City of South Lake Tahoe
TMDL Baseline Pollutant Load Estimate

South Lake Tahoe, CA

September 2011

Prepared for:

Prepared by:

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LIST OF ACRONYMS USED

CICU	Commercial/institutional/communications/utilities
CRC	Characteristic Runoff Concentration
DCIA	Directly connected impervious area
DN	Dissolved nitrogen
DP	Dissolved phosphorus
ECAM	Existing conditions analysis memorandum
FSP	Fine sediment particles
GIS	Geographic information system
HSC	Hydrologic source control
ICIA	Indirectly connected impervious area
LRWQCB	Lahontan Region Water Quality Control Board
MFR	Multi-family residential
NDEP	Nevada Division of Environmental Protection
PSC	Pollutant source control
SEZ	Stream environment zone
SFR	Single family residential
SWT	Storm water treatment
TMDL	Total maximum daily load
TN	Total nitrogen
TP	Total phosphorus
TRPA	Tahoe Regional Planning Agency
TSS	Total suspended sediment
UPC	Urban planning catchment
WQIP	Water quality improvement project

EXECUTIVE SUMMARY

In 2011, the California Water Quality Control Board – Lahontan Region issued an *Order to Submit Technical Reports in Accordance with California Water Code – Lake Tahoe Urban Stormwater Implementation* (13267 Order) to the City of South Lake Tahoe (City) and the other Tahoe MS4 permitees. The 13267 Order requires that the City estimate a baseline pollutant load to Lake Tahoe for fine sediment particles (FSP), total phosphorus (TP), and total nitrogen (TN) and submit the estimate for review and approval.

The Pollutant Load Reduction Model (PLRM) was used to estimate the City's baseline pollutant load. Because the PLRM was not developed to estimate jurisdictional scale pollutant loading, many individual PLRM models would be necessary to estimate pollutants loads for the entire urban area of the City. To conserve resources, roughly 50% of the City's urban area was modeled using PLRM by selecting urban planning catchments (UPCs) within the City that represent a range of stormwater conditions. The results from detailed PLRM modeling were extrapolated by developing regression relationships to estimate pollutant loading in UPCs not explicitly modeled to derive a total baseline pollutant load. For UPCs that discharge stormwater to meadows or marshes within the City, a connectivity methodology was developed to estimate the proportion of stormwater and associated pollutant load that reaches Lake Tahoe in order to refine the baseline load estimate.

Table ES-1 displays the City's baseline pollutant load estimate for average annual surface runoff and pollutant loading for FSP, TP, and TN.

Table ES-1. City Baseline Condition Load Estimate

Urban Area (acres)	Surface Runoff (acre-feet/year)	Pollutant Loading			
		FSP	TP	TN	Units
5,500	1,200	389,000	1,740	7,410	lb/year
		176.7	0.8	3.4	metric tons/year
		1.94E+19	n/a	n/a	# particles/year[1]

[1] One kg FSP = 1.1×10^{14} particles FSP (Equation 0.3 LRWQCB and NDEP, 2009)

Over the next 15 years the TMDL calls for the City to meet load reduction milestones for FSP, TP, and TN. The load reduction milestones for FSP are shown in Table ES-2. In order to meet the first load reduction milestone by 2016, the City must demonstrate a 10% (39,000 lb/year) reduction in FSP from the baseline load.

Table ES-2. City FSP Load Reduction Milestones

Load	% Reduction	Year of measure	FSP Loading (lb/year)	FSP Reduction (lb/year)
City Baseline	-	2004	389,000	-
First Load Reduction Milestone	10%	2016	350,000	39,000
Second Load Reduction Milestone	21%	2021	307,000	82,000
Clarity Challenge Milestone	34%	2026	257,000	132,000

1.0 INTRODUCTION AND BACKGROUND

The California Water Quality Control Board – Lahontan Region (LRWQCB) and Nevada Division of Environmental Protection (NDEP) have completed a Lake Tahoe TMDL analysis (LRWQCB and NDEP, 2010) with the following key findings: 1) fine sediment particles (FSP <16µm) are the primary pollutant of concern impacting lake clarity; and 2) stormwater runoff originating in urban areas is estimated to contribute 72% of the annual FSP pollutant load to Lake Tahoe.

In 2011, the LRWQCB issued to the City of South Lake Tahoe (City) an *Order to Submit Technical Reports in Accordance with California Water Code – Lake Tahoe Urban Stormwater Implementation* (13267 Order). The 13267 Order requires that the City estimate a baseline pollutant load to Lake Tahoe for FSP, total phosphorus (TP), and total nitrogen (TN) and submit the estimate to the LRWQCB for review and approval. Additionally, the 13267 Order requires that the City submit a description of the methodologies and analysis assumptions used to derive the baseline pollutant load, which is intended to reflect the conditions present during the TMDL baseline period of October 1, 2003 – May 1, 2004.

Northwest Hydraulic Consultants (NHC) was contracted to develop the City's baseline pollutant load for urban stormwater to meet the standards required by the 13267 Order. NHC used the Pollutant Load Reduction Model (PLRM) for the analyses. The PLRM was developed to estimate catchment scale pollutant loads and evaluate potential load reductions for water quality improvement project (WQIP) alternatives. Because the PLRM was not developed to estimate jurisdictional scale pollutant loading, many individual PLRM models would be necessary to estimate pollutants loads for the entire urban area of the City. To conserve resources, roughly 50% of the City's urban area was modeled using PLRM by selecting urban planning catchments (UPCs) within the City that represent a range of stormwater conditions. The results from detailed PLRM modeling were extrapolated by developing regression relationships to estimate pollutant loading in UPCs not explicitly modeled to derive a total baseline pollutant load.

Supporting information provided by the City used to develop the baseline pollutant load consisted of the following:

- The City's Pollutant Load Reduction Strategy Report (2009).
- GIS shapefiles of catchments delineated by the City for the Pollutant Load Reduction Strategy Report.
- Digital files depicting the location of existing storm water treatment facilities, storm water outfalls, storm drain, and various conveyances throughout the City.
- Existing Conditions Analysis Memoranda (ECAMs) for Water Quality Improvement Projects

2.0 SUMMARY OF APPROACH

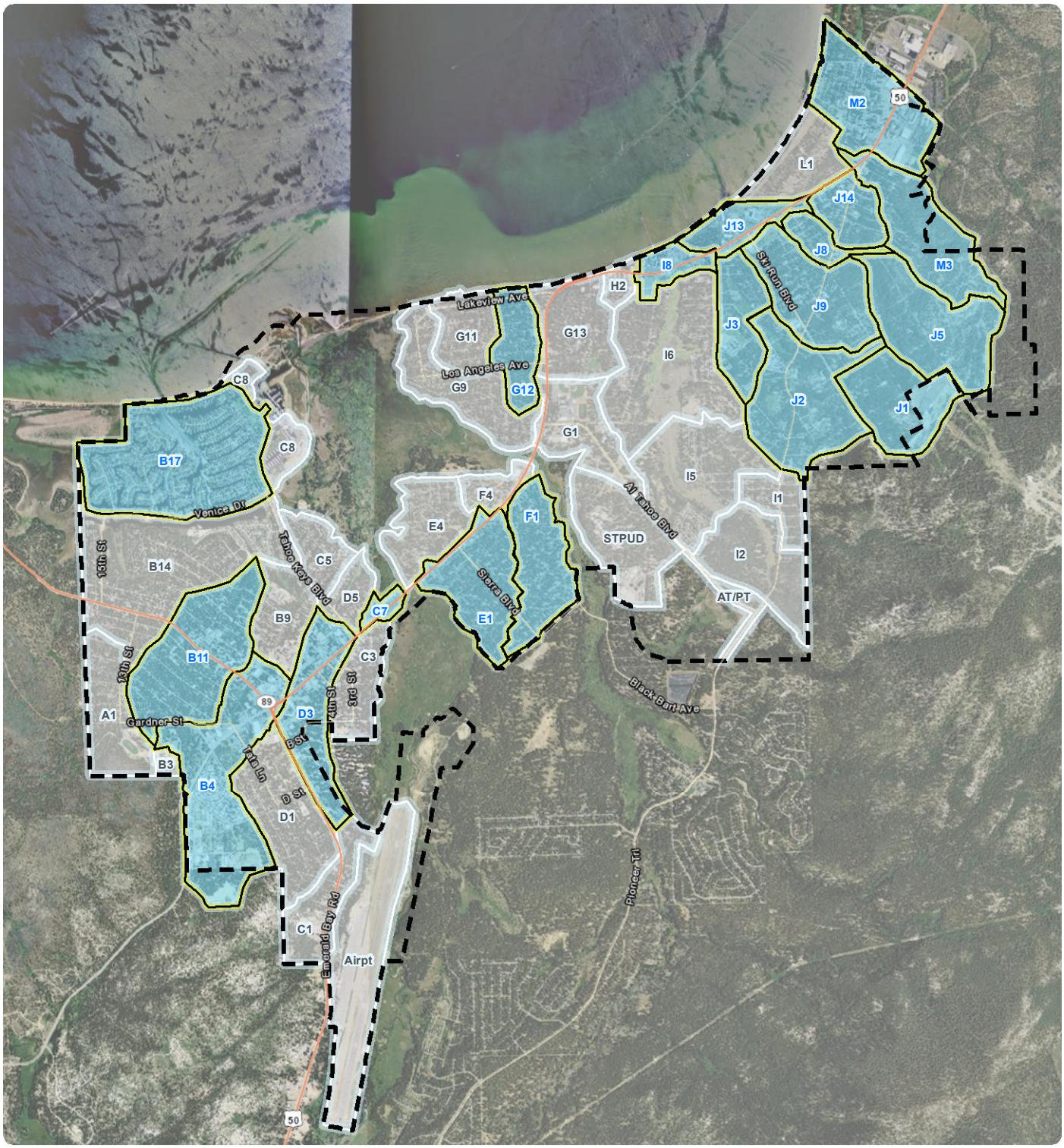
This section summarizes the process used to estimate the City's baseline pollutant load. Additional details are provided as individual sections of this report for the following steps: Step 5 - development of inputs for baseline PLRM models; Step 6 - extrapolation of PLRM output; and Step 7 - assessment of catchment connectivity.

Step 1 – Define the Urban Boundary for the Analysis:
The baseline loading analysis assessed pollutant loading generated in urban areas within the City boundary (Figure 1). Two exceptions were made to include urbanized areas that drain directly into City storm drainage infrastructure: 1) the California Lodge facilities associated with the Heavenly Ski Area; and 2) the industrial tract area south of the City Boundary. Undeveloped areas within the City boundary (e.g., Upper Truckee Meadow) and City-owned riparian corridors outside of the City Boundary (e.g. Cold Creek) were not analyzed for the baseline load estimate because they do not generate pollutant loading associated with urban stormwater runoff.

Step 2 – Delineate Urban Planning Catchments (UPCs):
The Lake Clarity Crediting Program Handbook (LRWQCB and NDEP, 2009) directs jurisdictions to estimate pollutant loads and load reductions using distinct urban catchments. The term "urban planning catchment" is used in this report and is synonymous with the Crediting Handbook term: "urban catchment". UPCs ensure that pollutant load estimates to Lake Tahoe are the sum of distinct input points (i.e. UPC outlets). The catchment delineation developed for the City's Pollutant Load Reduction Strategy report was aggregated for this analysis into a larger UPC delineation. A total of 44 UPCs were delineated for the City analysis (Figure 1).

Step 3 – Select UPCs to Model with PLRM:
The specific UPCs modeled in PLRM (Figure 2) were selected in coordination with the City Stormwater Coordinator. Recognizing that results from PLRM models would be extrapolated to other UPCs not modeled in PLRM, the primary criteria applied when selecting UPCs was to model a range of stormwater conditions present within the City. Below is a list of the prioritized criteria used to select UPCs and the rationale for each criterion:

1. *Select UPCs that represent a range of stormwater conditions* - ensures subsequent tasks that involve extrapolation of PLRM output are representative of all City stormwater conditions.
2. *Select UPCs where major stormwater treatment (SWT) facilities exist in the baseline condition (i.e. constructed prior to 2004)* - load reductions associated with large SWT facilities, which can be significant, will be accounted for in the baseline loading estimate.
3. *Select UPCs where PLRM input data has been previously developed* – assists in conserving resources.



Data Sources: ArcGIS Online Basemaps, 2011.

Legend

- City Boundary
- Modeled Urban Planning Catchments
- Non-Modeled Urban Planning Catchments

Reference Map

City of South Lake Tahoe Baseline Load Estimate

Urban Planning Catchments Modeled Using PLRM

Scale - 1:48,000 1 inch = 4,000 feet

0 2,000 4,000 8,000 Feet

CA State Plane, Zone II	NAD 83	horiz. units: feet
northwest hydraulic consultants	project no. 50620	July 2011

Figure 1 - Urban Planning Catchments Modeled Using PLRM

Step 4 - Delineate PLRM Catchments within UPCs:

A PLRM catchment is a discrete drainage area where pollutant loading is evaluated in the PLRM. The term "PLRM catchment" is used in this report and is synonymous with the Crediting Handbook term: "modeling catchment". PLRM catchments are typically smaller than a UPC or the boundaries of a WQIP. Therefore, multiple PLRM catchments are typically used to estimate pollutant loading from a UPC.

Figure 2 identifies the UPCs modeled and the specific PLRM catchments modeled within each UPC for the baseline loading analysis. The PLRM catchments shown in Figure 2 are based on the smaller catchment delineation conducted by the City for the Pollutant Load Reduction Strategy Report (2009). As shown in Figure 2 and tabulated in Table 1, roughly half of the City's urban area was modeled for this effort.

Table 1. Statistics on Modeled Area vs. Total Urban Area

Parameter	Modeled Area	Total Urban Area
Urban Area (acres)	2,647	5,500
Impervious Area (acres)	892	1,698
% Impervious	34%	31%
% of Urban Area Modeled	48%	

Step 5 – Develop Baseline PLRM Models:

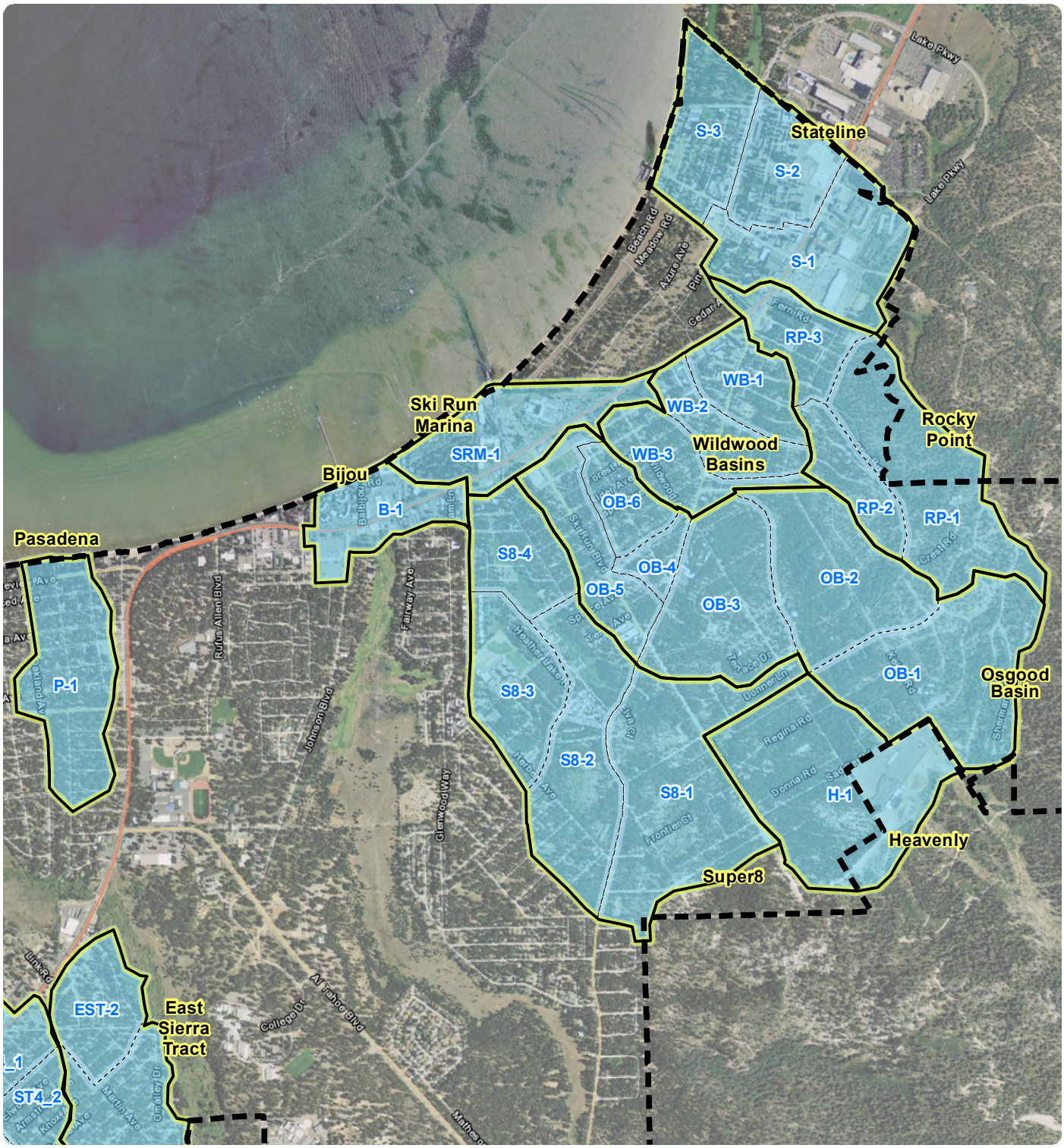
Baseline PLRM models were developed using: 1) analysis of Geographic Information System (GIS) data; 2) information and reports provided by City; and, 3) reconnaissance level field assessments of drainage conditions and design attributes of baseline SWT facilities. Section 3 describes the baseline PLRM model development.

Step 6 – Extrapolate Model Output:

Because the PLRM was developed for applications at the WQIP scale, it would be resource intensive to develop PLRM models for the entire urban area of the City to estimate a total baseline pollutant load. An extrapolation of pollutant loading using the output generated from the modeled PLRM catchments was used to estimate pollutant loading for UPCs not explicitly modeled. Section 4 of this report describes the methods used to extrapolate the results of modeled output.

Step 7 – Assess Catchment Connectivity:

The PLRM does not estimate potential reductions in pollutant loads for cases where stormwater runoff discharges to a meadow or other natural filtration systems prior to reaching Lake Tahoe. The analysis of catchment connectivity is particularly important for the City pollutant load estimate because a notable amount of the City's urban drainage discharges to meadows prior to reaching Lake Tahoe (e.g., Pope Marsh, Upper Truckee Marsh, etc.). Section 5 of this report summarizes the methods used to analyze catchment connectivity and the connectivity factors applied to pollutant load estimates for each UPC. Appendix D provides a detailed summary of the catchment connectivity methodologies developed.



Data Sources: ArcGIS Online Basemaps, 2011.

Legend

- City Limits
- PLRM Projects
- PLRM Catchments

Reference Map

City of South Lake Tahoe Baseline Load Estimate

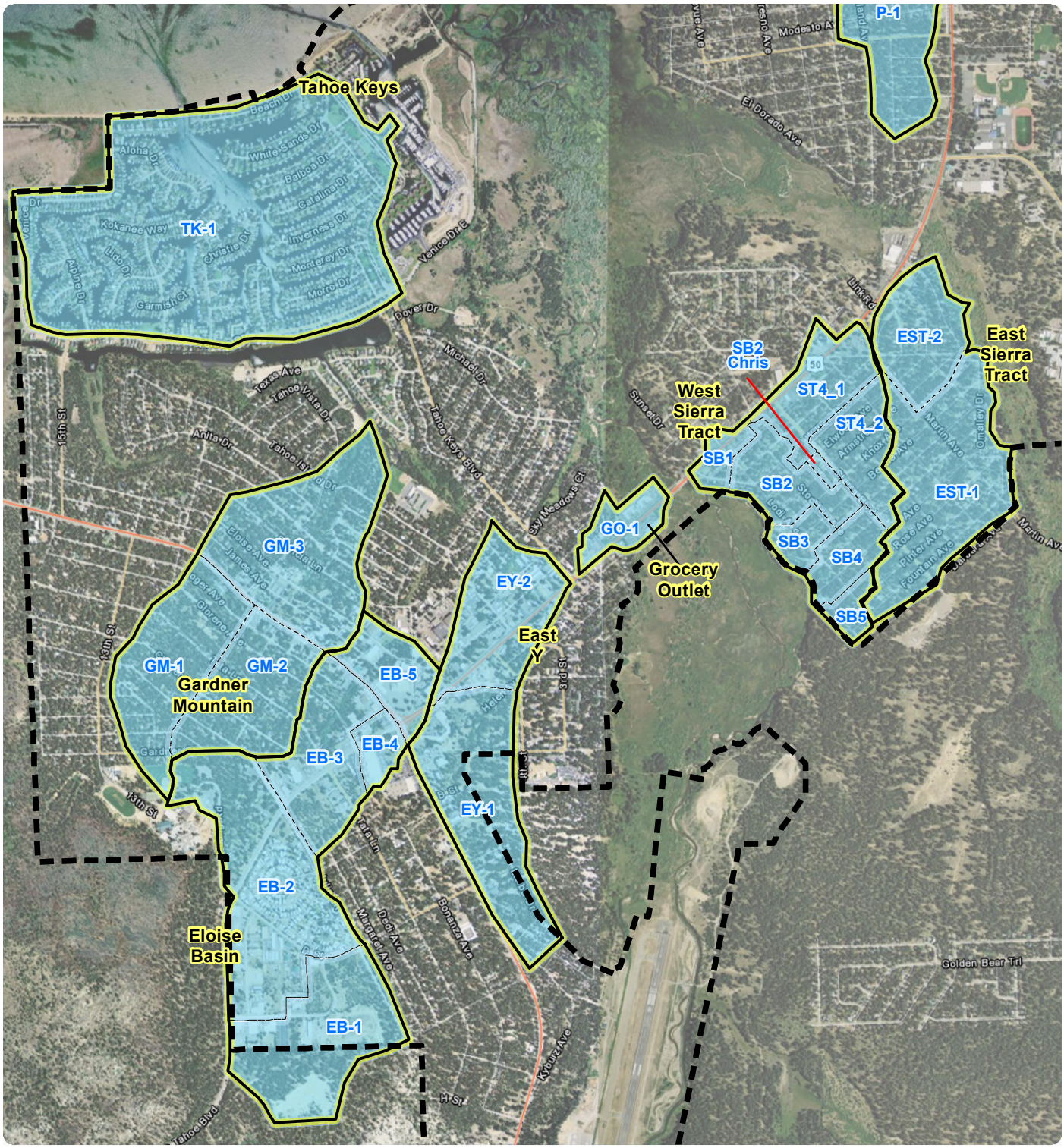
PLRM Catchments within Urban Planning Catchments

Scale - 1:24,000 1 inch = 2,000 feet

0 1,000 2,000 4,000 Feet

CA State Plane, Zone II	NAD 83	horiz. units: feet
northwest hydraulic consultants	project no. 50620	July 2011

Figure 2a - PLRM Catchments within Urban Planning Catchments



Data Sources: ArcGIS Online Basemaps, 2011.

Legend

- City Limits
- PLRM Projects
- PLRM Catchments

Reference Map

City of South Lake Tahoe Baseline Load Estimate

PLRM Catchments within Urban Planning Catchments

Scale - 1:24,000 1 inch = 2,000 feet

0 1,000 2,000 4,000 Feet

CA State Plane, Zone II	NAD 83	horiz. units: feet
northwest hydraulic consultants	project no. 50620	July 2011

Figure 2b - PLRM Catchments within Urban Planning Catchments

Step 8 – Sum UPC Scale Pollutant Load Estimates to Produce Baseline Load Estimate: The total baseline load estimate is the sum of the results of the PLRM baseline models and the extrapolation calculations for UPCs not explicitly modeled in PLRM. This summation includes any adjustments for catchment connectivity. Section 6 presents the City's baseline loading estimate.

3.0 PLRM BASELINE MODEL DEVELOPMENT

This section describes the process used to develop the inputs for all baseline PLRM models, and summarizes the PLRM output generated for each PLRM model. An Excel file is provided in Appendix A that documents all PLRM inputs and the supporting calculations used to develop the inputs. Appendix A also includes all baseline PLRM models. The boundaries of each baseline PLRM model and the associated PLRM catchments within each model are shown in Figure 2.

3.1 INPUT DATA

Input data for baseline PLRM models was developed using: 1) Geographic Information System (GIS) data; 2) information and reports provided by the City; and, 3) reconnaissance level field assessments of drainage conditions and design attributes of baseline SWT facilities.

1. GIS data was queried to develop input data for each PLRM catchment within a model (e.g., land use distribution, soil distribution, average slope, road risk, etc.). The GIS processes and algorithms used to develop the input data are described in the PLRM Applications Guide (NHC, 2010). The following GIS data sets were used:

    a. *TMDL Land Use GIS Layer*:

        i. Provides a planning level estimate of land use distribution and impervious area by land use for input within the Land Use Editor of the PLRM.
        ii. The layer can be downloaded from the LRWQCB website at http://www.waterboards.ca.gov/lahontan/water_issues/programs/tmdl/lake_tahoe/index.shtml

    b. *2006 Tahoe Basin Soil Survey*:

        i. Provides the distribution of soil map units for input within the Soil Editor of the PLRM. The distribution of soils is used by the PLRM to provide default values for hydrologic properties of soil.
        ii. The layer can be downloaded from the Natural Resources Conservation Service (NRCS) website for Soil Survey Symbol = CA693 at http://soildatamart.nrcs.usda.gov/Survey.aspx?State=CA

    c. *PLRM Road Risk Layer*:

        i. Provides the distribution of Road Risk for input within the Land Use Conditions Editor of the PLRM.

ii. Road Risk is used in the PLRM to categorize the pollutant potential of a road segment based on physiographic characteristics that are assumed to most strongly influence the quality of storm water generated, specifically: slope, traffic density, and adjacent land use.
iii. The 2009 default Road Risk layer was refined to better reflect City road operations and road conditions by incorporating the City's Sanding Map (Friedlander, 2009), and through consultations with the City Roads Supervisor and the City Stormwater Coordinator.
iv. The refined City Road Risk Layer used for the baseline condition estimate is provided digitally in Appendix B.

d. *PLRM Road Shoulder Conditions Layer*:

i. Classifies the condition of road shoulders to estimate: 1) pollutant generation using the PLRM Road Methodology (NHC et al. 2009) for input within the Road Conditions Editor of the PLRM; and, 2) impervious area connectivity of roads for input within the Drainage Conditions Editor of PLRM.
ii. The default Road Shoulder Conditions layer reflects conditions in the summer of 2010 and is not appropriate for baseline loading estimates where infrastructure improvements occurring after 2004 have changed the conditions of a road shoulder.
iii. The default Road Shoulder Conditions layer was refined by NHC to remove road shoulder improvements constructed after 2004 for the baseline condition estimate. Road shoulders with improvements associated with the following WQIPs constructed in the City between 2004 – 2010 were revised:
    1. Glorene and 8th Street
    2. Sierra Tract Phase 1
    3. Sierra Tract Phase 2
    4. Rocky Point 1&2
    5. Rocky Point 3&4
    6. Al Tahoe Phase 1
iv. The refined Road Shoulder Conditions Layer used for the baseline condition estimate is provided digitally in Appendix B.

e. *DEM of the Lake Tahoe Basin*:

i. Provides a means to calculate the average slope of each PLRM catchment for entry in the Catchment Properties Editor of the PLRM.
ii. This layer can be downloaded from the United States Geological Survey (USGS) Lake Tahoe Clearinghouse at http://tahoe.usgs.gov/DEM.html

2. To avoid including pollutant loads associated with transportation facilities operated by Caltrans within the City's baseline load estimate, the land use distribution for PLRM catchments that contain Primary Roads attributed to Caltrans were modified using the following approach.

a. The area of Primary Roads attributed to Caltrans was subtracted out of each City PLRM catchment and a separate Caltrans PLRM catchment was used to model the runoff and pollutant load associated with Caltrans facilities.
b. If a baseline SWT facility was present, all tributary catchments were routed to the SWT facility including any Caltrans PLRM catchments.
c. The PLRM was run under this scenario to estimated total pollutant loading from both City catchments and Caltrans catchments.
d. This first modeling scenario was copied in PLRM to create a second modeling scenario. In the second scenario the Caltrans PLRM catchments were deleted.
e. If a baseline SWT facility was present in the first scenario that treated both Caltrans and City stormwater runoff, then the size of the SWT facility size was decreased proportionally based on calculated pollutant loads to the SWT facility. For example, if City runoff contributed 90% of the average annual pollutant load to the SWT facility, with Caltrans runoff contributing the remaining 10%, then to model the City's load, the size of the SWT facility was decreased to be 90% of the size modeled in the first scenario. Note that this approach does not consider the timing of inflows within individual stormwater runoff events for Caltrans and City stormwater because the PLRM cannot track this potential performance metric for SWT facilities.
f. The second modeling scenario was run to estimate baseline pollutant loading attributed to City stormwater and is used in the City estimate.
g. Note that both modeling scenarios described above are provided with the baseline PLRM models (Appendix A).

3. ECAMs provided by the City to NHC were used to validate and refine input parameters developed in GIS. For example, ECAMs were used to estimate the baseline condition of road shoulders for WQIPs constructed between 2004 and 2010 to adjust the default Road Shoulder Conditions layer. The following ECAMs and reports informed the analysis:

    a. Rocky Point ECP Phase 3 and 4 ECAM (WRC, 2003)
    b. Sierra Tract ECP Phase 1 Hydrologic and Hydraulic Analysis Report (KB Foster and PWA, 2009)
    c. Sierra Tract ECP Phase 2 ECAM (CDM, 2004)
    d. Al Tahoe ECP ECAM (Wood Rodgers, 2009)
    e. East Pioneer Trail Watershed Hydrology Study (Lumos and Associates, 2004)
    f. CSLT Hydrology and Stormwater Outfall Study Report (NHC, 2003)

4. Reconnaissance level field inspections were used to validate PLRM inputs derived from the GIS data listed above and to inform PLRM input parameters that cannot be developed from a GIS analysis (e.g., SWT facility input parameters). The following are examples where field inspections were used to develop PLRM input data.

    a. <u>Impervious Area Connectivity of CICU, SFR, and MFR Land Uses</u> – The amount of impervious area associated with SFR, MFR, and CICU land uses that is directly connected impervious area (DCIA) was estimated through field inspection. Note that a GIS layer is not available for this PLRM input. The

values of DCIA estimated for the SFR, MFR, and CICU land uses by PLRM catchment are documented in Appendix A.

b. SWT Input Parameters – PLRM inputs that define the function of baseline SWT facilities (e.g., water quality volume of a dry basin) were primarily estimated through field inspection. For certain SWT facilities, available survey information (2NDNATURE and NHC, 2010) was used instead of reconnaissance level field surveys to develop PLRM inputs. The PLRM inputs that define each baseline SWT facility that was modeled for the analysis, as well as the basis for each estimate, is provided in Appendix A.

5. The 13267 Order requires that baseline PLRM models apply a set of standard modeling inputs that reflect average Tahoe Basin conditions for the 2004 baseline year. Table 2 lists the standard PLRM inputs required by the 13267 Order for a baseline loading estimate. The inputs shown in Table 2 were used for all PLRM models.

Table 2. Required PLRM Input Parameters for Baseline Condition Estimate

Description of PLRM Input	Land Use	PLRM Input
Degree of Private Property BMP Implementation (BMP Certificate)	Single-Family Residential	7% of Land Use
	Multi-Family Residential	19% of Land Use
	CICU	5% of Land Use
	Vegetated Turf	0% of Land Use
	Vegetated Turf with an Approved Fertilizer Management Plan	100% of Land Use (Source Control Certificate)
Road Abrasive Application Strategy	Secondary Roads – All Road Risk Categories	Minimal Controls
	Primary Roads – All Road Risk Categories	Moderate Controls
Type of Street Sweeper Used	Secondary Roads – All Road Risk Categories	Mechanical Broom Sweeper
	Primary Roads – All Road Risk Categories	Mechanical Broom Sweeper
Frequency of Street Sweeping	Secondary Roads – All Road Risk Categories	Winter = 0 times; Summer = 1-2 times
	Primary Roads – All Road Risk Categories	Winter and Summer = 1-2 times per season

3.2 SUMMARY OF OUTPUT

Table 3 below presents average annual estimates of pollutant loading for the pollutants of concern listed by the 13267 Order (FSP, TP, and TN) and average annual estimates of surface runoff. Note that in addition to estimating pollutant loads for FSP, TP, and TN, the PLRM estimates pollutant loading for Total Suspended Sediment (TSS), Dissolved Phosphorus (DP) and Dissolved Inorganic Nitrogen (DIN). The 13627 Order does not require reporting of baseline loads for TSS, DP, or DIN and that information is not presented in this summary of output. PLRM output for TSS, DP, and DN is provided in Appendix A and Appendix C.

The results shown in Table 3 are for the outlet of each PLRM model (Figure 2). The results represent the summation of pollutant loading from catchments within a PLRM model and include the effect of baseline SWT facilities when present. For example, the *Wildwood Basins* model includes a large SWT facility at its outlet. The PLRM estimates that the Wildwood SWT facility reduces a significant amount of inflowing pollutant loading. The performance of the SWT facility is the reason the pollutant loading from the *Wildwood Basins* model is relatively low compared to the size of its drainage area and the amount of impervious area within the drainage area.

Table 3. PLRM Output for Modeled UPCs

PLRM Model	Associated City UPC ID	Area (acres)	Impervious Area (acres)	Surface Runoff (ac-ft/year)	Pollutant Loading (lb/year)		
					FSP	TP	TN
Bijou	I8	41	30	34	16,885	64	233
East Sierra Tract	F1	155	55	41	9,234	58	257
East Y[1]	D3	140	59	88	30,047	123	508
Eloise Basin[1]	B4	281	113	199	66,730	297	1,249
Gardner Mountain	B11	228	66	62	29,733	115	451
Grocery Outlet	C7	16	10	16	8,181	30	107
Heavenly	J1	138	26	32	17,136	64	233
Osgood Basin[1]	J5 and J9	367	81	72	26,536	116	513
Pasadena	G12	79	28	17	4,402	26	113
Rocky Point	M3	169	27	33	19,455	69	266
Ski Run Marina	J13	62	27	27	10,869	47	187
Stateline[1]	M2	177	92	55	13,170	58	262
Super 8	J2 and J3	318	66	54	18,486	87	399
Tahoe Keys	B17	224	98	126	13,865	139	691
West Sierra Tract[1]	E1	146	71	54	16,579	77	315
Wildwood Basins[1]	J8 and J14	108	43	27	2,293	13	86
Totals:		**2,647**	**892**	**936**	**303,600**	**1,384**	**5,869**

[1] Baseline PLRM model includes at least one SWT facility

4.0 EXTRAPOLATING MODELED OUTPUT

Extrapolation of pollutant loading and surface runoff to UPCs without PLRM models was accomplished using the following approach.

1. Potential correlations between pollutant loading output generated from PLRM catchments relative to PLRM inputs was explored to determine if reasonable relationships could be identified to extrapolate estimates of pollutant loading to UPCs without PLRM models.

2. The regression relationships explored were limited to an assessment of PLRM inputs that could be calculated in GIS for the UPCs not explicitly modeled.

3. Ultimately, the best correlation found between PLRM inputs and PLRM generated output involved a multiple variable regression for key land use attributes that strongly influence pollutant loading estimates in PLRM. These attributes include:
    a. %IA – percentage of a catchment that is impervious;
    b. %DCIA – percentage of catchment comprised of directly connected roads;
    c. %CICU + % PR – percent of a catchment composed of land uses that typically generate high pollutant loads (i.e. CICU and City Primary Roads); and
    d. %HR – percentage of Secondary Roads within a catchment designated as high risk

4. PLRM inputs that were assessed but discarded because of poor correlations within single and multi-variable regressions included average annual precipitation; TMDL settings (i.e. concentrated or dispersed development); MFR and SFR land use distributions; and soil distributions.

5. Figure 3 illustrates the range of PLRM inputs for the key land use attributes within modeled UPCs and within non-modeled UPCs. Figure 3 demonstrates that the range of key land use attributes modeled in PLRM, which were used to develop the regression equations, span the range of attributes in UPCs that were not modeled. Box and whisker plots are provided in Figure 3 to illustrate the statistical range of key land use attributes within City UPCs.

6. Appendix C includes a spreadsheet displaying: 1) modeled output for each PLRM catchment; 2) input parameters used to develop the regression equations; and 3) statistics for each regression equation, which were calculated using the regression tool in Microsoft Excel applying a least squares method. The regression equations for surface runoff, FSP, TP, and TN are as follows:

$$Surface\ Runoff\ (\frac{in}{year}) = 5.6(\%IA) + 12.3(\%DCIA) + 9.8(\%CICU + PR)$$

$$FSP\ \left(\frac{lb}{year - acre}\right) = 47.9(\%IA) + 224.8(\%DCIA) + 472.1(\%CICU + PR) + 153.5(\%HR)$$

$$TP\ (\frac{lb}{year - acre}) = 0.5(\%IA) + 1.3(\%DCIA) + 1.6(\%CICU + PR) + 0.4(\%HR)$$

$$TN\ (\frac{lb}{year - acre}) = 2.2(\%IA) + 7.8(\%DCIA) + 5.4(\%CICU + PR) + 1.2(\%HR)$$

7. The regression equations shown above were applied to each UPC not modeled in the PLRM to estimate pollutant loading and surface runoff (see Appendix B). The key land use attributes for each UPC that inform the regression equations were derived in GIS using the data and approaches described in Section 2. Table 4 presents the results of the extrapolation.

Figure 3 – Range of Key Land Use Attributes Informing Regressions

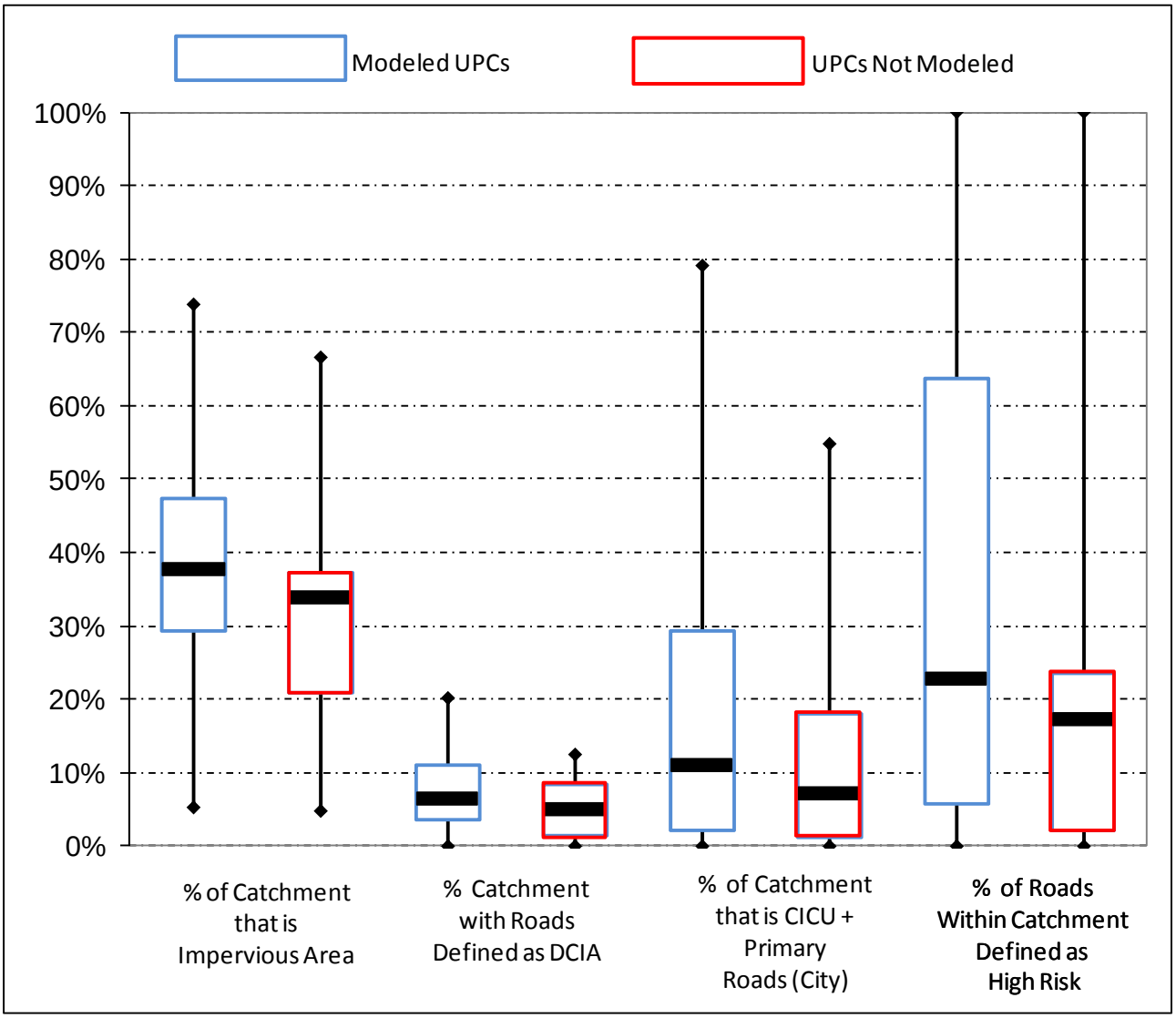


Table 4. Extrapolated Output by UPC

UPC ID	Area (Acres)	% IA	% SR DCIA	% CICU + PR	% HR	Surface Runoff		FSP		TP		TN	
						(ac-ft/yr)	(in/yr)	(lb/yr)	(lb/yr/acre)	(lb/yr)	(lb/yr/acre)	(lb/yr)	(lb/yr/acre)
B9	89	39%	2%	13%	23%	26	3.6	10,321	116	45	0.5	171	1.9
F4	38	45%	6%	41%	20%	23	7.3	9,820	258	39	1.0	148	3.9
E4	108	37%	8%	15%	2%	41	4.6	12,219	113	58	0.5	251	2.3
G11	77	47%	0%	2%	0%	18	2.8	2,339	30	20	0.3	87	1.1
G9	141	37%	0%	1%	0%	26	2.2	3,255	23	28	0.2	126	0.9
G13	125	35%	7%	13%	18%	42	4.1	15,281	123	68	0.5	278	2.2
H2	21	67%	12%	55%	55%	18	10.6	8,340	402	33	1.6	125	6.1
G1	116	37%	7%	15%	69%	42	4.4	24,125	209	92	0.8	348	3.0
A1	118	20%	5%	0%	17%	17	1.8	5,622	48	28	0.2	125	1.1
I5	198	21%	5%	0%	21%	31	1.9	11,074	56	53	0.3	230	1.2
I6	286	23%	5%	1%	24%	49	2.1	18,479	65	86	0.3	363	1.3
D1	166	33%	10%	7%	13%	53	3.8	15,520	94	77	0.5	344	2.1
D5	44	31%	1%	6%	45%	9	2.4	4,988	114	20	0.4	70	1.6
I2	144	5%	1%	1%	24%	7	0.6	6,950	48	24	0.2	83	0.6
C8	48	36%	11%	30%	2%	25	6.3	8,863	186	38	0.8	156	3.3
Airpt	236	34%	0%	8%	0%	52	2.6	12,183	52	67	0.3	271	1.1
STPUD	149	19%	0%	18%	0%	35	2.8	14,102	94	56	0.4	207	1.4
AT/PT	25	16%	9%	7%	100%	6	2.8	5,489	216	19	0.7	69	2.7
B3	11	44%	0%	0%	0%	2	2.4	230	21	2	0.2	11	1.0
B14	324	28%	8%	2%	13%	74	2.7	19,924	62	106	0.3	485	1.5
C1	96	11%	3%	7%	18%	14	1.7	7,102	74	27	0.3	106	1.1
I1	57	33%	9%	4%	11%	16	3.4	4,108	72	22	0.4	103	1.8
C5	60	37%	3%	0%	5%	12	2.4	1,889	31	14	0.2	65	1.1
C3	85	40%	12%	36%	36%	51	7.2	22,808	269	90	1.1	353	4.2
L1	93	7%	2%	0%	0%	6	0.7	841	9	6	0.1	33	0.4
Totals:	**2,853**					**695**		**245,873**		**1,118**		**4,606**	

5.0 CATCHMENT CONNECTIVITY ADJUSTMENTS

The PLRM is an urban stormwater model that can be applied to estimate pollutant loads to Lake Tahoe for situations where stormwater discharges to surface waters or to Lake Tahoe directly. The current version of the PLRM (v1.1) does not estimate potential reductions in pollutant loads for cases where stormwater runoff discharges to a meadow or other natural filtration systems prior to reaching Lake Tahoe. In these cases, only a fraction of the total pollutant load may reach a surface water and Lake Tahoe. An analysis of total stormwater runoff, and associated pollutant loads reaching Lake Tahoe is important to the City because a significant amount of the City's urban drainage area discharges to meadows prior to reaching Lake Tahoe (e.g., Pope Marsh, Upper Truckee Marsh, Bijou Meadow, etc.).

The Crediting Handbook (LRWQCB and NDEP, 2009) uses the term catchment connectivity to address this topic. In the context of the Crediting Handbook and this report, the term catchment connectivity is intended to describe the portion of surface runoff and associated pollutant load discharged from a discrete urban drainage catchment that reaches Lake Tahoe. The Crediting Program requires that catchment connectivity be expressed as a percentage (0% - 100%) in the catchment registration process. Catchment connectivity expressed as a percentage is termed a connectivity factor in this report. When registering a catchment with the Crediting Program, the estimated pollutant load discharged from an urban drainage catchment is multiplied by a connectivity factor to produce an estimate of the pollutant load reaching Lake Tahoe.

The catchment connectivity methodologies developed for the City baseline load estimate are summarized below. A detailed description of the methodologies is provided in Appendix D.

5.1 POPE MARSH CONNECTIVITY METHODOLOGY

Pope Marsh is estimated to receive roughly one quarter of the City's total FSP load. Given the significance of the estimated FSP load to Pope Marsh, as well as the challenges presented in simulating the hydrology and pollutant removal mechanisms in the marsh system using numerical models, a connectivity factor was derived for Pope Marsh using a methodology specific to this location.

The premise for estimating a connectivity factor for urban drainage through Pope Marsh is that stormwater and its associated pollutant load in the marsh only reaches Lake Tahoe during periods of barrier beach break-out. The approach taken adapts the long-term continuous simulation PLRM models developed for the City baseline load estimate to account for the timing and duration of barrier beach break-outs to compute the total stormwater runoff volume that occurs during barrier beach break-outs. The connectivity factor is calculated based on the ratio between the stormwater runoff volume generated in the model during barrier beach break-outs relative to the total stormwater runoff volume generated for the entire simulation period. The following summarizes the steps in the Pope Marsh connectivity methodology.

- <u>Step 1 – Extend Meteorological Record for Continuous Simulations:</u> The PLRM database was updated to include quality assured precipitation and temperature data

through water year 2011. This step was completed in order to include the observed 2011 barrier beach break-out in the analysis.

- Step 2 – Estimate Barrier Beach Break-Outs: Based on anecdotal information, barrier beach break-outs were assumed to occur in water years with above average precipitation. The timing and duration of barrier beach break-outs caused by spring runoff were estimated based on an analysis of long-term precipitation data. The timing and duration of barrier beach break-outs caused by rain-on-snow events were estimated based on an analysis of long-term Upper Truckee River flow data.

- Step 3 – Modify PLRM Models in SWMM5 to Track Break-Out Periods: PLRM models developed for the City's baseline loading estimate that discharge to Pope Marsh were modified in the EPA's Storm Water Management Model version 5 (SWMM5) to track stormwater runoff during barrier beach break-out periods.

- Step 4 – Estimate Stormwater Runoff Connectivity Factor: Model simulations tracking stormwater runoff estimated that roughly 19% of the total stormwater runoff volume generated over the simulation period occurs during the barrier beach break-out periods. The 19% value was used as the connectivity factor for stormwater runoff, as well as for all TMDL pollutants to refine the City's baseline loading estimate for UPCs discharging stormwater to Pope Marsh.

5.2 GENERAL CONNECTIVITY METHODOLOGY

A general connectivity methodology was developed to estimate connectivity factors for stormwater discharged to City meadows (other than Pope Marsh). The approach adapted long-term continuous simulation PLRM models to include a representation of a pervious receiving area (i.e. meadow) with stage dependent functions for storage, area of inundation, infiltration, and discharge of treated stormwater. The approach also accounts for seasonally high groundwater by adjusting infiltration rates during time periods with estimated high groundwater. Connectivity factors are calculated using the ratio of stormwater runoff volumes and pollutant loads discharged to and from a pervious receiving area.

Below is a summary of the general connectivity methodology. A detailed description of the Pope Marsh connectivity methodology is provided in Appendix D.

- Step 1 – Modify PLRM model to include Pervious Receiving Area: To set up the model structure to represent the function of a pervious receiving area, an existing PLRM model was modified to include a Dry Basin just upstream of the outfall in the model.

- Step 2 – Estimate the Hydrologic Function of the Pervious Receiving Area: The key functions of drainage channels and/or meadow areas downstream of the urban outfalls within a UPC were estimated using a combination of field inspection, direct measurement, and literature review.

- Step 3 – Modify Function of Pervious Receiving Area in SWMM5: The PLRM Dry Basin that was added to represent a pervious receiving area was modified in SWMM5 to create customized stage-storage, stage-infiltration, and stage-treated discharge relationships based on field estimates of hydrologic function.

- Step 4 – Estimate Periods of Seasonally High Groundwater: Periods of seasonally high groundwater were estimated for the simulation period (water years 1989 to 2011) to inform an algorithm that impedes infiltration during wet periods (i.e. spring runoff).

- Step 5 – Adjust Infiltration for Elevated Groundwater in SWMM5: The current version of PLRM uses an outlet in SWMM5 to simulate infiltration from a Dry Basin. Using control rules in SWMM5, the flow rate from the outlet may be adjusted. A control rule was developed to turn off infiltration during periods when the pervious receiving area is estimated to have elevated groundwater or standing water.

- Step 6 – Estimate Connectivity Factors from SWMM Output: Two separate SWMM models were built to estimate connectivity factors: 1) Model #1 does not have a pervious receiving area; and 2) Model #2 has a pervious receiving area. Output from the two models was used to develop connectivity factors based on the following equations:

$$Connectivity\ Factor_{Stormwater\ Runoff} = \frac{Stormwater\ Runoff_{Model\ \#2}}{Stormwater\ Runoff_{Model\ \#1}} \times 100\%$$

$$ConnectivityFactor_{TMDL\ Pollutant} = \frac{TMDL\ Pollutant\ _{Model\ \#2}}{TMDL\ Pollutant\ _{Model\ \#1}} \times 100\%$$

5.2 SUMMARY OF CONNECTIVITY FACTORS

Table 5 displays the connectivity factors calculated for each UPC within the City for FSP loading. The location of the UPCs in Table 5 can be reviewed on Figure 1. Connectivity factors for stormwater runoff and all TMDL pollutants used to adjust the City's baseline loading estimate can be reviewed in Appendix D.

Table 5. Catchment Connectivity Factors for FSP Loading

UPC Count	UPC ID	Associated PLRM Model	Connectivity Factor		UPC Count	UPC ID	Associated PLRM Model	Connectivity Factor
1	A1		19%		23	G11		100%
2	Airpt		100%		24	G12	Pasadena	100%
3	AT/PT		48%		25	G13		100%
4	B11	Gardner Mountain	19%		26	G9		20%
5	B14		19%		27	H2		100%
6	B17	Tahoe Keys	100%		28	I1		48%
7	B3		19%		29	I2		48%
8	B4	Eloise Basin	19%		30	I5		48%
9	B9		19%		31	I6		48%
10	C1		100%		32	I8	Bijou	100%
11	C3		100%		33	J1	Heavenly	100%
12	C5		20%		34	J13	Ski Run Marina	100%
13	C7	Grocery Outlet	100%		35	J14	Wildwood Basins	100%
14	C8		100%		36	J2	Super8	100%
15	D1		100%		37	J3	Super8	100%
16	D3	East Y	100%		38	J5	Osgood Basin	100%
17	D5		100%		39	J8	Wildwood Basins	100%
18	E1	WestSierraTract	100%		40	J9	Osgood Basin	100%
19	E4		20%		41	L1		100%
20	F1	East Sierra Tract	20%		42	M2	Stateline	100%
21	F4		20%		43	M3	Rocky Point	100%
22	G1		100%		44	STPUD		100%

6.0 BASELINE POLLUTANT LOAD ESTIMATE

Table 6 displays the baseline pollutant load estimate of average annual surface runoff and pollutant loading for FSP, TP, and TN for the City. Table 6 was generated by tabulating output from baseline PLRM models and applying the extrapolation techniques discussed in Section 4 for the UPCs not modeled in PLRM. The total pollutant load estimate is the sum of the results of the PLRM baseline models (see Table 3); the results of the extrapolation calculations for UPCs not explicitly modeled in PLRM (see Table 4); and the estimated connectivity factors for each UPC (see Table 5 and Appendix D).

Table 6. City Baseline Condition Load Estimate

Urban Area (acres)	Surface Runoff (acre-feet/year)	Pollutant Loading			
		FSP	TP	TN	Units
5,500	1,200	389,000	1,740	7,410	lb/year
		176.7	0.8	3.4	metric tons/year
		1.94E+19	n/a	n/a	# particles/year[1]

[1] One kg FSP = 1.1×10^{14} particles FSP (Equation 0.3 LRWQCB and NDEP, 2009)

For all jurisdictions regulated under the TMDL, load reduction allocations will be determined using the same relative basis. Specifically, all jurisdictions will be required to reduce their loads by the same percentage from their baseline estimate. Regulatory goals include a 34% reduction in FSP baseline loads to meet the Clarity Challenge Milestone in 2026 and a 71% reduction in FSP baseline loads to attain the clarity standard for Lake Tahoe (LRWQCB and NDEP, 2010). The City's baseline FSP load is estimated to be 389,000 lb/year. In order to meet the first load reduction milestone, the City must demonstrate a 10% (39,000 lb/year) reduction from the baseline load. The City load reduction milestones for FSP over the next 15 years are shown in Table 7.

Table 7. City FSP Load Reduction Milestones

Load	% Reduction	Year of measure	FSP Loading (lb/year)	FSP Reduction (lb/year)
City Baseline	-	2004	389,000	-
First Load Reduction Milestone	10%	2016	350,000	39,000
Second Load Reduction Milestone	21%	2021	307,000	82,000
Clarity Challenge Milestone	34%	2026	257,000	132,000

6.1 SPATIAL ANALYSIS OF LOAD ESTIMATES

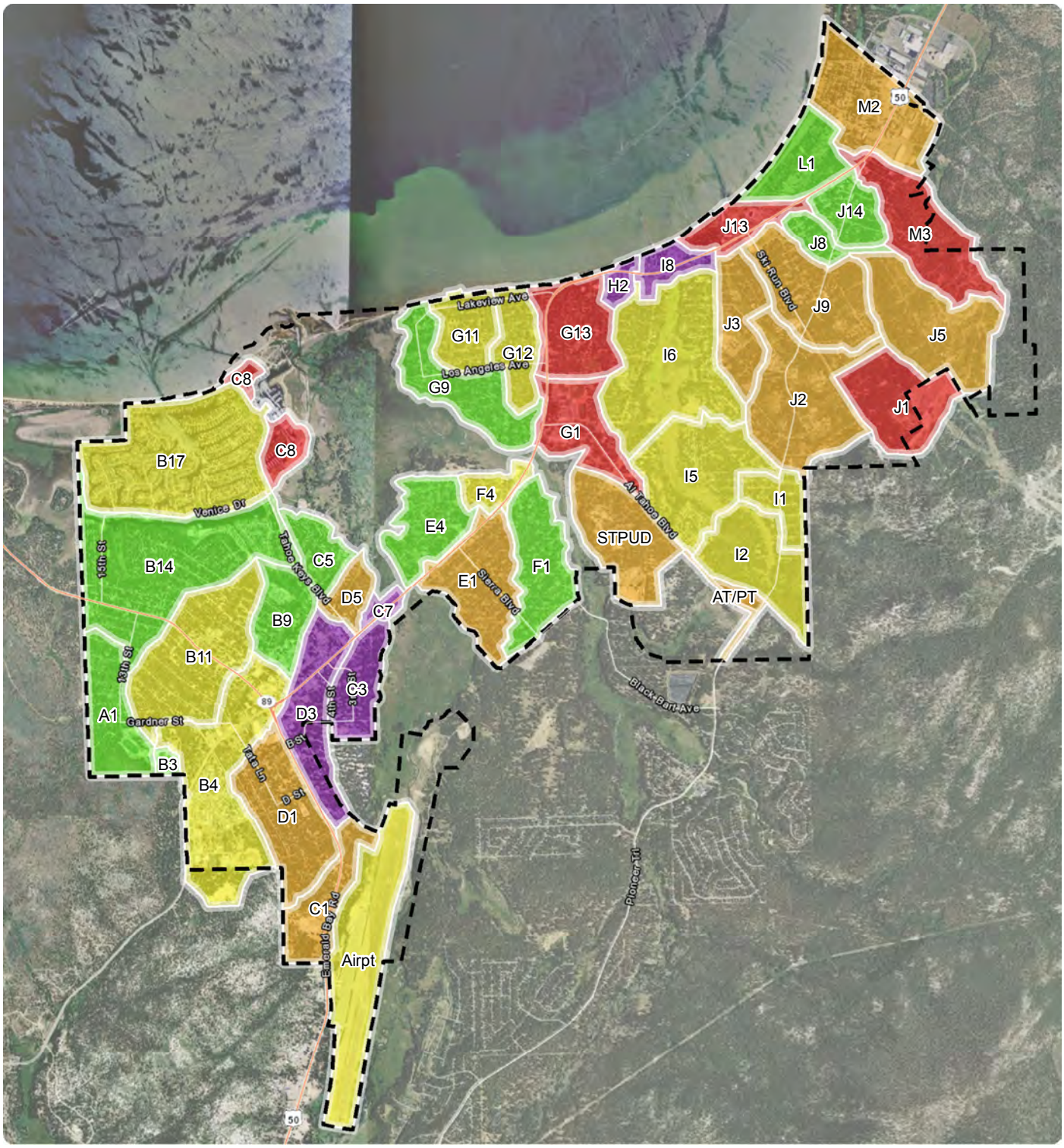
Figure 4 illustrates the results of the baseline pollutant load analysis for UPCs in the City after adjusting UPC load estimates using the connectivity factors (Table 5). For comparative purposes, FSP loading per unit of area (lb/year/acre) is presented to identify UPCs that contribute relatively high FSP loads per unit area. Note that Figure 4 displays estimated FSP loading for the baseline condition, and does not account for WQIPs or private BMPs built since 2004.

The breakpoints in unit FSP loading in Figure 4 were selected using the following approach:

- Lowest (<23 lb/year/acre) – UPCs in the 0 to 25th percentile of unit FSP loads;
- Low (23-57 lb/year/acre) – UPCs in the 25th to 50th percentile of unit FSP loads;
- Moderate (58-114 lb/year/acre) – UPCs in the 50th to 75th percentile of unit FSP loads;
- High (115-209 lb/year/acre) – UPCs in the 75th to 90th percentile of unit FSP loads;
- Highest (>210 lb/year/acre) – UPCs in the top 10 percentile of unit FSP loads.

The following points are noted about Figure 4:

- The densest urban areas in the City that do not have major SWT facilities and have significant amounts of CICU development typically have the highest unit FSP loads.
- The UPCs in the “Highest” and “High” unit FSP load categories encompass 17% of the urban area in the City. Collectively these UPCs contribute 47% of the total estimated FSP load from urban stormwater runoff.
- The UPCs in the “Lowest” FSP loading category encompass 21% of the urban area in the City. Collectively these UPCs contribute 4% of the total estimated FSP load from urban stormwater runoff.
- The UPCs in the “Low” FSP loading category encompass 35% of the urban area in the City. Collectively these UPCs contribute 19% of the total estimated FSP load from urban stormwater runoff.
- The UPCs in the “Moderate” FSP loading category encompass 27% of the urban area in the City. Collectively these UPCs contribute 30% of the total estimated FSP load from urban stormwater runoff.
- The specific time series of meteorological data used for each PLRM model varies based on the location of the UPC being modeled (NHC et al., 2009). It should be noted that total precipitation declines significantly in the City from west to the east. For example, the most westerly UPC modeled (*Eloise Basin*) averaged 33.7 inches of precipitation per year, whereas the most easterly UPC modeled (*Stateline*) averaged 18.6 inches of precipitation a year. The differences in precipitation amounts based on location within the City are an important factor influencing estimated pollutant loads and surface runoff.



Data Sources: ArcGIS Online Basemaps, 2011.

Legend

City Boundary

Fine Sediment Particle Load (lbs per acre per year)

- Lowest (Less than 23)
- Low (23 - 57)
- Moderate (58 - 114)
- High (115 - 209)
- Highest (210 to 455)

Reference Map

City of South Lake Tahoe Baseline Load Estimate

Estimated FSP Loading by Urban Planning Catchment

Scale - 1:48,000 1 inch = 4,000 feet

0 2,000 4,000 8,000 Feet

CA State Plane, Zone II	NAD 83	horiz. units: feet
northwest hydraulic consultants	project no. 50620	September 2011

Figure 4 - Estimated FSP Loading by Urban Planning Catchment (Caltrans Not Included)

6.2 UNCERTAINTY OF LOAD ESTIMATES

Pollutant load estimates presented in this report rely on estimates developed from the PLRM, which contains a number of assumptions and uncertainties that can be reduced through continued stormwater monitoring and validation efforts. In the near-term, the LRWQCB plans to accept the risk associated with modeling uncertainties and will honor baseline load estimates produced by PLRM for the duration of catchment credit schedules, which are proposed by a jurisdiction and approved by the LRWQCB (B. Larsen, pers. comm. 21 April 2011).

The following are key considerations regarding modeling uncertainties:

- The function and performance of SWT facilities in the baseline condition are modeled assuming SWT facilities are adequately maintained within an acceptable condition range.

- PLRM algorithms relate specific actions for road operations to changes in the condition of the road, which in turn influences the characteristic runoff concentration (CRC) for the road. While this approach is considered a reasonable methodology to determine relative road conditions on an average annual basis, there are gaps in available supporting water quality data to confidently link specific actions for road operations to a magnitude of water quality improvement. Additional research, monitoring, and evaluation are necessary to validate and improve modeling algorithms to improve confidence that the actions implemented are achieving the load reduction estimated.

- The current version of the PLRM does not include algorithms to vary estimated pollutant generation from private land uses (e.g., commercial) based on the condition of the land use. The PLRM uses TMDL stormwater monitoring data to estimate CRCs for average Tahoe Basin conditions for each private land use. If land use conditions notably vary within a jurisdiction relative to the average Tahoe Basin condition, the PLRM may not accurately predict pollutant loads from that land use.

- Because private property BMPs are predominantly constructed and maintained by individual parcel owners, improper construction and unreliable maintenance are potential performance issues. The PLRM baseline estimate assumes that private BMPs are constructed correctly and are maintained to ensure proper function (e.g., continue to infiltrate at or above the design target). If a significant number of private property BMPs installed are not maintained over the long-term, the average load reduction for private property BMPs estimated by the PLRM may not be accurate.

7.0 REFERENCES

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Appendix A – PLRM Inputs and Baseline PLRM Models

Select example files are provided in hard copy.

All files provided digitally.

City of South Lake Tahoe (CSLT) Pollutant Load Reduction Model (PLRM) Baseline Conditions Inputs

This spreadsheet contains a series of worksheets that were used to build the PLRM inputs for CSLT Baseline Condition models by catchment. The boundaries of each PLRM catchment are defined in a separate GIS file titled "PLRM_Catchments_August2011". The worksheets in this spreadsheet are organized by the steps used to populate catchment inputs for PLRM. Most inputs were derived using tabulations of several ArcGIS layers identifying land use, elevations, soils, and road shoulder conditions. Throughout the worksheets there are cells containing values that have been highlighted. Highlighted values indicate changes that have been made from the values generated from the ArcGIS tabulations of spatial attributes. Each worksheet has a legend at the top that provides the rationale for the changed values.

Steps 1 and 2: Physical Attributes and Land Use Distribution

1. Catchment area was calculated from the land use distribution.
2. Average slope was calculated using the Digital Elevation Model (DEM) in ArcGIS and the average length of the urban area in the catchment.
3. The distribution of land uses was calculated from the Land Use Tabulation worksheet, which is based on the Lahontan LRWQCB TMDL Land Use GIS Layer.
4. Primary roads managed by Caltrans are modeled as separate PLRM catchments at the City's request, and the area of each Caltrans catchment was separated out at this step. While Caltrans drainage areas were modeled as one scenario, a second scenario that excluded Caltrans drainage areas was also modeled and the results from these simulations are used to estimate the City's baseline load.

Step 3: Soils Distribution

The distribution of soils was calculated from the Soils Tabulation worksheet, which is based on the 2006 Tahoe Basin Soil Survey GIS Layer.

Step 4 - Road Risk

The distribution of Road Risk was calculated from the Road Risk Tabulation worksheet. The shapefile used to calculate Road Risk by catchment is the City of South Lake Tahoe Road Risk Layer, which was revised from the default PLRM Road Risk layer (Dec 2009) by the City and NHC in the fall of 2010. The revised road risk layer is provided in Appendix B of the City Baseline Loading Report.

Step 4 - Road Shoulder Condition

Road shoulder condition is calculated by Road Risk category. The tabulation of road condition was derived from a GIS shapefile of CSLT road shoulder conditions produced by NHC. The road conditions layer is provided in Appendix B of the City Baseline Loading Report.

Step 5 - Drainage Conditions

1. The tabulation of road connectivity was derived from a GIS shapefile of CSLT road shoulders conditions produced by NHC. The road conditions layer is provided in Appendix B of the City Baseline Loading Report.
2. The connectivity of other urban land uses (SFR, MFR, and CICU) is based on an assessment of connectivity of the impervious area of the land use to the road right-of-way; and the connectivity of the right-of-way to the catchment outlet.

Step 5 -Road Ksat

A modified approach was used to better estimate infiltration in road shoulders based on observed compaction in the road shoulder. This approach overrides the PLRM defaults for road shoulders, which are based on the soil information entered in Step 3.

All Other Worksheets with "Tabulate" in the Name

All worksheets not specifically called out in these notes are raw GIS outputs and tabulations that was post-processed to produce the PLRM inputs discussed above.

Legend

XX.X% Indicates a change in percentage from the original calculated value. This change was usually due to very small distributions of a land use (<0.5%) in another category being rolled out of or into this category.

	Size	Avg. Slope	SFR		MFR		CICU		Secondary Roads		City Primary Roads								
Catch_ID	Acres	%	% Catch	% IMP	% Catch	% IMP	% Catch	% IMP	% Catch	% IMP	% Catch	% IMP	Ski_Runs-Pervious	Veg_Turf	Roads_Unpaved	Veg_UI _2	Veg_UI _3	Veg_UI _4	Check
B-1	41.2	1%	5.4%	42.7%	8.0%	69.7%	75.0%	78.2%	10.8%	80%	0.0%	90%	0.0%	0.0%	0.0%	0.0%	0.0%	0.8%	100.0%
EB-1	78.8	2%	2.1%	45.7%	0.5%	45.6%	22.8%	47.4%	6.3%	80%	0.0%	90%	0.0%	0.0%	0.8%	18.7%	47.6%	1.2%	100.1%
EB-2	108.7	1%	2.1%	20.2%	57.2%	55.1%	15.3%	62.0%	12.1%	80%	0.0%	90%	0.0%	0.0%	0.0%	0.0%	10.4%	2.9%	99.9%
EB-3	54.3	1%	12.5%	19.8%	5.4%	39.6%	31.0%	73.8%	15.5%	80%	0.0%	90%	0.0%	0.0%	0.0%	0.0%	32.2%	3.4%	100.1%
EB-4	11.2	1%	0.0%	0.0%	0.0%	0.0%	76.0%	74.7%	16.6%	80%	0.0%	90%	0.0%	0.0%	0.0%	0.0%	1.2%	6.2%	100.0%
EB-5	27.8	1%	2.4%	25.1%	0.9%	28.7%	58.1%	83.0%	26.8%	80%	0.0%	90%	0.0%	0.0%	0.0%	0.0%	6.1%	5.7%	100.0%
EST-1	113.2	1%	52.6%	31.5%	5.4%	47.5%	4.0%	46.2%	25.1%	80%	0.0%	90%	0.0%	0.0%	0.0%	0.0%	12.9%	0.0%	99.9%
EST-2	41.5	1%	33.0%	24.4%	14.4%	30.6%	10.9%	45.5%	18.9%	80%	0.0%	90%	0.0%	0.0%	0.0%	4.1%	18.7%	0.0%	100.0%
EY-1	84.9	2%	4.7%	9.1%	12.2%	44.8%	26.7%	57.7%	17.5%	80%	0.0%	90%	0.0%	0.0%	0.0%	0.0%	17.0%	21.9%	100.0%
EY-2	54.7	1%	8.5%	37.1%	7.1%	61.3%	53.2%	65.7%	21.1%	80%	0.0%	90%	0.0%	0.0%	0.0%	0.0%	7.9%	2.2%	99.9%
GM-1	68.9	4%	53.8%	21.2%	10.0%	17.0%	1.0%	5.7%	13.0%	80%	0.0%	90%	0.0%	0.0%	0.0%	0.0%	15.7%	6.5%	100.1%
GM-2	58.4	4%	45.4%	22.1%	10.5%	17.7%	10.9%	51.9%	14.7%	80%	0.0%	90%	0.0%	0.0%	0.0%	0.0%	13.3%	5.2%	100.1%
GM-3	100.4	2%	39.9%	29.6%	12.5%	42.2%	11.4%	59.5%	15.8%	80%	0.0%	90%	0.0%	0.0%	0.0%	0.8%	18.5%	1.1%	100.0%
GO-1	15.6	1%	3.3%	23.8%	6.5%	21.1%	79.0%	75.6%	6.8%	80%	0.0%	90%	0.0%	0.0%	0.0%	3.6%	0.0%	0.8%	100.0%
H-1	138.2	15%	11.9%	13.4%	4.0%	30.3%	12.7%	88.6%	3.3%	80%	3.0%	80%	15.7%	0.0%	0.0%	47.6%	1.8%	0.0%	100.0%
OB-1	108.6	14%	27.6%	15.2%	4.6%	28.4%	1.5%	69.3%	14.0%	80%	0.0%	90%	0.0%	0.0%	0.0%	52.3%	0.0%	0.0%	99.9%
OB-2	84.9	15%	21.2%	14.1%	17.5%	15.6%	0.0%	0.0%	8.7%	80%	0.0%	90%	0.0%	0.0%	0.0%	47.3%	5.3%	0.0%	100.1%
OB-3	83.7	9%	28.5%	16.5%	15.0%	42.3%	1.7%	28.6%	7.9%	80%	2.9%	80%	0.0%	0.0%	0.0%	30.1%	10.3%	3.6%	100.1%
OB-4	13.5	4%	21.0%	22.2%	30.3%	44.1%	2.5%	45.0%	26.6%	80%	7.7%	80%	0.0%	0.0%	0.0%	0.0%	9.6%	2.3%	99.9%
OB-5	50.9	2%	18.9%	19.6%	19.2%	47.6%	23.3%	52.4%	11.4%	80%	15.4%	80%	0.0%	0.0%	0.0%	0.0%	10.1%	1.7%	99.9%
OB-6	25.6	3%	36.1%	20.8%	26.8%	43.6%	1.2%	7.2%	24.2%	80%	0.0%	90%	0.0%	0.0%	0.0%	0.0%	11.0%	0.7%	100.0%
P-1	78.8	1%	52.5%	28.2%	12.9%	42.5%	5.1%	52.8%	19.4%	80%	0.0%	90%	0.0%	0.0%	0.0%	0.0%	10.1%	0.0%	100.0%
RP-1	101.0	14%	20.4%	9.9%	0.6%	56.0%	0.0%	0.0%	4.3%	80%	0.0%	90%	0.0%	0.0%	0.0%	72.7%	2.0%	0.0%	100.0%
RP-2	31.0	13%	22.8%	20.5%	20.9%	28.8%	0.0%	0.0%	16.1%	80%	0.0%	90%	0.0%	0.0%	0.0%	31.9%	8.3%	0.0%	99.9%
RP-3	36.5	4%	19.5%	16.0%	19.1%	46.9%	19.7%	75.7%	20.0%	80%	2.6%	90%	0.0%	0.0%	0.0%	1.4%	17.7%	0.0%	99.9%
S-1	78.6	4%	2.4%	14.4%	9.5%	49.4%	56.7%	72.8%	17.3%	80%	0.0%	90%	1.4%	0.0%	0.0%	4.9%	9.2%	0.0%	101.4%
S-2	44.6	3%	2.2%	12.6%	5.2%	47.7%	62.7%	76.8%	23.8%	80%	0.0%	90%	0.0%	0.0%	0.0%	0.0%	6.1%	0.0%	100.0%
S-3	53.8	1%	37.7%	26.5%	3.5%	47.4%	15.2%	56.6%	16.9%	80%	0.0%	90%	0.0%	0.5%	0.0%	4.0%	22.2%	0.0%	100.0%
S8-1	129.3	2%	27.6%	12.2%	5.5%	23.2%	5.1%	9.0%	7.0%	80%	4.1%	80%	0.0%	0.0%	0.0%	38.1%	11.4%	1.2%	100.2%
S8-2	88.2	1%	22.0%	15.2%	14.8%	57.5%	0.0%	0.0%	9.9%	80%	1.9%	90%	0.0%	0.0%	0.0%	2.5%	45.4%	3.5%	99.8%
S8-3	56.4	1%	29.3%	17.9%	20.8%	50.0%	12.7%	29.0%	15.1%	80%	0.0%	90%	0.0%	7.5%	0.0%	0.0%	9.6%	5.0%	99.9%
S8-4	44.5	1%	37.2%	24.4%	16.5%	40.8%	8.6%	28.7%	22.1%	80%	0.0%	90%	0.0%	0.0%	0.0%	0.0%	15.6%	0.0%	100.0%
SRM-1	62.1	1%	5.0%	9.1%	28.1%	51.6%	38.8%	60.4%	6.4%	80%	0.7%	90%	0.0%	0.0%	0.0%	0.0%	21.0%	0.0%	99.9%
TK-1	223.9	1%	66.5%	41.5%	4.4%	47.5%	2.1%	28.4%	19.9%	80%	0.0%	90%	0.0%	1.0%	0.0%	6.1%	0.0%	0.0%	100.1%
WB-1	36.3	4%	26.8%	25.5%	19.5%	51.5%	26.4%	58.3%	16.0%	80%	2.4%	90%	0.0%	0.0%	0.0%	0.0%	7.9%	1.0%	100.1%
WB-2	32.9	5%	27.3%	23.1%	12.8%	51.0%	16.0%	73.3%	18.0%	80%	1.7%	90%	0.0%	0.0%	0.0%	0.0%	21.7%	2.5%	100.0%
WB-3	38.5	4%	27.4%	22.8%	26.8%	44.0%	1.7%	47.7%	26.5%	80%	0.0%	90%	0.0%	0.0%	0.0%	1.3%	15.3%	1.0%	100.0%
WST-1	135.5		36.6%	32.7%	12.1%	47.2%	15.6%	67.2%	25.6%	80%	0.0%	90%	0.0%	0.0%	0.0%	0.6%	9.3%	0.1%	100.0%

	Size	Avg. Slope	CA Primary Roads	
Catch_ID	Acres	%	% Catch	% IMP
B-CA	3.2		100%	90%
EB-CA	2.6	1%	100%	90%
EY-CA	3.6	1%	100%	90%
GM-CA	2.0	1%	100%	90%
GO-CA	2.2	1%	100%	90%
RP-CA	0.9	1%	100%	90%
S-CA	2.8	1%	100%	90%
SRM-CA	3.3	1%	100%	90%
WB-CA	2.1	2%	100%	90%
WST-CA	4.2		100%	90%
Area Check	2,663.6			
Area Check	2,663.6			

Legend

XX.X% Indicates a change in percentage from the original calculated value. This was usually a 1%+/- change to achieve 100% for the catchment due to rounding discrepancies.

MapUnit (omit the "A" when inputting Map Unit in PLRM, also, don't input the "W" MapUnit, which is Water, just add the percentage to the dominant map unit if you encounter "W")

Catch_ID	A_7031	A_7422	A_7413	A_7412	W	A_7423	A_7424	A_7421	A_9444	A_7411	A_7041	A_7444	A_7471	A_7462	A_7541	A_7461	A_7492	A_7491	A_7061	A_7043	A_7051	A_7441	Check
B-1	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	24%	72%	0%	0%	0%	0%	0%	0%	4%	0%	0%	100%
EB-1	22%	0%	4%	3%	0%	0%	0%	0%	0%	0%	0%	46%	0%	0%	23%	2%	0%	0%	0%	0%	0%	0%	101%
EB-2	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	17%	0%	14%	56%	13%	0%	0%	0%	0%	0%	0%	101%
EB-3	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	19%	25%	0%	49%	7%	0%	0%	0%	0%	0%	0%	100%
EB-4	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	57%	0%	0%	43%	0%	0%	0%	0%	0%	0%	0%	100%
EB-5	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	69%	31%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
EST-1	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	94%	2%	0%	0%	0%	0%	0%	0%	0%	0%	3%	99%
EST-2	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	8%	92%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
EY-1	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	69%	14%	0%	7%	10%	0%	0%	0%	0%	0%	0%	100%
EY-2	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	57%	43%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
GM-1	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	4%	0%	16%	0%	80%	0%	0%	0%	0%	0%	0%	100%
GM-2	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	44%	0%	25%	0%	31%	0%	0%	0%	0%	0%	0%	100%
GM-3	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	50%	36%	0%	0%	14%	0%	0%	0%	0%	0%	0%	101%
GO-1	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	37%	42%	0%	0%	0%	0%	0%	0%	0%	21%	0%	0%	99%
H-1	0%	28%	11%	11%	0%	0%	0%	50%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
OB-1	0%	30%	26%	7%	0%	1%	1%	32%	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	102%
OB-2	0%	48%	6%	3%	0%	0%	0%	35%	0%	0%	0%	0%	0%	0%	0%	0%	0%	8%	0%	0%	0%	0%	100%
OB-3	0%	15%	0%	27%	0%	0%	0%	19%	0%	0%	0%	0%	0%	0%	0%	0%	36%	3%	0%	0%	0%	0%	99%
OB-4	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	2%	36%	0%	0%	0%	12%	50%	0%	0%	0%	0%	100%
OB-5	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	55%	26%	0%	0%	0%	1%	18%	0%	0%	0%	0%	100%
OB-6	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	17%	77%	0%	0%	0%	0%	6%	0%	0%	0%	0%	100%
P-1	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
RP-1	0%	35%	17%	11%	0%	0%	2%	33%	0%	0%	0%	0%	0%	0%	0%	0%	0%	2%	0%	0%	0%	0%	100%
RP-2	0%	10%	0%	0%	0%	0%	0%	80%	0%	0%	0%	0%	0%	0%	0%	0%	0%	10%	0%	0%	0%	0%	100%
RP-3	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	53%	0%	0%	0%	0%	0%	40%	6%	0%	0%	0%	101%
S-1	0%	0%	0%	0%	0%	0%	0%	5%	0%	0%	4%	39%	0%	0%	0%	0%	0%	2%	50%	0%	0%	0%	101%
S-2	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	89%	0%	0%	0%	0%	0%	0%	11%	0%	0%	0%	100%
S-3	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	50%	50%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
S8-1	0%	4%	0%	35%	0%	0%	0%	51%	0%	3%	2%	0%	0%	0%	0%	0%	2%	3%	0%	0%	0%	0%	100%
S8-2	0%	0%	0%	0%	0%	0%	0%	5%	0%	0%	13%	7%	28%	0%	0%	0%	0%	29%	0%	0%	0%	18%	100%
S8-3	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	14%	44%	0%	0%	0%	0%	0%	39%	0%	0%	0%	3%	100%
S8-4	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	20%	46%	34%	0%	0%	0%	0%	0%	0%	0%	0%	0%	99%
SRM-1	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
TK-1	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%	100%
WB-1	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	52%	4%	0%	0%	0%	0%	44%	0%	0%	0%	0%	100%
WB-2	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	7%	28%	0%	0%	0%	0%	64%	0%	0%	0%	0%	100%
WB-3	0%	0%	0%	0%	0%	0%	0%	3%	0%	0%	0%	0%	60%	0%	0%	0%	2%	35%	0%	0%	0%	0%	100%
WST-1	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	79%	11%	0%	0%	0%	0%	0%	0%	0%	0%	10%	100%

Catch_ID
B-CA
EB-CA
EY-CA
GM-CA
GO-CA
RP-CA
S-CA
SRM-CA
WB-CA
WST-CA

Soils for Caltrans catchments didn't matter as we overrode the Ksat values because of road shoulder compaction. See worksheet titled Step 5 - Road Ksat.

Legend

XX.X% Indicates a change in percentage from the original calculated value. This was usually a 1%+/- change to achieve 100% for the catchment due to rounding discrepancies.

Secondary Road Risk

CATCH_ID	High	Moderate	Low	Check
B-1	81%	0%	19%	100%
EB-1	39%	35%	26%	100%
EB-2	35%	14%	51%	100%
EB-3	33%	35%	32%	100%
EB-4	100%	0%	0%	100%
EB-5	100%	0%	0%	100%
EST-1	3%	12%	85%	100%
EST-2	7%	58%	35%	99%
EY-1	42%	7%	51%	100%
EY-2	78%	11%	11%	100%
GM-1	23%	45%	32%	100%
GM-2	28%	29%	43%	99%
GM-3	31%	16%	53%	100%
GO-1	100%	0%	0%	100%
H-1	64%	21%	15%	100%
OB-1	69%	31%	0%	100%
OB-2	93%	7%	0%	100%
OB-3	13%	87%	0%	100%
OB-4	0%	100%	0%	100%
OB-5	0%	99%	1%	100%
OB-6	0%	100%	0%	100%
P-1	6%	26%	68%	100%
RP-1	9%	91%	0%	100%
RP-2	84%	16%	0%	100%
RP-3	91%	3%	6%	99%
S-1	79%	13%	8%	100%
S-2	20%	80%	0%	100%
S-3	18%	0%	82%	100%
S8-1	37%	55%	8%	100%
S8-2	4%	30%	66%	100%
S8-3	23%	6%	72%	100%
S8-4	9%	53%	38%	100%
SRM-1	12%	46%	42%	100%
TK-1	5%	17%	78%	100%
WB-1	56%	40%	4%	100%
WB-2	14%	48%	38%	100%
WB-3	22%	77%	1%	100%
WST-1	21%	32%	48%	100%

City Primary Road Risk

CATCH_ID	High	Moderate	Low	Check
OB-3	20%	30%	50%	100%
OB-4	0%	0%	100%	100%
OB-5	0%	20%	80%	100%
RP-3	0%	0%	100%	100%
S8-1	40%	30%	30%	100%
S8-2	0%	50%	50%	100%
SRM-1	0%	0%	100%	100%
WB-1	0%	0%	100%	100%
WB-2	0%	0%	100%	100%
WB-3	0%	0%	100%	100%
H-1	100%	0%	0%	100%

Caltrans Primary Road Risk

CATCH_ID	High	Moderate	Low	Check
B-CA	100%	0%	0%	100%
EB-CA	100%	0%	0%	100%
EY-CA	100%	0%	0%	100%
GM-CA	100%	0%	0%	100%
GO-CA	100%	0%	0%	100%
RP-CA	100%	0%	0%	100%
S-CA	100%	0%	0%	100%
SRM-CA	100%	0%	0%	100%
WB-CA	100%	0%	0%	100%
WST-CA	100%	0%	0%	100%

Legend

XX.X% Indicates a change in percentage from the original calculated value. This was usually a 1%+/- change to achieve 100% for the catchment due to rounding discrepancies.

Condition Key

Condition	Description
H_E	High Risk Erodible
H_P	High Risk Protected
H_S	High Risk Stable
H_SP	High Risk Stable and Protected
L_E	Low Risk Erodible
L_P	Low Risk Protected
L_S	Low Risk Stable
L_SP	Low Risk Stable and Protected
M_E	Moderate Risk Erodible
M_P	Moderate Risk Protected
M_S	Moderate Risk Stable
M_SP	Moderate Risk Stable and Protected

Secondary Road Conditions

Condition	EB-2	WB-1	RP-1	TK-1	EST-1	P-1	S-3	WB-3	OB-3	SRM-1	S8-1	S8-3	EY-1	GM-1	WST-1	B-1	GO-1	OB-1	H-1	S-1	S-2	RP-2	OB-2	OB-4	OB-5	OB-6	WB-2	S8-2	S8-4	EST-2	EY-2	EB-1	EB-4	EB-5	GM-3	EB-3	GM-2	RP-3
H_E	5%	100%	0%	0%	76%	93%	44%	32%	0%	25%	6%	40%	33%	100%	72%	41%	100%	9%	0%	7%	0%	78%	11%	0%	0%	0%	100%	78%	82%	100%	48%	0%	0%	69%	100%	22%	100%	95%
H_P	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	4%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	3%
H_S	8%	0%	67%	0%	0%	0%	0%	68%	0%	0%	0%	16%	0%	0%	20%	0%	0%	25%	12%	5%	0%	22%	65%	0%	0%	0%	0%	0%	0%	0%	22%	0%	0%	3%	0%	7%	0%	2%
H_SP	87%	0%	33%	100%	24%	7%	56%	0%	100%	75%	90%	44%	67%	0%	8%	59%	0%	66%	88%	88%	100%	0%	24%	0%	0%	0%	0%	22%	18%	0%	30%	100%	100%	28%	0%	71%	0%	0%
L_E	100%	100%	0%	0%	95%	100%	89%	100%	0%	80%	41%	56%	100%	97%	69%	14%	0%	0%	47%	66%	0%	93%	0%	0%	50%	0%	66%	43%	83%	100%	82%	30%	0%	100%	96%	97%	100%	0%
L_P	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	35%	0%	0%	0%	0%	0%	0%	0%	40%	0%	0%	0%	0%	0%	0%	0%	0%	15%	13%	0%	0%	0%	0%	0%	0%	0%	0%	100%
L_S	0%	0%	0%	0%	5%	0%	2%	0%	0%	0%	0%	0%	0%	0%	10%	0%	0%	0%	0%	17%	0%	7%	0%	0%	0%	0%	34%	0%	0%	0%	0%	0%	0%	0%	4%	3%	0%	0%
L_SP	0%	0%	0%	100%	0%	0%	8%	0%	0%	20%	24%	44%	0%	3%	20%	86%	0%	0%	13%	17%	0%	0%	0%	0%	50%	0%	0%	42%	4%	0%	18%	70%	0%	0%	0%	0%	0%	0%
M_E	22%	100%	0%	0%	100%	100%	0%	88%	27%	46%	48%	50%	100%	100%	71%	0%	0%	27%	12%	71%	6%	0%	13%	49%	12%	98%	92%	50%	66%	100%	94%	12%	0%	0%	100%	29%	100%	0%
M_P	0%	0%	0%	0%	0%	0%	0%	0%	3%	0%	9%	0%	0%	0%	2%	0%	0%	0%	0%	0%	8%	0%	0%	0%	0%	0%	0%	2%	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%
M_S	63%	0%	6%	0%	0%	0%	0%	1%	47%	0%	0%	0%	0%	0%	21%	0%	0%	19%	50%	5%	27%	0%	56%	33%	83%	0%	0%	20%	20%	0%	0%	0%	0%	0%	0%	11%	0%	0%
M_SP	15%	0%	94%	100%	0%	0%	0%	11%	23%	54%	43%	50%	0%	0%	7%	0%	0%	54%	38%	24%	59%	0%	31%	18%	5%	2%	8%	28%	11%	0%	6%	88%	0%	0%	0%	60%	0%	0%
High Risk Check	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	0%	0%	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	101%
Low Risk Check	100%	100%	0%	100%	100%	100%	100%	100%	0%	100%	100%	100%	100%	100%	100%	100%	0%	0%	100%	99%	0%	100%	0%	0%	100%	0%	100%	100%	100%	100%	100%	100%	0%	100%	100%	100%	100%	100%
Mod Risk Check	100%	100%	100%	100%	100%	100%	0%	99%	100%	100%	100%	100%	100%	100%	100%	0%	0%	100%	100%	100%	99%	0%	101%	100%	100%	100%	100%	100%	99%	100%	100%	100%	0%	0%	100%	100%	100%	0%

City Primary Road Conditions

Condition	WB-1	WB-3	OB-3	S8-1	H-1	OB-5	WB-2	S8-2	RP-3	SRM-1	OB-4
H_E	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
H_P	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
H_S	0%	0%	100%	59%	5%	0%	0%	0%	0%	0%	0%
H_SP	100%	0%	0%	41%	95%	0%	100%	0%	0%	0%	0%
L_E	0%	0%	19%	0%	0%	0%	0%	0%	0%	0%	2%
L_P	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
L_S	100%	100%	0%	24%	0%	0%	100%	56%	50%	0%	98%
L_SP	0%	0%	81%	76%	0%	100%	0%	44%	50%	100%	0%
M_E	0%	0%	70%	23%	0%	5%	0%	0%	0%	0%	98%
M_P	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
M_S	0%	0%	30%	25%	0%	60%	0%	45%	0%	0%	2%
M_SP	0%	0%	0%	52%	0%	35%	0%	55%	0%	0%	0%

Caltrans Primary Road Conditions

Condition	B-CA	EB-CA	EY-CA	GM-CA	GO-CA	RP-CA	S-CA	SRM-CA	WB-CA	WST-CA
H_E	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
H_P	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
H_S	0%	15%	0%	0%	0%	0%	0%	0%	0%	0%
H_SP	100%	85%	100%	100%	100%	100%	100%	100%	100%	100%

Legend

XX.X%	Indicates a change in percentage from the original calculated value. This was based on SEZ 1B coverage being predominant within the ICIA areas.
XX.X%	Indicates a change in percentage from the original calculated value. This was based on connection to existing CSLT storm drain facilities.
XX.X%	Indicates a change in percentage from the original calculated value. This was based on parcel frontage along Caltrans and/or CSLT Primary roads.
XX.X%	Indicates a change in percentage from the original calculated value. This was based on the majority of Parcels being ICIA for the catchment.
XX.X%	Indicates a change in percentage from the original calculated value. This was based on the majority of Parcels having DCIA road frontage.
XX.X%	Indicates a change in percentage from the original calculated value. This was based on high density/high impact use with highly compacted road shoulders.
	Indicates values for catchments were developed from Sierra Tract Phase 3 and 4 anlaysis conducted for City of South Lake Tahoe. Assumptions are documented in Appendix A of Sierra Tract Phase 3 and 4 PLRM anlaysis.

Secondary Roads

				Estimated DCIA to R-O-W			Calculated DCIA to Outlet			Notes/Assumptions		
CATCH_ID	DCIA	ICIA	Check	SFR	MFR	CICU	SFR	MFR	CICU	SFR	MFR	CICU
B-1	62%	38%	100%	20%	80%	95%	12%	80%	95%	Few parcels, the just driveways	Mostly high-density apartments/condos	High density w/min. perv. area, Caltrans frontage
EB-1	95%	5%	100%	40%	50%	95%	38%	48%	90%	Small lots, just the driveways	Predominatly paved areas	High density, min. perv. area, LTB frontage/drainage
EB-2	84%	16%	100%	30%	90%	95%	9%	76%	95%	Predominantly just the driveways	Trailer park & med.-density apartments	High density, min. perv. area, LTB frontage/drainage
EB-3	52%	48%	100%	30%	60%	95%	16%	60%	95%	Predominantly just the driveways	Predominatly paved areas	High density, min. perv. area, LTB frontage/drainage
EB-4	100%	0%	100%	0%	0%	95%	0%	0%	95%	No SFR within the Basin	No MFR within the Basin	High density, min. perv. area, LTB/Caltrans frontage
EB-5	37%	63%	100%	30%	40%	95%	11%	40%	95%	Predominantly just the driveways	Predominatly paved areas	High density w/min. perv. area, Caltrans frontage
EST-1	9%	91%	100%	50%	50%	0%	50%	50%	0%	Small lots, high density,driveways	Medium/high-density apartments	Portion of LTCC Parcel, all ICIA
EST-2	1%	99%	100%	40%	70%	95%	40%	70%	95%	Small lots, med. density,driveways	Mostly high-density apartments	High density w/min. perv. area, Caltrans frontage
EY-1	88%	12%	100%	15%	80%	95%	13%	70%	95%	Few parcels, the just driveways	Medium/high-density apartments	High density w/min. perv. area, Caltrans frontage
EY-2	34%	66%	100%	30%	75%	95%	10%	75%	95%	Predominantly just the driveways	Medium/high-density apartments	High density w/min. perv. area, Caltrans frontage
GM-1	61%	39%	100%	40%	40%	20%	24%	24%	12%	Small lots, 4% ave. slope, driveways	Mostly medium-density apartments	Predominatly pervious area
GM-2	2%	98%	100%	30%	50%	90%	3%	5%	90%	Ave. lots, 4% ave. slope, driveways	Mostly medium-density apartments	High density w/low perv. area, Caltrans frontage
GM-3	2%	98%	100%	50%	60%	95%	18%	21%	95%	Small lots, high density,driveways	Medium/high-density apartments	High density w/low perv. area, Caltrans frontage
GO-1	0%	100%	100%	0%	0%	95%	0%	0%	95%	A couple parcels being all ICIA	A couple parcels being all ICIA	High density w/min. perv. area, Caltrans frontage
H-1	69%	31%	100%	30%	50%	95%	30%	50%	95%	Ave/large lots, just the driveways	Mostly med.-density apartments/condos	High density Heavenly CA Lodge & parking lot(s)
OB-1	83%	17%	100%	30%	50%	75%	30%	50%	75%	Ave/large lots, just the driveways	Mostly med.-density apartments/condos	Predominatly paved/hardscape areas, min. perv. area
OB-2	99%	1%	100%	20%	60%	0%	20%	59%	0%	Large lots, just the driveways	Large condos, small parcels, paved areas	No CICU within the catchment
OB-3	87%	13%	100%	30%	70%	40%	26%	70%	40%	Ave/large lots, just the driveways	Mostly high-density apartments	Predominatly paved areas
OB-4	51%	49%	100%	30%	70%	70%	30%	70%	70%	Small lots, just the driveways	Medium/high-density apartments	Predominatly paved/hardscape areas, min. perv. area
OB-5	93%	7%	100%	40%	70%	80%	37%	65%	80%	Small lots, med. density,driveways	Medium/high-density apartments	Med./High density w/low perv. area, Ski Run frontage
OB-6	24%	76%	100%	40%	70%	0%	40%	70%	0%	Small lots, med. density,driveways	Medium/high-density apartments	NE portion of Paradise DB, all pervious & ICIA
P-1	4%	96%	100%	40%	60%	50%	40%	60%	50%	Small lots, just the driveways	Medium/high-density apartments	Predominatly paved areas
RP-1	100%	0%	100%	25%	75%	0%	25%	75%	0%	Large custom lots, just driveways	Large condos, small parcels, paved areas	No CICU within the catchment
RP-2	100%	0%	100%	30%	60%	0%	30%	60%	0%	Large lots, just the driveways	Large condos, small parcels, paved areas	No CICU within the catchment
RP-3	67%	33%	100%	30%	70%	95%	30%	70%	95%	Average lots, just the driveways	Medium/high-density apartments	High density w/min. perv. area, Caltrans frontage
S-1	85%	15%	100%	15%	80%	95%	15%	80%	95%	Few parcels, the just driveways	Mostly high-density apartments	High density w/min. perv. area, Caltrans frontage
S-2	99%	1%	100%	15%	80%	95%	15%	79%	94%	Few parcels, the just driveways	Mostly high-density apartments	High density w/min. perv. area, Caltrans frontage
S-3	23%	77%	100%	30%	50%	80%	30%	50%	80%	Ave/large lots, just the driveways	Mostly med.-density apartments/condos	High density w/low perv. area, high paved area
S8-1	84%	16%	100%	20%	50%	30%	17%	42%	25%	Predominantly just the driveways	Predominatly paved areas	Predominatly paved areas
S8-2	49%	51%	100%	25%	90%	0%	19%	68%	0%	Predominantly just the driveways	Trailer park & high-density apartments	No CICU within the catchment
S8-3	73%	27%	100%	25%	80%	30%	18%	58%	22%	Predominantly just the driveways	Mostly high-density apartments	Predominatly paved areas
S8-4	44%	56%	100%	40%	60%	30%	26%	39%	20%	Small lots, just the driveways	Mostly medium-density apartments	Predominatly paved areas
SRM-1	73%	27%	100%	10%	80%	95%	10%	80%	95%	Few parcels, the just driveways	Mostly high-density apartments	High density w/min. perv. area, Caltrans frontage
TK-1	100%	0%	100%	40%	50%	80%	40%	50%	80%	Small lots, just the driveways	Good landscape buffers	Predominatly paved parking areas
WB-1	34%	66%	100%	25%	80%	95%	19%	60%	95%	Predominantly just the driveways	Medium/high-density apartments	High density w/min. perv. area, Caltrans frontage
WB-2	24%	76%	100%	30%	80%	95%	15%	40%	95%	Predominantly just the driveways	Medium/high-density apartments	High density w/min. perv. area, Caltrans frontage
WB-3	58%	42%	100%	40%	70%	50%	40%	70%	50%	Small lots, just the driveways	Medium/high-density apartments	Predominatly paved areas
ST4_1	60%	40%	100%	50%	75%	95%	30%	45%	95%	Small lots, high density,driveways	Medium/high-density apartments	High density w/min. perv. area, Caltrans frontage
ST4_2	7%	93%	100%	50%	70%	75%	25%	30%	50%	Small lots, high density,driveways	Medium/high-density apartments	Predominatly paved/hardscape areas, min. perv. area
SB1_City	17%	83%	100%	40%	80%	95%	7%	14%	95%	Small lots, high density,driveways	Mostly high-density apartments	High density w/min. perv. area, Caltrans frontage
SB2	31%	69%	100%	50%	70%	95%	16%	22%	95%	Small lots, high density,driveways	Medium/high-density apartments	High density w/min. perv. area, Caltrans frontage
SB2_Chris	31%	69%	100%	50%	70%	0%	16%	22%	0%	Small lots, high density,driveways	Medium/high-density apartments	No CICU within the catchment
SB3	6%	94%	100%	30%	30%	0%	15%	15%	0%	Small lots, med. density,driveways	Predominatly paved areas	No CICU within the catchment
SB4	58%	42%	100%	40%	30%	0%	23%	17%	0%	Small lots, med. density,driveways	Predominatly paved areas	No CICU within the catchment
SB5	89%	11%	100%	30%	30%	0%	27%	27%	0%	Small lots, med. density,driveways	Predominatly paved areas	No CICU within the catchment

City Primary Roads

CATCH_ID	DCIA	ICIA	
OB-3	60%	40%	100%
OB-4	100%	0%	100%
OB-5	100%	0%	100%
RP-3	100%	0%	100%
S8-1	80%	20%	100%
S8-2	80%	20%	100%
SRM-1	100%	0%	100%
WB-1	100%	0%	100%
WB-2	100%	0%	100%
WB-3	100%	0%	100%
H-1	100%	0%	100%

Caltrans Primary Roads

CATCH_ID	DCIA	ICIA	
B-CA	100%	0%	100%
EB-CA	100%	0%	100%
EY-CA	100%	0%	100%
GM-CA	100%	0%	100%
GO-CA	100%	0%	100%
RP-CA	100%	0%	100%
S-CA	100%	0%	100%
SRM-CA	100%	0%	100%
WB-CA	100%	0%	100%
WST-CA	100%	0%	100%
SB1-CA	100%	0%	100%
ST4-CA	100%	0%	100%

Notes: **1. The Final Ksat Value column (value entered into the PLRM) is a weighted average for the roads within a catchment calculated as shown below.**
2. All Caltrans catchments have a Ksat Value of 0.38.
3. Land uses other than roads use the Ksat Value predicted by the current PLRM algorithm.

Secondary Roads

	Compaction Category				Average Ksat Value				
CATCH_ID	High	Moderate	PLRM	Check	High	Moderate	PLRM		Final Ksat Value
B-1	100%	0%	0%	100%	0.38	1.67	0.43		0.38
EB-1	100%	0%	0%	100%	0.38	1.67	0.32		0.38
EB-2	97%	3%	0%	100%	0.38	1.67	0.41		0.42
EB-3	85%	9%	6%	100%	0.38	1.67	0.42		0.49
EB-4	N/A	N/A	N/A	N/A	0.38	1.67	0.17		0.38
EB-5	100%	0%	0%	100%	0.38	1.67	0.43		0.38
EST-1	62%	12%	27%	100%	0.38	1.67	0.42		0.54
EST-2	85%	3%	11%	100%	0.38	1.67	0.4		0.43
EY-1	82%	8%	10%	100%	0.38	1.67	0.41		0.49
EY-2	87%	9%	3%	100%	0.38	1.67	0.43		0.50
GM-1	58%	24%	18%	100%	0.38	1.67	0.43		0.70
GM-2	43%	51%	6%	100%	0.38	1.67	0.43		1.04
GM-3	96%	4%	0%	100%	0.38	1.67	0.43		0.44
GO-1	100%	0%	0%	100%	0.38	1.67	0.3		0.38
H-1	35%	16%	49%	100%	0.38	1.67	0.38		0.58
OB-1	38%	62%	0%	100%	0.38	1.67	0.34		1.19
OB-2	61%	39%	0%	100%	0.38	1.67	0.32		0.89
OB-3	95%	2%	3%	100%	0.38	1.67	0.25		0.40
OB-4	98%	2%	0%	100%	0.38	1.67	0.17		0.41
OB-5	96%	0%	4%	100%	0.38	1.67	0.35		0.38
OB-6	98%	0%	2%	100%	0.38	1.67	0.4		0.38
P-1	100%	0%	0%	100%	0.38	1.67	0.43		0.38
RP-1	0%	100%	0%	100%	0.38	1.67	0.35		1.67
RP-2	17%	83%	0%	100%	0.38	1.67	0.39		1.44
RP-3	99%	1%	0%	100%	0.38	1.67	0.4		0.39
S-1	99%	1%	0%	100%	0.38	1.67	0.19		0.40
S-2	100%	0%	0%	100%	0.38	1.67	0.06		0.38
S-3	98%	2%	0%	100%	0.38	1.67	0.43		0.41
S8-1	10%	64%	26%	100%	0.38	1.67	0.28		1.18
S8-2	57%	5%	37%	100%	0.38	1.67	0.34		0.43
S8-3	51%	12%	38%	100%	0.38	1.67	0.37		0.53
S8-4	87%	5%	9%	100%	0.38	1.67	0.36		0.44
SRM-1	52%	24%	24%	100%	0.38	1.67	0.43		0.70
TK-1	0%	0%	100%	100%	0.38	1.67	0.1		0.10
WB-1	38%	62%	0%	100%	0.38	1.67	0.25		1.18
WB-2	58%	42%	0%	100%	0.38	1.67	0.16		0.93
WB-3	86%	7%	7%	100%	0.38	1.67	0.28		0.47
SB1-City	100%	0%	0%	100%	0.38	1.67	0.1		0.38
SB2	50%	50%	0%	100%	0.38	1.67	0.2		1.03
SB2-Chris	50%	50%	0%	100%	0.38	1.67	0.1		1.03
SB3	50%	50%	0%	100%	0.38	1.67	0.1		1.03
SB4	0%	100%	0%	100%	0.38	1.67	0.1		1.67
SB5	0%	100%	0%	100%	0.38	1.67	0.1		1.67
ST4-1	100%	0%	0%	100%	0.38	1.67	0.1		0.38
ST4-2	50%	50%	0%	100%	0.38	1.67	0.1		1.03

Primary Roads

					Average Ksat Value				
CATCH_ID	High	Moderate	PLRM	Check	High	Moderate	PLRM		Final Ksat Value
H-1	0%	0%	100%	100%	0.38	1.67	0.25		0.25
OB-3	100%	0%	0%	100%	0.38	1.67	0.17		0.38
OB-5	16%	0%	84%	100%	0.38	1.67	0.23		0.25
S8-1	27%	13%	60%	100%	0.38	1.67	0.19		0.44
S8-2	4%	21%	75%	100%	0.38	1.67	0.22		0.53
WB-1	100%	0%	0%	100%	0.38	1.67	0.16		0.38
WB-2	100%	0%	0%	100%	0.38	1.67	0.11		0.38
WB-3	55%	45%	0%	100%	0.38	1.67	0.18		0.96
SMR-1	0%	0%	100%	100%	0.38	1.67	0.28		0.28
RP-1	100%	0%	0%	100%	0.38	1.67	0.26		0.38
OB-4	100%	0%	0%	100%	0.38	1.67	0.12		0.38

8/29/2011

1. The basis for PLRM input assumptions for each SWT facility present in the baseline condition are described in this file.
2. Input assumptions are for PLRM models with Caltrans runoff. The approach for adjusting the size of SWT facilities to exclude Caltrans runoff is described in the main report on pages 9-10.

Description of SWT Facilities

1. Modeling as two separate facilities termed Wildwood and Marriot_Wet in series
2. City Stormwater Coordinator indicated that a construction flaw is allowing outflow from Wildwood to bypass Marriot_Wet. The baseline model recognizing this issue and includes a Divider that routes low flow around Marriot_Wet.

Assumptions for Wildwood

1. This is the two basins upstream of Highway 50 which are connected under Wildwood Avenue.
2. Modeling as a Dry Basin.
3. Surface area was estimated in GIS at 2.25 acres for both basins.
4. Shallow basin, assuming an average depth of 1.0 feet at brim full.
5. Assuming a 96 hour draw down based on anecdotal observations of standing water in these basins.

PLRM SWT Parameters for Wildwood

			Calcs		
1. Water Quality Volume = 1.75 acres x 43560 SF/acre x 1.5 feet =	98010	CF	2.25	43560	1
2. Footprint = 1.75 acres x 43560 SF/acre =	98010	SF	2.25	43560	
3. Infiltration Rate (assuming very low)=	0.02	inch/hour			
4. Brim Full Draw Down (see #6 above)=	96	hours			

Assumptions for Marriot_Wet

1. This is the linear basin adjacent to the Marriot and downstream of Highway 50.
2. Modeled as a Wet Basin.
3. Surface area was estimated in GIS at 1.75 acres
4. Assuming over the entire footprint the basin will have relatively shallow flow = 0.5 feet on average
5. Assuming negligible surcharge storage in this Basin
6. We've noticed a bug in PLRM v1.1 when you set Surcharge Storage = 0, so we typical set it to a nominal value in this case.
7. Assuming minimum HRT for this system is 24 hours

PLRM SWT Parameters for Marriot_Wet

			Calcs		
1. Wet Pool Volume = 1.75 acres x 43560 SF/acre x 1.5 feet =	38115	CF	1.75	43560	0.5
2. Wet Pool Footprint = 1.75 acres x 43560 SF/acre =	76230	SF	1.75	43560	
3. Minimum HRT (see #6 above) =	24	hours			
4. Surcharge Basin Volume (see #4 and #5 above)=	1000	CF			
5. Brim Full Draw Down (see #6 above)=	48	hours			

Description of SWT Facilities

1. Modeling as two separate facilities termed Osgood_Basin and Osgood_SEZ in parallel.
2. Runoff from catchments OB1-OB5 goes to the Osgood_Basin and OB6 goes to Osgood_SEZ.

Assumptions for Osgood Basin

1. Values for volumes and footprints based on 2NDNATURE survey of the basin
2. Modeling as a Wet Basin
3. Wet pool is relatively small and taken as depth below orifices in outlet weir
4. Minimum HRT assumed as 24 hours
5. There are three 6-inch orifices but they are block by rocks, sediment, and filter fabric on upstream side. Assuming brim full draw down is 48 hours.

PLRM SWT Parameters for Osgood_Basin

1. Wet Pool Volume =	3100	CF
2. Wet Pool Footprint =	2250	SF
3. Minimum HRT (see #3 above) =	24	hours
5. Surcharge Basin Volume =	19200	CF
4. Brim Full Draw Down (see #4 and 5 above) =	48	hours

Assumptions for Osgood_SEZ

1. This is a relatively flat SEZ area where water from OB-6 is routed and can spread.
2. The total surface area of this lot is estimate at 1 acre. However, its unlikely that surface flow inundates this complete area.
3. Assuming the best representation of this feature is a shallow Wet Basin in PLRM with minimal surcharge storage.
4. Assuming half the area is typically inundated with surface flow = 0.5 acres
5. Surface flow comprising the wet pool storage is shallow - say 0.25 feet
6. Minimum HRT is 24 hours
7. We've noticed a bug in PLRM v1.1 when you set Surcharge Storage = 0, so we typical set it to a nominal value in this case.

PLRM SWT Parameters for Osgood_SEZ

		Calcs		
1. Wet Pool Volume = 1.75 acres x 43560 SF/acre x 1.5 feet =	5445	0.5	43560	0.25
2. Wet Pool Footprint = 1.75 acres x 43560 SF/acre =	21780	0.5	43560	
3. Minimum HRT (see #6 above) =	24			
5. Surcharge Basin Volume (see #7 and #8 above)=	500			
4. Brim Full Draw Down (see #6 above)=	48			

Description of SWT Facilities

1. Modeling as three separate facilities termed UpperParkWetBasin, LowerParkBasin, and LinearParkBasin
2. Runoff from S-1 goes to UpperParkWetBasin then to LowerParkBasin
3. Runoff from S-2 goes to LinearParkBasin
4. Review of historical imagery (Google Earth) shows the UpperParkWetBasin and LowerParkBasin constructed as of June 2004

Assumptions for UpperParkWetBasin and LowerParkBasin

1. Modeling assumptions developed through the PLRM stormwater research project and 2NDNATURE surveys

Assumptions for LinearParkBasin

1. These are the linear basins along Park, which are models as one Dry Basin
2. Surface area was estimated in GIS at 0.5 acres in total
3. Average depth of water at brim full is assumed at 1 foot.
4. Assuming a 60 hour draw down.
5. Based on anecdotal observation, this Basin is typically dry and the soils in that area are very sandy.

PLRM SWT Parameters for LinearParkBasin

		Calcs		
1. Water Quality Volume =	21780	0.5	43560	1
2. Footprint =	21780	0.5	43560	
3. Infiltration Rate (see #5 above)=	0.2			
4. Brim Full Draw Down (see #4 above)=	60			

PLRM SWT Parameters for UpperParkWetBasin

1. Wet Pool Volume =	13344	CF
2. Wet Pool Footprint =	28392	SF
3. Minimum HRT =	24	hours
5. Surcharge Basin Volume =	32063	CF
4. Brim Full Draw Down =	48	hours

PLRM SWT Parameters for LowerParkBasin

1. Water Quality Volume =	71135
2. Footprint =	43641
3. Infiltration Rate =	0.4
4. Brim Full Draw Down =	60

Description of SWT Facilities

1. Modeling as two separate facilities termed EloiseBasin and TuckerBasin in series
2. Runoff from catchments EB1-EB3 and EB5 goes to the EloiseBasin and EB4 goes to TuckerBasin.
3. Tucker Basin is upstream of the Eloise Basin.

Assumptions for EloiseBasin

1. Modeled as a Wet Basin
2. Surface area is roughly 0.35 acres
3. Minimum HRT assumed as 24 hours
4. From 2NDNATURE survey overflow is at 3.5 feet
5. Assuming 1 foot is wet pool and 2.5 feet is Surcharge
6. Assuming Brim Full Draw Down is 60 hours

PLRM SWT Parameters for EloiseBasin

1. Wet Pool Volume =	15250
2. Wet Pool Footprint =	15250
3. Minimum HRT (see #3 above) =	24
5. Surcharge Basin Volume =	38000
4. Brim Full Draw Down (see #6 above) =	60

Assumptions for TuckerBasin

1. Modeled as a Dry Basin
2. The total surface area is estimated as 0.1 acres in GIS
3. Assuming a 1 foot depth
4. Low infiltration since wet area and old basin - say 0.05 inch/hour
5. Assume 60 hour draw down

PLRM SWT Parameters for TuckerBasin

		Calcs		
1. Water Quality Volume =	4356	0.1	43560	1
2. Footprint =	4356	0.1	43560	
3. Infiltration Rate (assuming very low)=	0.05			
4. Brim Full Draw Down (see #6 above)=	60			

Description of SWT Facilities

1. Modeling as two separate facilities termed EastY_DB and EastY_WB in parallel.
2. Runoff from catchment EY1 goes to the EastY_DB and EY2 goes to EastY_WB.

Assumptions for SWT facilities

1. Values for volumes and footprints and draw down times based on field survey

PLRM SWT Parameters for EastyY_WB

1. Wet Pool Volume =	10000	CF
2. Wet Pool Footprint =	20000	SF
3. Minimum HRT (see #3 above) =	24	hours
5. Surcharge Basin Volume =	2500	CF
4. Brim Full Draw Down (see #4 and 5 above) =	48	hours

PLRM SWT Parameters for EastY_DB

1. Water Quality Volume =	18000
2. Footprint =	18000
3. Infiltration Rate =	0.05
4. Brim Full Draw Down =	60

Description of SWT Facilities

1. Includes the Chris Basin, Vortechnics, and Dry Basin constructed for the Beecher-Lodi ECP.
2. All modeling assumption were developed for the Sierra Tract Phase 3 and 4 analysis conducted for City of South Lake Tahoe. Assumptions are documented in Appendix A of Sierra Tract Phase 3 and 4 PLRM analysis.

Appendix B – Supporting GIS Files

All files provided digitally.

Appendix C – Extrapolation Spreadsheet

Select example files are provided in hard copy.

All files provided digitally.

The following provides a brief summary of the worksheets included in this file.
29-Aug-11

Worksheet Title	Description
BaselineLoadSummary	Summary of loading estimate (without connectivity considered). Two tables are included, one without Caltrans loads and one with Caltrans loads included. The table without Caltrans loads is used for the City report to provide the City's baseline load estimate.
Mod_Project_Loads_NoCA	Sum of loading from each PLRM model, which includes the effect of baseline SWT facilities when defined as present. This is PLRM output without Caltrans pollutant loads included.
Mod_Project_Loads_CA	Sum of loading from each PLRM model, which includes the effect of baseline SWT facilities when defined as present. This is PLRM output with Caltrans pollutant loads included.
ModCatchLoads	Modeled pollutant loading from each PLRM catchment within a PLRM model, this output is used to develop the extrapolation and regression equations. SWT facilities are not considered here.
ExtrapCatchLoads_NoCA	Extrapolated pollutant loads for UPCs not modeled in PLRM. This is extrapolated output without Caltrans drainage areas included.
Lake Tahoe TMDL City estimate (for comparison)	Extrapolated pollutant loads for UPCs not modeled in PLRM. This is extrapolated output with Caltrans drainage areas included.
RV	Regression equation and statistics for surface runoff volume
TSS	Regression equation and statistics for TSS
FSP	Regression equation and statistics for FSP
TP	Regression equation and statistics for TP
SRP	Regression equation and statistics for SRP
TN	Regression equation and statistics for TN
DIN	Regression equation and statistics for DIN

Tables below are supporting GIS information and PLRM output used to develop the calculations. Many formulas in this spreadsheet reference these worksheets.

Worksheet Title	Description
LoadSummary	Summary numbers pulled from PLRM Scenario Output that populate the worksheet ModCatchLoads
LU_Modeled	Land use tabulation data for PLRM catchments
WestSierraTract	Land use tabulation data for the West Sierra Tract PLRM model
LU_NotModeled	Land use tabulation data for the UPCs not modeled
RR_NotModeled	Road Risk tabulation for the UPCs not modeled
DCIA_Notmodeled	DCIA tabulation for the UPCs not modeled

Loading estimates below for the City do not include Caltrans runoff and do not consider connectivity of catchments. This table is used in the August 2011 report.

	Urban Area	Surface Runoff		Pollutant Loading (lb/year)						Pollutant Loading (# particles/year)
	(acres)	(ac-ft/ year)	% Surface Runoff	TSS	FSP	TP	SRP	TN	DIN	FSP
	5,473	1,631	13.8%	913,000	549,000	2,500	770	10,470	1,310	2.74E+19
Placer (for comparison)	5,735	1,486	8.8%	875,000	516,000	2,450	550	10,220	1,260	2.57E+19
Lake Tahoe TMDL City estimate (for comparison)					1,495,000	7,960		35,860		7.46E+19

Loading estimates below for the City include Caltrans runoff and do not consider connectivity of catchments.

Urban Area	Surface Runoff		Pollutant Loading (lb/year)						Pollutant Loading (# particles/year)
(acres)	(ac-ft/ year)	% Surface Runoff	TSS	FSP	TP	SRP	TN	DIN	FSP
5,521	1,688	14.3%	977,000	590,000	2,640	800	10,970	1,380	2.94E+19

The following reports Scenario Totals for the PLRM models without Caltrans runoff, and includes the effect of baseline SWT facilities when present.

PLRM Project	Volume(ac-ft/yr)	TSS(lbs/yr)	FSP(lbs/yr)	TP(lbs/yr)	SRP(lbs/yr)	TN(lbs/yr)	DIN(lbs/yr)
WestSierraTract	53.5	27,716	16,579	77	25	315	39
Stateline	55.3	20,268	13,170	58	23	262	31
Bijou	33.8	27,003	16,885	64	30	233	28
OsgoodBasin	72.4	44,547	26,536	116	22	513	68
TahoeKeys	125.9	31,707	13,865	139	32	691	78
GardnerMountain	61.7	47,447	29,733	115	30	451	55
EloiseBasin	199.0	106,681	66,730	297	109	1249	171
EastY	88.3	47,523	30,047	123	48	508	63
GroceryOutlet	15.8	12,938	8,181	30	16	107	13
EastSierraTract	40.8	16,887	9,234	58	14	257	30
Pasadena	17.4	7,775	4,402	26	6	113	14
SkiRunMarina	26.6	17,788	10,869	47	20	187	24
Super8	54.0	32,210	18,486	87	14	399	52
WildwoodBasins	27.0	2,640	2,293	13	4	86	10
RockyPoint	32.9	30,755	19,455	69	15	266	34
Heavenly	31.9	27,456	17,136	64	24	233	29

The following reports Scenario Totals for the PLRM models with Caltrans runoff, and includes the effect of baseline SWT facilities when present.

PLRM Project	Volume(ac-ft/yr)	TSS(lbs/yr)	FSP(lbs/yr)	TP(lbs/yr)	SRP(lbs/yr)	TN(lbs/yr)	DIN(lbs/yr)
WestSierraTract	59.7	35,862	22,090	93	26	370	46
Stateline	56.9	21,130	13,733	60	24	271	32
Bijou	37.3	32,091	20,101	74	31	268	33
OsgoodBasin	72.4	44,547	26,536	116	22	513	68
TahoeKeys	125.9	31,707	13,865	139	32	691	78
GardnerMountain	65.2	52,615	32,999	125	31	486	60
EloiseBasin	203.8	111,272	69,671	307	110	1,286	176
EastY	94.2	56,156	35,505	140	50	567	70
GroceryOutlet	19.1	17,784	11,245	40	16	140	17
EastSierraTract	40.8	16,887	9,234	58	14	257	30
Pasadena	17.4	7,775	4,402	26	6	113	14
SkiRunMarina	30.0	22,670	13,955	56	20	221	28
Super8	54.0	32,210	18,486	87	14	399	52
WildwoodBasins	28.9	2,837	2,466	14	4	92	10
RockyPoint	34.0	32,457	20,530	73	15	277	36
Heavenly	31.9	27,456	17,136	64	24	233	29

City of South Lake Tahoe
TMDL Baseline Pollutant Load Estimate

South Lake Tahoe, CA

Appendix D – Catchment Connectivity Methodology

September 2011

Prepared for:

Prepared by:

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D.1 BACKGROUND AND PURPOSE

The Pollutant Load Reduction Model (PLRM) is an urban stormwater model that can be applied to estimate pollutant loads to Lake Tahoe for situations where stormwater is discharged to surface waters or to Lake Tahoe directly. The current version of the PLRM (v1.1) does not estimate potential reductions in pollutant loads for cases where stormwater runoff discharges to a meadow or other natural filtration systems prior to reaching Lake Tahoe. In these cases only a fraction of the total pollutant load may reach a surface water and Lake Tahoe. An analysis of total runoff volume, and associated pollutant loads reaching Lake Tahoe is important to the City of South Lake Tahoe (City) because a significant amount of the City's urban drainage area discharges to meadows prior to reaching Lake Tahoe (e.g., Pope Marsh, Upper Truckee Marsh, Bijou Meadow, etc.).

> ***Note:***
>
> PLRM v1.1 does include algorithms that produce load reductions in stormwater treatment facilities that simulate concepts similar to how natural filtration systems reduce stormwater runoff volumes and pollutant loads.

The Crediting Handbook (LRWQCB and NDEP, 2009) uses the term *catchment connectivity* to address this topic. In the context of the Crediting Handbook and this report, the term *catchment connectivity* is intended to describe the portion of surface runoff and associated pollutant load discharged from a discrete urban drainage catchment that reaches Lake Tahoe. The Crediting Program requires that catchment connectivity be expressed as a percentage (0% - 100%) in the catchment registration process. Catchment connectivity expressed as a percentage is termed a *connectivity factor* in this report. When registering a catchment with the Crediting Program, the estimated pollutant load discharged from an urban drainage catchment is multiplied by a connectivity factor to produce an estimate of the pollutant load reaching Lake Tahoe.

> ***Note:***
>
> *Catchment connectivity is a different concept than impervious area connectivity. The current version of PLRM (v1.1) simulates impervious area connectivity, which allows a user to define directly and indirectly connected impervious areas within a catchment to inform storm water calculations that estimate runoff rates, volumes, and pollutant loads that are discharged at the outlet of the catchment.*

Two previous Tahoe Basin assessments of catchment connectivity were reviewed for this effort. A brief summary of each assessment is provided below.

1. <u>Maximum Hydrologic Connectivity Transmission Distance Envelope Curve (Alexander, M. and Wigart, R., 2009)</u> – The authors measured the transmission distance required to infiltrate stormwater runoff discharged from selected urban outfalls during various runoff events in the El Dorado County portion of the Tahoe Basin. Observed transmission distances were related to precipitation intensity and tributary right-of-way impervious area to predict the maximum transmission distance of stormwater runoff for individual outfalls. This information was then compared to the actual distance between an outfall and a receiving water to identify outfalls disconnected from receiving waters, and to identify outfalls that may be connected to receiving waters during certain runoff events.

2. Outfall Connectivity RAM User's Guide (NTCD, 2010) – The authors developed a methodology that estimates the degree of catchment connectivity for a stormwater outfall based on a qualitative relationship between the distance of the outfall to a waterbody and the observed distance of erosion/deposition in the channel downstream of the outfall.

The previous assessments of catchment connectivity described above provide methodologies that may be appropriate for use in distinguishing between catchments connected to surface waters all the time (connectivity factor of 100%) relative to catchments that are not connected to surface waters (connectivity factor very near 0%). A limitation of the methodologies discussed above is that they do not analyze stormwater runoff over a full range of hydrologic conditions. Consequently, the methodologies discussed may not be appropriate for use when estimating average annual runoff volumes delivered to receiving waters for partially connected catchments (connectivity factors between 0%-100%).

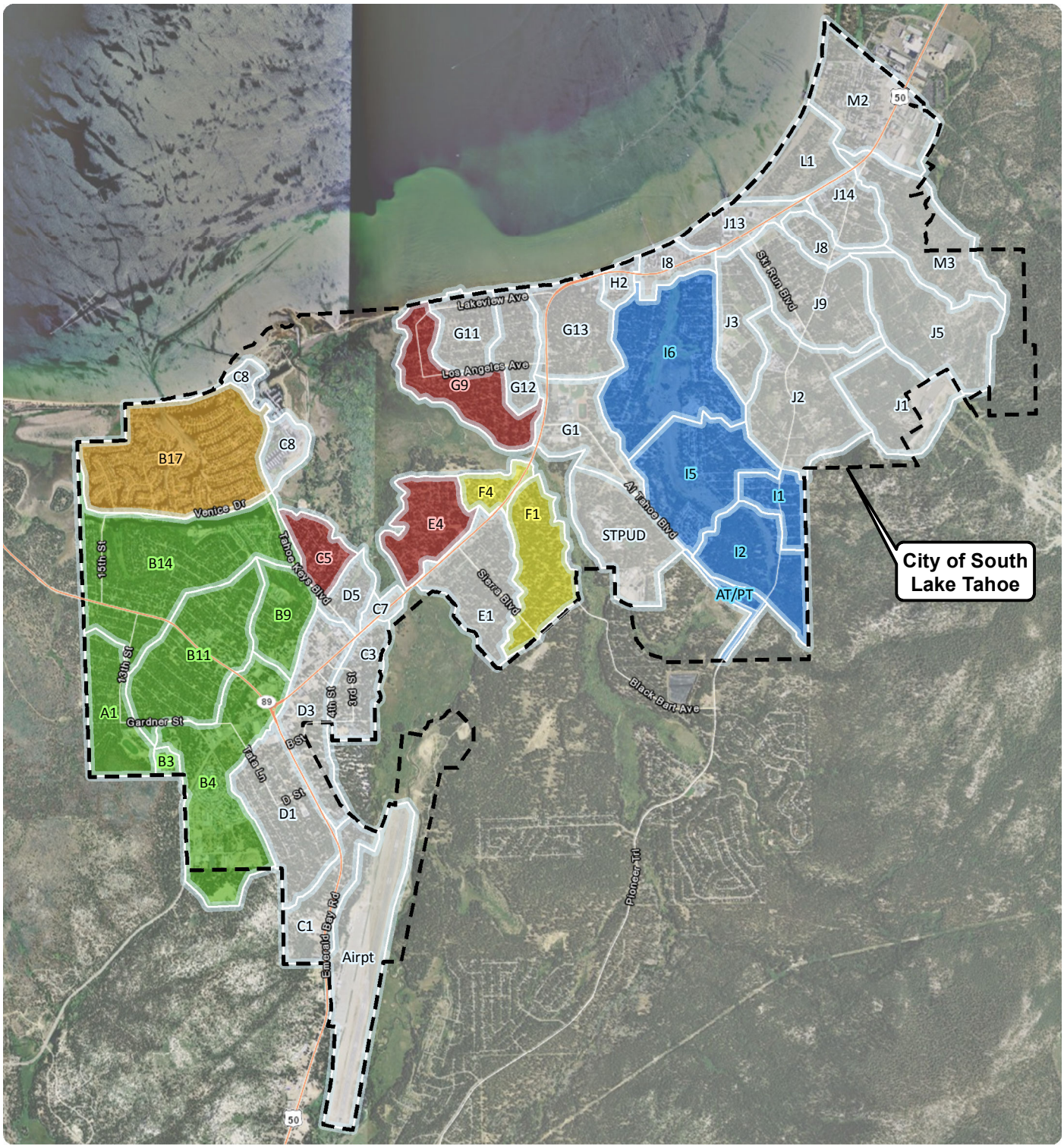
The catchment connectivity methodology developed for the City baseline load estimate attempts to improve upon previous efforts by incorporating the long-term continuous simulation modeling capabilities of the PLRM to estimate connectivity factors based on an analysis of a wide range of hydrologic conditions. The following sections describe the approach and results of the catchment connectivity methodology.

D.2 STORMWATER DISCHARGE ASSESSMENT

The first step of the analysis screened the delineated urban planning catchments (UPCs) within the City to identify UPCs directly connected to a surface water (i.e. connectivity factor = 100%). The primary source of information used to screen and categorize UPCs was the City's Asset Information Management System (2011). The Asset Information Management System is an online resource that identifies the location of City storm drainage infrastructure and drainage channels. The location of drainage infrastructure was cross-referenced with the City's UPC delineation to identify direct connections to surface waters. The following rules were used to categorize UPCs.

- Rule 1 – If the majority of a delineated UPC discharges to a perennial creek, stream, or Lake Tahoe, then the UPC has a connectivity factor equal to 100%.
- Rule 2 – If the majority of a delineated UPC discharges to an ephemeral drainage channel that does not allow for significant dissipation and distribution of runoff, then the UPC has a connectivity factor equal to 100%. This rule was incorporated into the analysis to provide a conservative estimate of baseline pollutant loading, assuming that in large events ephemeral drainage channels that primarily confine and convey runoff may resuspend and transport previously deposited material to a receiving water.

Figure D.1 displays the stormwater discharge assessment using the rules described above. UPCs that discharge to a surface water have a connectivity factor of 100%. UPCs identified to discharge to a meadow (connectivity factor < 100%) are categorized in Figure D.1 by the area that receives the stormwater runoff. These partially connected UPCs are analyzed using the methodologies described in this report to develop connectivity factors, which are used to refine the estimates of baseline pollutant loading reaching Lake Tahoe for each partially connected UPC.



Data Sources: ArcGIS Online Basemaps, 2011.

Discharge Location

- Surface Water
- Bijou Meadow
- Pope Marsh
- Trout Creek Meadow
- Tahoe Keys (Surface Water)
- Upper Truckee Marsh

Reference Map

City of South Lake Tahoe Baseline Load Estimate

Stormwater Discharge Assessment

Scale - 1:48,000 1 inch = 4,000 feet

0 2,000 4,000 8,000 Feet

CA State Plane, Zone II	NAD 83	horiz. units: feet
northwest hydraulic consultants	project no. 50620	September 2011

Figure D-1 - Stormwater Discharge Assessment

As shown in Figure D.1, there are four locations in the City where UPCs discharge to a meadow or pervious receiving area prior to stormwater reaching Lake Tahoe. The meadow systems receiving City stormwater include the Bijou Meadow, Pope Marsh, Trout Creek Meadow, and the Upper Truckee Marsh. The Tahoe Keys is identified separately in Figure D.1. For the purposes of this analysis the Tahoe Keys UPC is assumed to discharge to surface water since there is a connection between the waters in the Keys and Lake Tahoe.

Table D.1 displays the proportion of City's total estimated baseline fine sediment particle (FSP) load that discharges to surface waters and meadows. The FSP load estimates in Table D.1 are taken directly from the City's baseline loading estimate without making adjustments using connectivity factors. As shown in Table D.1, over half (60% including the Tahoe Keys) of the City's total FSP load estimate is discharged to surface waters. Among discharges of FSP loads to meadow systems, Pope Marsh is estimated to receive roughly one quarter of the City's total FSP load (24%). The combined FSP loading to Bijou Meadow, Trout Creek Meadow, and the Upper Truckee Marsh is estimated to be 16% of the City's total FSP load.

Table D.1. Distribution of FSP Loading by Discharge Location

Discharge Location	Unadjusted Baseline FSP Load Estimate (lb/year)	Percentage of Total Unadjusted FSP Load
Surface Waters	320,500	58.3%
Bijou Meadow	46,100	8.4%
Pope Marsh	132,600	24.1%
Tahoe Keys (Surface Water)	13,900	2.5%
Trout Creek Meadow	19,100	3.5%
Upper Truckee Marsh	17,400	3.2%

D.3 POPE MARSH CONNECTIVITY METHODOLOGY

Given the significance of the estimated FSP load to Pope Marsh, as well as the challenges presented in simulating the hydrology and pollutant removal mechanisms in the marsh system using numerical models, a connectivity factor was derived for Pope Marsh using a methodology specific to this location. The following describes the approach used to estimate a connectivity factor for stormwater runoff discharged to Pope Marsh.

D.3.1 HYDROLOGIC BACKGROUND

Historically, the Upper Truckee Marsh was the single largest wetland in the Sierra Nevada range (Goldman, 2006). In the late 1950s, approval was given to the Dillingham Corporation to develop the Tahoe Keys subdivision in the center of the Upper Truckee Marsh, which at that time was roughly 1,340 acres in size. The construction of the Tahoe Keys dredged and filled roughly 600 acres of the marsh and fragmented it into two pieces, referred to today as the Pope Marsh to the west of the Tahoe Keys and the Upper Truckee Marsh to the east of the Tahoe Keys. The construction of the Tahoe Keys also isolated Pope Marsh from the Upper Truckee River.

Figure D.1 identifies the developed portion of the City that drains to Pope Marsh. Roughly 1,050 acres of urban land drains to Pope Marsh (19% of the urban area within the City Boundary). Roughly 1,300 forested acres located to the south of Pope Marsh is also tributary to the marsh.

Photo 1: Pope Marsh looking northwest from Venice Drive

Figure D.2 provides an overview of the Pope Marsh system focusing on flow pathways through the marsh. The majority of the City's urban stormwater runoff that reaches the marsh first enters Tallac Lagoon, where a weir on the western edge of Tallac Lagoon controls discharge to the marsh. When the water level rises high enough in Tallac Lagoon, water discharges over the weir into Pope Marsh were it distributes through the 165 acre marsh. A natural barrier beach retains surface water in the marsh. In above normal water years, surface water in Pope Marsh breaks through the barrier beach next to the Lighthouse Shores development within the Tahoe Keys and discharges to Lake Tahoe. A concrete weir constructed by the Dillingham Corporation adjacent to the Lighthouse Shores development regulates flow out of the marsh during periods of barrier beach break-out.

Note:

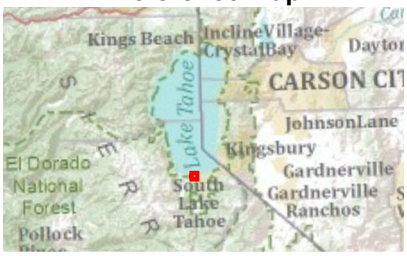
During the 2011 water year, which was significantly above normal, the barrier beach break-out was observed to begin in the middle of March and last until the end of June. The aerial in Figure D.2 was taken in the middle of June 2011.

Data Sources: ArcGIS Online Street Basemap, 2011. Google Earth color aerial imagery, 15 June 2011.

Legend

- Waterbody
- Flow Direction

Reference Map



City of South Lake Tahoe Baseline Load Estimate

Pope Marsh Overview

Scale - 1:8,400 1 inch = 700 feet

0 350 700 1,400 Feet

CA State Plane, Zone II	NAD 83	horiz. units: feet
northwest hydraulic consultants	project no. 50620	September 2011

Figure D-2 - Pope Marsh Overview

D.3.2 TECHNCIAL APPROACH

The premise for estimating a connectivity factor for urban drainage through Pope Marsh is that stormwater and its associated pollutant load in the marsh only reaches Lake Tahoe during periods of barrier beach break-out. Another key premise for estimating a connectivity factor is that the majority of pollutants retained in the marsh are not resuspended and flushed from the marsh during break-out periods. This premise is supported by the observations that: 1) flow in the marsh is distributed; 2) the marsh is densely vegetated; 3) the concrete weir at the outlet regulates flow and reduces the potential for erosion to migrate back into the marsh; and 4) limited water quality sampling during barrier beach break-outs has shown surface water discharges from the marsh have low levels of turbidity.

Note:

Limited turbidity data collected by the City during the 2011 break-out confirmed that turbidity improved from roughly 30 NTU at the outlet of the Eloise Basin to roughly 5 NTU at the break-out location discharging surface runoff to Lake Tahoe (pers. comm. R. Erlich, 2011).

The approach taken adapts the long-term continuous simulation PLRM models developed for the City baseline load estimate to account for the timing and duration of barrier beach break-outs to compute the total stormwater runoff volume that occurs during barrier beach break-outs. The connectivity factor is calculated based on the ratio between the stormwater runoff volume generated in the model during barrier beach break-outs relative to the total stormwater runoff volume generated for the entire simulation period.

A complicating factor with the selected approach is that the timing and duration of barrier beach break-outs is difficult to accurately estimate because: 1) research conducted to support the connectivity analysis did not locate historical records of barrier beach break-outs or long-term groundwater monitoring in the marsh that could be used to infer break-outs; and 2) hydrologic simulations that predict barrier beach break-outs in the marsh would be an extremely complicated modeling exercise and are beyond the scope of this connectivity analysis. To develop estimates of the timing and duration of barrier beach break-outs, anecdotal information was obtained by contacting the water supervisor for the Tahoe Keys Water Department (G. Trischler, pers. comm. 2011). Mr. Trischler provided the following information:

- Surface water in Pope Marsh breaks-out through the barrier beach every water year that is above normal. The break-outs occur during the spring melt/runoff period and typically occur anytime from the middle of April through the middle of June.
- Pope Marsh does not break-out during below normal water years.
- Surface water has never been observed to break-out from a summer/fall thunder storm event.
- Surface water in Pope Marsh did break-out during the 1997 and 2005 rain-on-snow events.

The following describes the steps used to develop a connectivity factor for stormwater discharged to Pope Marsh. The methodology uses PLRM models developed for the City's baseline loading estimate, anecdotal information provided by Mr. Trischler, and the observed timing of the barrier beach break-out that occurred in water year 2011.

Step 1 – Extend Meteorological Record for Continuous Simulations:
The PLRM database was updated to include quality assured precipitation and temperature data through water year 2011 for the two SnoTel gages that generate meteorological data in PLRM for areas within the City Boundary (Fallen Leaf gage and Hagan's Meadow gage). This step was completed in order to include the observed 2011 barrier beach break-out in the analysis, which is used as the basis for estimating the timing and duration of all barrier beach break-outs (see Step 2).

Step 2 – Estimate Barrier Beach Break-Outs:

Step 2A – Identify Above Normal Water Years:
Barrier beach break-outs are assumed to occur in water years with above average precipitation. To identify water years in the simulation period that are above average, precipitation data was analyzed from the Eloise Basin model (PLRM grid cell 634), which uses data from the Fallen Leaf Lake SnoTel gage. Table D.2 shows total precipitation for each water year as predicted in PLRM grid cell 634 for the available simulation period (water years 1989 through 2011). Table D.2 also calculates the percentage of precipitation in a water year relative to the calculated average, which is used to identify above average water years when barrier beach break-outs are assumed to occur.

Table D.2. Precipitation Amounts by Water Year (Eloise Basin Model)

Water Year	Precipitation (in/year)	% Average	Assume Break-Out Occurred
1989	33.8	101%	Yes
1990	21.2	63%	No
1991	23.3	70%	No
1992	20.7	62%	No
1993	39.7	119%	Yes
1994	17.1	51%	No
1995	55.4	166%	Yes
1996	45.2	136%	Yes
1997	51.9	156%	Yes
1998	43.0	129%	Yes
1999	40.7	122%	Yes
2000	30.4	91%	No
2001	14.4	43%	No
2002	27.6	83%	No

Water Year	Precipitation (in/year)	% Average	Assume Break-Out Occurred
2003	29.8	89%	No
2004	26.4	79%	No
2005	36.1	108%	Yes
2006	49.3	148%	Yes
2007	21.5	64%	No
2008	24.1	72%	No
2009	29.1	87%	No
2010	32.1	96%	No
2011	54.8	164%	Yes
Average	**33.4**	**n/a**	**n/a**

Step 2B – Estimate Duration and Timing of Break-Outs (Spring Runoff):
For above normal water years, the timing and duration of barrier beach break-outs caused by spring runoff were estimated by using the observed characteristics of the break-out in water year 2011 as a bookend to scale estimates to other water years. Table D.3 shows the rules developed, which are based on the following:

- Any above normal water year will cause a barrier beach break-out for a minimum of one month.
- As the ratio of total precipitation in a given water year increases relative to the calculated average, the duration of the barrier beach break-out increases until reaching the observed maximum duration of the 2011 barrier beach break-out; plus 0.5 months.
    - This rule assumes some stormwater entering Pope Marsh prior to a break-out, but contributing to the break-out, may reach Lake Tahoe.
    - Therefore, the observed 2011 break-out that physically lasted roughly 3.5 months is estimated to have created a 4-month period of potential discharge of stormwater to Lake Tahoe through Pope Marsh.
    - The centroid of barrier beach break-outs was estimated to be between April 15th and May 15th, which is the centroid of the observed 2011 break-out.

Table D.3. Rules for Spring Runoff Break-Out

Water Year Precipitation Relative to Average Precipitation		Barrier Beach Break-Out		
Lower Bound	Upper Bound	# Months	Start Date	End Date
100%	110%	1	15-Apr	15-May
111%	120%	1.5	1-Apr	15-May
121%	130%	2	1-Apr	31-May
131%	140%	2.5	15-Mar	31-May
141%	150%	3	15-Mar	15-Jun
151%	160%	3.5	1-Mar	15-Jun
161%	200%	4	1-Mar	30-Jun

Step 2C – Estimate Duration and Timing of Break-Outs (Rain-on-Snow Events): Barrier beach break-outs are known to occur during large rain-on-snow events. To confirm the timing of large rain-on-snow events during the simulation period (water years 1989 through 2011), stream discharge data for the Upper Truckee River was reviewed to indentify significant peak flows occurring prior to the onset of spring runoff. Two large rain-on-snow events occurring in water year 1997 (3,150 peak cfs on 1/2/1997) and in water year 2006 (2,250 peak cfs on 12/31/1995) were identified from the Upper Truckee River discharge data. These events were estimated to cause barrier beach break-outs from 12/26/1996 to 1/26/1997 and from 12/24/2005 to 1/24/2006. The barrier beach break-outs caused by rain-on-snow events are assumed to close prior to reopening from spring runoff.

Table D.4 summarizes how the rules developed above define the estimated timing and duration of barrier beach break-outs from spring runoff and rain-on-snow events over the simulation period.

Table D.4. Estimated Break-Out Periods

Water Year	Precip (in/year)	% of Average	Spring Runoff		Rain-on-Snow	
			Start	End	Start	End
1989	33.8	100%	15-Apr	15-May		
1990	21.2	63%				
1991	23.3	69%				
1992	20.7	61%				
1993	39.7	117%	1-Apr	15-May		
1994	17.1	50%				
1995	55.4	164%	1-Mar	30-Jun		
1996	45.2	134%	15-Mar	31-May		

Water Year	Precip (in/year)	% of Average	Spring Runoff		Rain-on-Snow	
			Start	End	Start	End
1997	51.9	154%	1-Mar	15-Jun	26-Dec	26-Jan
1998	43.0	127%	1-Apr	31-May		
1999	40.7	120%	1-Apr	31-May		
2000	30.4	90%				
2001	14.4	42%				
2002	27.6	81%				
2003	29.8	88%				
2004	26.4	78%				
2005	36.1	107%	15-Apr	May 15		
2006	49.3	146%	15-Mar	15-Jun	25-Dec	25-Jan
2007	21.5	64%				
2008	24.1	71%				
2009	29.1	86%				
2010	32.1	95%				
2011	54.8	162%	1-Mar	30-Jun		

Step 3 – Modify PLRM Models in SWMM5 to Track Break-Out Periods:

Two PLRM models developed for the City's baseline loading estimate are within the urban drainage area of Pope Marsh: 1) the Eloise Basin model; and 2) the Gardner Mountain model. These models were modified in the EPA's Storm Water Management Model version 5 (SWMM5) to track stormwater runoff during barrier beach break-out periods. The tracking of stormwater runoff volumes was accomplished by developing a control rule in SWMM5 to activate or deactivate links in the model dependent on the time period in the simulation. The link simulating discharge to Lake Tahoe was only active for the break-out periods shown in Table D.4. The code for the SWMM5 control rule is provided in Attachment D.7 (see SWMM5 Control Rule #1).

Note:

SWWM5 is the parent model for PLRM, and running a PLRM simulation in SWMM5 allows for model adaptations (e.g., adjusting the simulation period to run through water year 2011) and detailed interpretation of continuous time-series output (e.g., assessing a time series of runoff at a user-defined interval).

Step 4 – Estimate Stormwater Runoff Connectivity Factor:

The results from the Eloise Basin and Gardner Mountain model simulations that track stormwater runoff during barrier beach break-out periods are shown in Table D.5. Between the two models, roughly 19% of total stormwater runoff volume generated over the simulation period occurs during the estimated barrier beach break-out periods.

Table D.5. Pope Marsh Connectivity Factor (Stormwater Runoff)

Model	Stormwater Runoff Over Simulation Period (WY 1989-2011) in acre-feet			Break-Out Ratio (Connectivity Factor)
	Break-Out Periods	Non Break-Out Periods	Total	
Eloise Basin	830	3,760	4,590	18%
Gardner Mountain	290	1,130	1,420	20%
			Average of two models:	19%

Step 5 – Estimate Optional TMDL Pollutant Connectivity Factors:

Because Pope Marsh is a large wetland, it may be reasonable to assume that stormwater runoff routed through the marsh that reaches Lake Tahoe during break-out periods will improve in quality. To estimate the load reduction benefit of the marsh, the effluent quality of stormwater during break-out periods was set to the PLRM characteristic effluent concentration (CECs) for Dry Basins. (The CECs for a Dry Basin were selected instead of the CECs for a Wet Basin to provide a conservative estimate of water quality performance in the marsh since minimal supporting water quality data is available for the marsh). For TMDL pollutants, PLRM CECs for Dry Basins are shown below. As a basis of comparison, PLRM CECs for Wet Basins are also shown:

- FSP : (Dry Basin = 25 mg/L; Wet Basin = 10 mg/L)
- TP: (Dry Basin = 0.16 mg/L; Wet Basin = 0.10 mg/L)
- TN = (Dry Basin = 1.1 mg/L; Wet Basin = 0.95 mg/L)

Table D.6 estimates connectivity factors for TMDL pollutants before and after assigning the Dry Basin CECs to the volume of stormwater calculated during break-out periods to compute break-out pollutant loads. Total pollutant loads shown in Table D.6 are taken from the SWMM model output and are estimates of total loads discharged to the Marsh.

Table D.6. Pope Marsh Connectivity Factor (TMDL Pollutants)

TMDL Pollutant	Model	Pollutant Load Over Simulation Period (WY 1989-2011) in pounds (WY 1989-2011)			Break-Out Ratio	
		Break-Outs (No Treatment)	Break-Outs (Dry Basin Treatment)	Total Discharged to Marsh	No Treatment	Dry Basin Treatment
FSP	Eloise Basin	358,800	56,400	1,975,500	18%	3%
	Gardner Mountain	144,600	19,700	680,700	21%	3%
				Average of two models:	**20%**	**3%**

TMDL Pollutant	Model	Pollutant Load Over Simulation Period (WY 1989-2011) in pounds (WY 1989-2011)			Break-Out Ratio	
		Break-Outs (No Treatment)	Break-Outs (Dry Basin Treatment)	Total Discharged to Marsh	No Treatment	Dry Basin Treatment
TP	Eloise Basin	1,490	361	8,250	18%	4%
	Gardner Mountain	540	126	2,620	21%	5%
				Average of two models:	**19%**	**5%**
TN	Eloise Basin	6,040	2,483	33,150	18%	7%
	Gardner Mountain	2,150	867	10,310	21%	8%
				Average of two models:	**20%**	**8%**

Step 6 – Select Connectivity Factors to Adjust Baseline Loading Estimate:
In Table D.5, the 19% break-out ratio is considered a probable maximum for the total amount of stormwater discharged to Pope Marsh that could reach Lake Tahoe during barrier beach break-out periods. The estimate is conservative because it assumes that all stormwater runoff conveyed to Pope Marsh during barrier beach break-outs will reach Lake Tahoe, which ignores losses in Pope Marsh as well as in the conveyances to Pope Marsh (e.g., Tallac Lagoon). The conservative 19% break-out ratio is used as the connectivity factor for stormwater runoff to Pope Marsh.

In Table D.6, the estimated connectivity factors for TMDL pollutants indicate that additional pollutant load reductions may be achieved during break-out periods assuming that the marsh is treating the stormwater. However, a key weakness of the methodology used is the assumption that all surface runoff, regardless of flow rate, discharged through the marsh to Lake Tahoe is treated to the CECs applied in the model. Because of the limitations of the modeling representation, additional water quality monitoring of water discharged through Pope Marsh is recommended prior to adjusting pollutant loads to consider stormwater treatment in the marsh.

Based on the considerations above, the surface water break-out ratio calculated in Table D.5 was used as the connectivity factor for stormwater runoff, as well as for all TMDL pollutants. Specifically, the following connectivity factors were used to refine the City's baseline loading estimate for UPCs discharging stormwater to Pope Marsh.

- Stormwater Runoff = 19%
- FSP = 19%
- TP = 19%
- TN = 19%

D.4 GENERAL CONNECTIVITY METHODOLOGY

The following describes the steps used to develop a connectivity methodology for stormwater discharged to the City's meadows, which are termed *pervious receiving areas* in the connectivity methodology. The approach adapts long-term continuous simulation PLRM models to include a representation of a pervious receiving area with stage dependent functions for storage, area of inundation, infiltration, and discharge of treated stormwater. The approach also accounts for seasonally high groundwater by adjusting infiltration rates during time periods with estimated high groundwater. Connectivity factors are calculated using the ratio of stormwater runoff volumes and pollutant loads discharged to and from a pervious receiving area.

Section D.4.1 describes the general steps in the connectivity methodology. Section D.4.2 describes how the methodology was applied to estimate connectivity factors for UPCs that discharge to meadows within the City Boundary.

D.4.1 TECHNCIAL APPROACH

Step 1 – Modify PLRM model to include Pervious Receiving Area:
To set up the model structure to represent the function of a pervious receiving area, an existing PLRM model was modified to include a Dry Basin just upstream of the outfall in the model. The Dry Basin was positioned within the model to receive all stormwater runoff, with the outlet of the Dry Basin connected to the outfall in the model. A PLRM Dry Basin was selected as the template for representing the functions of a pervious receiving area because:

- The current modeling components of a Dry Basin in PLRM allow for representation of storage, inundation area, infiltration, and treatment of flows.
- Sensitivity tests confirmed that the modeling parameters listed in the previous bullet were the most sensitive parameters to the computation of long-term surface runoff volumes and pollutant loads. Examples of insensitive modeling parameters to the computation of long-term surface runoff volumes and pollutant loads were surface roughness and slope.

Step 2 – Estimate the Hydrologic Function of the Pervious Receiving Area:
The key functions of drainage channels and/or meadow areas downstream of the urban outfalls within a UPC were estimated using a combination of field inspection, direct measurement, and literature review. Parameters estimated include:

- The maximum area and volume of stormwater inundation between the outfall and the surface water.
- A stage dependent relationship between stormwater inundation and stormwater storage to the maximum area and storage estimated.
- Saturated hydraulic conductivity.

Step 3 – Modify Function of Pervious Receiving Area in SWMM5:

The PLRM Dry Basin that was added to represent a pervious receiving area was modified in the EPA's Storm Water Management Model version 5 (SWMM5) to customize the hydrologic functions of the pervious receiving area based on the Step 2 estimates. Specifically, the stage-storage, stage-infiltration, and stage-treated discharge relationships that PLRM automatically builds were modified using SWMM5 to better represent the function of the pervious receiving area based on the depth of stormwater.

Note:

SWWM5 is the parent model for PLRM. Adjustments to the PLRM input file in SWMM5 allow for model adaptations and customization (e.g., building stage dependent storage relationships).

Step 4 – Estimate Periods of Seasonally High Groundwater:

Periods of seasonally high groundwater were estimated for the simulation period (water years 1989 to 2011) to inform an algorithm that impedes infiltration during wet periods (i.e. spring runoff). Table D.7 shows the method used to estimate periods of seasonally high groundwater, which are based on the following rules:

- Any water year with 80% or more of the average amount of precipitation will cause elevated groundwater for a minimum of one month.
- The centroid for the timing of elevated groundwater for the minimum one-month period is May 1st to May 31st.
- As the ratio of total precipitation in a given water year increases relative to the calculated average, the duration of elevated groundwater increases until reaching a maximum of five months, which is roughly the duration observed in the significantly above normal 2011 water year.

Table D.7. Estimated High Groundwater Timing and Duration

Water Year Precipitation Relative to Average Precipitation		Infiltration Impeded by Elevated Groundwater		
Lower Bound	**Upper Bound**	**# Months**	**Start Date**	**End Date**
80%	90%	1	1-May	31-May
90%	100%	1.5	15-Apr	31-May
101%	110%	2	15-Apr	15-Jun
111%	120%	2.5	1-Apr	15-Jun
121%	130%	3	1-Apr	30-Jun
131%	140%	3.5	15-Mar	30-Jun
141%	150%	4	15-Mar	15-Jul
151%	160%	4.5	1-Mar	15-Jul
161%	200%	5	1-Mar	31-Jul

To identify water years in the simulation period above the selected threshold of 80% of normal precipitation, data was analyzed from the Eloise Basin model (PLRM grid cell

634). Table D.8 shows total precipitation for each water year as predicted in PLRM grid cell 634 for the simulation period. Table D.8 also calculates the percentage of precipitation in a water year relative to the calculated average, which is used to identify water years when elevated groundwater is estimated to have occurred. Finally, the relative percentage of precipitation in a given water year is related to Table D.7 to estimating the timing and duration of elevated groundwater in that water year.

Table D.8. Estimated Period of Elevated Groundwater

Water Year	Precip (in/year)	% of Average	Elevated Groundwater (# months)	Start	End
1989	33.8	101%	2	15-Apr	15-Jun
1990	21.2	63%	0		
1991	23.3	70%	0		
1992	20.7	62%	0		
1993	39.7	119%	2.5	1-Apr	15-Jun
1994	17.1	51%	0		
1995	55.4	166%	5	1-Mar	31-Jul
1996	45.2	136%	3.5	1-Apr	30-Jun
1997	51.9	156%	4.5	1-Mar	15-Jul
1998	43.0	129%	3	1-Apr	30-Jun
1999	40.7	122%	3	1-Apr	30-Jun
2000	30.4	91%	1.5	15-Apr	31-May
2001	14.4	43%	0		
2002	27.6	83%	1	1-May	31-May
2003	29.8	89%	1	1-May	31-May
2004	26.4	79%	0		
2005	36.1	108%	2	15-Apr	15-Jun
2006	49.3	148%	4	15-Mar	15-Jul
2007	21.5	64%	0		
2008	24.1	72%	0		
2009	29.1	87%	1	1-May	31-May
2010	32.1	96%	1.5	15-Apr	31-May
2011	54.8	164%	5	1-Mar	31-Jul

Step 5 – Adjust Infiltration for Elevated Groundwater in SWMM5:

The current version of PLRM uses an outlet in SWMM5 to simulate infiltration from a Dry Basin. Using control rules in SWMM5, the flow rate from the outlet may be adjusted. A control rule was developed to turn off infiltration during periods when the pervious receiving area is estimated to have elevated groundwater or standing water. Using SWMM5, the flow rate was set to zero at the outlet that simulates infiltration for the time

periods shown in Table D.8. The code for the SWMM5 control rule is provided in Attachment D.7 (see SWMM5 Control Rule #2).

Step 6 – Estimate Connectivity Factors from SWMM Output:
Two separate SWMM models were built to estimate connectivity factors:

1. Model #1 – No pervious receiving area: In this simulation the PLRM model is adjusted in SWMM5 to include additional meteorological data to simulate stormwater runoff and pollutant loading through water year 2011. The simulation does not include a pervious receiving area and model output is considered the pollutant load and stormwater runoff delivered to the pervious receiving area.

2. Model #2 – Pervious receiving area: A pervious receiving area was added to the same PLRM model in Simulation #1 following Step 1 in the methodology above. The model was adjusted in SWMM 5 to simulate stormwater runoff and pollutant loading through water year 2011. Then the functions of the pervious receiving area was modified in SWMM5 using the methods described in Steps 2 through 5. Model output is considered the pollutant load and stormwater runoff delivered to surface water.

Note:

The algorithms for the general connectivity methodology are based on the algorithms for a PLRM Dry Basin. Specifically, low flows receive stormwater treatment up to a threshold calculated based on available storage and a minimum retention time in the pervious receiving area. High flows are discharged to surface waters without treatment. This approach should be representative of meadow functions and the methodology incorporates this treatment component when estimating connectivity factors. Note that connectivity factors for stormwater runoff will be higher than TMDL pollutants using the general connectivity methodology since stormwater treatment is considered.

Output from the two SWMM5 simulations for stormwater runoff and TMDL pollutants was used to develop connectivity factors based on the following equations:

$$Connectivity\ Factor_{Stormwater\ Runoff} = \frac{Stormwater\ Runoff_{Model\ \#2}}{Stormwater\ Runoff_{Model\ \#1}} \times 100\%$$

$$ConnectivityFactor_{TMDL\ Pollutant} = \frac{TMDL\ Pollutant\ _{Model\ \#2}}{TMDL\ Pollutant\ _{Model\ \#1}} \times 100\%$$

D.4.2 APPLICATION TO DEVELOP CITY ESTIMATES

The general connectivity methodology was applied under two cases to estimate connectivity factors for City UPCs discharging to meadows: 1) Trout Creek Meadow and Upper Truckee Marsh; and 2) Bijou Meadow. Two separate modeling representations were developed based on the differing characteristics of the meadows. Both cases are discussed below.

Trout Creek Meadow and Upper Truckee Marsh

The Trout Creek Meadow and Upper Truckee Marsh were lumped in the analysis because both meadow systems were found to have similar characteristics during field inspections; specifically both meadow systems have:

- Relatively large distances between the location of urban outfalls and surface waters (i.e. Upper Truckee River and Trout Creek).
- Areas of significant dispersion for stormwater runoff through dense vegetation
- Notable amounts of storage in meadow depressions and remnant disconnected channels

Photos 2 and 3 illustrate the typical characteristics of the Trout Creek Meadow and Upper Truckee Marsh within the City Boundary.

Photo 2: Looking Downstream of Outfall to Trout Creek Meadow

Photo 3: Looking Back Towards Outfall In Upper Truckee Marsh

The following uses the steps defined in the general connectivity methodology to document how connectivity factors for stormwater runoff and TMDL pollutants were developed for UPCs discharging stormwater to the Trout Creek Meadow and the Upper Truckee Marsh.

<u>Step 1 – Modify PLRM model to include Pervious Receiving Area:</u>
The baseline East Sierra Tract model, which discharges to the Trout Creek Meadow, was used for the analysis. The modeling results from the analysis were extrapolated to all UPCs discharging to the Trout Creek Meadow and the Upper Truckee Marsh. This simplification was made based on the field observations noted above that found that the characteristics of pervious receiving areas in both meadows were very similar.

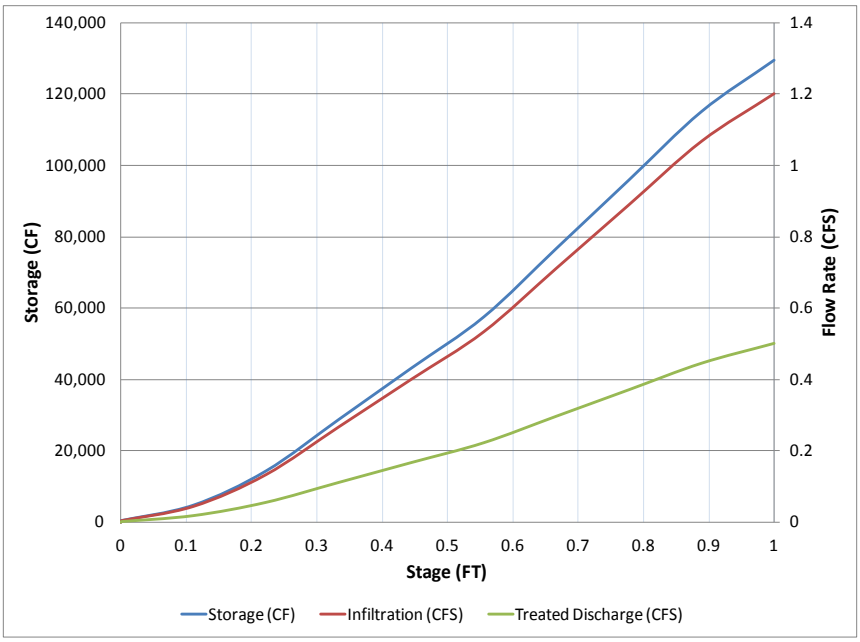
A Dry Basin was added to the model and positioned in the model to be tributary to the PLRM catchments with discharge from the Dry Basin routed to the outfall of the model.

Step 2 – Estimate the Hydrologic Function of the Pervious Receiving Area:
Using field inspection and literature review, the meadow area downstream of the urban outfalls from the East Sierra Tract UPC were surveyed to estimate:

- The maximum area of stormwater inundation = 3 acres. This estimate was made by identifying three notable outfalls to the Trout Creek Meadow from the UPC, each with roughly 1 acre of estimated inundation.
- The maximum volume of stormwater storage = 130,000 CF. This estimate was made by estimating an average maximum depth of 1 foot in the pervious receiving areas.
- Saturated hydraulic conductivity = 0.4 in/hour. This value was selected based on review of soil data in the Upper Truckee Marsh and Trout Creek Meadow and with consideration to the recommended ranges in PLRM documentation.
- A stage dependent relationship between stormwater inundation and stormwater storage = see Step 3.

Step 3 – Modify Function of Pervious Receiving Area in SWMM5:
Figure D.3 displays the estimated stage relationships for stage-storage; stage-infiltration, and stage-treated discharge. The stage-treated discharge relationship assumes a drain time of 72 hours for storage in pervious receiving areas. The relationships shown in Figure D.3 were converted to SWMM5 code and entered into the SWMM5 model.

Figure D.3 – Stage Dependent Functions (TC Meadow and UT Marsh)



Steps 4 and 5 – Adjust Infiltration for Elevated Groundwater in SWMM5:
The estimated periods of high groundwater shown in Table D.8 were used to adjust infiltration by inputting SWMM Control Rule #2 (see Attachment D.7) into the SWMM5 model.

Step 6 – Estimate Connectivity Factors from SWMM Output:
Table D.9 presents the results of the two SWMM simulations, which used the East Sierra Tract model and the characteristics of the pervious receiving area described above to estimate connectivity factors, which are applied to all highlighted catchments shown in Figure D-1 draining to the Trout Creek Meadow and the Upper Truckee Marsh.

Table D.9. Estimated Connectivity Factors for TC Meadow and UT Marsh

Model	Over Simulation Period (WY 1989-2011)			
	Stormwater Runoff (AF)	FSP (lb)	TP (lb)	TN (lb)
East Sierra Tract to Pervious Receiving Area	940	213,500	1,330	5,910
East Sierra Tract with Pervious Receiving Area to Surface Water	430	41,800	250	1,520
Connectivity Factor:	46%	20%	19%	26%

Bijou Meadow

The following characteristics of the Bijou Meadow were noted during field inspection:

- The meadow was much drier relative to the Upper Truckee Marsh and the Trout Creek Meadow, which were inspected on the same day.
- Stormwater runoff from urban outfalls is primarily discharged to a network of shallow channels throughout the meadow.
- The shallow channels eventually connect to larger irrigation channels and Bijou Creek, which is an ephemeral stream.

Photos 4 and 5 illustrate the typical characteristics of Bijou Meadow.

Photo 4: Looking south towards Rancho Circle in Bijou Meadow

Photo 5: Looking north towards Bijou Golf Course in Bijou Meadow

The following uses the steps defined in the general connectivity methodology to document how connectivity factors for stormwater runoff and TMDL pollutants were developed for UPCs discharging stormwater to Bijou Meadow.

<u>Step 1 – Modify PLRM model to include Pervious Receiving Area:</u>
PLRM models for UPCs discharging to Bijou Meadow were not developed for the City's baseline loading estimate (UPCs discharging to Bijou Meadow have extrapolated estimates of baseline loading). In order to provide a representative analysis, the "Super 8" PLRM model was used to develop estimated connectivity factors. The Super 8 model was selected because the land use conditions in the UPCs that make up the Super 8 model are very similar to land uses conditions in UPCs that drain to Bijou Meadow. The intention of selected a PLRM model with similar land use conditions was to produce a representative flow time-series of stormwater runoff that discharges to Bijou Meadow. Furthermore, the total area of UPCs in the Super 8 model is similar in size to the total area of City UPC "I6", which drains to Bijou Meadow.

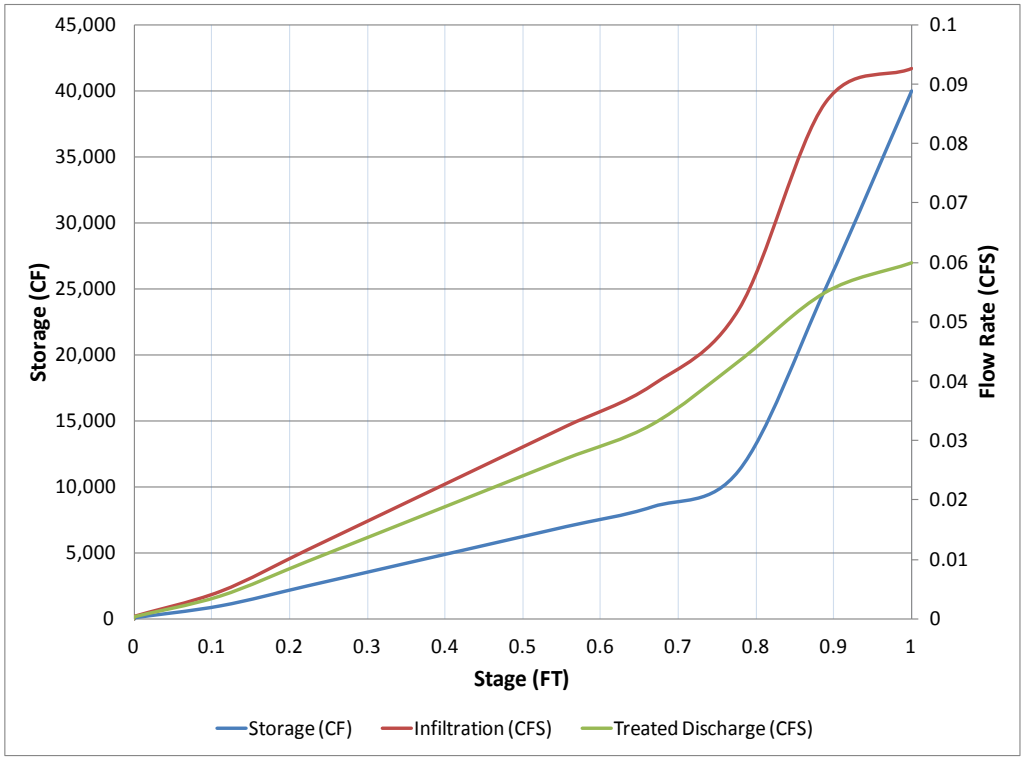
A Dry Basin was added to the Super 8 model and positioned in the model to be tributary to the PLRM catchments with discharge from the Dry Basin routed to the outfall of the model.

Step 2 – Estimate the Hydrologic Function of the Pervious Receiving Area:
Using field inspection and literature review, the meadow area and channels downstream of the urban outfalls from UPC I6 were surveyed to estimate:

- The maximum volume of stormwater inundation = 40,000 CF. This estimate was made by:
    - Estimating the length of channels from urban outfalls = 5,000 feet
    - Estimating the channel dimensions = 3 feet wide by 0.75 feet deep
    - Estimating that during overbank flows stormwater will inundate roughly 10 feet to each side of the main channel to a depth of 0.25 feet
- Saturated hydraulic conductivity = 0.2 in/hour. This value was selected based on review of previous measurements in Bijou Meadow (TBI, 2005).
- A stage dependent relationship between stormwater inundation and stormwater storage = see Step 3.

Step 3 – Modify Function of Pervious Receiving Area in SWMM5:
Figure D.4 displays the estimated stage relationships for stage-storage; stage-infiltration, and stage-treated discharge. The stage-treated discharge relationship assumes a drain time of 72 hours for storage in pervious receiving areas. The infiltration rate in the overbank area of the main channel was estimated to average 0.15 in/hour. The relationships shown in Figure D.4 were converted to SWMM5 code and entered into the SWMM5 model.

Figure D.4 – Stage Dependent Functions (Bijou Meadow)



Steps 4 and 5 – Adjust Infiltration for Elevated Groundwater in SWMM5:
The estimated periods of high groundwater shown in Table D.8 were used to adjust infiltration by inputting SWMM Control Rule #2 (see Attachment D.7) into the SWMM5 model.

Step 6 – Estimate Connectivity Factors from SWMM Output:
Table D.10 presents the results of the two SWMM simulations, which used the Super 8 model to estimate runoff to Bijou Meadow and the characteristics of the pervious receiving area described above to estimate connectivity factors for the Bijou Meadow.

Table D.10. Estimated Connectivity Factors for Bijou Meadow

Model	Over Simulation Period (WY 1989-2011)			
	Stormwater Runoff (AF)	FSP (lb)	TP (lb)	TN (lb)
Super 8 to Pervious Receiving Area	1,250	213,500	1,330	5,910
Super 8 with Pervious Receiving Area to Surface Water	700	102,600	540	2,980
Connectivity Factor:	56%	48%	41%	50%

D.5 SUMMARY OF CONNECTIVITY FACTORS AND ADJUSTED POLLUTANT LOADS

Table D.11 summarizes the connectivity factors used to refine the estimates of baseline pollutant loading and stormwater runoff reaching Lake Tahoe. Table D.11 is categorized by the area that receives the stormwater runoff.

Table D.11. Summary of Connectivity Factor Estimates

Discharge Location	Estimated Connectivity Factors			
	Stormwater Runoff Volume	FSP	TP	TN
Surface Water	100%	100%	100%	100%
Bijou Meadow	56%	48%	41%	50%
Pope Marsh	19%	19%	19%	19%
Tahoe Keys (Surface Water)	100%	100%	100%	100%
Trout Creek Meadow	46%	20%	19%	26%
Upper Truckee Marsh	46%	20%	19%	26%

Table D.12 summarizes pollutant loading and stormwater runoff with and without the connectivity factors applied. Estimates of pollutant loads and stormwater runoff with connectivity factors applied are used as the City's baseline loading estimate. Detailed tabulations showing how connectivity factors were applied to UPCs for stormwater runoff and TMDL pollutants are provided in Attachment D.7. The following points are noted:

- The connectivity factors reduced the City's estimated baseline loading to surface water by 29% for FSP (160,000 lb/year).
- The 160,000 lb/year of FSP estimated to be retained in the City's meadow systems is estimated to be distributed in the following manner: Pope Marsh = 107,000 lb/yr; Bijou Meadow = 24,000 lb/year; Upper Truckee Marsh = 14,000 lb/year; and Trout Creek Meadow = 15,000 lb/year.

Table D.12. City's Baseline Loading Estimate with Connectivity Factors

Estimate	City Baseline Loading Estimates			
	Stormwater Runoff Volume (AF/Year)	FSP (lb/year)	TP (lb/year)	(lb/year)
Annual Loading Estimate without Connectivity Factors Applied	1,630	549,000	2,500	10,470
Annual Loading Estimate with Connectivity Factors Applied	1,200	389,000	1,740	7,410

D.6 REFERENCES

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D.7 ATTACHMENTS

<u>SWWM5 Control Rule #1</u>
Pope Marsh Barrier Beach Break-outs

```
RULE R1
IF SIMULATION DATE >= 4-15-1989
AND SIMULATION DATE <= 05-15-1989
OR SIMULATION DATE >= 4-1-1993
AND SIMULATION DATE <= 5-15-1993
OR SIMULATION DATE >= 3-1-1995
AND SIMULATION DATE <= 6-30-1995
OR SIMULATION DATE >= 3-15-1996
AND SIMULATION DATE <= 5-31-1996
OR SIMULATION DATE >= 12-26-1996
AND SIMULATION DATE <= 1-26-1997
OR SIMULATION DATE >= 3-1-1997
AND SIMULATION DATE <= 6-15-1997
OR SIMULATION DATE >= 4-1-1998
AND SIMULATION DATE <= 5-31-1998
OR SIMULATION DATE >= 4-1-1999
AND SIMULATION DATE <= 5-31-1999
OR SIMULATION DATE >= 4-15-2005
AND SIMULATION DATE <= 5-15-2005
OR SIMULATION DATE >= 12-25-2005
AND SIMULATION DATE <= 1-25-2006
OR SIMULATION DATE >= 3-15-2006
AND SIMULATION DATE <= 6-15-2006
OR SIMULATION DATE >= 3-1-2011
AND SIMULATION DATE <= 6-30-2011
THEN PUMP Overflow STATUS = ON
AND PUMP Normal_Flow STATUS = OFF
ELSE PUMP Overflow STATUS = OFF
AND PUMP Normal_Flow STATUS = ON
```

<u>SWWM5 Control Rule #2</u>
Elevated Groundwater Impeding Infiltration

```
RULE R2
IF SIMULATION DATE >= 4-15-1989
AND SIMULATION DATE <= 6-15-1989
OR SIMULATION DATE >= 4-1-1993
AND SIMULATION DATE <= 6-15-1993
OR SIMULATION DATE >= 3-1-1995
AND SIMULATION DATE <= 7-31-1995
OR SIMULATION DATE >= 4-1-1996
AND SIMULATION DATE <= 6-30-1996
OR SIMULATION DATE >= 3-1-1997
AND SIMULATION DATE <= 7-15-1997
OR SIMULATION DATE >= 4-1-1998
AND SIMULATION DATE <= 6-30-1998
OR SIMULATION DATE >= 4-1-1999
AND SIMULATION DATE <= 6-30-1999
OR SIMULATION DATE >= 4-15-2000
AND SIMULATION DATE <= 5-31-2000
OR SIMULATION DATE >= 5-1-2002
AND SIMULATION DATE <= 5-31-2002
OR SIMULATION DATE >= 5-1-2003
AND SIMULATION DATE <= 5-31-2003
OR SIMULATION DATE >= 4-15-2005
AND SIMULATION DATE <= 6-15-2005
OR SIMULATION DATE >= 3-15-2006
AND SIMULATION DATE <= 7-15-2006
OR SIMULATION DATE >= 5-1-2009
AND SIMULATION DATE <= 5-31-2009
OR SIMULATION DATE >= 4-15-2010
AND SIMULATION DATE <= 5-31-2010
OR SIMULATION DATE >= 3-1-2011
AND SIMULATION DATE <= 7-31-2011
THEN OUTLET Perv_Rec_Area_GwOI SETTING = 0
ELSE OUTLET Perv_Rec_Area_GwOI SETTING = 1
```

Connectivity Factor Adjustments to Stormwater Runoff

UPC IDs	Associated PLRM Model	Outfall Discharges To:	Connectivity Factor	Surface Runoff (AF/year)	
				No Connectivity Factor Applied	After Connectivity Factor Applied
A1		Pope Marsh	19%	17	3
Airpt		UT River	100%	52	52
AT/PT		Bijou Meadow	56%	6	3
B11	Gardner Mountain	Pope Marsh	19%	62	12
B14		Pope Marsh	19%	74	14
B17	Tahoe Keys	Tahoe Keys	100%	126	126
B3		Pope Marsh	19%	2	0
B4	Eloise Basin	Pope Marsh	19%	199	38
B9		Pope Marsh	19%	26	5
C1		UT River	100%	14	14
C3		UT River	100%	51	51
C5		UT Marsh	46%	12	5
C7	Grocery Outlet	UT River	100%	16	16
C8		UT River	100%	25	25
D1		UT River	100%	53	53
D3	East Y	UT River	100%	88	88
D5		UT River	100%	9	9
E1	West Sierra Tract	UT River	100%	54	54
E4		UT Marsh	46%	41	19
F1	East Sierra Tract	TC Meadow	46%	41	19
F4		TC Meadow	46%	23	11
G1		Trout Creek	100%	42	42
G11		Lake	100%	18	18
G12	Pasadena	Lake	100%	17	17
G13		Lake	100%	42	42
G9		UT Marsh	46%	26	12
H2		Lake	100%	18	18
I1		Bijou Meadow	56%	16	9
I2		Bijou Meadow	56%	7	4
I5		Bijou Meadow	56%	31	17
I6		Bijou Meadow	56%	49	27
I8	Bijou	Lake	100%	34	34
J1	Heavenly	Ski Run Marina	100%	32	32
J13	Ski Run Marina	Lake	100%	27	27
J2 and J3	Super 8	Ski Run Marina	100%	54	54
J5 and J9	Osgood Basin	Ski Run Marina	100%	72	72
J8 and J14	Wildwood Basins1	Ski Run Marina	100%	27	27
L1		Lake	100%	6	6
M2	Stateline	Lake	100%	55	55
M3	Rocky Point	Lake	100%	33	33
STPUD		Lake	100%	35	35

Connectivity Factor Adjustments to FSP Loading

UPC IDs	Associated PLRM Model	Outfall Discharges To:	Connectivity Factor	FSP Loading (lb/year)	
				No Connectivity Factor Applied	After Connectivity Factor Applied
A1		Pope Marsh	19%	5,622	1,068
Airpt		UT River	100%	12,183	12,183
AT/PT		Bijou Meadow	48%	5,489	2,638
B11	Gardner Mountain	Pope Marsh	19%	29,733	5,649
B14		Pope Marsh	19%	19,924	3,785
B17	Tahoe Keys	Tahoe Keys	100%	13,865	13,865
B3		Pope Marsh	19%	230	44
B4	Eloise Basin	Pope Marsh	19%	66,730	12,679
B9		Pope Marsh	19%	10,321	1,961
C1		UT River	100%	7,102	7,102
C3		UT River	100%	22,808	22,808
C5		UT Marsh	20%	1,889	370
C7	Grocery Outlet	UT River	100%	8,181	8,181
C8		UT River	100%	8,863	8,863
D1		UT River	100%	15,520	15,520
D3	East Y	UT River	100%	30,047	30,047
D5		UT River	100%	4,988	4,988
E1	West Sierra Tract	UT River	100%	16,579	16,579
E4		UT Marsh	20%	12,219	2,392
F1	East Sierra Tract	TC Meadow	20%	9,234	1,808
F4		TC Meadow	20%	9,820	1,923
G1		Trout Creek	100%	24,125	24,125
G11		Lake	100%	2,339	2,339
G12	Pasadena	Lake	100%	4,402	4,402
G13		Lake	100%	15,281	15,281
G9		UT Marsh	20%	3,255	637
H2		Lake	100%	8,340	8,340
I1		Bijou Meadow	48%	4,108	1,974
I2		Bijou Meadow	48%	6,950	3,340
I5		Bijou Meadow	48%	11,074	5,322
I6		Bijou Meadow	48%	18,479	8,880
I8	Bijou	Lake	100%	16,885	16,885
J1	Heavenly	Ski Run Marina	100%	17,136	17,136
J13	Ski Run Marina	Lake	100%	10,869	10,869
J2 and J3	Super 8	Ski Run Marina	100%	18,486	18,486
J5 and J9	Osgood Basin	Ski Run Marina	100%	26,536	26,536
J8 and J14	Wildwood Basins1	Ski Run Marina	100%	2,293	2,293
L1		Lake	100%	841	841
M2	Stateline	Lake	100%	13,170	13,170
M3	Rocky Point	Lake	100%	19,455	19,455
STPUD		Lake	100%	14,102	14,102

Connectivity Factor Adjustments to TP Loading

UPC IDs	Associated PLRM Model	Outfall Discharges To:	Connectivity Factor	TP Loading (lb/year)	
				No Connectivity Factor Applied	After Connectivity Factor Applied
A1		Pope Marsh	19%	28	5
Airpt		UT River	100%	67	67
AT/PT		Bijou Meadow	41%	19	8
B11	Gardner Mountain	Pope Marsh	19%	115	22
B14		Pope Marsh	19%	106	20
B17	Tahoe Keys	Tahoe Keys	100%	139	139
B3		Pope Marsh	19%	2	0
B4	Eloise Basin	Pope Marsh	19%	297	56
B9		Pope Marsh	19%	45	8
C1		UT River	100%	27	27
C3		UT River	100%	90	90
C5		UT Marsh	19%	14	3
C7	Grocery Outlet	UT River	100%	30	30
C8		UT River	100%	38	38
D1		UT River	100%	77	77
D3	East Y	UT River	100%	123	123
D5		UT River	100%	20	20
E1	West Sierra Tract	UT River	100%	77	77
E4		UT Marsh	19%	58	11
F1	East Sierra Tract	TC Meadow	19%	58	11
F4		TC Meadow	19%	39	7
G1		Trout Creek	100%	92	92
G11		Lake	100%	20	20
G12	Pasadena	Lake	100%	26	26
G13		Lake	100%	68	68
G9		UT Marsh	19%	28	5
H2		Lake	100%	33	33
I1		Bijou Meadow	41%	22	9
I2		Bijou Meadow	41%	24	10
I5		Bijou Meadow	41%	53	21
I6		Bijou Meadow	41%	86	35
I8	Bijou	Lake	100%	64	64
J1	Heavenly	Ski Run Marina	100%	64	64
J13	Ski Run Marina	Lake	100%	47	47
J2 and J3	Super 8	Ski Run Marina	100%	87	87
J5 and J9	Osgood Basin	Ski Run Marina	100%	116	116
J8 and J14	Wildwood Basins1	Ski Run Marina	100%	13	13
L1		Lake	100%	6	6
M2	Stateline	Lake	100%	58	58
M3	Rocky Point	Lake	100%	69	69
STPUD		Lake	100%	56	56

Connectivity Factor Adjustments to TN Loading

UPC IDs	Associated PLRM Model	Outfall Discharges To:	Connectivity Factor	TN Loading (lb/year)	
				No Connectivity Factor Applied	After Connectivity Factor Applied
A1		Pope Marsh	19%	125	24
Airpt		UT River	100%	270	270
AT/PT		Bijou Meadow	50%	69	35
B11	Gardner Mountain	Pope Marsh	19%	451	86
B14		Pope Marsh	19%	485	92
B17	Tahoe Keys	Tahoe Keys	100%	691	691
B3		Pope Marsh	19%	11	2
B4	Eloise Basin	Pope Marsh	19%	1,249	237
B9		Pope Marsh	19%	171	33
C1		UT River	100%	106	106
C3		UT River	100%	353	353
C5		UT Marsh	26%	65	17
C7	Grocery Outlet	UT River	100%	107	107
C8		UT River	100%	156	156
D1		UT River	100%	344	344
D3	East Y	UT River	100%	508	508
D5		UT River	100%	70	70
E1	West Sierra Tract	UT River	100%	315	315
E4		UT Marsh	26%	251	65
F1	East Sierra Tract	TC Meadow	26%	257	66
F4		TC Meadow	26%	148	38
G1		Trout Creek	100%	348	348
G11		Lake	100%	87	87
G12	Pasadena	Lake	100%	113	113
G13		Lake	100%	278	278
G9		UT Marsh	26%	126	32
H2		Lake	100%	125	125
I1		Bijou Meadow	50%	103	52
I2		Bijou Meadow	50%	83	42
I5		Bijou Meadow	50%	230	116
I6		Bijou Meadow	50%	363	183
I8	Bijou	Lake	100%	233	233
J1	Heavenly	Ski Run Marina	100%	233	233
J13	Ski Run Marina	Lake	100%	187	187
J2 and J3	Super 8	Ski Run Marina	100%	399	399
J5 and J9	Osgood Basin	Ski Run Marina	100%	513	513
J8 and J14	Wildwood Basins1	Ski Run Marina	100%	86	86
L1		Lake	100%	33	33
M2	Stateline	Lake	100%	262	262
M3	Rocky Point	Lake	100%	266	266
STPUD		Lake	100%	207	207