APPENDIX A
MONITORING APPROACHES

The purpose of this appendix is to put water quality constituent monitoring in context with other monitoring approaches, such as sediment chemistry monitoring, toxicity testing, use of biological indicators (for use in receiving water impact assessments), visual monitoring, and watershed monitoring. These other methods can be used to supplement water quality constituent monitoring, and many monitoring programs include a variety of approaches. The following discussion outlines the advantages, disadvantages, and applicability of these various approaches for monitoring of stormwater runoff from transportation-related facilities.

➤ WATER QUALITY CONSTITUENT MONITORING

Water quality constituent monitoring generally focuses on measurement of chemical parameters such as metals, organics, dissolved oxygen, nutrients, and physical parameters such as pH, suspended solids, and temperature. This type of monitoring usually involves sampling of stormwater in conveyance channels, detention and retention basins, stormwater outfalls or receiving waters during storm events. Such monitoring can have a variety of purposes, including: water quality characterization, compliance evaluation, estimating trends, or evaluating the effectiveness of pollution control measures.

Advantages

- Generally accepted sampling methods and protocols are already established.
- Historical databases are already established for water quality constituent monitoring. Existing databases on highway stormwater runoff quality would allow comparison between local and national data.
- Existing local databases can be used to assess whether water quality degradation has occurred over time (provided quality of the existing dataset is adequate).

Disadvantages

- Multiple sampling events at multiple stations are generally required to determine statistically significant trends or differences (this is expensive).
- Because of the highly variable nature of stormwater data, samples must be collected during a representative range of storm events to accurately characterize event mean concentrations.
- Requires accurate measure of storm flows and either costly automated sampling equipment or extensive manpower investment.
- Sampling may provide only a “snapshot" of what is occurring during a particular storm event.

➤ SEDIMENT CHEMISTRY MONITORING

Constituents found in stormwater runoff can become attached to sediments, settle to the bottom, and accumulate in slower moving receiving waters, detention and retention basins, and wetlands. The sediment can be analyzed for presence and mass of chemical constituents using laboratory methods in a manner similar to analyzing for constituents in water.

This type of monitoring is most suitable for evaluating conditions over the long-term as well as for evaluating the extent of localized impacts. Analysis of sediments provides a "time-integrated" picture of pollutant effects; thus, trends in sediment constituent concentrations can reveal long-term changes in pollutant loadings. By sampling along a linear transect at various distances from a suspected source or discharge location, constituent mass can be correlated with the distance from the source, revealing the extent of localized impacts. However, to determine if sediments are contaminated by anthropogenic sources, comparisons must generally be made to reference water bodies where sediment contamination from such sources has not occurred.

Advantages

- Generally accepted sampling methods and analysis protocols are already established.
- Impacts are generally localized; thus sources of constituents in the sediments can be more readily assessed. This work can be coordinated with water quality constituent monitoring to help determine sources of specific constituents of concern.
- Provides long-term, time-integrated indication of pollutant loading.
- Relatively easy to collect samples, particularly in shallow water bodies or under dry conditions.
- Sediment chemistry monitoring is considered a more direct measure of potential environmental effects to the benthic (bottom dwelling) community.

Disadvantages

- No sediment criteria or guidelines have been developed for California; thus, there are no guidelines for direct comparison of sediment pollutant concentrations. Sediment chemistry could be compared to guidelines developed by other states, although these are few, particularly for fresh water sediments.
- Method is useful only for constituents that attach to sediment particles (e.g. metals) and does not take the dissolved pollutant fraction into account.
- Because of resuspension and redistribution of sediments, sediment sampling is not useful as a real-time indicator of pollutant reduction measures.

- Requires numerous samples, both spatially and at various depths, to determine whether contamination comes from anthropogenic sources. May require years to acquire data sufficient for trend analysis.
- Concentrations of chemicals can be dependent on soil composition and particle size distribution (i.e., fine-grained sediments tend to sorb higher concentrations than coarse-grained sediments); thus, distribution of chemicals tends to be non-homogenous. This method requires careful study design and sample compositing schemes to obtain representative data.

➤ TOXICITY TESTING

Toxicity testing is used to assess potential impacts of stormwater constituents to aquatic systems. Testing in freshwater systems is usually conducted in the laboratory using species such as the water flea (*Ceriodaphnia dubia*) and fathead minnow (*Pimephales promelas*), although in situ testing could also be conducted. The test organisms are exposed to stormwater runoff samples for a pre-determined period of time (e.g., 7 days). The organisms are then assessed to determine if exposure to the sample produced lethal or sublethal effects including mortality, limited reproduction, or growth abnormalities. Behavioral changes (e.g., feeding, swimming) in response to exposure to the sample may also indicate the presence of constituents at toxic levels.

Acute toxicity tests focus on effects that are apparent over a short interval, usually 24 to 96 hours. Mortality is commonly the endpoint in these tests. Chronic tests focus on sublethal effects, such as reproduction and behavioral changes, apparent over a longer interval, usually seven days or more.

Toxicity identification evaluations (TIEs) can be conducted on samples that show acute toxicity in order to identify the probable cause of the observed toxicity. The TIE is a stepwise analytical procedure that first identifies the probable class of a toxicant (e.g., metals, organics), and eventually a specific toxicant. Once the toxicant or class of toxicants is known, control measures can be devised and implemented specifically for the toxicant.

Most current toxicity testing protocols were designed originally for use with continuous flow discharges (e.g., from wastewater treatment plants). This may limit the applicability of the methods to intermittent stormwater discharges. However, toxicity testing can be combined with general chemical constituent monitoring, because runoff sampling is similar for both types of testing. Toxicity testing can be viewed by the sampling crew as an additional "constituent" for analysis. This testing then simply requires additional sample volume.

Advantages

- A more direct measure of potential impacts to aquatic life than water quality or sediment chemistry monitoring.

- Generally accepted sampling and testing methods and protocols are already established.
- Toxicity testing can easily be incorporated into water quality constituent monitoring programs either at the outset, or on a tiered basis where water quality constituent monitoring has shown potential water quality degradation.
- There is a large amount of existing information on acute and chronic toxicity limits for various aquatic species.
- Identification of pollutants allows focusing of pollution reduction measures.

Disadvantages

- Laboratory toxicity testing conditions are not intended to simulate conditions found in the natural environment.
- Several possible factors, in addition to contaminant concentration and exposure time, can influence toxicity, including toxicant interactions, physical conditions (temperature, pH, etc.) and the organisms environmental conditioning or acclimation.
- The same test species may exhibit varying tolerance levels for different pollutants or combination of pollutants.
- There is some disagreement among practitioners as to what constitutes unacceptable aquatic impacts.

➤ BIOLOGICAL INDICATORS

This monitoring tool involves the evaluation of characteristics of biological populations to assess potential impacts to receiving waters. This group of methods may therefore be applicable only where discharges from Caltrans facilities combine with other discharges to create potential effects on biological assemblages in receiving waters

There are a number of biological methods that can be used in monitoring potential impacts to receiving waters from stormwater runoff. These include, but are not limited to, assessment of fish populations, benthic (bottom dwelling) invertebrate populations, monitoring of a single aquatic species as an indicator, or monitoring a composite of biological populations (e.g. fish species diversity, invertebrate indices, and algal communities). A wide array of indicators can be used to assess whether an impact has or is occurring. For example, assessment of fish populations can include measures of diversity of species, abundance of individual of a given species, prevalence of disease, and fish pathology (presence of tumors, fin damage, parasite infestations, etc.). Similar measures of species abundance and diversity can be used for invertebrate and algal populations.

Although assessment of biological indicators has the advantage of providing a direct measure of potential impacts to aquatic ecosystems, the use of biological indicators would generally have limited applicability as a monitoring tool for impacts from highway stormwater runoff on a statewide basis as this type of monitoring would be limited to areas where highway runoff directly enters natural water bodies supporting aquatic life.

Advantages

- Direct measure of impact to aquatic ecosystems.
- Fish, invertebrate, and algal species are relatively easy to collect and identify (Benthic invertebrates have limited mobility and may remain in an area throughout their lifespan. Thus, they may be a better indicator of a given area than fish, which move about freely).
- The environmental requirements and life history of many species are well documented.

Disadvantages

- Useful only in areas where highway runoff directly enters a natural water body.
- May be extremely difficult to separate impacts due to highway runoff from impacts due to other pollutant sources to a water body.
- May be extremely difficult to separate natural population and distribution changes from those caused by impacts from highway runoff.
- Requires the use of unimpacted reference sites with similar habitat and species types for comparison. It may be difficult to locate similar reference areas.

- Lack of species diversity in a given area may be due to confounding problems such as poor habitat, low flow, high water temperatures, fish barriers, or fishing pressure and may not be representative of impacts from runoff.
- Other tools (e.g. water quality constituent monitoring, toxicity testing) would still be necessary to more precisely characterize causes of degradation.
- Data collected may not be readily compared between regions due to differences in species, habitat types, etc.

➤ VISUAL MONITORING

Visual monitoring can provide useful information in understanding and interpreting stormwater quality results and may also help to identify potential sources of constituents of concern. Receiving water visual observations may include changes in stream flow characteristics, accelerated bank erosion, extensive algae growth, unusual color or odor, presence of floating solids, grease, oil, or foam. If the visual inspection suggests that physical conditions are not likely to be the sole cause of water quality problems or biological impacts, an assessment of surrounding land uses may help identify potential pollution sources.

Advantages

- May provide valuable information at a relatively low cost.
- Can be used in concert with other data (e.g., water quality, biological, sediment) to identify potential sources of adverse impacts.
- May provide insight for the modification of existing monitoring efforts.
- Visual observations made during dry weather may be extremely valuable. For example, illicit discharges to the storm drain system, which contribute to pollution of downstream receiving waters, can be identified.

Disadvantages

- There is a possibility that visual observations will not provide any valuable information or insight.
- Visually “clean” water does not always indicate good water quality, e.g. high or low pH water may appear “clean”.

➤ WATERSHED MONITORING

A watershed monitoring approach, that involves the pooling of stakeholders resources and expertise, can provide a better overall understanding of impacts and strategies for water quality improvement. Stakeholders may include representatives of local municipalities and districts, state and federal agencies, agriculture, industry, landowners, environmental organizations, universities, technical consultants, watershed conservancies, and the general public. Coordination among these stakeholders can lead to the development of a comprehensive monitoring program within the watershed to identify the causes, effects and extent of constituents of concern that affect the beneficial uses of water. The watershed monitoring effort can also measure progress as control strategies are implemented.

Advantages

- May provide a large cost savings over individual stakeholder monitoring and mitigation efforts.
- Redundant efforts can be avoided.
- Creates an opportunity for information sharing.
- Provides consistency in sample collection and analysis, which provides better data quality assurance and acceptance.

Disadvantages

- Stakeholders may have conflicting monitoring goals.
- Inflexibility may exist due to individual program constraints.
- Financial and other benefits may not be clear to all stakeholders.