APPENDIX 2
TRIBUTARY MONITORING PLAN
FOR BIG BEAR LAKE WATERSHED

AGREEMENT NO. 04-204-558-0

1.0 TRIBUTARY MONITORING APPROACH

The intended purpose for the tributary monitoring stations is to facilitate and improve the collection of flow, water quality, and sediment data. The data collected will be used to: 1) calculate tributary loadings of nitrogen, phosphorus, and sediment into Big Bear Lake, and 2) provide potential data for calibration and validation of future watershed models. Where planned, tributary nutrient and sediment monitoring stations will be located near or adjacent to continuous flow measuring devices to enable load calculations from concentration and flow data. When possible, tributary sediment sampling events will coincide with tributary water quality sampling events.

The tributary monitoring strategy is described in detail below. Although many of the sampling efforts will be performed simultaneously, the sampling approach is described in three separate sections within this document. In order of sampling priority, the sections are: 1) water quality, 2) flow, and 3) sediment sampling. With the exception of pathogens, all parameters measured by this study will be sampled in accordance with the measures and goals provided below. Pathogen sampling is restricted to Knickerbocker Creek only, and is described in association with the Source Identification Survey Effort (see Appendix 6 of the QAPP).

2.0 EXPERIMENTAL DESIGN

Tributary Water Quality Monitoring Stations

Tributary water quality sampling stations will be established at the following locations:

- Grout Creek (MWDC3);
- Rathbun Creek @ Sandalwood (MWDC4);
- West Summit Creek (MWDC5);
- Knickerbocker Creek at Hwy. 18 (MWDC8);
- Boulder Creek at Hwy. 18 (MWDC13); and,
- Bear Creek (MWDC2 – Dam Outlet).

The Grout Creek, Rathbun Creek, West Summit Creek, and Knickerbocker Creek tributaries are 303d listed by the Regional Water Quality Control Board and therefore, are considered impaired water bodies. The 303d listed tributaries are the primary focus of tributary sampling activities. Boulder Creek (MWDC13) is intended to serve as a

"reference tributary" for water quality monitoring purposes. Finally, Bear Creek or the Dam Outlet station sampling activities will provide nutrient concentration and load release data from Big Bear Lake. The Bear Creek Outlet will be sampled **only** on a monthly basis from March through November of 2006. The other tributaries will be sampled in accordance with flow status (i.e., baseline, snow melt, and storm event) as described below. Tributary water quality sampling and visual monitoring locations are presented in Figure 6-2 in the QAPP. A summary of the corresponding GPS coordinates for the tributary water quality monitoring stations is presented in Table A2-1.

In addition to actual water quality sampling, primary tributary sampling locations will be visually monitored at a frequency of no less than once every two weeks on a year round basis for the duration of this project. Tributary visual monitoring activities consist of completing the tributary monitoring form provided in Table A2-2.

Tributary Flow Status and Water Quality Sampling Frequency

In the Big Bear Lake watershed, water flowing in tributaries (or flow type) is most likely the result of one or a combination of the following:

- Baseflow (generally spring fed flow);
- Snow Melt; and,
- Storm Event (rain precipitation).

Note: In all cases, it is extremely important for field personnel to clearly identify in the field notes and the chain-of-custody, the type of flow (or nature of the discharge) that was sampled.

Tributary water quality sampling frequency and sampling approach is dependent on the type of flow event and the time of year. Under this plan, tributary monitoring will be performed at the following frequencies for these established flow types:

- Baseflow – January through December – at a frequency of once per month when baseflow is present. If flow is absent, conduct visual monitoring only;

- Snow Melt – January through June – Snow melt sampling efforts are to be initiated a after a substantial snowfall event resulting in an accumulation of 1.0 foot or more of snow and after January 1st of each year; and,

- Storm Events – January through December - The storm event sampling objective is to capture a total of three to four storm events. Specifically, the goal will be to collect representative storm data from two (2) storm events during Southern California's wet season (October – March) and sampling one (1) summer storm event during California's dry season (April – September).

For the snow melt sampling period (January through June), grab samples will be collected twice (2x) a week for the first two (2) weeks of the snow melt event. If ambient air temperatures remain above freezing after two weeks have passed, snow melt

sampling will then be performed once every two weeks until the snow melt period ceases. Snow melt cessation will be determined by one of the following:

- Ambient air temperatures drop below freezing during most of the day;
- There has been no flow observed for seven (7) consecutive days; or,
- A storm/rain precipitation event occurs after the snow melt event was initiated.

Snow melt flow status, referenced above, will generally be evaluated in the afternoon, when ambient air temperatures are highest and flow potential is greatest. Also, beginning on March 15th of each year, it is anticipated that snow melt flows will more likely be continuous since ambient air temperatures will more frequently remain above freezing. Therefore, from March 15th through June of each year, snow melt sampling events will simply be conducted once every two weeks, without the more intensive sampling performed in association with the initiation of a snow melt event. The "spring runoff period" will be assumed complete no later than the end of June each year. Further, while the snow melt season is underway, the snow melt samples collected will satisfy the requirements for baseline flow sampling when water is present.

In addition, to ensure that an adequate number of water quality samples are collected, the following sample number target goals have been established:

- Baseline Flow: N=12 from each applicable tributary (includes visual events when flow is absent);

- Snow Melt Flow: N=8 from each applicable tributary; and,

- Storm Event Flow: N=24 to 32 from each applicable tributary; the goal is to sample three to four separate storm events over the project time period and collect eight samples from each event over the hydrograph.

Tributary Water Quality Sampling Techniques

Water quality samples will be collected using one of the two following techniques:

- Automated Equipment (AE); or,
- Instantaneous Manual Grab (IMG).

In general, automated ISCO sampling equipment will only be utilized to collect storm event water quality samples at stations for which automated sampling equipment is available (i.e., Grout Creek, Rathbun Creek, and Knickerbocker Creek). Storm event samples collected from other tributary sampling locations will be sampled manually by taking instantaneous grab samples. Each sampling event will carefully document the sampling technique utilized as well as the type of flow sampled.

Instantaneous manual grab sampling will be used to collect baseflow, snow melt and some storm event samples. Corresponding tributary flows at the time of sampling will be

recorded by the available flow equipment (i.e., pressure transducers). In the absence of flow measuring equipment, tributary flows will be estimated by water depth flowing over the constructed weir or a flow equation/calculation using dimension information about the channel.

Water Quality Sample Types

Baseline and snow melt water quality samples will generally be collected only by manual means. If the flow sampled was the result of a storm event, then sample type will be designated as one of the following:

- First Flush (FF) or Hydrograph Discrete #1 (HD#1)
- Hydrograph Discret (HD #2-8)

First Flush samples capture the first 30 minutes of tributary discharge during a storm event. The highest concentrations of contaminants (e.g., nutrients and sediments) are often found in the "first flush" discharges, which occur during the first major storm event after an extended dry period.

Hydrograph Discreet #2 - #8 samples are discrete samples that will be intended to characterize water quality concentrations at discrete points along the hydrograph. Each ISCO sampling device is equipped with eight (8), two (2) liter bottles that are rotated in the counter clockwise direction. Ideally, the storm event sampling program input into the ISCO sampling device will enable the collection of discrete water quality samples over the entire hydrograph associated with a given storm event. Each ISCO sampling device will utilize a similar sampling program. An example of the ISCO sampler program utilized for this study is attached to the tributary water quality SOP (BBMWD11-4).
Note: Flow Composite Storm Water Samples will not be collected during this study. Flow Composite samples are time-weighted composite samples historically collected over a 2.5 hour interval.

Other Samples

If storm event, snow melt, and/or baseflow samples are collected manually, the sampler will document the exact date and time of sample collection, type of flow observed, and flow velocity. For snow melt and rain events, the sampler will make every attempt to document the start time of the event, the start time of the first observed discharge, the duration of the event, and any other informational observations.

Tributary Water Quality Sampling Parameters

Regardless of flow status, tributary samples will be analyzed for the following:

- Total Nitrogen
- Total Dissolved Nitrogen
- Ammonia-Nitrogen
- Nitrate-Nitrite

- Total Phosphorus
- Total Dissolved Phosphorus
- Orthophosphate
- Total Suspended Solids
- Volatile Suspended Solids
- Hardness
- Alkalinity
- Water Temperature
- Dissolved Oxygen
- Conductivity
- pH

Water quality indicators such as water temperature, dissolved oxygen, conductivity, and pH will be measured using an YSI 556-02 multi-parameter portable field meter. All other samples will be submitted to the selected analytical laboratories for analyses.

Tributary Flow Monitoring Stations

Tributary flow monitoring stations will be established at the following locations:

- Boulder Creek at Hwy. 18 (MWDC13);
- Grout Creek (MWDC3);
- Rathbun Creek @ Sandalwood (MWDC4);
- Knickerbocker Creek at Hwy. 18 (MWDC8);and,
- Bear Creek Outlet (MWDC2 – Dam Outlet).

Note: West Summit Creek will not be equipped a flow measuring structure or device. Although this station will periodically be monitored for water quality parameters, this tributary often goes underground, which makes flow monitoring difficult for this waterbody.

Boulder Creek – At this location, an existing compound weir (5 cfs rectangular and v-notch weir) located just upstream of the Highway 18 crossing and a water level pressure transducer will be utilized to collect flow data. At high lake levels, the existing weir is submerged by backwater, therefore, flow data at this location will not be available under these conditions. In addition to the existing weir and the data logging pressure transducer, a U.S. Geological Survey staff gage (0 to 6 feet in depth range) will also be installed in Boulder Creek as time and resources allow. The pressure transducers and staff gage will measure water level in the stream and then, in conjunction with pre-established formulas, recorded water level data will be converted to stream flow data.

Grout Creek – Flow measurements from Grout Creek are extremely critical to project efforts as flows from this tributary primary consist of property owned by the U.S. Forest Service. Grout Creek may also be the only tributary monitoring to provide data from the north shore of the lake.

At Grout Creek, the District plans to utilize the dimensions of the existing bridge culvert and pressure transducers to collect continuous flow data. Originally, plans were to construct a broad-crested concrete weir along the base of all three archways associated with the Highway 38 bridge. However, the Highway 38 bridge is only designed to handle a 20-year flood flow event and there were substantial concerns about the impact of the concrete weirs and their potential to reduce the capacity of the bridge.

To measure flow, a data logging pressure transducer and a U.S. Geological Survey staff gage (covering a range of 0 to 6 feet) will be installed and utilized at this location adjacent to the bridge. The devices provide continuous water level measurements in the stream, stream flow data, and peak flow information. Finally, the only other device planned for installation is a continuous dissolved oxygen meter. When water is present, the dissolved oxygen meter would record the oxygen concentrations associated with stream flow and flow status.

Rathbun Creek – Near the mouth of Rathbun Creek, an existing 50 cfs compound weir structure will continue to be utilized for flow measurements. However, modification of this weir will include attaching a sharp-edge to the existing broad crested weir, installing a pressure tranducer at the site, and a U.S.G.S staff gage. This existing concrete weir and box culvert are located on the downstream side of the culvert at the Sandalwood Road crossing of Rathbun Creek. A sharp-edged steel weir will be installed along the full length of the existing concrete weir to improve the accuracy of flow measurements and will be bolted to the top edge of the concrete weir. In addition, one or two check structures are also tentatively proposed for Rathbun Creek. These check structures would be located upstream of the box culvert on Sandalwood Road to protect the weir and culvert from sediment accumulation behind the weir. The check structures would provide a more convenient location for cleaning out sediment transported by flowing water.
Again, as with the other tributary locations, self-powered data logger pressure transducer, a U.S. Geological Survey staff gage, and a dissolved oxygen meter will also be installed in Rathbun Creek near the slightly modified concrete weir.

Knickerbocker Creek – Downstream of the Highway 18 crossing of Knickerbocker Creek, this tributary channel has been armored with rip rap rocks. It is on this segment of the creek that the District plans to install a weir, data logging pressure transducer, U.S.G.S. staff gage and dissolved oxygen meter. Specifically, the District anticipates that the weir structure will be installed on top of the remains for an existing concrete structure in the streambed. From the weir, out to the channel edges, a small concrete wall with a sharp-edged steel weir, would also be installed. This concrete wall would also serve as a broad-crested weir for flows that exceeded the capacity of the weir.

Bear Creek Outlet - No additional structure or equipment installation is required to obtain flow measurements at this site. The existing weir and water level data logging device as well as the data collection system will be utilized by the District for flow measurements at this location.

Tributary Sediment Monitoring Stations

Tributary sediment sampling stations will be established at the following locations:

- Grout Creek (MWDC3);
- Rathbun Creek @ Sandalwood (MWDC4); and,
- Knickerbocker Creek (MWDC8).

Of these three creeks, only Rathbun Creek was 303d listed as impaired for siltation/sedimentation. However, since a primary goal of this effort is to collect some empirical sediment loading data, suspended sediment and bed load sediment sampling will also be performed on Grout Creek and Knickerbocker Creek.

Tributary Sediment Sampling Techniques and Equipment

Selected tributaries will be sampled for both suspended sediments and bed load sediments. Sediment samples will be collected following the collection of any water quality samples and will generally utilize wading-type of sediment samplers (when flows are wadable). Suspended sediment samplers collected by wading will be collected using a DH-81 sampler with a wading rod and adapter. If necessary, suspended sediment samples for storm events will be sampled using a bridge board-reel assembly and a DH-95 sampler. Bedload sediment samples will be collected with a BLH-84 sampler with net and wading rod.

The sediment sampling method utilized will be the Equal-Width-Increment sampling approach.

For suspended sediment sampling events, a pre-established number of cross-sectional vertical passes will be taken for tributary sampling locations during each sampling event (see below and SOP BBMWD Form11-5).

For each suspended sediment concentration sampling event, the following number of vertical passes at equal-width increments will be taken for applicable sampling locations:

- Knickerbocker Creek = four (4) vertical passes;
- Rathbun Creek = five (5) vertical passes; and,
- Grout Creek = six (6) vertical passes.

According to the literature, in streams less than 50 feet wide that are well-mixed, two evenly-spaced sample points are adequate, however the BBMWD staff will always attempt to sample the targeted number of vertical passes.

When the stream depth is below the un-sampled zone (i.e., approximately less than 4.0 inches), sample collection must be obtained by manual sampling means (i.e., equal aliquots collected across the stream width).

Warning: For suspended sediment samples, if the sample container becomes completely filled during a sampling event, the sample will not be representative and must be discarded. The target volume filling capacity of the DH-81 bottle is approximately 750 mL. The volume of each sample aliquot collected during a vertical pass is primarily dependent upon the stream velocity and the duration of sampler submersion.

For bedload sediment sampling events, collected during storm events only, five (5) cross-sectional intervals, equally spaced across the stream, will be taken for sampled tributary sampling locations (see SOP BBMWD Form11-5). According to the literature, for stream widths less than 100 feet, the bedload sampler should be deployed at five (5), equally-spaced points per traverse for 2 minutes. Two traverses are recommended for a total of 20 minutes of bedload sampling per station.

Sediment sampling equipment required is as follows:

Suspended Sediment Equipment (Depth-integrated sampling)

- Two (2) US DH-81 Suspended Sediment Wading Type Hand Sampler (with wading rod and adapter)
- One (1) US DH-95 Suspended Sediment Sampler for High Flow Event
- Four (4) Sets of Plastic Nozzles (Sizes 3/16 (small),1/4 (medium), 5/16 (large); Used for both DH-81 and DH-95 Samplers
- Bridge Board and Sounding Reel Assembly
- Plastic 1.0 L Nalgene Bottles (24 total); Used for both DH-81 and DH-95 Samplers.

Bedload Equipment

- One (1) US BLH-84 Wading Type Bed Load Sampler
- Five (5) Sampler Bags
- Ziplock Plastic Bags

Tributary Sediment Sampling Frequency

To ensure that an adequate number of suspended sediment and bedload samples (storm event only) are collected, the following sample number target goals have been established:

- Baseline Flow: N=4 from each applicable tributary (suspended sediment only);

- Snow Melt Flow: N=4 from each applicable tributary (suspended sediment only); and,

- Storm Event Flow: N=8 from each applicable tributary (suspended sediment and bedload sediment samples); the goal is to collect two to three samples during each storm event over the project time period. Depending on availability of

sampling personnel, one to three suspended sediment and/or bedload samples may be collected from each tributary per storm event. Given that sediment sampling is manual process, it may not be possible to sample all tributaries during a storm event. In addition, bedload samples will only be collected if the water is wadable and safe to sample.

The goal of sampling of storm events is to provide data from a wide range of flow conditions. A target of three storm events for the duration of the project has been established.

Tributary Sediment Parameters

Tributary sediment parameters targeted for analyses include the following:

- Suspended sediment (concentration; grain-size analyses for storm events only)
- Bed load sediment (concentration and grain-size analyses; storm events only)
- Total nitrogen (suspended sediment samples only; storm events only)
- Total phosphorus (suspended sediment samples only; storm events only)

Sediment samples will be collected after the water samples and will generally utilize wading-type of sediment samplers. Bedload sediment concentration, sediment total nitrogen associated with suspended sediment concentration, and sediment total phosphorus associated with suspended sediment concentration will be analyzed for storm event samples only.

3.0 SITE INACCESSIBILITY ISSUES

Site inaccessibility may be an issue for stream sites, under various circumstances described below.

1. If inaccessibility to a site results from a storm event, in which it would be dangerous to approach the stream, the sampling team will delay sampling for 24 hours up to 48 hours after the storm event (determined by either precipitation amount in inches, i.e., a storm event will be more than 0.25 inches in a 24-hour period, or by base flow, i.e., a storm event will be a doubling of flow within a 24-hour period, if a stream gauge is present or as visually estimated). Alternatively, if a bridge is available from which to conduct sampling, sampling will occur on schedule in that location from the bridge.
2. If sampling sites are temporarily or permanently blocked by a physical obstruction, such as downed trees or evidence of land- or rockslide, or ice or snow, the sampling team will move 25-50 ft. upstream or downstream from the site and conduct sampling there. If there still is no suitable access, the project team will discuss the possibility of sampling further away (up to 100 ft.) from the original station with the project manager, who will approve the change.
3. If the sampling site comes under new ownership, such that previously granted access is now denied, permission will be obtained from the new owner. If this is still denied, a permanent new location will be selected if not too far away from the

original station (i.e., within 1,000 ft. and not in a morphologically different stream reach).

4.0 OTHER TRIBUTARY-RELATED ISSUES

In addition to the monitoring described above, tributaries will also be monitored for other parameters not described within this Monitoring Plan, but described by separate project plans. The identity of separate Project Plans that have been prepared or will be prepared include the following:

- Tributary Monumented Cross-Section Plan – a preliminary plan has been provided to the RWQCB. The monumented cross-section locations are summarized in Table A2-3;
- Tributary Beneficial Use Survey;
- Tributary Recreational Use Survey; and,
- Tributary Channel Stability and Condition Survey.

TABLE A2-1. SUMMARY OF TRIBUTARY MONITORING STATIONS AND GPS COORDINATES (a)

Site No.	Site Name/Description	Latitude	Longitude	Flow Device	Water Level Device	Sampling Technique
Sites						
MWDC2	Bear Creek Outlet (at Dam)	34° 14' 31.4"	116° 58' 37.4"	Compound Weir	Pipe	Manual
MWDC3	Grout Creek (at Hwy 38)	34° 16' 10.0"	116° 56' 54.4"	Existing Culverts	Bubbler	Automated Equipment
MWDC4	Rathbun Creek (at Sandalwood Road)	34° 13' 49.5"	116° 51' 34.9"	Compound Weir	Bubbler	Automated Equipment
MWDC5	West Summit Creek (at Swan Road)	34° 14' 55.3"	116° 53' 37.6"	None	None	Manual
MWDC8	Knickerbocker Creek (at Hwy 18)	34° 14' 37.9"	116° 54' 37.6"	Compound Weir	Pressure Tranducer	Automated Equipment
MWDC13	Boulder Creek (at Hwy 18)	34° 14' 14.7"	116° 57' 11.1"	Compound Weir	Pressure Tranducer	Manual

BIG BEAR LAKE TRIBUTARIES **VISUAL OBSERVATION FORM**

DATE: _____

(must record!)

					FLOW STATUS AT WEIR		WATER CONDITION CODES				NUMERIC CODE KEY	
TRIBUTARY STATION	**STATION ID.**	**Time**	**Sample Type** (see key)	**Water Level (units)**	**Flow Code**	**Flow/Equiment Comments**	**Color Code**	**Color Description**	**Other Code**	**Other Code**	**Flow Code**	
Grout Creek	MWDC3										1	No Flow: dry, no water
											2	No Flow: standing water
Rathbun Creek	MWDC4										3	Baseline Flow
											4	Stormwater Flow
West Summit Creek	MWDC5										5	Snowmelt Flow
											6	Trickle Flow
Boulder Creek	MWDC13											
											Water Condition	
Knickerbocker Creek	MWDC8										1	Clear
											2	Color
											3	Visible Oily Sheen
											4	Visible Scum
											5	Visible Suds/Foam
											6	Other

Observers Name (please print): _____

Observers Signature: _____

Sample Type Key:

AE = Automated Equipment

MG = Manual Grab

TABLE A2-3. MONUMENTED CROSS-SECTION IDENTIFICATIONS AND GPS COORDINATES

Site No.	Site Name/Description	Latitude	Longitude
Cross-Section Creek			
Grout Creek	Grout Creek Trib 1 - 4668	N34.28884	W116.95952
	Grout Creek Trib 2 - 2628	N34.28722	W116.96214
	Grout Creek Trib 3 - 5637	N34.28637	W116.96528
	Lower Grout Creek - 1058	N34.27623	W116.95946
	Upper Grout Creek - 14345	N34.27093	W116.97221
Knickerbocker Creek	Knickerbocker Creek - 4540	N34.23427	W116.91117
Rathbun Creek	Mouth of Rathbun (downstream of Sandalwood)	need	need
	Lower Rathbun - 9050	N34.24058	W116.86966
	Lower Sand Canyon 1 - 4150	N34.23368	W116.85450
	Upper Sand Canyon 2 - 5920	N34.23091	W116.84988
	Upper Sand Canyon 3 - 8616	N34.22673	W116.84304

Note: The monumented cross-section site to be located near the mouth of Rathbun Creek was added at the September 7, 2005 meeting per request of the Regional Board.