dominated waterbodies cannot be translated to an impairment of beneficial uses without site-specific studies of the receiving waters' beneficial uses. That approach requires a significantly different type of monitoring program than periodic measurements at a particular location in a waterbody. Similar problems occur with respect to TOC, TSS and other constituents which are often present in irrigated agricultural runoff/discharges.

The recommended initial NPS monitoring program includes sampling near the primary and secondary tributary mouths' discharge points to the Sacramento and San Joaquin Rivers. The specific location for the initial monitoring is to be selected after a critical review of the factors that can influence monitoring results that are discussed herein. All of the constituents that could be derived from agricultural land, such as those listed above, should be monitored. In addition, all chemicals that are added to agricultural lands and the potential transformation products should be included in the monitoring program. The minimum recommended monitoring program involves monthly sampling of a list of waterbodies that, based on previous studies, have been found or are suspected to be impacted by irrigated agricultural runoff/ discharges. In addition, event-based monitoring is recommended to coincide with or immediately follow situations that could lead to runoff/discharges of potential pollutants from agricultural lands. This monitoring would include monitoring of stormwater runoff events, as well as releases/discharges from agricultural lands that follow the application of chemicals to the areas of concern. Since the loads of potential pollutants are of concern, the monitoring stations should be located where gaging of the stream/tributary flow can occur.

**Evaluation of the Significance of a Water Quality Objective Violation.** A key component of developing a technically valid, cost-effective water quality management program is an evaluation of the water quality significance of exceedance of a water quality criterion/standard/objective. In accord with the requirements of the Clean Water Act, the US EPA water quality criteria were designed to be protective of aquatic life and other beneficial uses in all waterbodies. It has been understood since the early 1970s by those familiar with how chemical constituents impact aquatic life that criteria designed to be protective of aquatic life and other beneficial uses in all waterbodies – i.e., worst-case-based water quality criteria and standards based on these criteria – would, in many waterbodies, for certain constituents (especially heavy metals, certain organics, etc.), be overprotective. As discussed herein, this issue was addressed by the National Academies of Science and Engineering (NAS/NAE, 1973) in their development of the 1972 Blue Book of Water Quality Criteria. This overprotection could lead to greater expenditures for chemical constituent control from its sources than is necessary to protect the aquatic life or other designated beneficial uses of a waterbody. Guidance is provided herein on evaluating the water

quality significance of exceeding a numeric water quality objective and/or a narrative toxicity limit.

**Evaluation of Runoff BMP Efficacy.** This report provides guidance on some of the issues that need to be considered in developing a water quality monitoring program associated with agricultural runoff best management practice (BMP) evaluation. The importance of obtaining pre-BMP implementation data and conducting an adequate monitoring program to overcome the inherent variability of agricultural stormwater runoff chemical constituent concentrations is discussed.

**Cost.** Unit cost information for sample analysis and collection is provided. Because of limitations on the funding available for NPS monitoring, there will likely be need to prioritize the monitoring locations, parameters monitored, etc. This prioritization should be done by the stakeholders (agricultural dischargers, regulatory agencies, environmental groups and members of the public) to maximize the amount of useful information obtained for the funds expended.