SECTION 9
PREPARATION AND LOGISTICS

Adequate pre-storm preparations are essential for a successful stormwater monitoring event. Prior to deployment of field crews and the initiation of stormwater monitoring, it is imperative that weather systems are adequately tracked, field personnel are prepared, all necessary equipment is inventoried, and sample bottles are labeled.

Stormwater monitoring preparation and logistics should include the following basic elements:

KEY TOPICS

- **Weather Tracking**
- **Storm Selection Criteria**
- **Storm Action Levels**
- **Communications**
- **Ordering Sample Bottles**
- **Sample Bottle Labeling**
- **Field Equipment Preparations**
- **Mobilization of Field Crews**
- **Programming of Automated Equipment**

The above listed elements are discussed in this section.

➤ WEATHER TRACKING

It is recommended that project managers contract with a private weather forecasting service to provide custom forecast services on a weekly or semi-weekly basis, and to be available on an as-needed, on-call basis for telephone consultations regarding impending storm events. Reference for some California weather forecasting services are provided in ***Appendix G***. It is also valuable to maintain a computer modem capability to access National Weather Service (NWS) forecasts (www.nws.noaa.gov), as well as other weather information available through local ALERT systems and over the Internet. For example, hourly weather observations are available by modem from a network of surface weather monitoring stations throughout California. (See ***Appendix G*** for additional information regarding California meteorology and weather tracking). An example of a typical weather forecast printout is presented in ***Appendix G***.

Initially, at time periods of up to one week prior to arrival of a storm system, NWS model predictions and satellite imagery form the basis of the predictive information provided by NWS and private forecasters. As candidate storms approach, radar observations and

hourly reports from the land-based weather stations are used to track and evaluate storm progress. Telephone communication with a contract forecaster is an effective way to access current information from these sources. This information can be supplemented by weather news available on the Weather Channel and local television forecasts, as well as satellite imagery and other information available on the Internet. As rainfall becomes imminent, observations from local field personnel also can be useful.

A crucial role of the contract weather forecasting services is projection of a quantity of precipitation forecast (QPF) for an impending storm. This is the amount of precipitation (in inches) expected for the storm event, and is normally provided along with the expected duration of the storm. This information serves two essential purposes. First, it is necessary to determine, prior to making the decision to mobilize for a storm event, whether the storm will produce adequate runoff to permit collection of a meaningful set of samples. Second, because composite samples are typically collected on a flow-weighted basis, samples must be collected at appropriate intervals so as to not under-fill nor over-fill the composite bottles, based on the rainfall/runoff amounts expected during the course of the storm.

If a storm event QPF is over-predicted, and the actual rainfall amount falls far short of the prediction, there may not be enough sample collected during the course of the monitoring event to conduct the specified analyses. If the QPF under-predicts the amount of rainfall actually received, then the composite bottles may need to be replaced one or more times during the event, and if necessary the sampling frequency can be reduced at the time of such a bottle change.

During the wet season, when the stormwater monitoring program is active, the monitoring task manager or field coordinator continuously tracks weather conditions and potential storms. The frequency of weather tracking increases as incoming storms are identified as candidates for stormwater monitoring.

➤ STORM SELECTION CRITERIA

Specific storm selection criteria should be established to aid in the process of deciding whether or not to monitor an impending storm. The following are types of criteria which may be helpful when determining which storms to monitor:

- If the sampling plan allows, establish criteria that will allow monitoring of storms at different stages of the wet season, under a variety of antecedent conditions, and of varying duration, to characterize seasonal and hydrological variability. For example, it may be useful to monitor the first storm of the season (if practical) to account for constituent build up during the dry season, and then to follow up with additional monitoring events throughout the wet season.

- Establish a recommended minimum target storm event size for each site. A typical minimum QPF for stormwater monitoring is 0.25 to 0.50 inches of

precipitation, although in some cases a minimum storm event size of 0.1 inches may be appropriate. The make-up of a drainage area (size, slope, permeability) and the rainfall intensity will determine the amount of precipitation that must be delivered during any given storm before runoff begins. In areas with abundant rainfall, a minimum target storm event size of 0.5 inches of precipitation will help ensure that adequate runoff occurs for a successful monitoring event. In arid climates, smaller storms (such as 0.1 inches) may need to be targeted for sampling, to provide for an adequate number of monitoring opportunities.

- Identify any practical or logistical constraints on monitoring. These could include days of the week and hours during which monitoring can or cannot be conducted, holiday schedules, and competing personnel job responsibilities.

➤ STORM ACTION LEVELS

It is recommended that storm action levels be defined for the purpose of stormwater monitoring preparation, mobilization, and demobilization. An example of typical storm action levels is shown in Figure 9-1. All project management, field personnel, and laboratory personnel involved are notified each time there is a storm action level change.

➤ COMMUNICATIONS

A telephone tree should be developed to clearly define lines of communication and notification responsibilities. The telephone tree is used for stormwater monitoring preparation activities, personnel notification of storm action level changes, communications during stormwater monitoring, and coordinating demobilization activities following a monitored storm event. The telephone tree graphically shows the notification sequence from the project management personnel to field team leaders and finally to field personnel. The telephone tree should list laboratory personnel numbers for the purpose of after-hours sample delivery. Emergency telephone numbers should be listed, including numbers of hospitals nearest the monitoring stations. The telephone tree should include office, pager, cellular, home and any other pertinent telephone numbers for each person involved in the project. It is essential that each person listed on the telephone tree has access to a copy of the telephone tree at all times during the stormwater monitoring season. An example of a telephone tree is presented as Figure 9-2.

Action Level	*Condition*	*Action*
Non-monitoring	Not actively seeking candidate storms	*Task Manager*: • Monitor weather reports weekly *Field Crews*: • No impact on activities
Standby	Evaluating developing storm systems	*Task Manager*: • Monitor weather reports semi-weekly *Field Crews*: • Notify Project Manager where you will be and how you can be reached if you leave the area for more than one or two days • Arrange for substitute if needed
Pre-Alert	Target storm expected within the next 72 hours	*Task Manager*: • Monitor weather reports every 24 hours • Verify operation of monitoring equipment as needed • Alert field crews regarding change in action level • Verify availability of field crew *Field Crews*: • Remain in local area if possible • Verify availability with Project Manager
Alert	Target storm expected within the next 24 hours	*Task Manager*: • Monitor weather reports every 6 hours • Alert field crews regarding change in action level and probable time of storm • Alert analytical laboratory *Field Crews*: • Prepare monitoring equipment for sampling
Go	Precipitation is imminent or has begun on targeted storm	*Task Manager*: • Monitor weather reports as needed • Mobilize field crews *Field Crew*: • Mobilize to sample collection stations
Post-Storm	Precipitation ceased or desired storm duration reached	*Task Manager*: • Demobilize field crews *Field Crew*: • Split composite samples for field duplicates • Ensure timely delivery of samples to analytical laboratory • Complete field notes • Prepare for next storm - inventory/clean/organize/replace equipment as necessary *Laboratory* • Analyze samples

Figure 9-1. Storm Action Levels

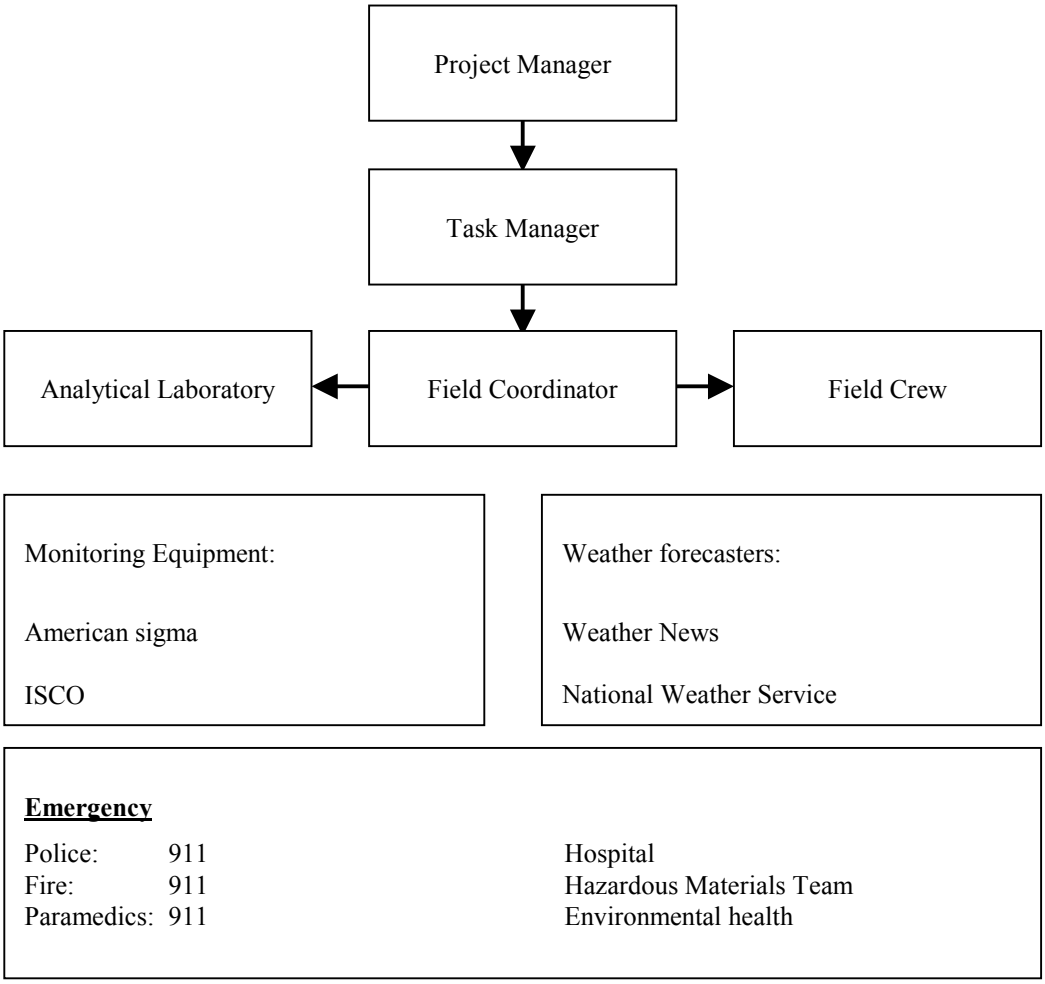


Figure 9-2. Telephone Tree Example

➤ ORDERING SAMPLE BOTTLES

Prior to the first targeted storm of each monitoring season a sample bottle order is placed with the analytical laboratory. Enough bottles should be ordered for multiple events so as to have plenty of bottles on hand. Immediately following each monitoring event, the bottle inventory should be checked and additional bottles ordered as needed. Bottles are ordered for all planned stormwater samples, including quality control samples. The bottle order should also include blank water for the collection of required field blank samples. See ***Section 11*** for QA/QC sample collection guidance. The bottles must be the proper size and material, and contain preservatives as appropriate for the specified laboratory analytical methods (***Section 12***). Additional bottles should be ordered in case of accidental breakage or contamination.

Composite bottles must be pre-cleaned according to the procedures specified in ***Appendix E***. Field crews must inventory sample bottles upon receipt from the laboratory to assure that adequate bottles have been provided to account for the analytical requirements of all composite and grab samples.

➤ SAMPLE BOTTLE LABELING

All sample bottles should be pre-labeled to the extent possible before each stormwater monitoring event. Pre-labeling sample bottles simplifies field activities, leaving only date, time, sample number, and sampling personnel names to be filled out in the field. Basic water-proof bottle labels are available pre-printed with space to pre-label by hand writing or typing. Custom bottle labels may be produced using blank water-proof labels and labeling software. A standardized bottle label should include the following information, with other items as appropriate:

- ✔ Project Name
- ✔ Station Name
- ✔ Event Number
- ✔ Date and Time
- ✔ Sample Type (grab or composite)
- ✔ Bottle __ of __ (for multi-bottle samples)
- ✔ Collected by:
- ✔ Preservative, and
- ✔ Analysis

Since field blank and field duplicate samples are typically sent to the analytical laboratory "blind", bottle labels for these QA/QC samples should be completed with pseudonym site names. Actual QA/QC sample collection site information must be carefully noted in the field log. See ***Section 11*** for detailed QA/QC sample information.

Bottles should be labeled in a dry environment prior to field crew mobilization. Attempting to apply labels to sample bottles after filling will cause problems, as labels usually do not adhere to wet bottles. The labels should be applied to the bottles rather than to the caps. An example of a typical bottle label is shown below as Figure 9-3. See ***Section 12*** for required sample bottle types and preservatives.

Project:	Stormwater Quality Monitoring Program		
Station:	Neal Road	Event:	Event #1
Date:	12/15/98	Time:	0300
Sample Type:	X Grab _ Composite	Bottle:	1 of 2
Preservative:	Sodium thiosulfate	Collected By:	John Smith
Analysis:	Fecal Coliform		

Figure 9-3. Typical Sample Bottle Label Example

Computer labeling programs can save a great deal of time in generating bottle labels. The sites and analytical constituent information can be entered in the computer program for each monitoring program in advance, and printed as needed prior to each monitoring event.

➤ FIELD EQUIPMENT PREPARATION

Prior to the first targeted storm event of each monitoring season, and immediately after each monitored event, the field crews will inventory, restock, replace, clean, calibrate, maintain, and test field equipment as needed. Field equipment is inventoried using a comprehensive checklist of all required field equipment (tools, sample bottles, flashlights, extra batteries, safety equipment, first-aid kit, cellular telephone, etc.). Field equipment should be kept in one location which is used as a staging area to simplify field crew mobilization. An example field equipment checklist is provided as Figure 9-4.

The following equipment preparation procedures should be conducted prior to each targeted storm:

- ✔ Inspect the pump tubing and replace if necessary,
- ✔ Inspect intake tubing condition and connections,
- ✔ Inspect desiccant cartridges in sampler and flow meter,
- ✔ Inspect rain gauge for blockage,
- ✔ Check all electrical connections,
- ✔ Ensure that batteries are adequately charged and positioned,
- ✔ Insert sample bottles into sampler (see ***Section 10*** and ***Appendix F*** for detailed bottle changing procedures),
- ✔ Place ice around sample bottle in non-refrigerated samplers,
- ✔ Reset automatic sampler, and

- ✔ Calibrate any portable analytical meters that will be used to make field measurements.

At a minimum, the frequency and nature of equipment maintenance for all field equipment should be consistent with the manufacturer's recommendations.

➤ MOBILIZATION OF FIELD CREWS

When a potentially acceptable storm is approaching (i.e., the storm meets the storm selection criteria, as discussed previously in this section), the field crew and analytical laboratory will be alerted by the monitoring task manager. Field crews will be given notice to mobilize when precipitation is imminent or has begun.

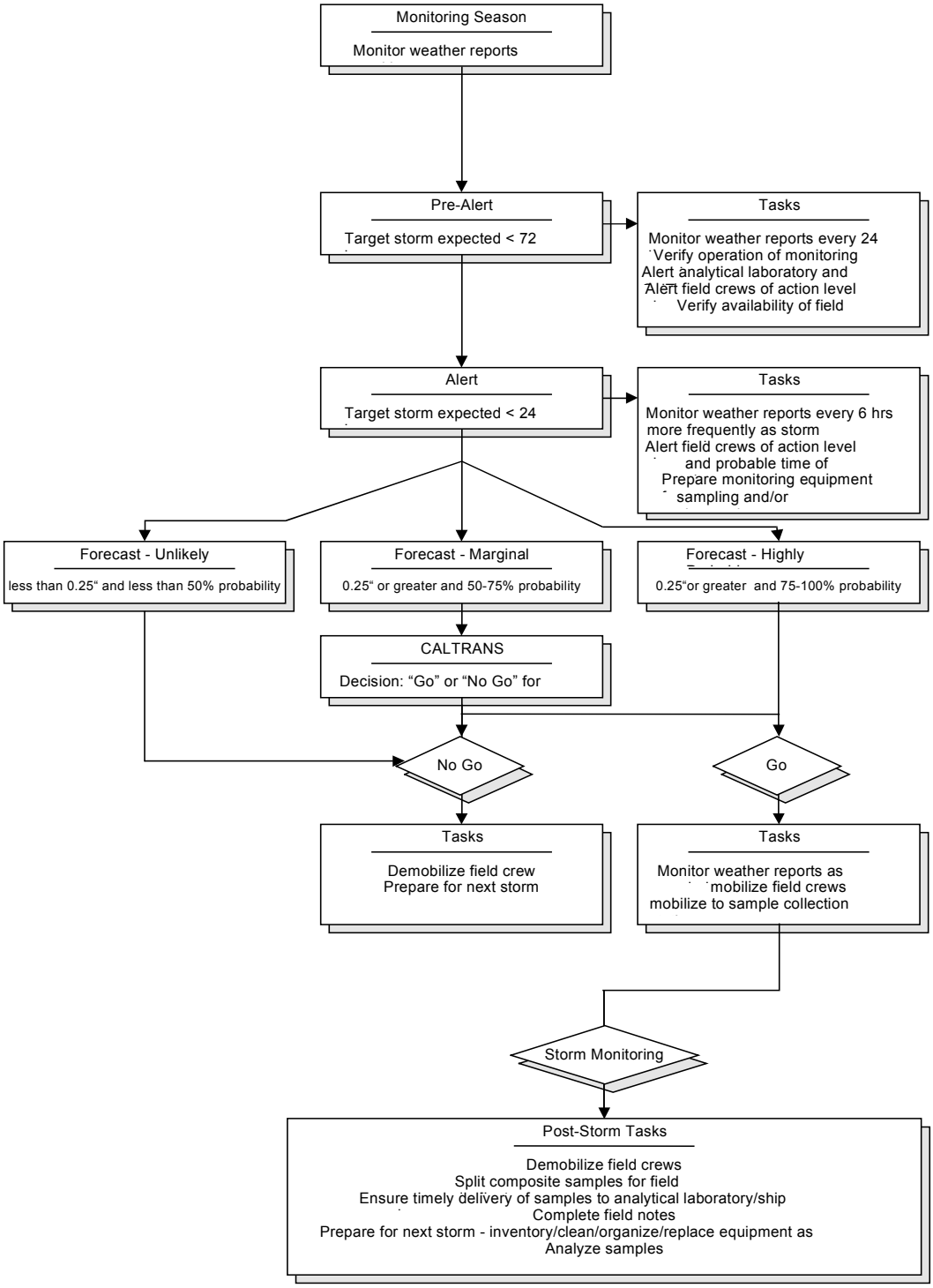
Establishing deployment criteria is recommended for the purpose of standardizing field crew mobilization. A flow chart that combines project specific storm selection criteria (i.e., antecedent conditions, storm size, storm duration) with storm action levels (Figure 9-1) can be useful for standardizing field crew mobilization for a given project. An example of a typical deployment flow chart is presented as Figure 9-5.

When first alerted, field crew members should consult their sampling plan and check monitoring equipment and supplies to ensure they are ready to conduct monitoring. Once given the go-ahead by the monitoring task manager, the field crew members will travel to their assigned locations and conduct final preparations for monitoring. Upon arrival at the monitoring site, the field crew should:

- ✔ Check battery levels,
- ✔ Check tubing and all connections,
- ✔ Install clean composite bottle(s) and remove lid(s) as necessary (see ***Section 10*** and ***Appendix F*** for detailed bottle changing procedures),
- ✔ Add ice to sampler if necessary, and
- ✔ Program automatic flow meter and sampler.

Storm Kit Equipment List	Storm Mobilization Equipment List
☐ First aid kit	☐ Storm kit
☐ Keys (to gates and to enclosures)	☐ Waterproof log books/log sheets
☐ Flashlights (2) - hand held and head mounted	☐ Paper towels
☐ Maps	☐ D.I. water squirt bottles
☐ Large flat screwdriver	☐ Ice scoop
☐ Small flat screwdriver	☐ Chain of custody forms
☐ Umbrella - large size	☐ Appropriate number of composite bottles with mesh carriers and buckets
☐ Alkaline batteries for flashlights	☐ Appropriate number of grab sample bottles
☐ Write in the rain" pens (2), waterproof markers-fine point (2)	☐ Bottle labels
☐ Spare sample bottle labels	☐ Coolers and ice
☐ Desiccant (for samplers and flow meters)	☐ Grab pole, rope and duct tape
☐ Diagonal cutters	☐ Laboratory-provided blank water
☐ Electrical tape	☐ Cellular phone
☐ Cable ties (assorted sizes)	☐ Personal extra change of clothes
☐ Utility knife	☐ Lighting
☐ Zip-lock baggies (assorted sizes)	☐ Personal rain gear
☐ Gloves - powder free nitrile	☐ Hard hats and orange safety vests
☐ Duct tape	☐ Traffic cones/signs
☐ Rubber bands	☐ Sampling Plan/Health and Safety Plan

Figure 9-4. Field Equipment Checklist



Note: Specific precipitation levels, etc. presented in this example are project specific.

Figure 9-5. Example Deployment Flow Chart

If sample collection is conducted at a station without a refrigerated sampler, or if grab samples are required, the field crew will need to obtain ice (for sample preservation) on the way to the sampling station. Composite sample bottles are required to be kept in a refrigerated sampler, or surrounded with ice during sample collection. Ice for grab samples should be kept in ice chests where full grab sample bottles will be placed. Keeping ice in double zip-lock bags facilitates clean easy ice handling. Refreezable ice packets are generally not recommended because they are susceptible to leakage.

➤ PROGRAMMING OF AUTOMATED EQUIPMENT

The steps involved will vary depending upon the software programs selected; however, the following steps illustrate what is generally involved when a stormwater monitoring event is anticipated:

- ✔ System counters (precipitation, runoff volume, sample count, etc.) are reset to zero,
- ✔ The mode is switched from non-monitoring mode to monitoring mode. This typically will increase data collection frequency and allow the system to begin sample collection once thresholds are met,
- ✔ Thresholds are set for all sampling locations to allow stations to enter sample collection mode. Thresholds can include the minimum precipitation amount, flow depth, or flow volume required to initiate the sample collection routine,
- ✔ For flow paced sampling, the flow volume per sample (i.e., the flow volume that passes between each composite aliquot collected) is set based on the expected amount of rainfall and runoff,
- ✔ The system should have "start sampling" and "stop sampling" options that can be selected when appropriate (e.g., at the beginning of a storm, during bottle changes, at the end of a storm),
- ✔ When all samples have been collected, the sampling event is terminated and software is switched back to the non-monitoring mode, and
- ✔ Data are downloaded from the data logger to a personal computer (PC) immediately following the storm event.

Most automated monitoring stations typically contain continuous flow measurement devices and data logging software. To collect flow-proportioned composite samples, the flow measurement device must be programmed to send a pulse to the sampler each time a specified flow volume has passed the flow sensor. The sampler, in turn, is programmed to collect a sample each time it receives a pulse. Therefore, each time the programmed flow volume per sample has passed the sampling location, a composite sample aliquot is collected.

To insure the collection of representative samples, automatic samplers should be programmed to perform a full back purge cycle between each sample aliquot collected. When multiple sample containers are used, samplers should be programmed to perform a full back purge cycle prior to the filling of each individual container. Purging the sample intake tube prior to the collection of each aliquot or individual container sample helps to keep the line clear. Debris at sample tubing intake may cause flow restriction, which reduces velocities within the intake tube. When intake tube velocities are reduced heavy particulates may not adequately represented in the sample. Additionally, reduced velocities may result in sampler aliquot volume calibration problems, or increased pump tubing wear. Automatic samplers may also be programmed to perform rinse cycles after the back purge cycle and prior to the collection of sample aliquots. However, for stations that have a high sampling head height or a long intake tubing length, rinse cycles are not advised because of additional wear on the pump tubing. Worn or split pump tubing will result in missed sample aliquots.

The flow volume per sample (the amount of flow that passes the sampling point between each aliquot collected) must be programmed into the flow meter in proportion to the predicted rainfall amount for each storm event, to set the sample pacing so as to fill the composite bottle(s) at an appropriate rate.

Calculation of the flow volume per sample is performed using the predicted rainfall amount (quantity of precipitation forecast, or QPF), the known or estimated drainage area, and the composite runoff coefficient for the area monitored to calculate the expected runoff flow volume for the storm event. Flow volume per sample can be determined using the formula presented below:

$$V_r\,(acre-feet) = QPF\,(inches) * \frac{1\,(ft)}{12\,(inches)} * A\,(acres) * C$$

$$V_r\,(cf) = V_r\,(acre-feet) * \frac{43{,}560\,(cf)}{1\,(acre-foot)}$$

$$V_s\,(cf) = \frac{V_r\,(cf)}{CSA}$$

QPF = quantity of precipitation forecast
A = drainage area
C = runoff coefficient
V_r = total runoff volume for forecast storm (calculated)
CSA = number of composite sample aliquots required for complete composite
V_s = flow volume per sample

Example:

0.33 inches = QPF (quantity of precipitation forecast)
150 acres = A (drainage area)
0.6 = C (runoff coefficient)
20 = CSA (number of composite sample aliquots required for complete composite)

$$V_r\ (acre-feet) = 0.33\,(inches) * \frac{1\,(ft.)}{12\,(inches)} * 150\ \ (acres) * 0.6 = 2.475(acre-feet)$$

$$V_r\ (cf) = 2.475\,(acre-feet) * \frac{43,560\,(cf)}{1\,(acre-foot)} = 107,811\,(cf)$$

$$V_s\ (cf) = \frac{107,811\,(cf)}{20\,(aliquots)} = 5,391\,(cf/aliquot)$$

The flow volume per sample is calculated so that if the predicted precipitation is delivered by the targeted storm, the automatic sampler will collect enough samples to conduct the set of analytical measurements specified in the sampling plan, plus any required QA/QC analyses. If the required analytical volume is less than the capacity of the composite bottle(s), then a margin of safety can be provided by setting the sample pacing to collect the needed composite sample volume at some fraction (typically one half to three quarters) of the predicted rainfall amount. This is done by using an appropriate fraction of the QPF in calculating the flow volume per sample. If less rainfall is received than predicted by the QPF, this may allow for collection of an adequate composite volume during the storm event.

The automatic sampler is programmed to collect a specific number of composite sample aliquots of specific volume before halting the sampling program, so as to fill the composite bottle(s) to the desired level, without overfilling (see ***Section 10***, Table 10-1 for minimum acceptable number of aliquots required to meet monitoring event representativeness requirements).

The number of composite sample aliquots ("CSA") used in the above equation may be determined based on total composite sample volume required and the desired sample aliquot volume. An adequate number of sample aliquots should be collected to produce a composite sample that is representative of the runoff for the entire sampling event. The total sample volume required for the laboratory to conduct all planned analyses, including QA/QC analyses, may be divided by the selected sample aliquot volume to produce the required sample aliquot number.

Because automated samplers tend to exhibit slight variations in aliquot volume delivered, it is recommended that the sample aliquot volume be a minimum of 200 milliliters. A typical sample aliquot volume is 500 milliliters. If 10 liters of composite sample volume is required to perform the specified laboratory analyses, then 20 composite sample aliquots would be required for a complete composite sample, at a sample aliquot volume of 500 milliliters. The input value used for the CSA variable would therefore be 20.

The runoff coefficient for a specific drainage area is defined as the fraction of total precipitation volume delivered to the area that ends up as stormwater runoff at the point of discharge. Runoff coefficients may be available from Caltrans District personnel or from local flood control or public works agencies. If not, the coefficient may initially be estimated to correspond to the fraction of impervious area within the drainage area. Or, if the pervious and impervious areas are known in a drainage area, it may be useful to modify the above equation to include separate runoff coefficients for pervious and impervious areas as follows:

$$V_r\ (acre-ft) = QPF\,(in.) * \frac{1\,(ft)}{12\,(in.)} * \left[\left(A_{pervious} * C_{pervious}\right) + \left(A_{impervious} * C_{impervious}\right)\right]$$

The number of sample aliquots per composite and the sample aliquot volume, once determined, are typically programmed into the automatic sampler. The CSA is used in the above equation throughout the monitoring season.

The flow volume per sample calculation normally requires input of only one variable for each storm event (the QPF), once the equations are set up for each monitoring station.

If a storm delivers more precipitation than expected, composite bottle replacement may be required to capture runoff from the entire storm event. ***Section 10*** describes composite bottle replacement procedures.

If less precipitation is received than predicted, the resulting composite sample volume may be insufficient to conduct all planned analyses. It may be possible to salvage a successful monitoring event in such cases by reducing the planned QA/QC analyses, or by eliminating some analytes while retaining others. Metals, for example, are key stormwater constituents which require relatively small sample volumes for analysis. To make well-informed decisions, the monitoring task manager should be familiar with the minimum sample volumes necessary to conduct each type of analysis (see ***Section 12***), as well as the overall goals and priorities of the monitoring program.

After one or two storms have been monitored, the flow volume per sample formula for each monitoring site should be checked for accuracy. To check the formula, the actual measured storm event precipitation should be plugged into the formula as the quantity of precipitation forecast (QPF). Then the resulting calculated total runoff volume (V_r) should be compared to the actual measured storm event total runoff volume. The formula may then be modified, if necessary, by modifying the runoff coefficient (C). Keep in mind that there will naturally be some variability from storm to storm at any given site because of non-uniform rainfall intensity throughout the drainage area and soil saturation (for sites with a significant pervious surfaces).