APPENDIX B

Developing Community-Based Watershed Strategies for the Lake Tahoe Basin – 2014/2015

EPA SPONSORED - SNPLMA FUNDING

Tahoe Resource Conservation District

A COMMUNITY WATERSHED PARTNERSHIP

Final Watershed Strategy Report
Tahoma, California

Produced by:
The Tahoe Resource Conservation District

Submitted to:
The Environmental Protection Agency

March 2015

We Do Conservation!

TABLE OF CONTENTS

ACRONYM LIST

TMDL	Total Maximum Daily Load
BMP	Best Management Practice
Tahoe RCD	Tahoe Resource Conservation District
LID	Low Impact Development
CWP	Community Watershed Partnership
SNPLMA	Southern Nevada Public Lands Management Act
NRCS	Natural Resource Conservation Service
EPA	Environmental Protection Agency
CTC	California Tahoe Conservancy
USFS	United States Forest Service
TRPA	Tahoe Regional Planning Agency
Water Board	Lahontan Regional Water Quality Control Board
NPDES	National Pollutant Load Elimination Permit
PLRM	Pollutant Load Reduction Model
IMP	Implementers' Monitoring Program
TAC	Technical Advisory Committee
RSWMP	Regional Stormwater Monitoring Program
CICU	Commercial/Industrial/Communications/Utilities
EIP	Environmental Improvement Plan
ROW	Right of Way
GIS	Geographic Spatial Information
SEZ	Stream Environment Zone
FSP	Fine Sedimanet Particles
SFR	Single Family Residential
TN	Total Nitrogen
TP	Total Phosphorus
QA/QC	Quality Assurance and Quality Control
CFS	Cubic Feet Per Second

INTRODUCTION

Lake Tahoe is among the largest, deepest, and clearest lakes in the world. Its cobalt blue appearance, spectacular alpine setting, and remarkable water clarity is recognized worldwide. Recreational opportunities and scenic vistas have made Lake Tahoe a top national and international tourist destination. While visibility into the lake's depths is currently at 70 feet, it is listed as impaired because over thirty feet of clarity has been lost since the late 1960s. To address the impairment, the Lake Tahoe Total Maximum Daily Load (TMDL) program was adopted in 2011; it brought with it new regulatory requirements for state and local stormwater jurisdictions to reduce urban pollutant loads to Lake Tahoe.

Approved by the Environmental Protection Agency and the states of California and Nevada, the TMDL sets targets for a significant reduction of fine sediments, nitrogen, and phosphorus flowing to Lake Tahoe. Currently, stormwater jurisdictions are required to implement urban best management practices (BMPs) to decrease pollutant loading from urban runoff as part of their TMDL requirements. Through this process area-wide stormwater treatment has become a preferred strategy for effective TMDL implementation. Expected benefits include costs savings related to the economy of scale, and effective maintenance and tracking of pollutant loads.

In 2014, the Tahoe Resource Conservation District (Tahoe RCD) performed a technical analysis of the Tahoma watershed to help support TMDL adaptive management actions. This work was performed under a program called the Community Watershed Partnership. Through this program and the BMP retrofit program the Tahoe RCD has provided homeowners with free technical services related to residential BMP planning and implementation, and is now evaluating the use of LiDAR identified microbasins (small depressions on the landscape) to assist in the effort to implement Low Impact Development (LID) techniques within an area-wide stormwater system versus implementing residential BMPs on parcel by parcel basis.

PROJECT BACKGROUND

The Community Watershed Partnership (CWP) was developed through funding provided by the Southern Nevada Public Lands Management Act (SNPLMA), and sponsored by both the Natural Resources Conservation Service (NRCS) and the Environmental Protection Agency (EPA). The funding for this program is intended to identify and address natural resource concerns or needs at a watershed level, and is designed to engage a variety of stakeholders to help facilitate communication between landowners, the general public, and Basin managers in furthering TMDL implementation and the restoration of Lake Tahoe.

The CWP approach compliments the many environmental improvement projects implemented around the Lake Tahoe Basin by the California Tahoe Conservancy (CTC), U.S.D.A. Forest Service (USFS), the Counties of El Dorado and Placer, and the City of South Lake Tahoe (local stormwater jurisdictions). Improvements gained in water quality have largely resulted from urban capital improvement projects, as well as restoration work in stream environment zones. In addition to implementing large scale projects, there are opportunities for each private property owner to contribute to watershed restoration efforts by either implementing individual water quality BMPs on their parcel, or by partnering with stormwater jurisdictions on area-wide treatment. Ultimately, successful implementation of BMPs on both the public and private scale will move Lake Tahoe closer to attaining its clarity goals. How each neighborhood or urban center executes this process will be a focus for Basin managers for the next several decades.

In 2002, the Tahoe RCD, the Nevada Tahoe Conservation District (NTCD), NRCS, and the Tahoe Regional Planning Agency (TRPA) adopted a Memorandum of Understanding to establish a partnership that would provide technical support to homeowners, contractors and property managers in implementing water quality BMPs. Through grant funded incentive programs, the Tahoe RCD and its partners provided cost free property evaluations and BMP implementation plans for over fifteen years, however deadlines for Basin-wide compliance have come and gone since 2008. After more than a decade, only about three out of every ten private properties on the California side of the Tahoe Basin has achieved BMP compliance; the level of implementation in Tahoma is even lower at approximately 14 percent.

In addition, following the adoption of the TMDL in August 2011, the Lahontan Regional Water Quality Control Board (Water Board) approved a Municipal National Pollutant Discharge Elimination System (NPDES) permit requiring the 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 fine sediment and nutrient inputs, and must monitor and evaluate select urban catchment outfalls and County owned BMPs for flow volumes and sediment and nutrient loads.

In order to assist with implementing TMDL objectives, in 2013 the Tahoe RCD developed a monitoring plan with three primary goals: (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. Approved by both California and Nevada TMDL regulators in 2013, the Implementers' Monitoring Plan established a lake-wide partnership between the Tahoe RCD, El Dorado County, Placer County, the City of South Lake Tahoe, Caltrans, Douglas County, Washoe County, NTCD, and the Nevada Department of Transportation known as the Implementers' Monitoring Program (IMP).

PROJECT SCOPE

The Tahoma community was identified as a priority watershed for development of a community-based Watershed Strategy through a CWP ranking process that evaluated proximity to the lake, slope, soils, precipitation, and modeled pollutant load contributions. The development of the CWP Strategy was guided by a Technical Advisory Committee (TAC) led by the Tahoe RCD, and in partnership with EPA, El Dorado County, and the Water Board to ensure the project was well coordinated and relevant to other projects implemented in the watershed.

The goal of EPA's Community Based Watershed Strategy grant is to explore approaches that integrate strategies for public and private solutions using education, information sharing and partnership development in the watershed. Through this effort it is expected there will be an increased knowledge in the usefulness of using LiDAR for planning LID area-wide projects, modeling information related to TMDL adaptive management.

Primary deliverables presented in this report include:

- *Microbasin Field Evaluation* – collaboration with University California, Davis to ground truth LiDAR exercise to locate potential microbasin opportunities for LID area-wide treatment.
- *Pollutant Load Reduction Modeling* – to evaluate level of effort to achieve 100% c*ompliance for residential BMP com*pliance.
- *Water Quality Evaluation* – Evaluation in support of TMDL adaptive management.

Work performed under this project also highlights the monitoring performed by the IMP, as well as provide data comparisons between the currently accepted autosampler method described in the NPDES permit, and an in situ continuous automated turbidimeter method that may prove to be a reliable alternative method for monitoring sediment. The monitoring evaluation will also assess data resolution needs related to number of events collected per year under the NPDES permit.

Tahoma was one of the many sites selected by the IMP as a catchment outfall monitoring site for NPDES permit compliance. Under the current IMP monitoring plan, only four precipitation events per year are monitored. The additional level of data collection will help assess data resolution needs for attaining reasonable annual pollutant loads within the Tahoma catchment. With these funds the Tahoe RCD monitored an additional seven storms beyond what is stated in the IMP Monitoring Plan for the Tahoma Watershed.

Furthermore, data collected under the NPDES permit and the EPA funds are complementary to long-term regional stormwater monitoring efforts proposed under the Tahoe Basin's Regional Storm Water Monitoring Program (RSWMP). All data was 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 (DRI et al 2011a), Quality Assurance Project Plan (DRI et al 2011b), and Sample Analysis Plan (DRI et al 2011c).

WATERSHED CONDITION

Lake Tahoe is currently listed as an impaired water body. The TMDL program was developed to address this impairment through implementing a comprehensive, long-term plan to reverse the decline in deep-water transparency to the 1967-1971 level of 29.7 meters (97.4 feet). TMDL science suggests that approximately 70 percent of fine sediment particles (FSP, <16 µm in diameter), and between 15-35 percent of nutrients are coming from the built environment, and our roadways (Lake Tahoe TMDL Technical Report, 2010).

The Tahoma catchment is considered a rural community on the west shore of Lake Tahoe. The 49.5 acre catchment straddles the Placer County/El Dorado County border and comingles waters from both jurisdictions (Figure 1), 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 has strong hydrologic connectivity to Lake Tahoe and discharges pollutant loads directly to the lake.

No recent water quality improvement projects have been completed in this drainage. However, due to steep roadways, eroding cut slopes and direct discharges of untreated stormwater to Lake Tahoe, El Dorado County plans to implement a water quality improvement project in 2015, listed within the Lake Tahoe Environmental Improvement Program (EIP).

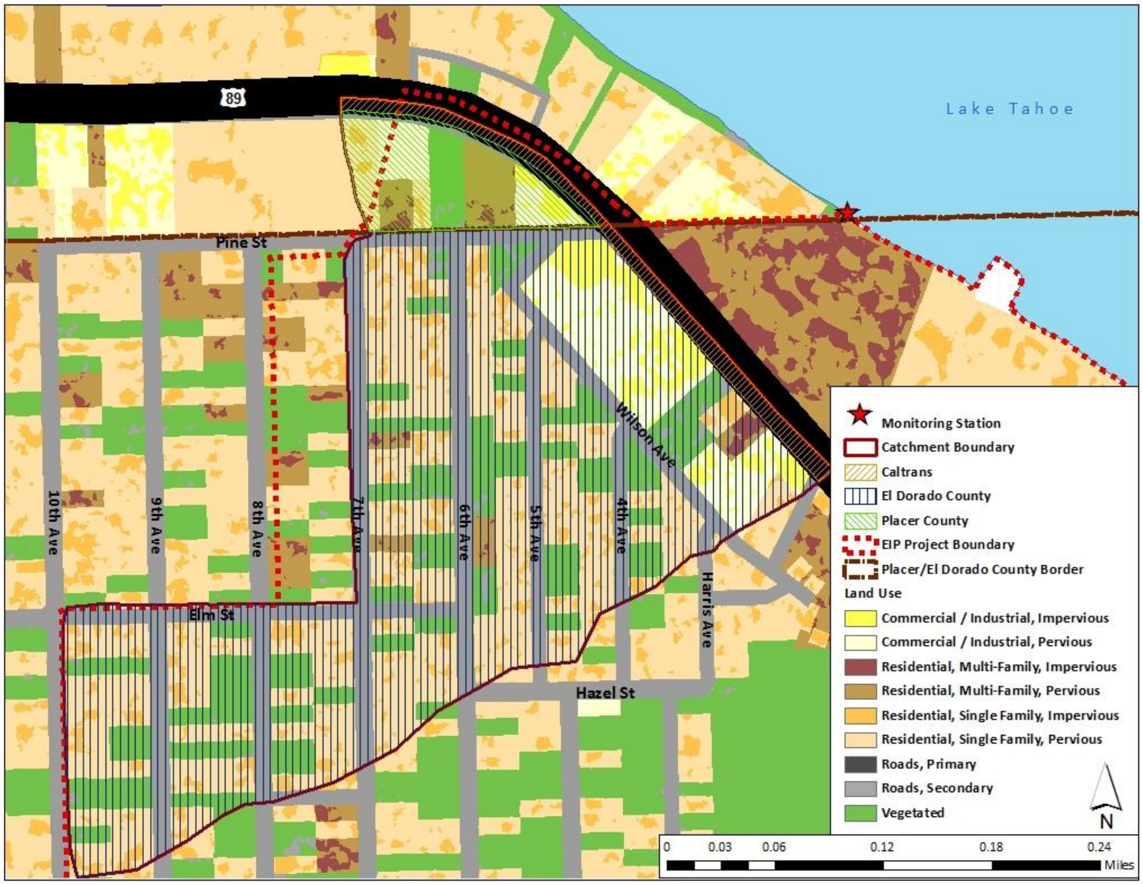

Figure 1: Tahoma monitoring station, including catchment boundary, EIP project boundary, and land use.

The EIP project will focus on reducing sediment delivery 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. It is anticipated that improved hydrologic design will store and spread out stormwater more effectively in the upper watershed and/or treat runoff from the El Dorado County right-of-way (ROW) before it discharges to Lake Tahoe. El Dorado also proposes to work with Caltrans, the CTC, Placer County, the Tahoe RCD and private land owners to develop a comprehensive watershed management plan within the project boundary.

The monitoring station (station T1) is located near the mouth of the drainage, and data from this site will characterize runoff from the catchment outfall. This site also provides the unique opportunity to collect data related to pre- and post- water quality improvements. The lessons learned in this catchment will be valuable to other moderate density residential neighborhoods with direct hydrologic connectivity to Lake Tahoe.

SOILS & VEGETATION

Tahoma soils have slopes that range from 2 - 50 percent. The Tahoma soil series consists of deep well drained soils that formed in material weathered from basic volcanic rock. Tahoma soils tend toward gravel and sandy and clay loam - forested on a southeast facing convex slope of 10 percent under a cover of red fir. Rock fragments in the upper 20 inches ranges from 5 to 35 percent gravel and 0 to 15 percent cobbles; the lower part ranges from 5 to 50 percent gravel and 0 to 20 percent cobbles and stones. The soil structure ranges from weak to strongly granular, but organic matter tends to be low at five to seven percent. The physical structure of the soils characteristics in this watershed result in predominantly well drained soils that are moderately permeability. The mean annual precipitation is approximately 40 inches.

Native vegetation is representative of a typical Mediterranean environment with mixed conifers and shrubs where the principal species are red fir, white fir, Jeffrey pine, lodgepole pine, mountain whitethorn, manzanita, and mahala mat (Watershed Assessment, 2000).

PROJECT APPROACH

Knowledge gained from this project will be used to assist El Dorado County with planning for future project implementation in the Tahoma, California watershed, as well as assist with TMDL adaptive management strategies related to EIP project effectiveness monitoring. Watershed evaluations presented in this section discuss opportunities for improving stormwater quality affecting Lake Tahoe, the specific tools, details on approach, and findings are summarized below.

DISPERSED MICROBASINS

Tahoe Resource Conservation District (Tahoe RCD) staff conducted a field assessment of potential microbasins identified by the University of California, Davis and the Universidad de Granada though the use of Light Detection and Ranging (LiDAR) data. The microbasins assessed were located on public lands in the Tahoma area. The main finding during field assessment was that all areas identified as potential microbasins were difficult to visually identify, and high groundwater was a common constraint.

Geoff Schladow (University of California, Davis) in collaboration with the Universidad de Granada, analyzed LiDAR data for the Tahoe basin to determine potential micro basins for storm water infiltration. The LiDAR data have a horizontal resolution of 0.5m and an estimated vertical accuracy of 3.5cm. The micro basins are identified as natural depressions in the landscape, and analyses is conducted to determine the potential volume of water that could be detained with retaining wall heights of 0.75m, 1m, 1.25m, 1.5m, 1.75m, and 2m. The idea is that these micro basins could be utilized to provide distributed storm water treatment capabilities similar to much larger detention basins at a fraction of the cost. The Tahoe RCD conducted an initial field assessment of the potential storm basins identified with LiDAR to determine if the basins would be feasible to install. The field assessment was focused in the Tahoma area (see Figure 2. below).

In collaboration with NRCS, Tahoe RCD staff identified the following selection considerations for initial assessment to narrow down the number of basins:

- Public land ownership, determined with a geographic information system (GIS)
- Hydrologic connectivity to urban areas, determined visually with GIS/Google Earth

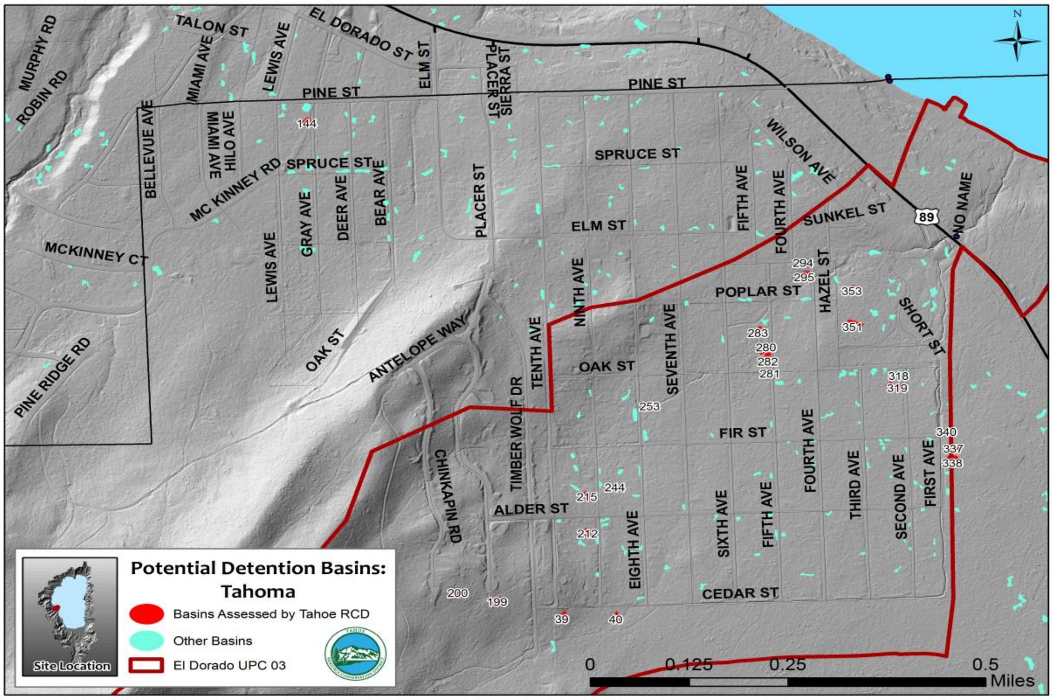

Figure 2. Tahoma Project Area and Microbasin locations.

During field visits it was found that using parcel addresses and measurements based off of parcel boundaries with a tape measure and compass was much more efficient for determining basin locations than GPS alone. During field assessments some or all of the following was conducted for each basin:

- Took photos of site
- Assessment of general vegetative type (wet/dry)
- Determining depth to seasonal groundwater table (< or > 12 inches), (using vegetative indicators and/or soil cores conducted by NRCS)
- Assessment of hydrologic connectivity to urban areas

In Tahoma, the LiDAR microbasin analysis identified a total of 372 potential detention basins. Using ArcGIS to determine the basins that lay *entirely* within public land boundaries lowered the number of potential basins down to 98. Of these, approximately 55 had the potential to catch urban runoff (based on visual assessment with ArcGIS/Google Earth), with the rest situated in non-urban areas. The Tahoe RCD focused efforts on potential detention basins within El Dorado County's Urban Planning Catchment 03 (EDC UPC03) because it identified 21 "potential" basins on public lands in the Tahoma area.

Tahoe RCD field investigations identified that for all potential microbasin locations identified by the LiDAR technique, they either lacked evidence of any surface flow to the location, or were identified as having shallow groundwater. After discussions with the California Tahoe Conservancy, it was determined that similar field assessment were conducted in the Meyers area of South Lake Tahoe and the CTC found similar results. Because of this, the Tahoe RCD took a revised approach in utilizing the LiDAR information to evaluate locations within the El Dorado County right of way (ROW). Additional information on steam environment zone (SEZ) location and PLRM modelling were also considered as part of the revised analysis; results are presented in the next section.

POLLUTANT LOAD REDUCTION MODELING

The Lake Tahoe TMDL requires that Tahoe jurisdictions reduce pollutant loading of FSP, TN, and TP to help improve water clarity in Lake Tahoe. The PLRM was developed as a tool to estimate pollutant load reduction to the lake based on the implementation of water quality improvement projects and management actions in a watershed. Using methods described in the Lake Tahoe Clarity Crediting Program Handbook (Crediting Handbook), pollutant load reductions are translated into Lake Clarity Credits used to track TMDL progress. All PLRM models were established using the approach described in the PLRM user's manual (NHC 2009**).**

Combining LiDAR, GIS, and PLRM tools, the Tahoe RCD focused on the upper portion of the Tahoma watershed which drains to a large (16,617ft^3) detention basin located on the corner of 6th Avenue and Elm Street (referred to as "6th Avenue detention basin"). For PLRM modeling purposes, the Tahoma catchment is divided into three separate sub-catchments: the area above 6th Avenue detention basin, the area below 6th Avenue detention basin, and the area within Caltrans' jurisdiction (Figure 3). The 6th Avenue detention basin was built in 1989 and is therefore modeled using baseline assumptions. According to PLRM v2, the 6th Avenue detention basin treats 90% of the runoff from the catchment that drains into it under baseline conditions. With maintenance, the basin would treat approximately 93 percent of fine sediment particle (FSP) loading, which equates to 0.56 credits (Table 1).

Table 1. Fine sediment particle (FSP) reduction (percent, pounds per year, and number of credits) by the 6th Avenue basin in Tahoma under baseline conditions and with basin maintenance.

Tahoma Catchment - Above 6th Ave Detention Basin 6th Ave Detention Basin FSP treatment efficiency			
	FSP % reduction	FSP lbs/year reduction	# Credits
Baseline	90	3153	None - Baseline
With Maintenance	93	3266	0.56

Due to the low number of TMDL credits achieved by this approach, the Tahoe RCD investigated what type of work could be performed below the 6th Avenue basin to help El Dorado County in achieving cost effective management strategies for TMDL implementation.

In the Tahoma sub-catchment below the 6th avenue detention basin, the pervious area in El Dorado County's ROW that is not located in SEZ totals 96,600sf. If less than 20 percent of the ROW (1ft depth) were converted to LID technology such as rain gardens, microbasins or bio-swales it would result in 16,430ft^3 of volume captured; similar to the volume capacity seen at the 6th Avenue detention basin. PLRMv2 model results of FSP reduction are shown in Table 3; the results indicate that the volume of FSP would be reduced by approximately 25 percent (2102 lbs/year reduction or 10.5 credits). Additionally, the PLRM estimates a reduction of approximately 7000 lbs/year of FSP (or 35 credits) if 100 percent of the road runoff is captured in the lower watershed.

Figure 3 below also shows BMP compliance rates for single family residential (SFR) in the Tahoma catchment. BMP compliance rates in each sub-catchment are shown in Table 2 (the Caltrans subcatchment contains no SFR parcels). There are currently 16 BMP compliance certificates identified in the Tahoma catchment with approximately 14 percent compliance, while 115 SFR parcels have not yet implemented BMPs.

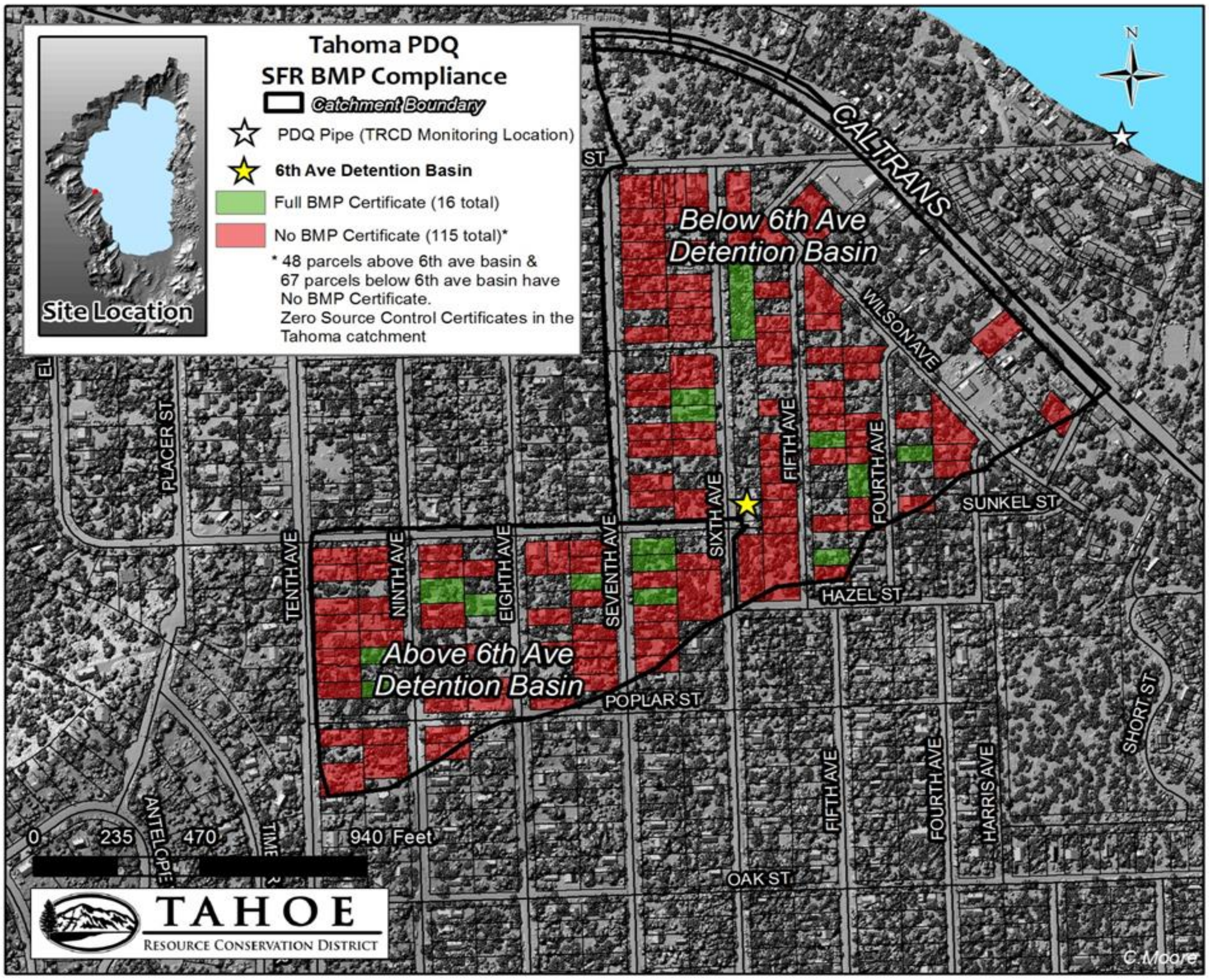

Figure 3. Tahoma Catchment and Single Family Residential BMP Compliance.

Table 2. BMP compliance rate for single family residential parcels in the Tahoma catchment.

Tahoma Catchment	SFR BMP Compliance Rate		
	Complete BMPs	Incomplete BMPs	% Compliance
Total	16	115	14
Above 6th Avenue	8	48	16
Below 6th Avenue	8	67	12

Table 3. Number of potential Lake Clarity Credits that could be obtained through 100% SFR BMP compliance in the Tahoma catchment.

Tahoma Catchment	100% SFR BMP Potential Credits
	# Credits
Above 6th Ave Basin	0.6
Below 6th Ave Basin	0.2

The range of TMDL pollutant load reduction credits achieved through implementing area-wide treatment in the county's ROW would provide the greatest potential for attaining TMDL credits. Alternatively, working with 115 individual homeowners to implement SFR BMPs is likely a more staff intensive and costly approach to attaining TMDL credits. Specifically, if the County were to achieve 100 percent SFR compliance in the Tahoma watershed they would attain only 0.8 credits (Table 3) as compared to between 10 and 30 credits by implementing dispersed LID treatment in the ROW (Table 4).

Figure 4. below identifies areas of impervious ROW where dispersed LID treatment of stormwater could likely be implemented.

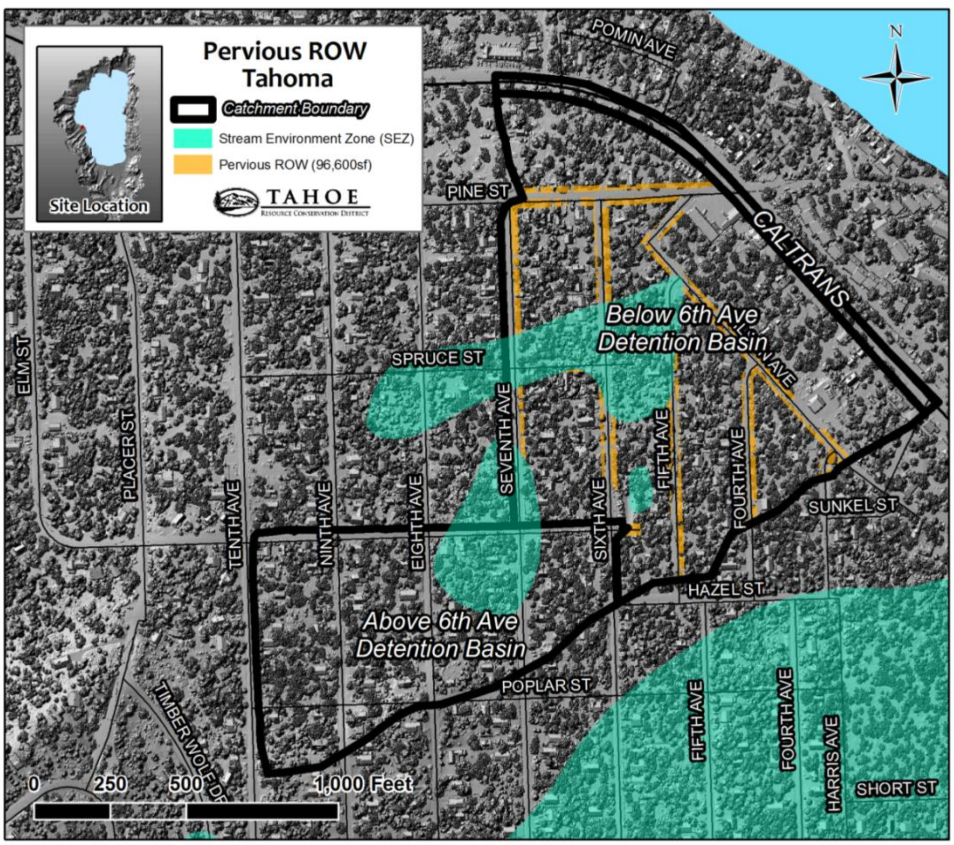

Figure 4. El Dorado county pervious right of way outside of the stream environment zone (SEZ) in the catchment below 6th Avenue detention basin in Tahoma.

Table 4. Tahoma catchment; volume capacity and associated FSP reduction.

Tahoma Catchment - Below 6th Ave Detention Basin Pervious channel with 16,430cf volume capacity			
% Roadway draining to LID	FSP % reduction	FSP lbs/year reduction	# Credits
25	24.9	2,102	10.5
50	49.6	4,186	20.9
75	73.9	6,234	31.1
100	83.1	7,008	35.0

In the upper portion of the watershed the PLRM results also indicate that maintaining the 6th Avenue basin would provide approximately the same amount of credits as those gained by regulating SFR BMP implementation. At this time, it is not likely that the County would pursue regulatory action to achieve this level of TMDL credit; a more palatable approach however, might involve the development of a Benefit Assessment that would guarantee long term maintenance of infrastructure, while homeowners could receive a complete BMP certificate from TRPA once source control measures alone are implemented. On average with a typical lot, installing SFR BMPs can cost between $1,500-$3,500. A common constraint for implementing BPMs is that many residents don't have the available funding to either install or pay someone to install their BMPs. A benefit Assessment could allow for a spreading out of the SFR cost over a 25 to 40 year period and the County would then have funding for maintenance and TMDL load reduction accounting; this approach offers regulatory compliance for homeowners and the County. Through similar CWP efforts in the Tahoe Basin, the Tahoe RCD and TRPA have seen that this type of private-public partnership encourages homeowners to do their part, especially when they see leadership from local government that brings cost effective solutions.

In summary, the LiDAR, GIS and PLRM analysis provided useful for evaluating implementation scenarios and identifying effective approaches to capturing stormwater and attaining TMDL credits. Although these results are modeled and therefore theoretical, it should be understood that PLRM results are driving management decisions in the Lake Tahoe Basin, and in times of funding shortfalls, the stormwater jurisdictions will be looking to the most cost effective approaches in achieving TMDL compliance.

WATER QUALITY EVALUATION

The Tahoma monitoring station – T1 provides a good opportunity to monitor pre- and post- EIP project implementation, with the hope that there will be detectable decreases in pollutant loading after the project is completed.

The T1 site is located at the outfall of the drainage and instrumentation in the pipe includes:

1. An automated ISCO sampler for logging stage and turbidity readings, calculating flows, and collecting samples
2. A bubbler module for measuring stage

3. A turbidimeter for measuring continuous turbidity
4. A solar panel for charging Marine Cycle 12V batteries to power equipment
5. A nearby meteorological station to record localized precipitation and ambient temperature. The meteorological station has a heated tipping bucket to record precipitation so that an accurate measurement can be taken when precipitation falls as snow.

Tahoe RCD staff members watched the weather carefully and prepared the automated sampler for event sampling prior to each predicted precipitation event. This includes ensuring that the automated sampler was full of clean sample bottles and programming the flow based pacing of the samples based on forecasted precipitation totals. During events, Tahoe RCD staff checked on the samplers often to ensure that sample pacing was accurate for actual precipitation totals, stage readings were correct in the pipe, and samplers were functioning properly.

At the end of each event, data was offloaded from the ISCO automated sampler and water quality samples were collected. Data was transferred to a central Tahoe RCD computer and added to an excel spreadsheet designed to manage continuous flow, continuous turbidity, sample dates and times, and event type. Samples were properly labeled in the field, transported to a laboratory immediately after collection in a cooler, composited on a flow-weighted basis, and shipped to an analytical laboratory using proper chain-of-custody procedures. Samples were analyzed for the Lake Tahoe TMDL pollutants of concern: fine sediment particles (FSP) concentration, total nitrogen (TN) concentration, and total phosphorus (TP) concentration.

Ten percent of all samples analyzed were quality assurance - quality control (QA/QC) samples. These samples were used to ensure proper instrument function, field sampling methods, sample handling procedures, and laboratory methods.

According to the Association of California Water Agencies, water year 2014 was one of the driest in the State's recorded history, with less than 60% of average precipitation. Figure 5 shows the continuous hydrology and cumulative precipitation for water year 2014. Three primary "seasons" are defined by the NPDES permit; fall/winter (October 1 – February 28), spring (March 1 – May 31), and summer (June 1 – September 30). The seasons are defined as such to better fit with precipitation patterns and storm event types that occur in the Tahoe Basin. The total precipitation for water year 2014 at the Tahoma meteorological station was 20.56 inches. The majority of the precipitation fell in the fall/winter season (14.95 inches). The spring season received 1.60 inches and the summer season received 4.01 inches (Precipitation occurring as snow is converted to inches of water). A total of 36 discrete precipitation events were measured at the Tahoma meteorological station, 15 in the fall/winter, 13 in the spring, and 8 in the summer. Fall/winter and spring precipitation events were either snow, rain, or mixed rain and snow. Summer events were either thunderstorms or frontal rain storms. Half of the events during water year 2014 produced less than a tenth of an inch of precipitation, and three quarters of the events produced less than half an inch. The largest storm occurred between February 7, 2014 and February 10, 2014, falling as mixed rain and snow and producing 9.32 inches of precipitation in Tahoma. However, the highest peak flows (about 3.2 cubic feet per second (cfs)) were experienced during a high intensity thunderstorm on August 10, 2014.

Flow weighted water quality samples were taken across the hydrograph for all eleven runoff events. Continuous hydrology, continuous turbidity and events sampled during water year 2014 are presented in Figure 6. The highest turbidities were seen during the largest storm of the year (February 7-10, 2014). The greatest flows were seen during the thunderstorm that occurred on August 10, 2014 as the peak precipitation reached 0.28 inches in ten minutes. Continuous hydrology, continuous turbidity, and water quality samples for the eleven individual events are presented in Appendix A.

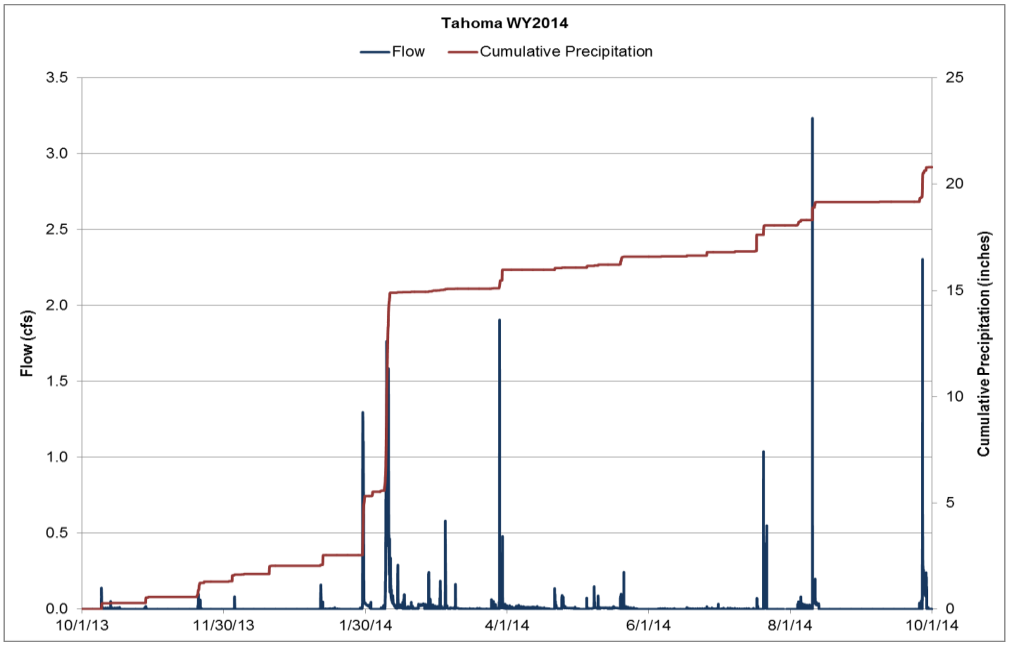

Figure 5: Continuous hydrology and cumulative precipitation at the Tahoma catchment outfall during water year 2014.

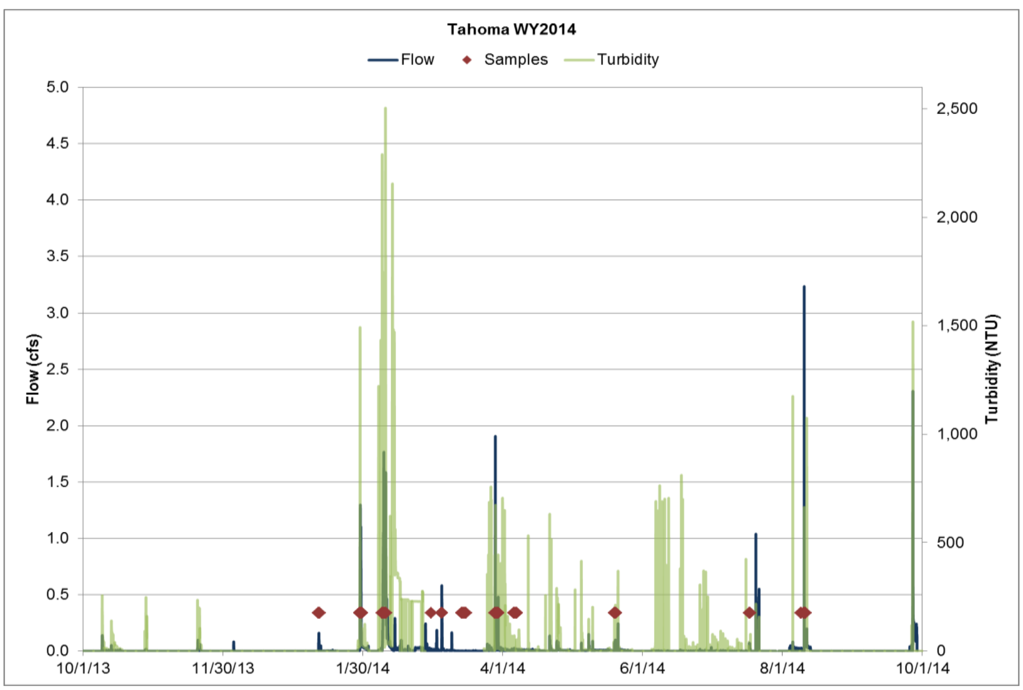

Figure 6: Continuous hydrology, continuous turbidity, and sampled events at the Tahoma catchment outfall during water year 2014.

Summary data for all eleven events are presented in Table 1. Three precipitation events were sampled during the fall/winter, six during the spring, and two during the summer. In general, only precipitation events greater than 0.3 inches produced sufficient runoff for water quality sampling, though one spring rain on snow event of only 0.05 inches produced sufficient runoff to sample as melting snow increased the total runoff volume. Two snowmelt events were sampled when temperatures rose to the mid-50˚F and snowmelt at the Tahoma catchment outfall was sufficient to sample. It is interesting to note that while FSP concentrations were extremely low for both snowmelt events, TN and TP concentrations were not. However, loads for all three pollutants were low for these two events as total runoff volumes were relatively low. The high intensity thunderstorm that began on August 10, 2014 had very high concentrations of all three pollutants, as did the first significant storm of the season beginning on January 11, 2014. Though FSP concentrations were about average, the highest FSP loads were produced during the two fall/winter mixed rain and snow events that occurred beginning January 29, 2014 and February 8, 2014 because of the large runoff volumes. These two events also produced the highest loads for TN and TP. The March 29, 2014 and August 10, 2014 also produced relatively large FSP loads. As one Lake Clarity Credit is equal to about 200 lbs, the volume from these four storms alone would be equal more than four TMDL credits if captured and infiltrated prior to discharging to the lake.

The NPDES permit requires that seasonal and annual precipitation and runoff volumes, as well as average seasonal and annual loads for FSP, TN, and TP are reported. These statistics are presented in Table 5. Seasonal and annual precipitation values represent the total precipitation that fell in the Tahoma catchment for that period, not just the sum of the storm totals of the events sampled. Seasonal and annual runoff volumes represent the cumulative runoff volume measured at the Tahoma outfall during the respective period, not just the sum of the volumes of the events sampled. As not every runoff event was sampled during the year, the average seasonal and annual loads represent an average (volume weighted) load estimation for the respective period based on the events that were sampled in that period.

It is not surprising that fall/winter accounts for the highest loading as the total runoff volume is approximately three times higher than the other two seasons. It is also interesting to note that though summer received significantly more precipitation than the spring did, the runoff volumes were similar. This is likely due to the additional runoff produced by snowmelt in the spring.

The PLRM estimates 5,263 pounds of FSP from the Tahoma catchment as an 18-year average. Considering that precipitation during water year 2014 was about 60 percent of average, FSP loads this year would be predicted to be about 3,158 pounds, which is not unreasonable compared to 2,503 lbs.

Table 5: Summary data for eleven sampled events at the Tahoma catchment outfall including runoff volumes, storm totals, and event mean concentrations (EMCs) and event loads for FSP, TN, and TP.

Season	Runoff Start (Date Time)	Runoff End (Date Time)	Runoff Duration (hh:mm)	Runoff Volume (cf)	Storm Total (in)	Event Type	% of Storm Sampled	FSP EMC (mg/L)	FSP event load (lbs)	TN EMC (ug/L)	TN event load (lbs)	TP EMC (ug/L)	TP event load (lbs)
Fall/Winter	1/11/14 11:30	1/11/14 22:10	10:40	2,048	0.52	rain/snow	75%	383	49	3,762	0.5	1,015	0.1
Fall/Winter	1/29/14 9:10	1/30/14 2:20	17:10	34,160	2.79	rain/snow	100%	120	255	1,408	3.0	318	0.7
Fall/Winter	2/8/14 1:20	2/10/14 4:30	51:10	120,236	9.32	rain/snow	100%	51	381	235	1.8	341	2.6
Spring	3/5/14 22:20	3/6/14 8:40	10:20	5,672	0.05	rain on snow	100%	179	63	793	0.3	984	0.3
Spring	3/14/14 16:00	3/16/14 16:00	48:00	175	na	snowmelt	100%	<1	<0.1	346	<0.1	55	<0.1
Spring	3/29/14 3:00	3/29/14 17:00	14:00	10,630	0.37	rain	100%	170	113	1,510	1.0	942	0.6
Spring	3/30/14 2:40	3/30/14 23:50	21:10	3,735	0.50	snow	70%	188	44	1,554	0.4	1,116	0.3
Spring	4/6/14 7:00	4/8/14 7:00	48:00	2,039	na	snowmelt	100%	<1	<0.1	388	<0.1	87	<0.1
Spring	5/20/14 0:00	5/20/14 21:40	21:40	1,943	0.38	rain	100%	57	7	851	0.1	402	<0.1
Summer	7/17/14 18:40	7/18/14 6:10	11:30	645	0.77	thunderstorm	100%	28	1	2,887	0.1	265	<0.1
Summer	8/10/14 14:50	8/11/14 6:00	15:10	7,086	0.59	thunderstorm	100%	270	120	2,337	1.0	1,769	0.8

Equations to convert turbidity to FSP have been developed specifically for the Lake Tahoe Basin (2NDNATURE 2014). Using these equations, continuous turbidity measurements at the Tahoma catchment outfall were converted to FSP load estimates. Table 7 summarizes the seasonal and annual FSP loads calculated using continuous turbidity data and compares them to the estimates made from event sampling (Table 6). Continuous turbidity appears to underestimate loads during spring and summer runoff and over estimate during the fall and winter season as compared to the autosampler; annual load estimates however, are reasonably close.

Table 6: Seasonal and annual precipitation and runoff volumes, plus average seasonal and annual load estimations for FSP, TN, and TP for Water Year 2014 at the Tahoma catchment outfall.

TAHOMA CATCHMENT	Precipitation (in)	Runoff Volume (cf)	FSP load (lbs)	TN load (lbs)	TP load (lbs)
Fall/Winter (Oct1-Feb28)	14.95	207,798	910	7	4
Spring (Mar1-May31)	1.60	65,114	673	5	3
Summer (Jun1-Sep30)	4.01	59,000	921	9	6
Annual Totals	20.56	331,911	2,503	21	14

Table 7: Comparison of FSP load estimates in the Tahoma catchment calculated using continuous turbidity and autosampler methods.

TAHOMA CATCHMENT	Runoff Volume (cf)	FSP load (lbs) from continuous turbidity	FSP load (lbs) from event sampling
Fall/Winter (Oct1-Feb28)	207,798	1,446	910
Spring (Mar1-May31)	65,114	204	673
Summer (Jun1-Sep30)	59,000	258	921
Annual Totals	331,911	1,908	2,503

Beyond understanding how these two methods compare in measuring specific pollutant values, a greater challenge with using the continuous turbidimeter is working with scientists and stakeholders to agree on acceptable QA/QC methods for smoothing out data that shows anomalies due to influx of large debris, pine needles, and other factors that affect reliable in situ readings throughout the year. This question is currently being addressed through the IMP and the RSWMP monitoring programs. Answering this question will greatly help with transparency and stakeholder trust toward switching to additional monitoring methods in the future. It should be noted that the Lake Tahoe Watershed Model, the PLRM, and NPDES pollutant load allocations were all based on data collected with the autosampler method. It is for this reason that scientific transparency and stakeholder dialogue is an important aspect of any adaptive management strategy.

Additional comparisons of stormwater data are shown in Table 8. Average seasonal and annual load estimations are calculated using all eleven storms (as in Table 6 and 7) collected in water year 2014. Results indicate that average seasonal and annual load estimations that would result from sampled the four largest as compared to the four smallest events of the season. In general, the load estimations calculated using the largest events were very similar to the load estimations calculated using all eleven events for water year 2014. This is likely due to the relatively large proportion of runoff volume contributed by the larger storms. It should be noted however, that this relationship may not hold if dissolved nutrients were also being monitored, as baseline TMDL data (personal communication with Alan Heyvaert) identified larger concentrations of dissolved nutrients present in smaller events; more specifically snowmelt events.

Table 8: Comparison of average seasonal and annual load estimations calculated using all eleven events sampled to estimations calculated using the largest or smallest event of the season.

TAHOMA CATCHMENT	FSP load (lbs)			TN load (lbs)			TP load (lbs)		
	all events	largest event	smallest event	all events	largest event	smallest event	all events	largest event	smallest event
Fall/Winter (Oct1-Feb28)	910	658	4,970	7	3	49	4	4	13
Spring (Mar1-May31)	673	692	232	5	6	3	3	4	2
Summer (Jun1-Sep30)	921	995	103	9	9	<0.1	6	7	1
Annual Totals	2,503	2,345	5,305	21	18	52	14	15	16

Information presented in Table 8 also illustrates that FSP would likely be significantly over estimated if monitoring efforts continuously captured the smallest events within the water year. In this case the average annual FSP loads would be approximately doubled. In addition, TN loads in the fall/winter of water year 2014 would be seven times higher, the summer TN loads would be at least 90 times lower, and average annual loads would be about two and a half times higher if only the smallest events were captured. Average annual TP load estimated using the smallest storms is similar to the load estimated using all eleven storms, however, fall/winter loads are increased by about three times, and summer loads by six times. Thus, average seasonal and annual load estimations are likely to be more accurate when a range of storm sizes are sampled in each season; however a concentrated effort to capture larger events less often throughout the water year appears to produce a reasonable annual load calculation - while achieving significant cost savings.

ADAPTIVE MANAGEMENT RECOMMENDATIONS

The Lake Tahoe TMDL has demonstrated the importance of reducing pollutant loads to Lake Tahoe in order to restore mid-lake clarity and near-shore condition. To encourage public support, adaptive management efforts have to make clear the potential benefits and values that private property owners will gain from becoming a financial partner in an area-wide storm water projects. Educating business and property owners about how implementing BMP's demonstrates good stewardship is not enough; if it were, BMP compliance rates would be much higher than currently realized. Demonstrated leadership from local government and community incentives such as improved bike trails, street lighting, and transportation coupled with stormwater infrastructure has proven to be an effective approach in both the Harrison Avenue and Kings Beach corridors within the Lake Tahoe Basin. In addition, for broader support beyond SFR parcels it is important to demonstrate the value a comprehensive storm water system can bring to a commercial district and the value it can add to individual property owners. For example, a large piece of commercial property may cost a half million dollars to adequately BMP, but as a partner in an area-wide system the property owner's contribution assessment could be less than half that cost. In addition, where usable space is a premium, a commercial property owner may find value in not using their parking space to install individual detention basins on site. In particular, when addressing commercial properties, systems that consider the integration of aesthetic enhancements, recreation benefits, parking and circulation improvements have a better chance of gaining investment (financially and politically) by commercial property owners as well (Tahoe RCD, 2015).

When considering adaptive management for monitoring TMDL progress, the Tahoe RCD is working with TMDL partners and Basin stakeholders to better understand implications of utilizing a suit of monitoring methods, and is currently through funding provided by SNPLMA and State Water Board, in the process of evaluating method costs, QA/QC, and side by side data comparisons. This work will be completed in 2016, as the data presented in this report should be considered preliminary. There is of course additional considerations beyond method cost and QA/QC, specifically individual project goals; as the continuous turbidimeter may not be appropriate for use when nutrient data is a central objective for monitoring as with issues related to near shore degradation.

REFERENCES

Final Watershed Strategy Report, Meyers California, Tahoe RCD, 2015.Lake Tahoe Watershed Assessment, USFS 2000.

Lake Tahoe Technical TMDL, Lahontan and NDEP, 2010.

Lake Tahoe Watershed Assessment, USDS Forest Service, 2000

Pollutant Load Reduction Model (PLRM) User's Manual, NHC, December 2009.

RSWMP Quality Assurance Project Plan, Lake Tahoe TMDL 2011.

Surrogate Indicators to Monitor Fine Sediment Particles in the Lake Tahoe Basin, 2NDNATURE, March 2014.

APPENDIX A – EVENT HYDROGRAPHS

Event hydrographs for each of the eleven sampled events are presented below. Individual samples are represented by red diamonds, and samples lying on the same horizontal line were composited into a flow weighted sample.

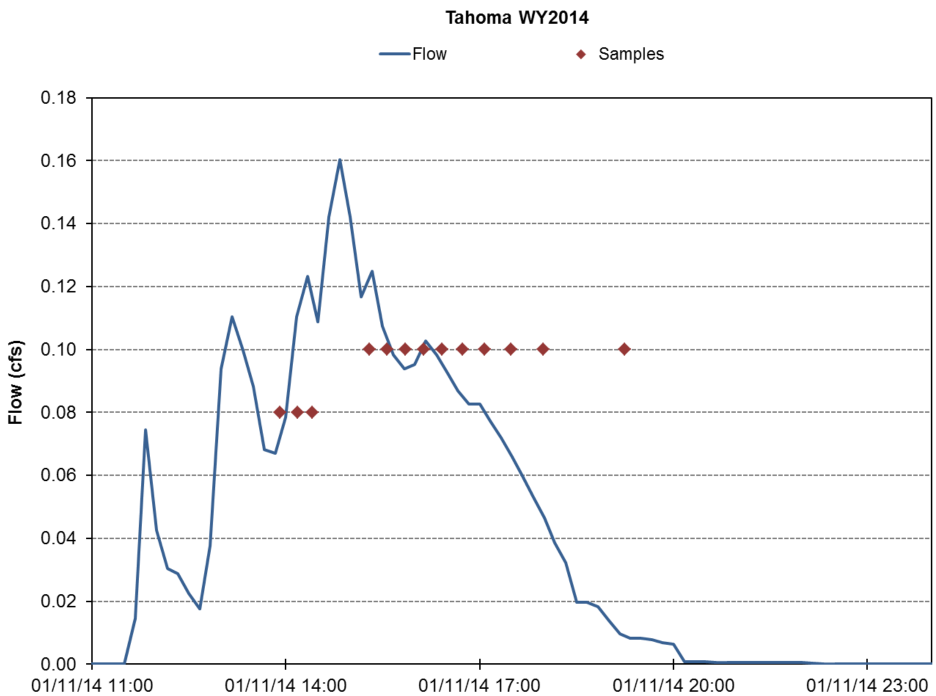

Figure A1: Continuous hydrology and water quality samples for the 1/11/2014 event. Total volume sampled: 2,048 cf. The continuous turbidity sensor failed during this event.

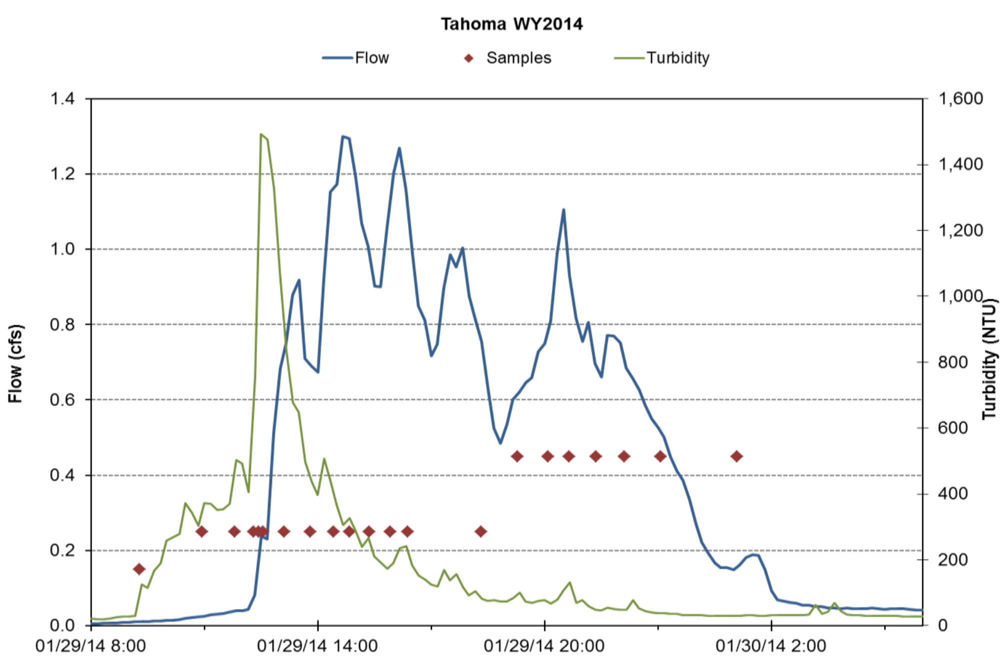

Figure A2: Continuous hydrology, continuous turbidity, and water quality samples for the 1/29/2014 event. Total volume sampled: 34,160 cf.

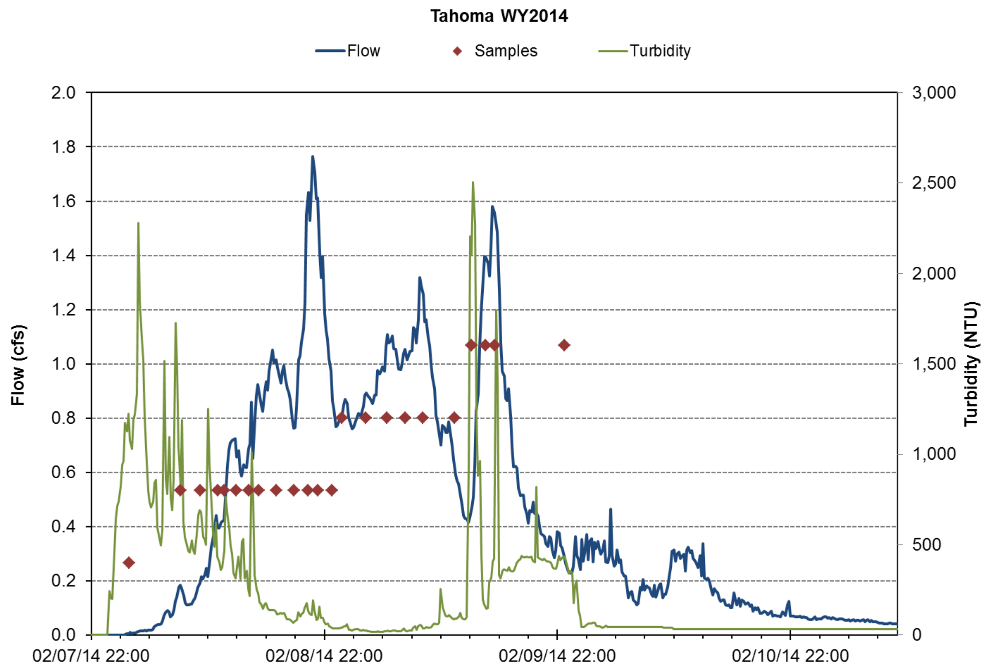

Figure A3: Continuous hydrology, continuous turbidity, and water quality samples for the 2/8/2014 event. Total volume sampled: 120,236 cf.

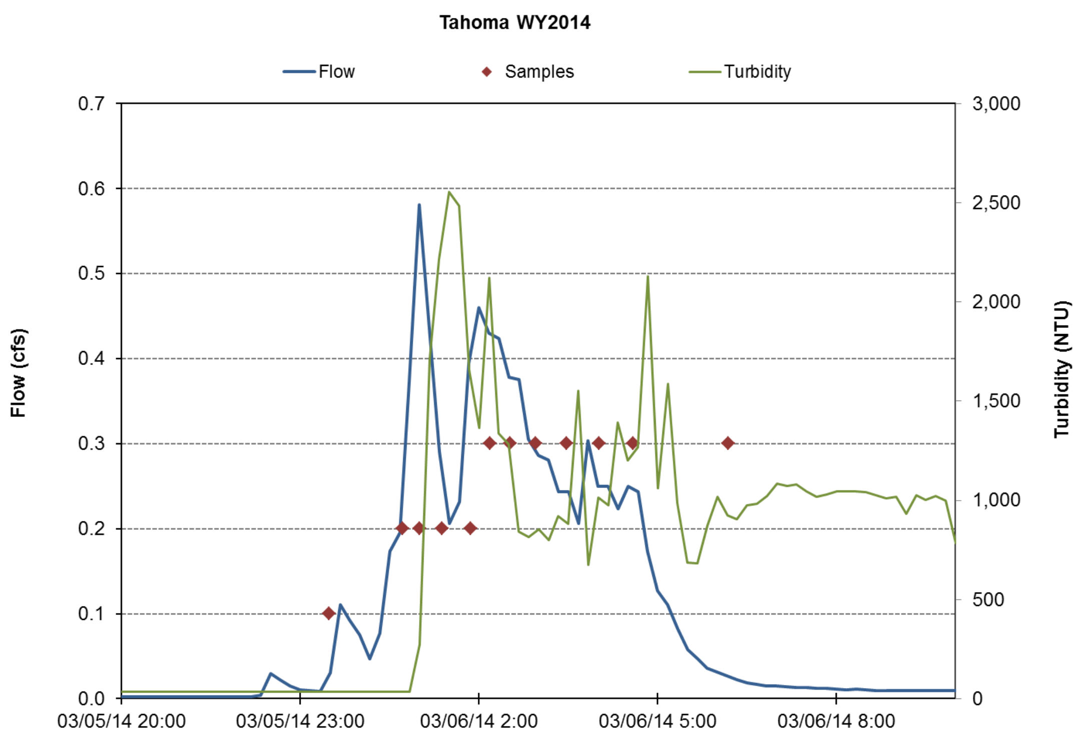

Figure A4: Continuous hydrology, continuous turbidity, and water quality samples for the 3/5/2014 event. Total volume sampled: 5,672 cf.

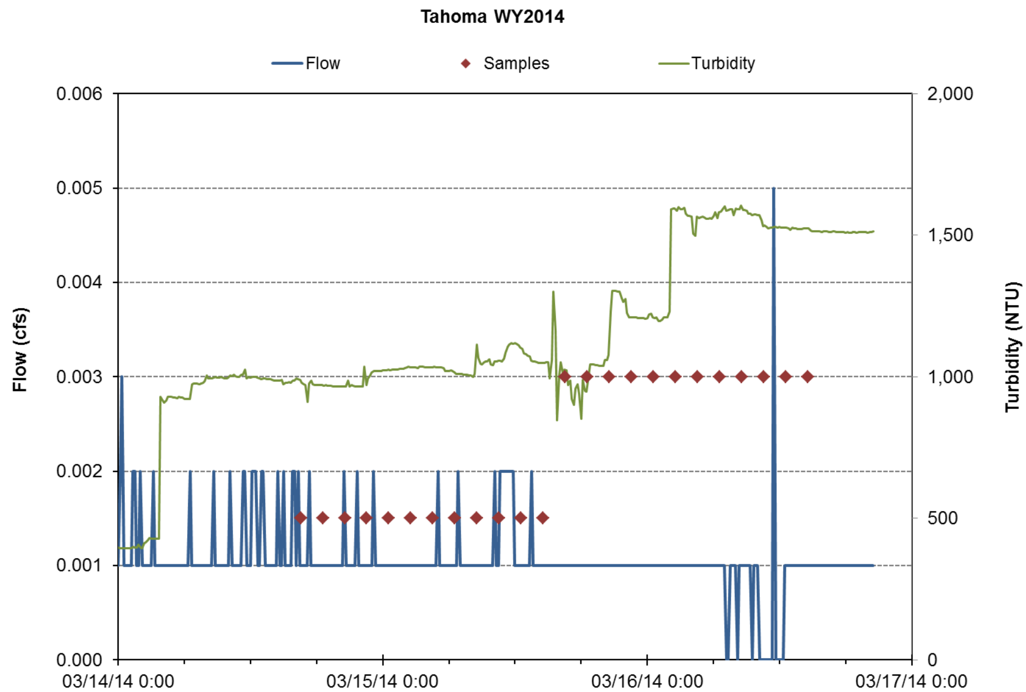

Figure A5: Continuous hydrology, continuous turbidity, and water quality samples for the 3/14/2014 event. Flows were extremely low during this event and result in the sporadic looking hydrograph.
Total volume sampled: 175 cf.

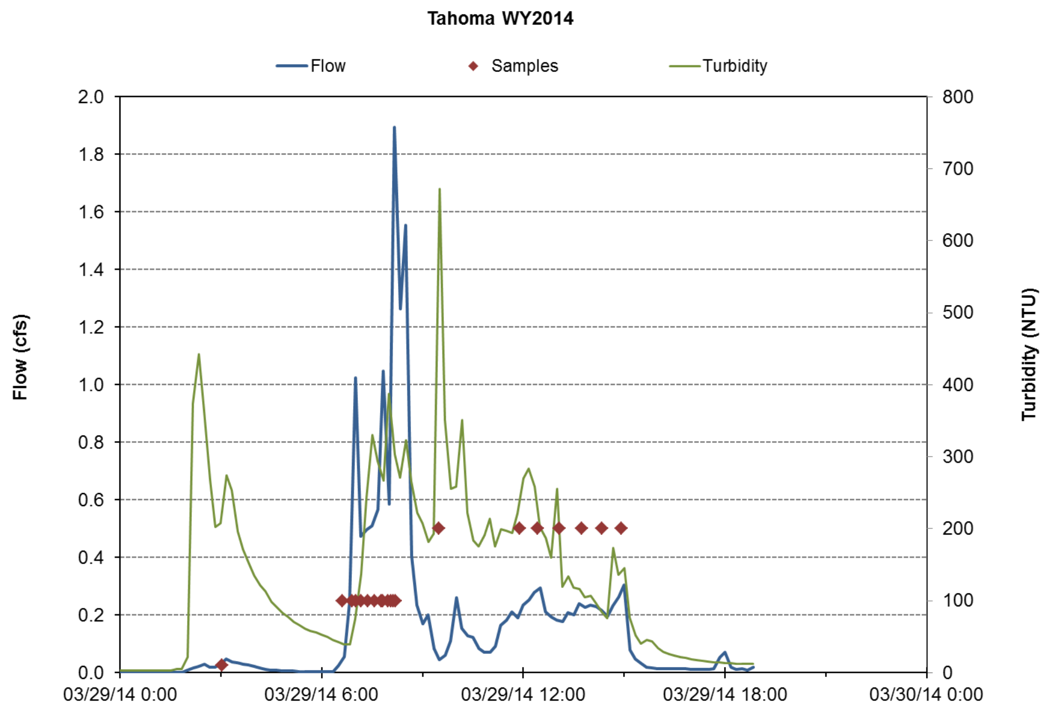

Figure A6: Continuous hydrology, continuous turbidity, and water quality samples for the 3/29/2014 event.
Total volume sampled: 10,630 cf.

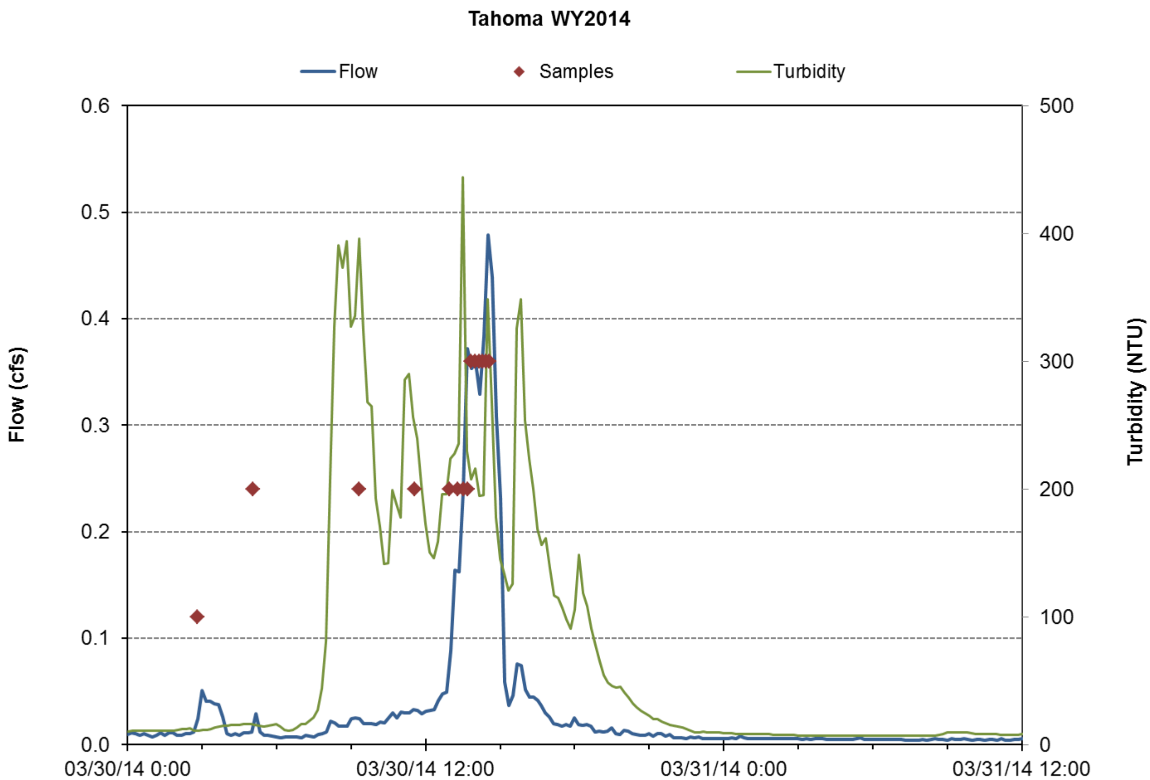

Figure A7: Continuous hydrology, continuous turbidity, and water quality samples for the 3/30/2014 event. Total volume sampled: 3,735 cf.

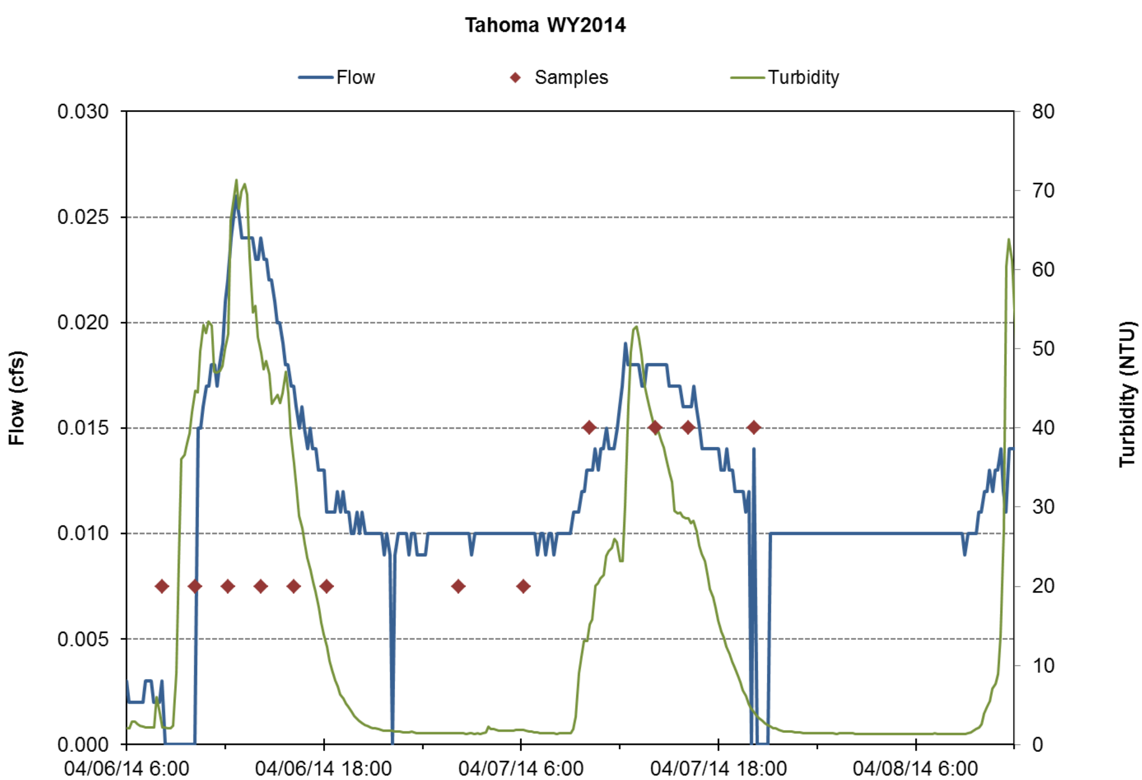

Figure A8: Continuous hydrology, continuous turbidity, and water quality samples for the 4/6/2014 event. Total volume sampled: 2,039 cf.

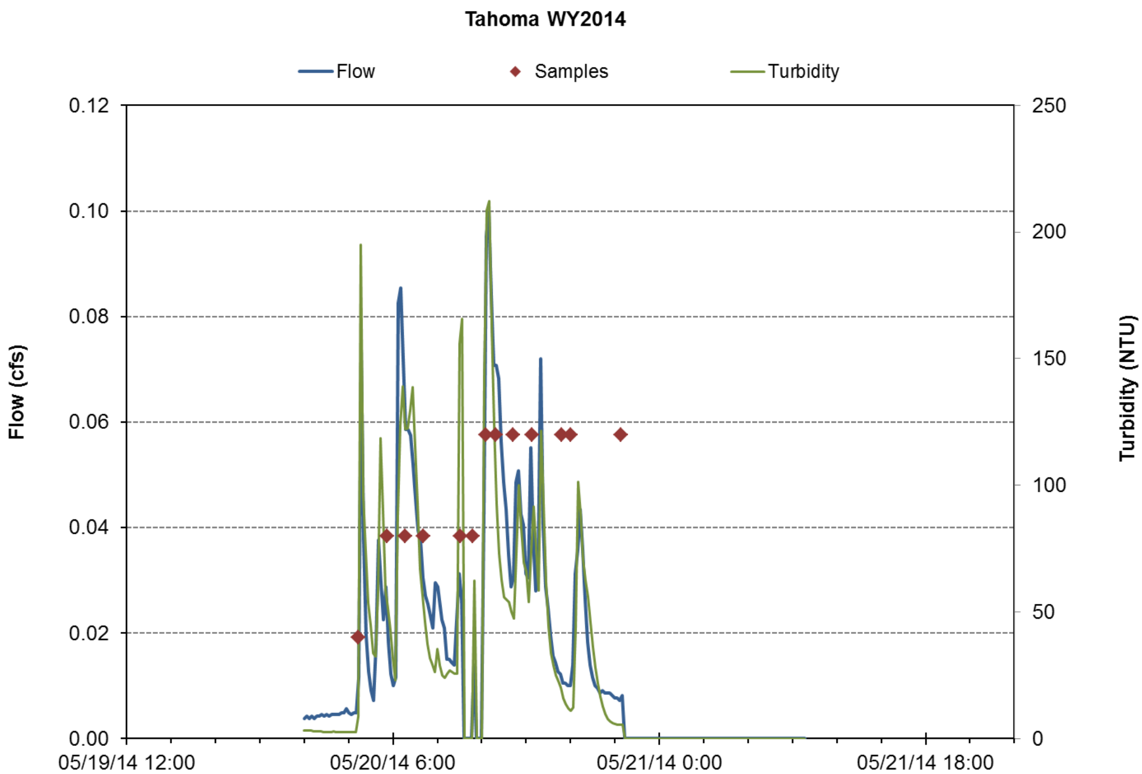

Figure A9: Continuous hydrology, continuous turbidity, and water quality samples for the 5/20/2014 event. Total volume sampled: 1,943 cf.

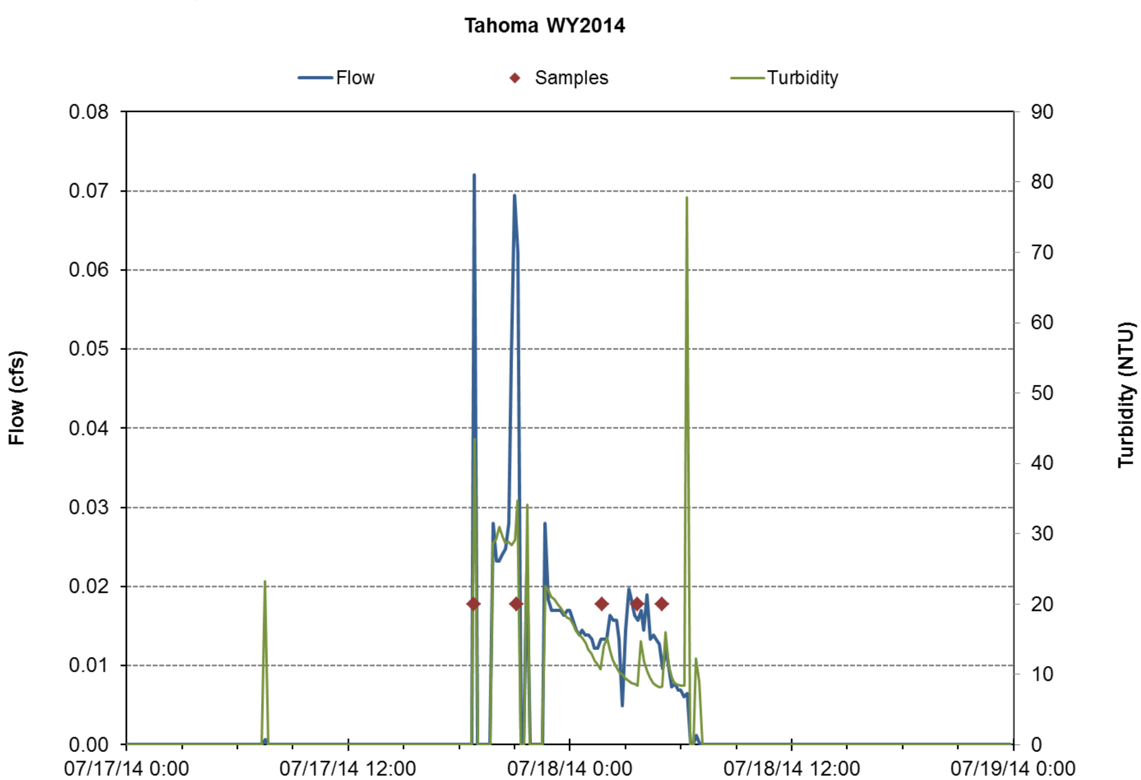

Figure A10: Continuous hydrology, continuous turbidity, and water quality samples for the 7/17/2014 event. Total volume sampled: 645 cf.

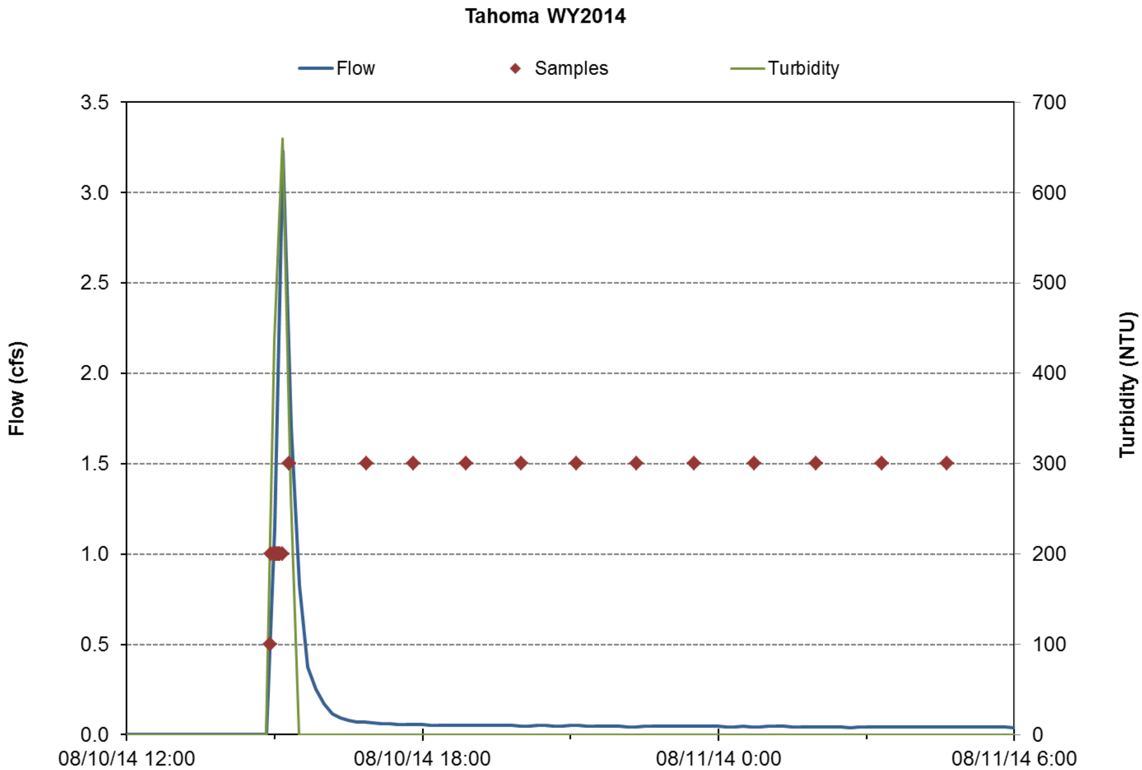

Figure A11: Continuous hydrology, continuous turbidity, and water quality samples for the 8/10/2014 event. Total volume sampled: 7,086 cf.

Tahoe Valley and Meyers, CA

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Final Watershed Strategy Report - November 2015

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TABLES

ACRONYM LIST

TMDL	Total Maximum Daily Load
BMP	Best Management Practice
Tahoe RCD	Tahoe Resource Conservation District
CWP	Community Watershed Partnership
SNPLMA	Southern Nevada Public Land Management Act
NRCS	Natural Resources Conservation Service
EPA	Environmental Protection Agency
CTC	California Tahoe Conservancy
USFS	United States Department of Agriculture - Forest Service
TRPA	Tahoe Regional Planning Agency
TAC	Technical Advisory Committee
PLRM	Pollutant Load Reduction Model
NHC	Northwest Hydraulic Consultants
SFR	Single Family Residential
SWOT	Strengths, Weaknesses, Opportunities, and Threats
Water Board	Lahontan Regional Water Quality Control Board
SEZ	Stream Environment Zone
CALTRANS	California Department of Transportation
EIP	Environmental Improvement Program
TTD	Tahoe Transportation District
FSP	Fine Sediment Particles
TN	Total Nitrogen
TP	Total Phosphorus
CICU	Commercial-Industrial-Communications-Utilities

INTRODUCTION

Lake Tahoe is among the largest, deepest, and clearest lakes in the world. Its cobalt blue appearance, spectacular alpine setting, and remarkable water clarity is recognized worldwide. Recreational opportunities and scenic vistas have made Lake Tahoe a top national and international tourist destination. While visibility into the lake's depths is currently at 70 feet, it is listed as impaired because over thirty feet of clarity has been lost since the late 1960s. To address the impairment, the Lake Tahoe Total Maximum Daily Load (TMDL) program was adopted in 2011; it brought with it new regulatory requirements for state and local stormwater jurisdictions to reduce urban pollutant loads to Lake Tahoe.

Approved by the Environmental Protection Agency and the states of California and Nevada, the TMDL sets targets for a significant reduction of fine sediments, nitrogen, and phosphorus flowing to Lake Tahoe. Currently, stormwater jurisdictions are required to implement urban best management practices (BMPs) to decrease pollutant loading from urban runoff as part of their TMDL permit. Through this process, area-wide stormwater treatment has become a preferred strategy for effective TMDL implementation. Expected benefits include costs savings related to the economy of scale, and effective maintenance and tracking of pollutant loads.

In 2014, the Tahoe Resource Conservation District (Tahoe RCD) reached out to the Meyers community, in El Dorado County, and the City of South Lake Tahoe through a program called the Community Watershed Partnership to provide landscape conservation planning and technical services related to BMP implementation and area-wide stormwater planning. As part of this community engagement effort the Tahoe RCD also surveyed Meyers' homeowners and business owners on their willingness to support the management and treatment of stormwater on an area-wide scale in lieu of implementing individual parcel-level infiltration BMPs. Individual commercial property owners within the City's Tahoe Valley Area Plan were also interviewed. The purpose of the interviews was to determine the level of interest commercial property owners might have for supporting the management and treatment of stormwater through a Greenbelt design project that might include bike and pedestrian connections, and recreation amenities that could serve both locals and visitors.

PROJECT BACKGROUND

The Community Watershed Partnership (CWP) was developed through funding provided by the Southern Nevada Public Land Management Act (SNPLMA), and sponsored by both the Natural Resources Conservation Service (NRCS) and the Environmental Protection Agency (EPA). The funding for this program is intended to identify and address natural resource concerns or needs at a watershed level, and is designed to engage a variety of stakeholders to help facilitate communication between landowners, the general public, and Basin managers while furthering TMDL implementation and the restoration of Lake Tahoe.

The CWP approach complements the many environmental improvement projects implemented around the Lake Tahoe Basin by the California Tahoe Conservancy (CTC), U.S.D.A. Forest Service (USFS), the Counties of El Dorado and Placer, and the City of South Lake Tahoe (local stormwater jurisdictions). Improvements gained in water quality have largely resulted from urban stormwater capital improvement projects, as well as restoration work in stream environment zones. In addition to implementing large scale projects, there are opportunities for each private property owner to contribute to watershed restoration efforts by either implementing individual water quality BMPs on their parcel, or by partnering with stormwater jurisdictions on area-wide treatment. Until very recently, the opportunity for private property owners to participate in an area-wide treatment facility was nonexistent. Ultimately, successful implementation of BMPs on both the public and private scale will move Lake Tahoe closer to attaining its clarity goals. How each neighborhood or urban center executes this process will be a focus for Basin managers for the next several decades.

In 2002, the Tahoe RCD, the Nevada Tahoe Conservation District, NRCS, and the Tahoe Regional Planning Agency (TRPA) adopted a Memorandum of Understanding to establish a partnership that would provide technical support to homeowners, contractors, and property managers in implementing water quality BMPs on private property. Through grant funded incentive programs, the Tahoe RCD and its partners provided cost free property evaluations and BMP implementation plans for over fifteen years. However, only about three out of every ten private properties on the California side of the Tahoe Basin has installed BMPs; the level of implementation in Meyers is even lower at approximately 17 percent.

Both the Meyers community and the City's Tahoe Valley Greenbelt project were selected for CWP engagement due to several factors: the development of the Meyers Area Plan by El Dorado County and TRPA, the development of the Tahoe Valley Area Plan by the City of South Lake Tahoe, low private property BMP implementation rates, and the potential for stormwater pollutant generation (Figures 1 & 2).

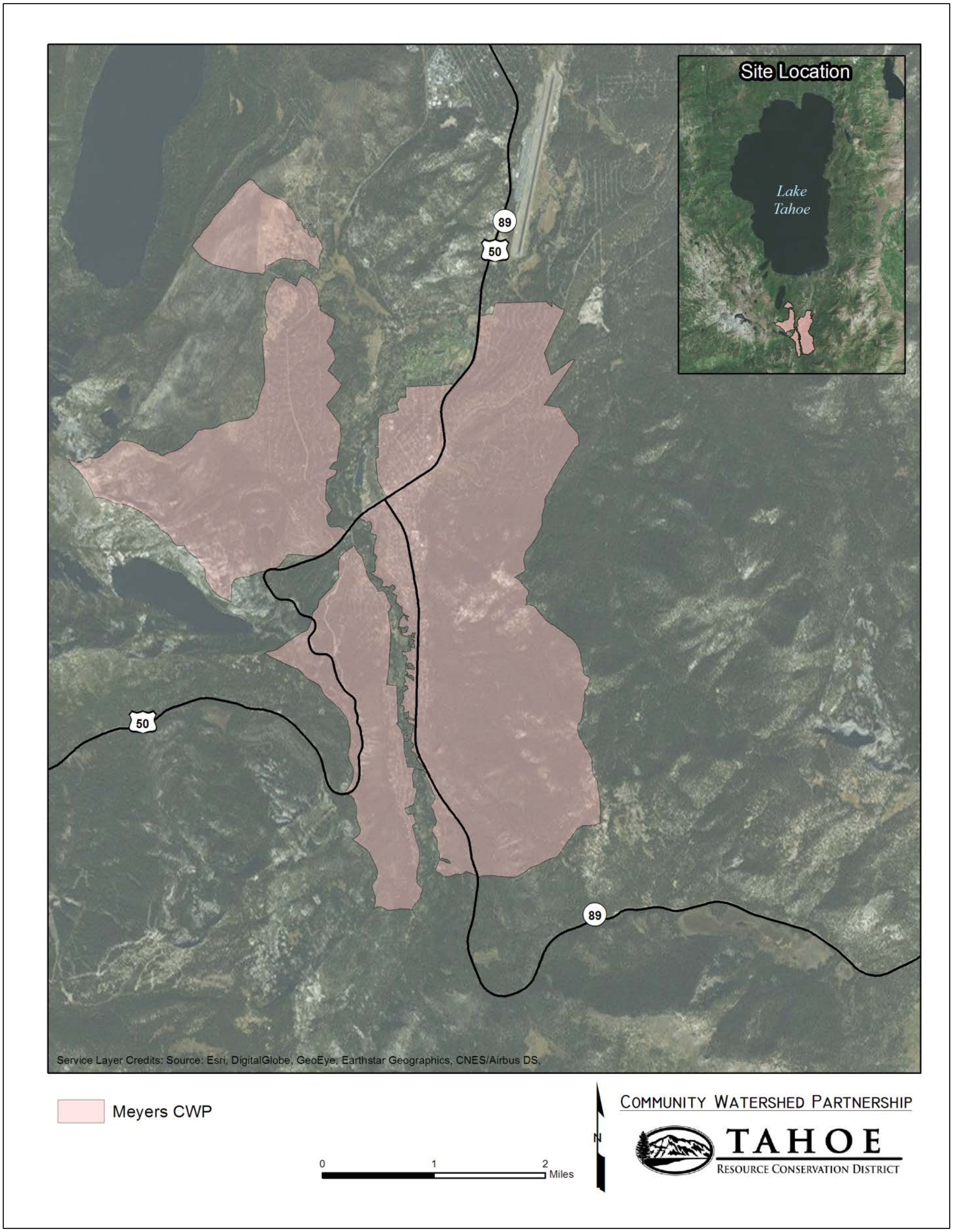


Figure 1. Community Watershed Partnership Modeling Project Area, Meyers California

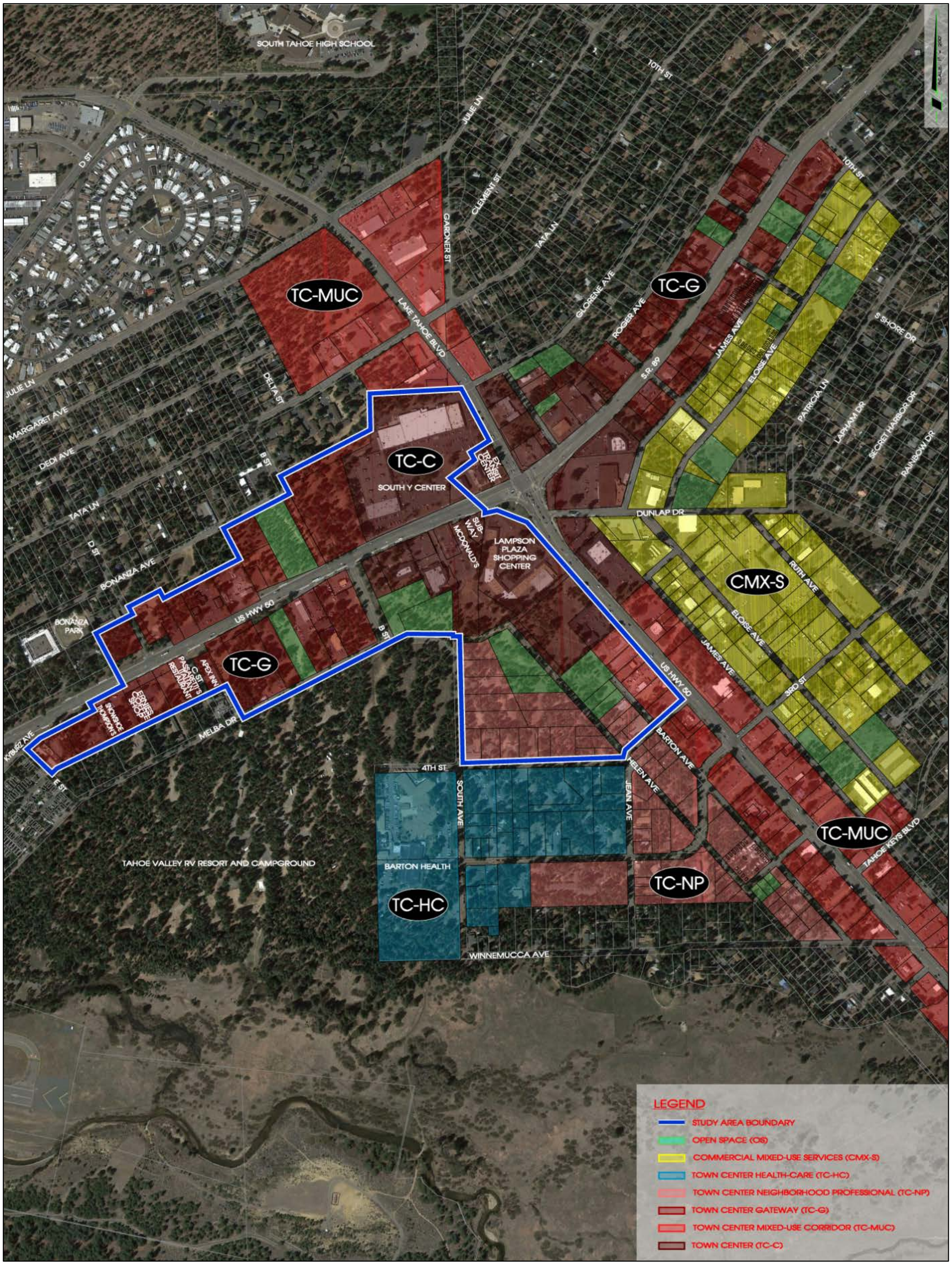


Figure 2. Community Watershed Partnership Initial Study Area, Tahoe Valley Greenbelt, City of South Lake Tahoe, California (solid blue line denotes boundary of study area)

MEYERS PROJECT SCOPE

The Meyers' CWP strategy is intended to provide useful TMDL implementation information to Basin managers, regulators, and stormwater jurisdictions. The Meyers community was identified as a priority watershed for development of a Community-based Watershed Strategy through a CWP ranking process that evaluated proximity to the lake, slope, soils, precipitation, and modeled pollutant load contributions (Figure 3). The development of the CWP Strategy was guided by a Technical Advisory Committee (TAC) led by the Tahoe RCD, and in partnership with EPA, the CTC, the USFS, El Dorado County, and the Lahontan Water Board to ensure the project was well coordinated and relevant to other projects implemented in the watershed. The TAC also helped identify project goals, and provided input on project execution.

Figure 3. Meyers Commercial Core, the Upper Truckee River, Tahoe Paradise Park with Lake Baron, Tahoe Paradise Residential Subdivision and Tahoe Paradise Golf Course (Source: Google earth)

The purpose for engaging the Meyers' community was to identify strategies for assisting private property owners, commercial businesses, and local jurisdictions with TMDL implementation through a community-based watershed approach. The goal of EPA's Community Based Watershed Strategy grant is to explore approaches that integrate strategies for public and private partnerships using education, information sharing and project implementation. Through a community-based approach it is expected there will be an increase in general knowledge of restoration objectives, opportunities for improving environmental stewardship, and enhancements to the Lake Tahoe Basin's BMP and TMDL programs.

The Tahoe RCD and its partners identified the following goals for this project:

- Improved water quality through area-wide storm-water conveyance and treatment,
- Inclusion of elements that focused on smart use of limited space, and enhanced aesthetics within the community,
- Enriched public/private partnership opportunities for this commercial-core,
- Development of an innovative/successful template for future area-wide projects in the Region,
- Expanded business opportunities in the Meyers commercial-core.

In support of the first two goals, this report includes two separate conceptual drawings for an area-wide stormwater system in Meyers, Pollutant Load Reduction Model (PLRM) estimates for single family residential (SFR) BMPs at theoretical rates of 30, 50 and 100 percent implementation, as well as PLRM estimates that represent the potential benefits of area-wide treatment in the Meyers commercial core, and pollutant load reduction estimates.

To achieve the remaining goals, key business owners were also engaged to discuss options for area-wide stormwater treatment. A case study is provided in this report that discusses the steps taken to engage the community, and the results of those efforts. A second case study describes the process for establishing a benefit assessment, if public support for such a mechanism is identified.

Traditional technical services related to SFR BMP implementation, as well as landscape conservation assistance were also provided throughout this project.

HISTORICAL INFLUENCES

Meyers was first established in 1851 as a stagecoach stop, trading post, and Pony Express way station. It lies in the headwaters of the largest tributary to Lake Tahoe, the Upper Truckee River at an elevation of 6352 feet (Watershed Assessment, 2000). In 1859, Martin Smith, Meyers' original developer, sold the station to Yank Clement, who named it Yank's Station. The station provided food, lodging, water, and pasture to the thousands of travelers and animals journeying over Echo Summit. Yank's Station included a hotel, two saloons, a general store, a blacksmith shop, a cooperage, private homes, and stables and barns.

In 1863, Carlo Giuseppe Celio homesteaded in what was known as the Upper Lake Valley of the South Shore of Lake Tahoe. Overtime, the Celio family accumulated over 4,000 acres including the town of Meyers which they bought in 1903. In 1903, the town included a variety of businesses and 22 buildings. The Celios operated a dairy (shipping Tahoe butter as far as San Francisco) with 125 cattle. In 1905, the Celio family incorporated and created a lumber company with milling facilities. Nineteen twelve (1912) marked the year the Celio family started harvesting beef in their new slaughter house and providing beef to the resorts popping up around the Lake Tahoe Basin. Both the beef and dairy cattle spent spring through early fall grazing on the grasses from Upper Lake Valley to Meiss Meadows. Every fall the cattle were driven (cattle drive) to the Placerville area to graze and wait out winter, and then they were driven back up the mountain again in the spring.

Historic Meyers California (Source: www.SierraCollege.edu)

During the 1960s, the area around Meyers was part of a large (even by today's standards) residential subdivision plan originally developed by two corporations: Tahoe Paradise Homes and Tahoe Paradise Properties, Inc. The new neighborhoods were to be called Tahoe Paradise. Since that time, the entire area is referred to as either Meyers or Tahoe Paradise. An area of ten (10) square miles was subdivided into 4,400 parcels.

CURRENT COMMUNITY CONTEXT

Meyers functions as one of 6 "gateways" into the Lake Tahoe Basin. However, more visitors enter the Tahoe Basin through Meyers than through any other entry point. Meyers serves as the residential, commercial and public service hub for the El Dorado County portion of the Lake Tahoe Basin. Meyers is separated from the more typical commercial centers found along the shore of Lake Tahoe and has retained its own character while accommodating many of the land uses found elsewhere in the Basin including dining, lodging and recreation.

In 1993, the Meyers Community Plan was adopted by both the TRPA and El Dorado County to guide planning and development in the Meyers commercial core and to be responsive to the unique circumstances found within the built environment and the natural landscape. Many of today's aesthetics and environmental problems can be attributed to past actions that occurred across the Meyers landscape without a clear vision for an effective business district or full recognition of resource sensitivities to development.

Meyers Study Area 2014 – Flooding Across from Lira's Market (Source: John Dayberry)

With the adoption of the TRPA's Regional Plan Update in 2012, an effort is underway to update existing Community Plans, which are now being called Area Plans, throughout the Basin. The Meyers Area Plan (Area Plan) was in the draft stages during the efforts of this study. The current draft of the Area Plan builds upon the 1993 plan. The Area Plan also includes lands not previously contained within the 1993 plan and includes additional implementation measures to achieve both economic and environmental objectives.

The Area Plan includes approximately 669 acres of mixed-use (industrial, commercial, and residential), recreational, and conservation land use designations. Land ownership within the area plan is 32 percent private and 69 percent public ownership (Meyers Area Plan Draft, June 2014). The public lands are primarily under the management of the US Forest Service and California Tahoe Conservancy. The Meyers Area Plan consists mainly of flat, high capability lands. There are three areas within the Area Plan that have been identified Stream Environment Zone (SEZ) and are considered environmentally sensitive and not available for additional development.

Land use in the commercial core is generally mixed (Figure 4) with both private and public land holdings. The biggest opportunity to work with public land holders is with the USFS and the CTC, each having substantial property at the east and west ends of the commercial core. At the east end of Meyers, there is also a small wetland in need of restoration that was identified by the TAC as an important feature that could take on rerouted stormwater while providing a hydrologic benefit through groundwater recharge of the meadow system.

During the development of El Dorado County's Pollutant Load Reduction Plans required by the Lake Tahoe TMDL, Meyers was identified as a significant pollutant load contributor (personal communication, Brendan Ferry, 2014). This fact, in combination with the knowledge that the Upper Truckee River accounts for 25 percent of tributary loads entering Lake Tahoe, makes this watershed a priority for implementing stormwater improvement actions.

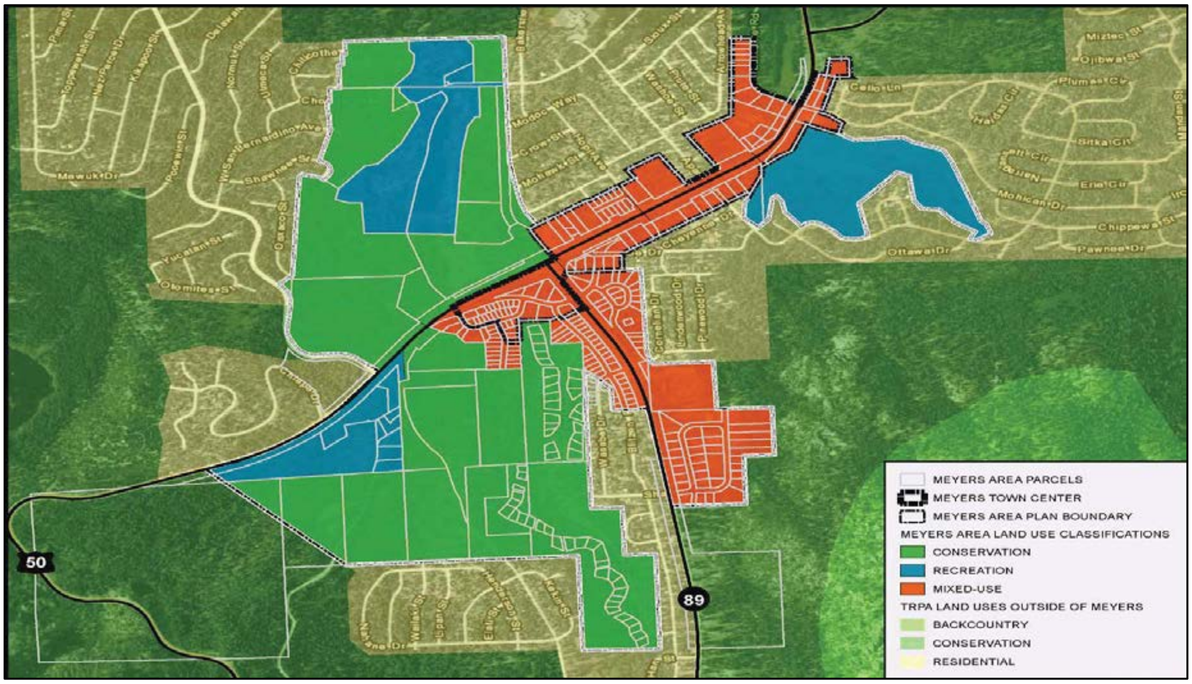


Figure 4. Meyers Land Use Map Recreated from the Meyers Area Plan (Source: http://www.edcgov.us/Meyers/)

MEYERS – A CASE STUDY

The first stages of this project were focused on convening a Technical Advisory Group (TAC) including agency representatives from the Tahoe RCD, EPA, El Dorado County, and the consultant team from RO Anderson. Three meetings with the TAC were held (December 13, 2013, February 10, 2014 and April 24, 2014). The project was initiated with a kick-off session that included a discussion detailing the purpose of the project, development of Critical Success Factors and a site visit to discuss opportunities, constraints, and the project area scope.

Project Critical Success Factors

The listed Critical Success Factors below represent the agreed upon outcomes to be realized with the completion of this study.

- Final Report provides EPA with helpful information on TMDL strategies.
- The identified approaches can be modeled in other communities.
- The identified strategies are actionable.
- The project increases awareness of the support El Dorado County and the Tahoe RCD provide to the Meyers community.
- The community feels empowered to reach common goals and objectives.

(Top Row left to right). Meyers Commercial-Core along US Highway 50 (Source: Coleen Shade)
(Bottom Row left to right). Meyers Creek and Adjacent Meadow (Source: Coleen Shade)

Based on the TAC field discussions, the consultant team was directed to develop two BMP concept strategies. The first concept was to focus on the Meyers commercial core between Apache (near the Agricultural Inspection Station) and Pioneer Trail. The second concept was to focus on the residential area along the Apache "uphill" loop where the City had installed BMPs 20+ years ago and was likely going to need infrastructure improvements.

While on the site visit, the TAC identified public lands that might be integrated with an area-wide strategy. In particular, the meadow at the north end of the study area adjacent to U.S. Highway 50 was identified as a restoration opportunity. The meadow, consisting of approximately 23 parcels, is impaired; running along the western edge of the meadow is the deeply incised Meyers Creek.

Between the first and second TAC meetings, R.O. Anderson's landscape architect/erosion control specialist, engineer, and project manager walked the proposed project area. At that time, the existing BMPs in the uphill neighborhood were judged to be functioning and in good working order. Based on this site visit the TAC recommended that the consultant team focus efforts on developing two concepts for the commercial-core area instead of one residential and one commercial site.

The second TAC meeting was attended by representatives from the Tahoe RCD, EPA, El Dorado County, the Lahontan Regional Water Quality Control Board, and the consultant team. Discussions included identification of current and foreseeable planning efforts in the area, opportunities and constraints, and a detailed discussion on approaches to BMP concepts; the following project summary information resulted.

Project Summary Information

- Current and Planned Projects in Meyers:
    - Caltrans – Begin May 2014. Curb, gutter, basins, crosswalk.
    - County EIP – Erosion control project within ROW from Apache to San Bernardino.
    - CA State Parks – Golf course relocation and river restoration.
    - CTC – Campground restoration.
    - TTD – Request for Congestion Mitigation and Air Quality Improvement funds to connect East and West San Bernardino via a bicycle/pedestrian bridge.
    - Strategic Growth Council – TRPA is applying for funds for the mid-level planning of the Meyers Corridor.
    - TRPA – On Our Way grant submittal for Meyers' core mobility enhancements.

- Constraints:
    - Shallow ground water-design considerations.
    - Caltrans right-of-way is not consistent (can go right up to the front door of businesses).
    - High Traffic Area.
    - Polarized Community: some don't want change.
    - Misunderstandings around the Area Plan and its process.
    - Topography – relatively flat.

- Opportunities:
    - Opportunity to rethink business frontages – Linear road separate from Hwy 50 integrating cars, pedestrians, and bikes.
    - County could take on portions of Caltrans right-of-way so better community planning can occur.
    - BMPs are required on all Commercial Properties.
    - Focus BMP needs on existing large parking lots (Liras, Steve's Transmission, Meeks, and Golf Course).
    - Meyers Creek – currently takes urban run-off through the meadow (Best case scenario is to add pipe for stormwater conveyance from Lira's side to meadow while Caltrans has road dug up for their project).
    - Meadow Restoration – convey flows from commercial core to meadow.
    - Public Lands – there are public parcels within the project area that may provide opportunities to enhance conveyance and detention.
    - Off-line linear option could include overflow with landscaping – There are property owners within the commercial core that own more than one parcel.

In addition to concept designs, the consultant team was asked to interview existing property and business owners within the Meyers commercial core that represented properties that had either complied with BMP requirements or had not yet installed BMPs. The purpose for the interviews was to gauge the interest in supporting (both in concept and financially) the implementation of an area-wide BMP/stormwater system that would provide conveyance and treatment throughout the identified study area for both public and private properties. The interviews were conducted in March and April of 2014. The summary of those discussions are below.

Concurrent to the Tahoe RCD's CWP effort in Meyers, the Area Plan led by El Dorado County and TRPA was nearing completion of a public draft. Both the content and the process of the Area Plan was questioned by the community, and during the summer of 2014 newspaper articles and public opinion seemed to suggest that the community was not interested in new development in Meyers. The controversy and skepticism of the Area Plan became a real constraint for implementing tasks planned for the CWP project. In fact, the Tahoe RCD was asked by the County and TRPA to hold off from bringing area-wide strategies to the Advisory Council and the community.

At the third and final TAC meeting, it was decided that due to low support from business and property owners, coupled with topographic constraints for developing an area-wide system, pushing forward with the CWP project at this time could affect future opportunities to gain community support for area-wide stormwater treatment and commercial-core upgrades.

Area-wide Stormwater Concept Plans

Two conceptual designs were developed by the consultant engineer and landscape architect. As noted above, the objective was to create two commercial-core design scenarios; the first simply addresses water quality improvements (Figure 5) and the second integrates water quality improvements with other elements that might bring additional value to property and business owners in the commercial core (Figure 6).

Conceptual Plan #1 works within the existing Caltrans right-of-way providing "rain-garden" type depressions connected to treat and convey storm water to the meadow for final treatment. Plan #1 also includes a potential public parking site at the north end of the study area in the same location that the draft Area Plan identifies. This concept is mainly focused on areas that are publicly owned.

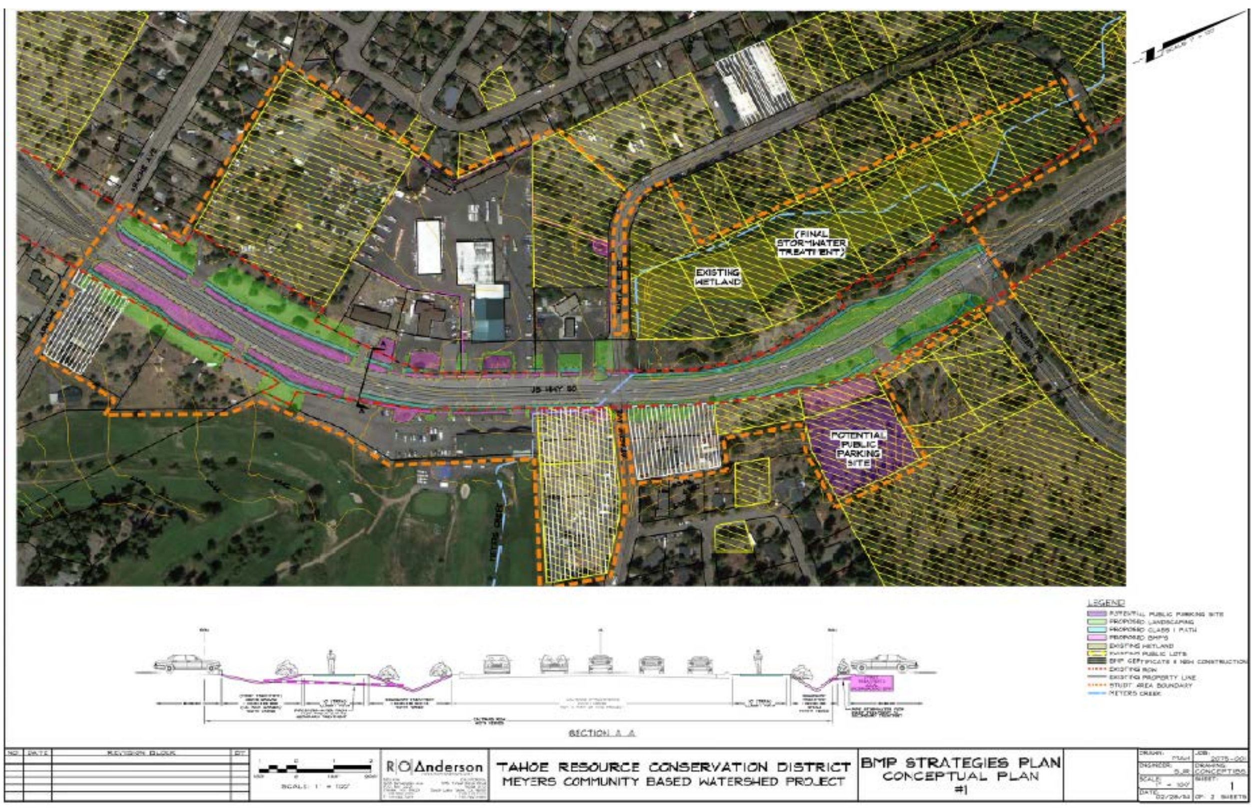


Figure 5. Meyers Study Area – Conceptual Plan #1

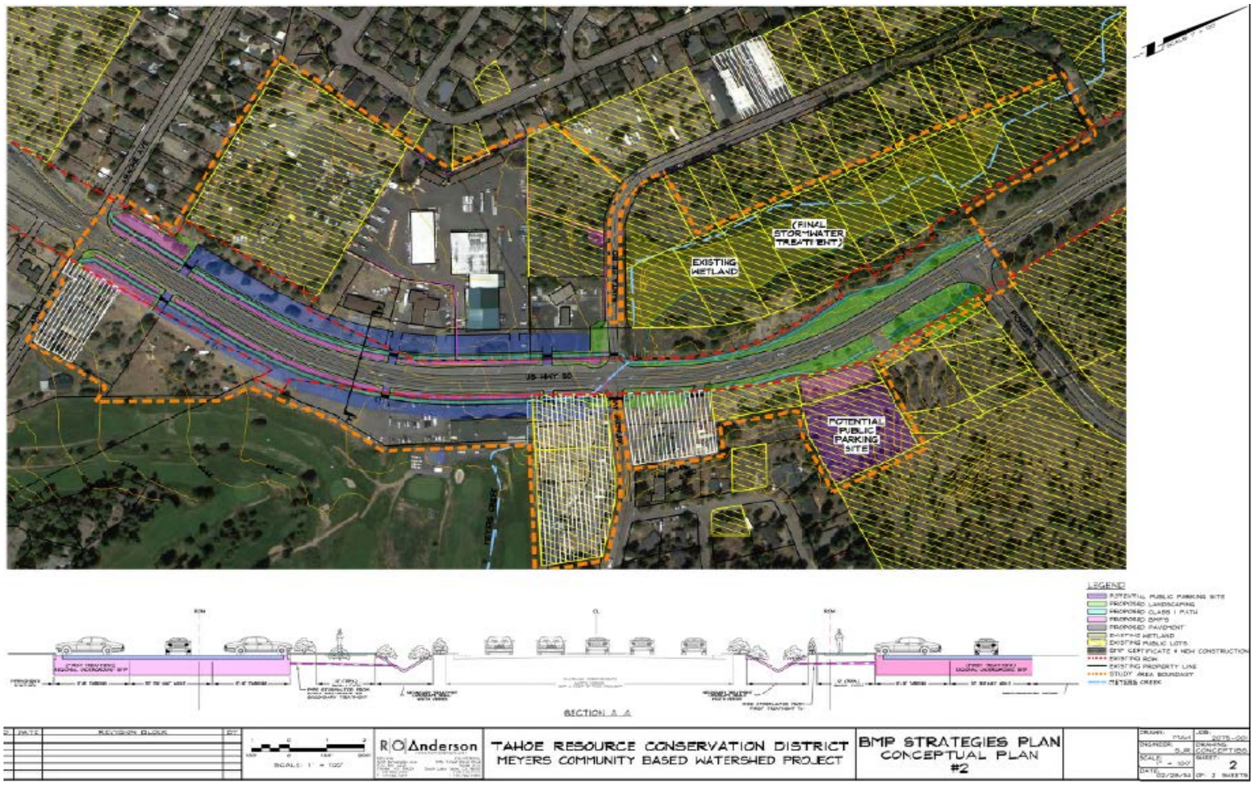


Figure 6. Meyers Study Area – Conceptual Plan #2

Conceptual Plan #2 works within the existing Caltrans right-of-way, within public lands, and on private property. Plan #2 includes improved circulation elements by adding a frontage "drive" along both sides of the highway. These one-way frontage drives allow for additional diagonal parking that separates the auto movement from the pedestrian and bicycle movement. The landscaped "rain-garden" structure separates the pedestrian and bicycle movement from the traffic on the highway. Plan #2 also includes additional public parking in a parking lot at the north end of the study area. These designs were inspired by the information presented at several Meyers Community Meetings.

The Meyers Community Watershed Partnership project also focused on presenting a model approach to developing a benefit assessment, or community facility district that could be used to support future stormwater projects or infrastructure in Meyers' commercial core. In addition to the technical and planning services the Tahoe RCD provided to the Meyers Community and El Dorado County, the Tahoe RCD wanted to provide community outreach services to discuss with pivotal landowners how they envision the future Meyers commercial core functioning, and what amenities would make them more likely to partner with the County and TRPA on future Area Plan implementation.

MODELING RESULTS

The Lake Tahoe TMDL requires that Tahoe jurisdictions reduce pollutant loading of fine sediment particles (FSP), total nitrogen (TN), and total phosphorous (TP) to help improve water clarity in Lake Tahoe. The Pollutant Load Reduction Model v1.1 (PLRM) was developed as a tool to estimate pollutant load reduction to the lake based on the implementation of water quality improvement projects and management actions in a watershed. Using methods described in the Lake Tahoe Clarity Crediting Program Handbook (Crediting Handbook), pollutant load reductions are translated into Lake Clarity Credits used to track TMDL progress. Currently, Lake Clarity Credits are based on the amount of FSP load reduction to Lake Tahoe (the crediting program assumes if FSP is reduced TN and TP are concurrently reduced); therefore, modeling results in this study focus solely on FSP load reductions. The objectives of the PLRMv1.1 modeling in this report are to 1) estimate the potential Lake Clarity Credits that could be obtained through traditional SFR BMP implementation in the Meyers area, and 2) estimate the potential Lake Clarity Credits that could be obtained through installation of area-wide BMPs in the Meyers Commercial Core. All PLRM models were established using the approach described in the PLRM User's Manual (NHC 2009).

PLRM Modeling: Single Family Residential BMPs

Four catchments in the Meyers area (Figure 7) were modeled using PLRMv1.1 to determine potential Lake Clarity Credits that could be obtained through SFR BMP implementation. Acreage of each catchment, percent of the catchment that is SFR, percent of SFR land use that is impervious area, and the number of SFR parcels for each catchment are summarized in Table 1.

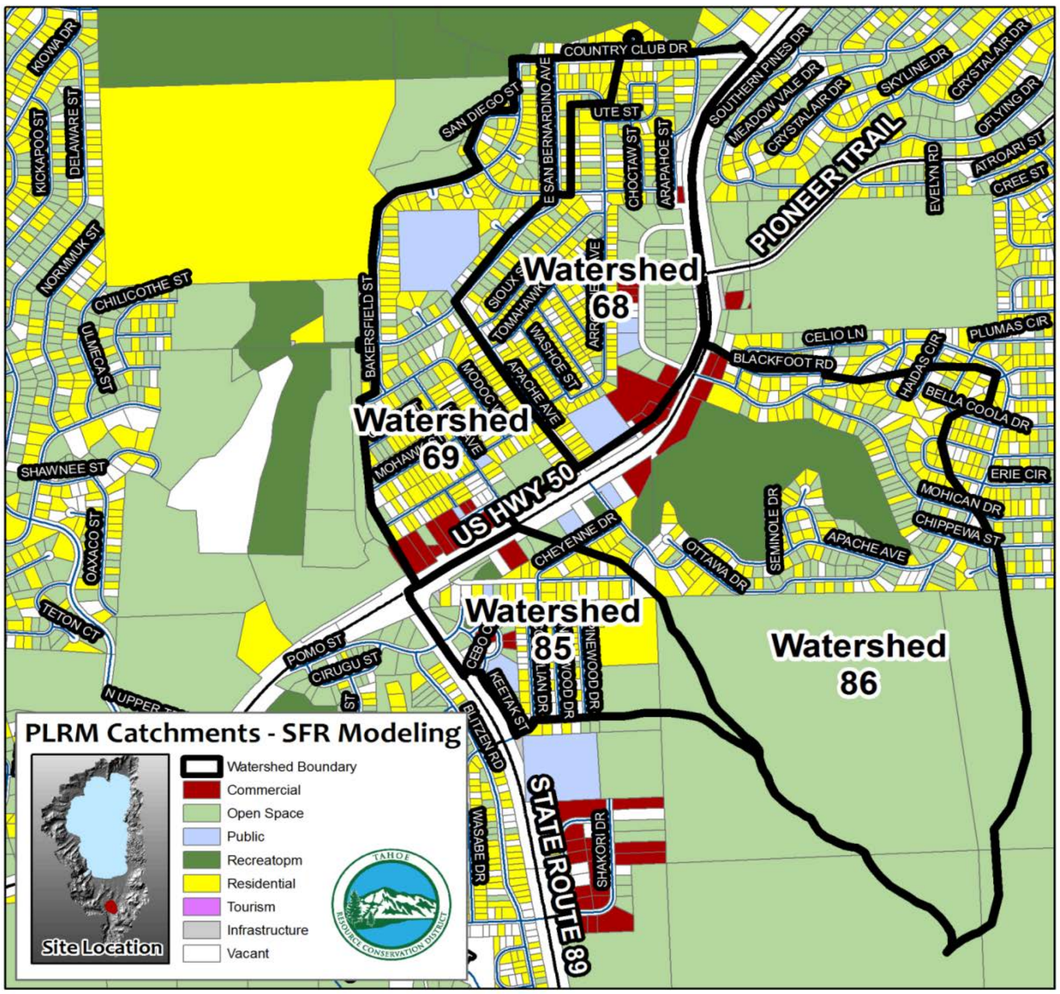


Figure 7. Catchment modeled with PLRM in the Meyers Study Area to estimate Lake Clarity Credits from SFR BMP implementation

Meyers Watershed Characteristics				
	Watershed 68	Watershed 69	Watershed 85	Watershed 86
Acres	163	137	78	340
SFR %	34	40	34	11
SFR Impervious Area %	32	28	23	18
# of SFR parcels	259	229	95	147

Table 1. Acres, total percentage SFR, percentage of SFR that is impervious area, and number of SFR parcels for the watersheds modeled with the PLRM

In order to calculate the potential Lake Clarity Credits that could be obtained with SFR BMP implementation, PLRM models were run with SFR BMP compliance rates of 30 percent (the approximate compliance rate for the Tahoe basin), 50 percent, and 100 percent; all model results are summarized in Table 2. For reference, Table 3 shows the number of SFR parcels that would be necessary to achieve 30, 50, and 100 percent SFR BMP compliance in the Meyers area. The maximum number of credits that could be obtained with 100 percent SFR BMP compliance ranges from 0.68 to 1.61 for the four basins modeled. The number of SFR BMP certificates necessary to achieve 100 percent SFR BMP ranges from 88 to 241 per watershed.

Estimated Lake Clarity Credits - Calculated by PLRM				
SFR BMP Implementation	Watershed 68	Watershed 69	Watershed 85	Watershed 86
30%	0.34	0.39	0.17	0.21
50%	0.64	0.74	0.32	0.39
100%	1.39	1.61	0.68	0.84

Table 2. Lake Clarity Credit potential for 30%, 50%, and 100% BMP compliance rates for the four Meyers catchments, determined through PLRM modeling

Number of SFR parcels to achieve BMP compliance				
	Watershed 68	Watershed 69	Watershed 85	Watershed 86
30% SFR BMP compliance (# parcels)	60	53	22	34
50% SFR BMP compliance (# parcels)	111	98	41	63
100% SFR BMP compliance (# parcels)	241	213	88	137

Table 3. Number of SFR parcels at baseline and the number of parcels that would be required to achieve 30%, 50%, and 100% SFR BMP compliance

PLRM Modeling: Area-Wide Stormwater Treatment

The Meyers commercial-core study area (Figure 8) was modeled using PLRMv1.1 to determine the potential Lake Clarity Credits that could potentially be obtained with the implementation of an area-wide stormwater treatment system. The area modeled covered 24.2 acres and is predominantly classified as commercial-industrial-communications-utilities (CICU) land use. Acreage of the area modeled, percent of the catchment that is CICU, percent of CICU that is impervious area, and the number of CICU parcels for the area modeled is summarized in Table 4 below. The PLRM model results estimate approximately 20 Lake Clarity Credits could be obtained through the implementation of area-wide treatment in the Meyers Commercial Core (Table 5).

Meyers Commercial Core	
Acres	24.2
CICU %	65.0
CICU Impervious Area %	73.5
# of CICU parcels	14

Table 4. Acres, total percentage commercial-industrial-communications-utilities (CICU) land use, percentage of CICU that is impervious area, and number of CICU parcels for the area modeled with PLRM

PLRM FSP Modeling in the Meyers Commercial Core
Estimated Lake Clarity Credits (#)
19.8

Table 5. A conservative estimate of the number of Lake Clarity Credits that could be claimed though Area-Wide Treatment of the Meyers Commercial Core, as modeled with PLRM

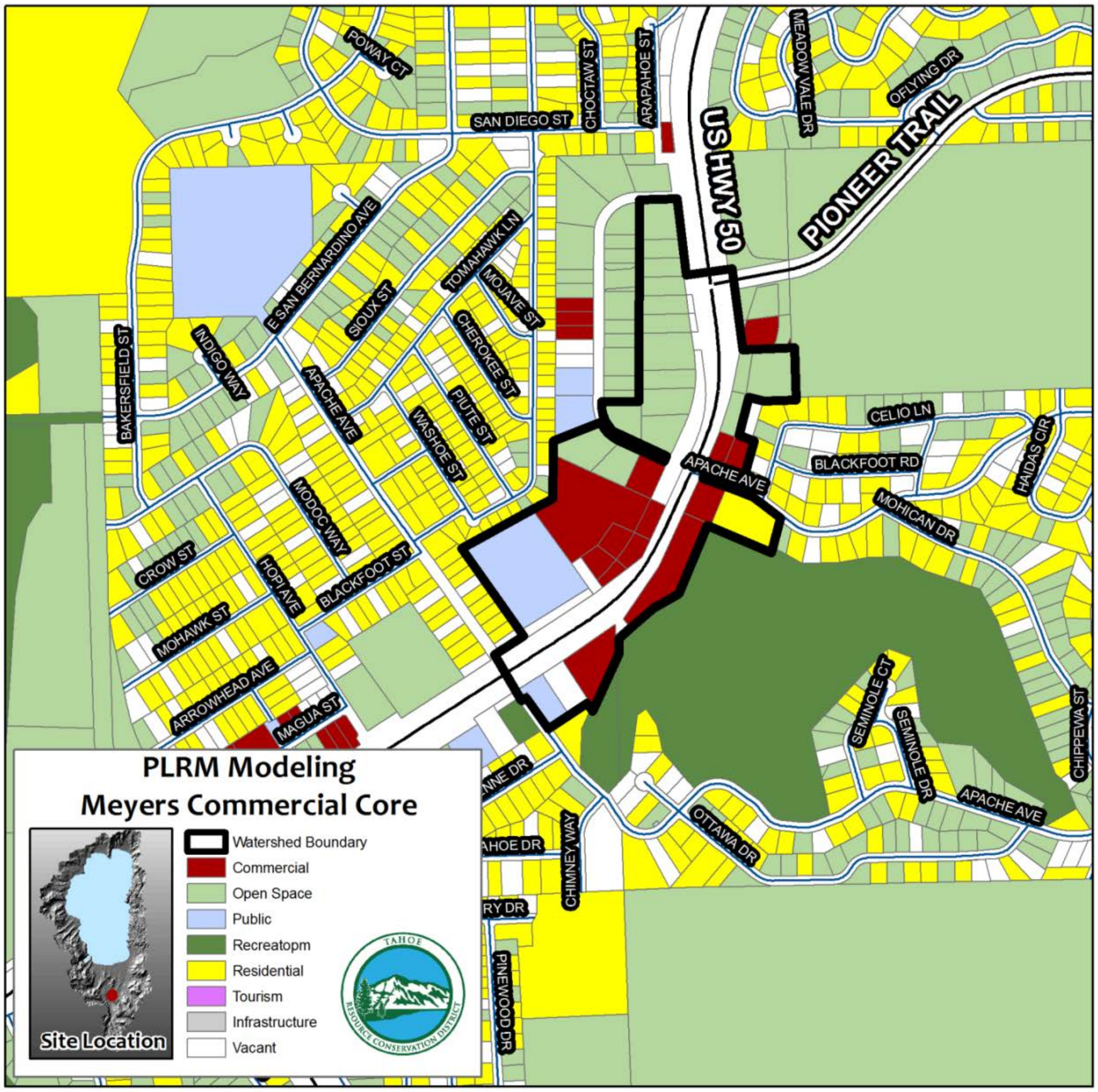


Figure 8. Meyers Commercial Core modeled with PLRM

PLRM Modeling: Discussion

This modeling exercise clearly demonstrates the advantages of a strategy that achieves BMP implementation in commercial corridors over individual SFR BMPs. The total number of Lake Clarity Credits that could be obtained through 100 percent SFR BMP implementation is approximately 4.5 credits, while an estimate of potential Lake Clarity Credits for area-wide treatment in the Meyers Commercial Core is approximately 20 credits; four times the amount of credits for 100 percent SFR BMP compliance. These numbers are not surprising in that the PLRM model assumes that pollutant loading from SFR parcels is relatively low when compared to commercial properties, and therefore much more credit can be gained through BMP implementation on commercial properties.

This study also illustrated the level of effort necessary to receive Lake Clarity Credits. Treating the commercial core is a much more efficient way to attain TMDL credits. Of course it would be necessary to get most of the CICU property owners on board with the plan, which would no doubt require a certain level of information sharing, coordination and commitment. In contrast, to obtain 100 percent SFR BMP compliance would require between 88 to 241 BMP certificates *per catchment; approximately 750 in total*. Single family residential property owners have been slow to comply with the TRPA ordinance, and it would be no small task to achieve this goal.

Finally, implementation of the Lake Tahoe TMDL is still in its early stages and jurisdictions are focused on the most cost-effective way to attain credits required by TMDL permits. In the future, however, as credits become harder to obtain, jurisdictions may take a second look at how SFR BMPs can help them achieve their pollutant reduction goals.

These models have been built as a planning exercise to understand the potential credits that could be claimed with SFR BMP implementation versus Meyers' commercial core area-wide treatment. It should be noted that these models s*hould not be considered finalized estimates of Lake Clarity Credits for the following reasons.* First, these models do not include stormwater infrastructure, as the plans are only in the concept phase. Additionally, these models were run using PLRM version 1.1, which was the version available at the time of modeling. Since the time modeling exercise was completed, PLRM version 2.1 was released.. Potential Lake Clarity Credits should not change substantially between PLRM version 1.1 and PLRM version 2.1, but results will be slightly different.

TAHOE VALLEY GREENBELT PROJECT SCOPE

The Tahoe Valley Greenbelt CWP strategy is to provide useful TMDL implementation information to Basin managers, regulators, and stormwater jurisdictions. The Tahoe Valley Greenbelt study area within the Tahoe Valley Area Plan was identified as a priority watershed for development of a Community-based Watershed Strategy through a CWP ranking process that evaluated proximity to the lake, slope, soils, precipitation, and modeled pollutant load contributions. The development of the CWP Strategy was guided by a Technical Advisory Committee (TAC) led by the Tahoe RCD, and in partnership with EPA, the City of South Lake Tahoe, the California Tahoe Conservancy and the Lahontan Regional Water Quality Control Board to ensure the project was well coordinated and relevant to other projects implemented in the watershed. The TAC also helped identify project goals, and provided input on project execution.

The Tahoe RCD and its partners outlined the following goals for this project:

- Concepts developed and agreed upon demonstrate the multiple benefits of area-wide stormwater management when it is successfully integrated with other public/private benefits (i.e., scenic, recreation, transportation/circulation, economic development).

- Demonstrates how in-lieu fees may be employed for BMPs.
- Demonstrates public/private partnership opportunities.
- Demonstrates pollutant load modeling (area-wide vs parcel by parcel).
- Demonstrates integrated approach to implementing the Environmental Improvement Program (EIP).
- The grant funded project is closed out by December 30, 2015.

The TAC was engaged in work sessions to explore strategies for assisting private property owners, commercial businesses, and local jurisdictions with TMDL implementation through a community-based watershed approach. The goal of EPA's Community Based Watershed Strategy grant is to explore approaches that integrate strategies for public and private partnerships using education, information sharing, and project implementation. Through a community-based approach it is expected there will be an increase in general knowledge of restoration objectives, opportunities for improving environmental stewardship, and enhancements to the Lake Tahoe Basin's BMP and TMDL programs.

Many of the Tahoe Valley Area Plan property owners (Greenbelt Advisory Group) within the study area were individually interviewed and all were invited to participate in three work sessions that took place over a year's time. The purpose of the work sessions was to share with the Advisory Group the Tahoe Valley Area Plan updates as it moved towards approval, solicit Greenbelt amenity ideas that will bring value to the businesses and the community, and discuss the interest in a public/private partnership to financially support the implementation of the Greenbelt vision. The Greenbelt Advisory Group was engaged to identify opportunities that bring economic, social and environmental benefit to the Tahoe Valley property owners and the City. The sessions included frank conversations about a public/private partnership between the property owners and the City of South Lake Tahoe to financially support an area-wide stormwater retention and treatment system, integrate additional connectivity, and include recreation amenities.

In support of the goals above, this report includes two separate conceptual drawings for an area-wide stormwater system with integrated community amenities. Also included in the report are the Pollutant Load Reduction Model (PLRM) estimates for single family residential (SFR), multi-family residential (MFR), and Commercial-Industrial-Communications-Utilities (CICU) BMPs at the current rate of implementation and theoretical rates of 50, 75, and 100 percent implementation and PLRM estimates that represent potential benefits of area-wide treatment in a selected area of the Tahoe Valley Area Plan. A little later in this report, the Tahoe Valley Greenbelt Case Study is presented to outline the steps taken to engage property owners and the results of those efforts.

Traditional technical services related to SFR, MFR and Commercial development BMP implementation, as well as landscape conservation assistance were also provided throughout this project.

HISTORICAL INFLUENCES

The area in and around the South Lake Tahoe "Y" has remained an important travel corridor and meeting place going back in history to the Washoe peoples' interactions within the Lake Tahoe Basin. A portion of the old Pony Express Trail ran through the Tahoe Valley Area Plan. Ranching was an important industry at the turn of the last century on the South Shore, supplying fresh meat, dairy products and vegetables to the burgeoning resorts. The Barton Ranch was located within the boundaries of today's Tahoe Valley Area plan. The ranch consisted of a ranch house (built in 1890) and several outbuildings. These buildings remained within the Tahoe Valley Area Plan until their recent removal in August 2015.

CURRENT COMMUNITY CONTEXT

The Tahoe Valley Area Plan is bounded on the north, west, and south primarily by residential subdivisions dating back to the 1960s. The plan area is bordered by the Upper Truckee Marsh and the South Lake Tahoe Airport on the southeast.

Today, the Tahoe Valley area is dominated by commercial development abutting U.S. Highway 50 and State Route 89. The Highway right-of-way lines meander inconsistently as do existing development setbacks.

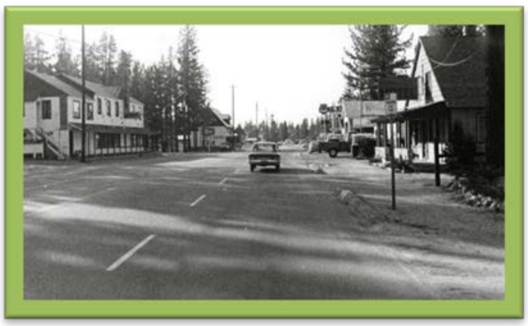
Parcel sizes vary and development is fragmented. New development, consistent with design, materials, and landscaping standards contrast with the many older motor lodges built in the 1960s. In addition to discontinuous landscape improvements, the lack of uniform connectivity of pedestrian and bicycle paths is a problem for both mobility and aesthetics.

Our study area land uses include residential, commercial, tourist accommodation and industrial. Tahoe Valley is the gateway neighborhood for South Lake Tahoe. Its commercial uses serve both the South Shore residents and visitors stocking up on their Tahoe-stay provisions. The commercial uses include clothing stores, factory outlets, drug stores, restaurants, and a supermarket. These uses occupy structures ranging in age and physical condition from the 1890's to present day construction.

Over the last century, the Tahoe Valley area has been heavily disturbed and its natural resources have been manipulated and reduced to a few vegetated and undeveloped parcels found behind the Highway 50 commercial "strip". An ephemeral stream (Tahoe Valley Creek) runs through the Greenbelt study area.

The plan area includes three drainage basins including the Tahoe Valley system that runs south of the "Y" intersection, which is directly connected to the Upper Truckee River. The other two drainage basins drain into the Tahoe Keys Lagoons before being released into Pope Marsh. Many properties contain excess coverage over the Bailey land capability limitations and approximately 50% of the commercial parcels have BMPs installed.

Tahoe Valley Commercial-Core; US Highway 50 & State Route 89 (Source: Google Earth 2015 and U.S. Geological Survey approx. 1969)



(Left) Tahoe Valley Commercial-Core; Heading east on US Highway 50 early 1960s (Source: Don Lane)
(Right) Tahoe Valley Commercial-Core; At B Street and US Highway 50 (Source: Bill Kingman)

TAHOE VALLEY GREENBELT – A CASE STUDY

The first stages of this project were focused on convening a Technical Advisory Group (TAC) including agency representatives from the Tahoe RCD, EPA, City of South Lake Tahoe, and the consultant team from RO Anderson. The project was initiated with a kick-off session (July 14, 2014) that included a discussion detailing the purpose of the project and development of critical success factors.

Project Critical Success Factors

The listed critical success factors below represents the agreed upon outcomes to be realized with the completion of this study.

- Property owner/business and public outreach achieves buy-in on concepts and potential assessment district.
- The process identifies multiple benefits that can result from the greenbelt concept; benefits include an integration of water quality, recreation, transportation/connectivity, visual enhancement and economic development.
- Boundaries are assessed and adjustments are made to support watershed functions.
- The identified concepts/strategies are actionable (they can be feasibly implemented).
- This process builds capacity to assist implementation opportunities.
- Process and deliverables will set the stage for moving forward with local TMDL goals (potential area to be treated, number of potential certifications, etc.).

Project Summary Information

Based on the TAC discussions, the consultant team was directed to prepare a site plan of the Greenbelt project area and Greenbelt amenity sample boards. In preparation for the first Advisory Group work session, property owner interviews were conducted to inform the work session process and to find out the property owners' level of interest in an area-wide stormwater treatment system. The interview results found that there were a high percentage of property owners interested in exploring the possibility of creating a public/private partnership for the purpose of implementing an integrated Greenbelt stormwater treatment system.

Informal and formal Trails south of Lampson Plaza (Source: Coleen Shade)

At the first Advisory Group work session, held September 30, 2015, the participants were facilitated through a Strengths, Weaknesses, Opportunities, and Strengths (SWOT) activity to inform the Greenbelt design process. In small groups, lists were developed that addressed:

- What are the strengths of the Tahoe Valley Area Plan and Greenbelt?
- What are the weaknesses?
- What are the opportunities for the area plan?
- What are the threats or risks that create barriers to implementing the Greenbelt project?

The following lists the feedback received from the Advisory Group members:

Strengths

- Community has endorsed a great idea (i.e., a Greenbelt stormwater system that is integrated with amenities)
- This collaborative effort will achieve multiple community goals

- The area provides strolling area for nearby higher density/mixed use residential
- CTC lands adjoin City's Greenbelt parcels expanding opportunities to meet infiltration capacity
- The area includes water features
- It is the entrance to Lake Tahoe's public assets such as beaches, campgrounds, trails, historic sites, wilderness areas, and open space
- It has a Gateway identity
- Local uses at the "Y"
- There are existing bike paths
- Adjacent to fulltime residential neighborhoods
- Great restaurant-row area

Weaknesses

- No visual access into Greenbelt; the current Greenbelt access is not welcoming
- Need to install environmentally-friendly access through wet areas where they don't exist (ie, boardwalks, bridges)
- Currently no wayfinding signage; no welcoming improvements for visitors
- Winter access/X-country skiing not accommodated
- Snow is currently stored at Greenbelt entry points
- The area is treated like a dump
- There is a bike path to nowhere; no formal connectivity to Barton Hospital, surrounding neighborhoods and Meyers
- Area has a number of vacancies and undeveloped parcels
- Existing situation doesn't encourage multi-use/passive activities
- Existing situation doesn't allow for enough or comfortable outdoor restaurants and seating
- Lack of lighting; safety issues are very immediate
- Crossing Highway 50 is "deadly" – lack of safe pedestrian and bike crossings
- Speed limit must be reduced – "Please!"
- Lack of family entertainment in the Tahoe Valley Area (movie theater replaced by CVS)

Opportunities

- Creation of a well-connected commercial core with sidewalks and bike trails that connect to neighborhoods
- Lose the "Y" name and go to "Gateway" or "Southgate"
- Creation of an area-wide stormwater system serving public and private properties
- Invest in community appeal
- Creation of spaces/places for gathering at the locals' end of town
- Create community vegetable garden in a sunny spot
- Use of the CTC parcel on Highway 50 (adjacent Factory Stores) Greenbelt for a gathering area
- Utilize area behind Pier 1 as a front (door) rather than the backdoor – community space for businesses
- Design better use of CalTrans right-of-way space
- Create safe pedestrian crossing (using Hwy median/islands)
- Create a permanent place to display banners for local events (over Hwy)
- Outdoor scenery/landscaping
- Development of a theater/outdoor or indoor venue
- Increase public safety, include well-designed lighting for safety

- Implement area-wide BMPs
- Create a pedestrian friendly area – park once/public parking
- Present the area with lighting so visitors know that they have arrived in South Tahoe (the HUB).
- Vehicle access to back of businesses for deliveries
- Decommission Barton Avenue
- Walk-up restaurant access from back of buildings and outdoor seating away from the highway
- Design lighting that is compatible with surrounding uses and non-impactful to night sky
- Control run-off and flooding through an area-wide designed system

Barriers to Success

- Achieving the necessary buy-in to gain political support
- Acquiring the necessary funds to implement the Greenbelt vision
- City able to support on-going maintenance costs
- Getting CTC to get over "Asset Lands" mindset
- Purpose for which CTC originally purchased properties (needs to be consistent with CTC Board authorized purchase purpose)
- Attempt to meet multiple town center goals – Integrate infill with Greenbelt
- High ground water (shallow aquifer at Ken's)
- Accommodations for mixed-use parking
- Caltrans/Permitting coordination and cooperation
- Open space for central plaza needs visual exposure from Hwy
- Multiple agencies and stakeholders
- Caltrans right-of-way varies; no consistent geographic setback to uniformly design within
- Within the Area Plan there are no Hwy 50 crosswalks except at the traffic light
- Speed limit does not promote safety or gathering

Greenbelt Integrated Area-Wide Stormwater Concept Plan

The second and third Advisory Group work sessions (July 16, 2015 and August 20, 2015) focused on soliciting ideas and preferences for the types of community amenities to integrate into the area-wide Greenbelt stormwater treatment system. Advisory Group participants were provided with two concept scenarios; one focused on amenities to support passive activities and the other on amenities to support active ventures. The group selected a combination of both active and passive activities to integrate.

At the last work session, the participants worked in smaller groups to identify six (6) amenities from their previously crafted list that best fit the landscape, and the project's environmental, social and economic revitalization goals. They were given the option to choose more than six (6) if they felt more amenities were warranted. Once they chose the amenities, they were asked to identify the geographical location for each within the Greenbelt study area. They could apply their chosen amenities to more than one location. At the end of the activity, each group shared their maps with the entire group. With very few exceptions, the groups' preferred design concepts were quite similar.

The Advisory Group participants were asked if they could come to a consensus on the preferred amenities. There was a consensus on the amenities which included a public plaza, a small community amphitheater, naturally designed playgrounds, community garden, multi-use paths, and recreational activities that flowed through Greenbelt (par course or Frisbee golf). Safety features were also integrated into all of the preferred concepts. These features included lighting and highway pedestrian and bicyclist crossings. Gateway features, art and wayfinding were also identified as important features that should be used to unifying and brand the Greenbelt. The geographical locations obtained about an 80% agreement. Without knowing the exact configuration of the stormwater features, preferred locations were a bit imprecise. Figure 9 and Figure 10 illustrate the Advisory Group's preferred concept.

The following lists the three (3) groups' preferences for community amenities.

Group A
"Green Belt opportunities include things that flow from one end of the Greenbelt to the other."

1. Amphitheater at the 'Y' corner
2. Gathering plaza/place behind Factory Outlet Stores
3. Community garden at both ends of Greenbelt
4. Playgrounds by community gardens and amphitheater
5. Lighting through Greenbelt, lighting trails and activities (safety)
6. Activities that flow through Greenbelt like jogging path, par course, Frisbee golf

Group B
"Gateways will be an important feature and should entice people into the Greenbelt."

1. Gateway and signage placed at entry points that draw attention and enhance the whole area
2. Lighting located through Green Belt to make it safe
3. Art, including permanent, temporary, and cultural events
4. Amphitheater/gathering place/cultural areas located behind Factory Outlet Stores
5. Passive seating areas located throughout the Greenbelt
6. Playground located near amphitheater and pharmacy

(The group had concerns with connecting to other side of U.S. Hwy 50 at B Street and crossing at 3rd Street to connect with bike path on Eloise.)

Group C
"Amenities should be integrated with art."

1. Playgrounds located as bookends to the Greenbelt and at the amphitheater
2. Amphitheater located behind and to the north of the Factory Outlet Stores
3. Gateways into Greenbelt integrated with art, as a part of enticing people to enter
4. Community garden integrated with art located off of B Street behind Pier One
5. Footbridges connecting people on both sides of detention basins with foot paths and trails
6. LED lighting throughout Greenbelt
7. Public restroom near amphitheater

Prior to the close of the third work session the participants were asked to indicate, by a show of hands, if they were interested in continuing to explore a public/private partnership with the City of South Lake Tahoe to financially support the implementation of the Greenbelt integrated area-wide stormwater project. All indicated they were interested in continuing the exploration. A few individuals wanted to make it clear that until the numbers were available (total cost and property owners' fair share) they could not commit to anything else at this point.

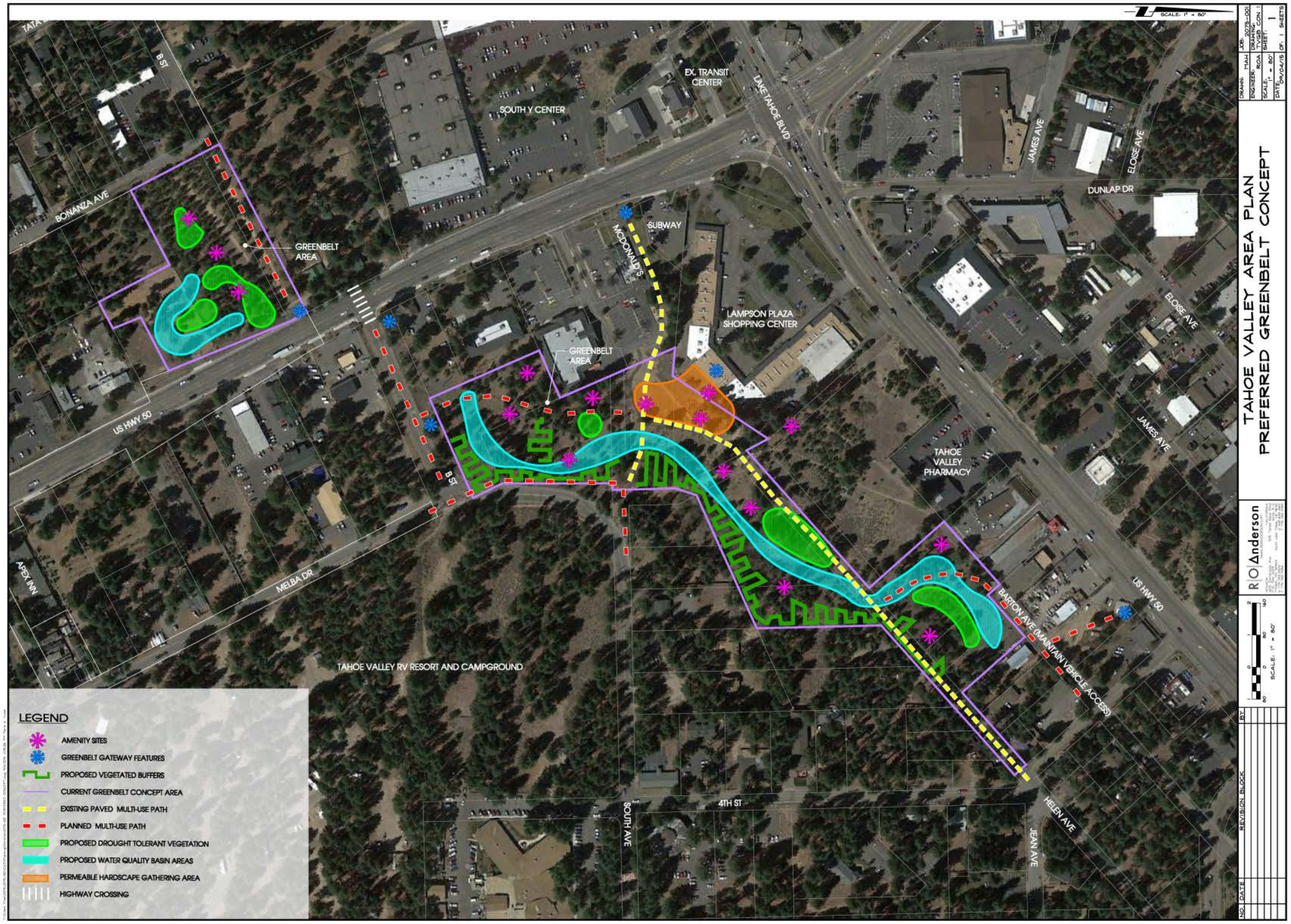


Figure 9. Advisory Group's Preferred Concept Plan

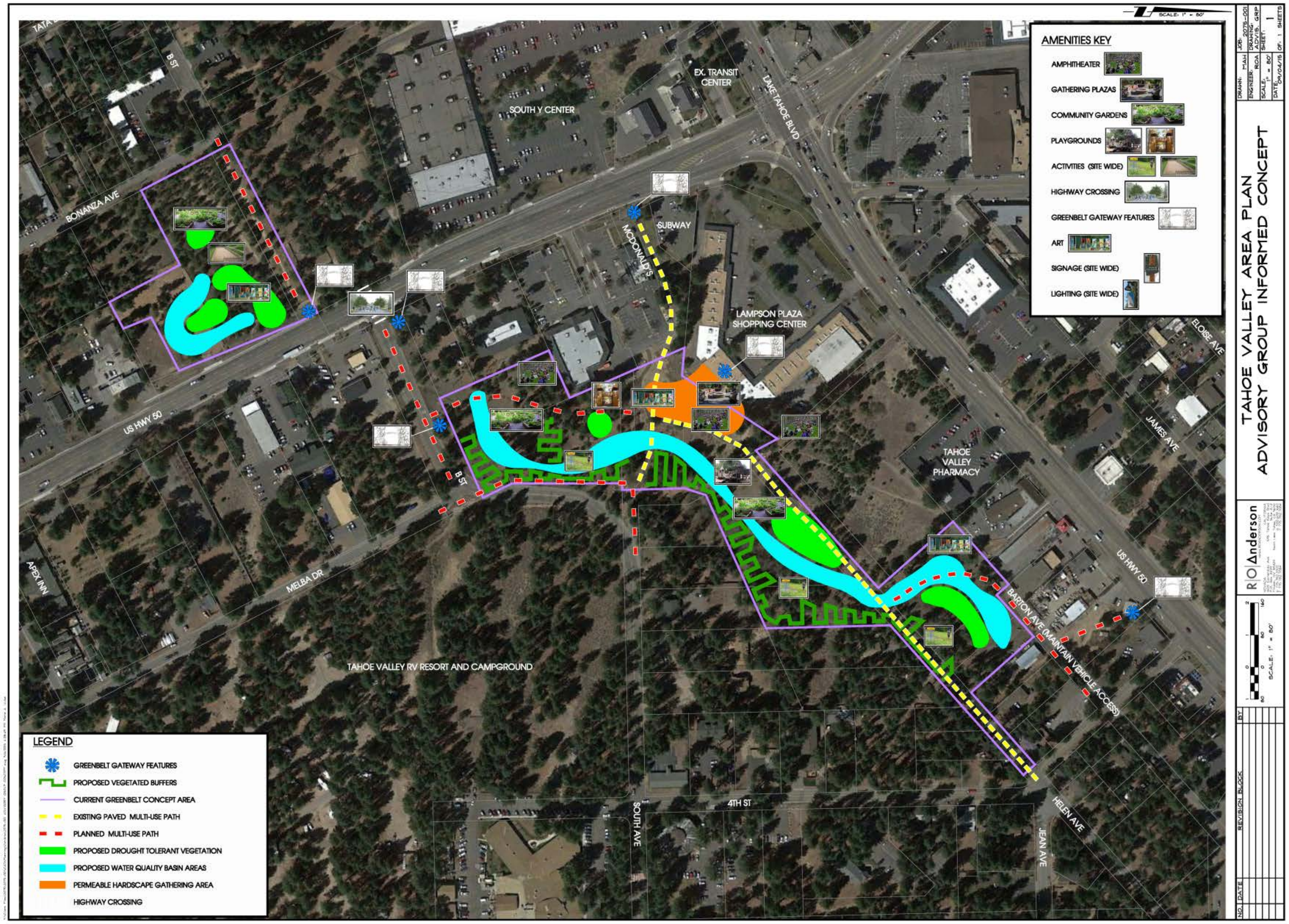


Figure 10. Advisory Group's Preferred Concept Plan with Amenities

MODELING RESULTS

The Tahoe Valley Greenbelt Community Watershed Partnership project also focused on presenting a model approach to developing a benefit assessment, or community facility district, that could be used to support future stormwater projects or infrastructure in the study area.

Pollutant Load Reduction Modeling

The Lake Tahoe TMDL requires that Tahoe jurisdictions reduce pollutant loading of FSP, TN, and TP to improve water clarity in Lake Tahoe. The Pollutant Load Reduction Model version 2.1 (PLRMv2.1) was developed as a tool to estimate pollutant load reduction to the lake based on the implementation of water quality improvement projects and management actions in a watershed. Using methods described in the Lake Tahoe Clarity Crediting Program Handbook Version 2 (LCCP Handbook v2 (2015)), pollutant load reductions are translated into Lake Clarity Credits used to track TMDL progress. All PLRM models in this were established using the approach described in the PLRM user's manual (NHC 2015) and the LCCP Handbook v2 (2015).

Private parcel and area-wide best management practice (BMP) credit potential was modeled using the PLRM v2.1 in the Tahoe Valley catchment. PLRM v2.1 modeling determined the credit potential for installing BMPs on single family residential (SFR), multi-family residential (MFR), commercial-industrial-communications-utilities (CICU) private parcels, along with the equivalent credit potential for an area-wide treatment system for CICU parcels (i.e., the Tahoe Valley Commercial Core). The area modeled is shown in Figure 11. According to the LCCP Handbook v2 (2015), BMP performance tends to decrease with time, and therefore LCCP modeling protocol states that BMPs older than 5 years must be modeled as though they treat only half the original BMP'ed area. It is possible to recertify the BMPs on an MFR or CICU property to receive full credit; however, the level of effort this will take on the part of the jurisdiction and land owner is unclear. In order to simplify interpretation of PLRMv2.1 results, the following discussion assumes all CICU and MFR BMP certificates are greater than five (5) years old, and therefore, treating only half the original BMP'ed area. According to the LCCP Handbook (2015) SFR BMPs are always worth their full value, regardless of age. An area-wide treatment system does not lose credit potential based on age but rather needs a score of greater than 2.5 (on a scale from 1 to 5) for a BMP Rapid Assessment Methodology (RAM) measurement to be considered fully functioning (BMP RAM is the LCCP (2015) approved method for assessing the function of BMPs).

To determine credit potential of private parcel BMPs at different rates of implementation, SFR, MFR, and CICU land uses were modeled using the current percentage (by area) of private parcel BMPs as well as hypothetical BMP'ed areas of 50%, 75%, and 100% (with MFR and CICU land BMPs treating only half capacity because they are assumed to be greater than 5 years old). The current rate of BMP implementation was calculated with GIS using the data included in the PLRM v2.1 download (https://www.enviroaccounting.com/TahoeTMDL/Program/Display/ForUrbanJurisdictions), which is the 2014 BMP status provided by the TRPA. The equivalent credit potential for an area-wide treatment system for the Tahoe Valley Commercial Core was determined by modeling CICU parcels with hypothetical BMP'ed areas of 50%, 75%, and 100% (treating full capacity because it is assumed the area-wide treatment system would be maintained at a BMP RAM score of 2.5 or greater). Results of these modeling efforts are shown in Table 6. For the LCCP, baseline BMP'ed areas were standardized for the entire Tahoe Basin at 5% for CICU, 19% for MFR, and 7% for SFR. The current BMP'ed area (assuming BMPs on MFR/CICU private parcels are greater than 5 years old) was determined with GIS for the three separate subcatchments in the Tahoe Valley catchment (TVToOutlet, TVHelenDB, and TVLindaWB; Figure 11 & Table 7). The greatest credit potential came from a hypothetical area-wide treatment of 100% of the Tahoe Valley Commercial Core at 168 credits (or 33,722 lbs/year FSP reduction). The

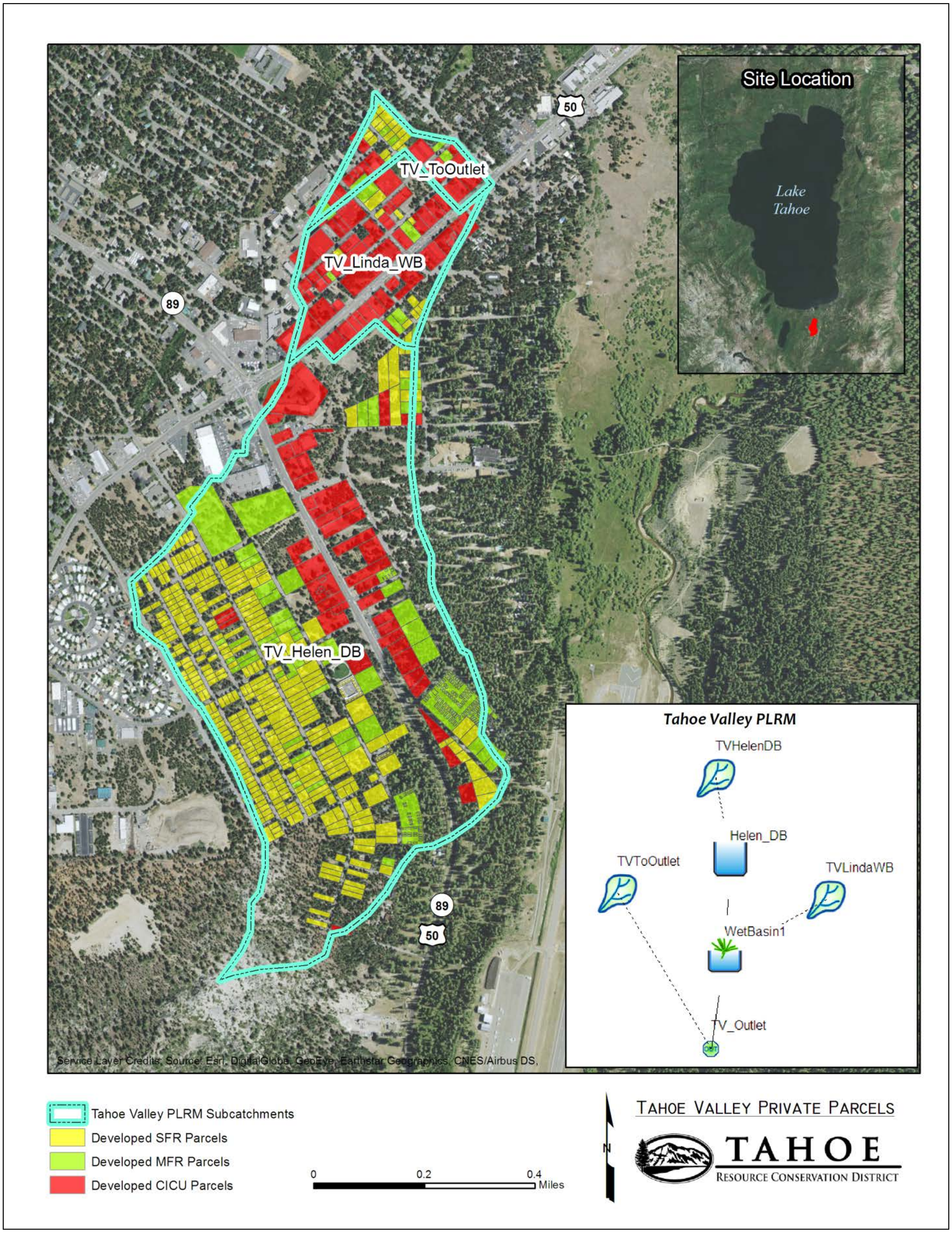


Figure 11. Project Area (Tahoe Valley Modeled Area), City of South Lake Tahoe, California

According to the Lake Clarity Crediting Program Handbook v2 (2015), MFR/CICU BMPs greater than 5 years old only treat half the original BMP'ed area, SFR parcels are always worth their original value, regardless of age, and area-wide treatments are worth original value if the BMP RAM score is > 2.5. Table 6 summarizes the results.

PLRM Annual Pollutant Loading and Credit Potential for BMPs in Tahoe Valley							
	Runoff	Annual Pollutant Load				FSP Load Reduction	Clarity Credits
BMP'd Area	Volume (ac-ft/year)	TSS (lbs/year)	FSP (lbs/year)	TP (lbs/year)	TN (lbs/year)	(lbs/year)	(#)
Baseline (SFR 7%; MFR 19%; CICU 5%)	155	106,697	68,002	250	954	-	-
Single Family Residential (SFR) BMPs **(BMP age doesn't influence credit potential)**							
Current Area (3.0 to 21.1%)	154	106,464	67,855	249	951	146	1
50%	153	105,941	67,529	248	945	473	2
75%	152	105,484	67,243	246	940	759	4
100%	151	105,020	66,951	245	935	1,051	5
Multi-Family Residential (MFR) BMPs **(> 5 years old)**							
Current Area*0.5 (0 to 7.0%)	156	107,747	68,651	253	967	-649	-3
50%	154	106,219	67,706	249	948	296	1
75%	152	105,214	67,083	246	936	918	5
100%	150	104,201	66,456	243	924	1,546	8
Commercial-Industrial-Communications-Utilities (CICU) BMPs **(> 5 years old)**							
Current Area*0.5 (18.25 to 30.6%)	146	100,112	63,801	235	900	4,201	21
50%	140	94,932	60,486	223	857	7,516	38
75%	131	87,676	55,844	206	797	12,158	61
100%	122	80,570	51,294	189	737	16,708	83
Area-Wide Treatment **(BMP RAM Score influences credit potential, assuming BMP RAM > 2.5)**							
50%	122	80,570	51,294	189	737	16,708	83
75%	103	66,890	42,518	157	621	25,484	127
100%	85	54,082	34,280	126	509	33,722	168

Table 6. Volume of runoff, pollutant loading, and credit potential for SFR, MFR, CICU, and Area-Wide Treatment at hypothetical BMP'ed areas of 50%, 75%, and 100% (and current BMP'ed rate included for SFR, MFR, and CICU) in the Tahoe Valley catchment

According to the Lake Clarity Crediting Program Handbook v2 (2015), MFR/CICU BMPs greater than 5 years old only treat half the original BMP'ed area. SFR parcels are always worth their original value, regardless of age. Table 7 and Figure 8 present these results.

Current BMP'ed Area			
Subcatchment	SFR (%)	MFR (%)	CICU (%)
***Assuming > 5 years old**			
TVToOutlet	5.4	7.0	21.6
TVHelenDB	21.1	6.1	18.3
TVLindaWB	3.0	0	30.6

Table 7. Current BMP'ed area for SFR, MFR, and CICU land uses

second greatest credit potential came from a hypothetical 100% CICU private parcel BMP'ed area at 83 credits, which is equivalent to a 16,708 lbs/year reduction in FSP. In contrast, a 100% MFR private parcel BMP'ed area resulted in 8 credits (1,546 lbs/year FSP reduction), while a 100% SFR private parcel BMP'ed area resulted in 5 credits (1,051 lbs/year FSP reduction). The current CICU private parcel BMP'ed area is higher than baseline conditions (baseline CICU BMPs implementation rate is 5%) for all three of the subcatchments (21.6% for TVToOutlet, 30.6% for TVLindaWB, and 18.3% for TVHelenDB); registration of this catchment with the current CICU BMP'ed area could provide 21 credits (4,201 lbs/year FSP reduction). Conversely, the current MFR BMP'ed area (7.0% for TVToOutlet, 6.1% for TVHelenDB, and 0% for TVLindaWB) is lower than baseline conditions (baseline MFR BMPs implementation rate is 19%), and therefore results in negative credit potential. SFR BMP'ed area varies among the subcatchments – it is higher than baseline conditions (baseline SFR BMPs implementation rate is 7%) at 21.1% in the TVHelenDB subcatchment, yet lower than baseline conditions in both TVToOutlet (5.4%) and TVLindaWB (3.0%). Because two of the subcatchments are lower than baseline and the TVHelenDB subcatchment drains to an existing dry basin, very little credit potential can be realized from registering the Tahoe Valley catchment at the current SFR BMP'd area (registration would result in 1 credit, which is equivalent to 146 lbs/year FSP). Figure 12 shows the FSP reduced/credit potential versus hypothetical BMP'ed areas in the Tahoe Valley catchment. For all land uses, the relationship is linear, and the large credit potential for CICU BMPs (both private and area-wide) over MFR and SFR BMPs is readily apparent.

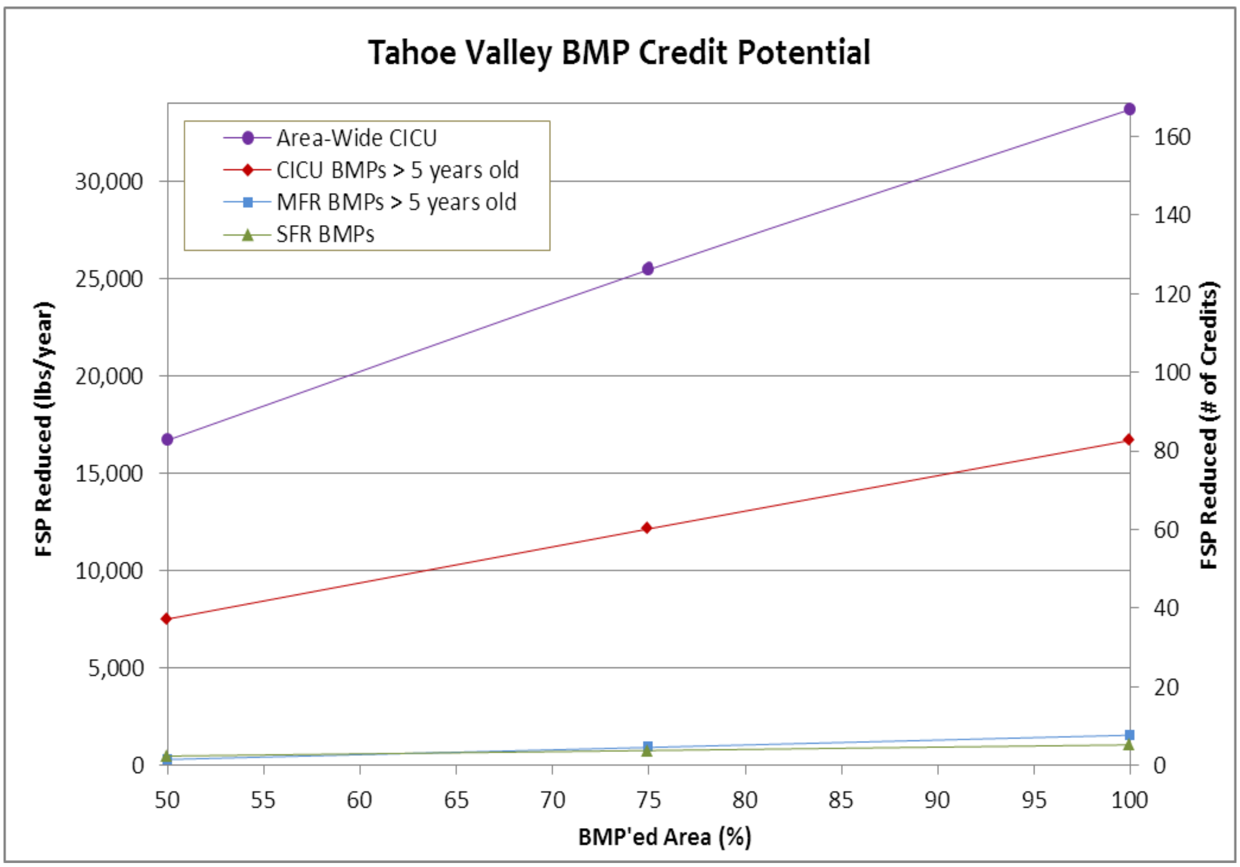


Figure 12. FSP reduced versus BMP'ed area for Area-Wide BMPs, CICU BMPs > 5 years old, MFR BMPs > 5 years old, and SFR BMPs in the Tahoe Valley catchment

While overall credit potential is important, understanding the total cost and cost-efficiency of different water quality improvement actions is essential for effectively managing resources. In order to better understand the installation cost of private parcel BMPs, total cost and cost per credit were calculated for 100% BMP'ed area on each land use using installation cost estimates provided by the TRPA ($5,000 for SFR and MFR; $50,000 for CICU). Cost estimates are provided in Table 8 and maps of current BMP'ed area in the Tahoe Valley catchment for SFR, MFR, and CICU are shown in Figure 13, Figure 14, and Figure 15, respectively. The highest total cost for private parcel BMPs was for CICU BMPs at $3,300,000 followed by SFR BMPs at $1,730,000 and finally MFR BMPs at $985,000. The lowest cost per credit came from a 100% CICU BMP'ed area at $53,226 per credit. A 100% MFR BMP'ed area came in at $89,545 per credit; however 3 of these credits would be needed just to bring the Tahoe Valley area up to baseline condition. The highest cost per credit was for 100% SFR BMP'ed area at $432,500. Since these numbers don't straightforwardly convey the level of effort required to achieve 100% BMP'ed area, the number of BMP certificates needed for 100% BMP'ed area are also shown in Table 8. The number of BMP certificates required to achieve 100% BMP'ed area is 66 for CICU, 197 for MFR, and 346 for SFR. Although cost-estimates for area-wide treatment are not provided in this study, cost-savings and project efficiency would likely be two benefits of treating runoff from CICU land uses in an area-wide treatment system since area-wide treatment systems are often more straight-forward to construct/maintain than BMPs on each individual parcel.

For SRF, MFR, and CICU parcels, a cost estimate is provided for total cost and cost per credit (Table 8). The lowest cost per credit potential exists for installing CICU BMPs. According to the Lake Clarity Crediting Program Handbook v2 (2015), MFR/CICU BMPs greater than five (5) years old only treat half the original BMP'ed area. SFR parcels are always worth their original value, regardless of age.

Cost of Install for 100% Private Parcel BMPs in Tahoe Valley			
Certificates Needed (#)	**Clarity Credits (#)**	**Install Cost TOTAL**	**Install Cost PER CREDIT**
Single Family Residential (SFR) BMPs **(BMP age doesn't influence credit potential)**			
346	5	$1,730,000	$432,500
MFR BMPs **(>5 years old)**			
197	8	$985,000	$89,545
CICU BMPs **(>5 years old)**			
66	83	$3,300,000	$53,226

Table 8. Cost of installation and number of certificates needed to achieve 100% private parcel BMP'ed area in the Tahoe Valley catchment

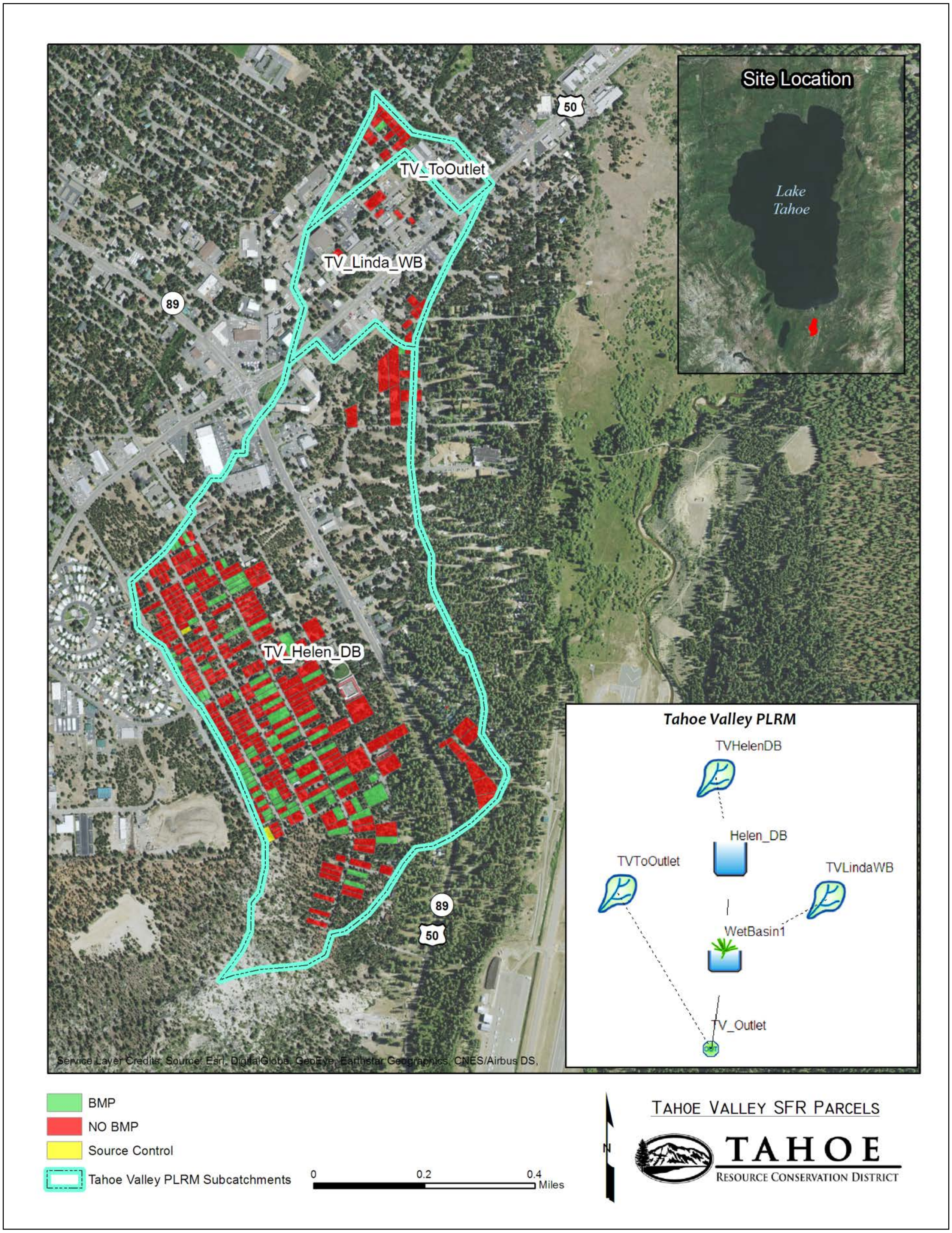


Figure 13. Current SFR BMP'ed area in the Tahoe Valley catchment (2 source control certificates)

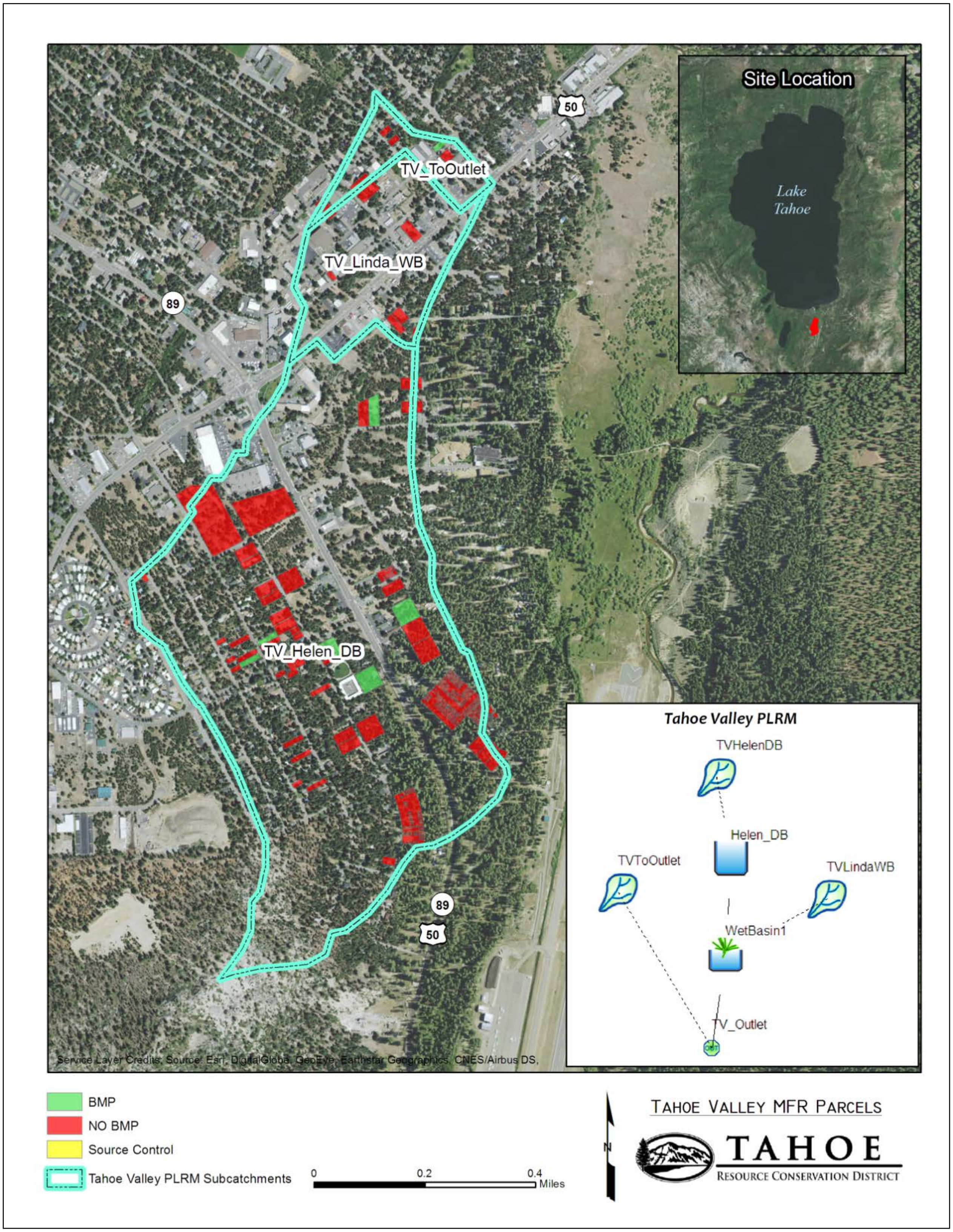


Figure 14. Current MFR BMP'ed area in the Tahoe Valley catchment (0 source control certificates)

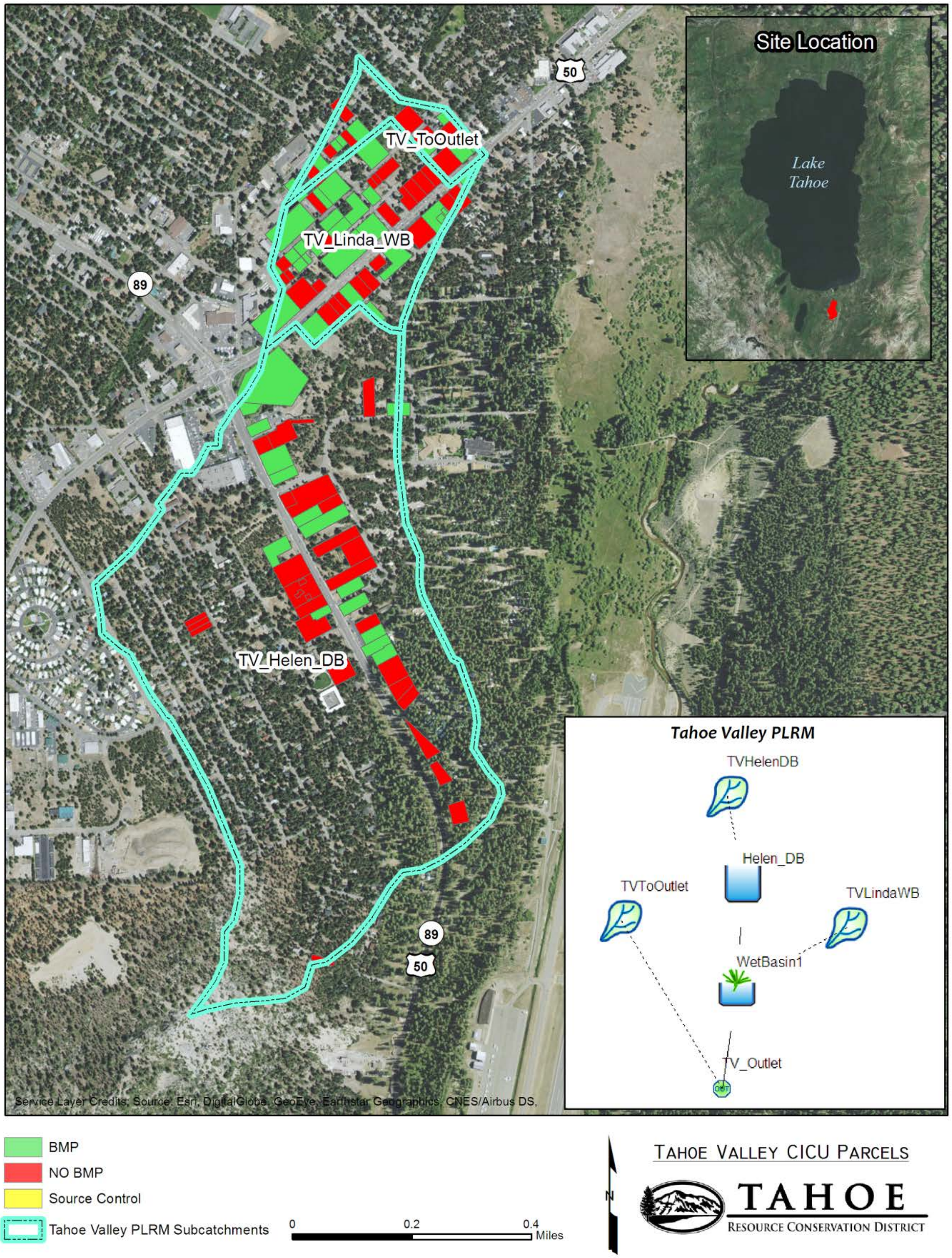


Figure 15. Current CICU BMP'ed area in the Tahoe Valley catchment (0 source control certificates)

Pollutant Load Reduction Modeling Discussion

This modeling exercise clearly demonstrates the advantages of private parcel BMP implementation in commercial corridors over individual SFR/MFR BMPs. The total number of Lake Clarity Credits that could be obtained through 100% private parcel BMP implementation is 5 credits for SFR, 8 credits for MFR, and 83 credits for CICU. Meanwhile, Lake Clarity Credits for area-wide treatment in the Tahoe Valley Commercial Core is estimated to be 168 credits; approximately 34 times the amount of credits for 100% SFR private parcel BMPs, 23 times the amount of credits for 100% private parcel MFR BMPs, and 2 times the amount of credit for 100% CICU BMPs. For MFR/SFR parcels, these numbers are not surprising in that the PLRMv2.1 model assumes that pollutant loading from SFR/MFR parcels is relatively low when compared to commercial properties; therefore much more credit can be gained through BMP implementation on commercial properties. The BMP'ed area, and in this case, the number of credits, decreases by half for CICU private parcel BMPs greater than 5 years old; to obtain full credit would require continual recertification of these properties, which would likely require a large effort. In contrast, maintaining an area-wide treatment system would likely be a simpler process than requiring maintenance/recertification for each individual CICU private parcel owner on a 5-year basis.

This study also illustrates level of effort and the potential cost necessary to receive Lake Clarity Credits. To obtain 100% BMP implementation on CICU parcels would require 66 BMP certificates. In contrast, to obtain 100% BMP implementation would require 346 SFR BMPs and 197 MFR BMPs. Single-family residential and multi-family residential property owners have been slow to comply with the TRPA ordinance, and it would be no small task to achieve this goal. The cost benefit of BMP installation for private parcel CICU is clear, with CICU private parcels costing $53,226 per credit, compared to $89,545 per credit for MFR, and $432,500 per credit for SFR. An area-wide treatment system for the Tahoe Valley Commercial Core would likely be even more cost efficient than individual parcel-level BMPs since an area-wide treatment systems may be simpler to construct and maintain than installing BMPs on each individual parcel. Treating the commercial core is a much more efficient way to attain TMDL credits; of course it would be necessary to get most of the CICU property owners on board with the plan, which would no doubt require a certain level of information sharing, coordination and commitment.

In closing, implementation of the Lake Tahoe TMDL is still in its early stages and jurisdictions are focused on the most cost effective way to attain credits required by TMDL permits. In the future however, as credits become harder to obtain, jurisdictions may take a second look at how SFR/MFR BMPs can help them achieve their pollutant reduction goals.

BENEFIT ASSESSMENT –A CASE STUDY

In the 1995 Bijou/Al Tahoe Community Plan (a City of South Lake Tahoe and TRPA land use document), the Harrison Avenue project had been identified as an important capital and environmental improvement project. In the preceding years there had been multiple attempts to design and implement a project in the Harrison Avenue commercial core. In December, 2011 the City of South Lake Tahoe's Council identified the Harrison Avenue commercial core improvements as its top priority project and hired a consultant team to design, engineer, obtain environmental clearance and permits, facilitate the formation of an assessment district, and provide public engagement. The key to the City Council's prioritization of this project was a timeline in which implementation would occur. The project, constructed in 2014, includes an area wide storm water system to improve water quality, streetscape, and mobility improvements.

Prior to the January 2012 project kick-off meeting, every property owner within the project area was contacted, interviews were conducted, and a personal invitation to the January kick-off meeting was extended. Of the fourteen private property owners, twelve owners or their representatives were in attendance. The first critical milestone achieved by this group was agreement on a design concept. This agreement led to preparation of the 20 percent engineered plans and a cost estimate. The engineer's cost estimate garnered more discussion about the design and what the property owners might be willing to finance as their fair share to implement the project. Assessment district best practices from other areas were presented.

Under the provisions of Proposition 218, property assessments may only charge for improvements that confer a special benefit to the property included in the district. This is based on the theory that the general public should not have to pay for the benefits that accrue to the few. The benefit analysis that was employed in the "fair" share calculations addressed the following:

- That an equitable method be used to identify the special benefit received from improvements.
- That all parcels receiving a special benefit, including publicly-owned parcels and utilities, had been identified and included in the district.
- The cost of the improvement had been reasonably apportioned among the benefitted parcels.
- Costs attributed to general benefits to the public at large (federally-owned parcels) were not paid from special assessments.

The amount of impervious surface on each parcel contributes storm water runoff to the area-wide BMP. With this in mind, owner costs were based on the amount of impervious land coverage existing and future potential for each parcel. Streetscape costs were calculated separately from the water quality improvements. The following four steps summarize the assumptions made in calculating the individual property owner water quality assessments:

1. Perform calculations for existing and build out scenarios for impervious land coverage for all private parcels and for the public's right of-way and parcels. This step provided a private/public ratio to be used in determining the private versus public share. Potential land coverage or built out scenarios were considered for two reasons: to assure the facilities built would have capacity to support runoff under future development conditions, and to ensure the private property owners who had undeveloped or underdeveloped parcels would be assessed appropriately for future BMP needs. Impervious land coverage outside of the public right of way and parcels (for which a land survey was completed) was determined based upon Google Earth images.

2. Based on the engineer’s estimate at the 50 percent design level, an impervious land coverage analysis was prepared that first identified the coverage ratio for public/private ownership.

3. There were three parcels within the project area that had already installed BMPs and the property owners did not feel they would gain a benefit from the water quality portion of the project. With a BMP certificate of completion from TRPA these three properties were excluded from the assessment calculations. With the above considerations, the private fair share per square foot of existing and potential land coverage was estimated.

4. A maximum of 50 percent land coverage was used in the individual private parcel calculations for undeveloped or underdeveloped parcels.

Streetscape improvement cost apportionments were similarly assigned. Although the improvements benefit the commercial properties directly in terms of enhancing their attractiveness and accessibility for customers, the Harrison Avenue improvements also create a general benefit to the City, its citizens, and visitors to the City by improving the attractiveness of the US Highway 50 corridor where it meets the lake front and providing on-street parking that will be used by visitors to the lake as well as to the commercial businesses. In reviewing the cost of the improvements in relation to the commercial value of the properties and the potential increase in business from the more attractive environment created by the improvements, it was determined that the special benefit conferred upon the property owners would not be more than half of the total cost of streetscape improvements in the area.

Most of the streetscape improvements are located on Harrison Avenue; however the project also included new alignments to incorporate diagonal parking, sidewalks and lighting on the side streets. The benefit assessment was calculated based on the amount of linear feet each parcel had on Harrison Avenue and the linear footage on a side street. It was negotiated that the benefit associated with the side streets was 25 percent that of the benefit gained from being on Harrison Avenue. As discussed above, the City deferred the assessments for residential and undeveloped parcels until such time as they develop into commercial uses.

The City agreed to a deferral of all assessments for undeveloped and residential parcels (there are two parcels with residences and four undeveloped parcels within the project area) and until which time the parcels are commercially developed. At such time the property owner will be responsible for the full assessment. This negotiated deferral was key to gaining support and passing the ballot vote by property owners which required, based on individual percent of assessment, at least 2/3 approval. Of the total amount assessed per parcel, the ballot vote for approval represented eighty-seven percent of the total assessment.

The successful progression of the Harrison Avenue project relied on the following planning elements:

- The City Council identified the implementation of this project as a high priority.
- An elected official and City administrator attended most of the advisory group meetings.
- Real time feedback, support and decision making allowed negotiations to move along quickly.
- A financial public-private partnership between the City and the property owners was key to moving this project forward.
- The process with the property owners was transparent and inclusive with room to negotiate.
- Public workshops informed the design and highlighted potential implementation issues.

The Harrison Avenue planning successes can be replicated at other locations around the Lake Tahoe Basin. Though each location is unique in its landscape and community character, economic and environmental values are similar. Commercial property owners at Lake Tahoe, in general, want to be seen as good environmental stewards of their property, contribute to their community's sustainability while insuring the viability of their own businesses and livelihood. In the process of building a public – private partnership the City of South Lake Tahoe provided strategic leadership and vision to move the project to construction. Replicating the Harrison Avenue public/private success in other places can happen when the property owners and community members trust their local leaders enough to make the investment in a vison that is shared.

MEYERS AND TAHOE VALLEY AREA PLAN GREENBELT CWP - LESSONS LEARNED

In the commercial core areas around the Lake Tahoe Basin there is a need to provide a concentrated education effort focused on strategies for improving water quality. The efforts have to make it very clear what the potential benefits and values will be to a private property owner when they become a financial participant in an area-wide stormwater project. Educating business and property owners about how implementing BMP's demonstrates good stewardship is not enough. The installation of BMPs on commercial properties cost tens of thousands of dollars if not hundreds of thousands of dollars.

From the planning and regulatory side it is important to demonstrate the value a comprehensive storm water system can bring to a commercial district and the value it can add to individual property owners. For example, a large piece of commercial property may individually cost a half million dollars to adequately BMP, but as a partner in an area-wide system the property owner's contribution assessment could be less than half that cost. In addition, where usable space is a premium, a commercial property owner may find value in not needing to remove parking spaces to install individual detention basins on site. In particular, when we are talking about commercial properties, systems that consider the integration of aesthetic enhancements, recreation benefits, parking and circulation improvements have a better chance of gaining investment (financially and politically) by commercial property owners.

On the other hand, for single family residences it is relatively less expensive to install BMPs. To ask the owner of a single family residence to pay more than a couple of thousand dollars into an assessment district in exchange for eliminating the requirement to install and maintain BMPs on the parcel will likely be challenging. An additional option for the Tahoe RCD and its stormwater partners is to explore an annual stormwater fee that would be relative to the average cost homeowners would pay to install BMPs, but spread out over a 40-50 year time frame. If implemented jurisdiction wide, stormwater managers would have a consistent annual budget to commit to infrastructure maintenance and BMP replacement; providing a long-term and reliable community-based restoration approach.

In both cases however, either a neighborhood benefit assessment or a jurisdiction-wide assessment, approximately 30 percent of individual private property owners on the California side of the Lake Tahoe Basin have already complied with TRPA's ordinance and installed BMPs. Although maintenance is an ongoing burden, these property owners would be less likely to volunteer to be financial partners in area-wide storm water projects.

Meyers Study Area – Looking West on US Highway 50 Across from Lira's Market (Source: Coleen Shade)

The Meyers and Tahoe Valley Greenbelt CWP projects had two very different outcomes. Both community locations were working through the process of adopting an Area Plan within their separate jurisdictions (El Dorado County and the City of South Lake Tahoe). Both CWP Study Areas concentrated on the commercial core properties and both projects anticipated area-wide stormwater solutions to benefit both public and privately owned parcels. U.S. Highway 50 runs down the middle of both study areas creating safety and connectivity constraints. Approximately 50% of the developed commercial properties have installed BMPs.

Though the similarities are numerous, the two CWP projects can be differentiated by just a couple of dissimilarities which can be attributed to politics/ leadership and education. The Meyers Area Plan update process was in its second year when Tahoe RCD embarked on the CWP for the Meyers core area. The Area Plan process had created mistrust in the community for both the process and the agencies involved. The process did not include opportunities to inform the Area Plan participants with visual examples of development scenarios the plan was contemplating. This approach left room for individual interpretation for what the implementation of the plan might look like; not all accurate or factual. Neither the County's Planning Director nor someone with experience in the preparation of Community Plans representing TRPA was engaged in the process. Planning staff assigned worked diligently to draft language that would be acceptable only to have it misrepresented by opposing views. Several meetings were facilitated by the County Supervisor for the Meyers area (District 5), which made the process more political than it needed to be. And, 2014 was an election year for the District 5 Supervisors seat.

In contrast, the City of South Lake Tahoe initiated its Tahoe Valley Area Plan process with a recap of where the process had been (the City had started the planning process in 2005) and asked participants to identify visual preferences based on examples of different types of development. In addition to planning staff, the City was represented at these meetings by the City Manager, Community Development Director and the Planning Director. At each subsequent meeting City staff made it clear both in the plan's language and visual examples what changes had been made because of the feedback that was received. Participants gained investment in the plan and were excited about plan elements such as the Greenbelt. The City's process nurtured trust and did not become political. Participants were educated along the way.

When individual interviews were conducted with the Meyers commercial property owners to explore their interest in an area-wide stormwater system, a common response heard was the mistrust for the County to do "right" by the property owners. When individual interviews were conducted with the Tahoe Valley Greenbelt property owners they were already excited about the Greenbelt element because of the City's Area Plan process. It should be added that at the time when the first Tahoe Valley Greenbelt interviews were being conducted (late summer 2014) the City was building the Harrison Avenue commercial district project.

Area-wide stormwater systems for the Lake Tahoe Basin's CICU development areas have been shown through modeling to provide the biggest bang for the buck. For the least amount of dollars per credit with the most pollutant load reduction it seems clear this is a tool local jurisdictions can use to achieve TMDL targets. However, there is significant work that needs to be accomplished up-front in order to establish the public/private partnerships that can be sustained through design development, the financial negotiations of an assessment district and implementation of the area-wide project.

RECOMMENDATIONS

One of the perceived benefits to working with the Meyers community is there was an established planning group (Meyers Community Advisory Council) working toward the adoption of the Meyers Community Area Plan. Like with any project however, timing is critical. Although the Tahoe RCD was successful at getting the area-wide stormwater treatment concept included in the Area Plan project list; there can be drawbacks to introducing another element, particularly an implementation element, if there are ongoing concerns from the community about the plan as a whole.

In order to continue our efforts in Meyers, the Tahoe RCD will stay connected to the community by providing continued Landscape Conservation education and technical services where possible. Tahoe RCD is also in the process of partnering with El Dorado County and the Lake Tahoe Environmental Magnet School to develop a rainwater harvest system that will serve as an innovative demonstration project to help highlight community stormwater projects and water conservation initiatives. Additionally, the Tahoe RCD is currently identifying grant opportunities that would assist with planning and implementing meadow restoration along Meyers Creek that would provide benefits to recreation, wildlife, water quality and aesthetics. By taking a leadership role in supporting conservation issues within the Meyers community, the Tahoe RCD and partner agencies can gain the trust of the community to ensure synergy with future collaborative endeavors.

Recommendations for Future Area Plan Collaboration

- Participants in the planning and design stages should be identified and engaged as early as possible in the process. Participants need to include: decision makers, property owners, and agencies with jurisdiction. Others to consider early in the process are utility providers, Caltrans, and potential funding agencies.
- If a financial partnership between public and private entities is a goal, the establishment of what the decision space will be (consensus, vote, public entity makes decision, etc.) is critical.
- Include an expert on assessment districts on the team who will clearly articulate financial requirements and opportunities under the law.
- Transparency is a critical piece to building trust and moving a process forward that depends on buy-in from property owners.

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A COMPARISON OF INFILTRATION OBSERVATIONS FOR DRY BASINS IN LAKE TAHOE

A comparison of infiltration observations for dry basins in Lake Tahoe

Contributing Authors:
Cara Moore, Tahoe Resource Conservation District
Oscar Atkinson, Tahoe Resource Conservation District

March 2015

Developed by:

Tahoe Resource Conservation District
www.tahoercd.org

Funded by:

Southern Nevada Public Lands Management Act (SNPLMA)
http://www.blm.gov/nv/st/en/snplma.html

Sponsored by:

California Environmental Protection Agency (CA EPA)
http://www.calepa.ca.gov/

A comparison of infiltration observations for dry basins in Lake Tahoe

Recommended citation:

Tahoe Resource Conservation District. 2014. A comparison of infiltration observations for dry basins in Lake Tahoe. Prepared for the Enviromental Prection Agency. March 2015.

We would like to thank the following individuals and organizations for their contribution to the content of this document:

Andrea Buxton, Tahoe Resource Conservation District
Kim Gorman, Tahoe Resource Conservation District
William Loftis, Natural Resources Conservation District
Karin Peternel, Douglas County Stormwater Program Manager

The Tahoe RCD would also like to thank the Environmental Protection Agency for supporting this project and SNPLMA for their generous funding support, without which this effort would not be possible.

TABLE OF CONTENTS

ACRONYMS

BMP	Best Management Practice
BMP RAM	Best Management Practice Rapid Assessment Methodology
CASQA	California Stormwater Quality Association
CHP	Constant Head Permeameter
CSLT	City of South Lake Tahoe
EDC	El Dorado County
EPA	Environmental Protection Agency
FSP	Fine Sediment Particles
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
RAM	Rapid Assessment Methodology
SNPLMA	Southern Nevada Public Lands Management Act
Tahoe RCD	Tahoe Resource Conservation District
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorous
UPC	Urban Planning Catchment

EXECUTIVE SUMMARY

The Lake Tahoe National Pollutant Discharge Elimination System (NPDES) permit was developed by the Lahontan Regional Water Quality Control Board to help implement the Lake Tahoe Total Maximum Daily Load (TMDL) to improve Lake Tahoe's deep water transparency. The permit requires that local California jurisdictions reduce pollutant loading of fine sediment particles (FSP), total nitrogen (TN), and total phosphorous (TP) to Lake Tahoe. As part of this permit, local California jurisdictions in the Tahoe Basin are required to monitor the performance of all "key and essential" Best Management Practices (BMPs) through the use of Rapid Assessment Methodologies (RAMs). In the fall of 2014, Tahoe Resource Conservation District (Tahoe RCD) staff tested three different methods for evaluating infiltration in dry basins as part of the BMP RAM measurements. The methods were tested in the City of South Lake Tahoe's Urban Planning Catchment (UPC) B14 and El Dorado County's UPC04 and included constant head permeameter (CHP), single-ring infiltrometer, and California Stormwater Quality Association (CASQA) 48-hour basin draw down time. This was an effort to provide BMP RAM data to these jurisdictions, and to evaluate each method's results and the efficiency with which the observations were obtained.

CHP is currently the recommended method for conducting BMP RAM on dry basins. However, CHP **does not evaluate infiltration at the soil surface, where infiltration nautrally occurs in a dry basin.** CHP punches a hole through the surface of the dry basin, the area that is prone to sedimentation and subsequent clogging,and measures saturated hyraulic conductivity in the subsurface. Single-ring infiltrometer and CASQA 48-hour basin draw down time both focus on infiltration at the soil surface and therefore may be more indicative of a dry basin's ability to infiltrate stormwater runoff.

Conducting CHP and single-ring infiltrometer measurements require similar amounts of staff time, while the **CASQA 48-hour basin draw down time took roughly 10% of the staff time required by the other two methods**. The main disadvantage of the CASQA method is that it is weather dependent, which creates scheduling difficulties. However, in basins where CHP/infiltrometer measurments are not possible (i.e. rock lined basins), CASQA may be the only viable option.

CASQA provides BMP standards that are nationally recognized. Due to the substantial decrease in required staff time, along with CASQA's reputation for setting the industry standard, the Tahoe RCD recommends that the CASQA 48-hour draw down time be used for BMP RAM on dry basins.

1 PURPOSE

The Lake Tahoe National Pollutant Discharge Elimination System (NPDES) permit was developed by the Lahontan Regional Water Quality Control Board to help implement the Lake Tahoe Total Maximum Daily Load (TMDL) to improve Lake Tahoe's deep water transparency. The permit requires that local California jurisdictions reduce pollutant loading of fine sediment particles (FSP), total nitrogen (TN), and total phosphorous (TP) to Lake Tahoe. The Lahontan Regional Water Quality Control Board also developed the Lake Clarity Crediting Program which requires California jurisdictions in the Tahoe Basin to monitor performance of all "key and essential" Best Management Practices (BMPs) through the use of Rapid Assessment Methodologies (RAMs). As of March 2015, the Lake Clarity Crediting Program Handbook offers the following regarding how "key and essential" is defined: "(a)s a rule of thumb, the complete absence or failure of an essential pollutant control could result in more than a 25% increase of the overall load from the catchment…" and "… the complete absence or failure of a key treatment BMP or source control could result in more than a few percent to a one third increase of the overall load from the catchment…". This study focused on dry basins because they are one of the most common infiltration BMPs in the Tahoe Basin. The purpose of this study is to (1) conduct BMP RAM assessments to be used by jurisdictions to evaluate BMP performance and to (2) evaluate the practicality, appropriateness, and amount of staff time needed to conduct BMP RAM on dry basins in El Dorado County (EDC) and the City of South Lake Tahoe (CSLT).

2 CATCHMENTS

BMP RAM was performed on dry basins for CSLT in Urban Planning Catchment (UPC) B14, and for EDC in UPC04 (Figure 1). CSLT UPC B14 contains three dry basins which overflow into a meadow and subsequently into Pope Marsh. EDC UPC04 contains eight dry basins; all runoff from EDC UPC04 catchment ultimately flows into Cold Creek before entering Lake Tahoe.

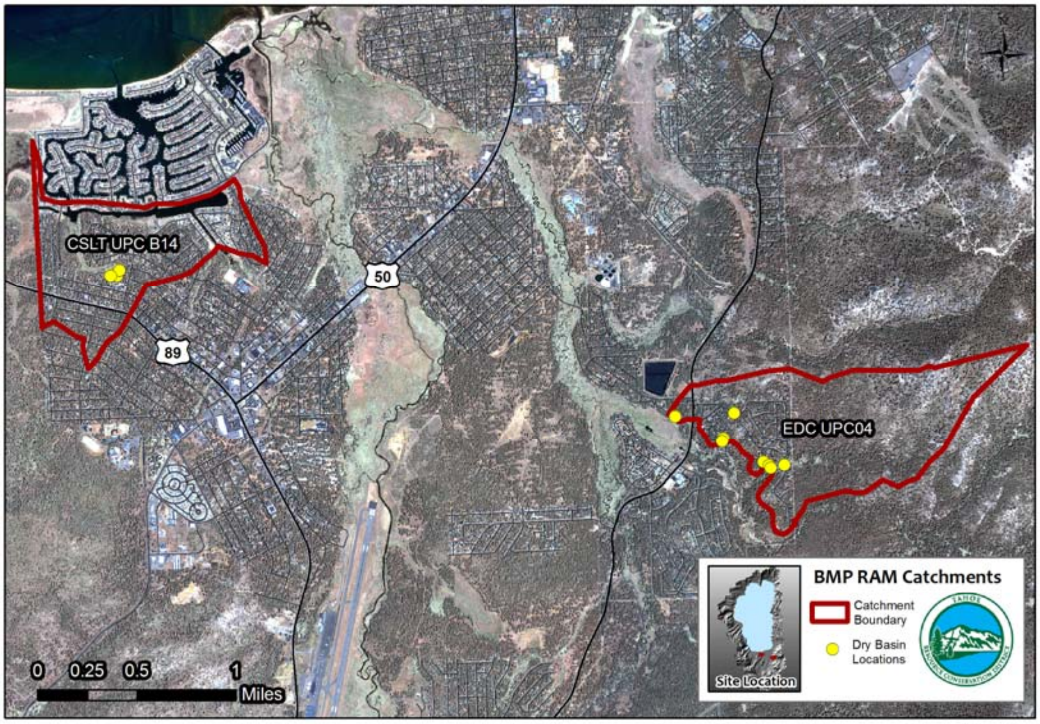

Figure 1 City of South Lake Tahoe's UPC B14 and El Dorado County's UPC04. BMP RAM measurements were conducted on dry basins within these catchments.

2.1 BMP RAM MEASUREMENTS

BMP RAM for dry basins consists of the following four evaluations: (1) assessment of vegetation type, (2) infiltration capacity, (3) material accumulation, and (4) conveyance. BMP RAM protocol recommends using constant head permeameter (CHP) as a measure of infiltration in dry basins. Tahoe RCD staff attempted to conduct BMP RAM in the field in the fall of 2014 and immediately noticed issues with the recommended infiltration measurement. CHP is used to measure the subsurface saturated hydraulic conductivity (k_{sat}) of soil. The tip of the instrument is inserted into a vertical bore hole in the soil and water is allowed to flow into the soil while a constant pressure head is maintained. A bore hole depth of 4 inches was suggested in the BMP RAM User's Manual (2NDNATURE 2009), however the National Resources Conservation Service (NRCS; the agency that developed the CHP method) stated that the measurement should be conducted at a depth of 12 inches (William Loftis, NRCS, personal communication, October 2014). NRCS also stated that **CHP is not the correct measurement for infiltration in a dry basin because the measurement occurs below the surface**, and infiltration in a dry basin occurs at the **soil surface**. For these reasons, three types of infiltration measurements were investigated: CHP, single-ring infiltrometer, and the CASQA 48-hour basin draw down time. BMP RAM using CHP and infiltrometer readings was performed on three dry basins in CSLT UPC B14 over four days in early November. BMP RAM using the CASQA method was conducted in CSLT UPC B14 and EDC UPC04 in less than one day in late November on all eleven dry basins. **The CASQA method took roughly 10% of the time it took to complete CHP or single-ring infiltrometer measurements.** The results of the measurements taken in CSLT UPC B14 can be found in Appendix A, and the results of the measurements taken in EDC UPC04 can be found in Appendix B.

2.1.1 CONSTANT HEAD PERMEAMETER

In CSLT UPC B14, CHP measurements were taken at depths of 4 inches and 12 inches to compare the method suggested by the BMP RAM User's manual and the protocol developed by NRCS. CHP measurements were taken at both of these depths in three locations per basin: near the inlet, in the middle, and near the outlet. One of the first technical difficulties noted was that it is very difficult to keep the CHP upright at a depth of 4 inches.

The BMP RAM User's Manual calls for 3 CHP measurements per surface type. Each measurement took 15-20 minutes, so **each basin will take, at a minimum, 45 minutes to an hour to conduct RAM observations with 1 staff member** using CHP (assuming one surface type per basin). CHP uses about a third of a gallon of water per measurement, or a minimum of **one gallon per basin**.

BMP RAM User's Manual protocol requires that CHP measurements begin immediately after water begins to flow. However, the soil has not reached saturation at this time and thus the measurement yields a value that is not the true k_{sat} of the soil (NRCS protocol, on the other hand, requires that the user wait until the CHP has reached steady-state to before taking measurements). If the soil is not at saturation for each measurement there can be inconsistencies between measurements based on the antecedent soil moisture. However, allowing the soil to reach saturation before each measurement would require approximately 10 more minutes per measurement (30 more minutes per basin).

Figure 2 shows CHP measurements for the three dry basins in the B14 UPC. Definitive conclusions cannot be drawn from such a small sample size; however, general observations on the nature of the measurements can be made. Measurements tended to have higher infiltration rates as well as larger variability between measurements at the 4" depth. Basin 1's CHP measurements ranged from 2.27 to 10.60 in/hr at a 4" depth – fairly slow to very fast CHP measurements. At the 12" depth Basin 1's CHP measurements were more consistent – ranging from 0.67 to 0.87in/hr (a very slow CHP measurement). In Basin 2 measurements ranged from 2.0 to 9.8in/hr, again, a range from fairly slow to very fast for CHP. Measurements at a 12" depth varied the most in Basin 2 – ranging from 0.20 to 6.27in/hr, which is a very slow to fairly fast CHP measurement range. Basin 3 had the most consistent CHP measurement at the 4" depth – ranging from 0.47 to 3.3in/hr – or very slow to fairly slow range of CHP measurements. CHP measurements at a 12" depth in Basin 3 ranged from 0.17 to 1.47in/hr – both very slow measurements for CHP.

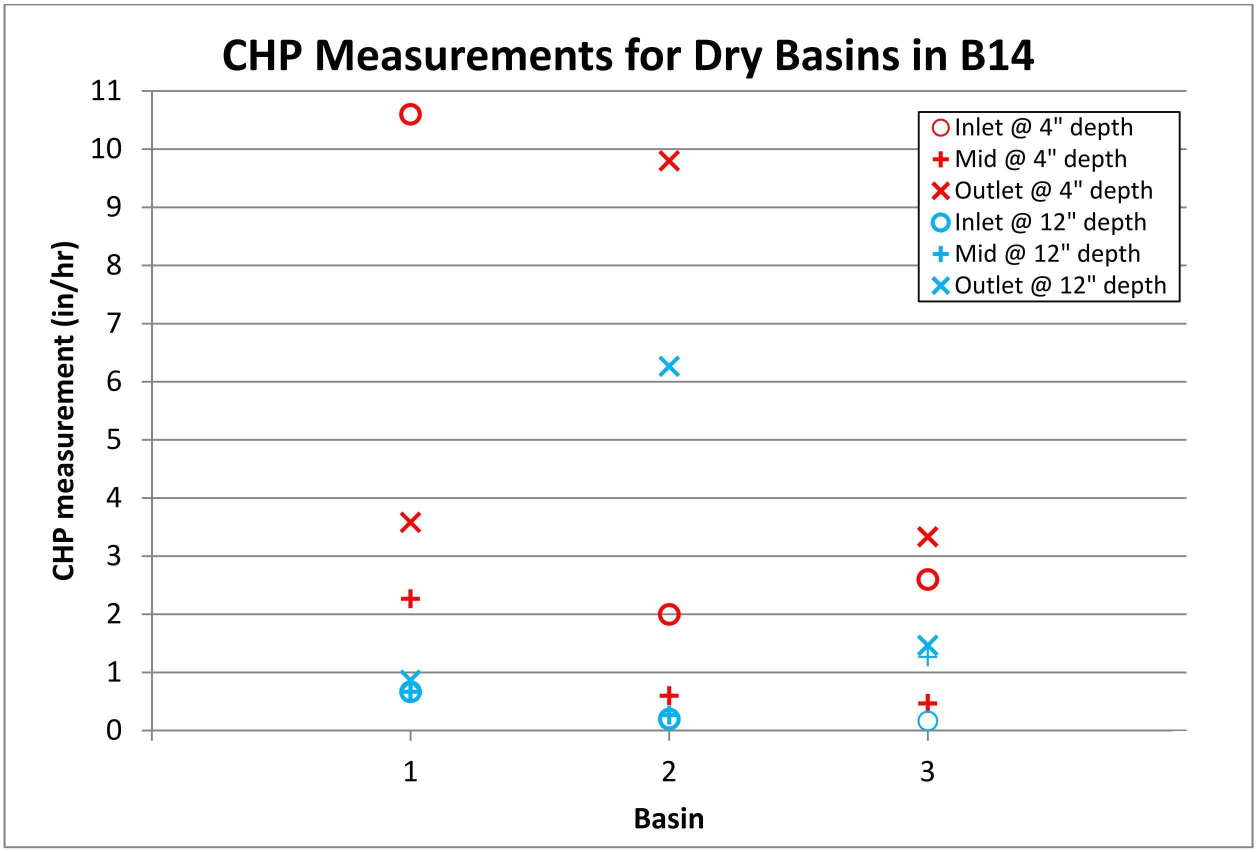

Figure 2 CHP measurements for the three dry basins in the B14 catchment; measurements were taken at both a 4" and a 12" depth at the inlet, middle, and outlet of each dry basin.

CHP measures the saturated hydraulic conductivity of the soil, which will be equal to the rate at which water moves through soil at saturation when there is no ponding. However, the measurement is taken in the subsurface and therefore fails to measure the rate at which water infiltrates at the soil surface. Without maintenance, fine sediment particles can build up in dry basins, causing an almost impermeable surface layer to form (William Loftis, NRCS, personal communication, October 2014). CHP measurements punch through this layer, giving potentially biased results of BMP performance. CHP may therefore be a poor choice of measurement for dry basins that are designed to infiltrate water at the soil surface. Additionally, several factors confound measurements conducted with a CHP. First, soil is not a homogenous medium, but rather is subject to a large degree of spatial heterogeneity. It is therefore nearly impossible to get repeatable measurements from the same location, and CHP measurements within the same basin may therefore show a wide range of saturated hydraulic conductivities (as was observed with the measurements in the three dry basins in B14 UPC). Additionally, CHP measurements will change with different soil temperatures, and although equations exist to account for this discrepancy, soil and air temperature are not often recorded with CHP measurements. Finally, it is not possible to conduct CHP in all locations such as areas with very rocky soils, very sandy soils, or very steep slopes.

2.1.2 SINGLE-RING INFILTROMETER

Single-ring infiltrometers are used to measure the rate at which water infiltrates into the soil at the soil surface. The measurement is subject to the antecedent soil moisture and the number of "presoaks" conducted prior to measurement. Dryer soil will tend to have a *much* greater infiltration rate than soil that is completely saturated due to the matric potential of the soil which causes water to be absorbed by dry soil at a much faster rate. In CSLT UPC B14, infiltrometer measurements were taken at three locations within each basin, similar to CHP: near the inlet, in the middle, and near the outlet. At each location three measurements were taken in succession to measure how the infiltration rate changed with increased soil wetness.

Each single-ring infiltrometer measurement took 10 to 20 minutes, so if three measurements per basin were conducted with one soak each, **each basin would take 30 - 60 minutes at a minimum to RAM with 1 staff member.** Like CHP, infiltrometer measurements require water to conduct the measurement; Each measurement takes about half a gallon of water, or **one and a half gallons per basin**.

In hydrology, it is well-established that infiltration rates in unsaturated soils tend to be very rapid initially and then quickly decline as the soil approaches saturation (Dingman 2002). As anticipated, the infiltration rates measured with the single-ring infiltrometer tended to decrease with the second and third measurements at the same location. This can be seen clearly in Figure 3, which shows pressure head of the water above the soil surface in inches versus time. The infiltration rate is equal to the slope (tangent) of the curve, with steeper slopes indicating higher infiltration rates. During the first soak, the infiltration rate is at its highest (steepest), but by the third soak the infiltration rate is approaching the flow rate at saturation. The infiltration rate for each soak was estimated from these data and is displayed in Table 1 - . The data clearly show the decrease in infiltration rate as the soil becomes more saturated, with a very high initial infiltration rate of 30 inches per hour, dropping to less than a third of that rate (9 inches per hour) by the final soak. A comparison of first soak infiltrometer measurements is shown in Figure 4. The range of observed infiltrometer measurements for each basin was quite large – ranging from 13.5 to 30in/hr in Basin 1; 1.25 to 15in/hr in Basin 2; and 7.5 to 20in/hr in Basin 3.

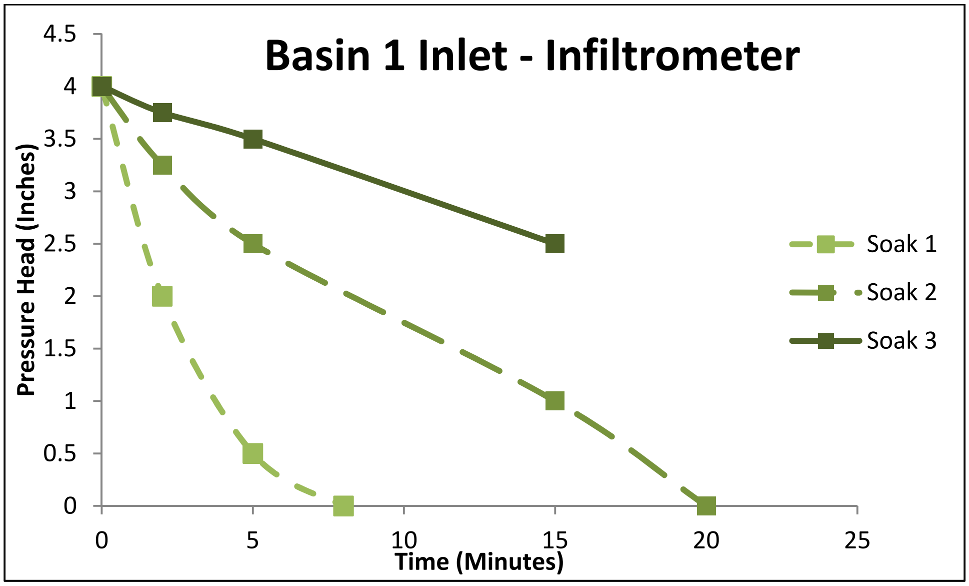

Figure 3 Infiltrometer measurements taken at the inlet of Basin 1 in the CSLT UPC B14 catchment. Infiltration rate decreases with the second and third soak. These measurements were taken on 10/30/2014.

Table 1 - Estimated infiltration rate at Basin 1 Inlet for soaks 1, 2, and 3 in CSLT UPC B14 in inches per hour (in/hr).

Infiltration Rate at Basin D Inlet (in/hr)		
Soak 1	Soak 2	Soak 3
30	12	9

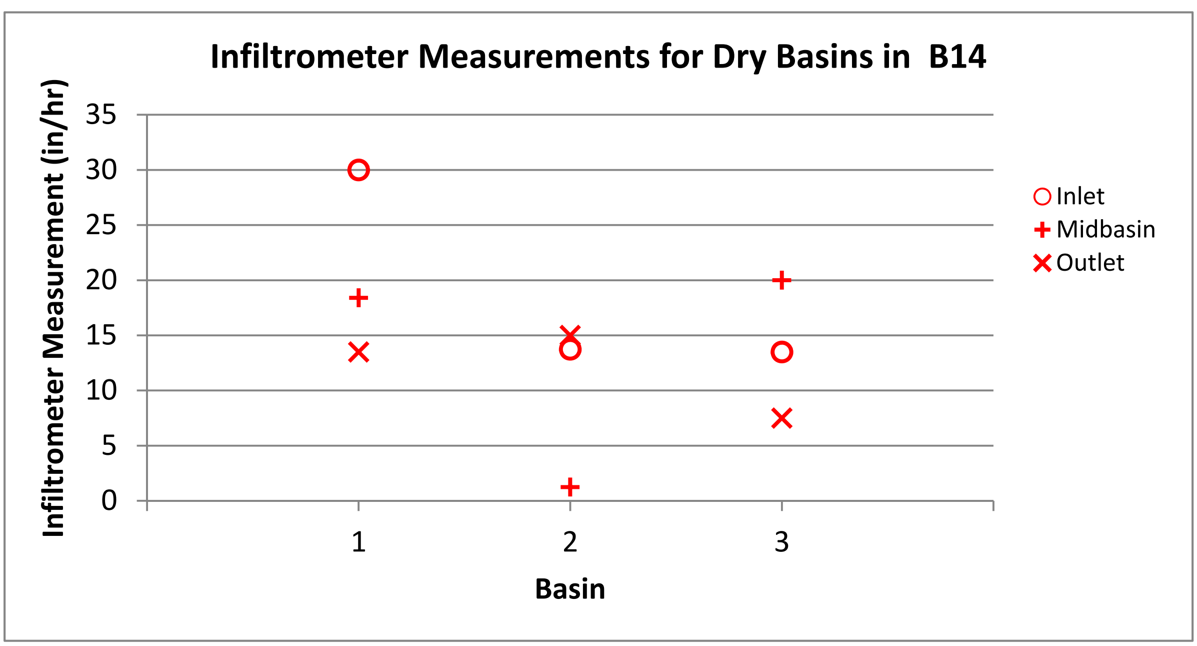

Figure 4 First soak infiltrometer measurements for the three dry basins in B14.

For evaluating infiltration in a dry basin, using an infiltrometer may be a better option than using CHP because it measures infiltration at the surface rather than the subsurface. However, like the CHP, it is very time consuming, and different results will be obtained based on the antecedent moisture level and the number of presoaks conducted prior to measurement. Similar to the CHP measurement, single-ring infiltrometer measurements are complicated by several issues. Spatial heterogeneity of the soil makes it nearly impossible to duplicate infiltrometer measurements. Single-ring infiltrometer measurements also require water to be ponded above the soil surface, causing higher infiltration rates due to additional pressure head. However, measuring infiltration rates with ponding may be desirable because during runoff events the dry basins will naturally have ponding that will change the infiltration rate with increased pressure head. Further complicating the infiltration rate measured by single-ring infiltrometers is that flow occurs horizontally as well as vertically, rather than the one dimensional vertical flow that is assumed by the user, so the infiltration rate may be skewed towards higher infiltration rates. However, this difference may be negligible because the single ring infiltrometer still measures the desired parameter of infiltration at the surface (William Loftis, NRCS, personal communication, January 2015).

2.1.3 CASQA 48-HOUR BASIN DRAW DOWN TIME

The California Stormwater Quality Association (CASQA) provides nationally recognized BMP standards. The CASQA Stormwater Best Management Practice Handbook’s recommendations on infiltration basins (i.e. dry basins) design guidelines suggest using a draw down time of 48 hours in most areas of California (See Appendix C for CASQA’s guidance for dry basin). Times longer than this are not suggested due to vector breeding, and times shorter than this are only suggested for areas with very rapidly draining soils. The CASQA method entails inspecting the facility 48 hours after the first large storm to determine whether the desired residence time for stormwater treatment has been achieved (CASQA 2003). Some advantages of the CASQA method over the CHP and infiltrometer methods are that it is less time and water intensive and that it clearly demonstrates whether or not the basin is working (either the basin has infiltrated water or it hasn’t). Similar to the infiltrometer method (and CHP if the measurement begins before steady state is achieved), antecedent moisture conditions may influence results. The main difference with this method is that it is weather dependent and must be scheduled within 48 hours of a large precipitation event. One disadvantage of the CASQA method is that it doesn’t give you an exact number for infiltration rate; the basin infiltrates water in either greater than or less than 48 hours. For basins where CHP/infiltrometer is not possible (i.e. rock lined basins), the 48-hour CASQA drawdown time may be the only viable option.

Tahoe RCD staff conducted full BMP RAM assessments using the CASQA method on all basins within CSLT UPC B14 and EDC UPC04 in one and a half hours on November 24th; each measurement took approximately 6 minutes per basin.

3 RECOMMENDATIONS

Under the NPDES permit issued by the Lahontan Regional Water Quality Control Board to ensure compliance with the Lake Tahoe TMDL, all California jurisdictions located in the Tahoe basin are required to inspect all “key and essential” BMPs using BMP RAM to ensure they are functioning properly. Tahoe RCD staff compared three methods of estimating infiltration capacity that could be used for conducting BMP RAM on dry basins. The methods compared were CHP (the current BMP RAM standard for dry basins), single-ring infiltrometer, and the CASQA 48-hour basin draw down time in catchments located within the City of South Lake Tahoe’s UPC B14 and El Dorado County’s UPC04. The CHP method measures saturated hydraulic conductivity at the subsurface rather than the soil surface; the soil surface is where infiltration would naturally occur in a dry basin and the area that is prone to sediment buildup and subsequent decrease in infiltration rate. In contrast, the single-ring infiltrometer and the CASQA 48-hour basin draw down time methods observe infiltration at the surface and are therefore may be more appropriate methods to assess infiltration in dry basins.

There are many advantages to using the CASQA 48-hour basin draw down time method over CHP and infiltrometer. First and foremost, **CASQA provides BMP information sheets that are nationally recognized and considered the industry standard**. In addition, both CHP and infiltrometer measurements were very time consuming, while the **CASQA 48-hour basin draw down time took roughly 10% of the time that the CHP or infiltrometer methods took**. Using the CASQA 48-hour basin draw down time, all eleven basins in both CSLT UPC B14 and EDC UPC04 could be evaluated in less than 2 hours. If CHP or infiltrometer methods were used, this same task would take one to two field days.

Furthermore, the CASQA method is the most representative observation by which to determine if the basins are infiltrating stormwater and only requires staff to check basins after a runoff event to see whether or not water has infiltrated within a 48-hour time period. The main disadvantage of the CASQA method is that scheduling measurements is weather dependent. In a drought year, it may not be possible to conduct measurements if large enough precipitation events do not occur, which could leave jurisdictions out of compliance with regulatory requirements. However, in basins where CHP/infiltrometer is not possible (i.e. rock lined basins), the 48-hour CASQA drawdown time may be the only viable option.

Despite potential scheduling difficulties, the Tahoe RCD recommends the CASQA 48-hour basin draw down time as the infiltration observation for BMP RAM in dry basins. The CASQA 48-hour basin draw down time is faster, cheaper, and requires fewer resources than both the CHP and the single-ring infiltrometer measurements.

4 REFERENCES

2NDNATURE LLC et al. September 2009. BMP RAM User's Manual. Prepared for the U.S. Army Corps of Engineers, Sacramento District.

California Stormwater Quality Association (CASQA) 2003. California Stormwater Quality Association Stormwater Best Management Practice Handbook – New Development and Redevelopment. "Infiltration Basin" Section 5.7 TC-11

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Lahontan Water Quality Control Board and Nevada Division of Environmental Protection. 2011. Lake Clarity Crediting Program Handbook: for Lake Tahoe TMDL Implementation v1.0. Prepared by Environmental Incentives, LLC. South Lake Tahoe, CA.

5 APPENDIX A – CHP/INFILTROMETER MEASUREMENTS

Basin D - 10/30/2014 11:30 AM - 40 F							Benchmark?
Depth:	Staff Plate Height: N/A						
Vegetation: 10% Tree, 85% Grass, 5% No veg.							Yes
CHP:	# of surfaces: 1		# of measurements: 3 @ 4”, 3 @ 12”				Yes
Location	1_Near Inlet 4" @ 11:50		2_Near Inlet 12" @ 12:25		3_Mid Basin 4" @ 12:45		
	time	reading	time	reading	time	reading	
1	0	165	0	155	0	128	
2	2	117	2	154	2	123	
3	8	56	8	150	8	109	
4	15	6	15	145	15	94	
Location	4_Mid Basin 12" @ 13:00		5_Near Outlet 4" @ 13:15		6_Near Outlet 12" @ 13:20		
	time	reading	time	reading	time	reading	
1	0	132	0	95	0	33	
2	2	130	2	86	2	29	
3	8	123	8	4	8	25	
4	15	122	12	52	15	20	
Conveyance:					Yes / No		
Comments:							

Infiltrometer:	BMP Area: 600sf						**Comments**
Location:	Near Inlet @ 11:30						
Trial:	One		Two		Three		
	time	reading	time	reading	time	reading	
1	0	4	0	4	0	4	
2	2	2	2	3.25	2	3.75	
3	5	0.5	5	2.5	5	3.5	
4	8	0	15	1	15	2.5	
5			20	0			
Location:	Mid Basin @ 12:45						
Trial:	One		Two		Three		
	time	reading	time	reading	time	reading	
1	0	4	0	4	0	4	
2	2	3.125	2.5	3.25	2	3.625	
3	5	2.125	5	2.5	5	3	
4	11	0.625	10	1.5			
5			15	0			

Location:	Near Outlet @ 13:35						
Trial:	One		Two		Three		
	time	reading	time	reading	time	reading	
1	0	4	0	4			
2	2	3.375	2	3.75			
3	5	2.125	5	3.25			
4	10	1.75	10.5	2.5			
5	14	1					
Date:	11/24/2014		**Time:**	16:30			
CASQA	**Standing Water?**		**Vegetation**				
48-hour	No		80% grass, 20% tree				
Notes:	Standing water in stand pipe						

Basin A, Upper - 11/5/2014 13:30 PM - 56 F							**Benchmark?**
Depth:	Staff Plate Height: N/A						
Vegetation: 10% Wetland species, 85% Grass, 5% No veg							**Yes**
CHP:	# of surfaces:		# of measurements:				**Yes**
Location	1_Near Inlet 4" @ 13:50		2_Near Inlet 12" @ 14:10		3_Mid Basin 4" @ 14:45		
	time	reading	time	reading	time	reading	
1	0	150	0	108	0	52	
2	2	144	2	107	2	51	
3	8	132	8	106	8	48	
4	15	120	15	105	15	43	
Location	4_Mid Basin 12" @ 15:05		5_Near Outlet 4" @ 14:05 on 11/10/14		6_Near Outlet 12" @ 14:25 on 11/10/14		
	time	reading	time	reading	time	reading	
1	0	174	0	115	0	137	
2	2	174	2	94	2	135	
3	8	172	8	40	8	88	
4	15	170	10	17	15	43	
Conveyance:					Yes / No		
Comments:							

Infiltrometer:	BMP Area: 800sf						**Comments**
Location:	Near Inlet @ 13:45						
Trial:	One		Two		Three		
	time	reading	time	reading	time	reading	
1	0	4	0	4	0	4	
2	2	3.375	2	3.875	3	3.675	
3	6	2.125	6	3.625	6	3.5	
4	10	1.625	10	3	10	3.25	
5	12	1.25	12	2.875	12	3.125	
Location:	Mid Basin @ 14:40						
Trial:	One		Two		Three		
	time	reading	time	reading	time	reading	
1	0	4	0	4	0	4	
2	2	3.9	2	3.925	4	3.95	
3	6	3.8	6	3.8	8	3.875	
4	10	3.75	10	3.75	12	3.825	
5	12	3.75	12	3.675	16	3.75	
Location:	Near Outlet @ 14:05 on 11/10/14						
Trial:	One		Two		Three		
	time	reading	time	reading	time	reading	
1	0	4	0	4	0	4	
2	2	3.25	2	3.5	2	3.75	
3	6	2.725	6	3.25	6	3.375	
4	10	1.5	10	2.875	10	3.125	
5							
Date:	11/24/2014		**Time:**	16:30			
CASQA	**Standing Water?**		**Vegetation**				
48-hour	Yes		80% grass, 20% tree				
Notes:	Standing water is frozen						

Basin A, Lower - 11/10/2014 15:00 PM - 55 F							**Benchmark?**
Depth:	Staff Plate Height: N/A						
Vegetation: 100% Grass							**Yes**
CHP:	# of surfaces:		# of measurements:				**Yes**
Location	1_Near Inlet 4" @ 15:15		2_Near Inlet 12" @ 15:30		3_Mid Basin 4" @ 15:50		
	time	reading	time	reading	time	reading	
1	0	143	0	166	0	148	
2	2	135	2	165	2	146	
3	8	120	8	164.5	8	143	
4	15	104	15	163.5	15	141	
Location	4_Mid Basin 12" @ 16:15		5_Near Outlet 4" @ 12:40 on 11.12.14		6_Near Outlet 12" @ 13:00 on 11.12.14		
	time	reading	time	reading	time	reading	
1	0	129	0	175	0	179	
2	2	122	2	167	2	171	
3	8	115	8	147	8	165	
4	15	110	15	125	15	157	
Conveyance:					Yes / No		
Comments:							

Infiltrometer:		BMP Area: 400sf					**Comments**
Location:	Near Inlet @ 15:00						
Trial:	One		Two		Three		
	time	reading	time	reading	time	reading	
1	0	4	0	4	0	4	
2	2	3.25	2	3.375	2	3.375	
3	6	2.5	6	2.5	6	2.5	
4	10	1.75	10	1.25	10	1.5	
5							
Location:	Mid Basin @ 15:50						
Trial:	One		Two		Three		
	time	reading	time	reading	time	reading	
1	0	3.5	0	3.5	0	3.5	
2	2	2.5	2	2.75	2	2.75	
3	6	1.5	6	1.5	6	1.75	
4			10	0.875	10	0.75	
5							

Location:	Near Outlet @ 12:40 on 11/12/14					
Trial:	One		Two		Three	
	time	reading	time	reading	time	reading
1	0	4	0	4	0	4
2	2	3.625	2	3.625	2	3.625
3	6	3.4	6	3.25	6	3.125
4	10	2.75	15	2.625	10	2.5
5						
Date:	11/24/2014		**Time:**	16:30		
CASQA	**Standing Water?**		**Vegetation**			
48-hour	No		95% grass, 5% tree			
Notes:						

6 APPENDIX B – CASQA 48-HOUR DRAW DOWN TIME MEASUREMENTS

Date:	11/24/2014	**Time:**	16:30
Black Bart	**Standing Water?**	**Vegetation**	**Staff Plate**
	No	95% grass, 5% tree	2.99'
Notes:			
Alice Lake	**Standing Water?**	**Vegetation**	**Staff Plate**
	No	100% grass	2.95'
Notes:			
Humboldt	**Standing Water?**	**Vegetation**	**Staff Plate**
	No	100% grass	3'
Notes:			
Copper	**Standing Water?**	**Vegetation**	**Staff Plate**
	No	100% grass	2.52'
Notes:			
Fortune	**Standing Water?**	**Vegetation**	**Staff Plate**
	No	100% grass	3.85'
Notes:			
Del Norte, West	**Standing Water?**	**Vegetation**	**Staff Plate**
	No	100% grass	2.82'
Notes:			
Del Norte, East	**Standing Water?**	**Vegetation**	**Staff Plate**
	No	100% grass	2.81'
Notes:			
Cold Creek, West	**Standing Water?**	**Vegetation**	**Staff Plate**
	No	50% grass, 50% bare	2.22'
Notes:			

7 APPENDIX C- CASQA DRY BASIN FACT SHEET (TC-11)

Infiltration Basin TC-11

Design Considerations

- Soil for Infiltration
- Slope
- Aesthetics

Targeted Constituents

	Constituent	Removal Effectiveness
☑	Sediment	■
☑	Nutrients	■
☑	Trash	■
☑	Metals	■
☑	Bacteria	■
☑	Oil and Grease	■
☑	Organics	■

Legend *(Removal Effectiveness)*

● Low ■ High

▲ Medium

Description

An infiltration basin is a shallow impoundment that is designed to infiltrate stormwater. Infiltration basins use the natural filtering ability of the soil to remove pollutants in stormwater runoff. Infiltration facilities store runoff until it gradually exfiltrates through the soil and eventually into the water table. This practice has high pollutant removal efficiency and can also help recharge groundwater, thus helping to maintain low flows in stream systems. Infiltration basins can be challenging to apply on many sites, however, because of soils requirements. In addition, some studies have shown relatively high failure rates compared with other management practices.

California Experience

Infiltration basins have a long history of use in California, especially in the Central Valley. Basins located in Fresno were among those initially evaluated in the National Urban Runoff Program and were found to be effective at reducing the volume of runoff, while posing little long-term threat to groundwater quality (EPA, 1983; Schroeder, 1995). Proper siting of these devices is crucial as underscored by the experience of Caltrans in siting two basins in Southern California. The basin with marginal separation from groundwater and soil permeability failed immediately and could never be rehabilitated.

Advantages

- Provides 100% reduction in the load discharged to surface waters.
- The principal benefit of infiltration basins is the approximation of pre-development hydrology during which a

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significant portion of the average annual rainfall runoff is infiltrated and evaporated rather than flushed directly to creeks.

- If the water quality volume is adequately sized, infiltration basins can be useful for providing control of channel forming (erosion) and high frequency (generally less than the 2-year) flood events.

Limitations

- May not be appropriate for industrial sites or locations where spills may occur.
- Infiltration basins require a minimum soil infiltration rate of 0.5 inches/hour, not appropriate at sites with Hydrologic Soil Types C and D.
- If infiltration rates exceed 2.4 inches/hour, then the runoff should be fully treated prior to infiltration to protect groundwater quality.
- Not suitable on fill sites or steep slopes.
- Risk of groundwater contamination in very coarse soils.
- Upstream drainage area must be completely stabilized before construction.
- Difficult to restore functioning of infiltration basins once clogged.

Design and Sizing Guidelines

- Water quality volume determined by local requirements or sized so that 85% of the annual runoff volume is captured.
- Basin sized so that the entire water quality volume is infiltrated within 48 hours.
- Vegetation establishment on the basin floor may help reduce the clogging rate.

Construction/Inspection Considerations

- Before construction begins, stabilize the entire area draining to the facility. If impossible, place a diversion berm around the perimeter of the infiltration site to prevent sediment entrance during construction or remove the top 2 inches of soil after the site is stabililized. Stabilize the entire contributing drainage area, including the side slopes, before allowing any runoff to enter once construction is complete.
- Place excavated material such that it can not be washed back into the basin if a storm occurs during construction of the facility.
- Build the basin without driving heavy equipment over the infiltration surface. Any equipment driven on the surface should have extra-wide ("low pressure") tires. Prior to any construction, rope off the infiltration area to stop entrance by unwanted equipment.
- After final grading, till the infiltration surface deeply.
- Use appropriate erosion control seed mix for the specific project and location.

Infiltration Basin TC-11

Performance

As water migrates through porous soil and rock, pollutant attenuation mechanisms include precipitation, sorption, physical filtration, and bacterial degradation. If functioning properly, this approach is presumed to have high removal efficiencies for particulate pollutants and moderate removal of soluble pollutants. Actual pollutant removal in the subsurface would be expected to vary depending upon site-specific soil types. This technology eliminates discharge to surface waters except for the very largest storms; consequently, complete removal of all stormwater constituents can be assumed.

There remain some concerns about the potential for groundwater contamination despite the findings of the NURP and Nightingale (1975; 1987a,b,c; 1989). For instance, a report by Pitt et al. (1994) highlighted the potential for groundwater contamination from intentional and unintentional stormwater infiltration. That report recommends that infiltration facilities not be sited in areas where high concentrations are present or where there is a potential for spills of toxic material. Conversely, Schroeder (1995) reported that there was no evidence of groundwater impacts from an infiltration basin serving a large industrial catchment in Fresno, CA.

Siting Criteria

The key element in siting infiltration basins is identifying sites with appropriate soil and hydrogeologic properties, which is critical for long term performance. In one study conducted in Prince George's County, Maryland (Galli, 1992), all of the infiltration basins investigated clogged within 2 years. It is believed that these failures were for the most part due to allowing infiltration at sites with rates of less than 0.5 in/hr, basing siting on soil type rather than field infiltration tests, and poor construction practices that resulted in soil compaction of the basin invert.

A study of 23 infiltration basins in the Pacific Northwest showed better long-term performance in an area with highly permeable soils (Hilding, 1996). In this study, few of the infiltration basins had failed after 10 years. Consequently, the following guidelines for identifying appropriate soil and subsurface conditions should be rigorously adhered to.

- Determine soil type (consider RCS soil type 'A, B or C' only) from mapping and consult USDA soil survey tables to review other parameters such as the amount of silt and clay, presence of a restrictive layer or seasonal high water table, and estimated permeability. The soil should not have more than 30% clay or more than 40% of clay and silt combined. Eliminate sites that are clearly unsuitable for infiltration.

- Groundwater separation should be at least 3 m from the basin invert to the measured ground water elevation. There is concern at the state and regional levels of the impact on groundwater quality from infiltrated runoff, especially when the separation between groundwater and the surface is small.

- Location away from buildings, slopes and highway pavement (greater than 6 m) and wells and bridge structures (greater than 30 m). Sites constructed of fill, having a base flow or with a slope greater than 15% should not be considered.

- Ensure that adequate head is available to operate flow splitter structures (to allow the basin to be offline) without ponding in the splitter structure or creating backwater upstream of the splitter.

TC-11 Infiltration Basin

- Base flow should not be present in the tributary watershed.

Secondary Screening Based on Site Geotechnical Investigation

- At least three in-hole conductivity tests shall be performed using USBR 7300-89 or Bouwer-Rice procedures (the latter if groundwater is encountered within the boring), two tests at different locations within the proposed basin and the third down gradient by no more than approximately 10 m. The tests shall measure permeability in the side slopes and the bed within a depth of 3 m of the invert.

- The minimum acceptable hydraulic conductivity as measured in any of the three required test holes is 13 mm/hr. If any test hole shows less than the minimum value, the site should be disqualified from further consideration.

- Exclude from consideration sites constructed in fill or partially in fill unless no silts or clays are present in the soil boring. Fill tends to be compacted, with clays in a dispersed rather than flocculated state, greatly reducing permeability.

- The geotechnical investigation should be such that a good understanding is gained as to how the stormwater runoff will move in the soil (horizontally or vertically) and if there are any geological conditions that could inhibit the movement of water.

Additional Design Guidelines

(1) Basin Sizing - The required water quality volume is determined by local regulations or sufficient to capture 85% of the annual runoff.

(2) Provide pretreatment if sediment loading is a maintenance concern for the basin.

(3) Include energy dissipation in the inlet design for the basins. Avoid designs that include a permanent pool to reduce opportunity for standing water and associated vector problems.

(4) Basin invert area should be determined by the equation:

$$A = \frac{WQV}{kt}$$

where A = Basin invert area (m^2)

WQV = water quality volume (m^3)

k = 0.5 times the lowest field-measured hydraulic conductivity (m/hr)

t = drawdown time (48 hr)

(5) The use of vertical piping, either for distribution or infiltration enhancement shall not be allowed to avoid device classification as a Class V injection well per 40 CFR146.5(e)(4).

Maintenance

Regular maintenance is critical to the successful operation of infiltration basins. Recommended operation and maintenance guidelines include:

- Inspections and maintenance to ensure that water infiltrates into the subsurface completely (recommended infiltration rate of 72 hours or less) and that vegetation is carefully managed to prevent creating mosquito and other vector habitats.
- Observe drain time for the design storm after completion or modification of the facility to confirm that the desired drain time has been obtained.
- Schedule semiannual inspections for beginning and end of the wet season to identify potential problems such as erosion of the basin side slopes and invert, standing water, trash and debris, and sediment accumulation.
- Remove accumulated trash and debris in the basin at the start and end of the wet season.
- Inspect for standing water at the end of the wet season.
- Trim vegetation at the beginning and end of the wet season to prevent establishment of woody vegetation and for aesthetic and vector reasons.
- Remove accumulated sediment and regrade when the accumulated sediment volume exceeds 10% of the basin.
- If erosion is occurring within the basin, revegetate immediately and stabilize with an erosion control mulch or mat until vegetation cover is established.
- To avoid reversing soil development, scarification or other disturbance should only be performed when there are actual signs of clogging, rather than on a routine basis. Always remove deposited sediments before scarification, and use a hand-guided rotary tiller, if possible, or a disc harrow pulled by a very light tractor.

Cost

Infiltration basins are relatively cost-effective practices because little infrastructure is needed when constructing them. One study estimated the total construction cost at about $2 per ft (adjusted for inflation) of storage for a 0.25-acre basin (SWRPC, 1991). As with other BMPs, these published cost estimates may deviate greatly from what might be incurred at a specific site. For instance, Caltrans spent about $18/ft3 for the two infiltration basins constructed in southern California, each of which had a water quality volume of about 0.34 ac.-ft. Much of the higher cost can be attributed to changes in the storm drain system necessary to route the runoff to the basin locations.

Infiltration basins typically consume about 2 to 3% of the site draining to them, which is relatively small. Additional space may be required for buffer, landscaping, access road, and fencing. Maintenance costs are estimated at 5 to 10% of construction costs.

One cost concern associated with infiltration practices is the maintenance burden and longevity. If improperly maintained, infiltration basins have a high failure rate. Thus, it may be necessary to replace the basin with a different technology after a relatively short period of time.

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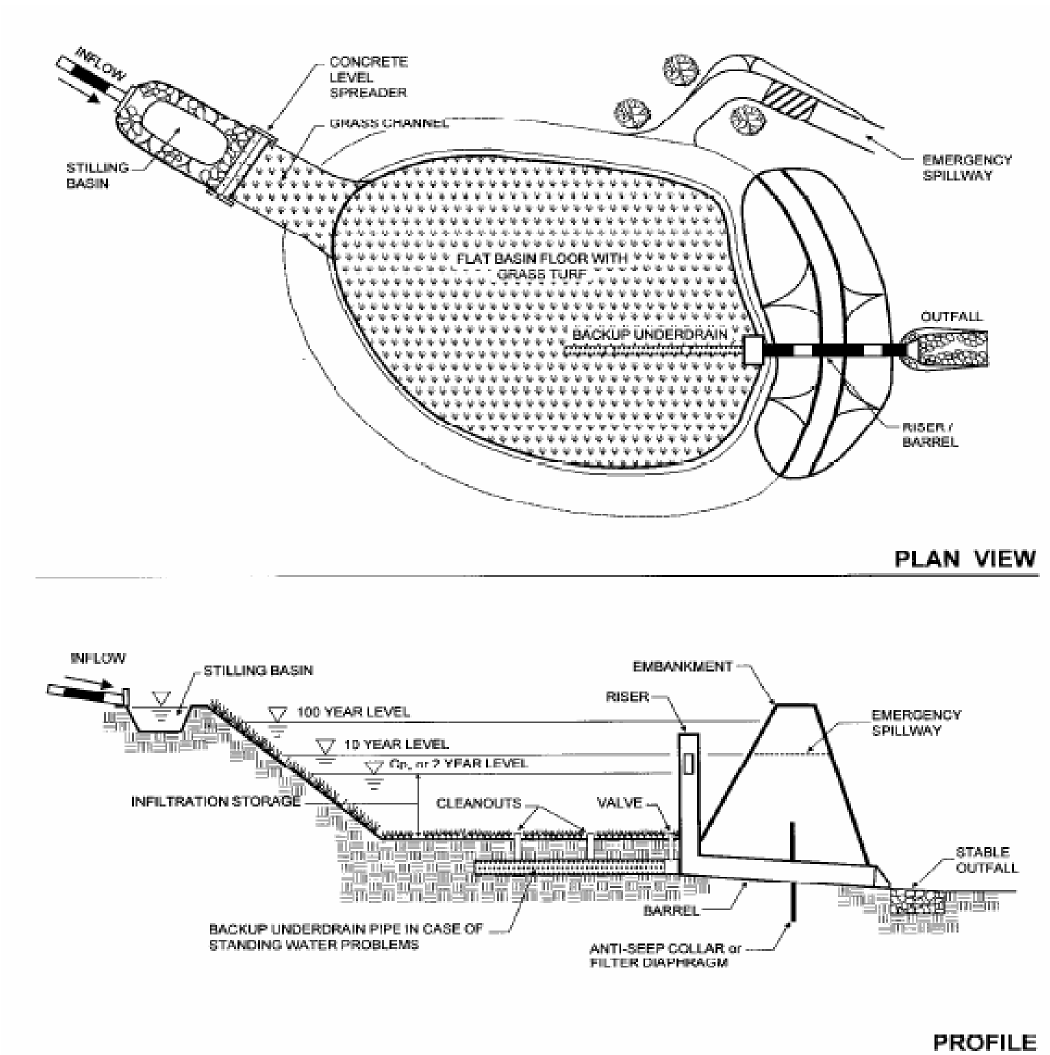
INFLOW
CONCRETE LEVEL SPREADER
GRASS CHANNEL
STILLING BASIN
EMERGENCY SPILLWAY
FLAT BASIN FLOOR WITH GRASS TURF
BACKUP UNDERDRAIN
OUTFALL
RISER / BARREL
PLAN VIEW
INFLOW
STILLING BASIN
EMBANKMENT
RISER
100 YEAR LEVEL
10 YEAR LEVEL
EMERGENCY SPILLWAY
INFILTRATION STORAGE
CLEANOUTS
VALVE
STABLE OUTFALL
BARREL
BACKUP UNDERDRAIN PIPE IN CASE OF STANDING WATER PROBLEMS
ANTI-SEEP COLLAR or FILTER DIAPHRAGM
PROFILE

TMDL CATCHMENT REGISTRATION AND TESTING TMDL TOOLS – PLRM MODELING IN THE CITY OF SOUTH LAKE TAHOE'S URBAN PLANNING CATCHMENT B14

TMDL Catchment Registration and Testing TMDL Tools

PLRM Modeling in the City of South Lake Tahoe's Urban Planning Catchment B14

November 2015

Developed by:

Tahoe Resource Conservation District
www.tahoercd.org

Funded by:

Southern Nevada Public Lands Management Act (SNPLMA)
http://www.blm.gov/nv/st/en/snplma.html

Sponsored by:

Environmental Protection Agency (EPA)
http://www.epa.gov/

TMDL Catchment Registration and Testing TMDL Tools: PLRM Modeling in the City of South Lake Tahoe's Urban Planning Catchment B14

Recommended citation:
Tahoe Resource Conservation District. 2015. TMDL Catchment Registration and Testing TMDL Tools: PLRM Modeling in the City of South Lake Tahoe's Urban Planning Catchment B14. Prepared for the Enviromental Protection Agency. June 2015.

We would like to thank the following individuals and organizations for their contribution to the content of this document:

Andrea Buxton, Tahoe Resource Conservation District
Kim Gorman, Tahoe Resource Conservation District
Oscar Atkinson, Tahoe Resource Conservation District
Jason Burke, City of South Lake Tahoe
Eric Friedlander, City of South Lake Tahoe
Karin Peternel, Douglas County

The Tahoe RCD would also like to thank the Environmental Protection Agency for supporting this project and SNPLMA for their generous funding support, without which this effort would not be possible.

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LIST OF ACRONYMS

B14	City of South Lake Tahoe's UPC B14
B14 NoTx	Area in UPC B14 draining untreated into Pope Marsh
B14 TallacTx	Area in UPC B14 treated by Tallac Meadow
BMP	Best Management Practice
CAP	Credit Accounting Platform
CICU	Commercial-Industrial-Communications-Utilities
DCIA	Directly Connected Impervious Area
FSP	Fine Sediment Particles
LID	Low Impact Development
LiDAR	Light Detection and Ranging
MFR	Multi-Family Residential
NPDES	National Pollution Discharge Elimination System
NRCS	National Resources Conservation Service
PLRM	Pollutant Load Reduction Model (Version 2.0.2)
PLRMv1	Pollutant Load Reduction Model (Version 1.1)
SFR	Single-Family Residential
Tahoe RCD	Tahoe Resource Conservation District
The City	City of South Lake Tahoe
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorous
UPC	Urban Planning Catchment

EXECUTIVE SUMMARY

The City of South Lake Tahoe's Urban Planning Catchment (UPC) B14 was modeled using the Pollutant Load Reduction Model (PLRM) version 2.0.2 under different water quality improvement scenarios to determine Lake Clarity Credit Potential for the Lake Tahoe TMDL. UPC B14 covers 327 acres that all eventually drain to Pope Marsh. Pope Marsh is intermittently connected to Lake Tahoe 19% of the time; therefore a 19% connectivity factor was applied to model results to determine Credit Potential. In UPC B14, 5.7 acres are located in the Caltrans right-of-way; these areas were not included in the model. A large portion (140 acres or 43%) of the catchment drains to the 8-acre Tallac Meadow (B14 Tallac Tx), which provides natural treatment for stormwater; as a result this area contributes minimal baseline pollutant loading to Lake Tahoe and was not the primary focus of this study. The remaining area in the catchment (182 acres or 56%) that drains into Pope Marsh untreated (B14 NoTx; Figure 1) is the main focus of the PLRM Credit Potential modeling due to its high pollutant loading. For this area, the largest Credit Potential came from disconnecting directly connected impervious area (16 Credits). Improvement of roads condition scores to a 3, 4 or 5 resulted in 0.04, 3.9 and 5.6 Credits, respectively. Improvement of road shoulder conditions to 100% stable and protected could provide 4 Credits. Credit Potential from 100%private parcel BMP implementation was minimal, with an area-wide total of 2.13 credits; the number of Credits that could be claimed was 0.39 for single-family residential (SFR) parcels, 0.51 for multi-family residential (MFR) parcels, and 1.23 for commercials-industrial-communications-utilities (CICU) parcels. To achieve 100% SFR BMP implementation it would cost homeowners an estimated $446,000 to $3,568,000 for installation. Improvement of baseline stormwater infrastructure (12th Street Basins 1, 2, and 3) would provide minimal Credit Potential due to the large basin size compared to the small drainage area as well as the subsequent treatment of basin effluent by Tallac Meadow. PLRM modeling on the 12th Street Basins was therefore performed as a theoretical exercise to better understand Credit Potential for improvement to older infrastructure. Theoretical analysis on 12th Street Basin 1 indicated that increasing dry basin volume provided diminishing returns on water quality improvement.

In light of these PLRM modeling results, the Tahoe Resource Conservation District (Tahoe RCD) recommends that water quality improvement actions for TMDL catchment registration in UPC B14 focus on disconnecting directly connected impervious area through Low-Impact-Development (LID) stormwater mitigation techniques (i.e. rain gardens, pervious channel) and improving the road surface condition scores to a 4 or 5.

PURPOSE AND BACKGROUND

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 urban areas, roadways in particular, account for approximately 72% of FSP that eventually enter the lake (Lake Tahoe TMDL Technical Report, 2010). The Lake Tahoe National Pollutant Discharge Elimination System (NPDES) permit was developed by the Lahontan Regional Water Quality Control Board to help implement the Lake Tahoe TMDL in California. The permit requires local California jurisdictions to reduce pollutant loading of fine sediment particles (FSP), total nitrogen (TN), and total phosphorous (TP) to Lake Tahoe. The Pollutant Load Reduction Model v2.0.2 (PLRM) was developed as a water quality planning tool to estimate pollutant load reductions for different water quality improvement actions. Under the Lake Clarity Crediting Program, these pollutant load reductions are translated into Lake Clarity Credits (Credits) when a catchment is registered in the TMDL Credit Accounting Platform (CAP) to track pollutant load reductions to Lake Tahoe. The purpose of this study is to assist the City of South Lake Tahoe with NPDES compliance by offering planning level PLRM modeling results to determine Credit Potential that could be obtained through registration of different water quality improvement scenarios in Urban Planning Catchment (UPC) B14.

PLRM MODELING

The City of South Lake Tahoe's (the City) UPC B14 was modeled in PLRM in order to determine potential Lake Clarity Credits that could be obtained under different water quality improvement scenarios. To achieve this aim, this study evaluated: 1) single-family residential (SFR) best management practice (BMP) implementation, 2) multi-family residential (MFR) BMP implementation, 3) commercial-industrial-communications-utilities (CICU) BMP implementation 4) improvement of road condition, 5) improvement of road shoulders, 6) disconnecting directly connected impervious area (DCIA), and 7) improvement to baseline stormwater infrastructure. The following describes these PLRM models and model results.

MODEL INPUTS

The PLRM modeling conducted in this study used PLRM version 2.0.2. The model was setup using instructions included in the PLRMv2.1 Quick Start Guide (NHC 2015). A full PLRMv2.1 User's Manual should be available in the future.

The following GIS shapefiles were used to determine basin characteristics (at the time of writing these shapefile were available at https://share.nhcweb.com/public.php?service=files&t=e5f9fc7fa18283ec3473ab19e87649a3, these files may have moved location since the time of writing):

1) **LandUse_2011Imp_2014LU.shp** – This file is a land use layer that was updated by Northwest Hydraulic Consultants (NHC) from the original TMDL land use layer created by Tetratech and used in PLRMv1. Updates were based on LiDAR defined impervious area.
2) **Soils_Baseline.shp** – Soils data based on the Natural Resources Conservation Service (NRCS) 2006 soil survey.
3) **BaselineRoadCondition_PACApprovedMay2015.shp** – Road conditions at baseline* (2004) conditions, created by NHC. These baseline road condition scores were approved by the Stormwater Tools Improvement PAC on May 2015. These roads have a higher pollutant loading than roads in PLRMv1.
4) **RoadShoulders_2011.shp** – Road shoulder conditions at baseline* (2004) conditions, created by NHC.
5) **RoadConnectivity_2011.shp** – Road connectivity at baseline* (2004) conditions, created by NHC.

Slope was estimated from Light Detection and Ranging (LiDAR) data. BMP implementation rates were set to baseline* rates for all models except for those analyzing Credit Potential from private property BMP implementation (baseline BMP implementation rates are 7% for SFR, 19% for MFR, and 5% for CICU land uses). Dry basin dimensions were provided by the City. The Lake Clarity Crediting Program currently uses FSP load reduction for the calculation of Lake Clarity Credits (operating under the assumption that decreases to FSP loading will provided subsequent decreases to TN and TP); therefore FSP is the only pollutant considered in this study. A copy of the PLRM models can be obtained by emailing Tahoe RCD staff member Cara Moore at cmoore@tahoercd.org.

*See the Lake Clarity Crediting Program Handbook (2011) for a description of baseline conditions

STUDY AREA: URBAN PLANNING CATCHMENT B14

The study area modeled was the City's UPC B14, located near "the Y" (the northern intersection between Hwy 89 and Hwy 50) in South Lake Tahoe, CA (Figure 1). The catchment covers 327 acres and the predominant land use type is SFR (44.9%; Table 1), followed by unimpacted vegetation (EP 1-5; 28.6%), roads (17.1%), MFR (6.5%), and CICU (2.9%). Subcatchment delineation was performed with the use of GIS analysis of LiDAR data and through field assessments; subcatchment boundaries are shown in Figure 1. The Caltrans Hwy 89 right-of-way bisects the catchment and covers 5.7 acres (Figure 1); this area was not included in PLRM modeling.

All subcatchments in UPC B14 ultimately drain to Pope Marsh, which is intermittently connected to Lake Tahoe. In the City of South Lake Tahoe's TMDL Baseline Loading Estimate (2011), the Pope Marsh connectivity factor to Lake Tahoe was estimated to be 19%. This means that 19% of the runoff volume discharges to Lake Tahoe. For all model runs except for the 12^{th} Street Basin 1 theoretical analysis, the Credit Potential and/or pollutant loading is provided assuming 19% connectivity to Lake Tahoe because of the intermittent Pope Marsh connectivity. Operating under this assumption, the total baseline FSP load for UPC B14 was calculated to be 3,947 lbs/year (Table 2).

Within UPC B14, there are 182 acres, or 56% of the catchment, that drain into Pope Marsh untreated (referred to as B14 NoTx; Figure 1). This is the main focus of the PLRM Credit Potential modeling due to the high pollutant loading of this area (3,665 lbs/year).

A large portion of UPC B14 (140 acres; 43%) drains into the 8-acre Tallac Meadow prior to entering Pope Marsh (referred to as B14 TallacTx; Figure 1 & Figure 2). Tallac Meadow is approximately 2,000 feet long and ranges from 100 to 300 feet in width. Meadows can provide water treatment through particle settling and nutrient uptake. The annual pollutant loading of this area is therefore minimal at 282 lbs/year.

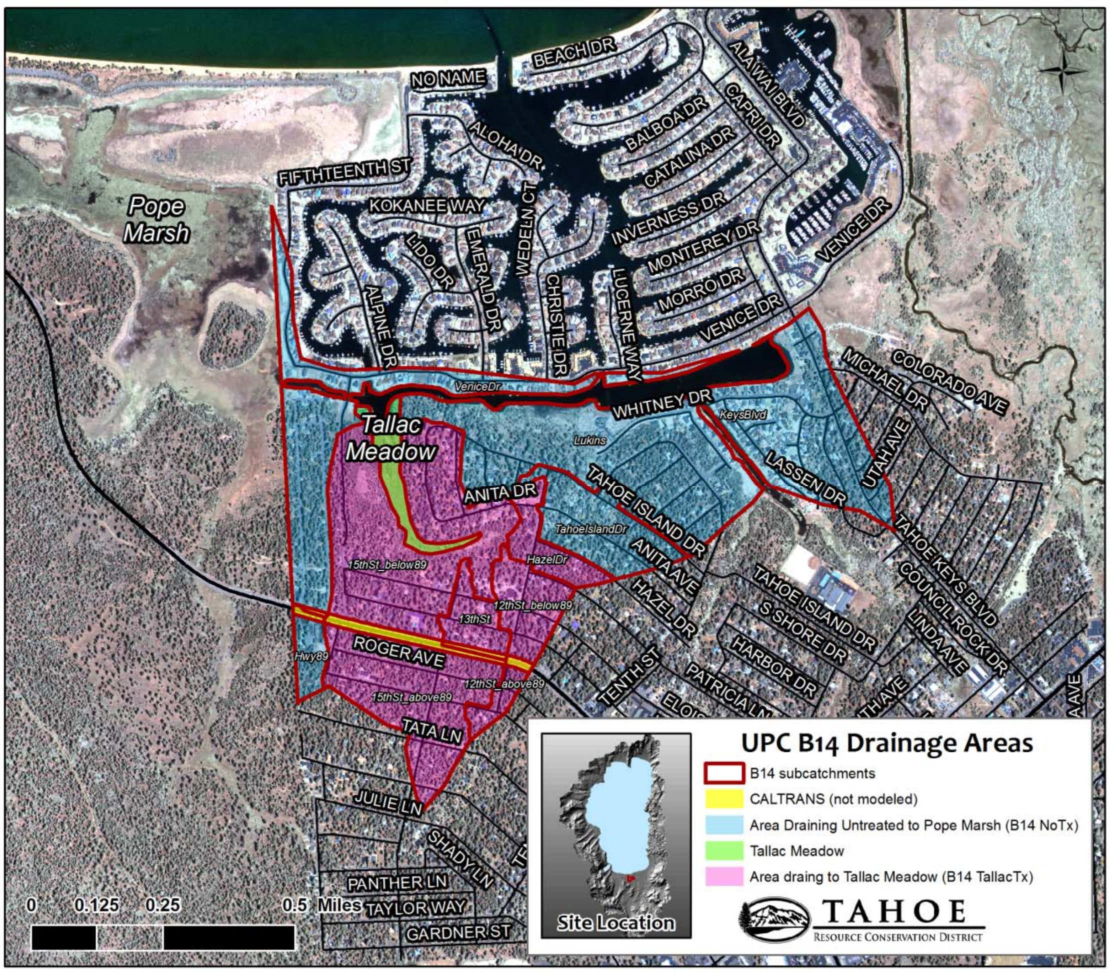

Figure 1 UPC B14 subcatchment delineation and drainage areas. Area draining to Tallac Meadow (B14 TallacTx) is highlighted in pink, area draining untreated to Pope Marsh (B14 NoTx) is highlighted in blue, and Caltrans area is highlighted in yellow (Caltrans not modeled).

Table 1 Land use by acres and % of catchment for single-family residential (SFR), unimpacted vegetation (EP 1-5), roads, multi-family residential (MFR), and commercial-industrial-communications-utilities (CICU) in the City of South Lake Tahoe's UPC B14.

Land Use	Acres	% of Catchment
SFR	146.8	44.9
Unimpacted Vegetation (EP 1-5)	93.4	28.6
Roads	55.8	17.1
MFR	21.1	6.5
CICU	9.5	2.9

Table 2 Baseline FSP load in pounds per year for the entire UPC B14 as well as B14 NoTx and B14 TallacTx drainages.

UPC B14 FSP Baseline Load	
	FSP Load (lbs/year)
UPC B14	3,947
B14 NoTx	3,665
B14 TallacTx	282

Figure 2 Image of Tallac Meadow, located in the City of South Lake Tahoe's UPC B14.

CREDIT POTENTIAL: SINGLE-FAMILY RESIDENTIAL BMP IMPLEMENTATION

All private parcels in Lake Tahoe are required to install BMPs for stormwater mitigation. The B14 NoTx area currently has a low SFR BMP compliance rate of 21%. PLRM models were run for the current rate of SFR BMP implementation (21%), as well as a theoretical 50% or 100% implementation; results for FSP reduced are summarized in Table 3. The Credit Potential for SFR BMP implementation at 21% (current rate) was 0.07 credits (14 lbs/year FSP load reduction), at 50% was 0.18 credits (36 lbs/year FSP load reduction), and at 100% was 0.39 credits (79 lbs/year FSP load reduction). For this area, BMPs would need to be implemented on 155 parcels to achieve 50% BMP compliance, and 446 parcels would need BMPs implemented in order to achieve 100% BMP compliance (Table 4). The cost to install SFR BMPs ranges from $1,000 to $8,000 per property, depending on site specific conditions. Based on these estimates, the collective cost to the homeowners would be between $155,000 and $1,240,000 to achieve 50% SFR BMP compliance and between $446,000 and $3,568,000 to achieve 100% SFR BMP compliance in this area (Table 4).

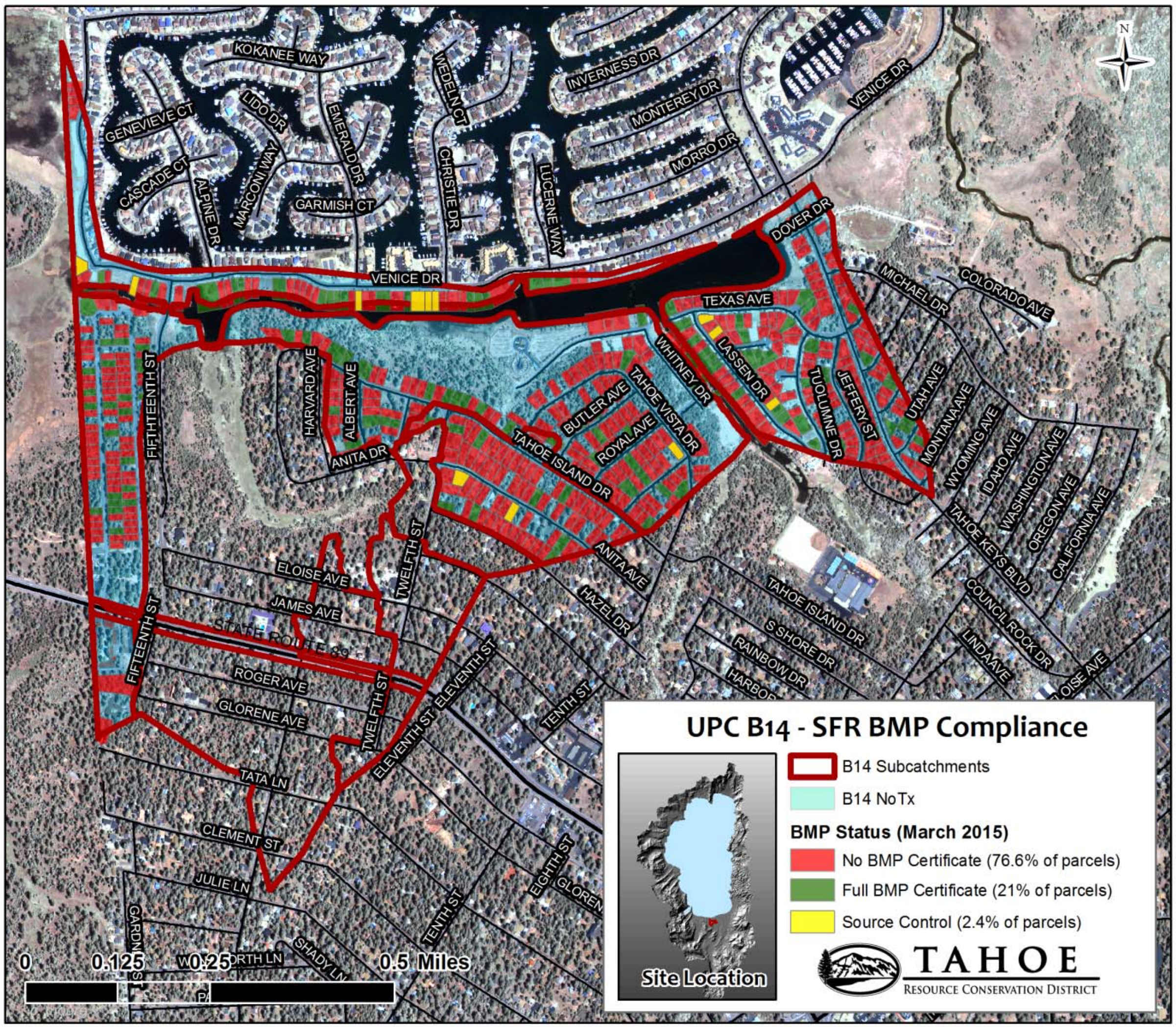

Figure 3 SFR BMP implementation in B14 NoTx.

Table 3 FSP load reduction (lbs/year) and potential Lake Clarity Credits that could be obtained from 21% (current rate), 50%, and 100% SFR BMP implementation in B14 NoTx.

Single Family Residential BMP Compliance Load Reduction and Credit Potential		
SFR BMP Compliance Rate	FSP Load Reduction (lbs/year)	Clarity Credits (#)
21% (as of March 2015)	14	0.07
50%	36	0.18
100%	79	0.39

Table 4 Total number of SFR parcels, number of SFR parcels needed for 50% and 100% BMP compliance rate, and approximate cost of install in B14 NoTx assuming a $1,000, $5,000, or $8,000 install rate. Out of 582 total parcels in B14 NoTx, 122 have full BMP certificates and 14 have source control certificates as of March 2015.

Cost of Install for Single Family Residential BMP Compliance in UPC B14					
SFR BMP Compliance Rate (% of Parcels)	SFR Parcels Total (#)	Certificates Needed to Achieve Compliance Rate (#)	Homeowner Cost ($1,000 install)	Homeowner Cost ($5,000 install)	Homeowner Cost ($8,000 install)
50%	582	155	$155,000	$775,000	$1,240,000
100%	582	446	$446,000	$2,230,000	$3,568,000

CREDIT POTENTIAL: MULTI-FAMILY RESIDENTIAL BMP IMPLEMENTATION

MFR parcels tend to have higher DCIA and more impervious area overall as compared to SFR parcels; this land use therefore has a higher pollutant loading than SFR parcels. In B14 NoTx, there are 19 MFR parcels, one of which is BMP certified (Figure 4 & Table 5). Despite this, very little Credit Potential exists in B14 NoTx for MFR BMP implementation. Results from PLRM model runs with 100% MFR BMP implementation in B14 NoTx are shown in Table 5. An estimated 0.51 credits (101 lbs/year FSP load reduction) could be claimed with 100% MFR BMP implementation. The cost to install MFR BMPs is highly variable due to site specific conditions such as amount of directly connected impervious area, soil conditions, and topography; cost estimates to install MFR BMPs are therefore not included in this analysis.

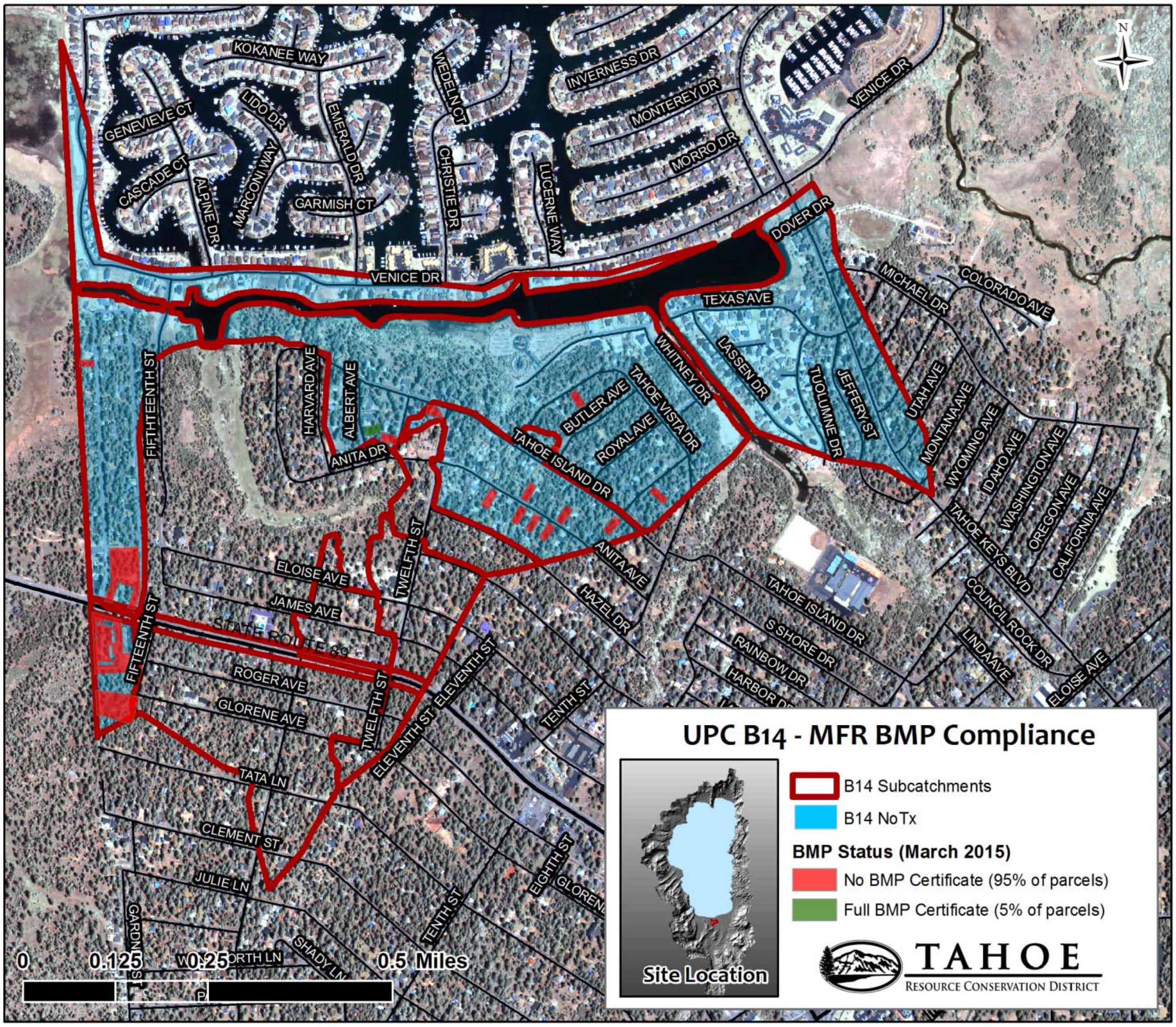

Figure 4 MFR BMP implementation in B14 NoTx.

Table 5 Number of MFR parcels, number of BMP certificates needed to achieve 100% compliance rate, FSP load reduction (lbs/year) and potential Lake Clarity Credits that could be obtained from 100% MFR BMP implementation in B14 NoTx.

Multi-Family Residential BMP Compliance Load Reduction and Credit Potential				
MFR BMP Compliance Rate (% of parcels)	MFR Parcels Total (#)	Certificates Needed to Achieve Compliance Rate (#)	FSP Load Reduction (lbs/year)	Clarity Credits (#)
100%	19	18	101	0.51

CREDIT POTENTIAL: CICU BMP IMPLEMENTATION

CICU parcels tend to have much higher DCIA and more overall impervious area than both SFR and MFR land uses; this land use therefore has a higher pollutant loading than MFR and SFR parcels. In B14 NoTx, there are 7 CICU parcels, and only one has a BMP certificate (Figure 5 & Table 6). Even so, CICU BMP implementation in B14 NoTx provided minimal Credit Potential. The FSP pollutant load reduction and Credit Potential from 100% CICU BMP implementation in B14 NoTx was analyzed using PLRM and results are shown in Table 6. An estimated 1.23 credits (247 lb/year FSP load reduction) could be claimed with 100% CICU BMP implementation if BMPs are less than 5 years old*. Similar to MFR BMPs, the cost to install CICU BMPs is variable due to site specific conditions; therefore no cost estimate for installing CICU BMPs is included in this analysis.

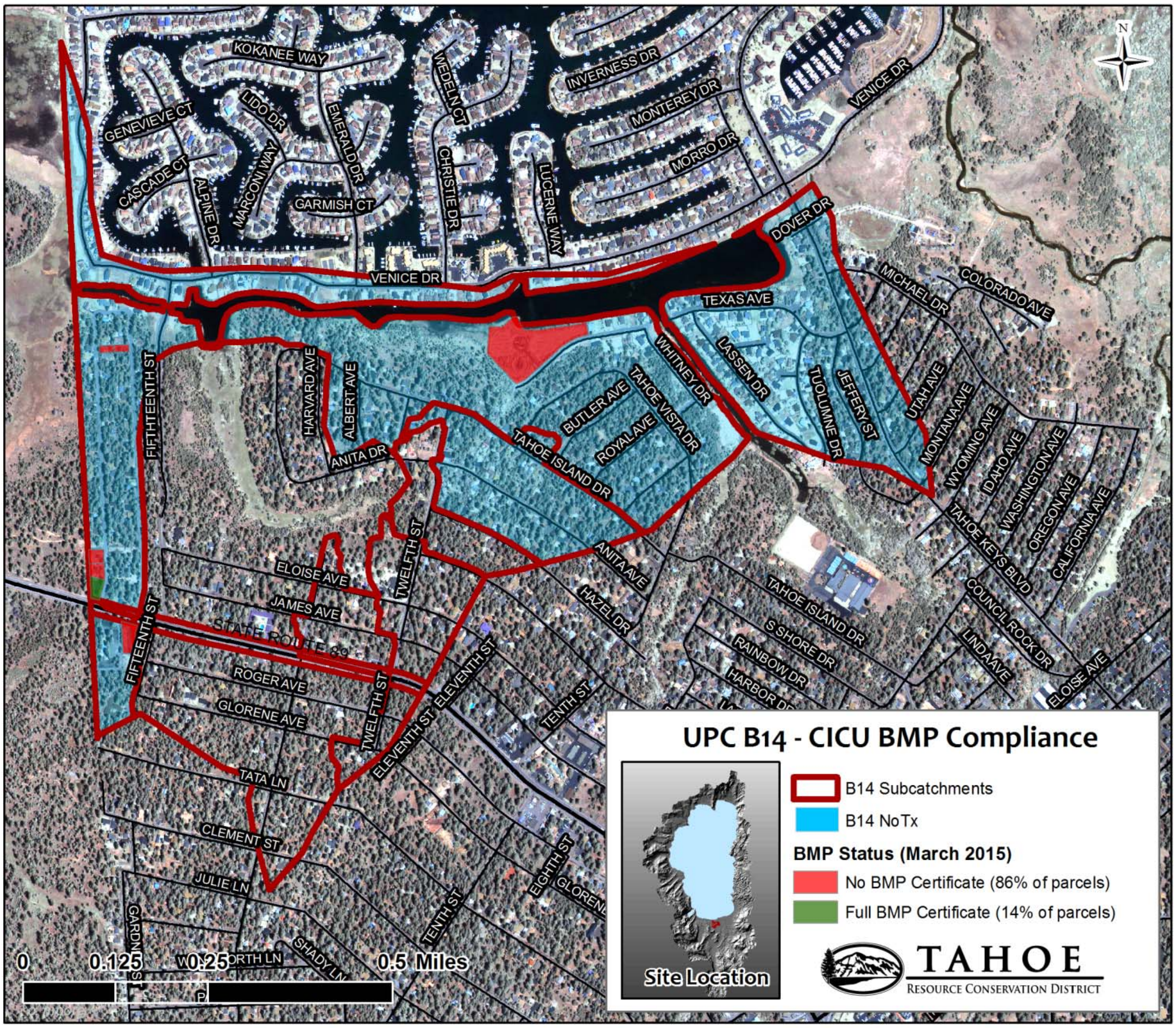

Figure 5 CICU BMP implementation in B14 NoTx.

Table 6 Number of CICU parcels, number of BMP certificates needed to achieve 100% compliance rate, FSP load reduction (lbs/year) and potential Lake Clarity Credits that could be obtained from 100% CICU BMP implementation in B14 NoTx.

CICU BMP Compliance Load Reduction and Credit Potential				
CICU BMP Compliance Rate	CICU Parcels Total (#)	Certificates Needed to Achieve Compliance Rate (#)	FSP Load Reduction (lbs/year)	Clarity Credits (#)
100%	7	6	247	1.23

*Refer to the 5/50 rule, which should be available in the updated version of the Crediting Program Handbook. The Parcel BMP working Group decided that credit for CICU BMPs greater than 5 years old should be worth 50% of the original credit, due to degradation of BMP performance over time.

CREDIT POTENTIAL: IMPROVING ROAD CONDITION

The Lake Clarity Crediting Program uses a road condition score from 1 to 5 (1 being the worst and 5 being the best) to describe road condition and associated pollutant loading in the Tahoe basin. Condition scores are based on how "dirty" or "clean" the roads are according to the Road Rapid Assessment Methodology (Road RAM User Manual 2010). In PLRM version 2.0.2, all roads are assumed to have a condition score of 2 or worse at baseline. The Credit Potential for improving the road conditions score to a 3, 4, or 5 was evaluated for B14 NoTx; results are shown in Table 7. PLRM model results for this area indicate that large water quality benefits exist for improving road condition to a score of 4 or greater. Minimal credits could be obtained if road condition is maintained to a score of a 3 (0.04 Credits or 7lbs/year FSP load reduction). Improvement of the road condition score to a 4 would result in 3.9 Credits 784lbs/year FSP load reduction). Further improvement of road condition score to a 5 would provide 5.6 Credits (1,115lbs/year FSP load reduction).

Table 7 FSP load reduction (lbs/year) and Credit Potential for improving road condition score to a 3, 4, or 5 in B14 NoTx.

Improvement to Road Condition Score Load Reduction and Credit Potential		
Road Condition Score	FSP Load Reduction (lbs/year)	Clarity Credits (#)
3	7	0.04
4	784	3.9
5	1,115	5.6

CREDIT POTENTIAL: ROAD SHOULDER STABILIZATION

Erosion of road shoulders can contribute large amounts of FSP loading to Lake Tahoe. The Credit Potential in B14 NoTx was evaluated in PLRM for improving road shoulder condition to 100% stable and protected; results are shown in Table 8. PLRM model results indicate that 4 Credits (820 lbs/year FSP load reduction) could be obtained with improvement of road shoulder condition.

Table 8 FSP load reduction and Credit Potential for improving road shoulder stabilization to 100% stable and protected in B14 NoTx.

Road Shoulder Stabilization Load Reduction and Credit Potential		
	FSP Load Reduction (lbs/year)	Clarity Credits (#)
100% Stable and Protected	820	4

CREDIT POTENTIAL: 0% DCIA

The Credit Potential of disconnecting all directly connected roads in B14 NoTx was evaluated using PLRM; results are shown in Table 9. PLRM assumes a tremendous water quality benefit for disconnecting DCIA. In fact, disconnecting roads provided the largest water quality benefit of all potential treatments analyzed in this study. PLRM results indicate that 16 Credits (3,120lbs/year FSP load reduction) could be obtained if DCIA for roads was 0% in B14 NoTx. These model results incentivize "green" water quality improvement actions such as removing traditional stormwater infrastructure (i.e. "convey away" curb and gutter and storm drain pipe) and replacing it with "slow the flow" low impact development (LID) infrastructure like rain gardens and pervious channels, which has become the trend nationwide.

Table 9 Load Reduction (lbs/year) and Credit Potential for disconnecting all roads in B14 NoTx (0% DCIA).

Disconnecting Roads Load Reduction and Credit Potential		
	FSP Load Reduction (lbs)	Clarity Credits (#)
0% DCIA	3,120	16

CREDIT POTENTIAL: IMPROVEMENT TO BASELINE STORMWATER INFRASTRUCTURE

There are 3 dry basins within UPC B14 (12th Street Basin 1, Basin 2, and Basin 3) that provide pre-treatment to some of the water entering Tallac Meadow. These basins were installed in 1994 and are therefore considered to be baseline condition. According to the Lake Clarity Crediting Program Handbook (2011), there is potential to receive Clarity Credits for improving the function of existing infrastructure:

> The baseline load reduction estimate assumes treatment BMPs installed before 2005 were maintained at a relatively poor condition reflective of a BMP RAM score of 2 for the treatment BMP. The expected loading estimate can assume improved conditions (equivalent to a BMP RAM score of 3) for all treatment BMPs constructed before the end of 2004 that are still functioning, inspected and maintained.
>
> Further, the urban jurisdiction may have significant opportunities to improve the load reduction potential of existing treatment BMPs through re-engineering. The opportunity to improve the effectiveness of existing treatment BMPs may provide low-cost load reductions and Credits by minimizing the need to acquire land and may not require construction permits for changes with minimal soil disturbance. Indicate significant design changes in the Baseline Treatment BMP Inventory.

Figure 6 shows the drainage area into the existing 12th Street Basins 1, 2, and 3. The area delineated in pink drains to 12th Street Basin 1, and the area delineated in yellow drains into 12th Street Basin 2 and subsequently into 12th Street Basin 3. These basins are relatively large compared to their respective drainage areas. Furthermore, effluent from these basins drains into Tallac Meadow and subsequently into Pope Marsh; therefore they contribute very little pollutant load to Lake Tahoe. The following model results are therefore presented as a theoretical exercise to understand Credit Potential for improving function of older basin infrastructure. The lessons learned from this exercise can be applied to basins outside of UPC B14 where connectivity is higher and/or less natural treatment in meadows and marshes is possible. These models assume 100% connectivity to Lake Tahoe (rather than the 19% Pope Marsh connectivity).

For each basin, FSP removal rates are shown in Table 10 assuming the slowest (0.05in/hr) and fastest (0.50in/hr) suggested PLRM dry basin infiltration rates, which represent the worst and best basin function, respectively. Even with the slowest infiltration rate, 12th Street Basins 1 and 2 provide a large water quality benefit (59% and 73% FSP removal, respectively), due to their large size compared to the drainage area (Basin 3 has a low FSP removal rate of 6% because it treats effluent from Basin 2). Improving basin function to the fastest PLRM infiltration rate increases the FSP removal rate for Basins 1, 2, and 3 to 68%, 82%, and 28%, respectively (Table 10). Table 10 also includes the theoretical Credits that could be claimed if these catchments were 100% connected to Lake Tahoe. PLRM model results indicate that for improvement of these basins to best functioning condition would result in 0.87 Credits for Basin 1, 1.14 Credits for Basin 2, and 0.47 Credits for Basin 3, or a total of 2.49 credits for all basins.

The influence of basin size on FSP removal rate was tested for 12th Street Basin 1; results are shown in Figure 7 and Table 11. Using the slowest and fastest PLRM infiltration rates, basin volumes were doubled for each successive model run (all basins assumed a 2 foot depth). Results indicate diminishing return on water quality benefit for increasing dry basin size.

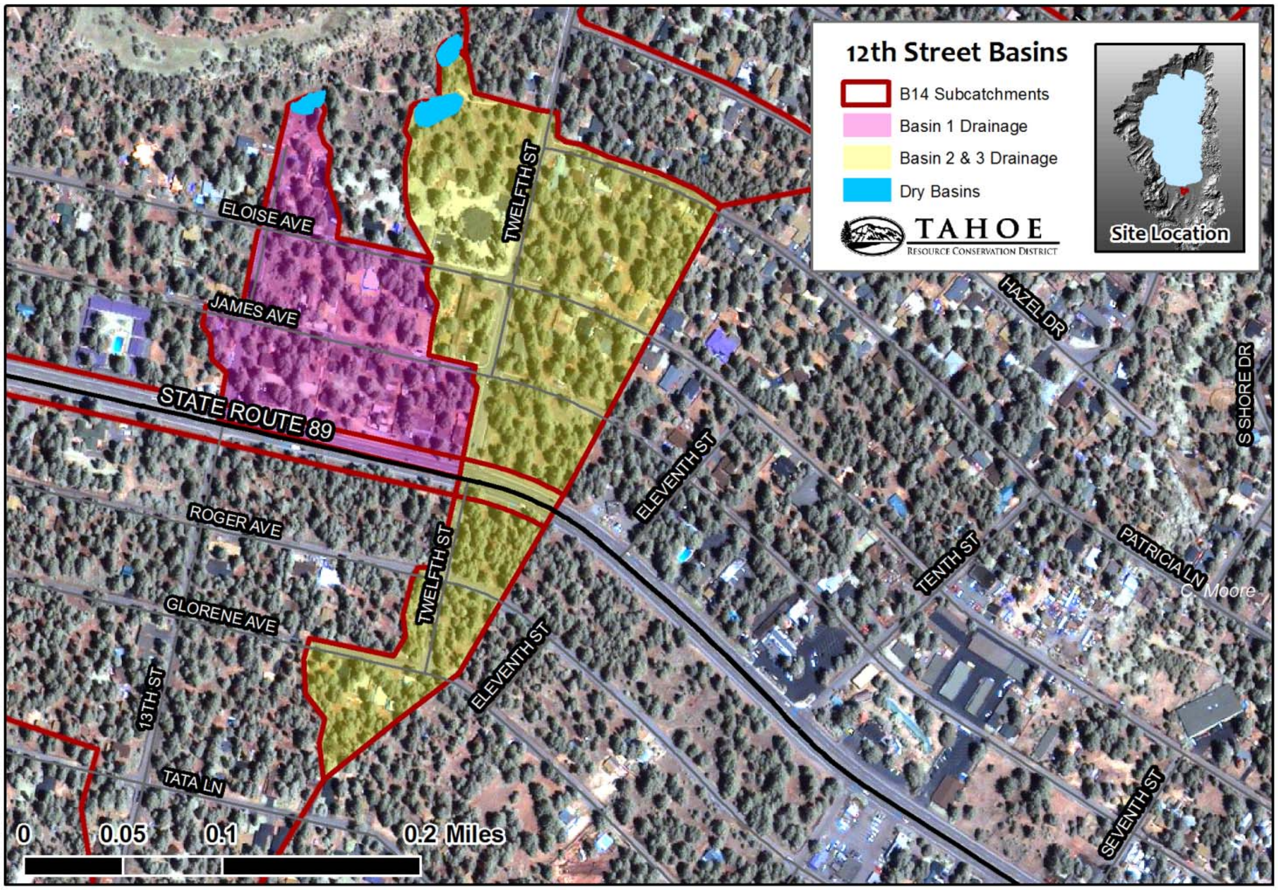

Figure 6 Drainage area into 12th Street Basin 1 (pink) and 12th Street Basin 2/Basin 3 (yellow) in the City of South Lake Tahoe's UPC B14.

Table 10 FSP removal rate (%) and potential Lake Clarity Credits (assuming 100% connectivity to Lake Tahoe) for the slowest (0.05 in/hr) and the fastest (0.50 in/hr) PLRM infiltration rate for the 12th Street Basins 1, 2, and 3 in UPC B14.

FSP Removal Rate and Theoretical* Clarity Credits for 12th Street Basins in UPC B14							
***Assuming 100% Connectivity to Lake Tahoe**	PLRM Infiltration Rate (in/hr)	FSP Removed (%)			Credit Potential (#)		
		12th Street Basin 1	12th Street Basin 2	12th Street Basin 3	12th Street Basin 1	12th Street Basin 2	12th Street Basin 3
Baseline Conditions	0.05	59	73	6	-	-	-
Basin in Best Possible Condition	0.50	68	82	28	0.87	1.14	0.47

capacity.

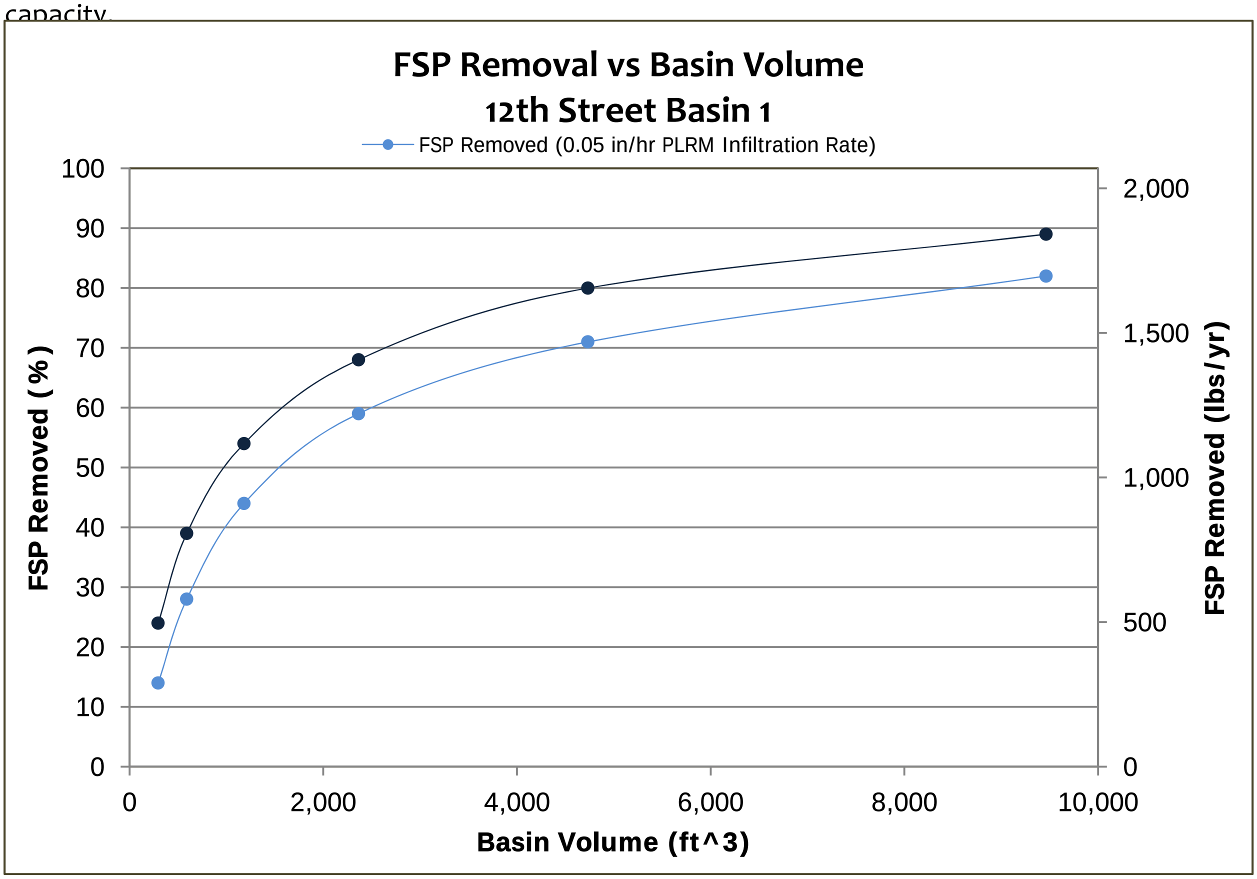

Figure 7 FSP removal in percent and pounds per year with increasing basin volume for the slowest (0.05in/hr) and fastest (0.50in/hr) PLRM infiltration rates for the 12th Street Basin 1 in UPC B14. Dots represent model runs. Basin volumes are doubled with each successive model run. Increasing basin volume provides diminishing returns on water quality benefit. All basins assume a 2ft depth

Table 11 FSP removal rate in percent and pounds per year with increasing basin volume for the slowest (0.05in/hr) and fastest (0.50in/hr) PLRM infiltration rate for the 12th Street Basin 1 in UPC B14. Increasing basin volume provides diminishing returns on water quality benefit. All basins assume a 2ft depth capacity.

FSP Removal versus Basin Volume 12th Street Basin 1				
Basin Volume (ft^3)	FSP Removed (%)		FSP Removed (lbs/year)	
	Slowest PLRM Infiltration Rate (0.05 in/hr)	Fastest PLRM Infiltration Rate (0.5in/hr)	Slowest PLRM Infiltration Rate (0.05 in/hr)	Fastest PLRM Infiltration Rate (0.5in/hr)
296	14	24	293	449
592	28	39	518	720
1,183	44	54	809	1,003
2,366 (Current Size)	59	68	1,092	1,267
4,732	71	80	1,327	1,495
9,464	82	89	1,519	1,651

DISCUSSION AND RECOMMENDATIONS

This study used the PLRM version 2.0.2 to determine the potential Lake Clarity Credits that could be obtained under different water quality improvement scenarios in the City of South Lake Tahoe's UPC B14. The water quality improvement scenarios analyzed to determine Credit Potential were SFR BMP implementation, MFR BMP implementation, CICU BMP implementation, improvement of road condition score, stabilization of road shoulders, the disconnection of DCIA, and improvement of existing stormwater infrastructure (dry basins). Since the catchments with existing dry basins in this study have very low pollutant loading to Lake Tahoe, the Credit Potential analyzed for improvement of existing stormwater infrastructure was purely theoretical. All areas in the UPC B14 eventually drain to Pope Marsh, which was determined by the City to have a connectivity factor of 19% to Lake Tahoe. This connectivity factor was applied to all analyses (with the exception of the theoretical improvement to dry basins) to determine Credit Potential.

Through field investigations for subcatchment delineation, it was determined that 140 acres of the 327 acre catchment drain to Tallac Meadow. Due to the treatment provided by Tallac Meadow, this area (B14 Tallac Tx) had minimal loading to Lake Tahoe and was not the focus of analyses. The Caltrans right-of-way, which makes up 5.7 acres in UPC B14, was not included in any analyses.

Potential Lake Clarity Credits were determined for the 187 acres that drain to Pope Marsh untreated (B14 NoTx); this was the main focus of analyses in this study. There is minimal Credit Potential from BMP implementation on SFR, MFR, and CICU land uses. Even with 100% SFR BMP compliance, only 0.39 Credits could be claimed. Achieving 100% SFR BMP compliance in this area would require 446 full BMP certificates and cost homeowners an estimated $446,000 to $3,568,000. Similarly, only 0.51 Credits could be obtained with 100% MFR BMP implementation, and 1.23 Credits could be obtained with 100% CICU BMP implementation. If these private parcels were treated area-wide, it would result in a total of 2.13 Credits could be claimed. Improving road condition scores to a 3 provided minimal Credit Potential in this area (0.04 Credits). In contrast, improving road condition scores to a 4 or 5 provided a much larger Credit Potential. For improvement of road condition score to a 4, 3.9 Credits could be claimed, while improvement of road condition score to a 5 would provide 5.6 Credits. Improvements to road shoulder conditions to 100% stable and protected would provide 4 Credits. The greatest Credit Potential came from disconnecting DCIA, which could provide 16 Credits. Local jurisdictions cannot simply disconnect roads without considering where the water will go as issues with flooding would no doubt result. If DCIA areas are to be disconnected, stormwater runoff must be mitigated by solutions such as rain gardens or dry basins. PLRM highlights the water quality benefit of disconnecting stormwater flow paths that drain directly to the Lake and could therefore incentivize implementation of modern LID stormwater management techniques in the Tahoe basin. As a result of this study, Tahoe RCD recommends that the City focus water quality improvement efforts on disconnecting DCIA through "green" LID stormwater management techniques as well as maintaining cleaner roads as a pollutant source control management technique in order to obtain the most Credit Potential for catchment registration.

Improvements to the functioning of the three existing dry basins (12th Street Basins 1, 2, and 3) in UPC B14 resulted in negligible Credit Potential due to their large size compared to a small drainage area as well as subsequent treatment of basin effluent by Tallac Meadow. However, improvement to existing infrastructure may be a viable option in other catchments. As such, analysis on these basins was performed as a theoretical exercise to better understand the Credit Potential for improving older infrastructure in general. It was determined that up to 2.49 Credits could be claimed with improvement of infiltration rates in these dry basins (assuming 100% connectivity to Lake Tahoe and no treatment by Tallac Meadow). Theoretical analysis was performed on 12th Street Basin 1 to determine the influence of basin size on FSP removal. Model results indicated diminishing return on FSP removal with increased basin size.

Applying connectivity factors greatly reduces the baseline pollutant loading as well as the Credits that can be obtained from water quality improvement projects. Assessing the connectivity of Urban Planning Catchments should be a priority for urban jurisdictions; it can help reduce TMDL target load reductions, making compliance easier to achieve, while shifting focus of water quality improvement actions towards higher polluting catchments. It is worth mentioning that past water quality improvement projects that were constructed in watersheds that are disconnected from Lake Tahoe are still perceived as having a positive impact on the environment. Moving forward, identifying areas with high impervious area connectivity to Lake Tahoe is crucial for targeting improvements in catchments with high pollution potential in order to use limited resources more efficiently and effectively, and to ultimately ensure protection of Lake Tahoe.

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PLRM RESULTS – LETTER TO EL DORADO COUNTY

TAHOE
RESOURCE CONSERVATION DISTRICT
870 EMERALD BAY ROAD SUITE 108, SOUTH LAKE TAHOE, CA 96150 530.543.1501 PH 530.543.1660 FAX TAHOERCD.ORG

July 2, 2015

Dear El Dorado County,

Per your request, the Tahoe RCD has completed modeling for Urban Planning Catchment (UPC) 04, aka Montgomery Estates, using the Pollutant Load Reduction Model version 2.1 (PLRM v2.1); results are shown in Table 1. Original PLRM v1 results, as modeled by El Dorado County for the Pollutant Load Reduction Plan (March 2013), are included in Table 2. Both models provide similar results for pollutant load reduction estimates. However, PLRM v2.1 provided slightly more reduction in pounds of fine sediment particles (FSP; 5,130 lbs/year and 4,938 lbs/year for v2.1 and v1, respectively) and corresponding Credits (26 and 25 Credits for v2.1 and v1, respectively). Additionally, the percent reduction over baseline was greater with PLRM v2.1 (33% and 26% for v2.1 and v1, respectively). The UPC 04 PLRM model and UPC 04 baseline/post project model output results are included as an attachment.

Table 1 Baseline loading and expected condition loading estimates, as modeled by Tahoe RCD using PLRM v2.1.

		Pollutant Load (lbs/yr)									
Project Area	TMDL UPC	TSS	FSP	TP	SRP	TN	DIN	lbs FSP Reduced	Credits	Baseline Load	% of Baseline Reduced
Montgomery Estates	4	17,702	10,496	40	5	149	19	5,130	26	15,626	33

Table 2 Baseline loading and expected condition loading estimates, as modeled by El Dorado County using PLRM v1 (from County of El Dorado Pollutant Load Reduction Plan Lake Tahoe Basin March 2013).

		Pollutant Load (lbs/yr)									
Project Area	TMDL UPC	TSS	FSP	TP	SRP	TN	DIN	lbs FSP Reduced	Credits	Baseline Load	% of Baseline Reduced
Angora	1	19,506	10,333	57	9	260	31	1,887	9	12,220	15%
Christmas Valley	2	9,358	5,043	29	8	125	14	12,910	65	17,956	72%
Apalachee	3	49,219	28,752	128	19	564	69	22,399	112	44,469	50%
Montgomery Estates	4	12,881	7,212	35	5	156	19	4,938	25	18,832	26%
Echo View / Sawmill	5	17,373	11,896	33	4	112	14	8,127	41	20,023	41%
Total		108,337	63,236	283	45	1,217	148	50,261	251	113,500	

Summary	Pollutant Load (kg)							Credits
Achieved	49,141	28,683	128	20	552	67	22,798	251
Required			73		327		19,958	220
% Attainment			176%		169%		114%	114%

The Tahoe RCD modified the original catchment shapefiles sent by El Dorado County by adding subcatchment delineations to indicate the areas draining to the eight dry basins in UPC 04 in order to determine the pollutant load reduction potential of each basin and classify them as an Essential, Key, or Supporting Best Management Practices (BMPs) (Figure 1, Table 3). The modified UPC 04 shapefile showing the subcatchments is included as an attachment. In UPC 04, no BMPs were classified as Essential, 3 BMPs were classified as Key, and 5 BMPs were classified as Supporting (it should be noted that 1 BMP, Black Bart Ct, was installed in 1995 and is therefore considered to be part of baseline conditions).

Figure 1 Modified subcatchment delineation for UPC 04.

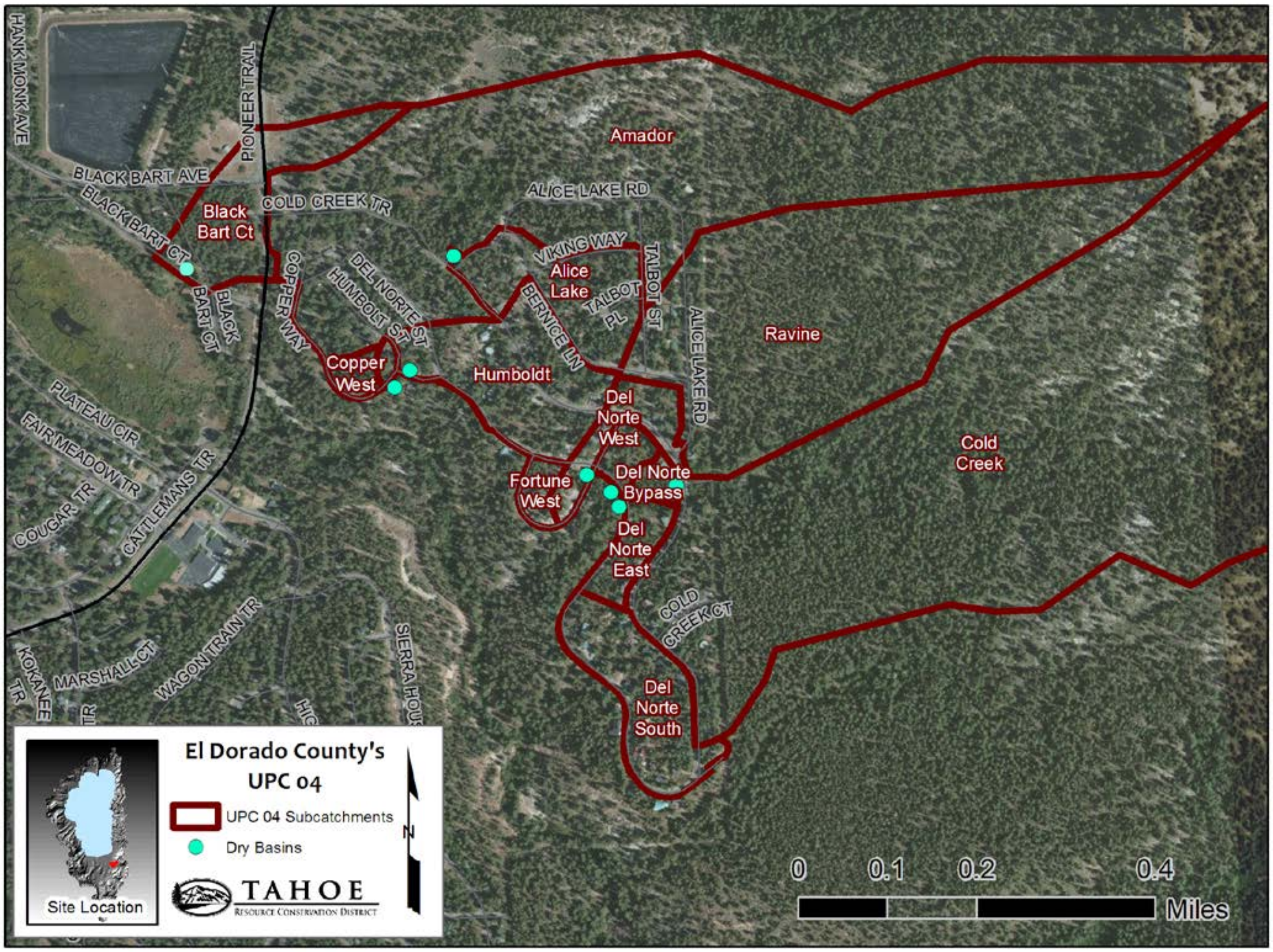

Table 3 Key and Supporting BMPs (dry basins) in UPC 04, as modeled by PLRM v2.1 (no BMPs were classified as Essential). TID stands for Treatment ID, an El Dorado County classification.

Basin Name	TID	lbs FSP Reduced	Credits	Key, Essential, or Supporting	Basin Volume (cf)	Basin Footprint (sf)	Basin Draw Down Time (hrs)	PLRM Infiltration Rate (in/hr)
Black Bart (BASELINE)	105	631.1	3.1	-	687	687	72	0.05
Copper	129	178.1	0.9	Supporting	326.5	437	48	0.4
Humboldt	130	1237.5	6.2	Key	797	1104	48	0.4
Fortune	131	407.8	2.0	Supporting	649.5	948	48	0.4
Cold Creek	132	848.9	4.2	Key	417	411	48	0.4
Alice Lake	133	1105.1	5.5	Key	525	702	48	0.4
Del Norte West	134	286.8	1.4	Supporting	421	580	48	0.4
Del Norte East	135	319	1.6	Supporting	1515.5	1200	48	0.4

BMP Rapid Assessment Methodology (RAM) observations were performed on all post project (built after baseline) basins in UPC 04. Three different BMP RAM methods were used to evaluate the function (as an infiltration rate) of the dry basins. Constant Head Permeameter (CHP) measurements were performed in winter and spring of 2015. Single-ring infiltrometers were also used to measure infiltration in spring 2015. California Stormwater Quality Association (CASQA) 48-hour draw down time method, which involves visiting dry basins 48 hours after a rain event to see whether or not the basin infiltrated water, was performed in fall 2014 and spring 2015.

All basins infiltrated water within 48-hours according to CASQA 48-hour draw down time protocols, indicating that no maintenance is required. Determining whether basins required maintenance using CHP and infiltrometer methods is a bit more convoluted. For instance, neither CHP nor infiltrometer measurements were available for all basins in Montgomery Estates at baseline conditions. These numbers would have provided the benchmark for the highest function achievable at each basin; a 20% reduction in function over baseline (as measured by infiltration) triggers the need for maintenance. Additionally, in the spring of 2015, a wide range of infiltration rates between basins was measured using the infiltrometer (from 3 in/hr up to 26 in/hr, 0). In contrast, the range of measured rates using the CHP method was not as wide between basins (0.2 in/hr to 5.5 in/hr, Table 5). However, CHP infiltration rates varied considerably *within* each basin; the largest range observed in a single basin was a minimum of 1.5 in/hr and a maximum of 5.5 in/hr (Fortune basin). Due to time constraints, only one infiltrometer measurement was taken per basin; therefore Tahoe RCD is unable to comment on the range of infiltrometer measurements within each basin at this time, although it is likely to vary considerably. The CHP and infiltrometer measurements were also more time consuming than the CASQA observation; the CASQA observations took one staff member less than 1 hour to complete, while the CHP and infiltrometer measurements took two staff members a day and a half. CHP, infiltrometer, and CASQA measurements for winter and spring of 2015 are included in the PLRM/RAM spreadsheet.

The Tahoe RCD would recommend the use of the CASQA 48-hour basin draw down time method over CHP and infiltrometer. It is a less time consuming and more representative observation of dry basin performance. The main disadvantage is it is subject to scheduling difficulties (staff must be ready to mobilize after a large enough storm event). It has also not been formally approved by the Lake Tahoe Crediting Program, although it has been given an informal nod of approval by local regulators.

Table 4 Infiltration rates for dry basins in UPC 04, as measured by an infiltrometer in spring 2015

Basin Name	TID	Infiltrometer (in/hr)
Alice Lake	133	15
Humboldt	130	26
Copper	105	8
Cold Creek West	132	13
Fortune	131	3
Del Norte West	134	4
Del Norte East	135	5

Table 5 Infiltration rate for dry basins in UPC 04, as measured by CHP in spring 2015. Three CHP observations were taken in each basin; these observations were averaged to provide one infiltration rate per basin.

Basin Name	TID	CHP 1 (in/hr)	CHP 2 (in/hr)	CHP 3 (in/hr)	Average CHP (in/hr)
Alice Lake	133	1.0	0.2	0.5	0.6
Humboldt	130	2.1	5.2	1.8	3.0
Copper	105	2.5	0.2	0.3	1.0
Cold Creek West	132	0.2	0.2	0.4	0.2
Fortune	131	1.5	5.5	3.2	3.4
Del Norte West	134	0.1	0.4	0.4	0.3
Del Norte East	135	0.3	0.1	0.7	0.4

Although not required for TMDL compliance, depth to sediment for sediment traps and drop inlets was measured during in fall 2014, winter 2015, and spring 2015, per El Dorado County's request, and are included in the PLRM/RAM Spreadsheet.

If El Dorado County is still interested in data entry for BMP RAM database and/or the Credit Accounting Platform (CAP), Tahoe RCD is available to provide assistance. We appreciate the opportunity to conduct this modeling and monitoring work on behalf of El Dorado County. Please let us know if there is any additional information we can provide.

Respectfully,

Cara Moore, Environmental Scientist II
Community Watershed Partnership Program
Phone: 530-543-1501 (ext.110)
cmoore@tahoercd.org
www.tahoercd.org

Attachments

UPC 04 PLRM Model (Folder: EDC_PLRP2015_UPC04_PLRM_Model)
UPC 04 Baseline/ Post Project Model Output Results (Folder: EDC_PLRP2015_UPC04_PLRM_ModelResults)
PLRM/RAM Spreadsheet (Folder: EDC_PLRP2015_UPC04_PLRM_Model)
Modified UPC 04 Subcatchment Shapefile (Folder: EDC_PLRP2015_UPC04_Subcatchments_TRCD_SHP)