Implementers' Monitoring Program (IMP)

Component of the
Regional Storm Water Monitoring Program (RSWMP)

Implementers' Monitoring Plan

Submitted to the Lahontan Regional Water Quality Control Board
and the Nevada Division of Environmental Protection

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Submitted by the Tahoe Resource Conservation District
in cooperation with:

<u>California</u>

El Dorado County

Placer County

City of South Lake Tahoe

California Department of Transportation

<u>Nevada</u>

Douglas County

Washoe County

Nevada Tahoe Conservation District

Nevada Department of Transportation

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AV	Area-Velocity
BMP	Best Management Practice
Caltrans	California Department of Transportation
CEDEN	California Environmental Data Exchange Network
cf	cubic feet
cfs	cubic feet per second
CICU	Commercial, Industrial, Communications, Utilities
CMP	Corrugated Metal Pipe
CRC	Characteristic Runoff Concentration
District	Tahoe Resource Conservation District
DRI	Desert Research Institute
DTU	Data Transfer Unit
EIP	Environmental Improvement Program
EMC	Event Mean Concentration
FSP	Fine Sediment Particles
ICR	Indirect Cost Rate
IMP	Implementers' Monitoring Program
IV	Incline Village
MFS	Media Filtration System
NDOT	Nevada Department of Transportation
NPDES	National Pollutant Discharge Elimination System
NTCD	Nevada Tahoe Conservation District
PD	Pasadena
PLRM	Pollutant Load Reduction Model
PLRP	Pollutant Load Reduction Plan
QAPP	Quality Assurance Project Plan
QC	Quality Control
RAM	Rapid Assessment Method
ROW	Right-of-Way
RSWMP	Regional Storm Water Monitoring Program
RTD	Rapid Transfer Device
RU	Rubicon
SAP	Sampling and Analysis Plan
SLRP	Stormwater Load Reduction Plan
SR	SR431
SWAMP	Surface Water Ambient Monitoring Program
TA	Tahoma
TN	Total Nitrogen
TMDL	Total Maximum Daily Load
TP	Total Phosphorus
TRPA	Tahoe Regional Planning Agency
UCD	University of California, Davis

μm	micro-meters
TSS	Total Suspended Solids
USDA	United States Department of Agriculture
WQIP	Water Quality Improvement Project

PREFACE

This document is intended to function as the Lake Tahoe Basin's first collaborative monitoring plan for implementation efforts related to the urban stormwater source category of the Lake Tahoe Total Maximum Daily Load (TMDL). This monitoring program was developed jointly by the California and Nevada implementing jurisdictions in an attempt to collectively fulfill California National Pollutant Discharge Elimination System (NPDES) Permit requirements or Nevada Interlocal Agreement commitments. However, this monitoring plan also represents a historic first step toward implementing a comprehensive Regional Stormwater Monitoring Program (RSWMP) envisioned for the Tahoe Basin. All data will be collected in a manner consistent with RSWMP monitoring protocols so it can easily be analyzed to align with the goals and objectives presented in the multi-agency driven RSWMP Data Quality Objective Plan (Heyvaert et al 2011a), Quality Assurance Project Plan (Heyvaert et al 2011b), and Sample Analysis Plan (Heyvaert et al 2011c).

Although the scope of this monitoring plan does not include answering the following four RSWMP Key Study Questions, the generated data and information will support and feed into the forthcoming RSWMP effort. These four questions were developed to guide the evaluation criteria for determining the success of the Lake Tahoe TMDL's pollutant reduction strategies and are a priority for Basin Managers. Additionally, they were established in concert with the Tahoe Science Consortium (TSC) and were previously endorsed by the Tahoe Inter-agency Executive Committee (TIE). The four Key RSWMP Study Questions that data collected under this monitoring plan will feed into are as follows:

1) ***Are the stormwater Characteristic Runoff Concentrations (CRCs) developed for identified land use types in the Tahoe Basin suitable for use in deriving Pollutant Load Reduction Model (PLRM) estimates of pollutant loading?***

2) ***Are the stormwater Characteristic Effluent Concentrations (CECs) developed for different treatment and source control practices appropriate for PLRM estimates of load reductions?***

3) ***Are drainage area load reduction estimates from PLRM projections verified by field data collected from the projects under construction?***

4) ***Are pollutant loads from urban stormwater runoff in the Tahoe Basin decreasing in response to Environmental Improvement Program (EIP) and TMDL implementation, and what are the long-term trends related to TMDL load reduction targets?***

Furthermore, the data collected as part of this monitoring will not determine TMDL pollutant load reduction credits, rather, it serves to support the TMDL Management System and the modeling and assessment tools associated with crediting. Thus, data collected under this monitoring plan will be evaluated by the Tahoe Resource Conservation District (Tahoe RCD) and presented to the Lahontan Regional Water Quality Control Board (Water Board) and the Nevada Division of Environmental Protection (NDEP) as part of meeting annual compliance reporting needs. This data will then be further analyzed under the purview of RSWMP such that recommendations can be provided to guide future stormwater program efforts. As this work progresses the following questions can also be explored:

5) ***On a site by site basis, what is the correlation between turbidity and fine sediment particle (FSP) concentrations?***

6) ***Once a site-specific rating curve has been developed between turbidity and FSP, is using a continuous turbidimeter in place of a traditional autosampler a suitable and cost effective alternative?***

7) ***How can monitoring data be used to support, enhance, and inform the jurisdictions' existing pollutant load estimates as modeled by the PLRM (or comparable models), and their condition assessment methods (Road RAM, BMP RAM or other comparable methods).***

Question 5 and 6 above will likely contribute to future RSWMP method development, model refinement, and cost effective implementation practices. This question is relevant because TMDL baseline conditions and associated load allocations were generated from data collected with traditional autosampler methodology. However due to the constant search for cost savings, continuous turbidity has been used in more recent studies (2NDNATURE and NHC 2010a), (2NDNATURE and NHC 2012). Since data collected by 2NDNATURE and NHC 2010b, and Heyvaert et. al., 2010 suggest there is a positive correlation between turbidity and fine sediment particles (FSP), one of Lake Tahoe's primary pollutants, work performed under this monitoring plan will employ, where feasible, the use of both autosampler and turbidimeter methodologies.

As part of fulfilling regulatory requirements, the jurisdictions will compile road operations and maintenance data, BMP maintenance records, as well as road and BMP condition assessments. This information will be summarized in annual reporting documents and will assist in answering Question 7. Knowing the condition of a road or BMP, the incidence of BMP maintenance, and/or the frequency of abrasive application and road sweeping prior to a monitored precipitation event lend valuable information to the interpretation of observed nutrient and sediment loads.

Lastly, RSWMP documents also identify the four "types" of monitoring needed to fill scientific data gaps; implementation, effectiveness, status and trend, and model support monitoring. The work performed under this monitoring plan will contribute to data collection that will help fulfill all of these monitoring needs. The California NPDES Permits and Nevada Interlocal Agreements qualify as implementation monitoring, whereas BMP evaluations would fall under effectiveness monitoring. Long-term consistent data sets generated through permit and agreement compliance will also be useful in refining model predictions and identifying status and trends in the watershed.

This monitoring effort will utilize and build upon a significant body of work performed by the California and Nevada stormwater jurisdictions, Desert Research Institute, University of California, Davis Tahoe Environmental Research Center, 2NDNATURE, and Northwest Hydrologic Consultants (NHC). In addition, data collected for this work will assist in serving larger programmatic and regulatory needs and will benefit the Lake Tahoe TMDL's Adaptive Management System, the Status and Trend Monitoring and Evaluation Program at TRPA (environmental indicator tracking), and even California's Surface Water Ambient Monitoring Program which reports on surface water quality around the state. The larger RSWMP group, composed of basin scientists, agency partners, implementers, regulators and funders, some of which are listed above, will be a part of the discussion on how the RSWMP structure will function in the future.

As previously stated, this monitoring plan was developed for the implementation of the TMDL through California NDPES Permits and Nevada Interlocal Agreements; however, much of this data will be evaluated as part of the larger RSWMP effort, and will allow for a consistent monitoring design, data collection, analysis and reporting approach. The ability to tie this monitoring plan to the RSWMP vision will take continued collaboration and partnership building, and is an excellent opportunity to discuss and adaptively manage future program improvements and requirements for the next monitoring period beginning in 2016.

Beyond partnership building, permit compliance and a functional RSWMP, there is still a significant challenge ahead, one in which all partners will need to work together to find realistic funding sources for long term implementation of RSWMP, as well as basic permit and agreement compliance monitoring. Funds provided to the Tahoe Resource Conservation District, through the State Water Quality Control Board's Proposition 84 Stormwater Grants Program, will help move the Tahoe Basin in addressing this next major hurdle. Initial planning and work agreements are expected to begin in late 2013-early 2014; the primary purpose being to further develop a comprehensive stormwater monitoring program in the Lake Tahoe Basin.

INTRODUCTION

The Lake Tahoe Total Maximum Daily Load (TMDL) is a comprehensive, long-term plan to reverse the decline in deep-water transparency of Lake Tahoe and restore mid-lake clarity to the 1967-1971 level of 29.7 meters (97.4 feet). TMDL science suggests that up to two thirds of the decrease in clarity is attributable to fine sediment particles (FSP, <16 µm in diameter), and that the urbanized areas, roadways in particular, account for approximately 72% of FSP that eventually enter the lake (Lake Tahoe TMDL Technical Report, 2010).

Following the adoption of the TMDL in August 2011, the Lahontan Regional Water Quality Control Board approved a Municipal National Pollutant Discharge Elimination System (NPDES) permit (NPDES NO. CAG616001 Updated Waste Discharge Requirements and National Pollutant Discharge Elimination System (NPDES) Permit for Stormwater/Urban Runoff Discharges from El Dorado County, Placer County and the City of South Lake Tahoe within the Lake Tahoe Hydrologic Unit, Order No. R6T 2011-101A) (herein after "Municipal permit") on December 6, 2011, and later amended on October 12, 2012 (attached herein as Appendix A).

The Municipal permit requires California jurisdictions in the Lake Tahoe Basin to take measures to decrease pollutant loading from stormwater runoff in urbanized areas. Local California jurisdictions must implement pollutant controls to decrease FSP and nutrient inputs, and must monitor and evaluate select urban catchment outfalls and Best Management Practices (BMPs) for flow volumes and sediment and nutrient loads. While monitoring data will not be used assess credits earned under the Lake Clarity Crediting Program for implementing effective pollutant controls, it will provide empirical data that will begin to (1) inform assumptions used to estimate runoff volumes and pollutant loads modeled with the Pollutant Load Reduction Model (PLRM) (2) assess nutrient and sediment loading at chosen catchments, (3) evaluate BMP effectiveness at chosen BMPs.

Similar permits or regulatory programs have been adopted for the California Department of Transportation (Caltrans) under NPDES NO. CAS000003, NPDES Statewide Stormwater Permit for Waste Discharge Requirements for State of California Department of Transportation, Order No. 2012-0011-DWQ effective July 1, 2013 (attached herein as Appendix B), The three urban jurisdictions located within Nevada, Washoe County, Douglas County and the Nevada Department of Transportation (NDOT) will each enter into Interlocal Agreements with the Nevada Division of Environmental Protection to implement the Lake Tahoe Total Maximum Daily Load. These agreements are expected to become effective in August 2013.

This document will therefore outline a monitoring plan that is sufficient to achieve compliance with the requirements described in Attachment C, sections IIIA and IIIB of the California Municipal permit, as well as the stormwater monitoring commitments contained in the Nevada agreements. This monitoring plan will also assist Caltrans in meeting their permit requirements to submit a Stormwater Monitoring Plan to meet Lake Tahoe TMDL Implementation Requirements by July 15, 2013.

BACKGROUND

Road systems and urban development have increased the total impervious area in the Tahoe basin, resulting in increased stormwater runoff volumes due to decreased natural infiltration. Stormwater runoff transports FSP, as well as nitrogen and phosphorus, resulting in more pollutant loading from the many highly impervious urban catchments located within each jurisdiction. Areas with greater hydrologic connectivity to Lake Tahoe are believed to have the highest potential to contribute FSP loads directly to the lake. To date, jurisdictions around the lake have spent tens of millions of dollars implementing projects as part of the many Water Quality Improvement Projects (WQIPs) which in this document are defined as those Environmental Improvement Programs (EIPs) whose primary purpose was to reduce impacts on Lake Tahoe from stormwater runoff. These projects often include numerous stormwater treatment strategies spread throughout the urban catchments, and may include stormwater infrastructure in the form of BMPs such as curb and gutter, sediment traps, a variety of treatment vaults and infiltration mechanisms, street sweepers, constructed wetlands, and source control measures like slope stabilization. Catchment scale runoff monitoring is needed to verify that cumulative implementation of pollutant control actions are resulting in measurable pollutant load reductions. BMP effectiveness monitoring is needed to verify that BMPs are reducing pollutant loads and to improve the installation and maintenance practices that will optimize water quality benefits over the long-term.

Furthermore, data collected under the Municipal permit are complementary to long-term regional stormwater monitoring efforts proposed under the Tahoe Basin's Regional Storm Water Monitoring Program (RSWMP). These data, in conjunction with the Tahoe Basin's long-term tributary monitoring program, will become valuable in helping to determine long-term status and trends related to upland runoff. Municipal permit compliance is a critical first step toward developing RSWMP, but it does not encompass the entire strategy or vision for RSWMP. The programmatic structure and implementation of RSWMP is being developed concurrently with permit monitoring using another funding source.

The Implementers' Monitoring Program (IMP) is a partnership between the Tahoe Resource Conservation District (the District), El Dorado County, Placer County, the City of South Lake Tahoe, Douglas County, Washoe County, the Nevada Tahoe Conservation District (NTCD), NDOT, and Caltrans. The District is the prime recipient of $750,000 from Round 12 of the Southern Nevada Public Lands Management Act (SNPLMA) issued through the USDA Forest Service, and will work on behalf of the local jurisdictions to implement coordinated monitoring requirements necessary for meeting Municipal permit needs. In addition to having in-house administrative and stormwater monitoring expertise, the District can also contract across jurisdictional and state lines, making it an ideal agency to coordinate and collaborate with both California and Nevada agency representatives. Functioning with the District as a cohesive unit, the IMP partners will support the “one lake, one plan” ideal, as well as promote cost savings gained through economies of scale.

GOALS FOR MONITORING

The goals of water quality monitoring under this plan are to (1) comply with the monitoring requirements contained in the stormwater permits and agreements, (2) collect meaningful data this is useful for informing jurisdictions’ efforts to effectively and efficiently manage their stormwater programs, and (3) support TMDL implementation progress assessment and program improvement. Additionally, implementation of this monitoring plan will facilitate a better understanding of stormwater model performance under actual, site-specific conditions in the selected catchments. The PLRM, as developed, has incorporated the best possible assumptions valid basin-wide for multiple jurisdictions. Thus, the PLRM is consistent across all catchments and an important load crediting tool. However, actual conditions in particular catchments would be expected to vary from the basin-wide assumptions to some degree. Comparing model results to measured data is critical to verify model performance. The current Municipal permit requires continuous flow data and a minimal number of events sampled per year (one per season) at each site pursuant to section III.A.3 of Attachment C. Over time, a robust dataset for each monitoring site will be developed, providing a greater degree of confidence in meeting the secondary goal.

Lastly, the uniqueness of the different monitoring and evaluation sites will contribute to initial development and eventual implementation of a basin-wide catchment scale monitoring network under RSWMP. Each site has implemented or planned water quality improvement strategies believed to represent the best known methods for reducing pollutant loading to Lake Tahoe. As this permit monitoring continues, it will help inform what types of sites and BMPs should be included in a regional stormwater monitoring network.

Five catchments have been chosen to be monitored. These catchments are defined as the area that drains to an outfall monitoring site and can be modeled as a PLRM catchment. (In some instances, PLRM catchments are subsets of larger Urban Planning Catchments.) Monitoring will include flow measurements and water quality sampling at eleven monitoring stations: the outfalls of the five selected catchments, and the inflows to and outflows from the selected BMPs located within three of those catchments.

The monitoring plan includes:

- Measuring continuous flow at each of the eleven monitoring stations,
- Measuring continuous turbidity at selected monitoring stations,

- Taking samples across the hydrograph during four different storm event types at ten of the eleven monitoring stations,
- Analyzing samples for total nitrogen (TN), total phosphorus (TP), total suspended solids (TSS), turbidity, and fine sediment particles (FSP),
- Calculating seasonal and annual runoff volumes at each of the eleven monitoring stations and nutrient and sediment loads at ten of the eleven monitoring stations.

The District is responsible for installations and, as needed, will coordinate with the University of California, Davis (UCD) and Desert Research Institute (DRI) staff to instrument the eleven stations and install the devices necessary to monitor flow, continuous turbidity, and to collect samples. Site instrumentation is expected to begin the summer of 2013 so that monitoring can commence on October 1, 2013 (the start of water year 2014 (WY14)). The District is also responsible for coordinating and performing all tasks associated with sampling, with assistance from the NTCD and UCD. Sampling tasks include, but are not limited to, collecting data and samples from the monitoring stations, filtering samples for TSS, and ensuring delivery of the samples to appropriate analytical laboratories. The District will also coordinate site and equipment maintenance, database management, data analysis, and complete annual and final reporting.

MONITORING SITES

Five catchment outfall sites and four BMP effectiveness projects covering two different treatment approaches have been selected for monitoring (Figure 1) in five locations: SR431 (SR), Incline Village (IV), Tahoma (TA), Rubicon (RU), and Pasadena (PD). Some of these locations will be used as both outfall and BMP sites; their descriptions are to follow in this section. All sites were chosen because of their high direct hydrologic connectivity to Lake Tahoe. In addition, there is one catchment located within each CA jurisdiction as required by the CA permit. Catchment outfall sites were selected based on a diversity of land uses, a range of catchment sizes, and a reasonably equitable distribution of sites among the participating jurisdictions. BMP effectiveness projects were selected because of their potential efficacy in treating storm water runoff characteristic of the Lake Tahoe basin, the broad interest in and lack of conclusive data regarding the efficiency of the selected BMPs in reducing runoff volumes and pollutant loads, especially FSP, and the importance of determining the maintenance required to retain effectiveness.

Table 1 summarizes the selected monitoring sites and their corresponding designation as catchment outfall and/or BMP effectiveness project. Total catchment area, percent impervious area in the catchment, and land-use distribution are also shown. The Other/Vegetated category includes mostly vegetated areas, but may also include unimproved roadside shoulders with sparse vegetation, and was not considered in the ranking.

Table 1: Selected monitoring sites and corresponding characteristics. Dark pink highlights the dominant urban land-use in the catchment, medium pink the second most dominant urban land-use, and light pink the third most dominant urban land-use.

Site Name	Outfall	BMP	# Monitoring Stations	Jurisdiction	Total Acres	% Impervious Area	Single Family Residential	Multi-Family Residential	CICU*	Primary Roads	Secondary Roads	Vegetated
SR431 (SR)	√	√ √	5	NDOT	0.61	99%	0%	0%	0%	95%	0%	5%
Incline Village (IV)	√		1	Washoe	83.6	46%	3%	38%	33%	10%	3%	13%
Tahoma (TA)	√		1	Placer, El Dorado, Caltrans	49.5	30%	41%	4%	12%	2%	15%	25%
Rubicon (RU)	√	√	2	El Dorado	13.8	24%	76%	0%	0%	0%	15%	8%
Pasadena (PD)	√	√	2	CSLT	78.9	39%	52%	13%	5%	0%	16%	13%

*Commercial, Industrial, Communications, Utilities

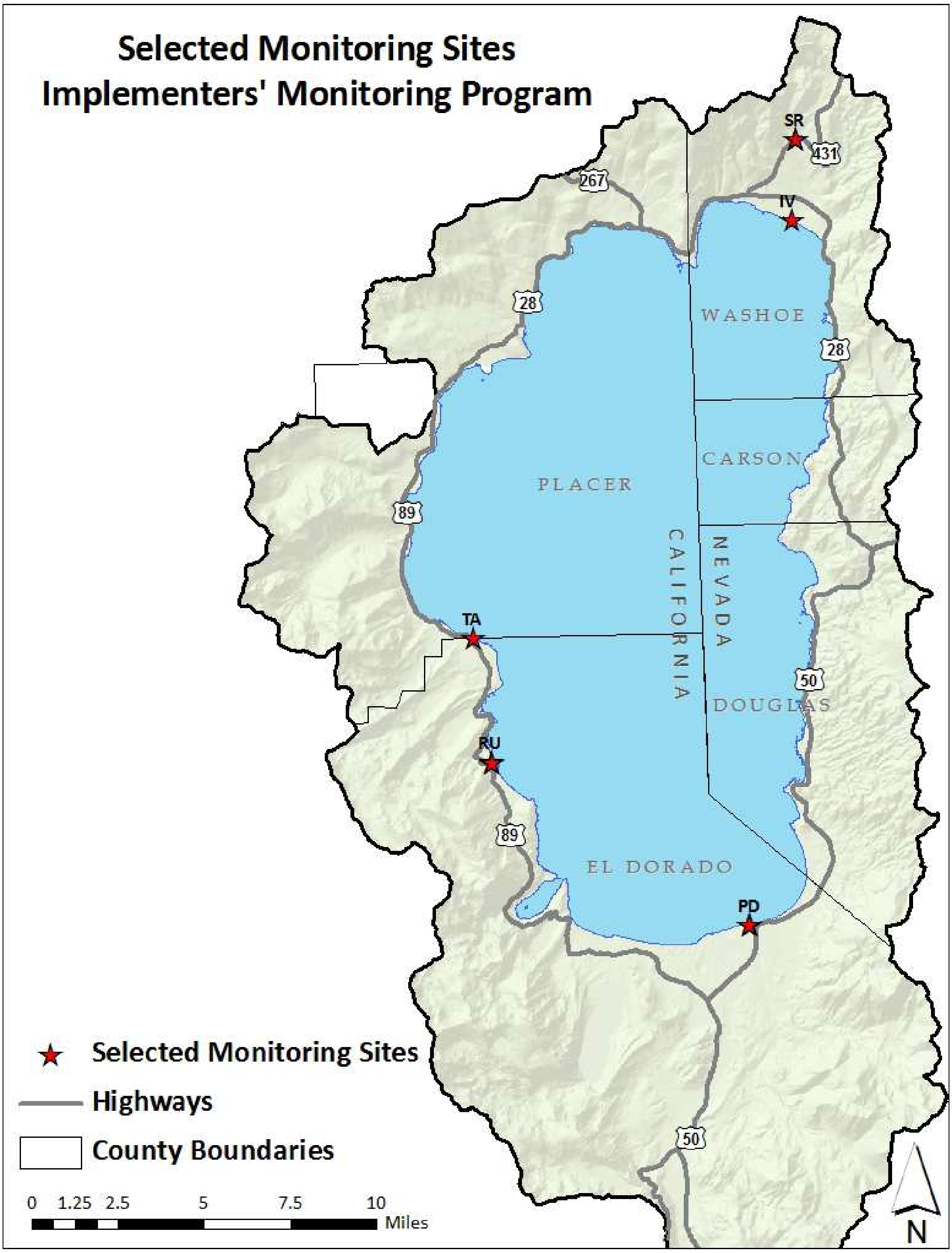

Figure 1: Distribution of selected monitoring sites. See Table 1 for site name acronyms and characteristics.

To reduce redundancy in data collection, each catchment has distinctive characteristics. SR431 is a small catchment dominated by primary road. Central Incline Village is a large catchment composed primarily of higher density development including multi-family residential and commercial properties and a relatively large proportion of primary roads. Tahoma and Pasadena are similar in that they are both medium density single-family residential neighborhoods crisscrossed with secondary roads, but they differ in size, slope, and distribution of the higher density land-uses of multi-family residential and commercial properties. Rubicon is a lower density single-family residential neighborhood with no multi-family residential or commercial properties. Though Tahoma, Pasadena, and Rubicon are all dominated by the single-family residential land-use classification, monitoring resources will be well spent because they represent the type of development most common around Lake Tahoe, and have widely different planned or implemented water quality improvement strategies. Water quality improvements in all five of these catchments span a wide range of strategies, from permeable pavement along roadway shoulders, to a variety of infiltration mechanisms, to treatment vaults, to erosion control methods. Each site has a unique combination of improvement strategies that will contribute to a greater understanding of their efficacy and avoid duplication of data collection efforts.

The chosen BMPs will provide comparative data from three different types of cartridge filter vault installations (a Contech Storm Filter, a Contech Media Filtration System (MFS) and an Imbrium Jellyfish membrane filtration cartridge) and evaluate a pair of subsurface infiltration chambers of a size and type commonly considered for private parcel BMPs as well as EIPs. As of 2006 (2NDNATURE, 2006) several infiltration basins and constructed wetlands had been monitored in the Tahoe Basin, but only one cartridge filter of the Storm Filter variety. The Storm Filter study was largely inconclusive due to sample handling discrepancies, difficulties monitoring low flow conditions, and poor maintenance practices. However, reductions in some pollutants were found to be significant. To date, no studies have been conducted to evaluate the efficiencies of the MFS or the Jellyfish, nor has conclusive study been done on a Storm Filter. This monitoring plan fills the need to monitor several different types of cartridge filters to begin to shed light on what type works best for stormwater characteristic to Lake Tahoe, especially with regards to FSP. Not only are the selected cartridge filter vaults designed specifically to remove FSP, but they offer the ability to treat stormwater in areas with limited space for treatment basin construction, a common problem in the densely developed areas that need stormwater treatment the most. Subsurface infiltration chambers are also a viable option for stormwater treatment in confined areas and preliminary unpublished studies have shown significant stormwater runoff volume reduction through infiltration. No formal studies have been done on infiltration chambers in the Tahoe Basin, but with their reputed effectiveness, they have the potential to become more widely used as a BMP. This monitoring plan will formally evaluate the effectiveness of infiltration chambers, providing efficiency data that may justify their widespread use. Monitoring data will also begin to inform maintenance schedules required for sustaining treatment effectiveness of each of the BMP types monitored. A detailed description of each site follows.

SR431

The SR431 monitoring site is located on State Route 431 in Washoe County above Incline Village, Nevada (Figure 2). At this location, State Route 431 is a two-lane road with a catchment area that includes 0.61 acres of NDOT right-of-way (ROW) of which approximately 95% of the surface is impervious. The catchment outfall discharges directly into a perennial stream called Deer Creek which connects with Third Creek and discharges into Lake Tahoe, giving this site the distinction of being directly connected to the lake despite being 2.5 miles from it. The adjacent, stabilized, vegetated hillside on the northeast side of the catchment represents approximately 14 acres and contributes no additional runon to the catchment. The area on the southwestern side of the highway slopes steeply downward and does not flow towards the catchment.

SR431 will be monitored as a catchment outfall site and for evaluating and comparing BMP effectiveness of two adjacent vaults containing different cartridge filter types. Though located in a rural area with moderate highway traffic density, SR431 is the only site that isolates the characterization of runoff from primary roads. All other selected sites have co-mingled runoff from various land-uses, making it difficult to determine FSP contribution from primary roads only. This is important because primary roads have been identified as the largest single generator of FSP in the Lake Tahoe basin (Lake Tahoe TMDL Technical Report, 2010). Though the catchment is of a size smaller than recommended for modeling using PLRM, this provides a unique opportunity to evaluate whether PLRM can reasonably estimate pollutant loads in a small catchment. Because the catchment is comprised of only a single land-use that is almost entirely impervious, PLRM has the potential to be acceptably effective at predicting pollutant loads, especially if coupled with shorter than 15 minute precipitation logging intervals. In addition, SR431 is the only site currently available where a true side-by-side comparison of stormwater cartridge filter types can be performed. There is little information available at this time regarding the FSP removal capability of different stormwater filter cartridges. This site will allow for a real-world comparison of two treatment technologies that may be applicable to stormwater treatment around the Lake Tahoe basin in the future.

An EIP (#01.01.02.11) was recently completed in this catchment. In addition to slope stabilization and installation of permeable pavers on the shoulders of the highway, two side-by-side stormwater cartridge filter vaults were installed on the south side of the highway, an Imbrium Jellyfish and a Contech MFS. Runoff sheetflows across a portion of State Route 431 and falls into a drop inlet (DI). Flow to the system is limited by an orifice plate installed in the drop inlet and the maximum amount of head that can be developed above the orifice. The DI includes a two-foot deep sump for capturing large particles. A 12-inch plastic pipe connects the DI to a splitter. The flow is split (approximately evenly) and runs 75 feet through two 8-inch plastic pipes to either the Jellyfish or the MFS. The stormwater is treated in one of the two cartridge filter vaults and discharged through two 8-inch outflow pipes to a short, steep swale that enters Deer Creek. Any flow exceeding the restriction at the orifice plate bypasses the system and flows on the shoulder surface to a triple wide drop inlet and is discharged to the same creek through a 24-inch outflow pipe from the triple wide drop inlet.

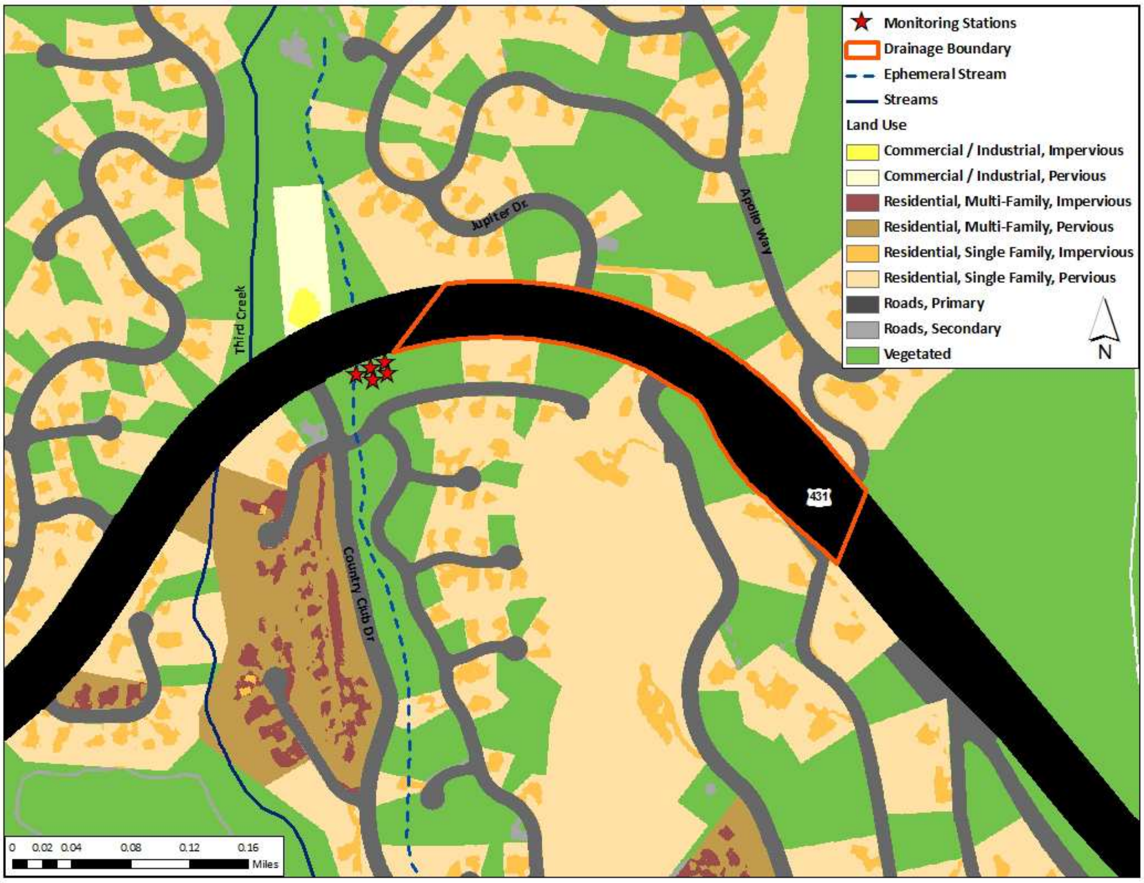

Figure 2: SR431 monitoring site, including monitoring station locations, catchment boundary and land use distribution.

The Jellyfish (Figures 3 and 4) consists of three membrane filtration cartridges, each containing eleven 2.75 inch diameter cylindrical membrane filters or "tentacles" 54 inches in length contained within a six foot diameter fiberglass chamber. The design treatment flow rate for the installed Jellyfish is approximately 0.3 cfs. The high surface area of the membranes ensures long-lasting treatment. Vibrational pulses dislodge sediment from the membrane surfaces during filtration. In addition, filtered water backwashes membrane filtration tentacles and sediment is continuously removed from the tentacles by gravity. The coarse particles settle to the sump at the bottom of the fiberglass cartridge. The Jellyfish is designed to remove 100% of trash, 89% of total suspended solids, 60% of total phosphorus, 50% of total nitrogen, greater than 50% of metals, and turbidity to less than 15 NTU.

Figure 3: View looking down on Imbrium Jellyfish membrane filtration cartridges installed in concrete vault at SR431.

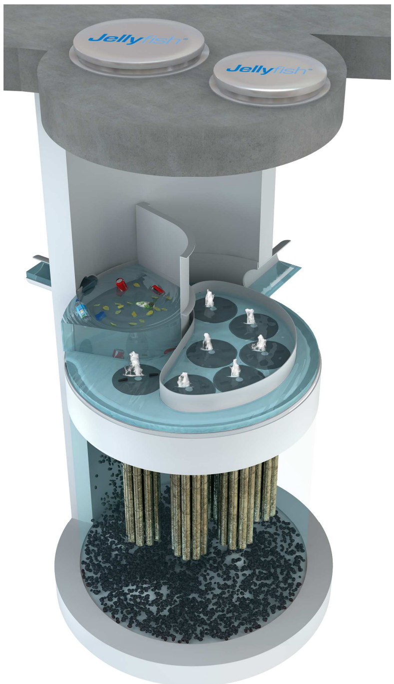

Figure 4: Schematic of inside of a single Imbrium Jellyfish membrane filtration cartridge (photo courtesy of Imbrium).

The Contech MFS consists of a series of nine upright, cylindrical filtration cartridges filled with media arrayed in an underground concrete vault (Figure 5). As stormwater enters the vault through an inflow pipe, the vault is filled and the cartridges are submerged. Polluted stormwater is forced through the outer screen of the cartridges and through the media, into a perforated center tube, and out through a pipe under the cartridges (Figure 6). The design treatment flow rate for the installed MFS is approximately 0.3 cfs, comparable to the Jellyfish. The outflow pipe will not discharge until the vault is filled to a certain level and float valve is opened. At SR431, the cartridges will be filled with perlite. Perlite was chosen as the media specifically because it has the potential to remove fine solids less than 15μm in diameter from runoff. Perlite will also remove a wide variety of other pollutants including heavy metals, oil and grease, and nutrients. In addition, the bottom of the concrete vault provides the opportunity for gravity settlement and storage of larger sized particles.

Figure 5: Contech MFS filter cartridges in underground concrete vault at SR431. Float valve is behind fiberglass shield. An outflow pipe runs underneath each row of cartridges.

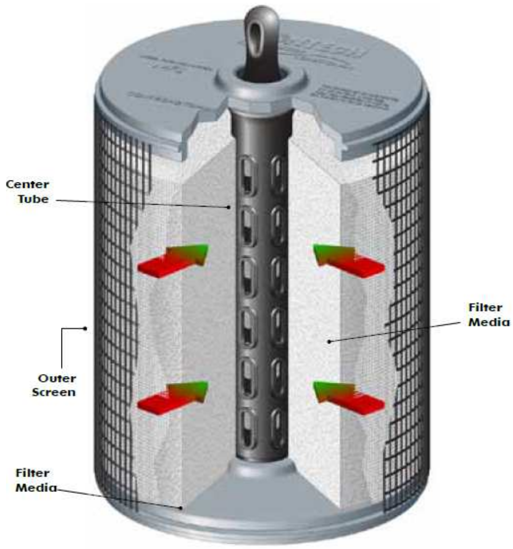

Figure 6: Schematic of single Contech MFS filter cartridge (photo courtesy of Contech).

Five monitoring stations will be instrumented at this site: on the inflow (J1) and outflow (J2) pipes of the Jellyfish, on the inflow (C1) and outflow (C2) pipes of the Contech MFS, and on the 24-inch bypass outflow pipe of the triple wide drop inlet (S1). Stations J1, J2, C1, and C2 each have a manhole specifically designed to facilitate monitoring and provide access to Parshall flumes designed for a wide range of flow rates in an 8-inch pipe. At S1, monitoring will occur directly in the outflow pipe that discharges the bypassed flow.

The sum of runoff volumes and pollutant loads from S1, J2, and C2 will be used to characterize the outfall from the catchment. Pollutant loads at the outflows of each cartridge filter type (J2 and C2) will be compared to pollutant loads at the inflows to each cartridge filter type (J1 and C1 respectively) to determine reductions attributable to each cartridge filter type. It is assumed that neither the Jellyfish nor the MFS retains or infiltrates any flow, so flow volumes will not be reduced. The two different cartridge filter types will also be compared to each other to determine which is more effective at retaining pollutants, FSP in particular. In addition, it is likely that after a certain amount of runoff volume, data will show that pollutant retention in the cartridge filter vaults begins to decline. Coupled with visual observations, this will help to determine maintenance schedules for the different cartridge filter types.

Incline Village

The Incline Village monitoring site is located on the western edge of the parking lot for Incline Beach Park near the end of Village Blvd on the south side of Lakeshore Blvd in Incline Village, Nevada. It will be monitored as a catchment outfall at one monitoring station (V1). At 83.6 acres, this is the largest catchment monitored and it includes runoff from Washoe County and NDOT jurisdictions. The catchment drains a relatively steep, highly urbanized area of Incline Village with dominant urban land-uses consisting of moderate to high density residential, commercial, and primary roads. Forty-six percent of the area is impervious and there is a lack of any intervening natural dispersion and infiltration areas. Runoff discharges directly to the lake via a 30-inch CMP that day-lights into a rock-lined ditch before entering Lake Tahoe. The monitoring station is located on the rock-lined ditch (Figure 7).

The catchment is located in the Wood Creek Watershed and includes both primary high-risk (Highway 28) and secondary high-risk (Village Blvd.) roads. Because of the highly urbanized nature of the catchment, the area has a high potential for generating FSP. There are numerous unarmored roadside ditches and bare shoulders used for parking that are known to contribute large amounts of sediment to runoff. Visual observations during past events have indicated that runoff is considerably turbid and therefore potentially high in nutrients and sediments (field observations by Andrea Parra).

Preliminary studies conducted during the Incline Village Commercial and Lower Wood Creek EIP#669 in 2000 have shown that an existing Vortechnics Vault immediately upstream of the monitoring station provides minimal treatment to approximately a quarter of the flow to the outfall, but the remainder of the flow is untreated (Lumos and Associates, 2000) as it flows through culvert pipes and compacted, eroding roadside ditches to the outfall location. The changes to FSP and nutrient concentrations are insignificant. A very small portion of the total flow from the catchment area (Lumos and Associates, 2000) is discharged to the east along the northern edge of Lakeshore Blvd. and does not go through the monitoring station. The loss will be accounted for when calculating total flow volumes from this catchment.

Washoe County has an EIP (#01.01.01.44) planned within this catchment that will extend to slightly outside of its borders for the summer of 2014. The main goal of the EIP is to improve stormwater quality, defined primarily by the reduction of FSP generated within the project area public ROW. Monitoring in this catchment will occur both during and post construction and will provide information regarding the efficacy of planned improvements. Anticipated improvements will be made in the County ROW or on public properties and include source controls in the form of slope, bare shoulder and channel stabilization. Other improvements include the installation of sediment traps throughout the project area to capture coarse sediments and the installation of a cartridge filter vault near the existing

Vortechnics Vault able to capture FSP. The possibility of eliminating parking along road shoulders will be analyzed, and the applicability of porous pavement will be explored as an infiltration option due to the absence of suitable infiltration areas. Some piped runoff on Village Blvd. may be diverted to a proposed infiltration feature on Incline Way outside of the catchment. Other potential water quality improvement strategies include various types of settlement and infiltration basins constructed where space allows, and the purchase of a high efficiency vacuum sweeper to remove a portion of the FSP generated on the roadways.

Because this catchment represents a large, directly connected, relatively densely urbanized area, it is likely to contribute large pollutant loads to Lake Tahoe. Monitoring at this site (station V1) will characterize the catchment outfall both pre- and post-construction, and will begin to allow for the evaluation of the efficacy of the planned water quality improvement strategies in reducing pollutant loads. The lessons learned in this catchment will likely have valuable application to other critical, large, highly urbanized areas around the lake that contribute significantly to pollutant loading. In addition, this catchment was monitored for flow and turbidity by 2NDNATURE from March 1, 2012 to February 28, 2013 and the final technical report is due for release in 2014. The data collected under this monitoring plan will expand the data set for this site using equipment already installed, allowing for cost savings. This is an excellent opportunity to collaborate with other stormwater monitoring efforts in the basin.

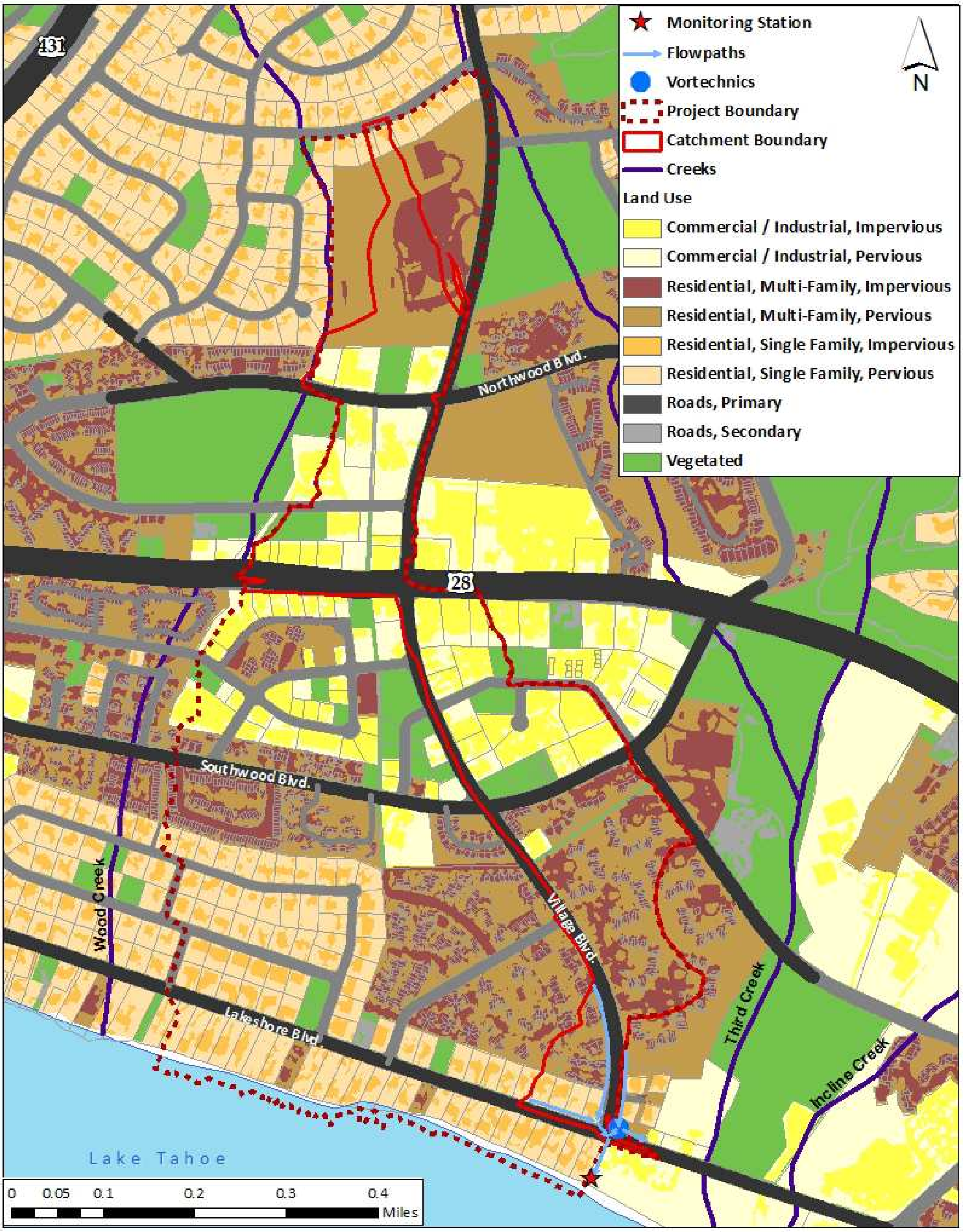

Figure 7: Central Incline Village II monitoring site, including monitoring station location, catchment boundary and land use distribution.

Tahoma

Tahoma will be monitored as a catchment outfall at one monitoring station (T1). The 49.5 acre catchment straddles the Placer County/El Dorado County border and comingles waters from both jurisdictions (Figure 8), plus waters from the Caltrans maintained Highway 89. The land-uses in this catchment are primarily moderate density residential and secondary roads in the Tahoe Cedars subdivision, but also include some commercial/industrial/communications/utilities (CICU) and primary roads. Twenty-eight percent of the catchment area is impervious. The runoff from this catchment discharges directly into Lake Tahoe via a 36-inch oval “squashed” corrugated metal pipe (CMP) at the bottom of the Water’s Edge North condominium complex driveway without infiltration or treatment. Because of the high direct connectivity between the catchment and Lake Tahoe, this storm drain system has great potential to deliver high FSP loads to the lake. Runoff from this CMP has been monitored periodically in the past with grab samples, and has been shown to be elevated in both nutrients and sediments (unpublished data, UC Davis).

No recent water quality improvement projects have been completed in this drainage. However, due to steep roadways, road sand and cinder accumulation, eroding cut slopes, drainages, and roadside ditches, as well as direct discharges of untreated stormwater to Lake Tahoe, the TRPA has identified the area as one that requires erosion control and water quality treatment BMPs. Therefore, EIP projects are planned in and around this catchment by El Dorado County for 2015 (EIP#10062, see project boundary, Figure 8) and by Caltrans for 2014 (EIP#995 for 03-1A845, ED 89 24.9/27.2). The EIP projects will focus on reducing the delivery of FSP to the lake through source control, hydrologic design, and stormwater treatment. Source control will be achieved by stabilizing eroding cut slopes with vegetation and/or rock armoring, stabilizing existing drainages with rock, and where feasible, with bio-engineering techniques, and eliminating eroding roadside ditches by installing curb and gutter or rock-lined channels and vegetated swales. Improved hydrologic design will store and spread out stormwater more effectively in the upper watershed prior to reaching the 36-inch discharge CMP and infiltrate and/or treat runoff from the El Dorado County and Caltrans ROWs before it discharges to Lake Tahoe. El Dorado also proposes to work with Caltrans, the California Tahoe Conservancy (CTC), Placer County, and private land owners to develop a comprehensive watershed management plan within the project boundary.

The monitoring station (station T1) will be located near the mouth of the CMP, and data from this site will characterize the catchment outfall. Like Incline Village, this site also provides the unique opportunity to monitor pre- and post- water quality improvement project. The lessons learned in this catchment will be valuable to other moderate density residential neighborhoods with high direct hydrologic connectivity to Lake Tahoe.

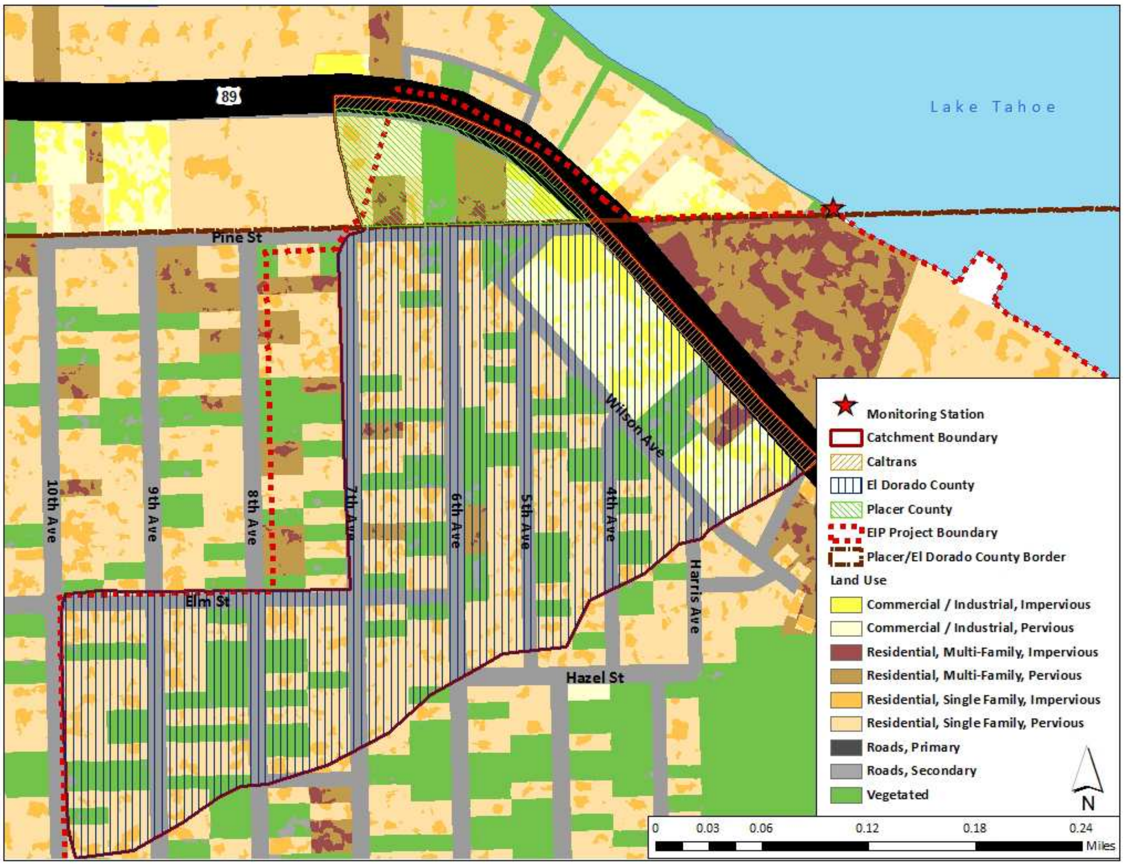

Figure 8: Tahoma monitoring site, including monitoring station location, catchment boundary, partial EIP project boundary, and land use distribution.

Rubicon

The Rubicon monitoring site is located on Rubicon Drive in the Rubicon Estates subdivision on the west shore of Lake Tahoe (Figure 9). At 13.8 acres, Rubicon is the second smallest monitored catchment and is characterized by low density single-family residential properties and relatively gentle slope near lake level. Most of the roadways have unimproved shoulders but a few steeper sections are lined by asphalt dikes. Twenty-four percent of the catchment is impervious.

Figure 9: Rubicon monitoring site, including monitoring station locations, Stormtech chambers location, catchment boundary, and land use distribution.

The Rubicon V Erosion Control Project in 2010 (EIP#713.3) installed two sets of parallel Stormtech stormwater retention chambers at the lowest point in the catchment to reduce stormwater runoff volumes prior to discharge into Lake Tahoe (Figure 10). Runoff primarily from Rubicon Dr. flows to a drop inlet where it is conveyed to a 48-inch diameter sediment trap for coarse particle removal before entering the Stormtech chambers. There are two additional sediment traps, one between the two sets of chambers and one at the outflow from the second set of chambers. Each chamber is a 51-inch long, 30-inch diameter half-pipe set atop two feet of rock. The first set consists of 24 chambers and the second set consists of 16 chambers. The combined volume capacity of both sets of chambers is 3,000cf. When all the chambers have filled, the overflow bubbles up through a grate in the roadway and then runs south along the shoulder to a residential property outfitted with several private property BMPs. Prior to installation, high end properties were being flooded by uncontrolled runoff that exited the County ROW only 400 feet from the lake. Being so near the lake, this site is highly hydrologically connected and allows for the potential transfer of large amounts of pollutants. The series of chambers were designed to infiltrate the runoff that was causing flooding with the explicit goal of reducing the average annual runoff volume and the amount of very fine, fine, and coarse inorganic sediment loading by 33%.

Figure 10: Rubicon Stormtech chambers during installation, 2010 (photo courtesy of El Dorado County).

Also included within the catchment boundary are four “fill and spill” microbasins designed to detain a small portion of the runoff before entering the Stormtech chambers and a small perforated pipe infiltration gallery. The microbasins consist of shallow depressions in the ground with a sediment trap at the down-gradient end.

The Rubicon site will be monitored as a catchment outfall and a BMP effectiveness project at two monitoring stations, R1 and R2. R1 is located at the inflow to the Stormtech chambers and R2 is located at the outflow from the Stormtech chambers. Flow volumes from R2 will be compared to flow volumes at R1 to assess the effectiveness of the BMP at reducing stormwater runoff volumes. R2 captures all catchment discharges and will therefore also be used to characterize the catchment outfall. This BMP is not intended to change nutrient or FSP concentrations the way the cartridge filter vaults at SR431 and Pasadena are, and therefore only flow monitoring will occur at R1. Because of its designation as a catchment outfall site however, samples will be collected at R2 for nutrient and sediment analyses in accordance with permit requirements. Monitoring at Rubicon will also allow for a better understanding of the level of maintenance required to ensure functionality of an infiltration chamber like this one, especially with regards to how infiltration capacity decreases with time. This will inform future design considerations with regards to treatment capacity, installation requirements, and maintenance schedules.

Pasadena

The Pasadena monitoring site is located at the northern most end of Pasadena Ave. in the City of South Lake Tahoe (Figure 11). It will be monitored as a catchment outfall and BMP effectiveness site. A 36-inch outfall CMP emerging from the side of the steep slope at the end of Pasadena Ave conveys runoff directly to Lake Tahoe. The pipe is the terminus of a 78.9 acre catchment designated the “G12 basin” by the City of South Lake Tahoe. The dominant land uses are moderate density single and multi-family residential and secondary roads. Thirty-nine percent of the catchment is impervious.

This outfall was the former Regan Beach TMDL monitoring site, one of 19 sites in the Tahoe Basin equipped with auto-samplers and monitored during 2003 and 2004 as part of the Lake Tahoe TMDL research effort conducted by DRI and UCD. Data collected at this site was used in the Lake Tahoe TMDL Technical Report to establish Event Mean Concentrations (EMCs) for modeled land-use categories. In addition, this catchment was monitored for flow and turbidity by 2NDNATURE from March 1, 2012 to February 28, 2013 and the final technical report is due for release in 2014. The data collected under this monitoring plan will expand the data set for this site using equipment already installed, allowing for cost savings. This is an excellent opportunity to collaborate with other stormwater monitoring efforts in the basin.

An EIP completed in 2010 (Al Tahoe ECP 1 EIP#696) made several improvements to the catchment, including the installation of 9,694 square feet of permeable pavement on the shoulders of six blocks of residential streets and 3,891 linear feet of perforated storm drain pipes to increase in-situ infiltration wherever feasible throughout the project area. Due to the gentle slope in the area, erosion control measures such as rock-lined channels and stabilization of cut slopes were not as important here. The perforated storm drain pipes include approximately 2,750 linear feet of main line 18-inch and 24-inch perforated pipes under roadways, and smaller diameter perforated pipes connecting drain inlets and sediment traps to back-of-curb infiltration areas. The permeable pavement was an attempt to maximize infiltration and stabilize road shoulders while providing parking and unimpeded snow removal on a stable surface, a challenge that California jurisdictions have been struggling with in their project designs for more than twenty years.

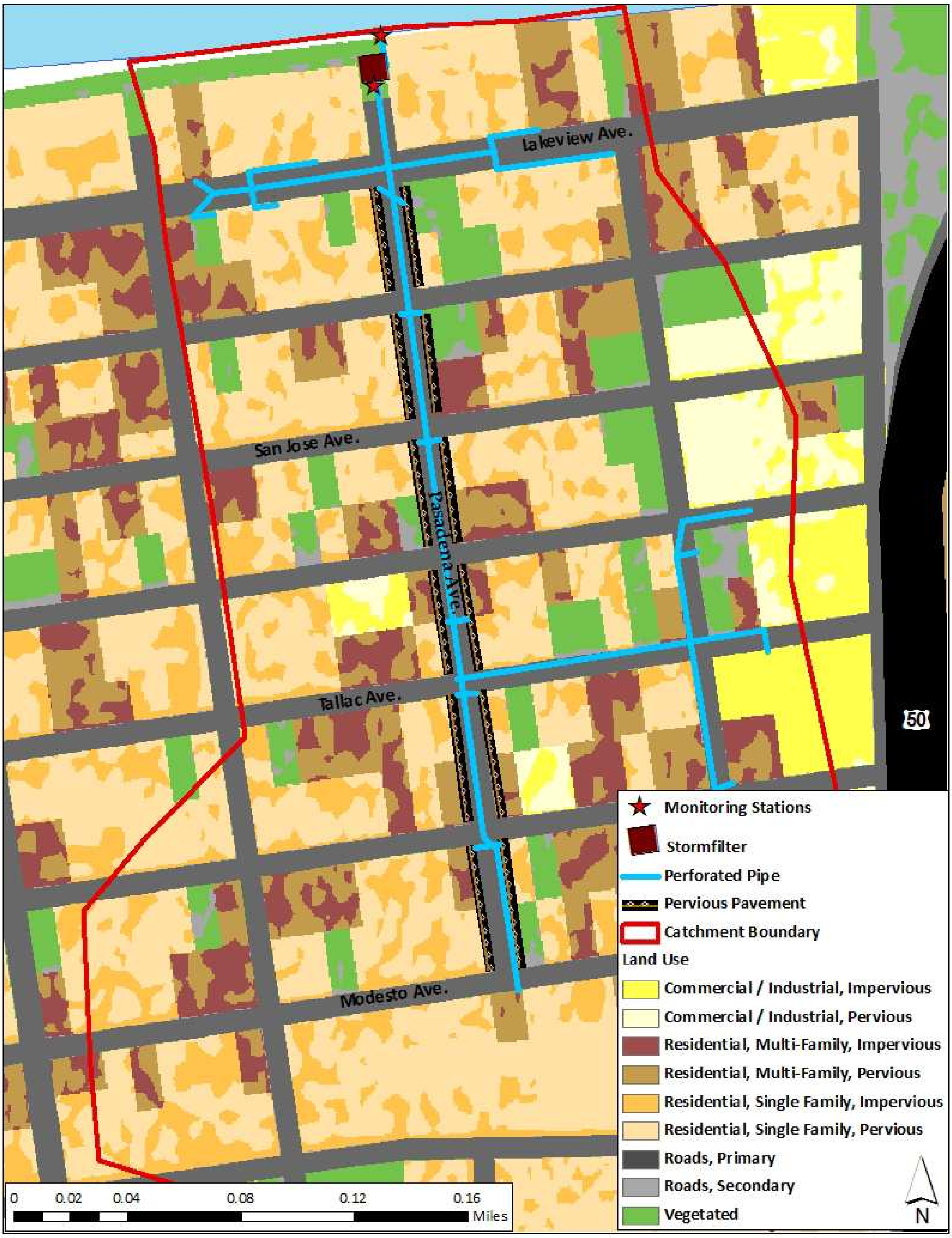

Figure 11: Pasadena monitoring site, catchment boundary and land use distribution.

In addition to the in-situ infiltration BMPs and a pre-treatment Vortechnics storm vault, two Contech Stormfilter vaults were installed in parallel at the end of the catchment before discharge to the lake through the 36-inch CMP. The vaults are configured as shown in Figure 12. The Contech Stormfilter installation located at the north end of Pasadena Ave. consists of two stormwater cartridge filter vaults, larger but outwardly similar to the Contech MFS vault installed at SR431. However, the MFS installed at SR431 has only one float valve that releases the treated stormwater from all the cartridges, while the Stormfilter cartridges have separate float valves on each cartridge (Figure 12). The Stormfilter cartridges have a different surface cleaning mechanism which Contech claims will extend maintenance intervals. The two Stormfilter cartridge vaults together are designed to treat up to 2.2 cfs, but as yet there is no confirmation that bypass starts when flows are greater than 2.2 cfs. Preliminary studies have estimated that only 1.1% of annual flows bypass the system.

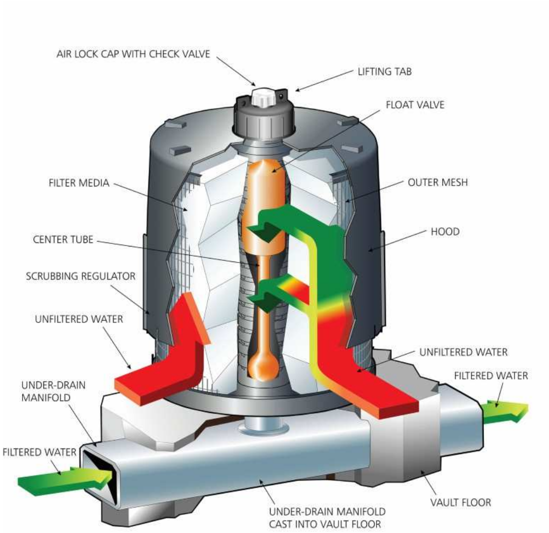

Figure 12: Schematic of single Contech Stormfilter cartridge (photo courtesy of Contech).

The two 8’x16’ vaults contain Stormfilter cartridges filled with a media of zeolite, perlite and granular activated carbon, a mixture called ZPG. The first vault is designed for low-flow conditions. It contains twenty-five 27-inch tall cartridges with smaller orifices, each with a maximum flow rate of 0.025 cfs through a radial media depth of 7-inches. The second vault is designed to handle larger flows. It contains thirty-two 27-inch tall cartridges with orifices that allow for a maximum flow rate of 0.050 cfs through a radial media depth of 7-inches. The lower flow cartridges will retain more sediment but will need to be replaced more frequently than the higher flow cartridges. Maintenance will be based on such factors as depth of sediment accumulation in the bottom of the vaults or on top of the cartridges, depth of static water in the cartridge bay, plugged media pores, and the like. Cartridges containing different filter media are available from Contech for both the Stormfilter and the MFS. If monitoring from the SR 431 site suggests that the cartridges with perlite media may improve BMP effectiveness, the City of South Lake Tahoe could consider ordering perlite cartridges when additional replacement cartridges are needed. By monitoring more than one type of a commonly-considered BMP (cartridge filters) as part of our collaborative monitoring effort, the IMP provides useful information on the effectiveness of Contech's filter cartridges, and improves our understanding of how cartridge filter systems should be maintained.

Two monitoring stations will be instrumented at Pasadena (Figure 13): one at the inflow to the Stormfilter vaults (M1) and one at the outflow from the vaults/catchment outfall (M2). Continuous flow measurements and samples taken at M1 will determine runoff volumes and pollutant loads exiting the dispersed small-scale infiltration BMPs in the catchment and entering the Stormfilter cartridge vaults. Continuous flow measurements and samples taken at M2 will determine runoff volumes and pollutant loads exiting the Stormfilter cartridge vaults, and characterize the catchment outfall. (It is assumed that the Vortechnics vault and junction box have negligible impacts on volume and FSP and nutrient load reductions.) Effluent pollutant loads will be compared to influent pollutant loads to assess the performance of the two-chambered Stormfilter cartridge vaults in reducing pollutant loading to Lake Tahoe. (It is assumed that the Stormfilter cartridge vaults have a negligible storage capacity and therefore will not reduce runoff volumes. In addition, preliminary data has shown that bypass occurs infrequently, however, a stage recorder will be installed at or near the junction box to confirm if/when bypass occurs, and adjustments to calculations will be made accordingly.)

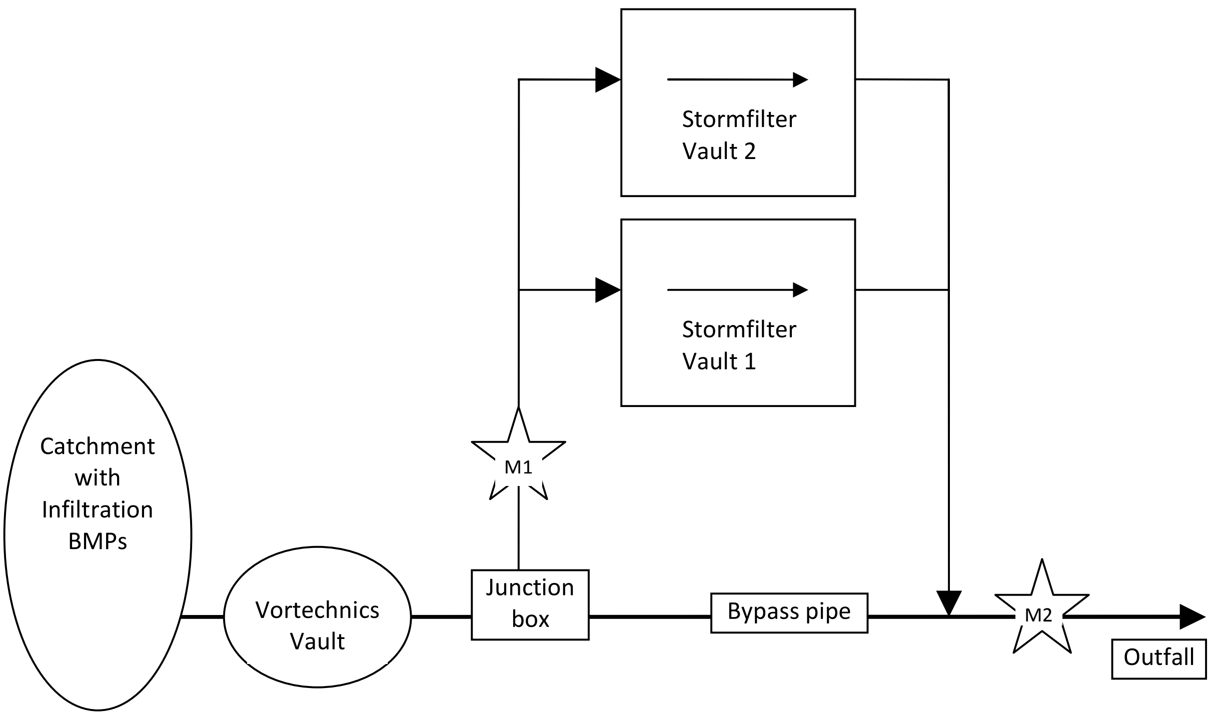

Figure 13: Contech Stormfilter vault configuration at Pasadena Ave. including flow routing and monitoring stations M1 and M2.

It is likely that after a large amount of runoff volume and/or FSP passes through the cartridges, data will show that the ability of the Stormfilter to retain pollutants diminishes. Coupled with visual observations and measurements, this will help to determine maintenance schedules for the two-chambered treatment system. Monitoring data could then be used to confirm whether maintenance, such as cartridge replacement, reverses declines in load reduction performance in the cartridge filter vaults.

STATION INSTRUMENTATION

Each of the eleven monitoring stations will be instrumented with similar equipment as suggested in the Regional Storm Water Monitoring Program Sampling and Analysis Plan (RSMWP SAP, Appendix C) section 6.4 and the Regional Storm Water Monitoring Program Quality Assurance Project Plan (RWSMP QAPP, Appendix D) section 11.1. Each station will have a Job Box to house all instrumentation and prevent loss of data and equipment from vandalism or theft.

The instrumentation at each station will include:

1. An automated sampler (Sigma or ISCO brand) for logging stage and turbidity readings, calculating flows, and collecting samples
2. A bubbler module for measuring stage or area-velocity sensor for measuring stage and velocity (dependent on site characteristics)

In addition, each monitoring site will include:

1. A solar panel for charging Marine Cycle 12V batteries to power equipment (unless access to electricity is available).
2. A nearby meteorological station to record, at a minimum, localized precipitation and ambient temperature. The meteorological station will have a heated tipping bucket to record precipitation so that an accurate reading can be made when precipitation falls as snow.

Turbidimeters for measuring continuous turbidity will be installed at a minimum of three of the five catchment outfalls.

Auto-samplers will be installed in accordance with suggestions outlined in the RSWMP SAP section 6.1.

SITE AND EQUIPMENT MAINTENANCE

The area surrounding each sampling station, as well as the equipment installed at each station will be maintained in accordance with guidelines outlined in the RSWMP SAP section 6.5 and the RWSMP QAPP sections 11.1 and 15. This includes (1) manual seasonal calibration of flow monitoring equipment, turbidity and other sensors, (2) cleaning of equipment and housings, (3) verifying that hoses, intake strainers, and electronics are in good condition, (4) clearing flumes of accumulated sediment and debris, and (5) any other site-specific maintenance activities as determined by monitoring staff.

FLOW MEASUREMENT

Flow will be measured continuously at each of the eleven stations via a bubbler module or area-velocity sensor (AV sensor) as described in the RSWMP SAP section 6.2. The use of a bubbler module or AV sensor will depend on site-specific characteristics. A bubbler module is preferred if site characteristics are such that flow monitoring will be most accurate using a flume or weir. The bubbler will log stage, and flow will be calculated using an equation specific to the flume or weir. If a bubbler module is mounted in a culvert pipe, stage will be converted to flow using the Manning's equation. An AV sensor can be used in a culvert pipe assuming laminar flow and less than 5% slope. Laminar flow can be achieved with a smooth walled pipe insert.

All monitoring stations will be configured such that there is positive outfall from each flow measuring device (i.e. flume, weir, or culvert pipe). No station will experience back-watering as it greatly confounds the data and is nearly impossible to correct.

Flow data will be collected on a continuous basis at all eleven monitoring stations to support seasonal [fall/winter (October 1-February 28), snowmelt (March 1-May 31), and summer (June 1-September 30)] volume reporting.

Flow data will be offloaded using a Rapid Transfer Device (RTD) for ISCO samplers and a Data Transfer Unit (DTU) for Sigma samplers post precipitation event, or at regular intervals during dry periods. Raw data, including but not limited to, flow, stage, velocity, sampling times, turbidity readings, and precipitation, will be transferred and stored on one central District computer.

EVENT PREPARATION, MONITORING AND SAMPLING

All monitoring staff will be trained in accordance with guidelines outlined in the RWSMP SAP sections 7 and 8 and the RSWMP QAPP sections 11.2 and 11.3. This will include weather monitoring, sample bottle preparation, equipment preparation, auto-sampler programming, and sample collection.

WATER QUALITY SAMPLING SCHEDULE

Samples will be taken at each of the five monitoring stations associated with the catchment outfall sites according to the requirements outlined in the Municipal permit, Attachment C.III.A. Samples will be taken at each of the additional monitoring stations associated with the four BMPs (with the exception of R1 at Rubicon) according to the requirements outlined in the Municipal permit, Attachment C.III.B. The sampling requirements outlined in C.III.A and C.III.B are similar and therefore the same sampling strategy will be used for both catchment outfalls and BMP effectiveness evaluation sites. The Municipal permit requires that samples be collected for each seasonal event type. All sampling events will occur during runoff events and sampling will be triggered at a site-specific water level (stage). Runoff events, as defined by the permit, are the result of (a) fall rain, (b) rain-on-snow, (c) spring snowmelt, and (d) summer thunderstorms. These four event types will each be sampled once during the water year at each monitoring station with the exception of station R1 at the Rubicon site. Table 2 outlines the sampling strategy for each water year. The fall rain, rain-on-snow, and summer thunderstorm events will capture the first flush, the rising limb, and the falling limb of the hydrograph. Samplers will be programmed to capture a minimum of twelve samples across the event hydrograph. The first flush sample will be a single sample. The rising limb sample will be a flow-weighted composite of at least five single samples taken during the rising limb of the hydrograph. The falling limb sample will be a flow-weighted composite of at least five single samples taken during the falling limb of the hydrograph. In addition, two single samples at each station for each event will be analyzed for turbidity and FSP. These single samples will be used to establish a site-specific rating curve relating turbidity to FSP concentration. The single samples will be selected to represent the range of expected turbidity and FSP concentrations experienced at the catchment outfall.

For snowmelt events, hydrographs typically follow a diurnal pattern that can repeat for many consecutive days. Due to this duration and complexity, samples from four consecutive snowmelt diurnals will be collected and analyzed. These four consecutive diurnals will be called one snowmelt event. The first of the four snowmelt sampling events will occur on the first spring day warm enough to produce melt (generally over 50 degrees Fahrenheit). The first flush, rising limb and falling limb of the diurnal pattern in the hydrograph will be captured in the same way described above for precipitation events. The following three snowmelt events will each be represented by a composite of 10-12 samples covering a complete diurnal cycle in the hydrograph. An attempt will be made to capture the highest diurnal peaks in the hydrograph over the course of spring snowmelt. These three composite samples will not have designated first flush, rising limb, and falling limb samples, but will represent a diel and allow for a spring season EMC to be estimated for each year sampled.

The sampling frequency presented in this monitoring plan is designed to meet the minimum requirements of the NPDES permit. It should also be adequate for beginning to address the secondary goal of enhancing the Permittees' existing load estimations, condition assessment methods, and the effectiveness of their overall pollutant load reduction program.

The monitoring methods implemented for this plan are comparable to methods outlined in the RSWMP SAP and the RSWMP QAPP. These methods have been developed over a decade, have withstood the rigors of intensive monitoring, and are generally used by the monitoring community in Lake Tahoe.

Table 2: The events sampled at each monitoring station, the corresponding samples generated for each event, and the total number of samples generated over the three year monitoring period.

Event #	Event Type	WYs monitored	Approximate Time Period	Season	Samples generated for TP, TN, TSS, Turbidity, and FSP analysis at each monitoring station per event	Additional samples generated for Turbidity and FSP analysis at each monitoring station per event	Total Samples Generated[2]
1	Fall Rain	14, 15, 16	October-November	Fall/Winter	1 first flush single 1 rising limb composite 1 falling limb composite 0.3 QC samples[1]	1 rising limb single 1 falling limb single	**159**
2	Rain on Snow	14, 15, 16	December-February	Fall/Winter	1 first flush single 1 rising limb composite 1 falling limb composite 0.3 QC samples[1]	1 rising limb single 1 falling limb single	**159**
3	Snowmelt	14, 15, 16	March-May	Spring	1 first flush single 1 rising limb composite 1 falling limb composite 3 diel composites 0.6 QC samples[1]	1 rising limb single 1 falling limb single	**258**
4	Thunderstorm	14, 15, 16	June-September	Summer	1 first flush single 1 rising limb composite 1 falling limb composite 0.3 QC samples[1]	1 rising limb single 1 falling limb single	**159**

[1]One QAQC sample will be taken at rotating sites for every 10 samples generated - does not consider additional FSP samples

[2]Number years*Number sites*Number samples per event*Number events per year

CONTINUOUS TURBIDITY MEASUREMENT

Recent studies have suggested that a significant site-specific correlation exists between turbidity and FSP concentration (2NDNATURE and NHC 2010b, Heyvaert et. al., 2010). Therefore, turbidity will be measured continuously at all sites unless site specific characteristics determine that the site is unsuitable for turbidimeter instrumentation. Coupled with the site-specific rating curve relating turbidity to FSP concentration generated by the required paired turbidity and FSP analyses, continuous turbidity readings are expected allow for reasonable estimation of FSP loading from each site. With the development of site-specific rating curves, monitoring efforts could become more cost-effective. In fact, if successful, turbidity data has the potential be used as a surrogate by which sediment and nutrient loads are extrapolated.

METEOROLOGICAL DATA

Meteorological data will be collected within 0.25 miles of the monitoring site. Depending on site specific characteristics, the data will be collected on a 5, 10 or 15 minute time interval and include, at a minimum, inches of precipitation and ambient temperature. These readings, coupled with long-term regional meteorological data, will allow for an assessment of whether the season was dry, average, or wet. In addition, collecting meteorological data is imperative to understanding runoff response to rain (i.e. calculating runoff coefficients (runoff volume per inch of rain) in each catchment). Determining rainfall-runoff response gives information as to the impervious connectivity, rainfall-runoff relationships, rainfall intensity and associated peak flows. The meteorological data is also critical for running catchment scale event simulations with the SWMM5 model. By analyzing multiple storm events with SWMM5, one can determine calibrated hydrologic parameters that can then be used in PLRM to generate pollutant load estimations with higher confidence. Indefinite model parameters such as connectivity, road condition, average slope, and others can be adjusted within a realistic range until the model reasonably predicts runoff volumes at each site. This work will be done in conjunction with NHC to ensure that parameters are adjusted in a manner consistent with previous modeling efforts. A strong correlation between model-predicted runoff volumes and empirical runoff volumes at each site can provide a better level of confidence in the PLRM predicted pollutant loads.

SAMPLE HANDLING AND PROCESSING

Sample handing and processing will follow guidelines outlined in the RSWMP SAP section 9 and the RSWMP QAPP section 12. This includes proper labeling of samples in the field, transporting samples to a laboratory immediately after collection in a cooler, compositing single samples on a flow-weighted basis, filtering samples within a 24-hour period before shipping to an analytical laboratory, and proper chain-of-custody procedures.

QUALITY CONTROL

A minimum of 10% of all samples analyzed will be quality control (QC) samples to identify problems related to field sampling and sample processing. The samples will include the following QC types: field blanks, method blanks, and field replicates as defined in the RSWMP SAP section 11 and the RSWMP QAPP section 14.1. These samples will be used to ensure proper instrument function, sample handling procedures, and laboratory methods. This equates to approximately three QC samples per storm event, rotating sites and QC sample type throughout the year.

SAMPLE ANALYSIS

Samples will be analyzed for the Lake Tahoe TMDL pollutants of concern: FSP concentration, total nitrogen (TN) concentration, and total phosphorus (TP) concentration. In addition, samples will be analyzed for total suspended solids (TSS) and turbidity. In addition to the single first flush samples, two additional single samples (i.e. not composite samples) from each station for each runoff event will be analyzed for turbidity and FSP concentration to establish a site-specific rating curve relating these two analytes. The single samples selected for turbidity and FSP analysis will span the range of expected turbidity and FSP concentrations at each monitoring station. TN, TP and TSS concentrations will be reported in mg/L and turbidity in NTUs. FSP concentration will be reported in mg/L and converted to number of particles per liter using a formula outlined in Heyvaert et. al. 2011. In order to determine FSP concentration, the recommended bin sizes for reporting particle size distribution analysis are taken from the phi series (Heyvaert et.al., 2011) and are from 0.5µm to <1, <2, <4, <8, <16, <31, <63, <125, <250, <500, <1000, and <2000 µm. FSP concentration will be the sum off all bin sizes 16 µm and less.

Analytical laboratories are selected in accordance with the RSWMP QAPP section 13 and require certification. Samples will be analyzed using methods recommended in Table 3, or a proven similar method, and follow quality control requirements outlined in the RSWMP QAPP section 14.2.

Table 3: Recommended analytical methods and reporting limits.

Analyte	Methods	Description	Target Reporting Limit
Total Dissolved Phosphorus as P	EPA 365.1 w/ USGS I-4600-85; or EPA 365.2; or EPA 365.3; or SM 4500-P-F	Colorimetric, persulfate digestion, phosphomolybdate	10 ug/L
Total Kjeldahl Nitrogen	EPA 351.1; or EPA 351.2	Colorimetric, block digestion, phenate	50 ug/L
Total Suspended Solids	EPA 160.2 or SM 2540-D	Gravimetric	1 mg/L
Turbidity	EPA 180.1 or SM 2130-B	Nephelometric	0.1 NTU
Particle Size Distribution	SM 2560 or RSWMP addendum SOP	Laser backscattering	na

DATA MANAGEMENT

Data will be offloaded from the auto-samplers with data transfer devices at the time samples are collected or maintenance is required. Any other field measurements and observations will be recorded in a field notebook. Samples, data transfer devices and notes will be transported to a processing lab immediately after collection. Data transfer devices will be offloaded onto a computer, and all data will be input into an Excel template for storing continuous parameters as well as sample dates and times. Each monitoring site will have its own workbook. A separate Excel template will be used for calculating flow-weighted compositing schedules for the rising and falling limb composites at each monitoring station. All samples will be filtered for TSS and values will be recorded on standard data sheets in the laboratory and entered into an Excel template for storing nutrient and sediment data. All samples will also be sent to proper laboratories within appropriate holding times for total phosphorus, total nitrogen, and particle size distribution (FSP) analysis. Results from analytical laboratories will be entered into the Excel template for storing nutrient and sediment data. All Excel workbooks will be housed on one central computer (with backup device) and managed by District staff.

DATA REVIEW

Analytical results will need to be reviewed for accuracy and precision. Data quality will be reviewed and data will be accepted or rejected following rules outlined in the RSWMP SAP section 12.1.

Continuous data series logged at each monitoring station consist of parameters measured in the field at a constant time interval. These data will include, at a minimum, stage, flow, and turbidity readings. These series will be reviewed and corrected following rules outlined in the RSWMP SAP section 12.2.

DATA ANALYSIS AND REPORTING

Data contained in the Excel templates described in the Data Management section of this document will be used to calculate flow volumes and pollutants loads to Lake Tahoe. In particular, the collected data will be analyzed to serve the following purposes:

1. Continuous flow data will be used to calculate event, seasonal, and annual flow volumes in cubic feet for fall/winter (October 1 – February 28), spring snowmelt (March 1 – May 31), and summer (June 1 – September 30) at the catchment outfalls. These volumes will be reported.
2. Continuous flow data will be used to calculate event, seasonal, and annual influent and effluent volumes in cubic feet for fall/winter (October 1 – February 28), spring snowmelt (March 1 – May 31), and summer (June 1 – September 30) at the BMPs. These volumes will be reported.
3. Flow-weighted Event Mean Concentrations (EMCs) will be calculated and reported for each catchment outfall for each season (based on a single event) at each monitoring station for TN, TP, FSP, TSS, and turbidity using the first flush single sample, the flow-weighted rising limb composite sample, and the flow-weighted falling limb composite sample. In the case of spring snowmelt, the three flow-weighted diel composites will also be included in the flow-weighted EMC. In addition, the first flush concentration will be reported for each station for each season using only the first flush sample concentrations.
4. Influent and effluent concentrations of TN, TP, FSP, TSS, and turbidity will be calculated and reported for each BMP for each season (based on a single event) using the EMCs described in (3).
5. Concentrations of TN and TP will be reported in mg/L. Concentrations of FSP will be reported in mg/L and number of particles per liter. Concentrations of TSS will be reported in mg/L, and turbidity in NTUs.
6. TN, TP, FSP, and TSS loads will be calculated and reported for each catchment outfall for each season (based on a single event) using the EMCs described in (3) and the continuous flow data.

7. Influent and effluent TN, TP, FSP, and TSS loads will be calculated and reported for each BMP for each season using the EMCs described in (3) and the continuous flow data. The influent and effluent loads will be compared and the pollutant load reduction resulting from the cartridge filter vaults and subsurface infiltration chambers will be reported for each season (based on a single event).
8. Loads will be reported in kilograms for TN, TP and TSS, and in number of particles for FSP.
9. Paired turbidity and FSP concentrations on single samples will be used to establish site-specific rating curves relating FSP concentration to turbidity. These rating curves will be applied to the continuous turbidity data collected at select monitoring stations and allow for calculations of FSP loading per season to be made at the catchment outfalls. This is a second method for determining FSP loads from catchment outfalls. *(The seasonal FSP load reduction calculated using this method will be different than the one calculated in (6) because it will be based on continuous data as opposed to a single event.)*
10. Results from the QC samples collected for the year will be summarized and reported.
11. Catchments will be modeled using PLRM. Modeled estimates of runoff volumes and pollutant loads ("expected" conditions) will be compared to empirical data ("actual" conditions) in the context of water year type (wet, average, dry).
12. Beginning with the second year of monitoring, data from all eleven monitoring stations will be compared to results from previous years, noting trends and inter-annual variability in the context of water year type (wet, average, dry)

As condition assessments (i.e. Road RAM and BMP RAM) are performed and resulting RAM scores are obtainable, analysis may also include correlations between scores and monitoring data. Because previous work has identified that road condition is a strong indicator of resulting water quality (2NDNATURE and NHC, 2012), condition assessment data, where and when available, will be collated to better understand the relationship between observed catchment or BMP condition and measured pollutant loads.

Under Annual Reporting Requirements, Section IV of the permit's Monitoring and Reporting Program, the District will not fulfill the requirements outlined in sections A-E or G-J. The District will *only* be responsible for section IV.F., Stormwater Monitoring Report. However, results reported in the Stormwater Monitoring Report will inform many of the requirements outlined in sections IV.A-E and G-J. The District, on behalf of the IMP, will submit a single annual report by January 15th of the year following the end of each water year (September 30th) to each participating jurisdiction, synthesizing all data collected for stormwater monitoring, including results and analyses described above. Table 4 outlines the annual monitoring schedule for each water year monitored. All required details and discussions listed in Section IV.F.1-16 of the permit will be included. This annual Stormwater Monitoring Report is meant to be included in each participating jurisdiction's larger NPDES report due March 15th of the year following the end of each water year to the Lahontan Regional Water Quality Control Board.

All electronic data will be in a format compatible with the Surface Water Ambient Monitoring Program (SWAMP) database and entered into the California Environmental Data Exchange Network (CEDEN). All monitoring data and associated analytical reports will be available to managers on permittees' websites or through a regional data center. Stakeholders and members of the general public will be notified of the availability of electronic and paper monitoring reports through notices distributed by appropriate means.

Table 4: Annual monitoring schedule for each water year monitored.

Annual Monitoring Schedule Implementers' Monitoring Program												
Tasks	**Repeating Schedule for Water Years 14-16**											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Planning												
Data Collection												
Data Analysis												
Reporting												

MONITORING PLAN UPDATE OR REVISION

This monitoring plan may be revisited and revised as new information becomes available, such as recommendations from the forthcoming RSWMP effort, or in response to modifications to permit or agreement language. Any proposed modifications would need to consider budget constraints and dollars available to implement a revised monitoring plan.

BUDGET

Table 5 shows a detailed budget identifying how SNPLMA funds and in-kind salary and equipment match from the District and partnering jurisdictions are expected to be utilized. Because the District views this project as an important service to the public and the jurisdictions, grant management of this project, including operations and administration, will be just over 10% of the total budget. Personnel related to "District and NTCD Monitoring Staff" have yet to be determined and will be hired as needed when monitoring begins in October 2013. Catchment outfall and BMP data collection, analysis, and site management will account for up to 25% of the total budget. Modeling and data reporting is projected to make up less than 10% of the total budget. Contracted services with UCD and DRI will compose approximately 4% of the total budget. The sampling supplies category is broadly defined as the District is still working with partner equipment match to determine what can be borrowed and what must be purchased. The sampling and filtering supplies categories account for about 6% of the total budget. Sample analysis accounts for about 10% of the total budget. The remaining 35% is accounted for by in-kind and equipment match. Matched amounts shown in italics indicate $100,000 in cash matched by NDOT. Hours projected for each task are also identified in Table 5.

Table 5: Detailed budget outlining expenditures and match.

	Description	Total Hours	Matched Hours	Amount Requested	Amount Matched	Total Budget
Task 1	**Grant Management**					**$ 158,000**
District	Operations			$ 51,000		
District	John Skeel	477	429	$ 30,000	$ 27,000	
District	Kim Gorman	208	832	$ 10,000	$ 40,000	
Task 2	**Collaborative Monitoring Plan**					**$ 7,000**
District	Andrea Parra	25	149	$ 1,000	$ 6,000	
Task 3	**Catchment Outfall Data Collection, Data Analysis, and Site Mgmt**					**$ 179,000**
District	Andrea Parra	1,735	347	$ 70,000	$ 14,000	
District	Kim Gorman	374	218	$ 18,000	*$ 10,500*	
District	District Monitoring Staff	737	517	$ 28,500	*$ 20,000*	
NTCD	NTCD Monitoring Staff	293	81	$ 18,000		
Task 4	**BMP Effectiveness Data Collection, Data Analysis, and Site Mgmt**					**$ 179,000**
District	Andrea Parra	1,735	347	$ 70,000	$ 14,000	
District	Kim Gorman	374	218	$ 18,000	*$ 10,500*	
District	District Monitoring Staff	737	517	$ 28,500	*$ 20,000*	
NTCD	NTCD Monitoring Staff	293	81	$ 18,000		
Task 5	**PLRM Modeling**					**$ 40,000**
District	District Modeling Staff	462		$ 17,000		
District	Andrea Parra	570		$ 23,000		
Task 6	**Contracted Scientific Advisor**					**$ 19,000**
DRI	Alan Heyvaert	125		$ 19,000		
Task 7	**Project Reporting**					**$ 98,500**
District	Andrea Parra	1,252		$ 50,500		
District	Kim Gorman	499	499	$ 24,000	$ 24,000	
	Contracted Service Costs (Monitoring Site Design, Installation, and Maintenance)					**$ 55,000**
UCD	Raph Townsend	800		$ 55,000		
	Sampling Supplies					**$ 65,500**
	Autosamplers, accessories, solar panels, flumes			$ 25,500		
	Weather station, accessories			$ 4,000		
	FTS-DTS12 Continuous Turbidimeters			$ 11,000		
	Repairs, Maintenance and Miscellaneous Supplies			$ 25,000		
	Filtering Supplies					**$ 28,000**
	Glassware, filter towers, filters, bottles, coolers, lab gloves etc…			$ 15,000		
	Turbidity meter, Hach 2100N range <0.1-4,000 NTU			$ 3,000		
	DI water system, miscellaneous supplies, and maintenance			$ 10,000		
	Sample Analysis					**$ 146,000**
	Fine Sediment Particles (FSP) - 820 samples at $45 each			$ 37,000	*$ 3,000*	
	Nutrients (Total Nitrogen, Total Phosphorus) - 548 samples at $89 each			$ 49,000	*$ 3,000*	
	Margin of safety (roughly 25% of analysis costs)			$ 21,000		
NDOT	SR431 Data Resolution Pilot Study				*$ 33,000*	
	Total Budget			**$ 750,000**	**$ 225,000**	**$ 975,000**
	Matched amounts in italics indicate NDOT cash					

BIBLIOGRAPHY

Assessment of Particle Size Analysis in the Lake Tahoe Basin. Heyvaert, Alan C., Nover, Daniel M., Caldwell, Todd G., Trowbridge, Wendy B., Schladow, S. Geoffrey, Reuter, John E. Prepared by Desert Research Institute, Division of Hydrologic Sciences, and University of California, Davis, Tahoe Environmental Research Center. Prepared for USDA Forest Service, Pacific Southwest Research Station. February 2011.

Data Quality Objectives, Tahoe Regional Stormwater Monitoring Program. Division of Hydrologic Sciences, Desert Research Institute and Tahoe Environmental Research Center, University of California, Davis. May 10, 2011a.

Focused Stormwater Quality Monitoring to Inform Assumptions and Evaluate Predictive Capabilities of Existing Tools, Final Technical Report. 2NDNATURE INC. and NHC. June 2012.

Incline Village Commercial and Lower Wood Creek Water Quality Improvement Project As-Built Plan Set. Lumos and Associates. 2000.

Lake Tahoe BMP Monitoring Evaluation Process, Synthesis of Existing Research. 2NDNATURE INC. October 2006.

Lake Tahoe Total Maximum Daily Load Technical Report. California Regional Water Quality Control Board, Lahontan Region, and Nevada Division of Environmental Protection. June 2010.

National Pollutant Discharge Elimination System (NPDES) Permit for Discharges from Nevada Department of Transportation System Municipal Separate Storm Sewer Systems, Permit NV0023329. Bureau of Water Pollution Control, Nevada Division of Environmental Protection. July 7, 2010.

National Pollutant Discharge Elimination System (NPDES) Statewide Storm Water Permit Waste Discharge Requirements (WDRS) for State of California Department of Transportation. NPDES No. CAS000003, Order No. 2012-0011-DWQ. California State Water Resources Control Board. Effective Date: July 1, 2013.

PLRM v1 Focused Stormwater Monitoring to Validate Water Quality Source Control and Treatment Assumptions Technical Report, Final Document. Prepared for the Army Corps of Engineers, Sacramento District. 2NDNATURE INC. and NHC. March 2010a.

PLRM Refinement Monitoring, Phase II Monitoring Plan, Final Document. Prepared for USFS Pacific Southwest Research Station. 2NDNATURE INC. and NHC. July 2010b.

Quality Assurance Program Plan, Tahoe Regional Stormwater Monitoring Program. Division of Hydrologic Sciences, Desert Research Institute and Tahoe Environmental Research Center, University of California, Davis. May 10, 2011b.

Sampling and Analysis Plan, Tahoe Regional Stormwater Monitoring Program. Division of Hydrologic Sciences, Desert Research Institute and Tahoe Environmental Research Center, University of California, Davis. May 10, 2011c.

Updated Waste Discharge Requirements and National Pollutant Discharge Elimination System (NPDES) Permit for Storm Water/Urban Runoff Discharges from El Dorado County, Placer County, and the City of South Lake Tahoe Within the Lake Tahoe Hydrologic Unit. Monitoring and Reporting Program, No. CAG616001, Order R6T-2011-0101A. California Regional Water Quality Control Board Lahontan Region, State of California. October 10, 2012.