RB-AR1459

RAA Subcommittee

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Modeling Presentation and RAA Subcommittee

September 17, 2013 at 12:30 PM

Los Angeles County Department of Public Works, Conference Room B
900 S. Fremont Ave, Alhambra, CA 91803

I. Introductions (5 minutes)

II. SBPAT – Ken Susilo, Geosyntec

   a. Presentation (30 minutes)
   b. Q & A (15 minutes)

III. WMMS – TJ Moon, LA County

   a. Presentation (30 minutes)
   b. Q & A (15 minutes)

IV. RAA Subcommittee Discussion

V. Action items

September 17, 2013 RAA Subcommittee Meeting

RAA Subcommittee			
9.17.2013	12:30 PM	Los Angeles County DPW	
Type of meeting	RAA Subcommittee		
Facilitator	Ivar K. Ridgeway		
Note taker	Ivar K. Ridgeway		
Attendees	RAA Subcommittee (Sign-In Sheet available upon request)		
[Agenda Topic]			
Discussion			
The question was posed to the group asking for input on what is the appropriate format for RAA meetings.			
Conclusions	The Group's consensus was the format of the September 24, 2013 was appropriate where there		
are technical presentations with a question/answer and group discussion following.			
Action Items		Person Responsible	Deadline
Finalize technical presentations/case studies for next RAA meeting.		IR w/group input	
[Agenda Topic]			
Discussion	Meeting Frequency		
Conclusions	The Group's consensus was that meetings should be held monthly to allow participants		
sufficient time to report back to Watershed Management Groups and other entities/groups.			
Action Items		Person Responsible	Deadline
None			
[Agenda Topic]			
Discussion	The RAA Group was asked to come up with issues/topics to address		
Conclusions	The Group came up with the following topics for future RAA meetings:		
1. Modeling Implementation.			
2. Non-Structural BMP Effectiveness (ex. Street sweeping, Public Education)			
3. Incorporation of New Develoopment/Redevelopment BMP Implementation			
4. Dry Weather Flow, how it is addressed?			
5. Model Input			
Action Items		Person Responsible	Deadline
Further define major topics and prioritize topics.		RAA Group	

Los Angeles County Watershed Management Modeling System

TAC Presentation

September 17, 2013

RB-AR1462

Components of the WMMS

Watershed Management Modeling System (WMMS)

LSPC
Loading Simulation Program C++
"Model"

SUSTAIN
System for Urban Stormwater Treatment and Analysis Integration
"BMP Selection Tool"

NIMS
Regional Optimization

RB-AR1463

Components of the WMMS

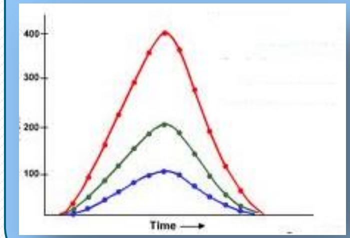
LSPC

Data

- Real Rainfall
- Stream Gage
- Monitoring
- Land Use
- Evaporation
- Infiltration
- Reservoir
- Spreading Ground
- Elevation
- Slopes

MapWindows

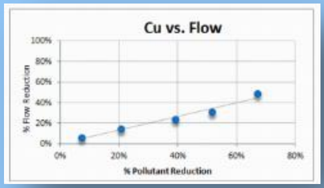
Results
Runoff
Metals
TSS
Nutrients
Bacteria*



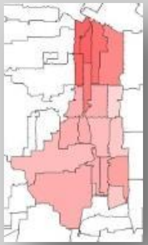
SUSTAIN

"BMP Selection Tool"

Subwatershed BMP Results



REGIONAL OPTIMIZATION

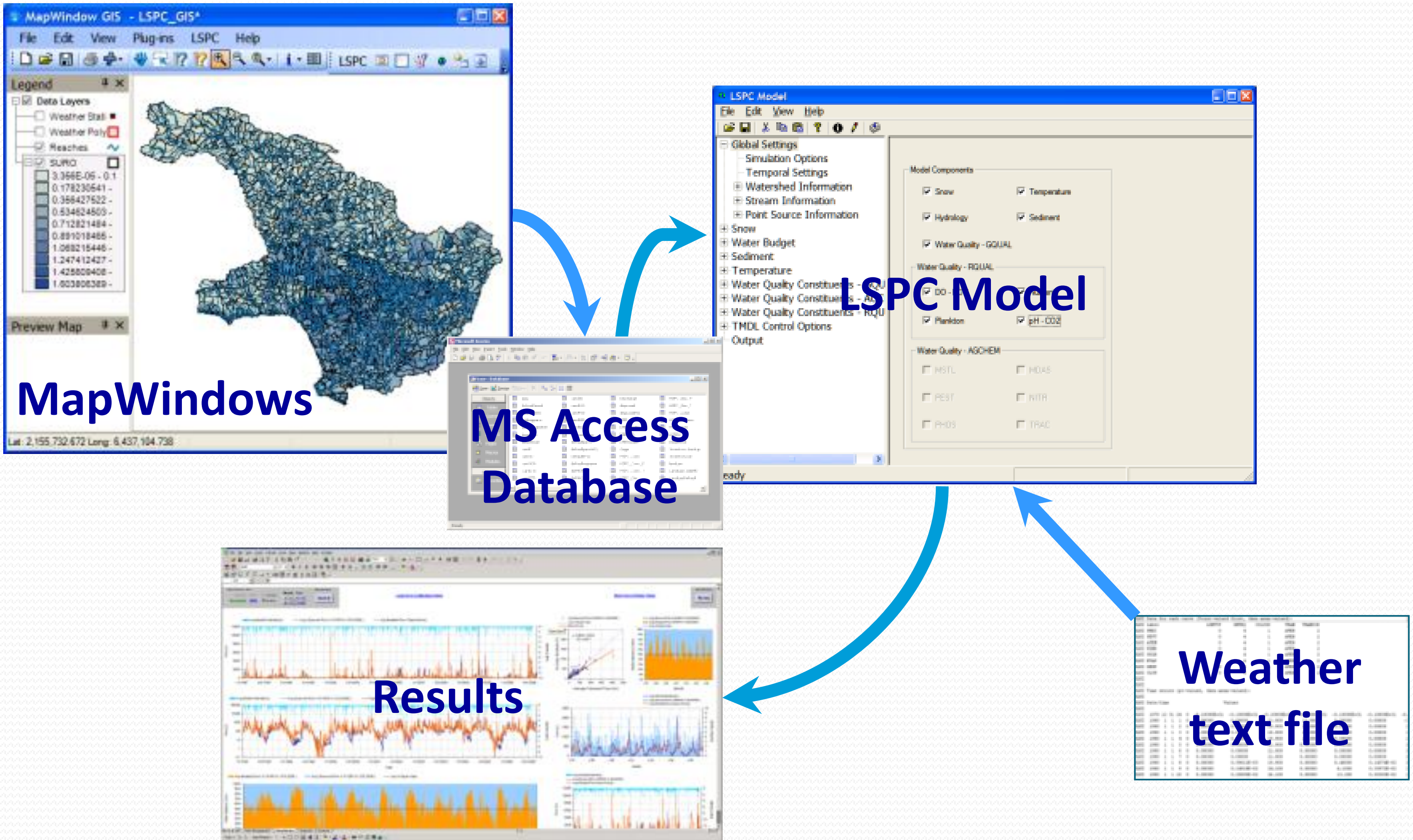


Large Scale BMP Results

RB-AR1464

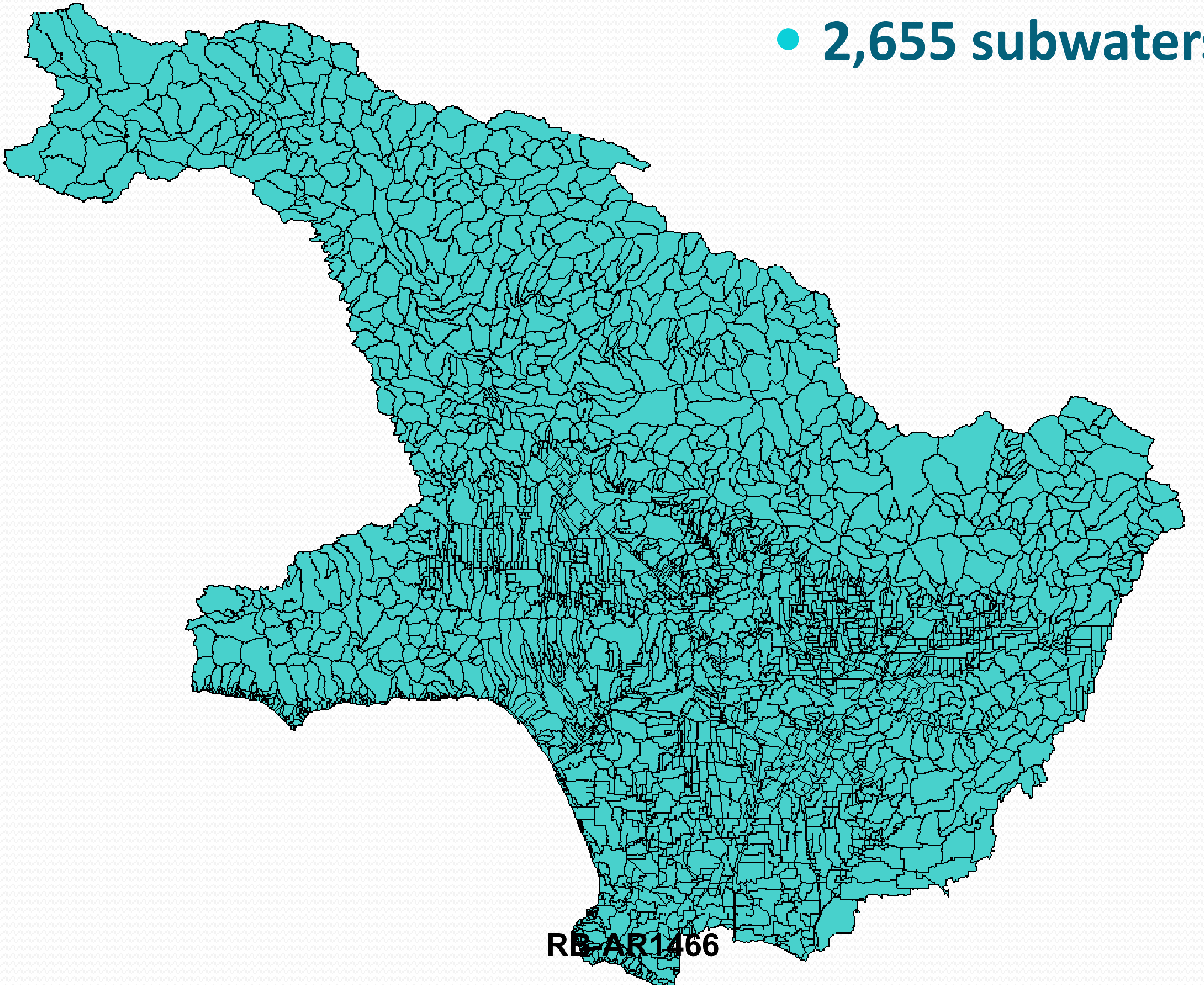
Loading Simulation Program C++

Components of LSPC



Subwatershed and Reach Representation
WMMS Resolution

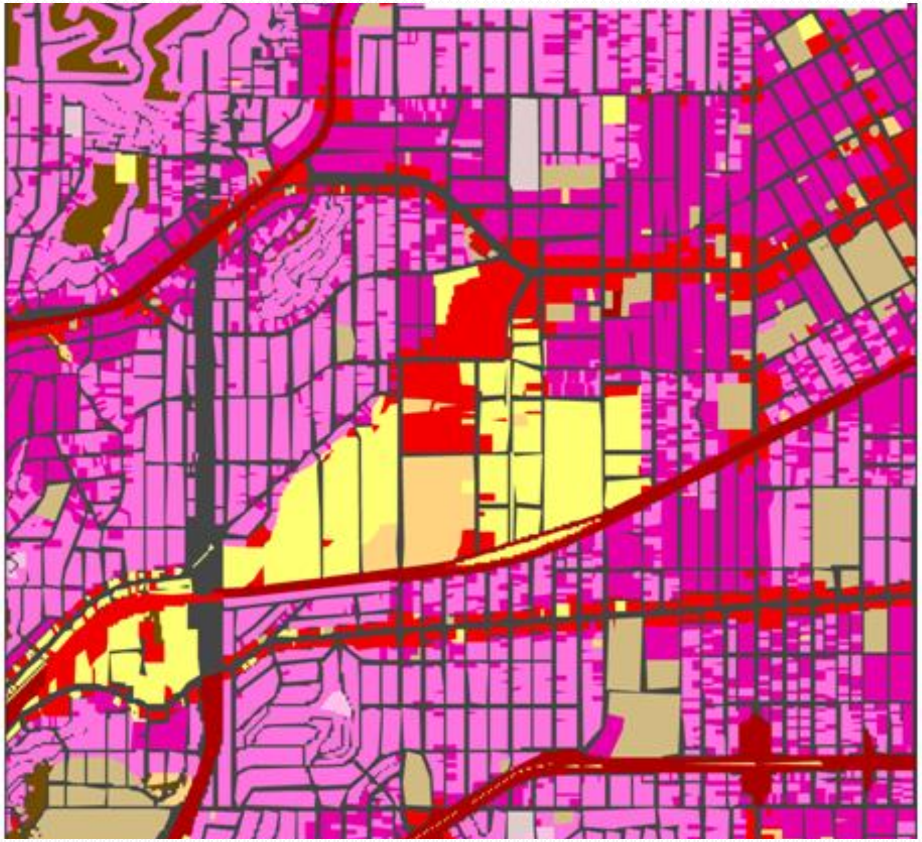
- 2,655 subwatersheds



RB-AR1466

Land Use Determination
Parcel Level Land Use Resolution

2005 SCAG Land Use



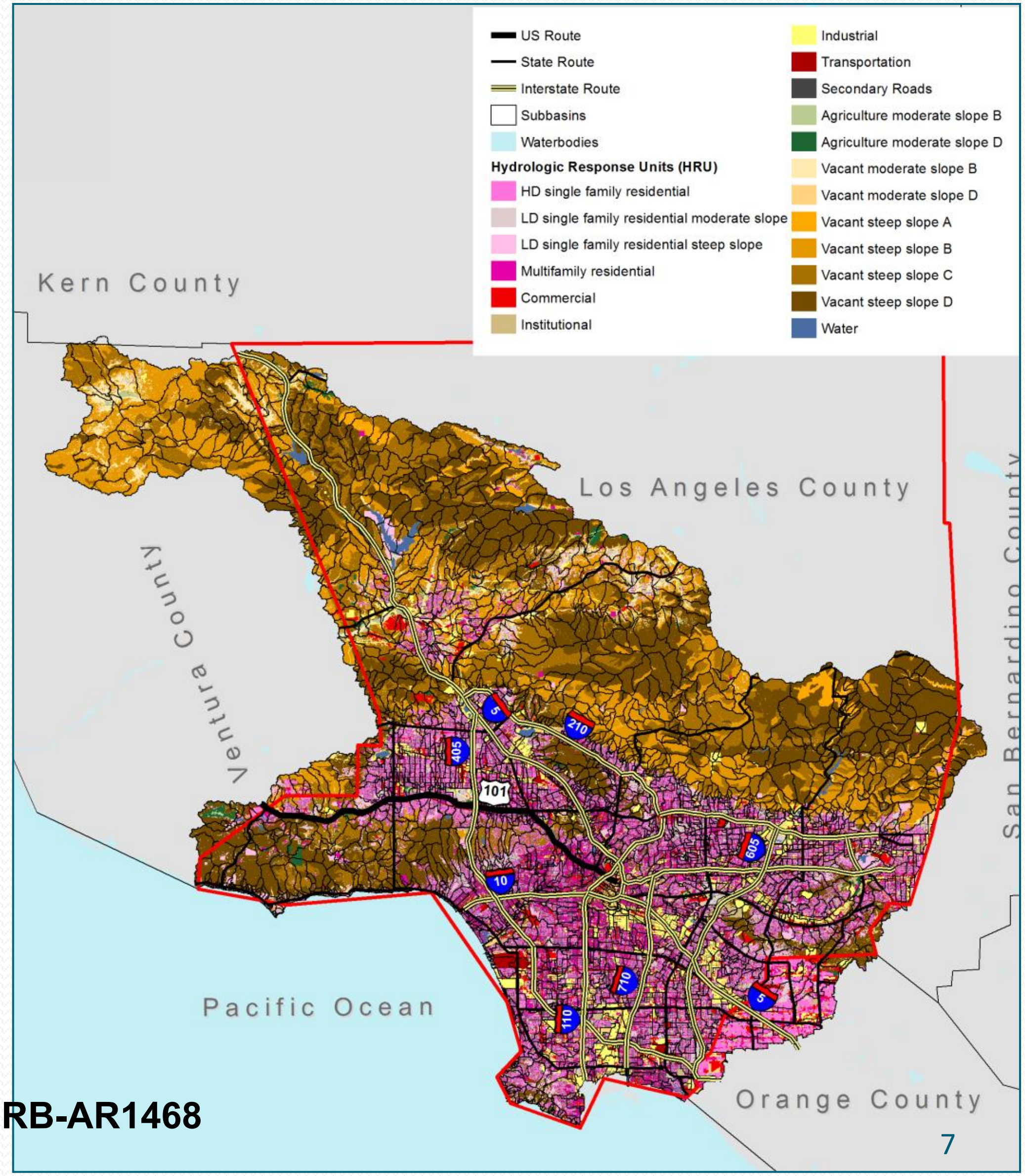
2008 WMMS Update Land Use

Hydrologic Response Unit (HRU)

HRU is the "C" in Q = CIA which incorporates

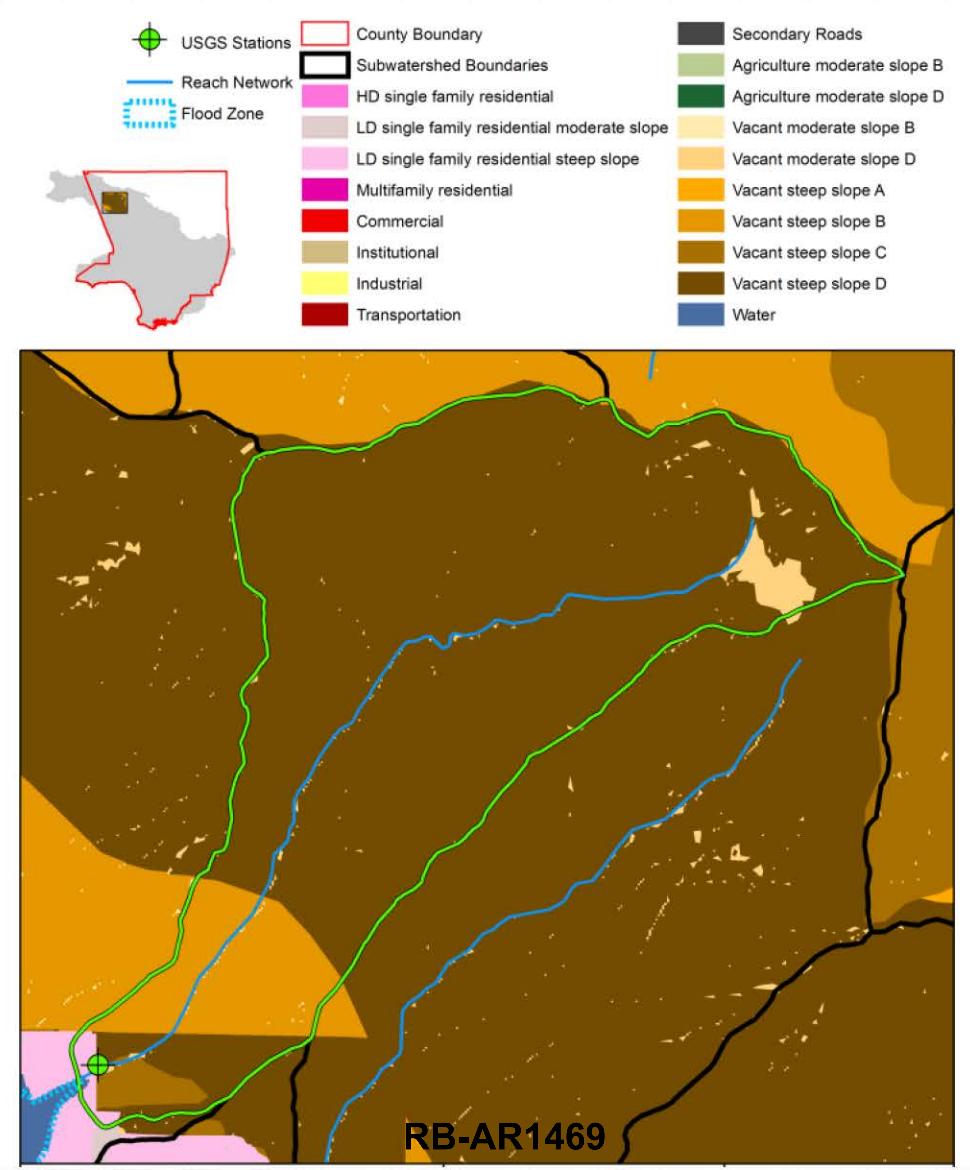
- **Land Use**
- **Slope (elevation)**
- **Soil Type**

21 Different HRU



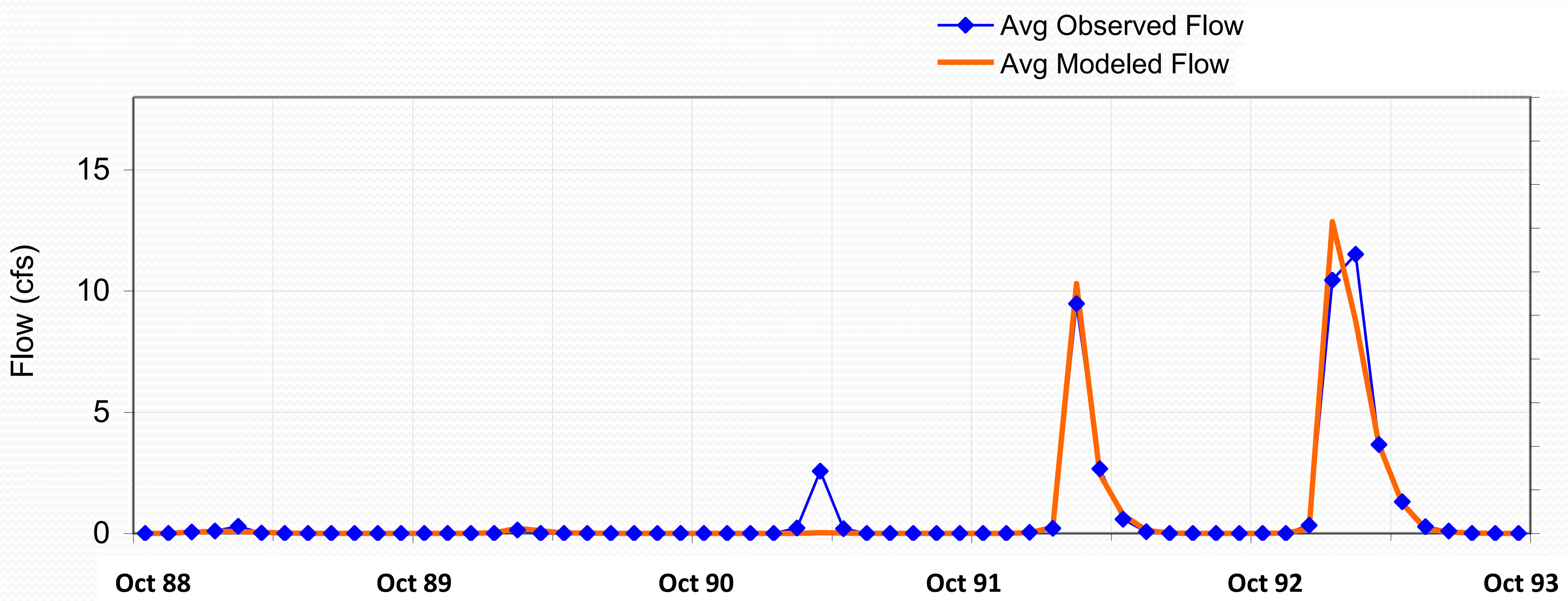
RB-AR1468

Hydrological Calibration Location
Vacant Steep Slope D



Hydrological Calibration Location

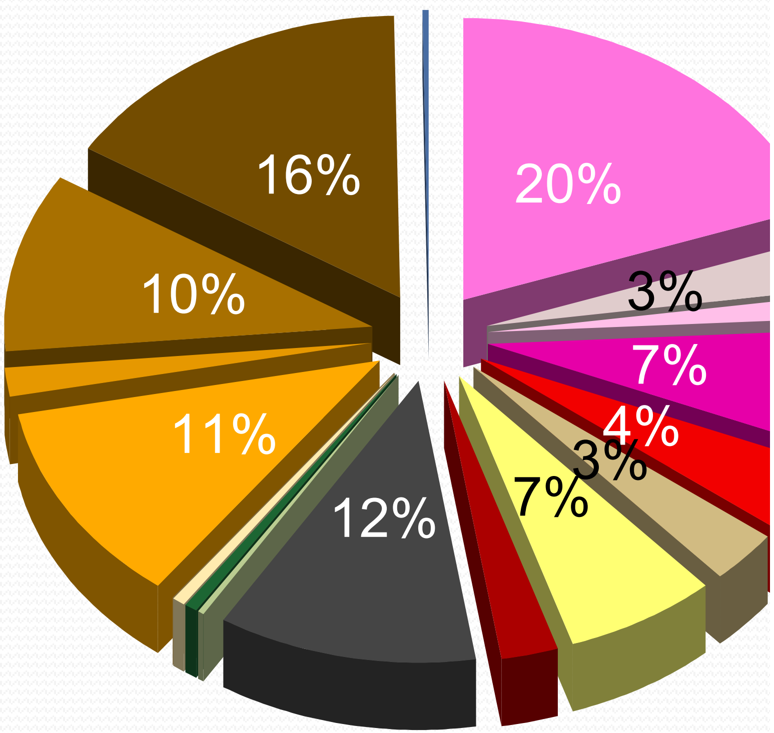
Vacant Steep Slope D

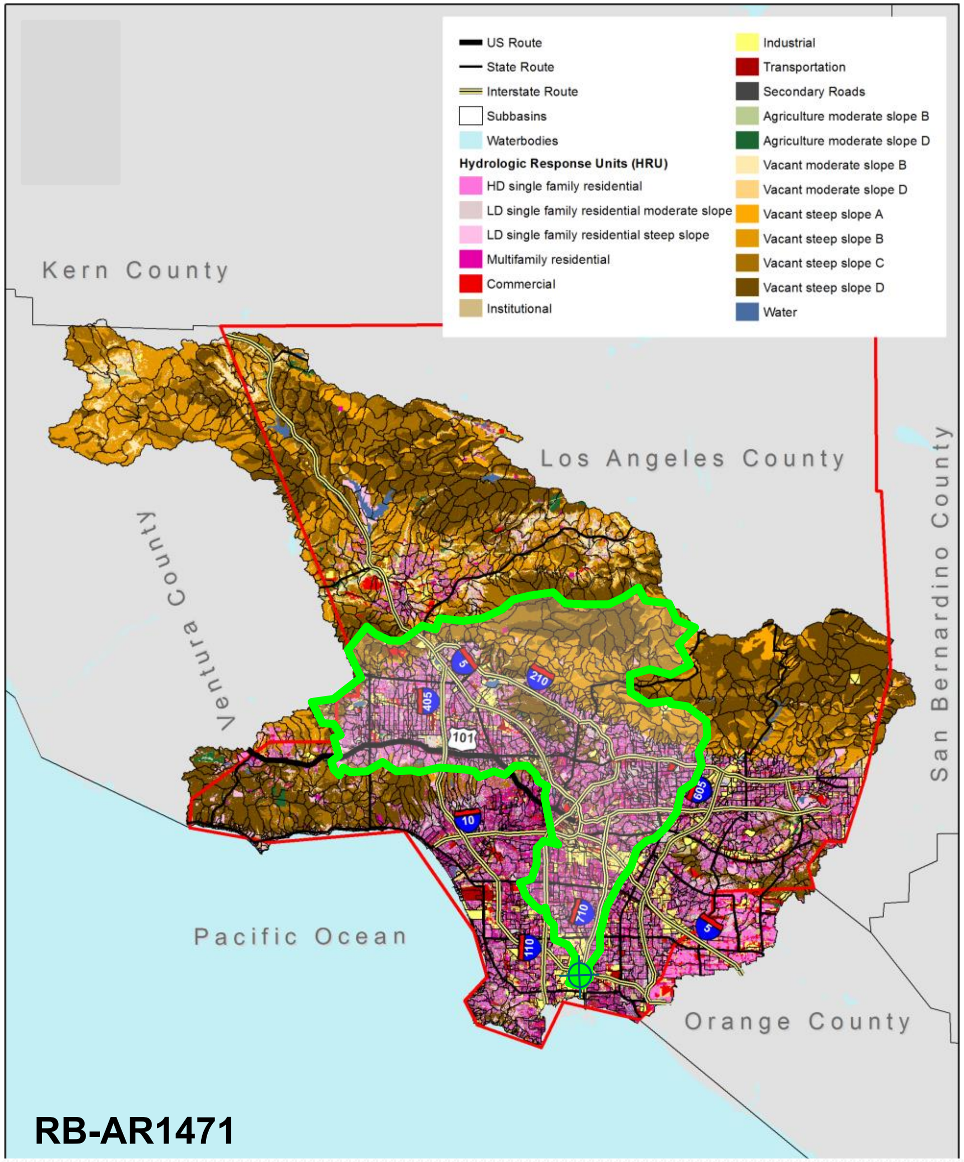


Observed vs. Modeled Flow

RB-AR1470

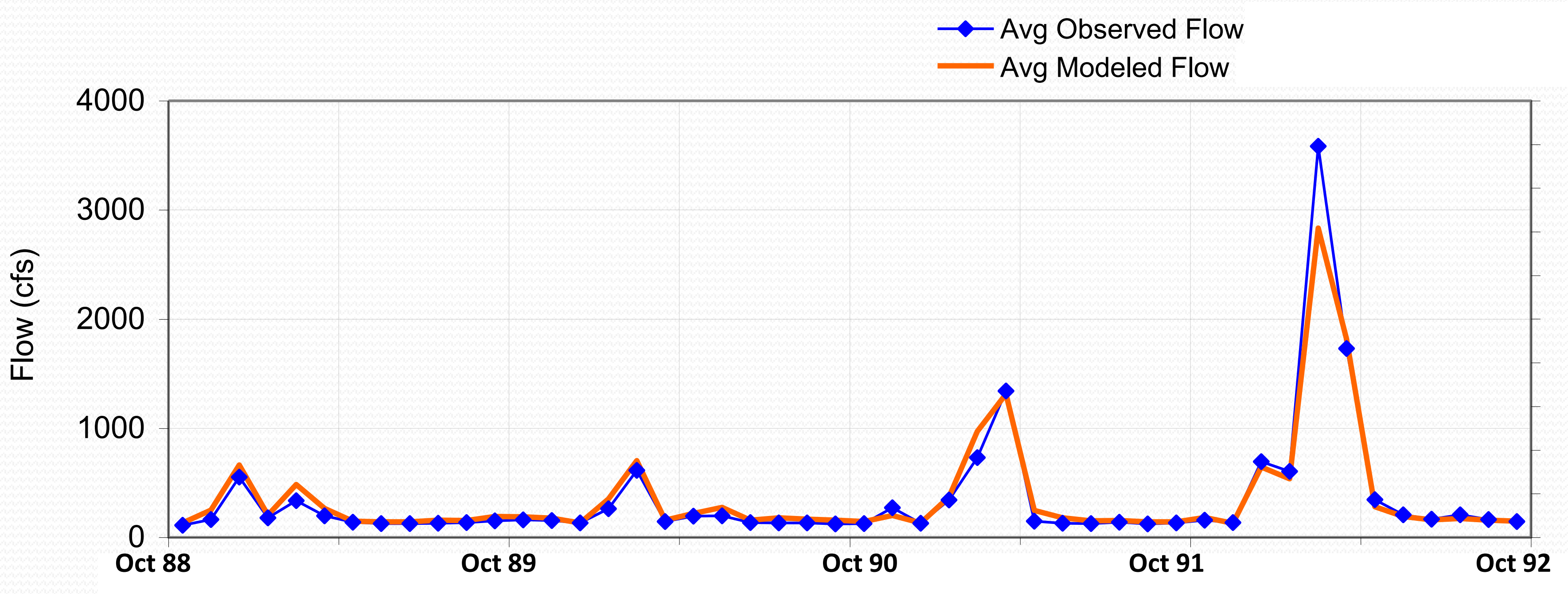
Hydrological Validation Location
Los Angeles River above Long Beach





Hydrological Validation Location

Los Angeles River above Long Beach



Modeled Flow vs. Observed Flow

RB-AR1472

Components of the WMMS

Watershed Management Modeling System (WMMS)

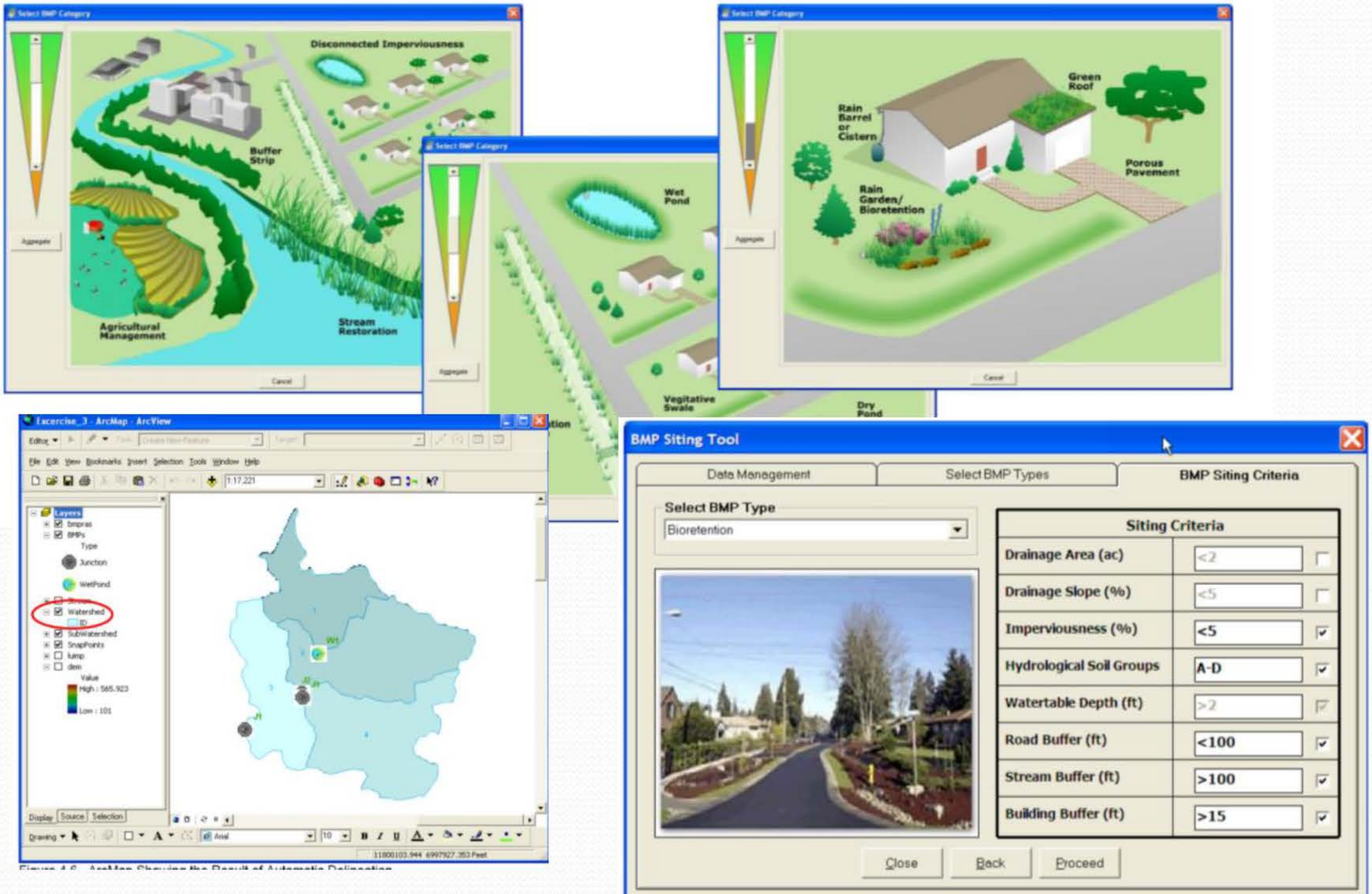
LSPC
Loading Simulation Program C++
"Model"

SUSTAIN
System for Urban Stormwater Treatment and Analysis Integration
"BMP Selection Tool"

NIMS
Regional Optimization

RB-AR1473

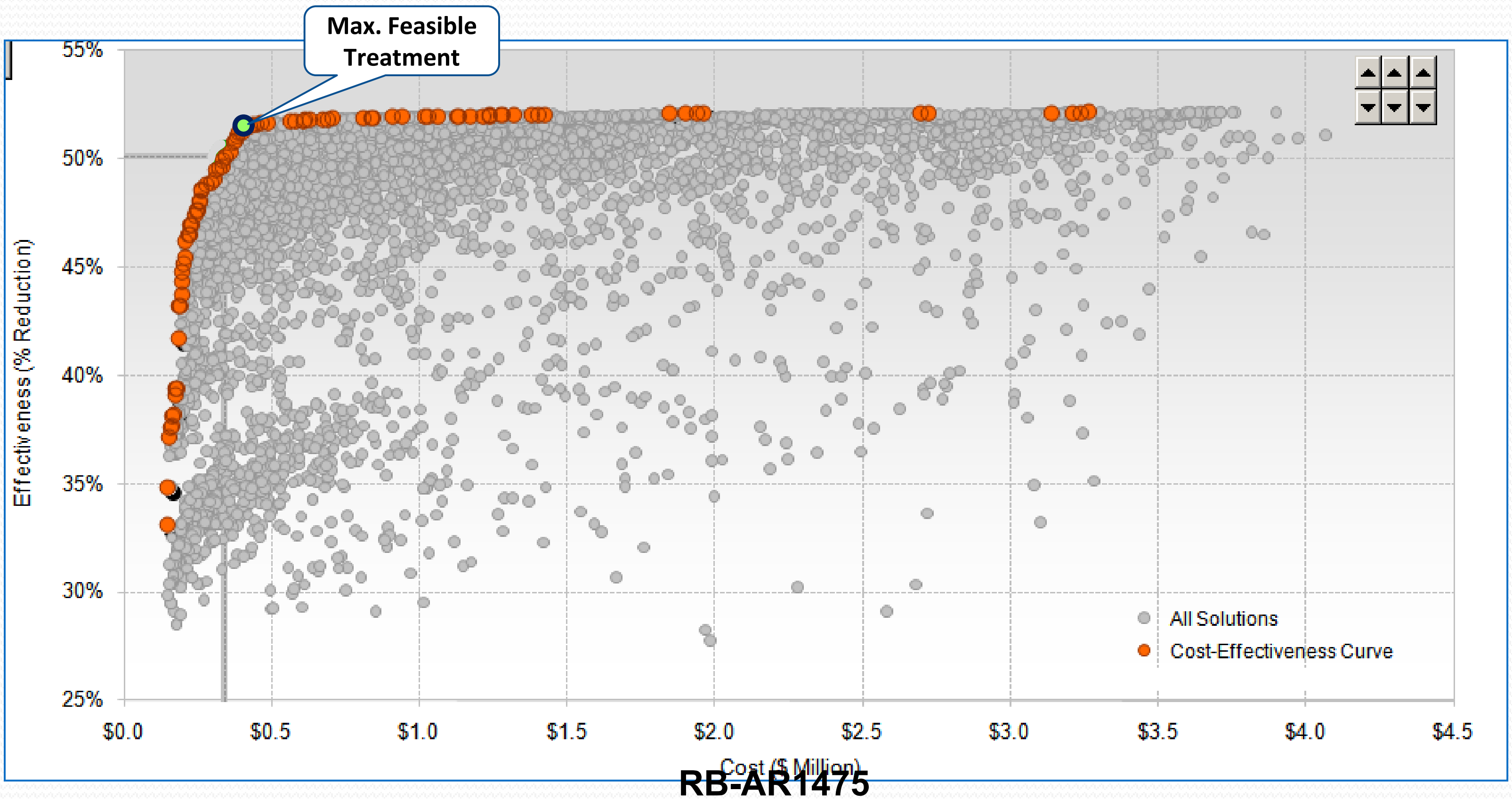
SUSTAIN
BMP Selection Tool



RB-AR1474

SUSTAIN
Cost-Effectiveness Curve

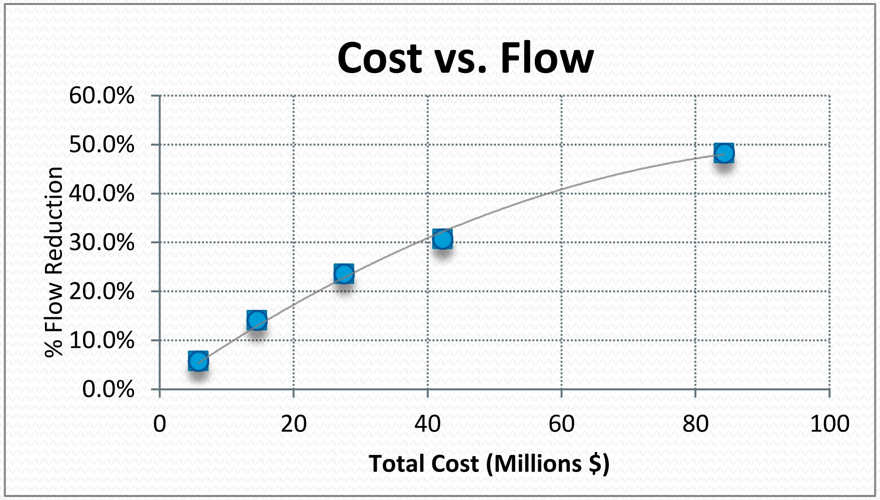
- The WMMS Post Processor calculates the most cost-effective set of BMPs for all possible BMP scenarios for each subwatershed

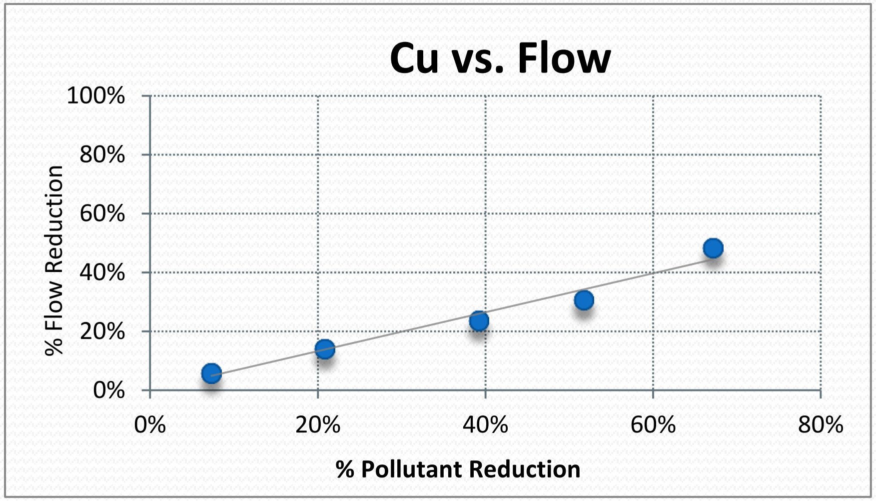


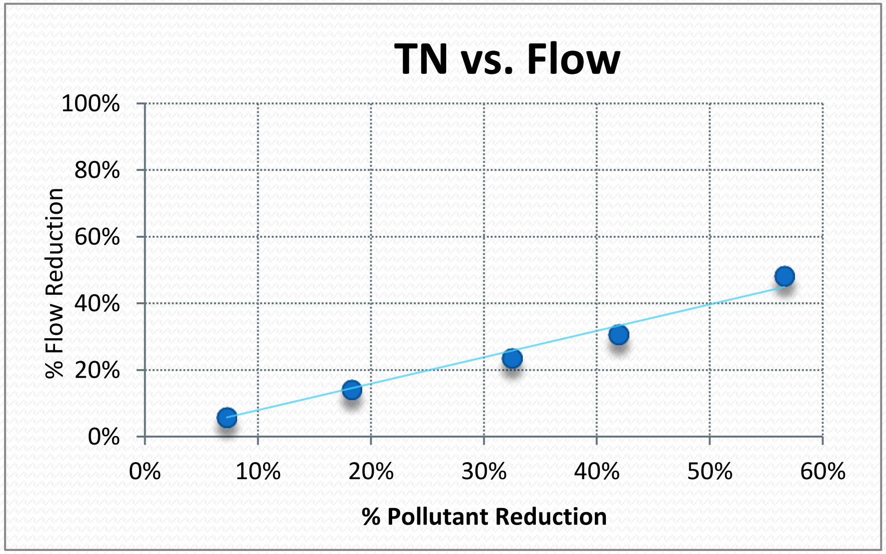
RB-AR1475

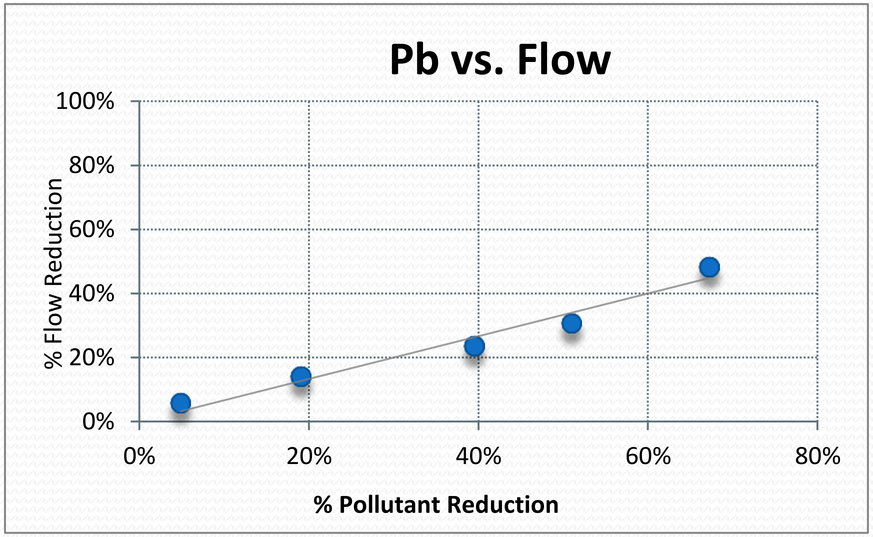
WMMS

Sample Reduction Results – BMP Selection Tool









RB-AR1476

WMMS

Sample Reduction Results – BMP Selection Tool

Subwatershed				
Land Use	**Impervious Area (ac)**	**BMP Type**	**# of Units**	**Capacity (ac-ft)**
Residential	*238.41*	Rain Barrel	0	0.00
		Bioretention	214	11.98
Commercial Industrial Institutional	*276.31*	Porous Pavement Bioretention	142 41	8.03 2.16
Transportation	*159.07*	Bioretention	158	8.72
Total Treatment Capacity (acre-ft)				**30.89**

RB-AR1477

Components of the WMMS

Watershed Management Modeling System (WMMS)

LSPC
Loading Simulation Program C++
"Model"

SUSTAIN
System for Urban Stormwater Treatment and Analysis Integration
"BMP Selection Tool"

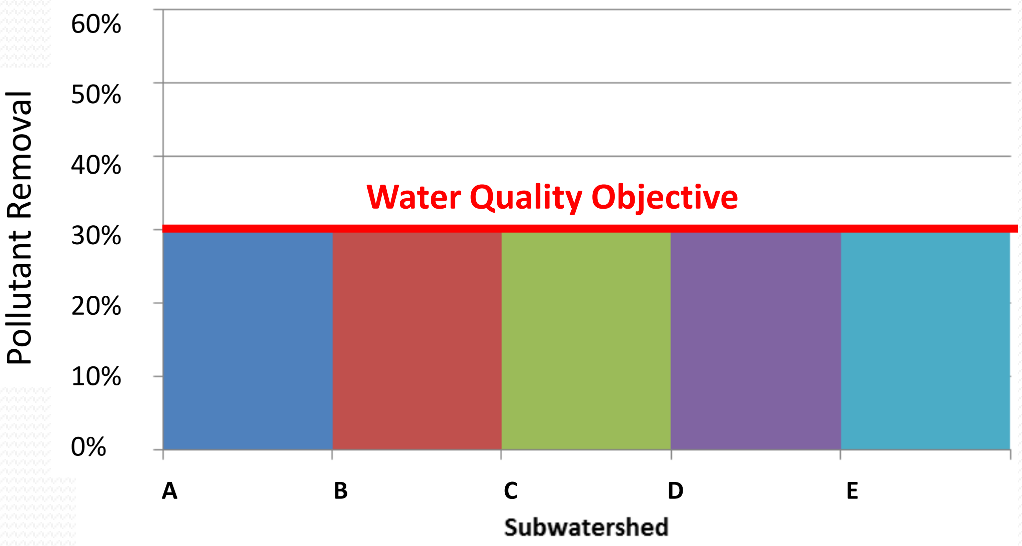
NIMS
Regional Optimization

RB-AR1478

Regional Optimization

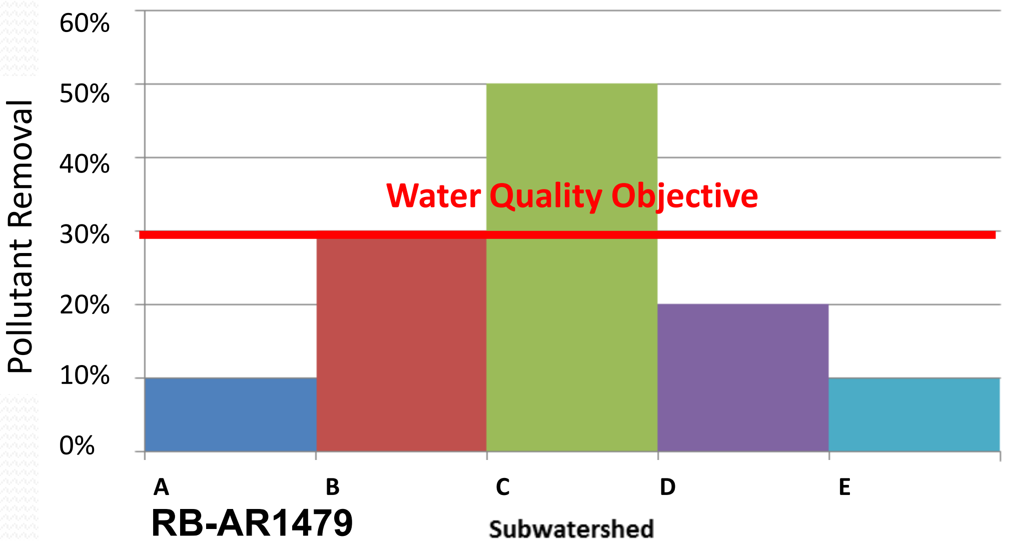
Proportional

Attain Water Quality Objective



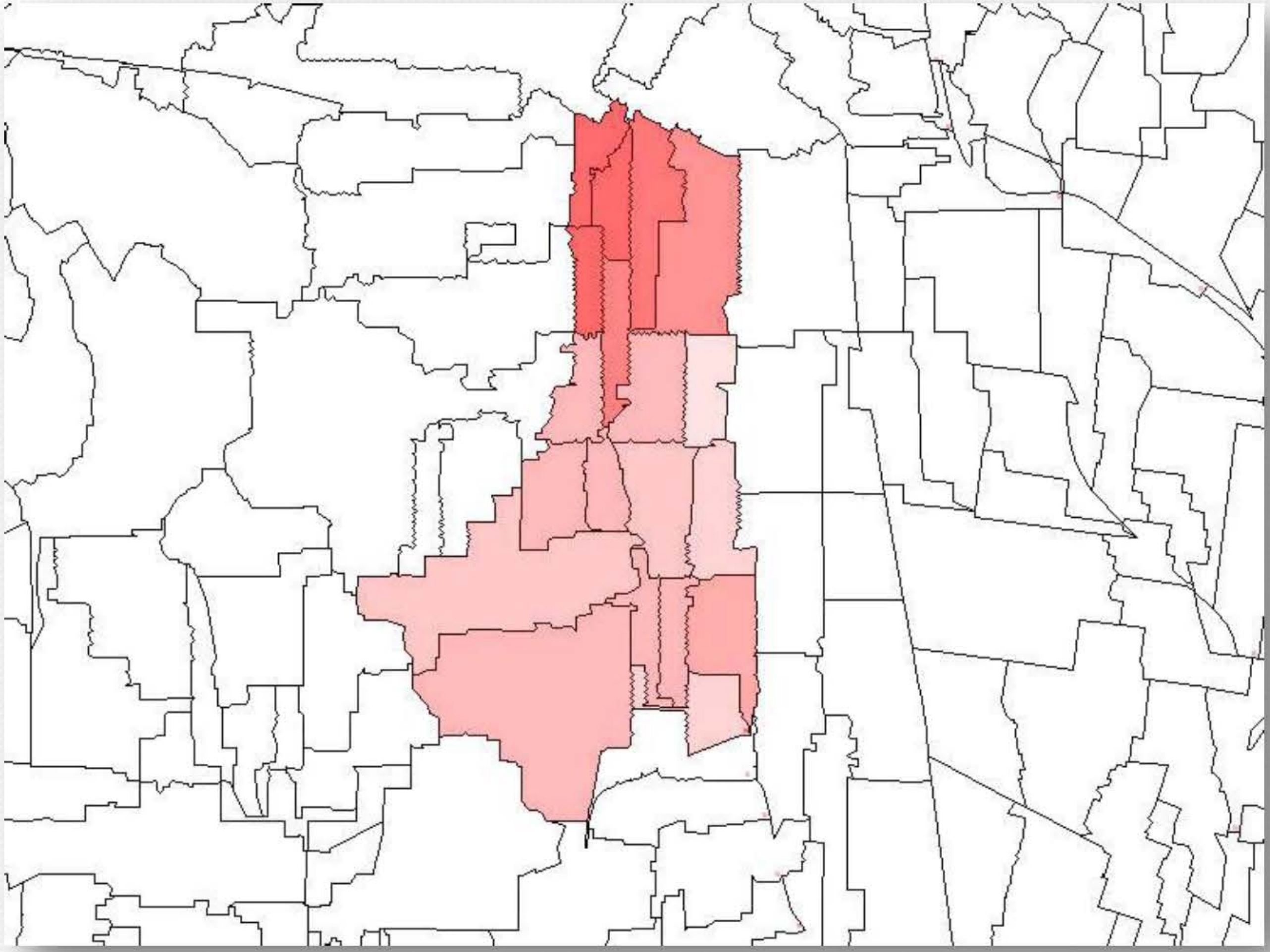
Targeted

Attain Water Quality Objective
At Lower Total Cost



Regional Optimization

Management Level Optimization Results



RB-AR1480

WMMS

Customization & Updates

LSPC

- Updating Weather Data
- Updating Land Use
- Jurisdictional Based / Non-Regional Project Modeling
- Hydrology/Water Quality Calibration

SUSTAIN

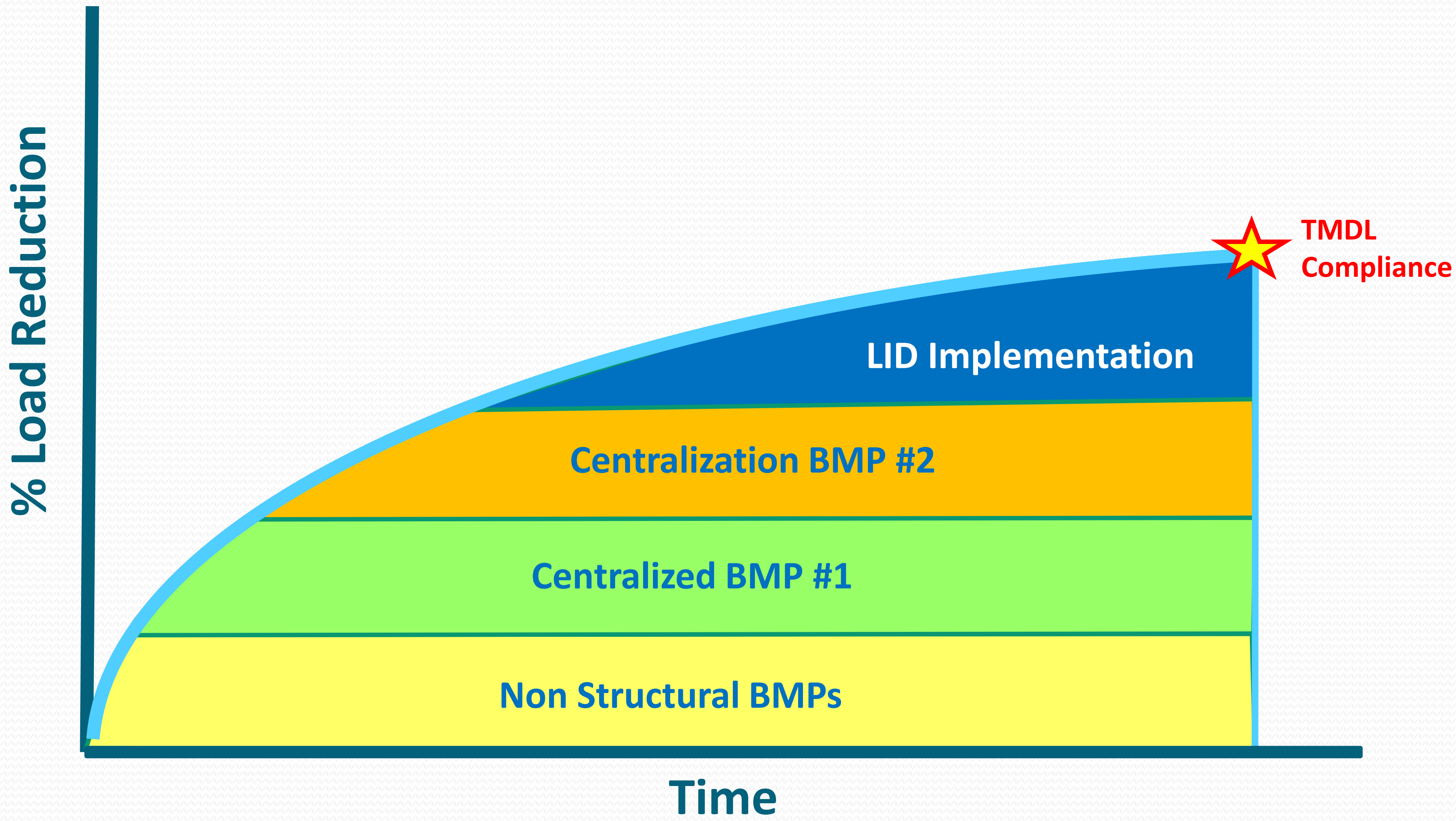
- BMP Assumptions (Effectiveness, Cost, Type)
- Cost Effectiveness Analysis

Regional Optimization

- Adjusting Compliance Targets
- Adding additional pollutants

Reasonable Assurance Analysis

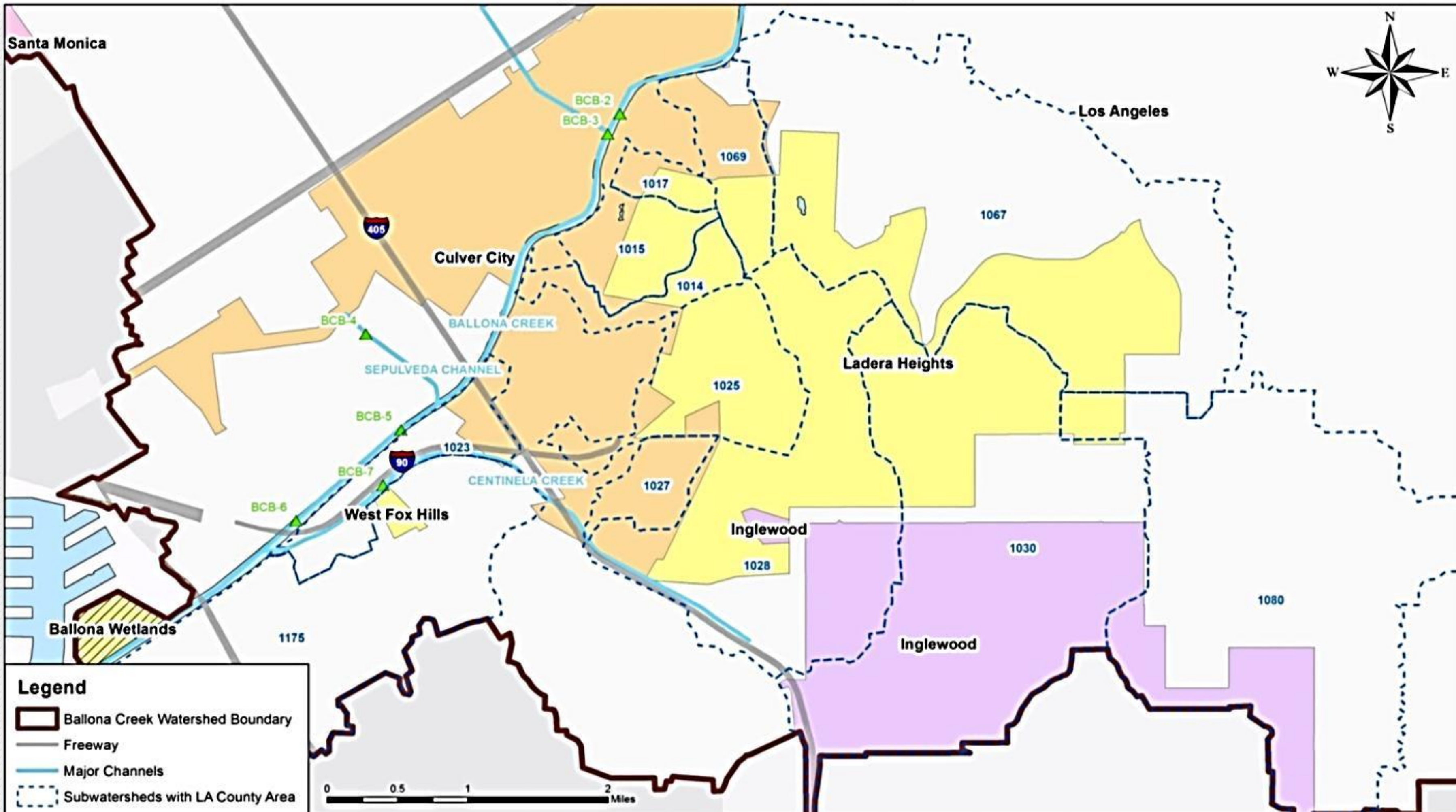
Example Timeline



RB-AR1482

WMMS - LSPC

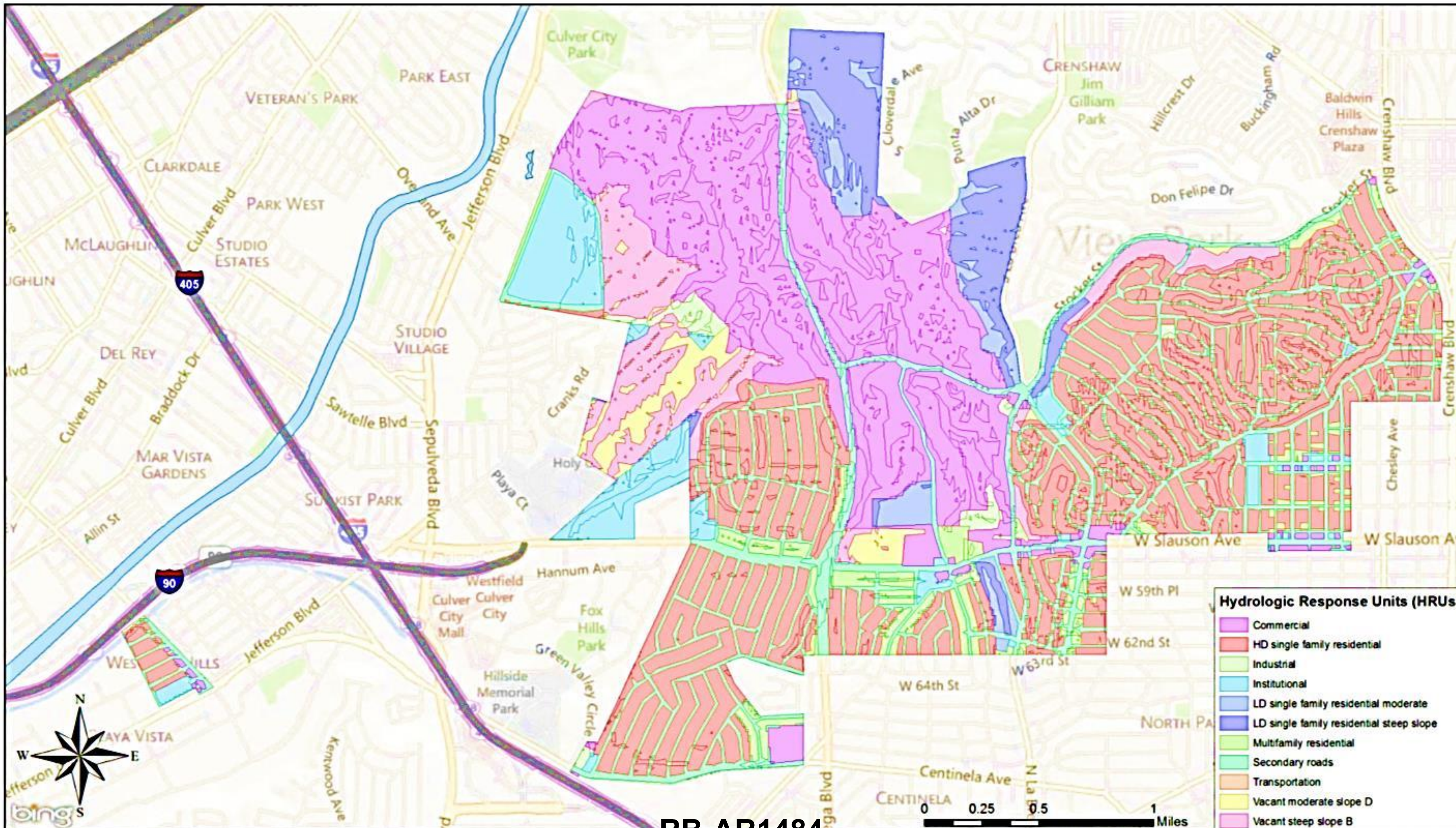
Sample Reasonable Assurance Analysis
Ballona Creek – County of Los Angeles



RB-AR1483

WMMS - LSPC

Sample Reasonable Assurance Analysis
Ballona Creek – County of Los Angeles



RB-AR1484

WMMS - LSPC

Sample Reasonable Assurance Analysis
Ballona Creek – County of Los Angeles

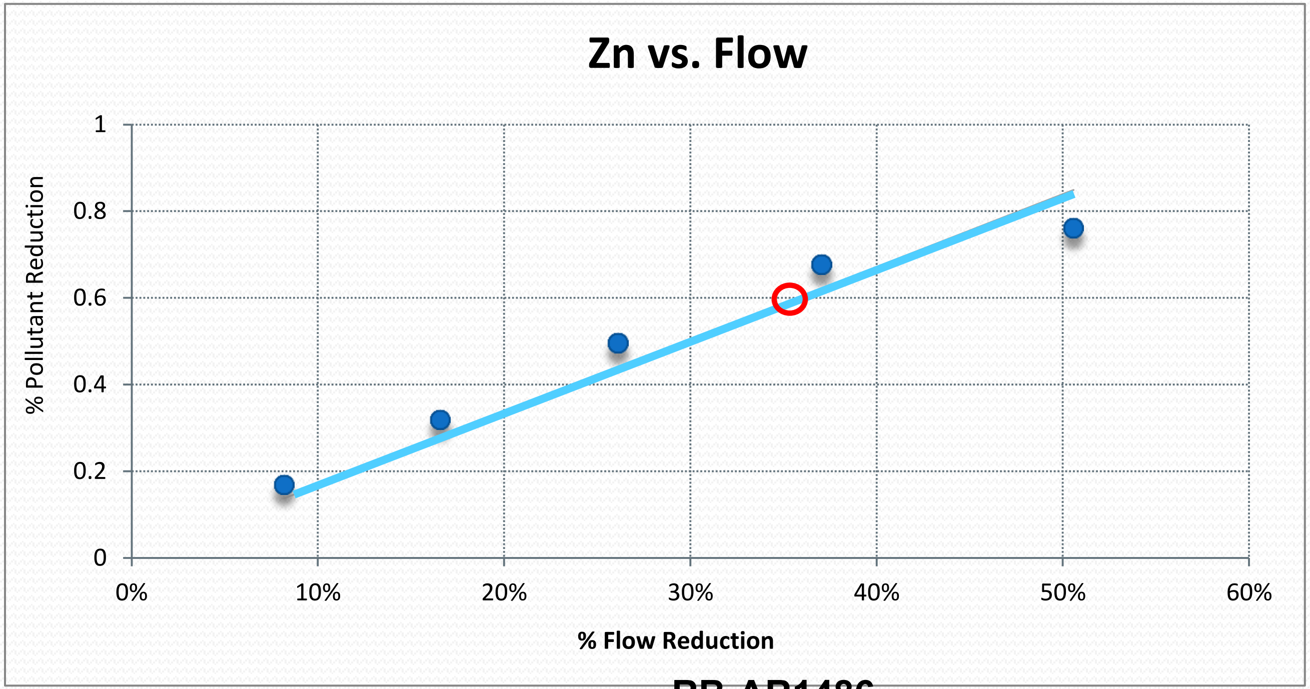
Ballona Creek Watershed	78,442 acres
County of Los Angeles	3,109 acres
County Percent of Watershed	**4%**

Ballona Creek Watershed	Zinc
TMDL Allowable Load	1003 kg/yr
TMDL Allowable County Load	40 kg/yr
County Modeled Load	**270 kg/yr**
Required Percentile Reduction	**85%**

WMMS – BMP Selection Tool

Sample Reasonable Assurance Analysis
Ballona Creek – County of Los Angeles

County Required Reduction	85%
Non-Structural Reduction*	25%
Remaining Reduction Required	**60%**



RB-AR1486

WMMS – BMP Selection Tool

Sample Reasonable Assurance Analysis
Ballona Creek – County of Los Angeles

BMPs associated with 60% Reduction from BMP Selection Tool

Land Use	BMP Type	Total Volume (ac-ft)
Residential	Rain Barrel	0.98
Residential	Bioretention	28.9
Commercial/Industrial/Institutional	Bioretention	10.8
Commercial/Industrial/Institutional	Porous Pavement	7.5
Transportation	Bioretention	16.9

WMMS – Regional Optimization

Sample Reasonable Assurance Analysis
Targeted Method

Sample Watershed	A	B	C
Required Percentile Reduction to Meet Compliance	70%	40%	20%
BMPs	**Percentile Reduction**		
Non Structural BMPs	20%	20%	20%
BMP Selection Tool	50%	20%	0%

RB-AR1488

Questions

www.LACountyWMMS.com
wmms@dpw.lacounty.gov

RB-AR1489

SBPAT:
MODELING OPTIONS IN SUPPORT OF REASONABLE ASSURANCE ANALYSES (RAA) COMPLIANT WITH R4-2012-0175 (LOS ANGELES MS4 PERMIT)

September 17, 2013
(Presented at the request of the City of Los Angeles)

RB-AR1490

Geosyntec consultants

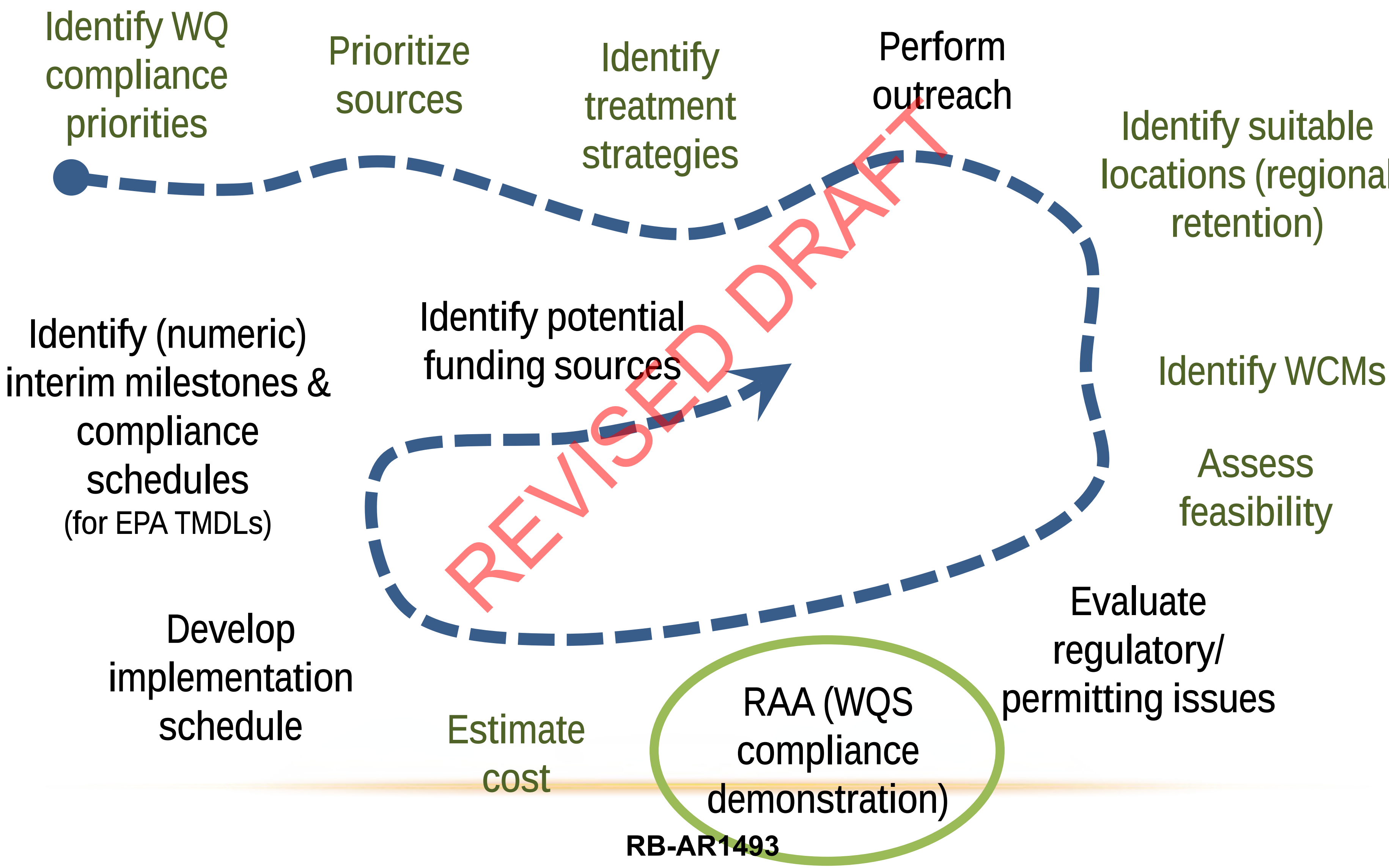
DISCLAIMER

This presentation is provided for informational purposes, and does not advocate or promote a specific approach to conducting Reasonable Assurance Analyses (RAAs). No warranty is implied or expressed. Geosyntec shall not be held responsible for any unauthorized use or redistribution. Note that the information presented herein is subject to change.

AGENDA

- Introduction to SBPAT for RAA
- Input types and inputting processes
- Target loading estimates/other implicit assumptions
- Format for information sharing, presentation, and use for decision support
- Quantified results
- Use of SBPAT results
- Target load reduction discussion
- Examples
- Potential Integration of multiple models

(Enhanced) Watershed Management Program

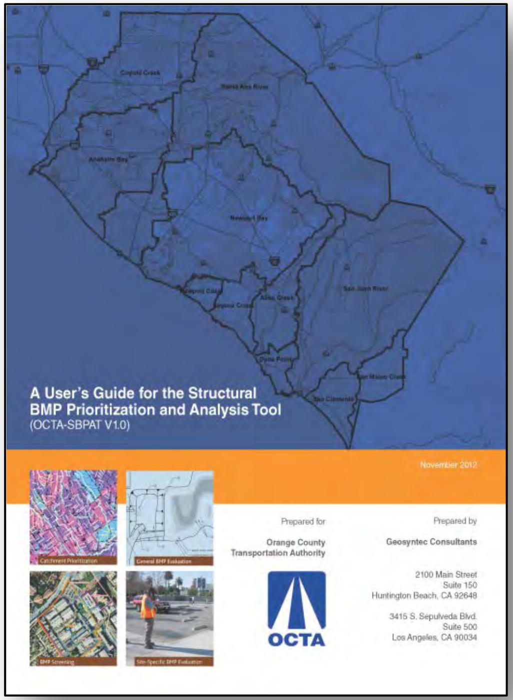


PERMIT PROVISION C.5.B.IV(5)

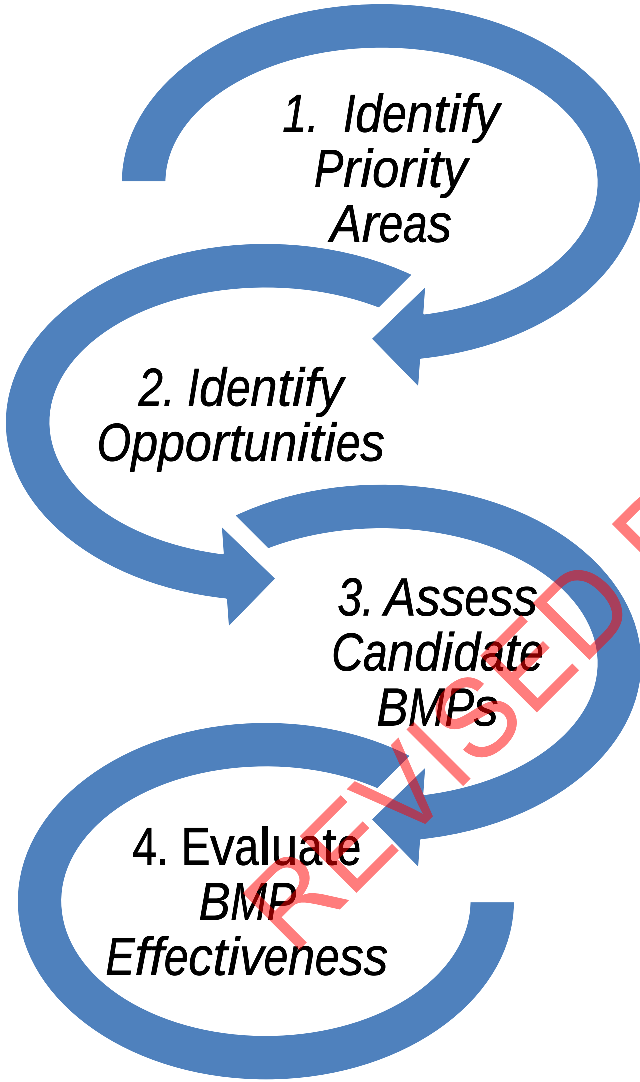
(5) Permittees shall conduct a Reasonable Assurance Analysis for each water body-pollutant combination addressed by the WatershedManagement Program. A Reasonable Assurance Analysis (RAA) shall be quantitative and performed using a peer-reviewed model in the public domain. Models to be considered for the RAA, without exclusion, are the Watershed Management Modeling System (WMMS), Hydrologic Simulation Program-FORTRAN (HSPF), and the Structural BMP Prioritization and Analysis Tool (SBPAT). The RAA shall commence with assembly of all available, relevant subwatershed data collected within the last 10 years, including land use and pollutant loading data, establishment of quality assurance/quality control (QA/QC) criteria, QA/QC checks of the data, and identification of the data set meeting the criteria for use in the analysis. Data on performance of watershed control measures needed as model input shall be drawn only from peer-reviewed sources. These data shall be statistically analyzed to determine the best estimate of performance and the confidence limits on that estimate for the pollutants to be evaluated. The objective of the RAA shall be to demonstrate the ability of Watershed Management Programs and EWMPs to ensure that Permittees' MS4 discharges achieve applicable water quality based effluent limitations and do not cause or contribute to exceedances of receiving water limitations.

STRUCTURAL BMP PRIORITIZATION AND ANALYSIS TOOL (SBPAT)

- SBPAT is:
  - Public domain, "open source" GIS-based water quality analysis tool
- Two major components:
  - Selection and Siting of BMPs
    - user-defined priorities
    - multiple pollutants
  - Quantification of pollutant reduction
    - Establishment of target load reductions (TLR)
    - Land use storm event pollutant concentrations
    - EPA-SWMM
    - USEPA/ASCE International BMP Database
    - Site and watershed-specific data
    - Monte Carlo approach



BASIC STEPS



www.sbpat.net

Original funding by agencies, SWRCB and RWQCB

RB-AR1496

1. IDENTIFY PRIORITY AREAS FOR BMP IMPLEMENTATION

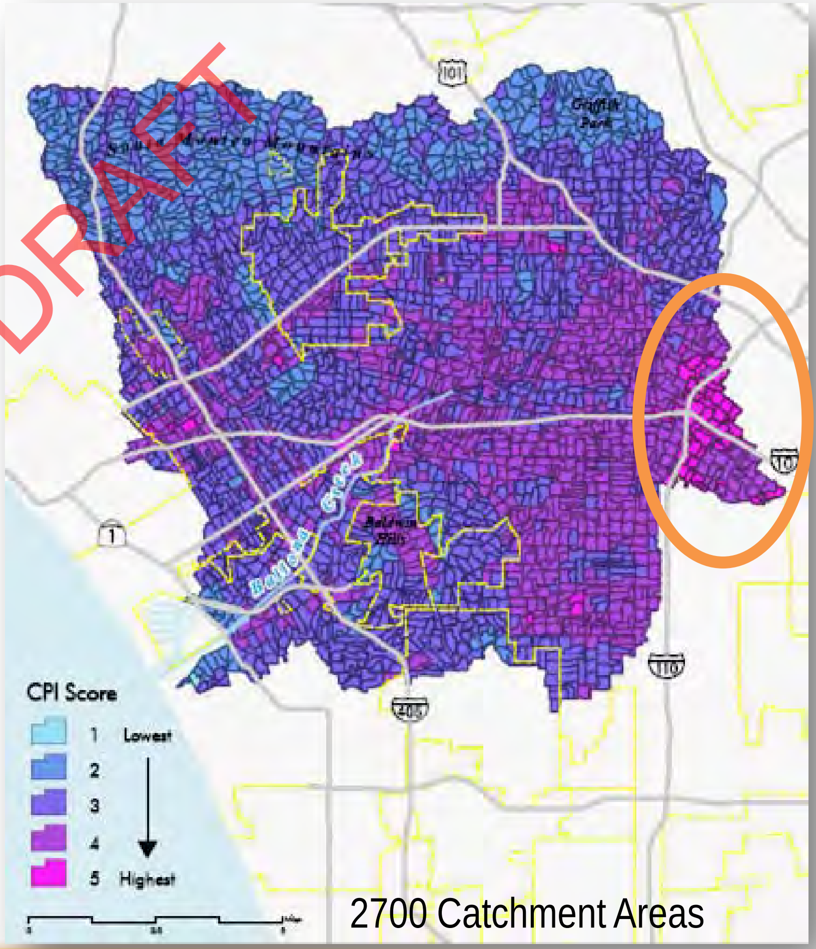
Permit Requirement

Based On

- Defined catchment areas
- Pollutant loading from catchments
- Pollutant priorities
  - severity and cause of impairments of receiving waters
  - TMDLs/303(d) listings
  - Stakeholder input

Result

- *Catchment Priority Index* (CPI) built from multiple pollutant loading model analyses



RB-AR1497

PRIORITIZATION DATA

Regularly Updated with New Data* (built in)

Pollutant Loading Based on Land Use

Land Use	Trash[10], cf/ac	Nitrate, mg/L-N	Total Copper, ug/L	Total Lead, ug/L	Total Zinc, ug/L	Fecal Coliform, MPN/100ml	TSS, mg/L
Agriculture	0.0	34.4	100.1	30.2	274.8	6.03E+4	999
Commercial	1.0	0.55	31.4	12.4	237.1	7.99E+4	67.0
Educational	1.0	0.61	19.9	3.6	117.6	7.99E+4	99.6
Industrial	1.0	0.87	34.5	16.4	537.4	3.76E+3	219
Transportation	1.0	0.74	52.2	9.2	292.9	1.68E+3	77.8
Open	0.0	1.17	10.6	3.0	26.3	6.31E+3	216.6
HDSF Residential	1.0	0.78	18.7	11.3	71.9	3.11E+4	124.2
MF Res/ Mixed Res.	1.0	1.51	12.1	4.5	125.1	1.18E+4	39.9

Simple Calculation Methodologies

$$PCPI_x = \frac{\sum_y (EMC_{x,y} * RC_y * A_y * P)}{\sum_y A_y}$$

Pollutant Priorities Reflected in Assigned Weights

Candidate Catchment Factors	Max Points
1. Rank catchment by pollutant load per unit area (5 bins each)	**50**
Trash	10
Nutrients (Nitrate)	10
Bacteria (Fecal Coliform)	10
Total Metals (Total Cu, Total Pb, Total Zn)	15
Sediment (TSS)	5
2. Multiply pollutant score by 2 if a d/s impairment, by 3 if a d/s TMDL	**x2 or x3**
3. Add 5 points for each "other" impairment (bioaccumulation, toxicity, legacy pesticides, and ecological impacts)	**20**
Theoretical maximum catchment pollutant load score	**170**

Stakeholder Driven Inputs to support prioritization**

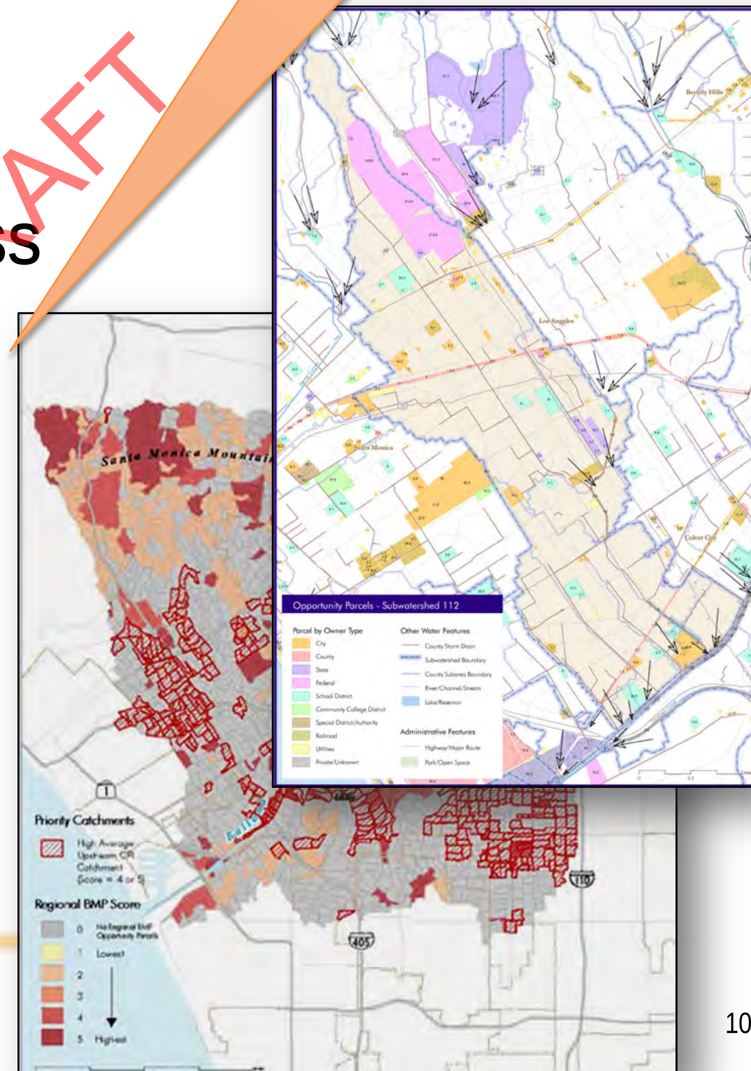
RB-AR1498

*Updated through efforts in San Diego and Orange County
**TMDL = Category 1; 303(d) = Category 2; etc.

2. IDENTIFY OPPORTUNITIES

Stakeholder Driven Inputs
(Supports Opportunity Development)

- BMP Types (Regional, Distributed, Institutional)
- Opportunity Screening Process
  - Parcels, Roadways, Storm Drains
  - BMP Opportunity Maps
    - Available Space
    - Ownership
    - Slopes, Liquefaction Zones
    - Environmental Priority
  - Link Priority to Opportunity



REGIONAL BMPS

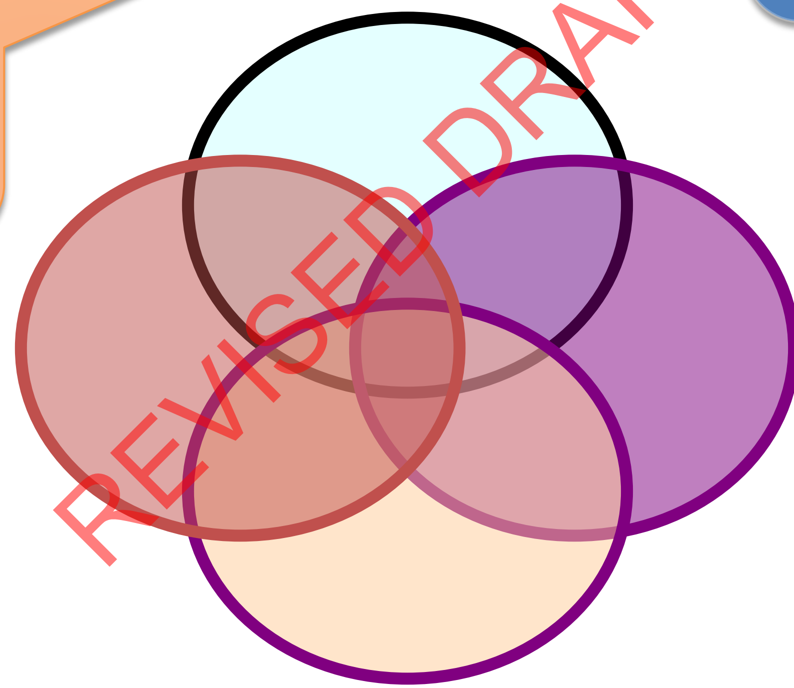
Different Infrastructure/Retrofit Conditions than Distributed BMPs
Multiple Types of Regional BMPs (such as Wetlands) Analyzed

RB-AR1500

3. ASSESS CANDIDATE BMPS

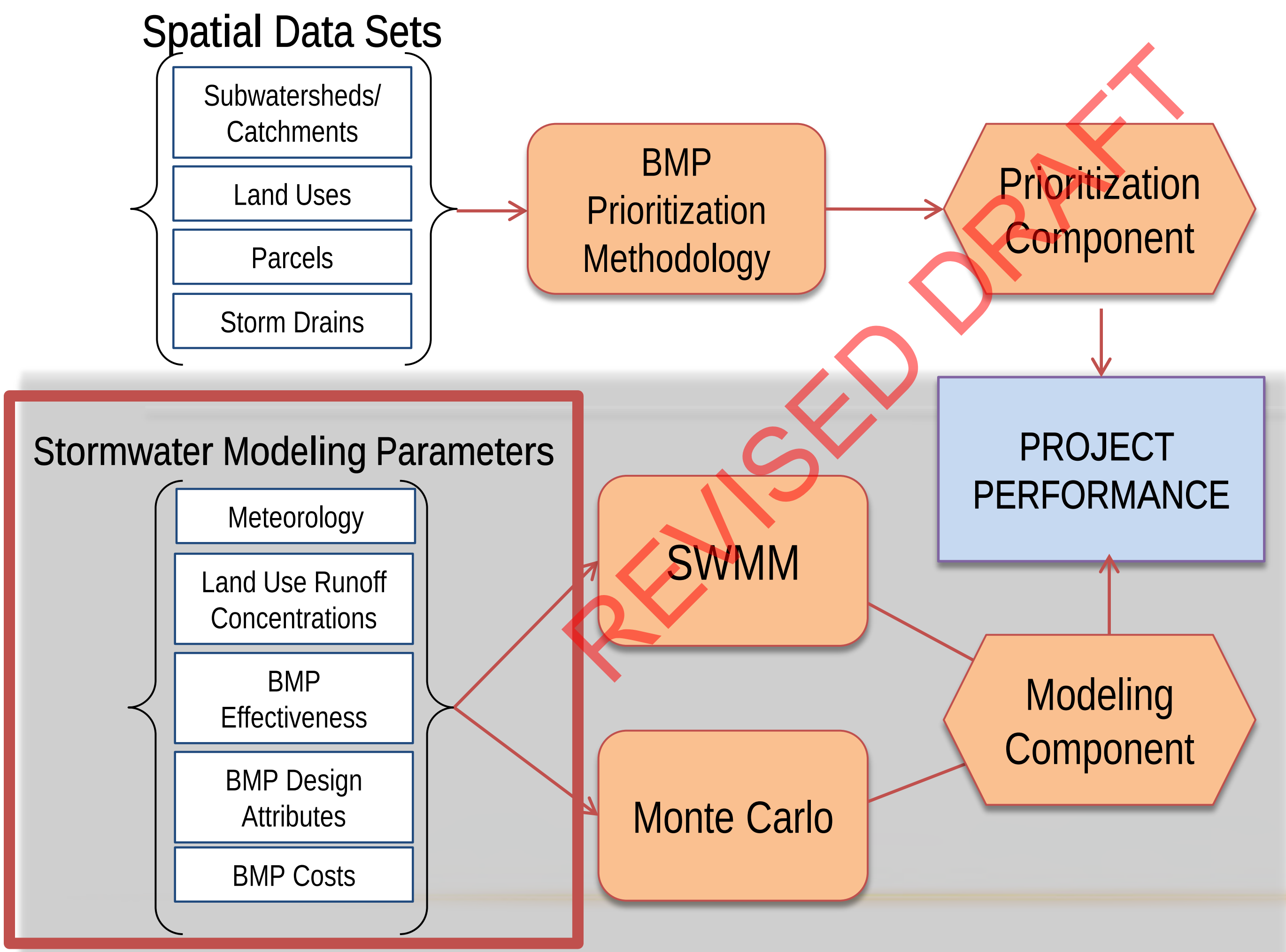
Stakeholders inform implementation priorities (relative importance)

Links *Pollutant-specific* BMP Performance to Management Priorities



RB-AR1501

4. EVALUATE BMP EFFECTIVENESS FOR REASONABLE ASSURANCE ANALYSIS



Evaluate performance relative to:

- Load reduction
- Frequency reduction
- Costs
- Risk

RB-AR1502

BMP DATABASE STATISTICS (2012 UPDATE)

INTERNATIONAL STORMWATER BMP DATABASE
www.bmpdatabase.org

International Stormwater Best Management Practices (BMP) Database Pollutant Category Summary Statistical Addendum:

TSS, Bacteria, Nutrients, and Metals

Prepared by
Geosyntec Consultants, Inc.
Wright Water Engineers, Inc.

Under Support From
Water Environment Research Foundation
Federal Highway Administration
Environment and Water Resources Institute of the American Society of Civil Engineers

July 2012

REVISED DRAFT

International Stormwater BMP Database

2.1 Total Suspended Solids

Figure 2. Box Plots of Influent/Effluent TSS Concentrations

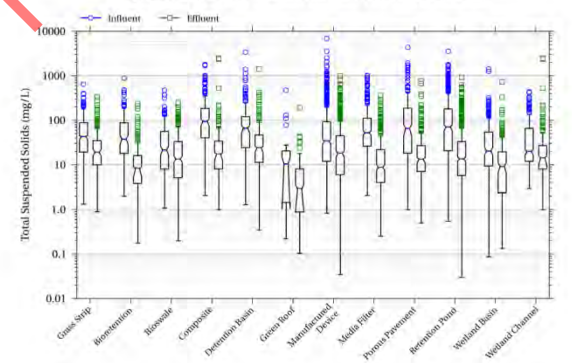


Table 2. Influent/Effluent Summary Statistics for TSS (mg/L)

BMP Type	Count of Studies and EMCs		25th Percentile		Median (95% Conf. Interval)*		75th Percentile	
	In	Out	In	Out	In	Out	In	Out
Grass Strip	19, 350	20, 286	19.3	10.0	43.1 (36.0, 45.0)	**19.1 (16.0, 21.5)****	88.0	35.0
Bioretention	14, 202	14, 193	18.0	3.8	37.5 (29.2, 45.0)	**8.3 (5.0, 9.0)****	87.8	16.0
Bioswale	21, 338	23, 354	8.00	5.12	21.7 (16.2, 26.0)	**13.6 (11.8, 15.3)****	56.0	33.0
Composite	10, 201	10, 163	40.3	8.0	94.0 (76.2, 107)	**17.4 (12.4, 18.8)****	184.0	34.0
Detention Basin	20, 278	21, 299	24.2	11.3	66.8 (52.3, 76.1)	**24.2 (19.0, 26.0)****	121.0	46.5
Green Roof	2, 20	4, 51	1.44	0.89	10.5 (1.13, 14.5)	2.9 (1.0, 3.5)	20.5	8.0
Manufactured Device	55, 923	63, 904	12.0	6.0	34.5 (30.0, 36.8)	**18.4 (15.0, 19.9)****	93.0	45.0
Media Filter	28, 442	29, 409	26.2	4.0	52.7 (45.9, 58.2)	**8.7 (7.4, 10.0)****	112.0	22.0
Porous Pavement	14, 246	23, 406	18.3	7.08	65.3 (45.0, 80.3)	**13.2 (11.0, 14.4)****	186.7	27.0
Retention Pond	47, 725	48, 723	20.7	5.72	70.7 (59.0, 79.0)	**13.5 (12.0, 15.0)****	180.0	33.0
Wetland Basin	15, 301	17, 305	9.4	2.36	20.4 (16.6, 24.4)	**9.06 (7.0, 10.9)****	54.4	19.5
Wetland Channel	8, 189	8, 154	12.0	8.0	20.0 (17.0, 22.0)	**14.3 (10.0, 16.0)****	66.0	27.0

*Computed using the BCa bootstrap method described by Efron and Tibshirani (1993)
**Hypothesis testing in Attachment 2 shows statistically significant decreases for this BMP category.

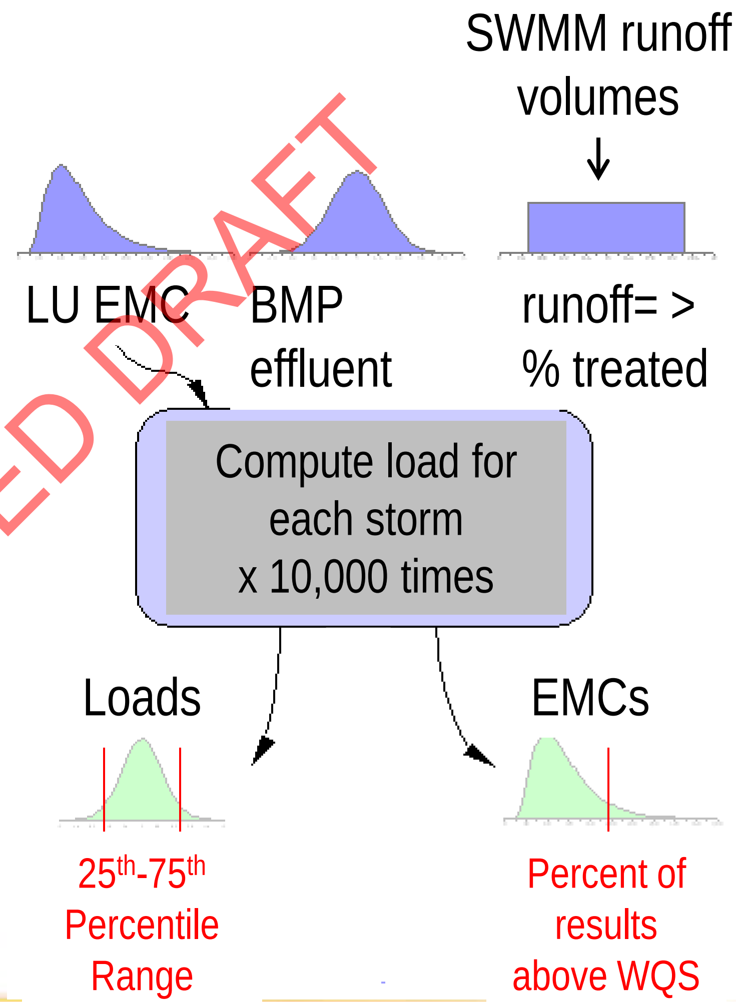
Pollutant Category Summary Addendum
July 2012
Page 5

RB-AR1503

STORMWATER MODELING ELEMENTS

- EPA SWMM4.4h (modified) accounts for:
  - Continuous hydrologic response and hydrologic performance of BMPs
  - Antecedent moisture conditions
  - Transient storage conditions
- Monte Carlo event simulation accounts for:
  - Tributary area properties
  - Interdependence of selected distributed/regional BMP types
  - Antecedent conditions
  - BMP volume, treatment rates, volume reduction processes and transient storage conditions
  - Observed variability in runoff quality
  - Observed variability in BMP effluent quality

WHAT IS MONTE CARLO?



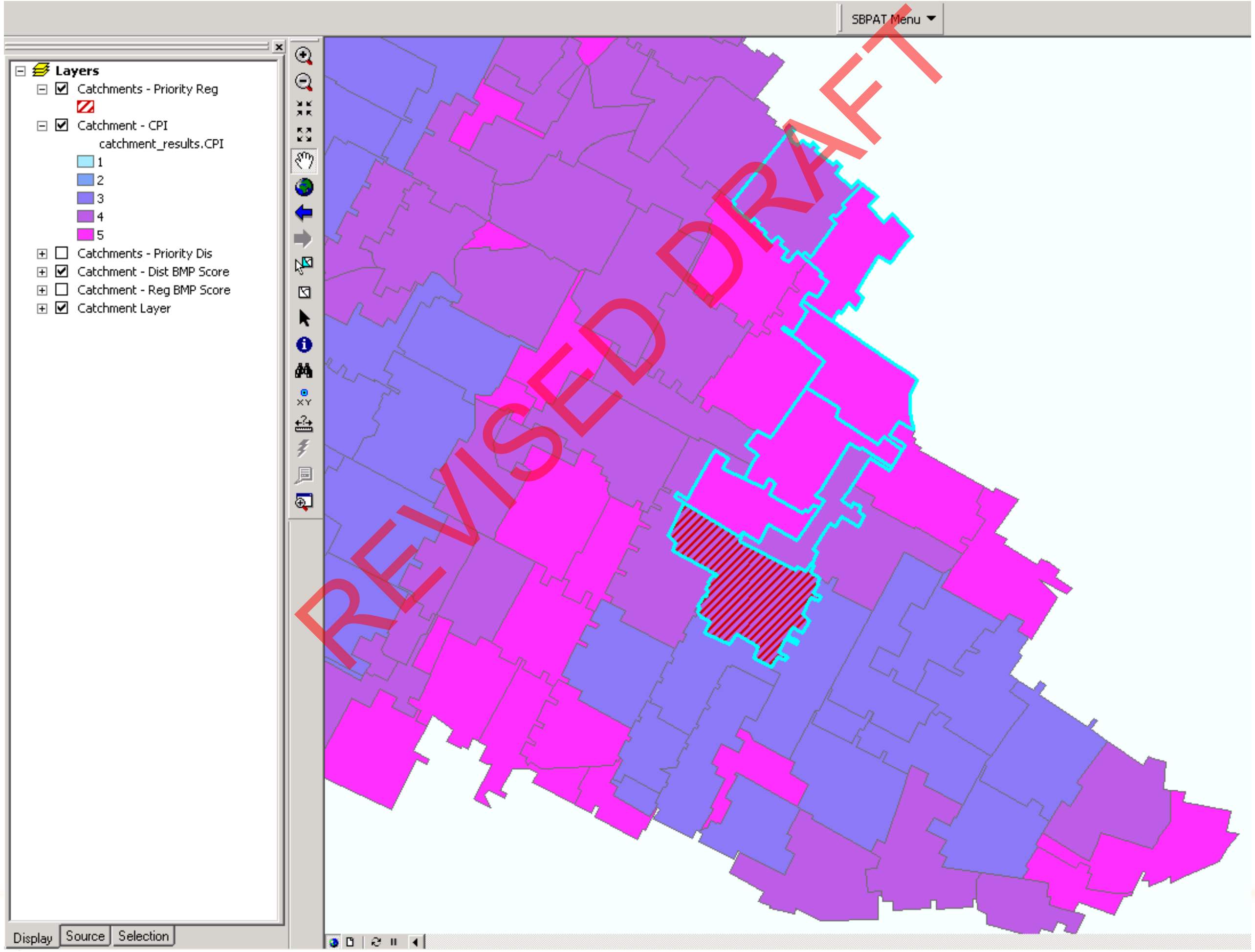
RB-AR1505

HOW TO USE SBPAT OUTPUT

- Establish target load reductions
- Build menu of structural BMPs
  - Performance, costs, uncertainties quantified
  - Provide transparent understanding of "role" of each menu item in phased compliance strategy
- Demonstrate target load reductions have been met (event, annual, and long term basis)
  - Describe variability and associated uncertainty

RB-AR1506

EXAMPLE SELECTED STUDY AREA



RB-AR1507

EXAMPLE CATCHMENT LAND USES

Land Use Group	Acreage
Commercial	55.4
Education	20.9
Industrial	103.2
MF Residential	39.4
Transportation	16.1
Vacant/Open Space	2.7
Total	237.6

RB-AR1508

EXAMPLE DISTRIBUTED BMP ASSIGNMENTS

Land Use Group	Cisterns	Bioretention	Perm. Pavement	Media Filters
Commercial	0%	0%	20%	20%
Education	20%	30%	0%	0%
Industrial	0%	0%	30%	50%
MF Residential	30%	20%	0%	0%
Transportation	0%	0%	0%	80%

Default, but can be modified for site-specific constraints

REVISED DRAFT

Distributed BMP	Acreage Treated	Default Design Size
Cisterns	10.8	0.75 in
Bioretention	10.0	0.75 in
Permeable Pavement	38.6	38.6 acres
Media Filters	69.1	0.2 in/hr
Total Impervious Area Treated By Distributed BMPs	118.1	
% of Total Impervious Area in Study Area	58%	

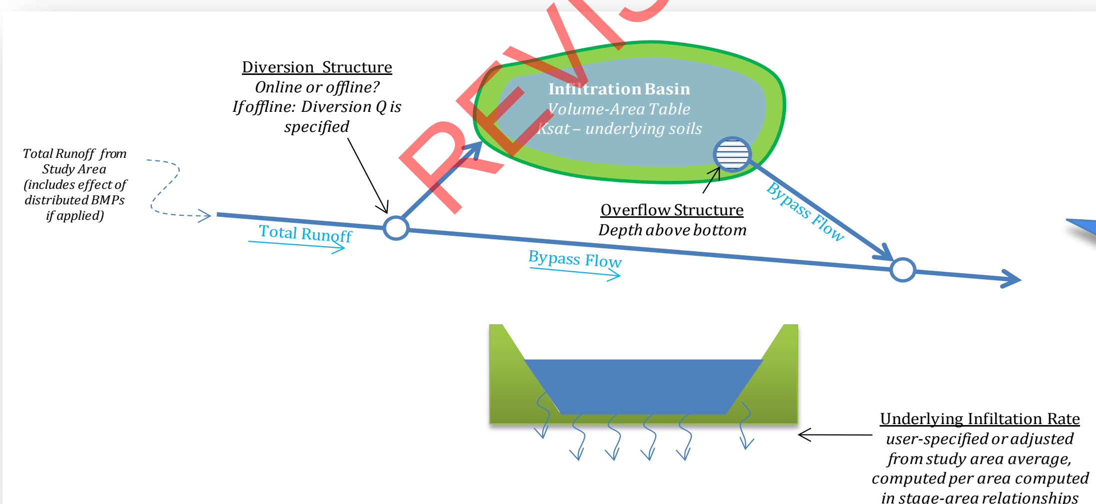
RB-AR1509

EXAMPLE REGIONAL BMP* SIZING

- Infiltration basin
- Total study area properties:
  - 7 catchments,
  - 238 acres,
  - 85% impervious

- Example design storm sizing approach:
  - 0.75-inch storm runoff
  - 7.9 ac-ft
  - 4 ft storage depth @ 1.2 in/hr design infiltration rate = 40 hour drawdown

85th Percentile to meet regional proj. def'n.*



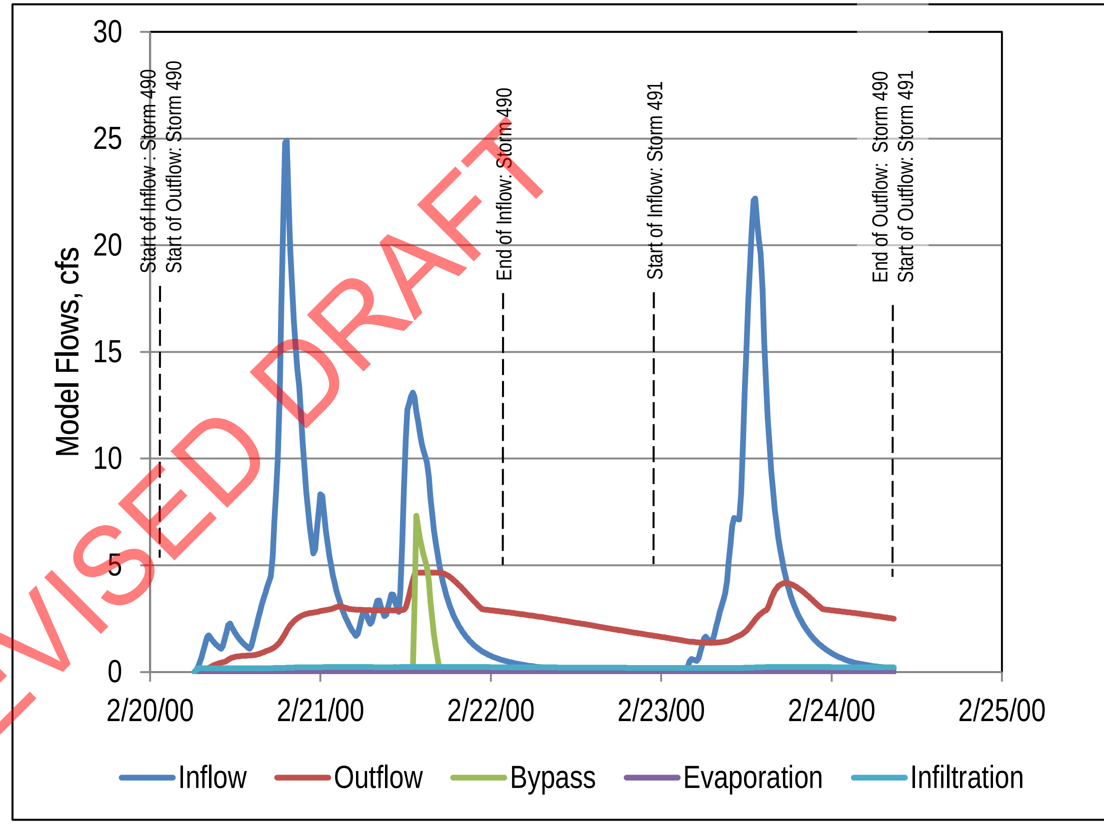
Flexible inputs to analyze surface or sub-surface infiltration system

RB-AR1510

* Could include functionally regional projects that do not meet regulatory definition at time of construction

EXAMPLE SWMM CONTINUOUS SIMULATION AND STORM EVENT TRACKING

- Tracks inflow, treated discharge, bypass, evaporation and infiltration at each 10 minute time step
- Discretizes runoff events by 6 hour minimum interevent time in rainfall record
- Tracks volume through BMP; summarizes by storm event
- Produces table of BMP hydrologic performance by storm event

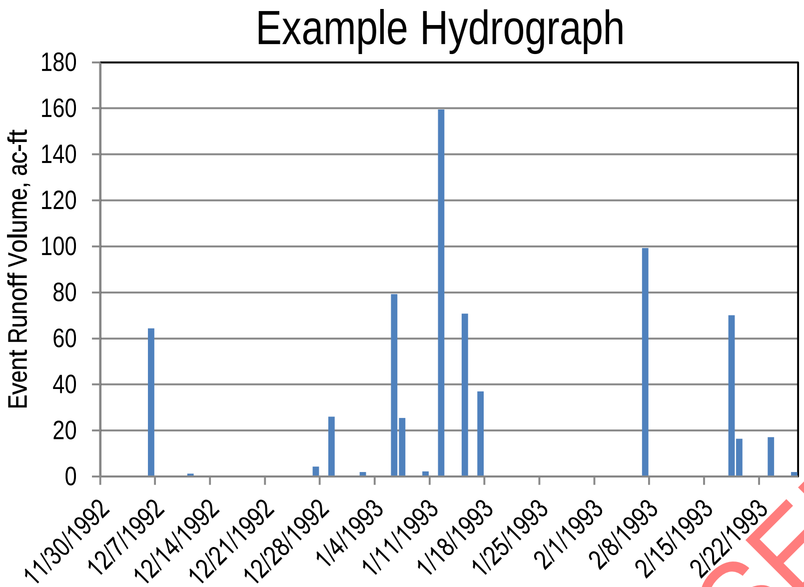


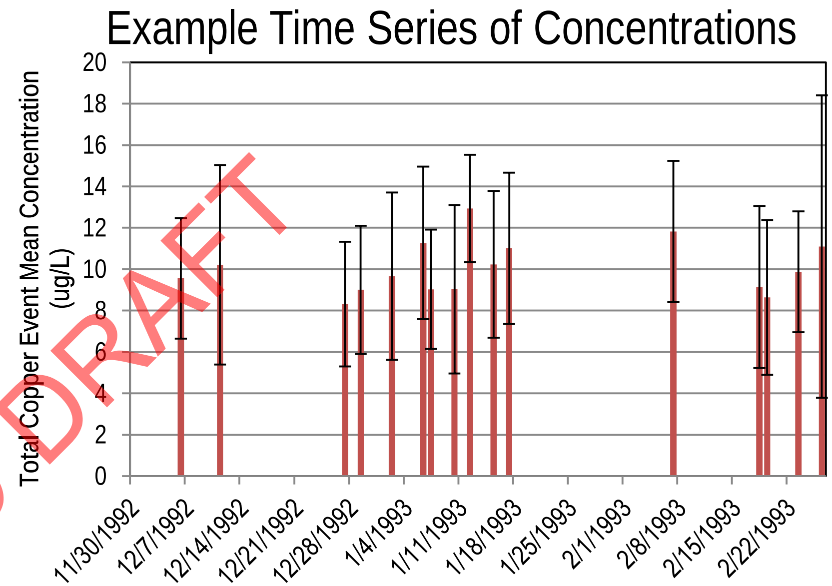
Storm Event Volumes, cu-ft							
Event No.	Inflow	Infiltration	Evaporation	Bypass	Outflow	% Capture	% Lost
486	48,600	16,300	136	0	34,000	100	33.5
487	185,000	28,500	237	0	157,000	100	15.4
488	34,700	15,400	129	0	19,200	100	44.3
489	54,600	17,900	239	0	36,500	100	32.8
490	774,000	59,500	793	52,700	663,000	93.2	7.7
491	444,000	42,600	568	0	399,000	100	9.6

Input to Monte Carlo WQ Analysis

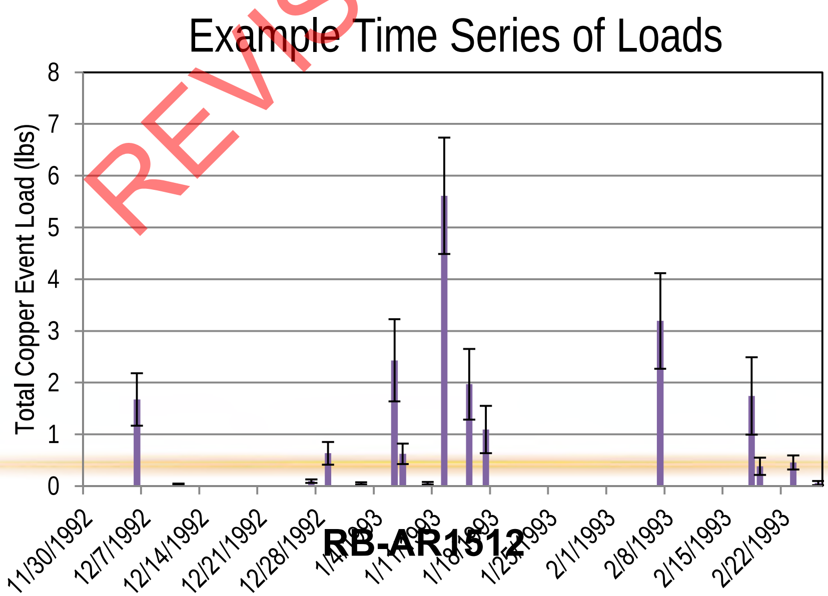
RB-AR1511

EXAMPLE DETAILED MONTE CARLO RESULTS (EVENT TIME STEP)





Plots show a subset of the simulated period of record



Error bars represent one standard deviation

EXAMPLE MODEL OUTPUT – ANNUAL AVERAGES

Average Annual Volume and Load Summary for Entire Study Area

		Average Annual Loads and Volumes			% Removed	
Pollutant	**Units**	**Pre-BMP**	**w/ Dist. BMPs**	**w/ Dist. + Reg. BMPs**	**w/ Dist. BMPs**	**w/ Dist. + Reg. BMP**
Total Runoff Volume	ac-ft	220	172	172	22%	[illegible]
DCu	lbs	8.8	6.9	6.8	22%	23%
DP	lbs	170	125	118	27%	30%
DZn	lbs	163	73	63	55%	62%
FC	10^12MPN	52.8	35.4	24.3	33%	54%
NH3	lbs	435	276	190	37%	56%
NO3	lbs	500	384	378	23%	25%
TCu	lbs	18.9	10.7	8.1	43%	57%
TKN	lbs	1645	1257	1194	24%	27%
TPb	lbs	7.63	4.18	3.54	45%	54%
TP	lbs	235	140	98	41%	58%
TSS	Tons	42	19	12	54%	71%
TZn	lbs	218	101	66	54%	70%

Compare to Target Load Reductions to Establish RAA

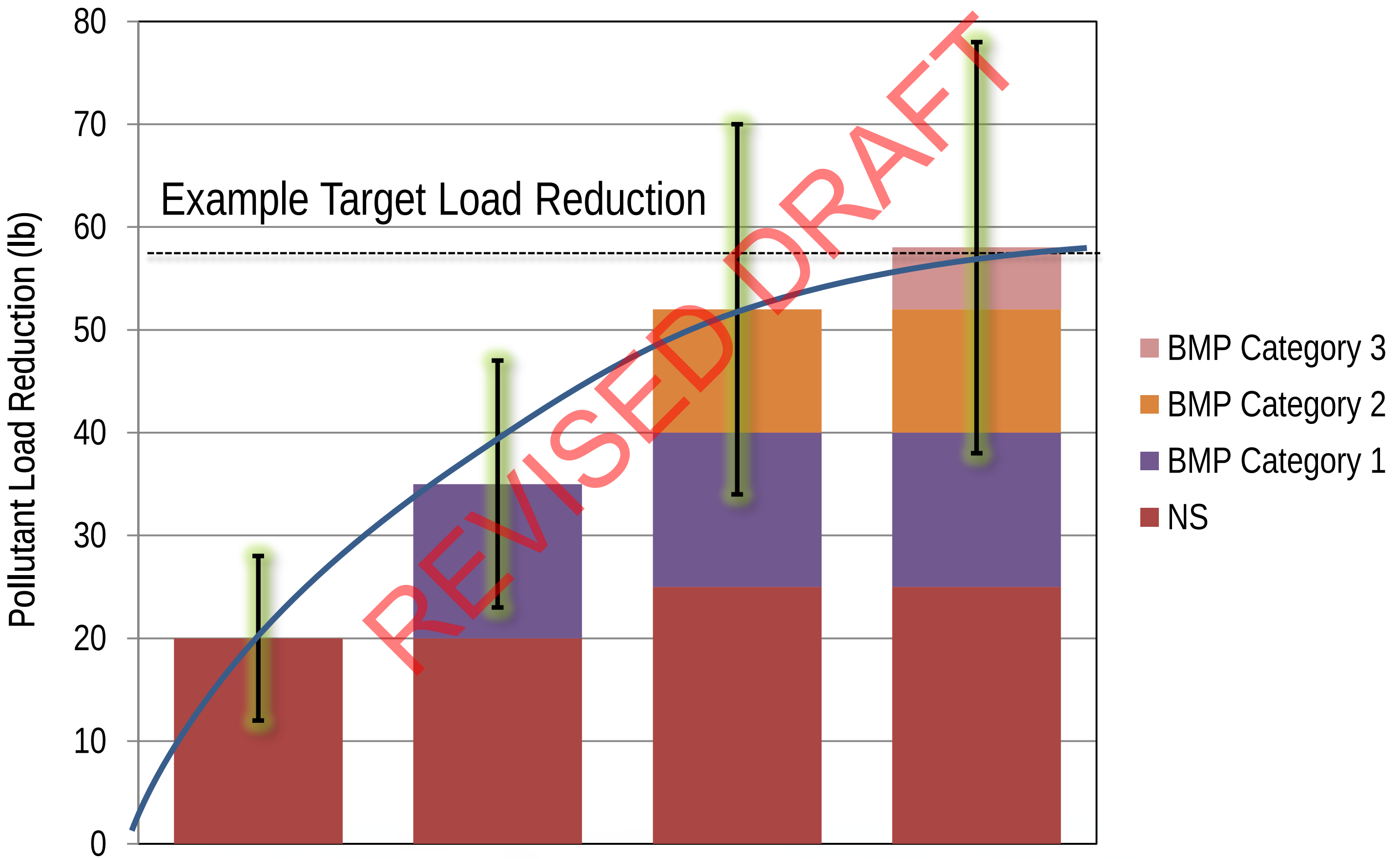
RB-AR1513

EXAMPLE MODEL OUTPUT - PLANNING LEVEL COST ESTIMATES*

BMP Capital, Maintenance and Land Costs						
	Capital Costs ($)		Maintenance Costs ($/yr)		Land Cost ($)	
BMPs	Low	High	Low	High	Low	High
Dry Detention Basin	586,874	981,207	3,036	5,058	3,718,940	4,648,676
Perm. Pavement	3,150,968	5,251,617	5,253	9,454	0	0
Media Filters	781,309	1,296,637	108,053	181,196	0	0
Cisterns	100,317	167,556	1,154	1,898	0	0
Bioretention	125,741	208,466	2,480	4,136	1,699,490	2,124,363

*Includes Retrofit Factor

EXAMPLE PHASED IMPLEMENTATION APPROACH



Demonstration that selected control measures have reasonable assurance to meet interim and final WQBELs and RWL milestones.

RB-AR1515

TARGET LOAD REDUCTION DISCUSSION (BACTERIA)

Note: The following method assumes utilization of SBPAT to establish the target load reductions; other methods include utilizing monitoring data to establish ultimate objectives.

SBPAT-BASED METHOD FOR BMP QUANTITATIVE ASSESSMENT (BACTERIA)

1) Determine Compliance Metric

- 17 Annual Exceedance Days (AED)
- FIB concentration criteria

2) Calculate Corresponding Target Load Reduction (TLR)

- Pick target year = assume "average" is reasonable
- Estimate FIB Loads all events: Total and MS4
- Estimate MS4 load reduction needed so that small storm days are compliant with TMDL Numeric Targets
- Conduct storm-by-storm analysis
- Determine load reduction to achieve AED

3) Analyze Proposed BMPs

- Calculate total load reduction range
- Evaluate BMP performance
- Remove overlapping benefits
- Determine percentage of total BMP load reduction that is considered effective for AED compliance

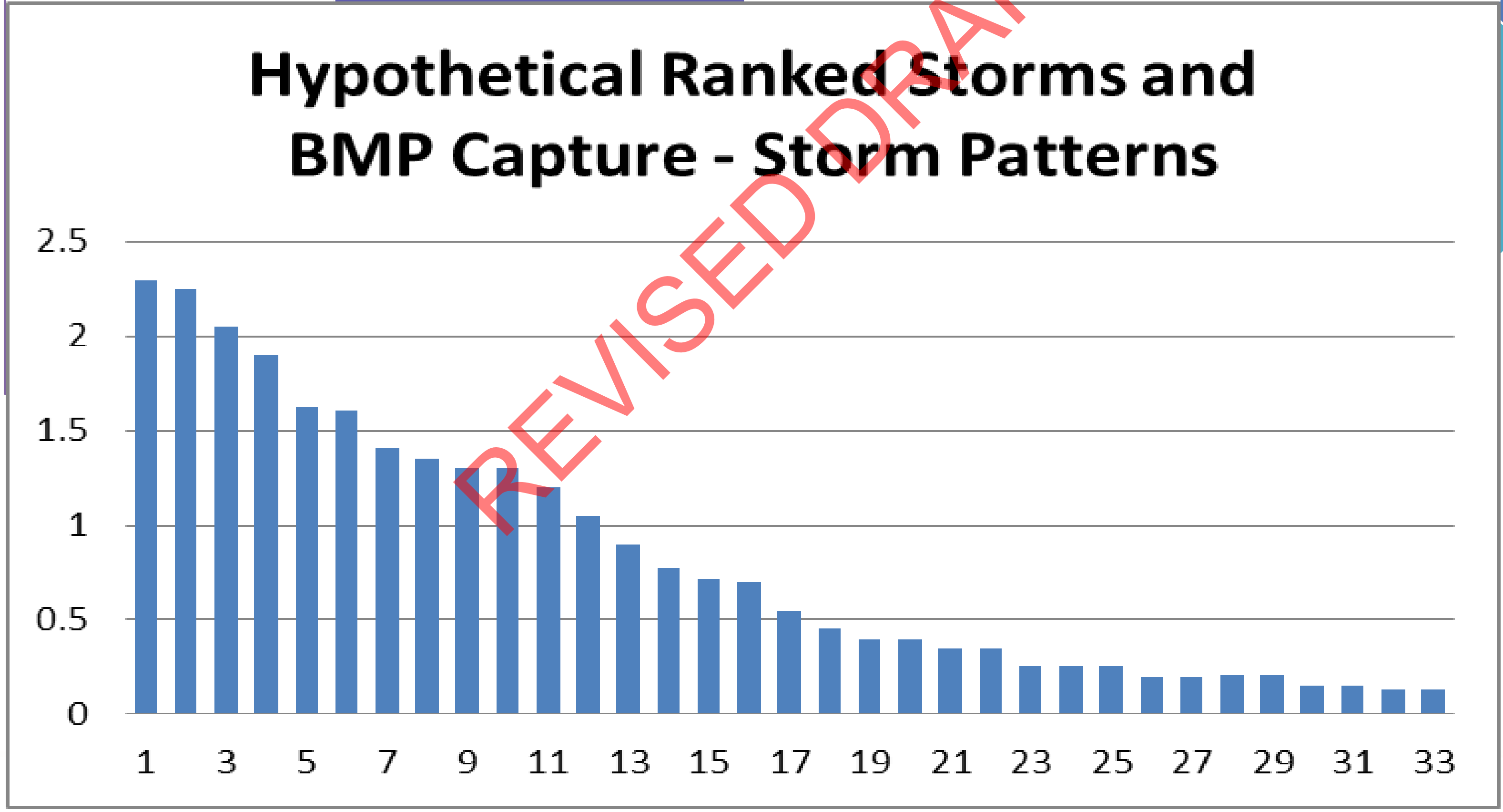
4) Compare Effective Load Reduction to TLR

- Calculate total load reduction that is considered effective for bringing smaller storms into compliance
- Compare this effective load reduction to TLR developed in Step 2

SBPAT-BASED METHOD FOR BMP QUANTITATIVE ASSESSMENT

1) Determine Compliance Metric

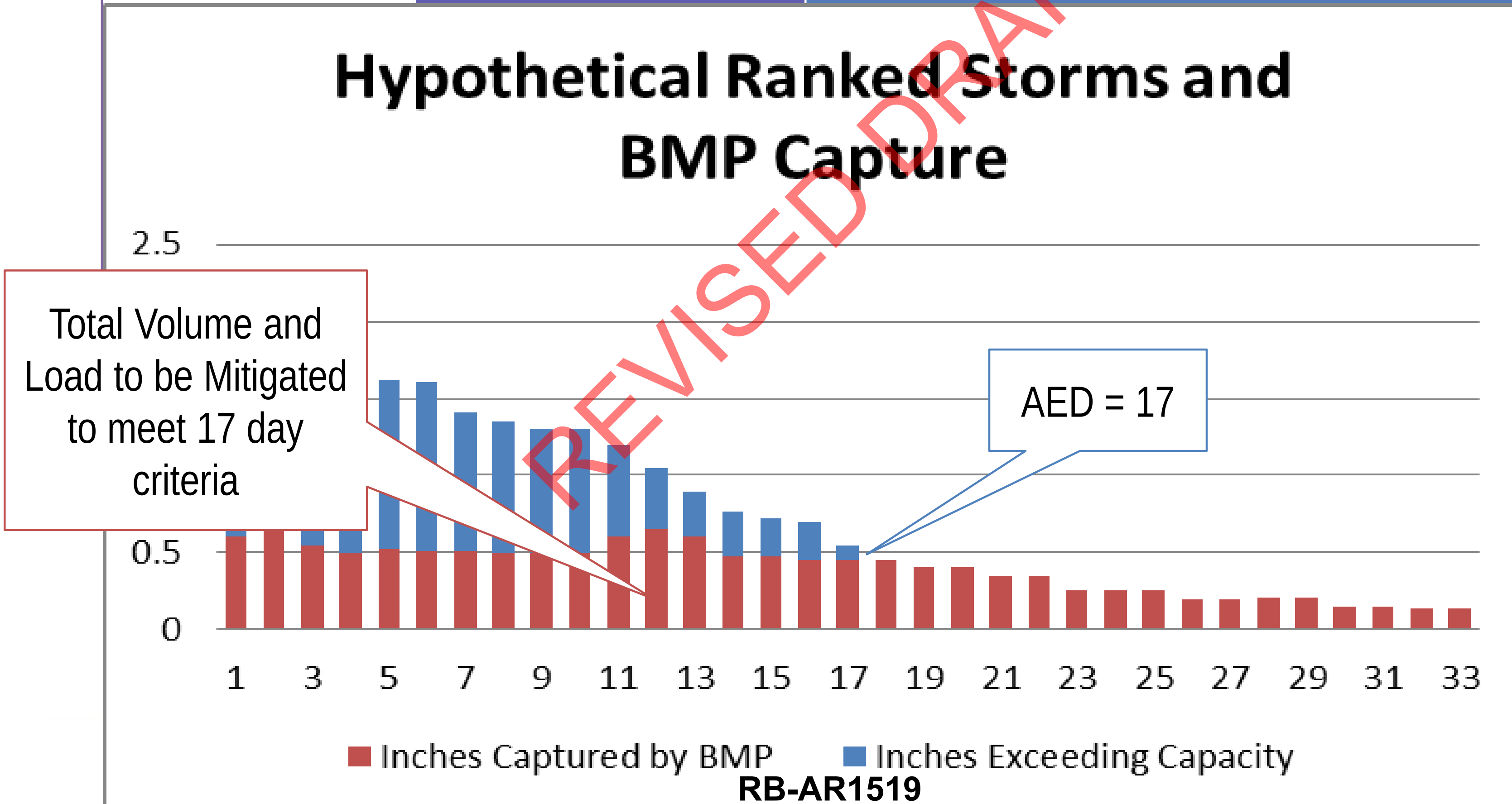
2) Calculate Corresponding Target Load Reduction (TLR)



SBPAT-BASED METHOD FOR BMP QUANTITATIVE ASSESSMENT

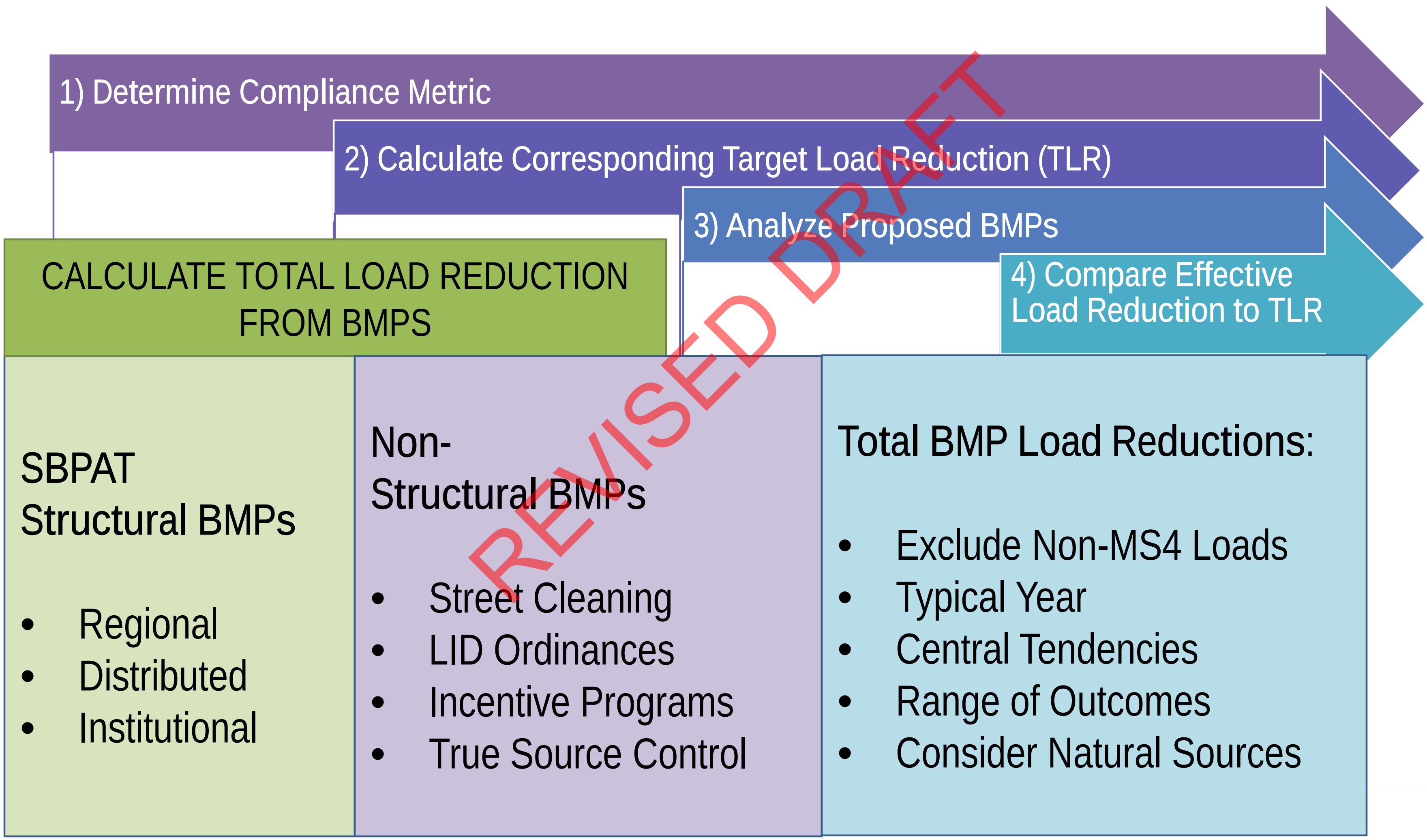
1) Determine Compliance Metric

2) Calculate Corresponding Target Load Reduction (TLR)

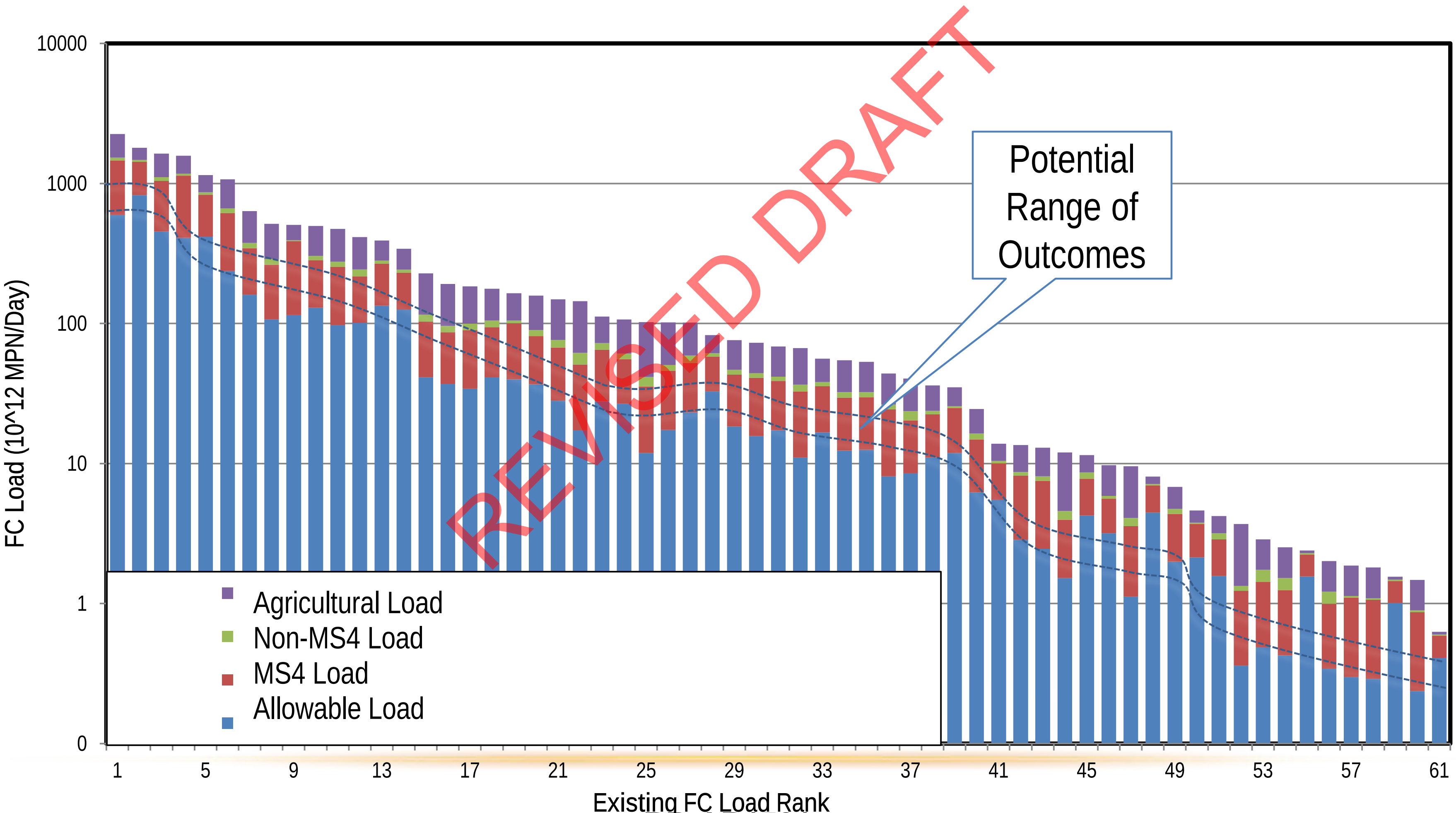


RB-AR1519

SBPAT-BASED METHOD FOR BMP QUANTITATIVE ASSESSMENT



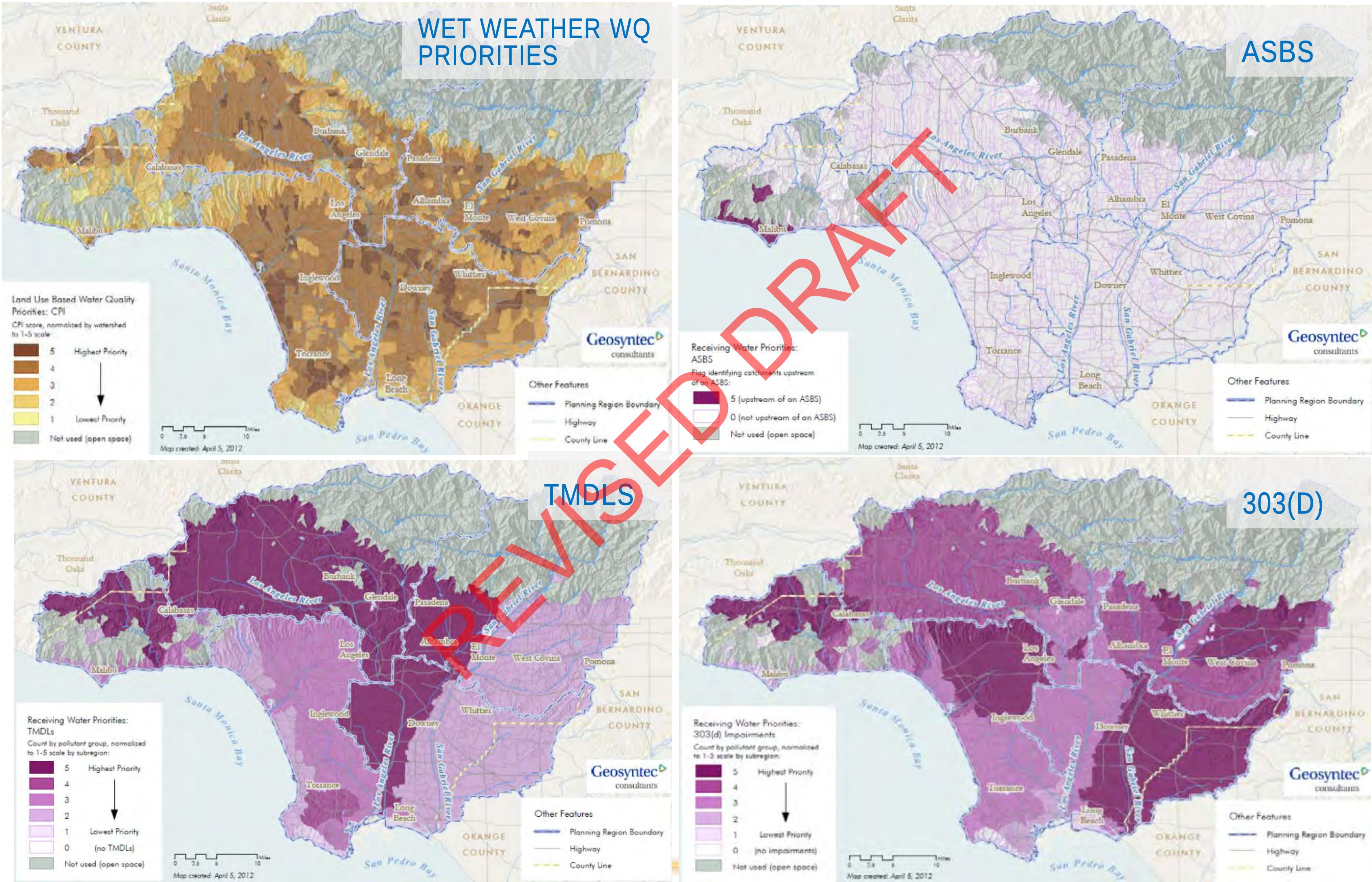
SAMPLE RESULTS DEMONSTRATING REASONABLE ASSURANCE



RB-AR1521

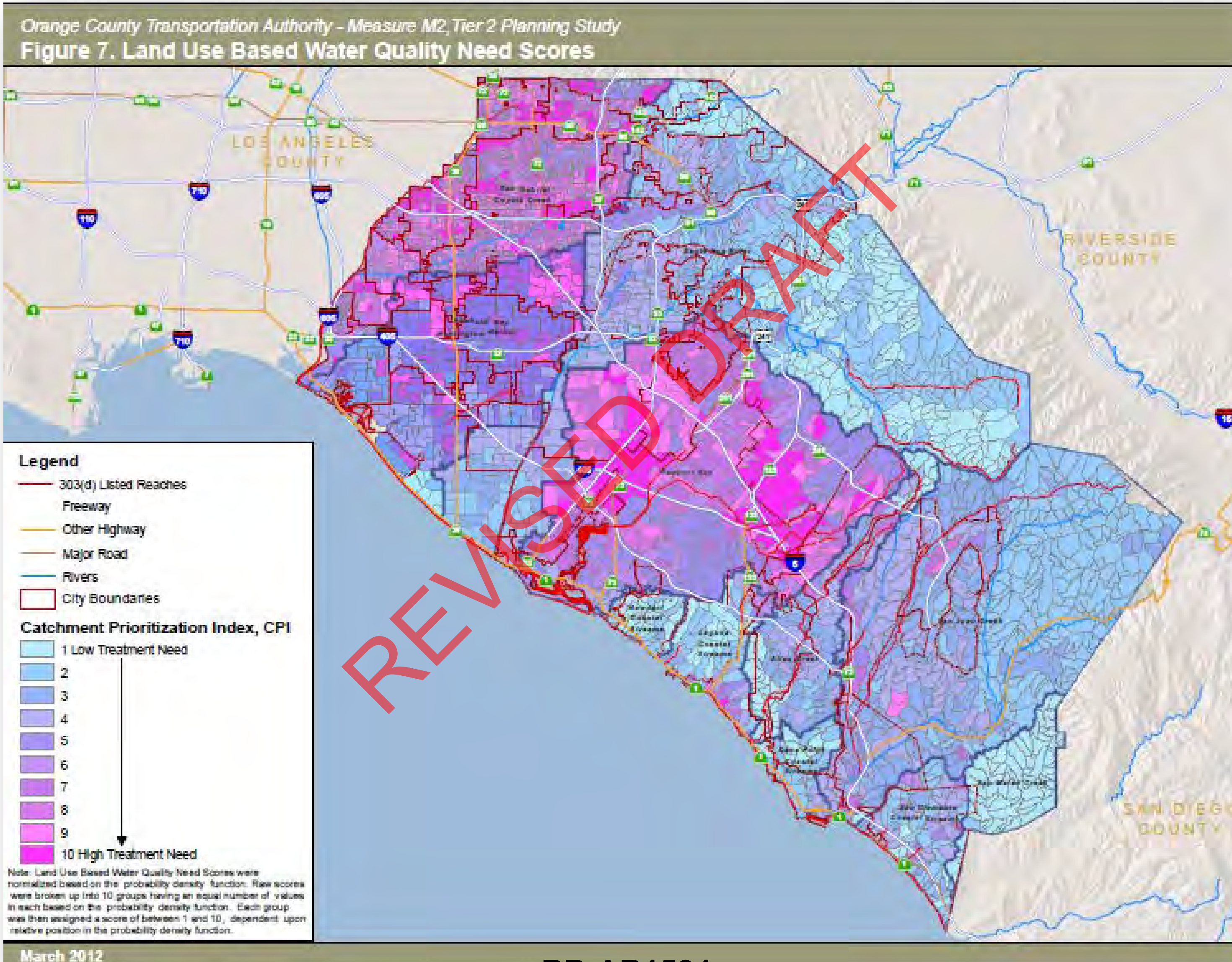
EXAMPLES OF USES

GLAC IRWMP DATA DEVELOPED COUNTY-WIDE



RB-AR1523

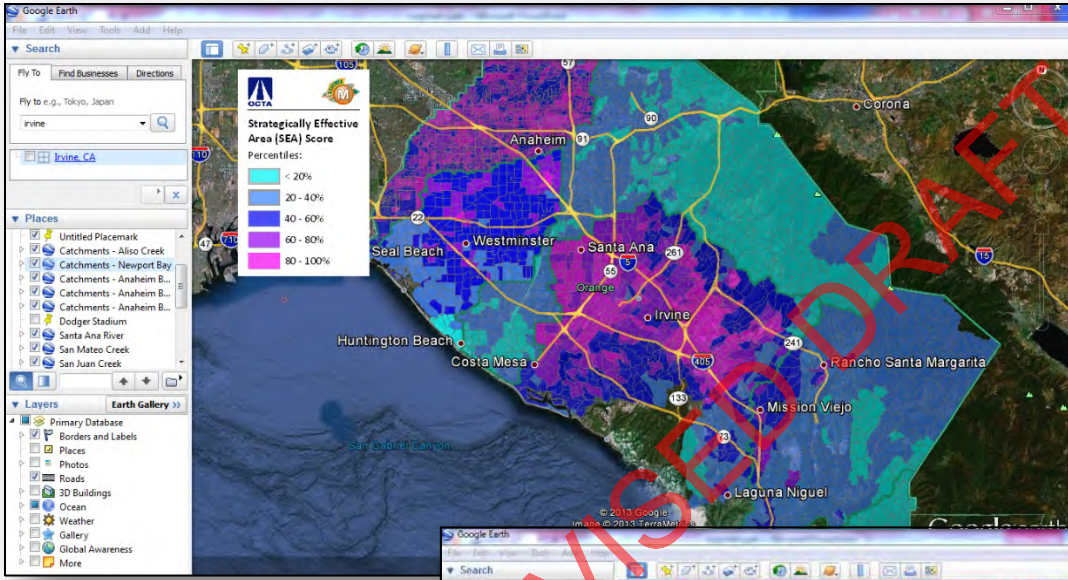
OCTA MEASURE M2

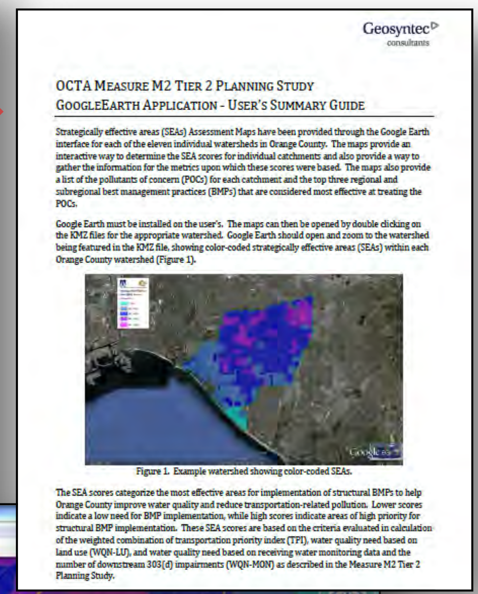


RB-AR1524

OCTA MEASURE M2

GOOGLE EARTH APPLICATIONS DEVELOPED





Geosyntec consultants

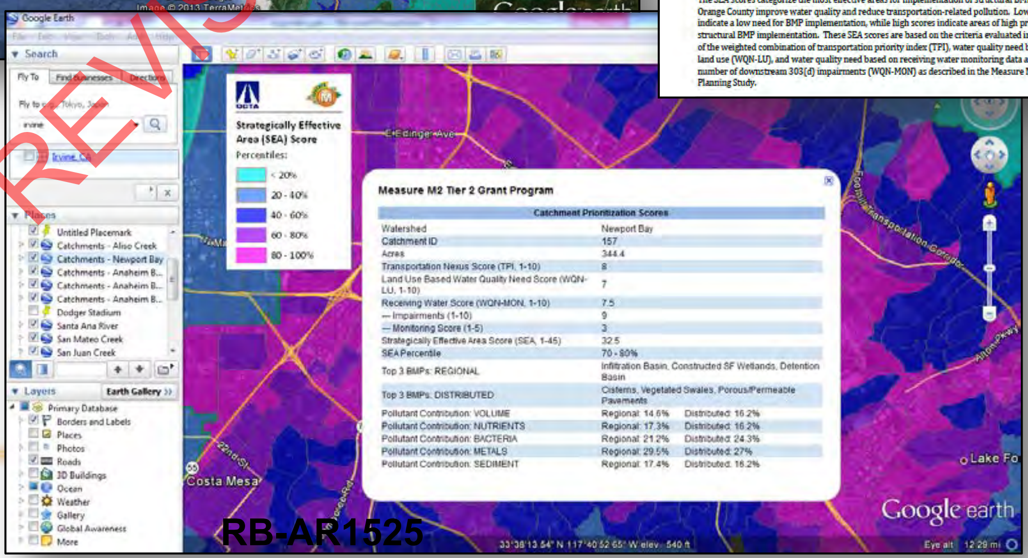
OCTA MEASURE M2 TIER 2 PLANNING STUDY
GOOGLEEARTH APPLICATION - USER'S SUMMARY GUIDE

Strategically effective areas (SEAs) Assessment Maps have been provided through the Google Earth interface for each of the eleven individual watersheds in Orange County. The maps provide an interactive way to determine the SEA scores for individual catchments and also provide a way to gather the information for the metrics upon which these scores were based. The maps also provide a list of the pollutants of concern (POCs) for each catchment and the top three regional and subregional best management practices (BMPs) that are considered most effective at treating the POCs.

Google Earth must be installed on the user's. The maps can then be opened by double clicking on the KMZ files for the appropriate watershed. Google Earth should open and zoom to the watershed being featured in the KMZ file, showing color-coded strategically effective areas (SEAs) within each Orange County watershed (Figure 1).

Figure 1. Example watershed showing color-coded SEAs.

The SEA scores categorize the most effective areas for implementation of structural BMPs to help Orange County improve water quality and reduce transportation-related pollution. Lower scores indicate a low need for BMP implementation, while high scores indicate areas of high priority for structural BMP implementation. These SEA scores are based on the criteria evaluated in calculation of the weighted combination of transportation priority index (TPI), water quality need based on land use (WQN-LU), and water quality need based on receiving water monitoring data and the number of downstream 303(d) impairments (WQN-MON) as described in the Measure M2 Tier 2 Planning Study.



RB-AR1525

BALLONA CREEK (LOS ANGELES COUNTY)

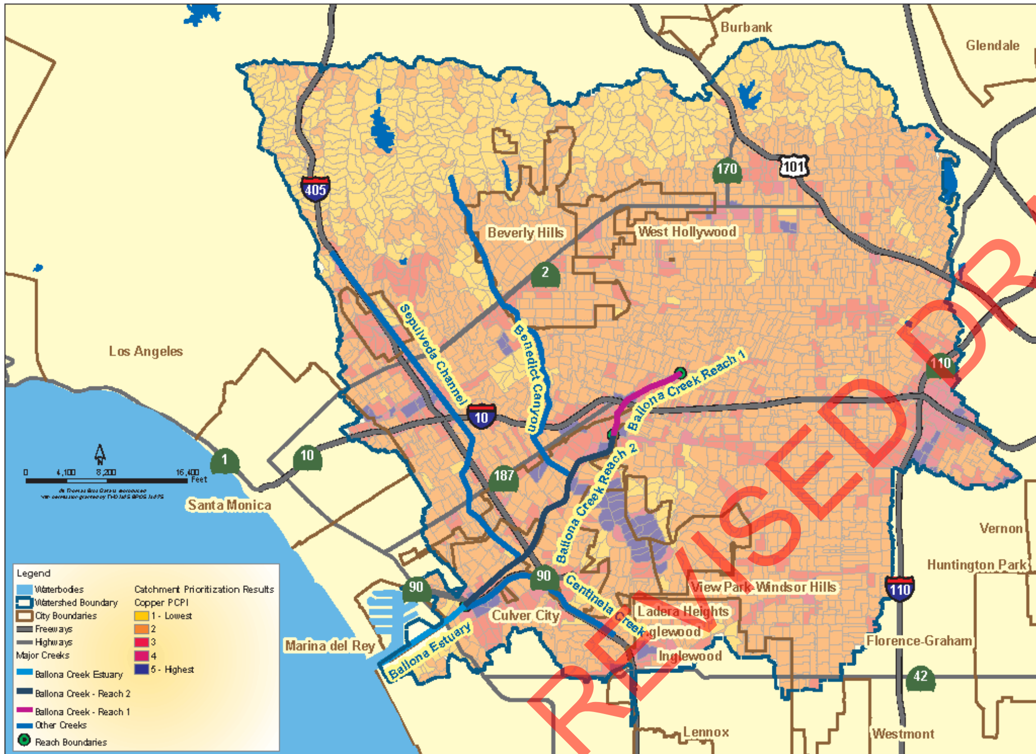


Figure 4-3 Ballona Creek Watershed - Copper Catchment Prioritization Index

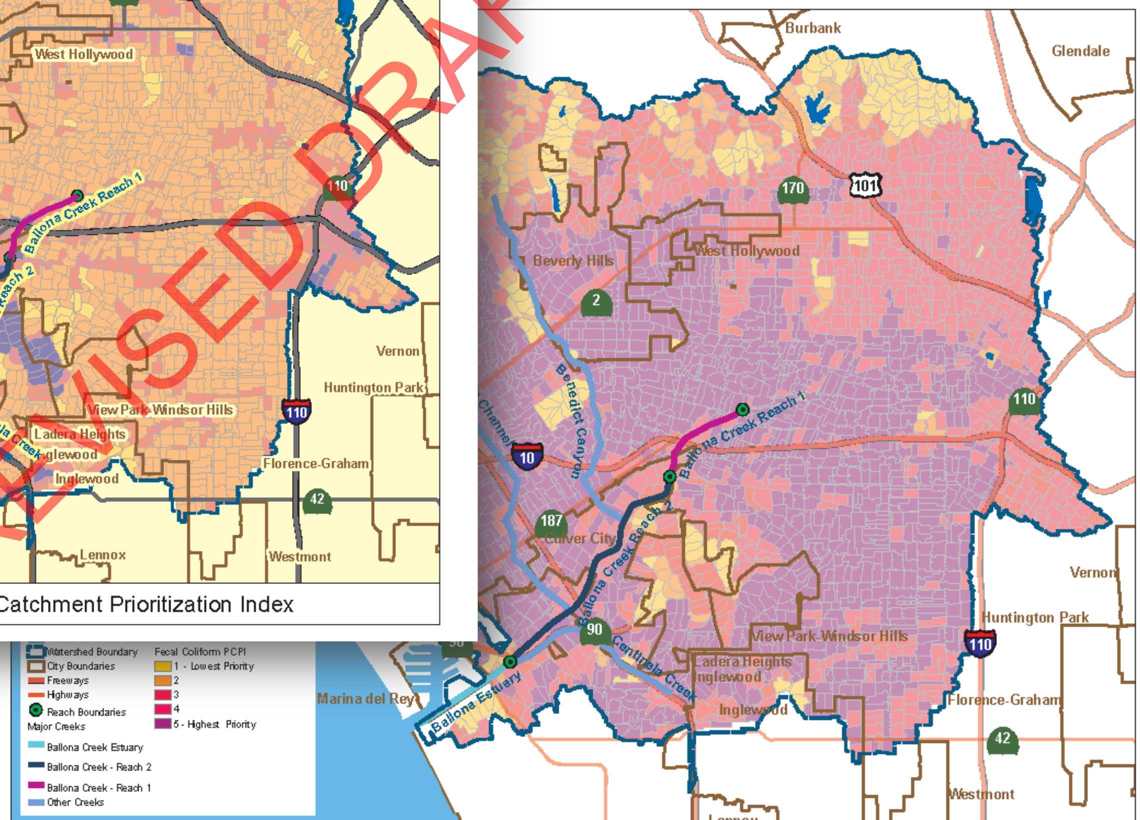
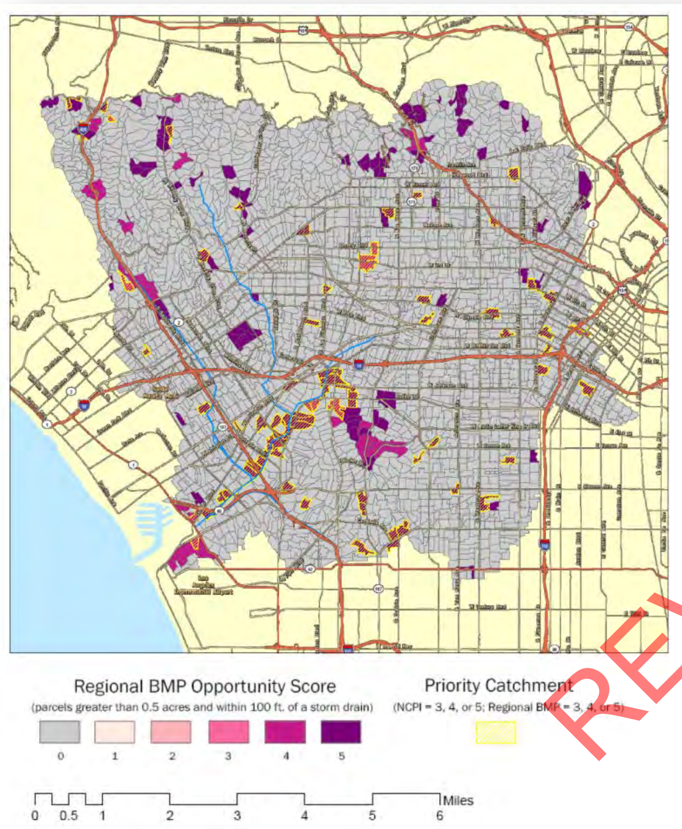
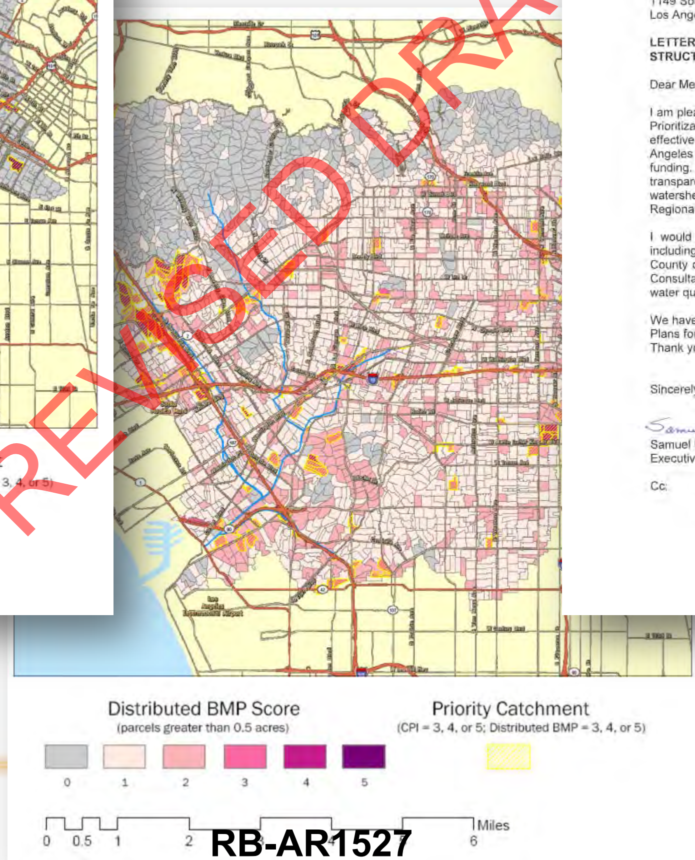


Figure 4-2 Ballona Creek Watershed - Fecal Coliform Catchment Prioritization Index

BALLONA CREEK (LOS ANGELES COUNTY)





California Regional Water Quality Control Board
Los Angeles Region

320 West Fourth Street, Suite 200, Los Angeles, California 90013
(213) 576-6600 • Fax (213) 576-6640
http://www.waterboards.ca.gov/losangeles

Linda S. Adams
Acting Secretary for Environmental Protection

Edmund G. Brown Jr.
Governor

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WATERSHED PROTECTION DIVISION

July 28, 2011

Mr. Adel H. Hagekhalil, Assistant Director, Bureau of Sanitation
Dr. Shahram Kharaghani, Program Manager, Watershed Protection Division
Department of Public Works,
City of Los Angeles,
1149 South Broadway, 9th Floor
Los Angeles, CA 90015

LETTER OF COMMENDATION FOR THE
STRUCTURAL BMP PRIORITIZATION AND ANALYSIS TOOL (SBPAT)

Dear Messrs. Hagekhalil and Kharaghani,

I am pleased to provide this commendation for your work developing the Structural BMP Prioritization and Analysis Tool (SBPAT). In order to develop integrated and cost-effective TMDL Implementation Plans and cost allocation strategies, the City of Los Angeles and its partners have developed this public-domain with State Water Board funding. SBPAT is a GIS-based tool that leverages current technologies and data, is transparent and reproducible, and supports the improvement of water quality in our watersheds. SBPAT filled a critical technology need for water quality planning, and the Regional Board and State Water Board are proud to have been a project sponsor.

I would like to recognize the contributions of the team responsible for this work, including yourselves and Wing Tam with the City of Los Angeles, Heal the Bay, the County of Los Angeles, GreenInfo Network, and your technical consultants, Geosyntec Consultants for their innovation, technical expertise, and commitment to meeting the water quality needs of the region.

We have seen the benefits of utilizing SBPAT in reviewing the City's TMDL Implementation Plans for Ballona Creek and Los Angeles River, and see other opportunities region-wide. Thank you for undertaking and completing this important project.

Sincerely,

Samuel Unger, P.E.
Executive Officer

Cc: Fran Diamond, Chair, Los Angeles Regional Water Quality Control Board
Jonathon Bishop, State Water Board
Mark Gold, D.Env. Heal the Bay

California Environmental Protection Agency

Recycled Paper

RB-AR1527

EXAMPLE: SAN DIEGO COUNTY COMPREHENSIVE LOAD REDUCTION PLANS (CLRPS)

New land use and receiving water monitoring data considered in both models

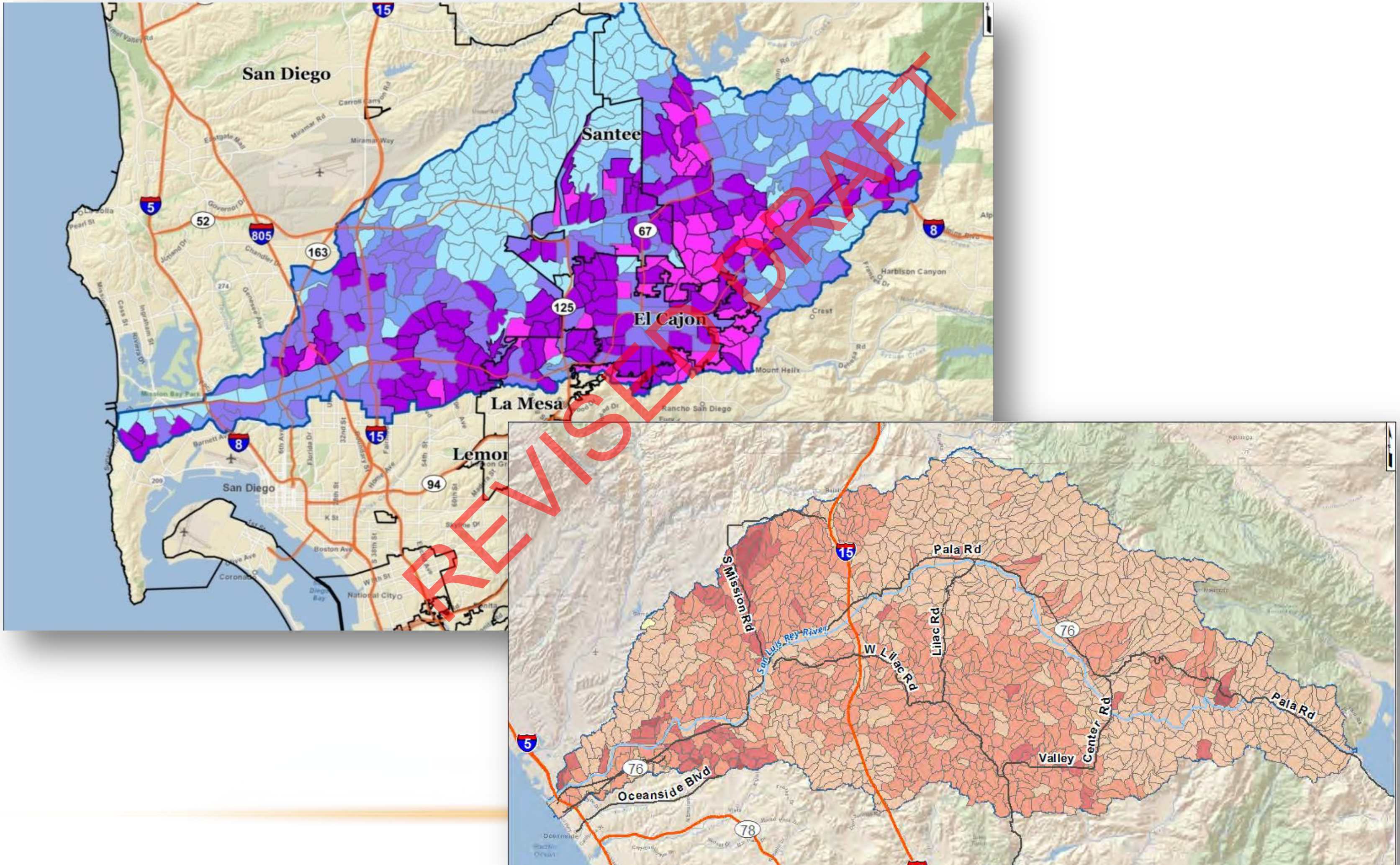
San Luis Rey River

- Area downstream of reservoir analyzed
- Larger Land Area Studied (~350 sq. miles study area)
- More Agriculture LU
- More Rural Residential LU
- More Septic Influence
- 3 Jurisdictions + Caltrans

San Diego River

- Area downstream of reservoirs analyzed (~180 sq. miles total study area)
- More Urban Area
- Larger Population
- Large Homeless Population
- 5 Jurisdictions + Caltrans
- More 303(d) Listings

SAN DIEGO RIVER & SAN LUIS REY CATCHMENT PRIORITIZATION INDICES (CPI)



RB-AR1529

SAN LUIS REY WATERSHED PRELIMINARY PLANNING LEVEL – RANGE OF EFFECTIVENESS

BMP CATEGORY	FC Load Reduction (10^{12} MPN/YEAR) 1993 WY Load[1] [Low-High Range]
Non-Structural BMPs	1,000 [260 – 1,700]
Regional Structural BMPs	700 [550 -790]
Wetland Mitigation Projects	100 [0 -240]
Distributed Structural BMPs	370 [200 – 430]
Subtotal	2,200 [1,000 -3,200]
Load Reduction Adjustment	-210 [-63 - -3
Load Reduction Effective Fraction	0.35
Load Reduction Sum	690 [330 - 990]
TARGET LOAD REDUCTION	670

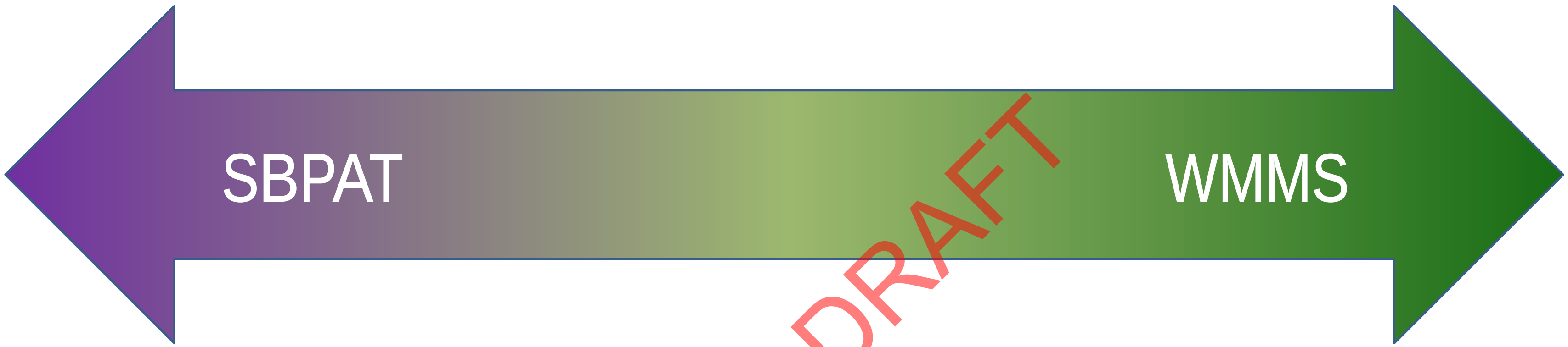
Elements Analyzed by SBPAT

RB-AR1530

CONSIDERATION OF MODELS TOGETHER

(provided for information an discussion only)

MODELING CONTINUUM

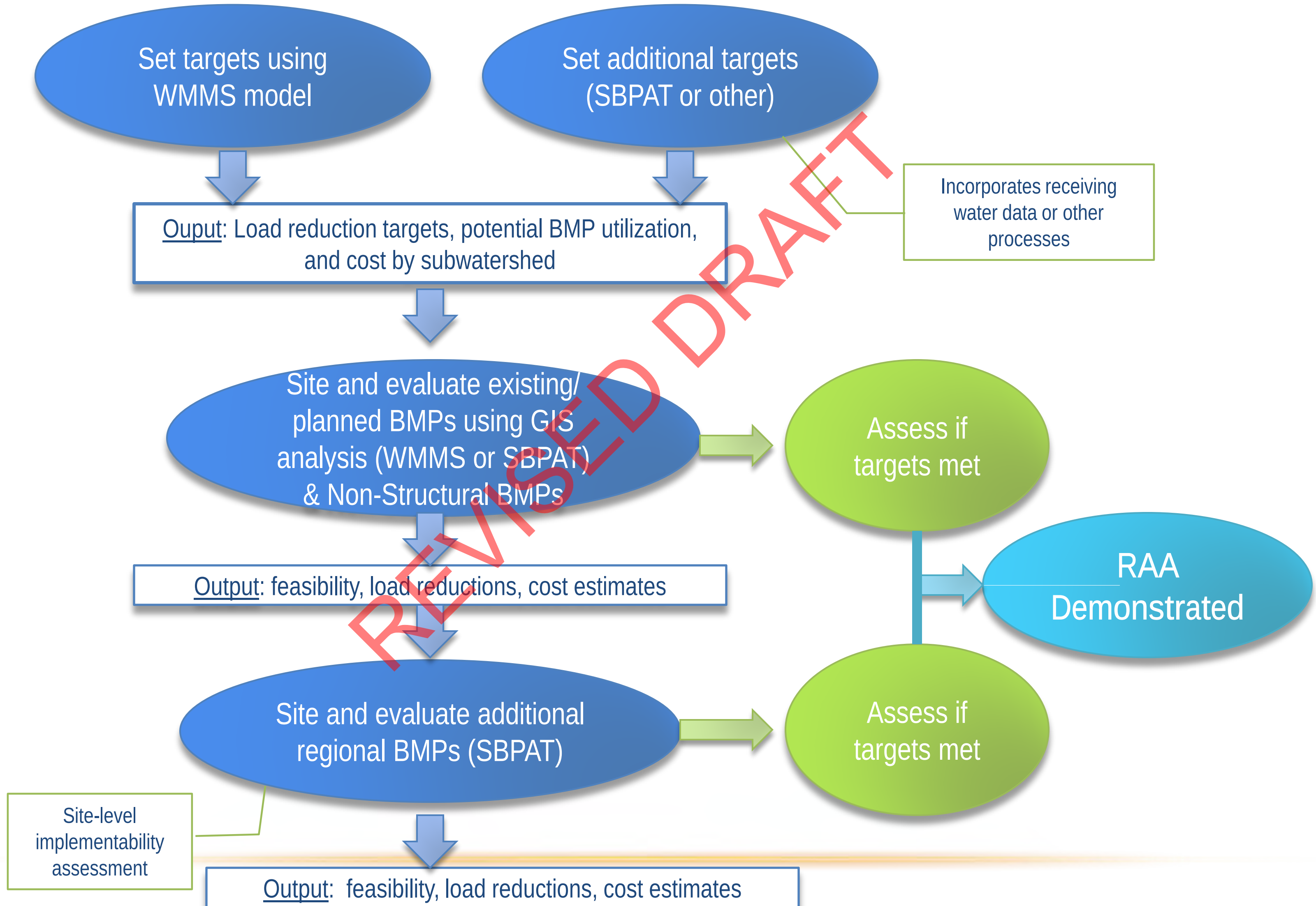


<u>Model Functionalities for RAA</u>

- Establish Target Load Reductions
- Estimate reductions achieved by non-structural BMPs
- Evaluate existing BMPs
- Site and evaluate new BMPs
- Demonstrate TLRs are met
- Produce cost estimates

MANY POSSIBLE COMBINATIONS

INFORMATION FLOW (DEPENDS ON CONDITIONS)



RB-AR1533

SUMMARY

- Introduction to SBPAT for RAA
- Input types and inputting processes
- Target loading estimates/other implicit assumptions
- Format for information sharing, presentation, and use for decision support
- Final quantified and presented results
- Use of SBPAT results
- Target load reduction discussion
- Examples
- Potential Integration of multiple models

ksusilo@geosyntec.com

QUESTIONS

Watershed Management Modeling with PLAT: Pollutant Loading Analysis Tool

City of Torrance

Carollo Engineers

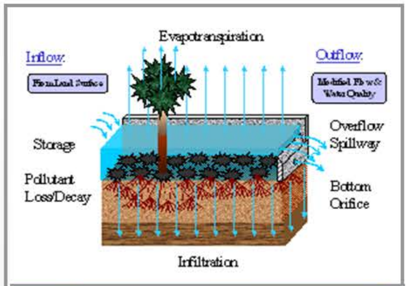
Engineers...Working Wonders With Water®

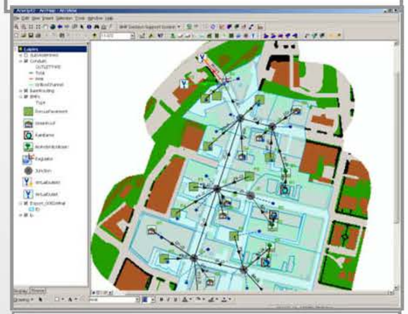
RB-AR1536

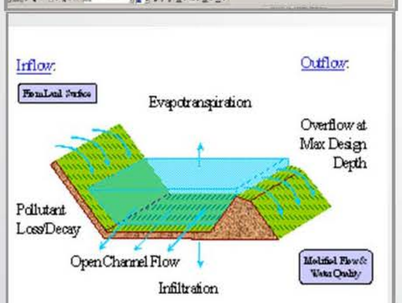
Presentation Outline

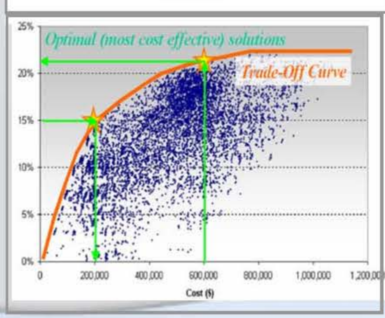
- **Project Background**
- **Water Quality Modeling with PLAT**
  - Satellite Imagery
  - PLOAD
  - P8
  - SUSTAIN
- **Conclusions**

The first step involves the evaluation and selection of the appropriate modeling tool(s)









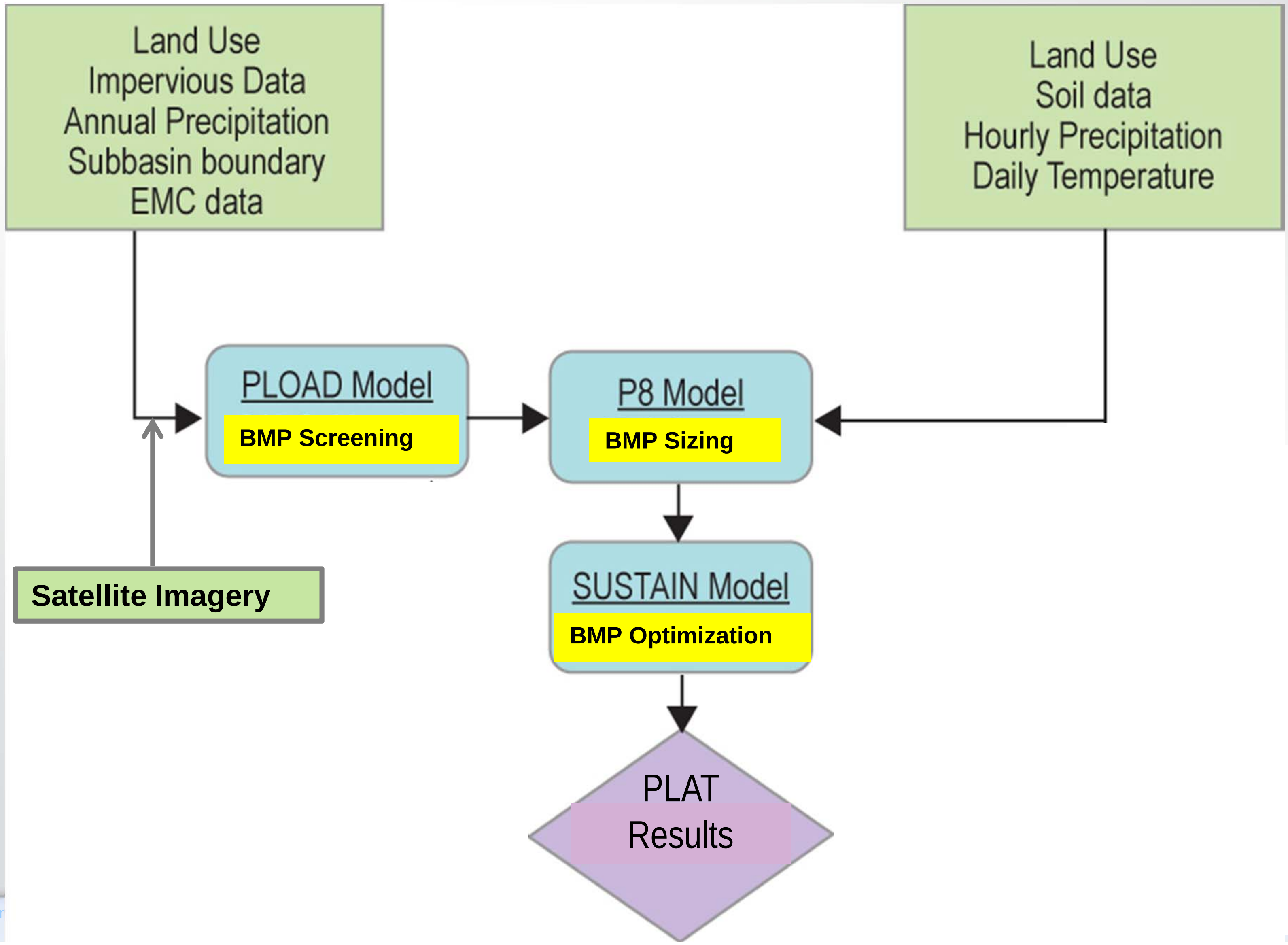
Model	Management Practice Evaluation Techniques	Water Quality Constituents
AnnAGNPS	• Sediment - RUSLE factors • Runoff curve number changes • Storage routing • Particle settling	• Sediment • Nutrients • Organic carbon
STEPL	• Sediment - RUSLE factors • Runoff curve number changes • Simple percent reduction	• Sediment • Nutrients
GWLF	• Sediment - USLE factors • Runoff curve number changes • User-specified removal rate	• Sediment • Nutrients
HSPF	• HSPF infiltration and accumulation factors • HSPF erosion factors • Storage routing • Particle settling • First-order decay	• Sediment • Nutrients
SWMM	• Infiltration • Second-order decay • Particle removal scale factor • Sediment - USLE (limited)	• Sediment • User-defined pollutants
P8-UCM	• Infiltration - Green-Ampt method • Second-order decay • Particle removal scale factor	• Sediment • User-defined pollutants
SWAT	• Sediment - MUSLE parameters • Infiltration - Curve number parameters • Storage routing • Particle settling • Flow routing • Redistribution of pollutants/nutrients in soil profile related to tillage and biological activities	• Sediment • Nutrients • Pesticides

Note: MUSLE = Modified Universal Soil Loss Equation; RUSLE = Revised Universal Soil Loss Equation; USLE = Universal Soil Loss Equation.

What is PLAT

- PLAT – Pollutant Loading and Analysis Tool
- Comprises of commonly used pubic domain models
- Designed to support decision-making
  - ➢ How effective are BMPs and GI in reducing runoff and pollutant load
  - ➢ What are the most cost-effective BMP options
    - ✓ Where to implement
    - ✓ What type
    - ✓ How large

The PLAT method efficiently screens BMPs prior to detailed modeling



RB-AR1540

Where It Applies?

- Evaluate and select BMPs to achieve loading targets set by a TMDL
- Identify protective management practices and evaluate pollutant loadings for **Surface Water Protection**
- Develop cost-effective management options for a MS4
- Determine a cost-effective mix of green infrastructure measures to help meet optimal flow reduction goals in SSO control programs

The Pollutant Loading Analysis Tool (PLAT) is an approach that combines three models and satellite data to achieve the City's goals

PLAT Component	Function	Public Domain Data
Satellite Imagery	• Impervious cover • Land cover • Preliminary Pollutant ranking	✓
PLOAD	• Pollutant loading & hot spots • Calibrate P8 model • Screen BMPs	✓
P8	• Simulate and route pollutants • Evaluate alternatives • Preliminary BMPs sizing	✓
SUSTAIN	• Final BMP sizing • BMP optimization • Assess TMDL compliance	✓

Watershed modeling requires several common input parameters

Land Use
- EMC (urban)
- Unit Load (Non-urban)

Soil & Rainfall
- Annual
- Hourly

Pollutant Load
- Before
- Treatment

Discount Factors
- BMP Specific
- Treatability Factor)

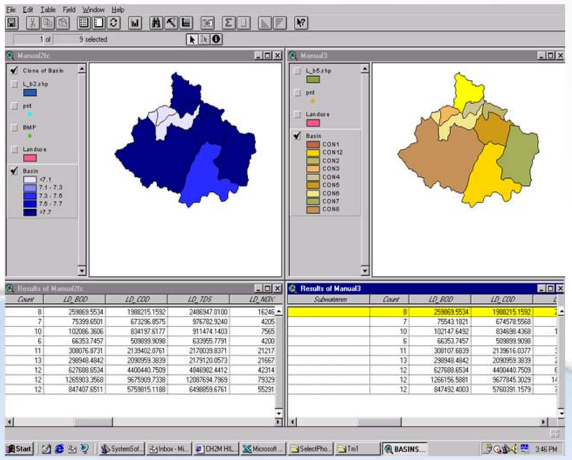
Pollutant Reduction
- Applied to base line load

BMPs
- Performance code
- Removal Efficiency

Water Quality Modeling with PLAT – Simple Approach

- Satellite Remote Sensing
  - Impervious cover mapping
  - Land cover mapping
  - Pollutant hot-spots characterization

- PLOAD Modeling
  - Pollutant load calculation and characterization
  - Initial data for calibration – P8 & SUSTAIN
  - BMP - Screening



Satellite imagery is a unique input parameter used with the PLAT approach

Satellite: WorldView-2
Company: DigitalGlobe's High Resolution

Benefits:

- Suitable for impervious mapping
  - Accurate & Recent
  - Frequently updated (every 1.5 days)
  - Cloud cover impact information
  - Site-specific
- Suitable for land cover mapping
  - Open space
  - Automated by digital image processing techniques
- Saves Time & Low Cost
  - City of Torrance ($1000)

Impervious Surface can be readily extracted from satellite imagery

Any surface not penetrable by water

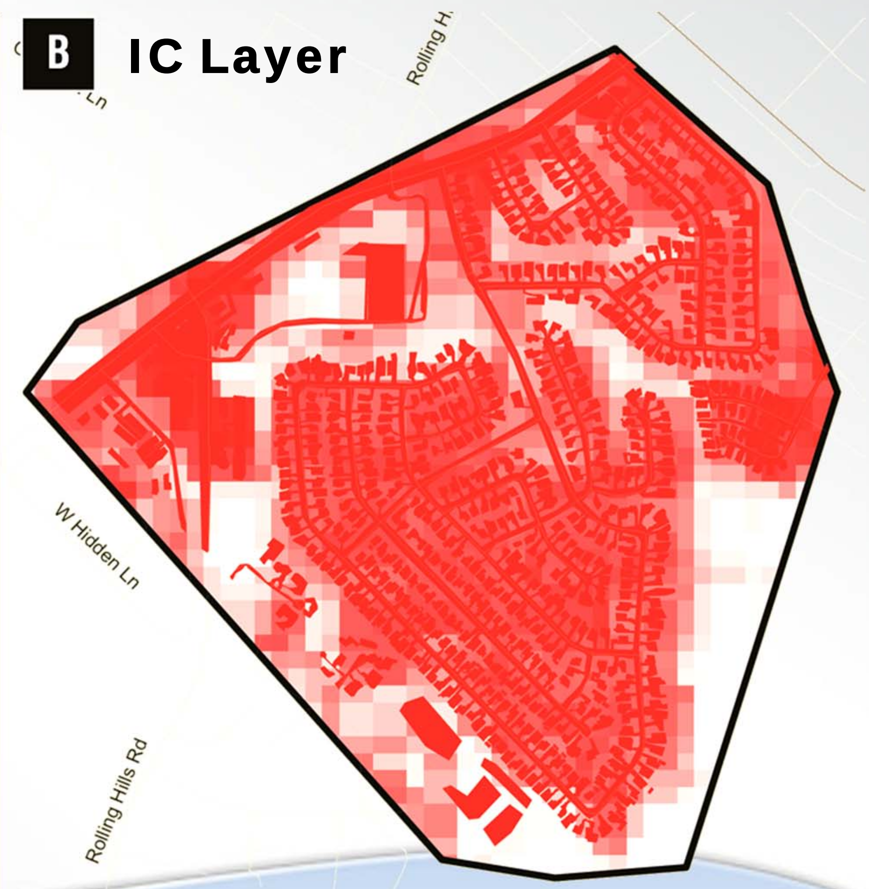
Includes streets, parking lots, side-walks and building roof tops

Transportation elements contribute the most to impervious surface area

Satellite imagery allows accurate and quick estimation of impervious areas

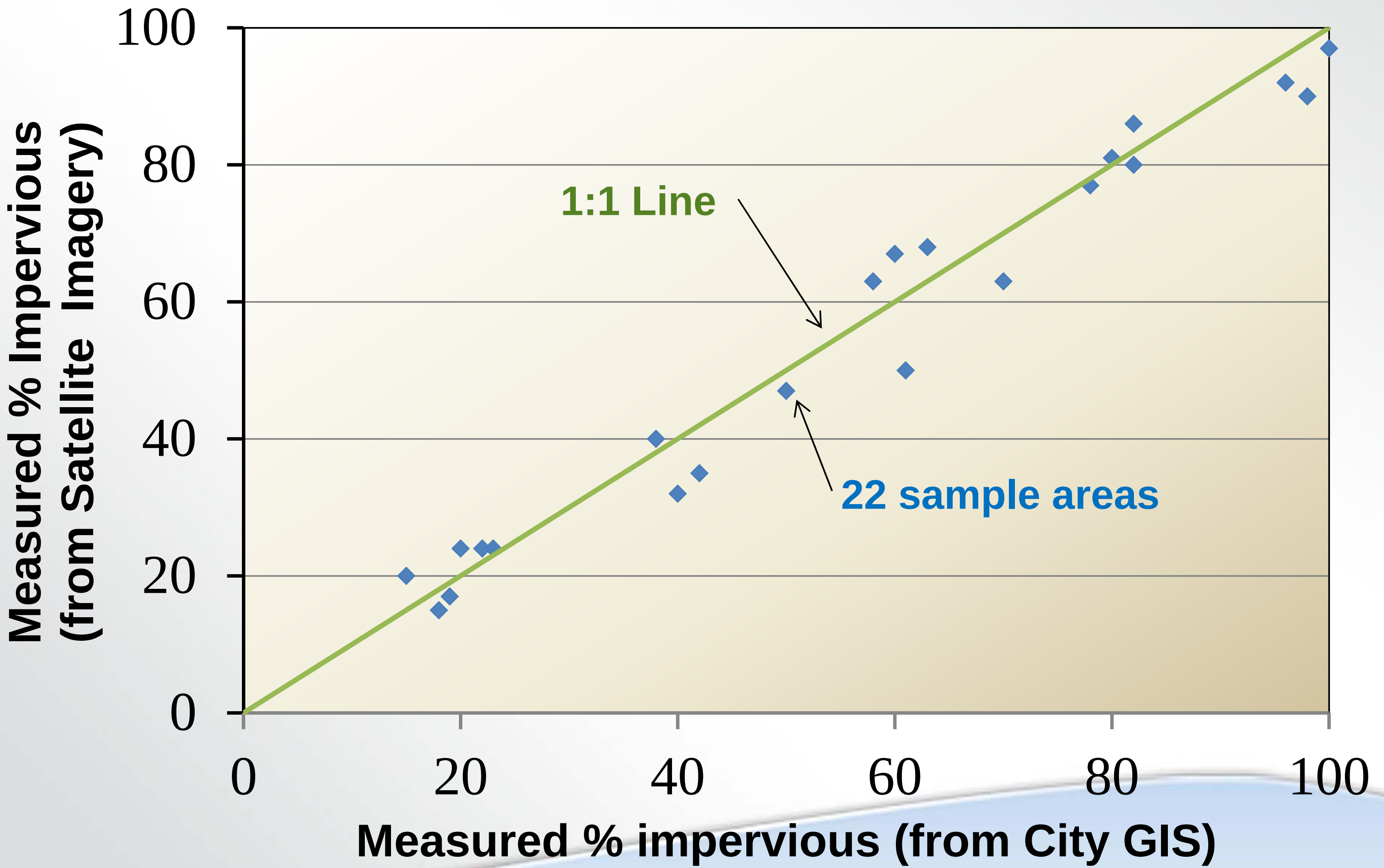
A Raw Satellite

B IC Layer



Filename.ppt

Comparison of % imperviousness of sample areas confirms accuracy of satellite imagery

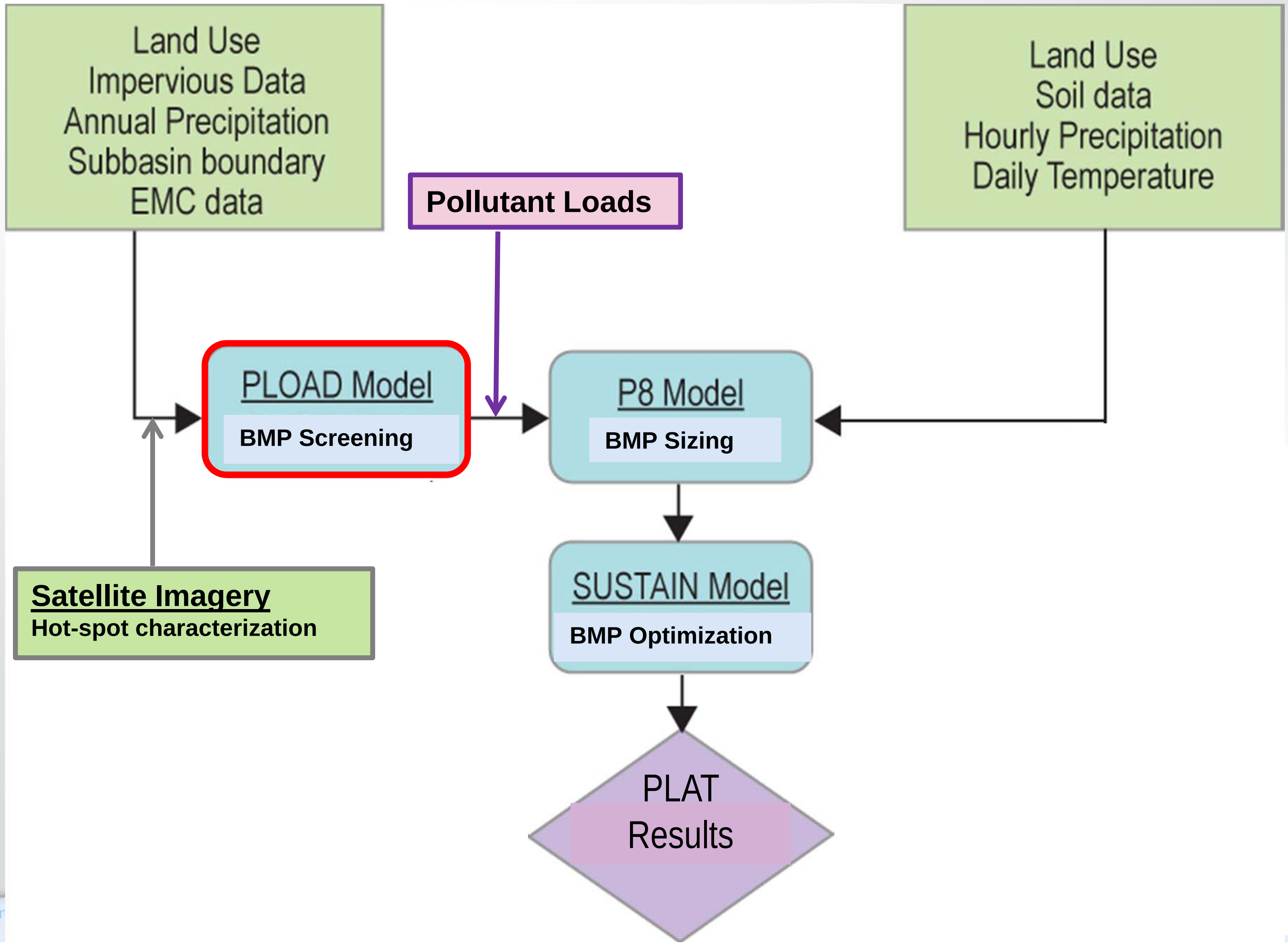


The same Satellite Imagery data can be used to quickly identify open space for BMP siting

- **Image classification:**
  - GIS Image Analysis Extension
  - Training set w/sun energy reflection
  - Identify open spaces, buildings, etc.
- **Vacant land selection:**
  - Prioritize city owned parcels
  - General Plan Land use
  - Proximity to stormdrains

RB-AR1549

PLOAD calculates pollutant loads by subbasin for BMP screening



RB-AR1550

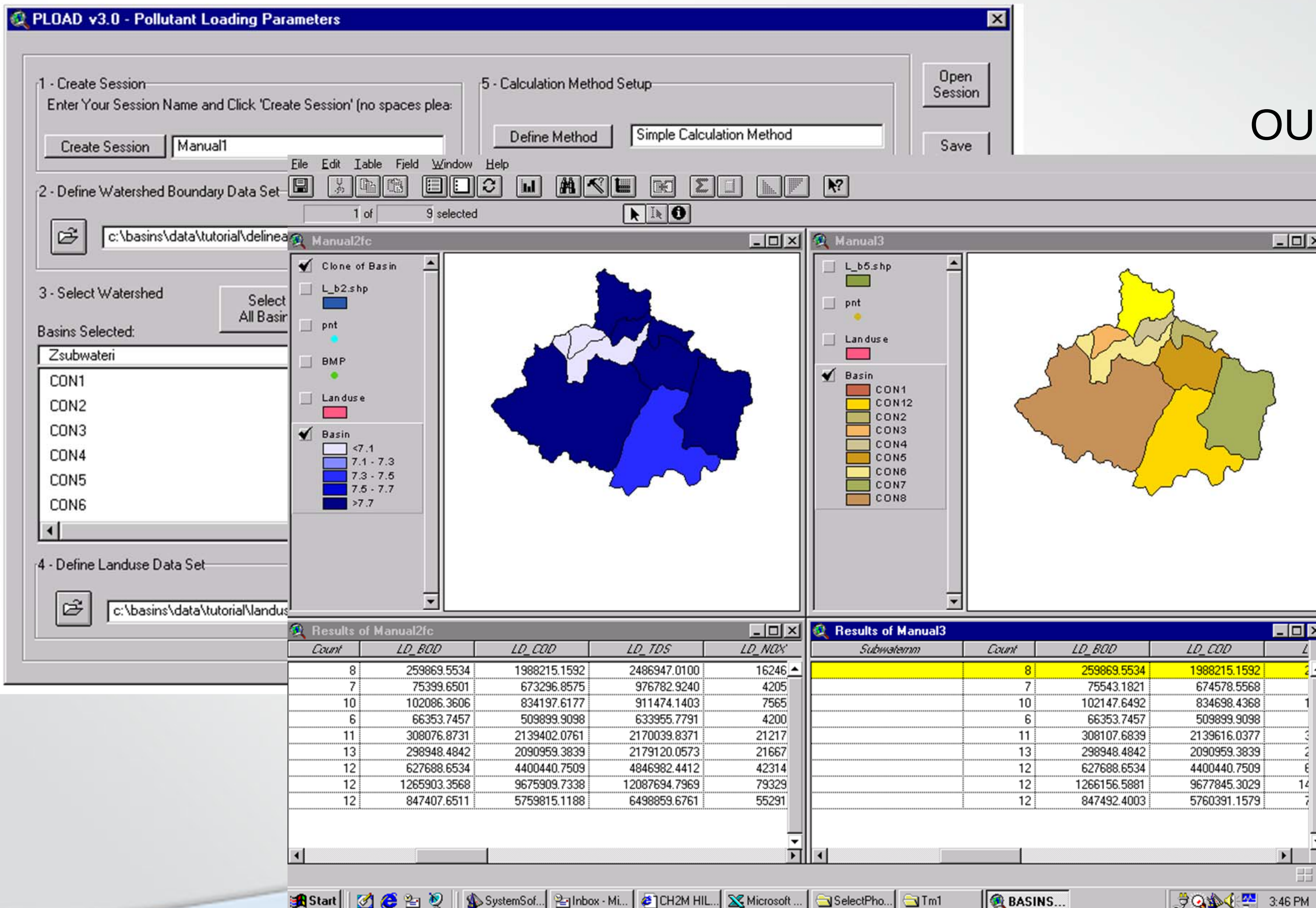
Simple Approach – PLOAD Modeling

- Simple spreadsheet model
- GIS based and a module of EPA BASINS
- Computes load on long term basis
- Uses imperviousness, land use and event mean concentration
- Efficient in screening BMPs
- Output can be used to calibrate other components of PLAT

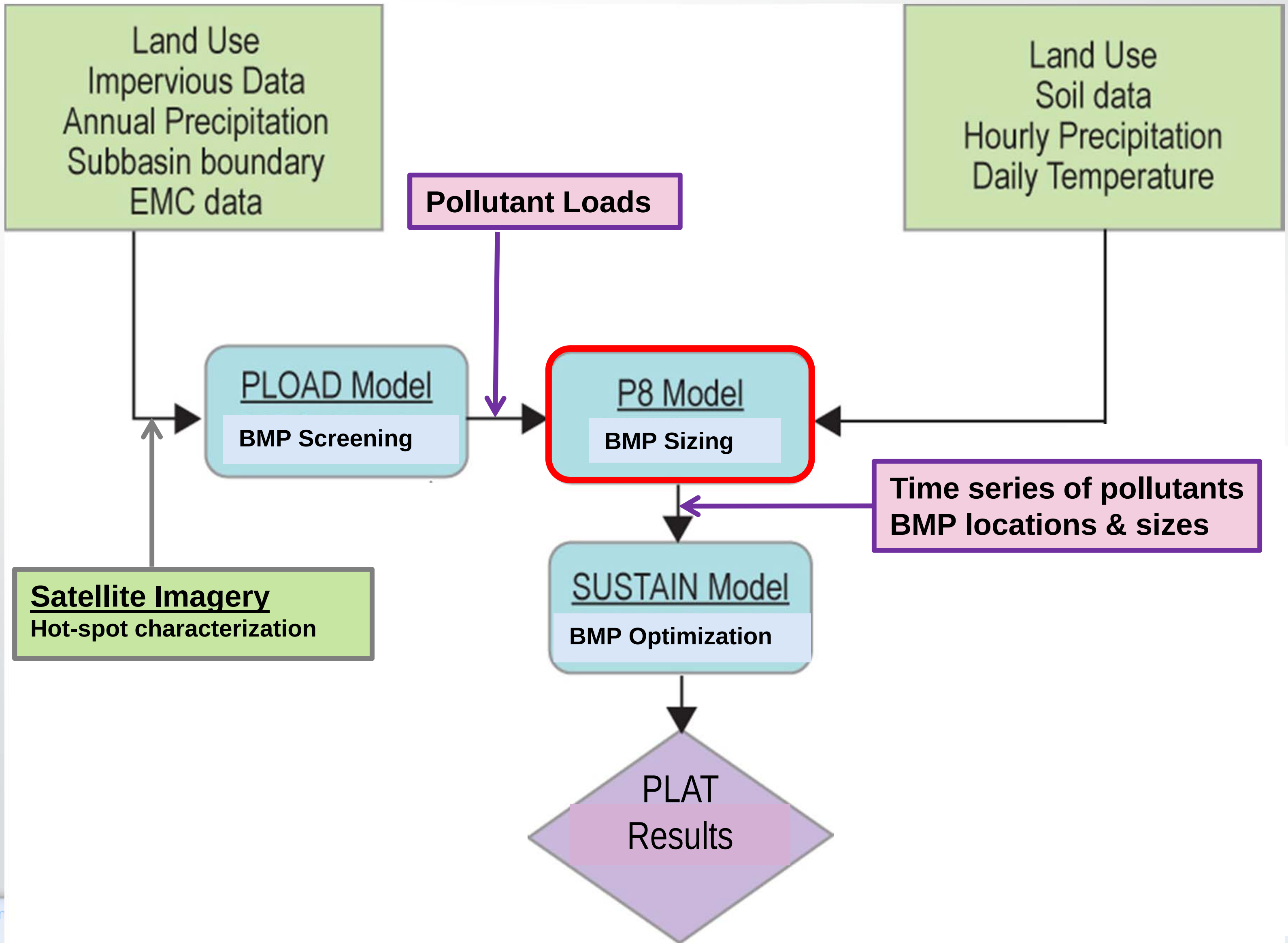
Pollutant load by subwatershed

INPUT

OUTPUT

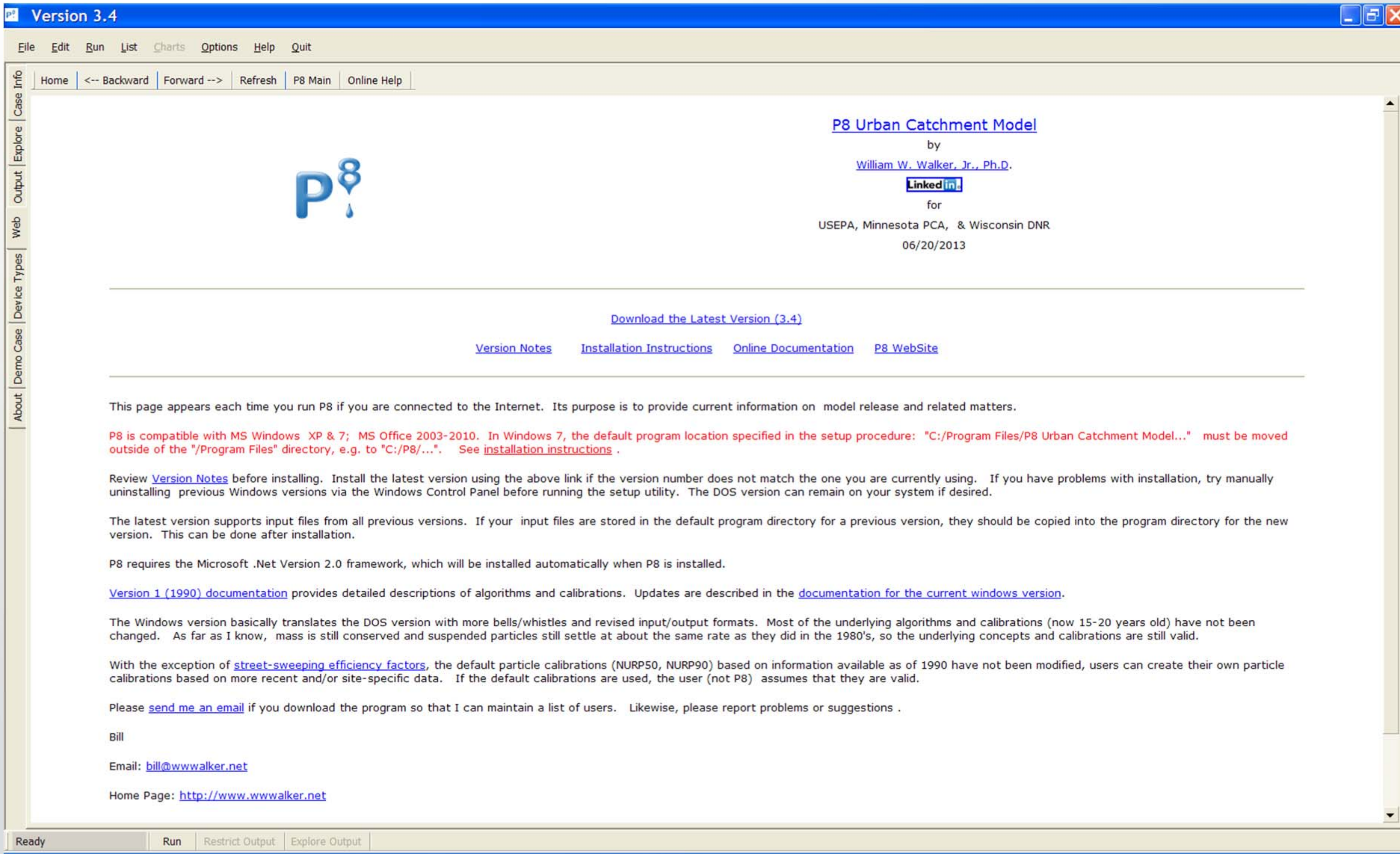


P8 calculates time-series pollutant loads by area for BMP sizing



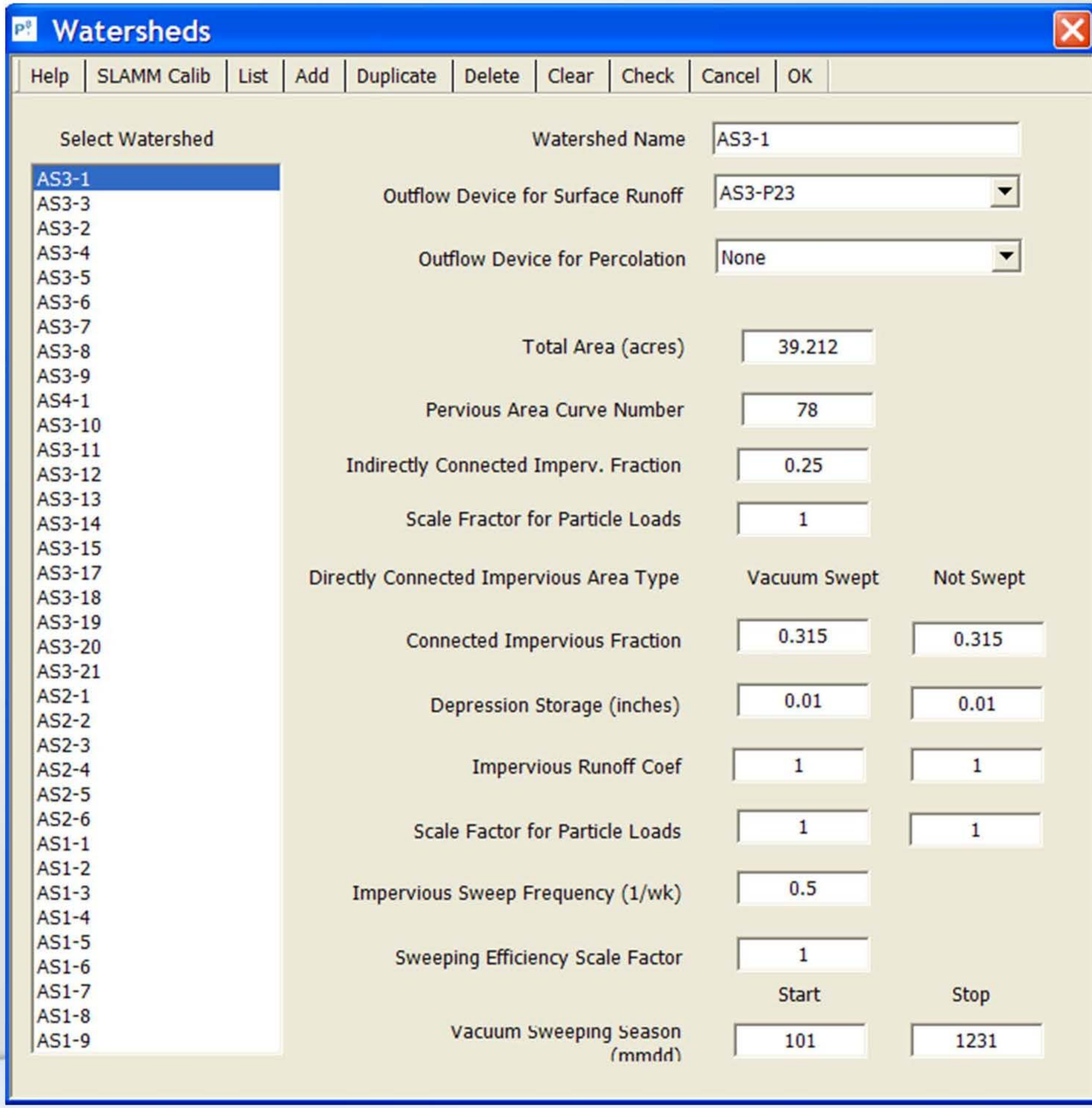
RB-AR1553

Advanced BMP Modeling with P8 (Urban Catchment Model)

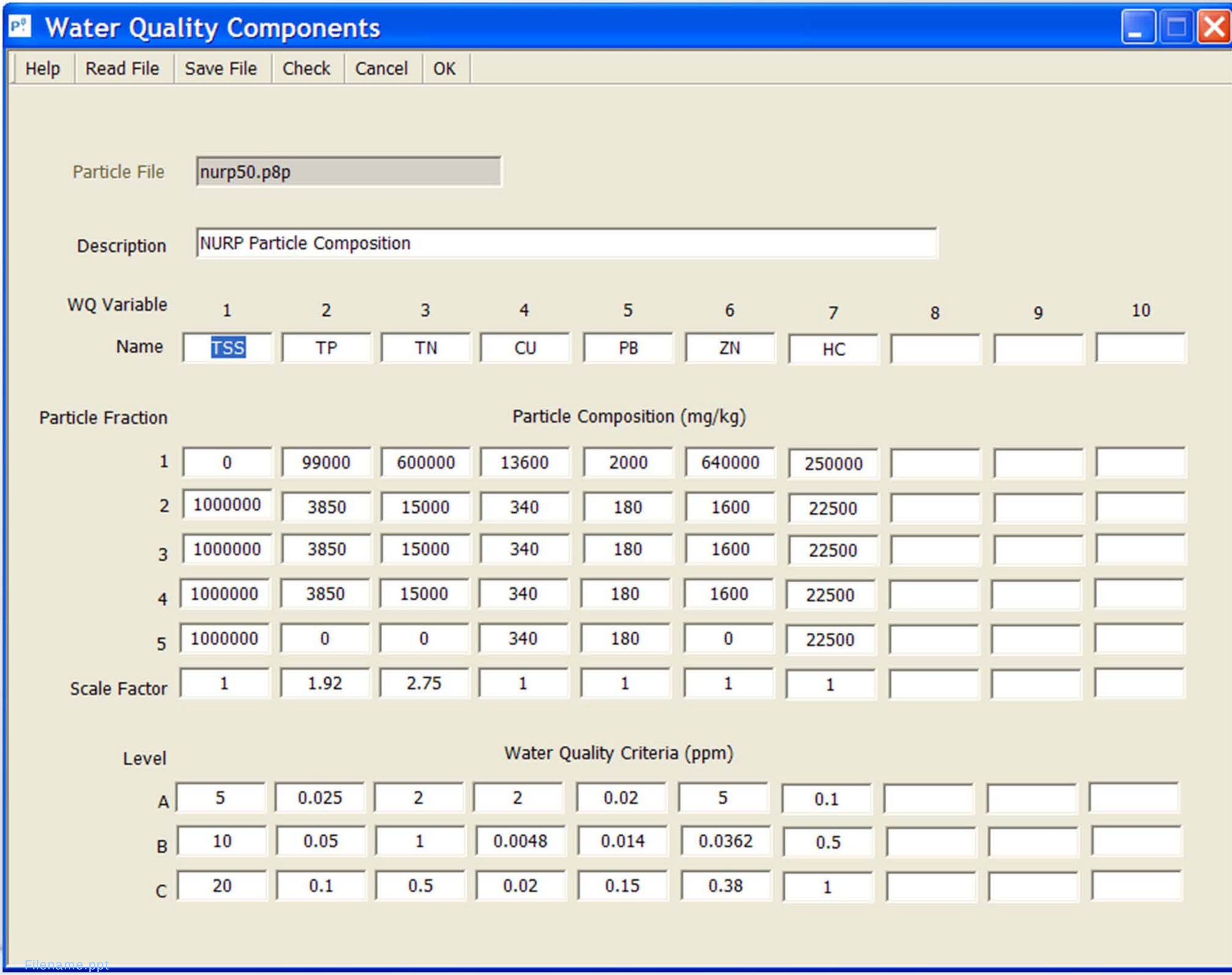


RB-AR1554

Watershed input data sheet



RB-AR1555



Water Quality Components

Help | Read File | Save File | Check | Cancel | OK

Particle File: nurp50.p8p

Description: NURP Particle Composition

WQ Variable	1	2	3	4	5	6	7	8	9	10
Name	TSS	TP	TN	CU	PB	ZN	HC			

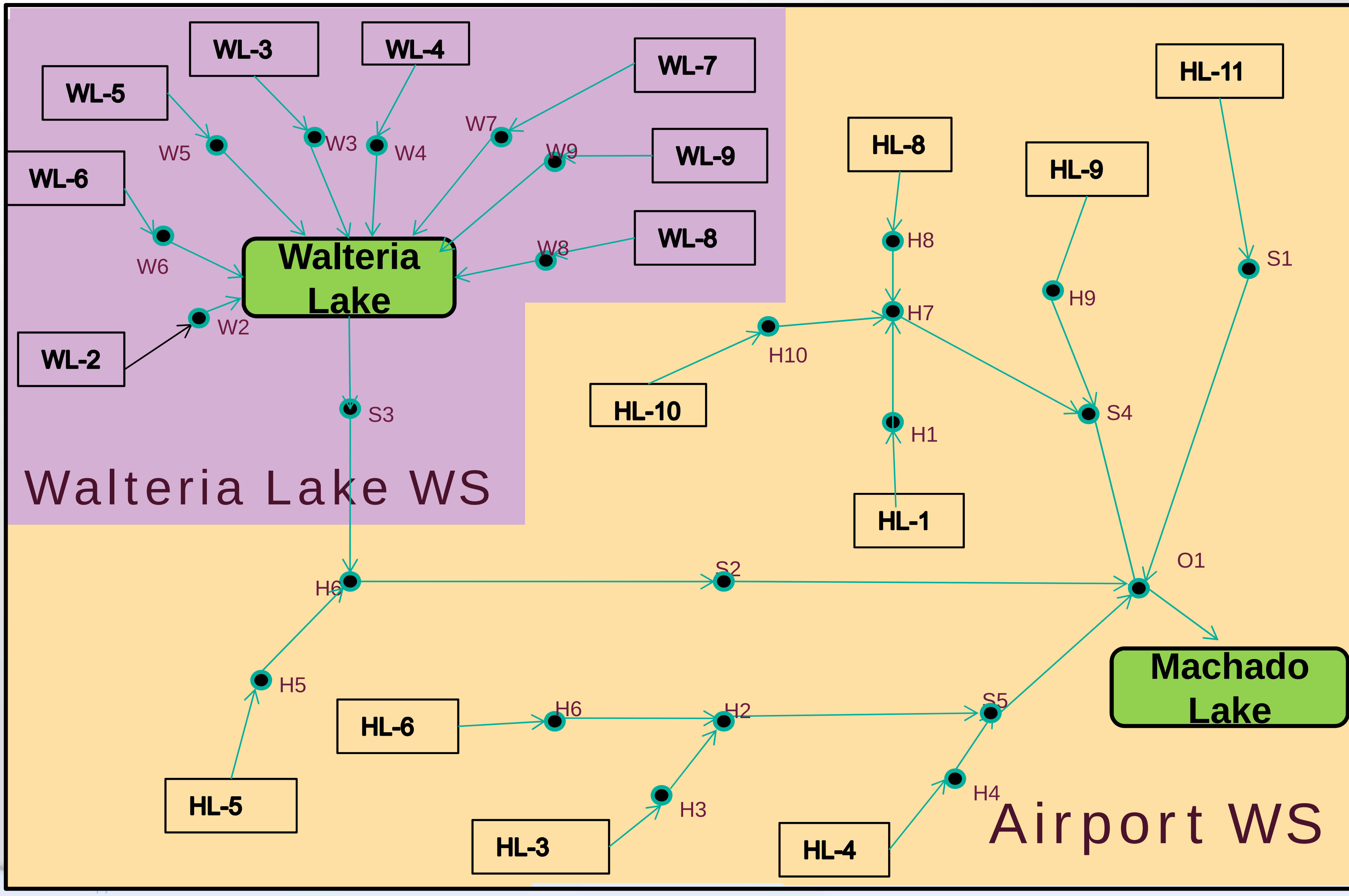
Particle Composition (mg/kg)

Particle Fraction	1	2	3	4	5	6	7	8	9	10
1	0	99000	600000	13600	2000	640000	250000			
2	1000000	3850	15000	340	180	1600	22500			
3	1000000	3850	15000	340	180	1600	22500			
4	1000000	3850	15000	340	180	1600	22500			
5	1000000	0	0	340	180	0	22500			
Scale Factor	1	1.92	2.75	1	1	1	1			

Water Quality Criteria (ppm)

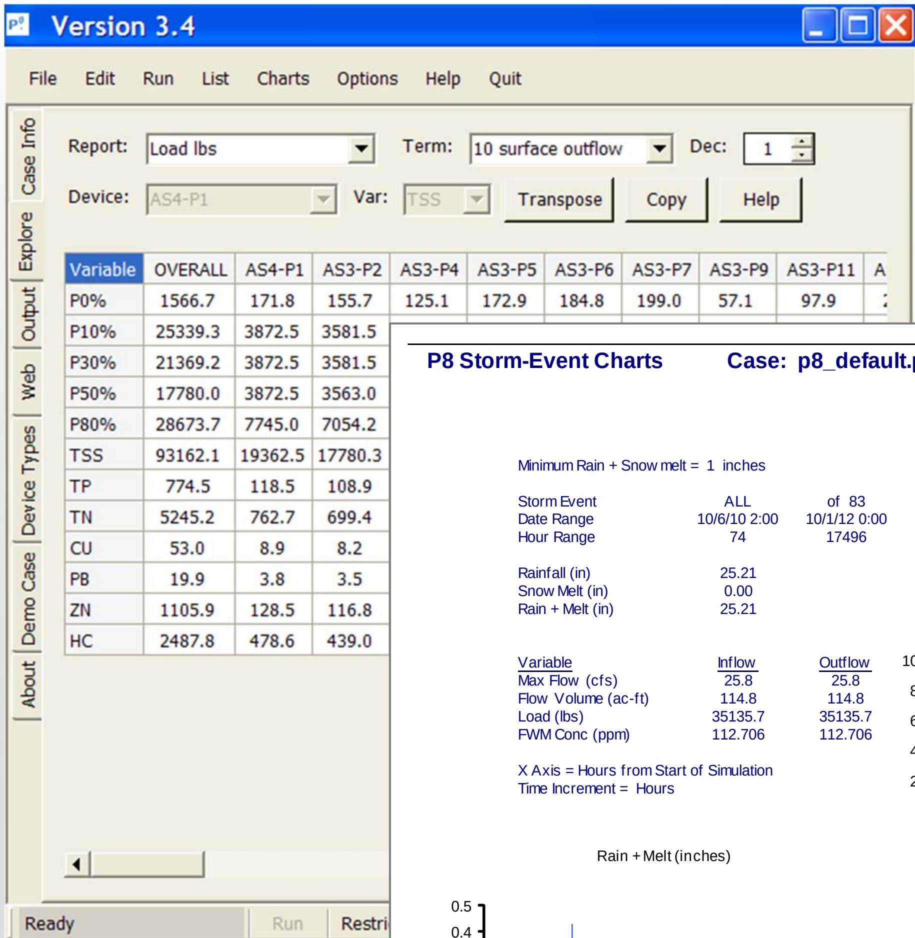
Level	1	2	3	4	5	6	7	8	9	10
A	5	0.025	2	2	0.02	5	0.1			
B	10	0.05	1	0.0048	0.014	0.0362	0.5			
C	20	0.1	0.5	0.02	0.15	0.38	1			

The P8 Model of Machado Lake contains 17 subareas for detailed BMP modeling



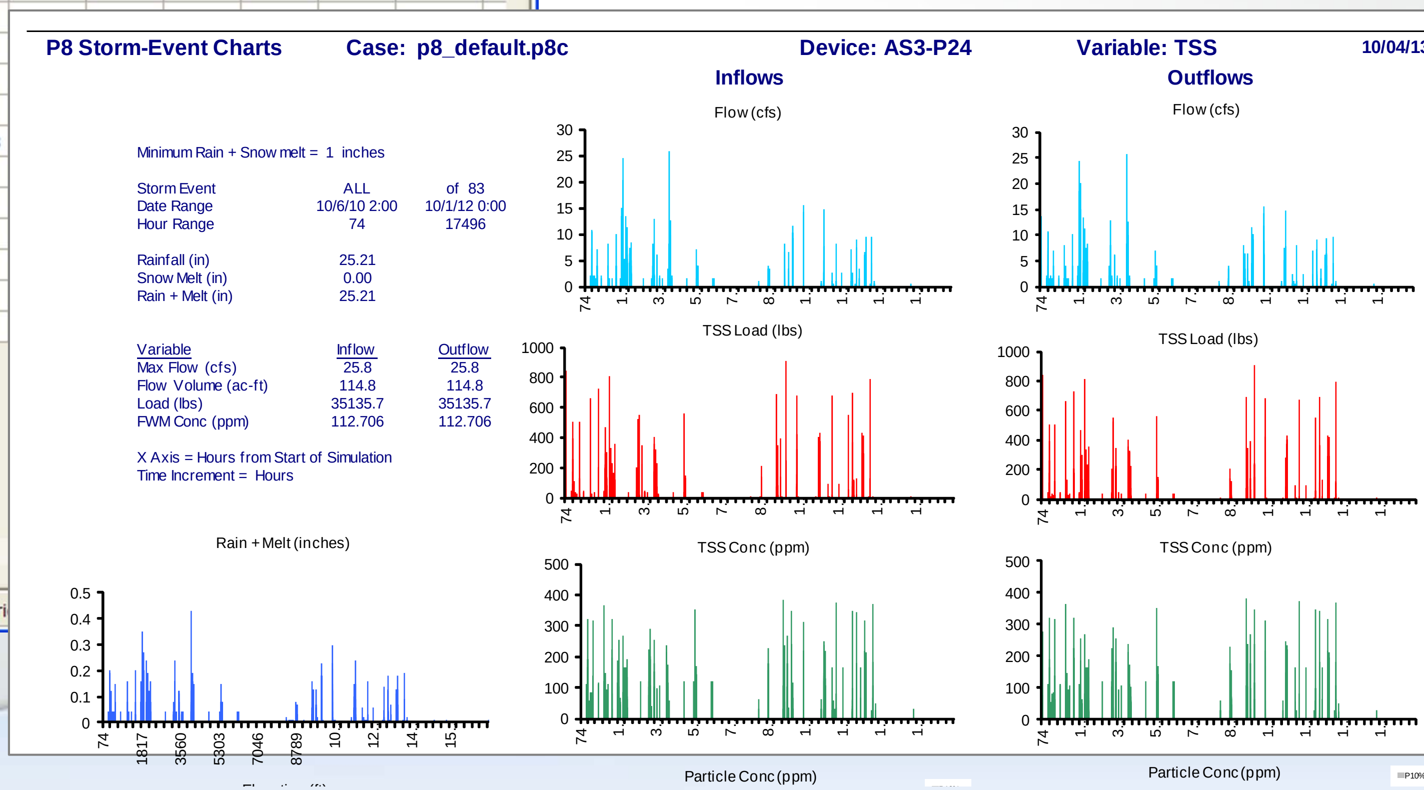
P8 Model produces time-series pollutant loads for BMP sizing and siting

INPUT



Variable	OVERALL	AS4-P1	AS3-P2	AS3-P4	AS3-P5	AS3-P6	AS3-P7	AS3-P9	AS3-P11	A
P0%	1566.7	171.8	155.7	125.1	172.9	184.8	199.0	57.1	97.9	2
P10%	25339.3	3872.5	3581.5							
P30%	21369.2	3872.5	3581.5							
P50%	17780.0	3872.5	3563.0							
P80%	28673.7	7745.0	7054.2							
TSS	93162.1	19362.5	17780.3							
TP	774.5	118.5	108.9							
TN	5245.2	762.7	699.4							
CU	53.0	8.9	8.2							
PB	19.9	3.8	3.5							
ZN	1105.9	128.5	116.8							
HC	2487.8	478.6	439.0							

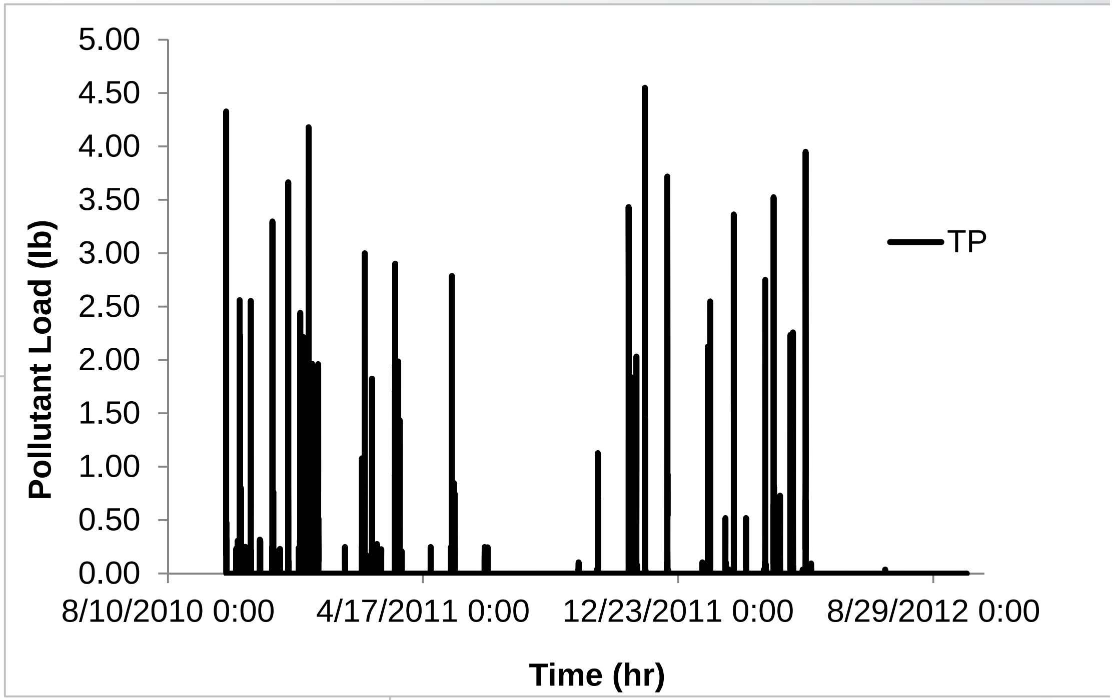
OUTPUT



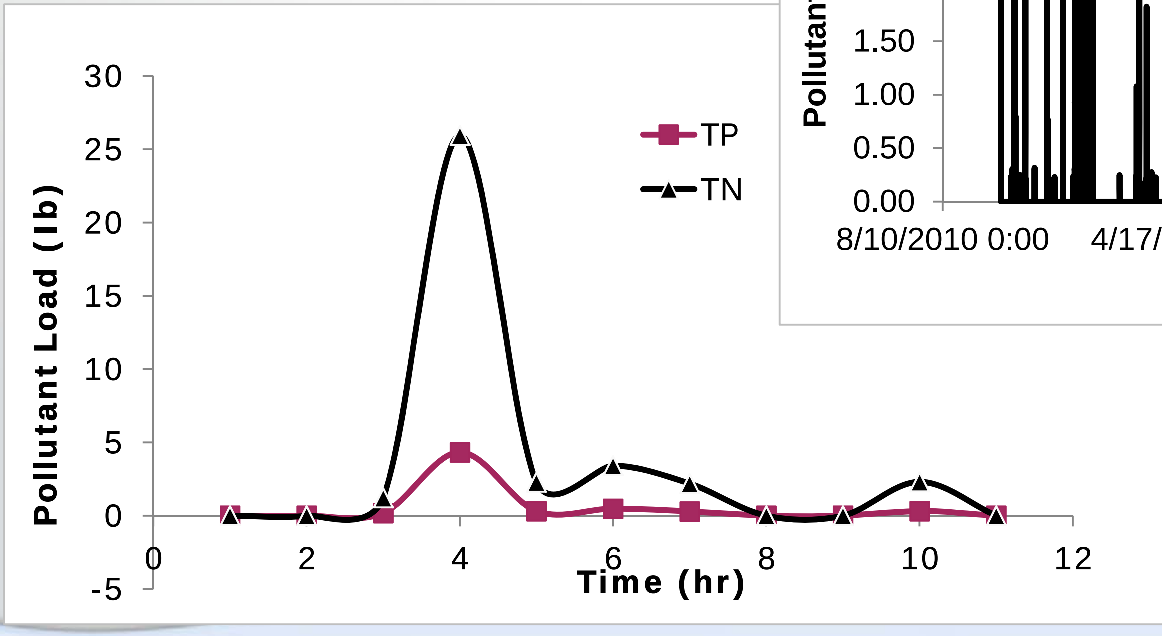
RB-AR1558

The P8 model can simulate both short-term storm events and long-term hydrology

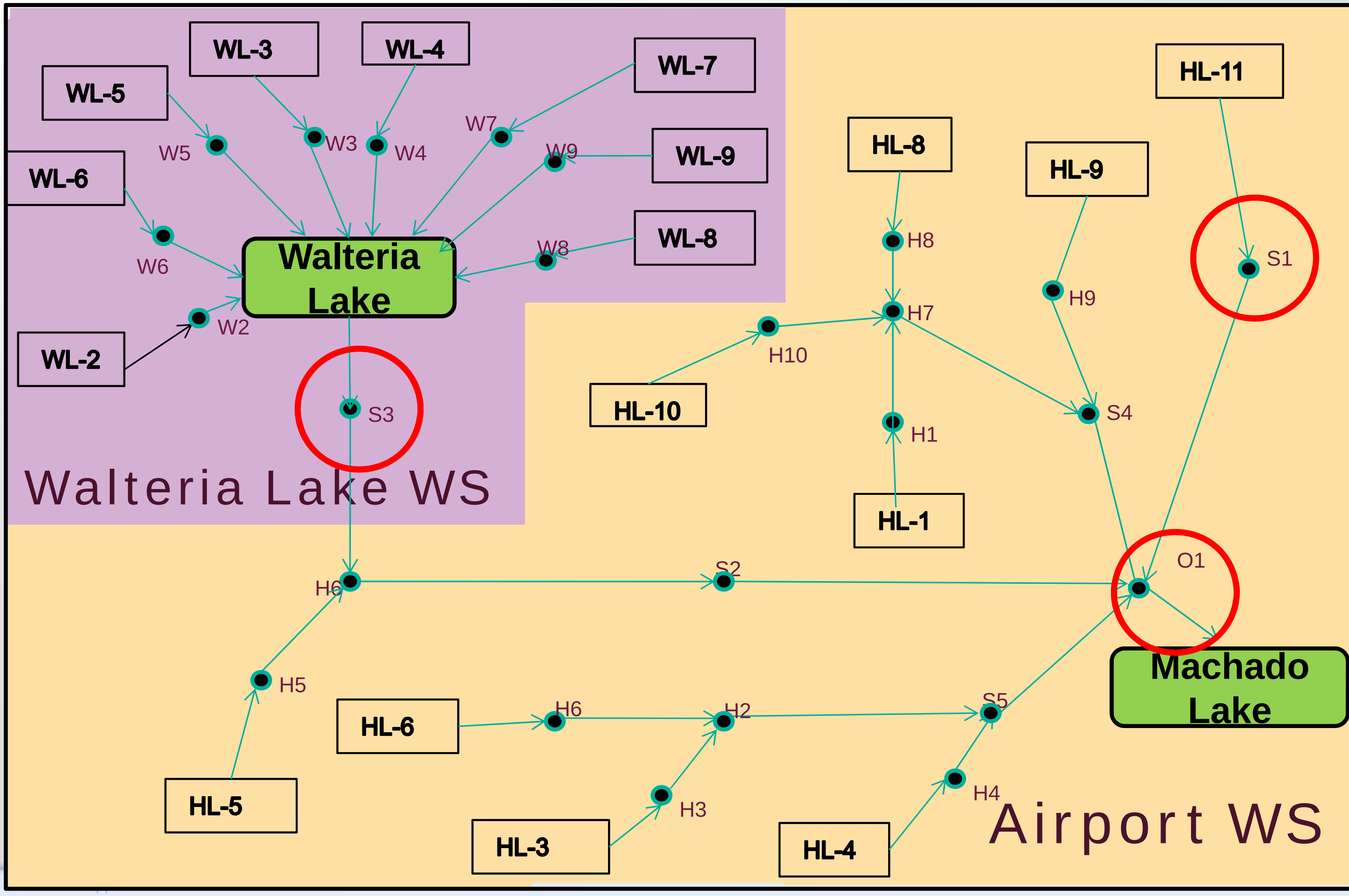
LONG-TERM
(from multiple storms to 30-yr hydrology)



SHORT-TERM
(24-hour design storm)

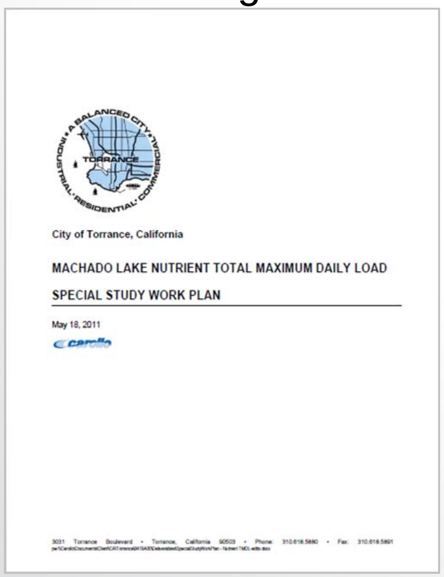


The P8 model allows for quick comparison of model and monitoring sampling data



The P8 model allows for quick comparison of model and monitoring sampling data

Machado Lake
Nutrient TMDL
Monitoring Plan



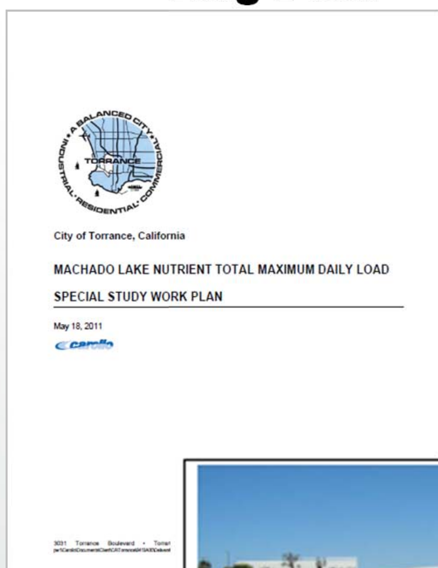
City of Torrance, California

MACHADO LAKE NUTRIENT TOTAL MAXIMUM DAILY LOAD

SPECIAL STUDY WORK PLAN

May 18, 2011

Machado Lake
Toxics TMDL
Monitoring Plan

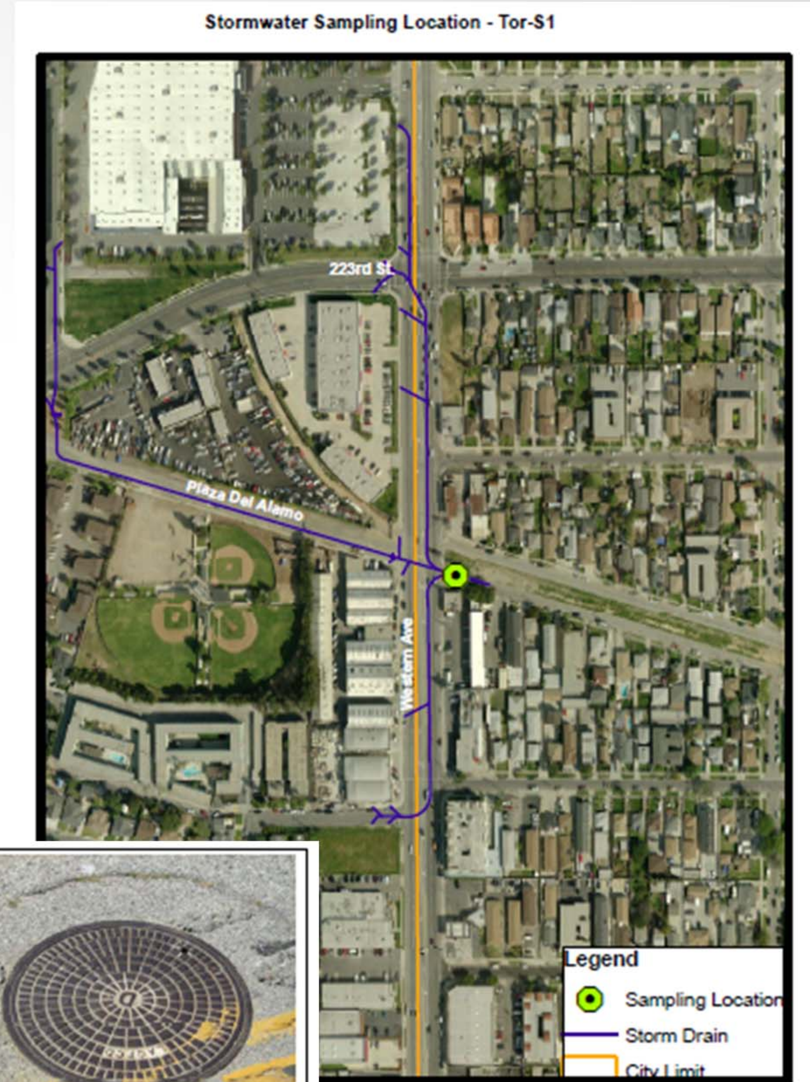


City of Torrance, California

MACHADO LAKE NUTRIENT TOTAL MAXIMUM DAILY LOAD

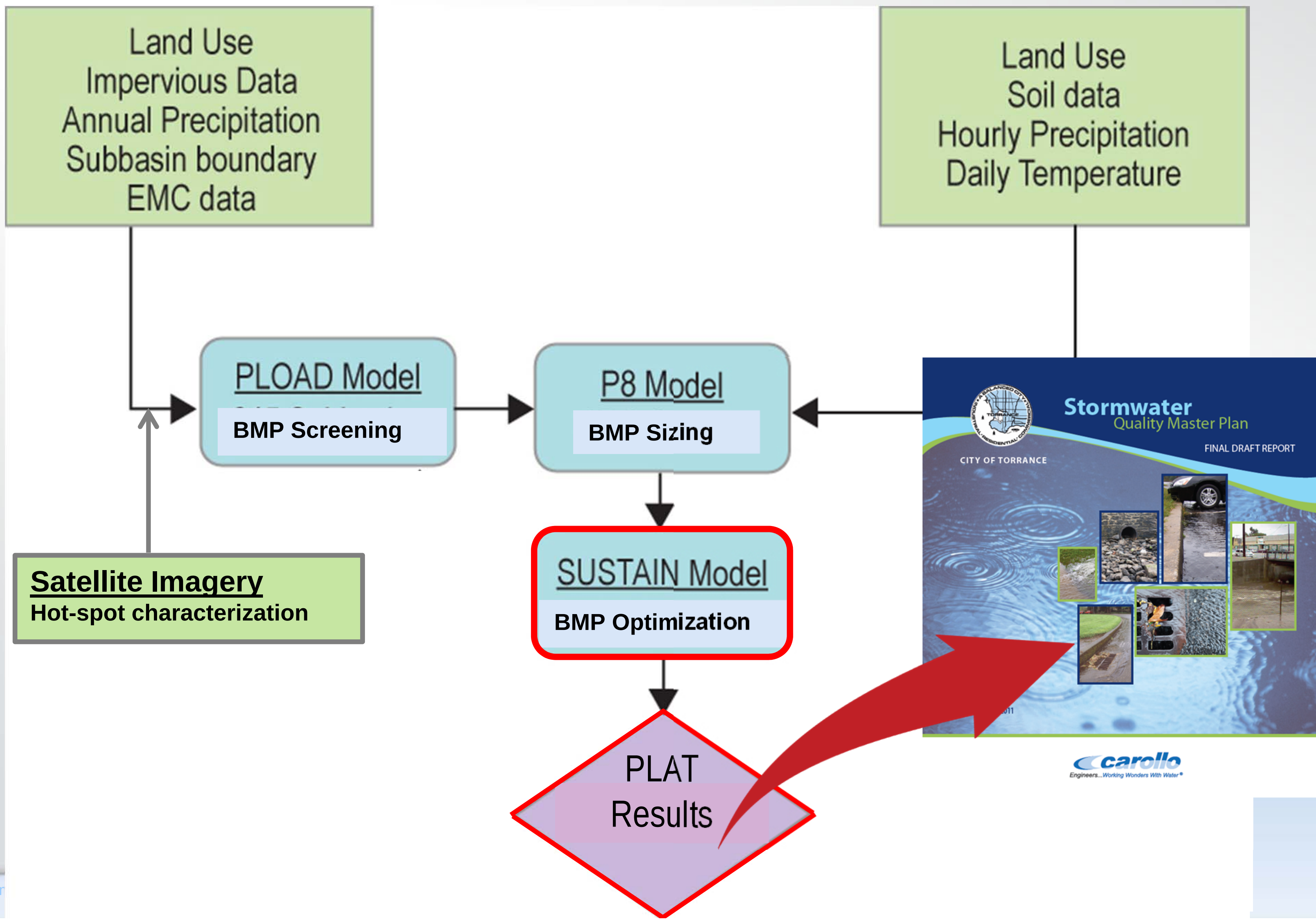
SPECIAL STUDY WORK PLAN

May 18, 2011



SAMPLING SITE TOR-S1

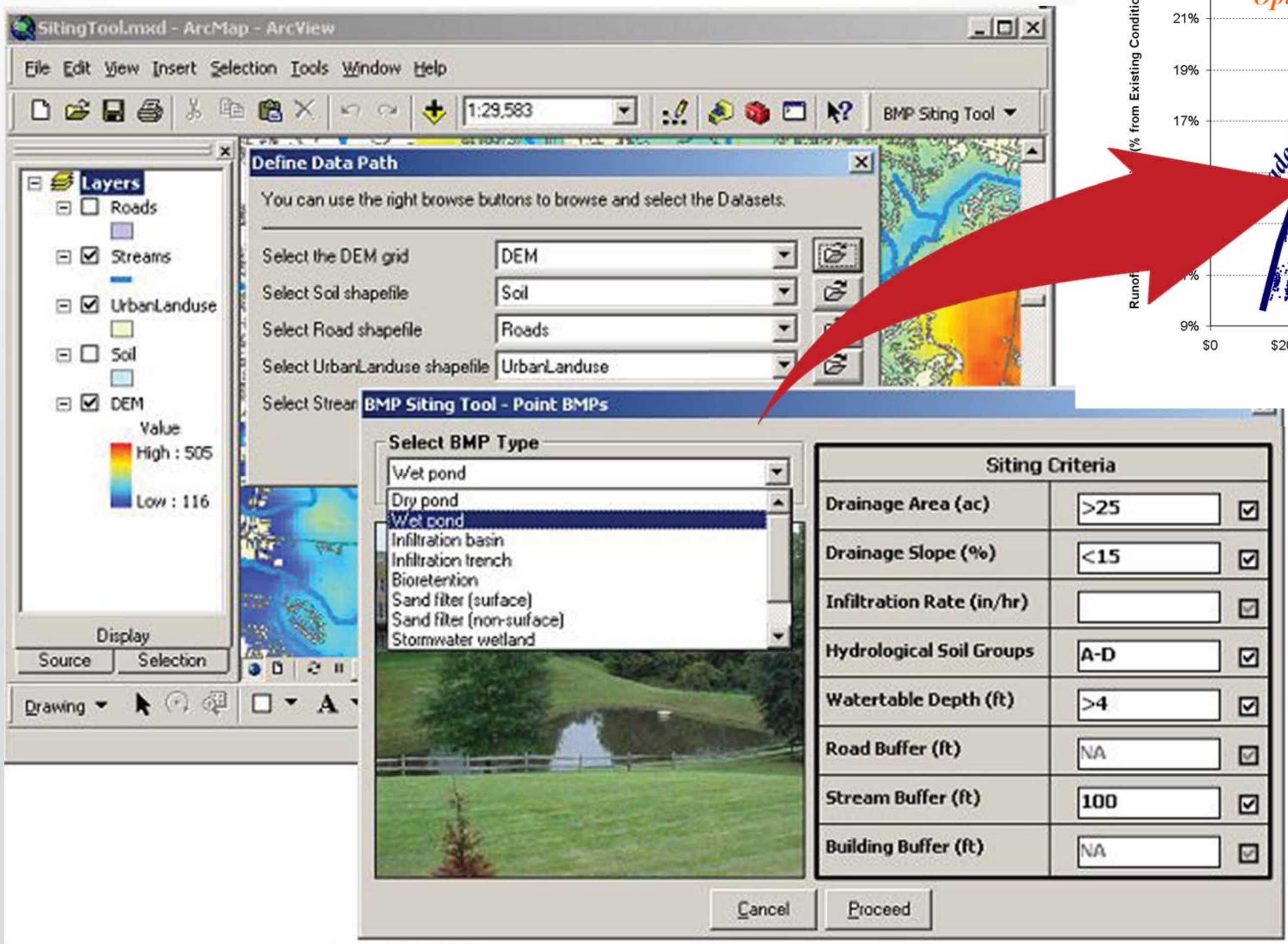
The last step of PLAT is BMP selection and optimization in SUSTAIN

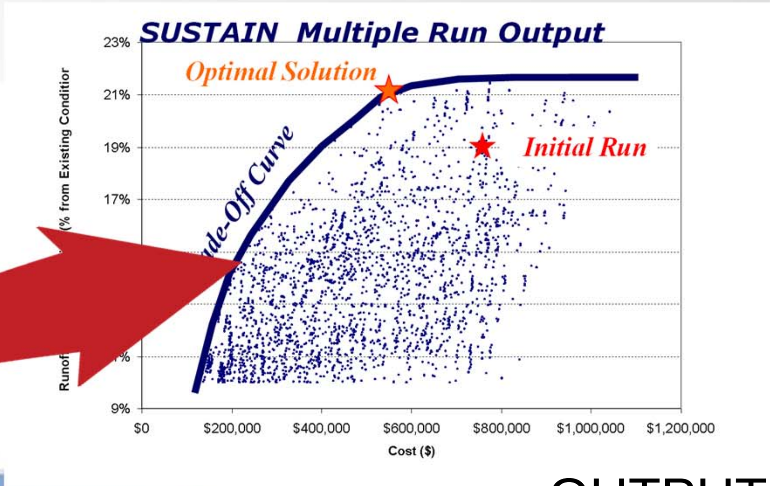


RB-AR1562

The SUSTAIN Model is used to optimize sizing and minimize cost

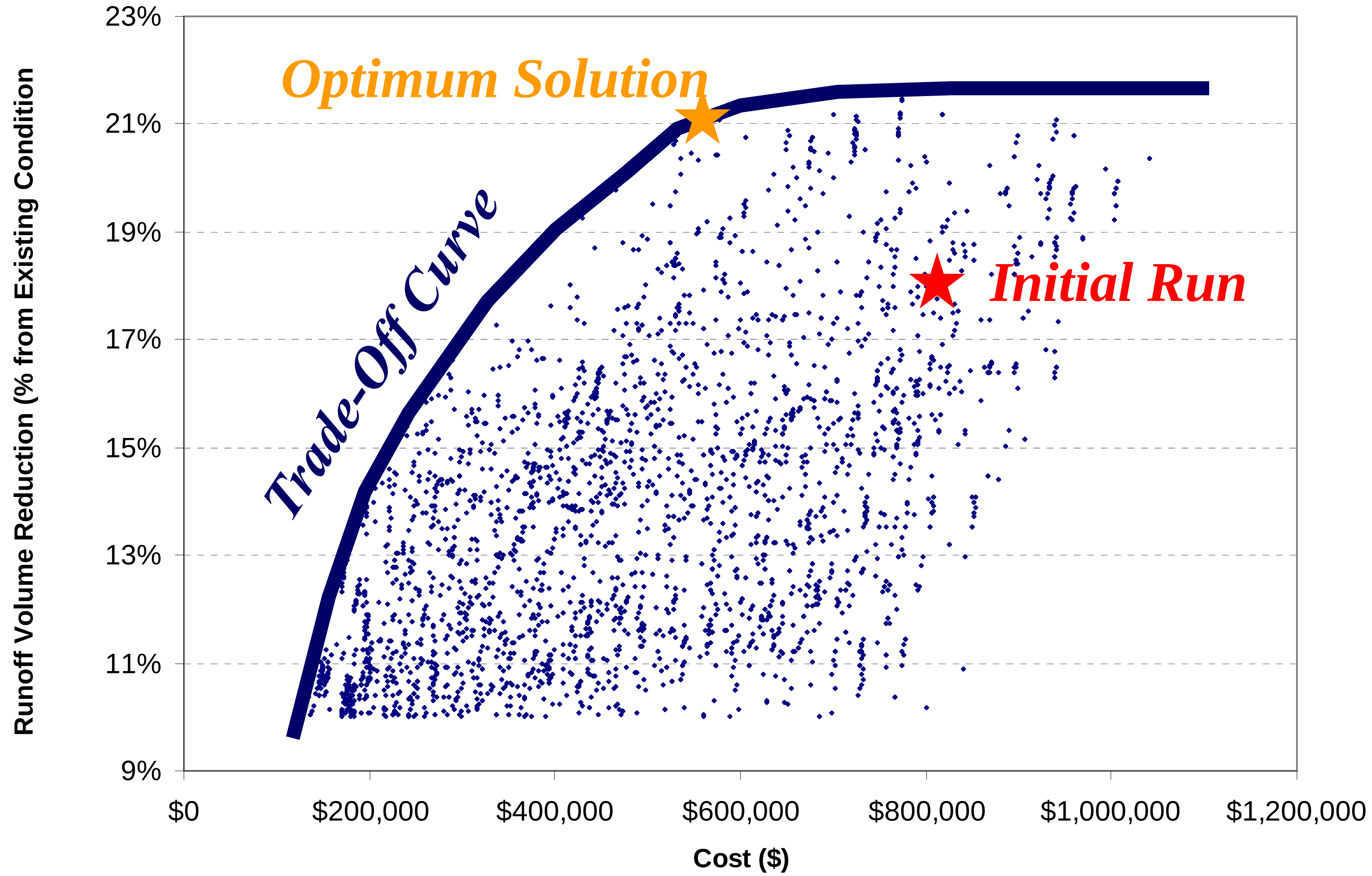
INPUT





OUTPUT

SUSTAIN identifies optimum solution by finding point of diminishing return on trade-off curve



Conclusions

- **PLAT Modeling Benefits**
  - Efficient due to initial BMP screening prior to detailed modeling process
  - Utilization of highly accurate satellite data
  - Applicable for both watershed and site-scale
  - Allows both short- and long-term durations
  - Utilizes non-proprietary tools for RWQCB approval
- **Satellite Imagery Benefits**
  - Recent data readily available
  - Accurate source to determine imperviousness
  - Cost-effective source to calculate imperviousness and pollutant loads
  - Accurate source for land characterization, including vacant land for BMP siting




Satellite Remote Sensing Based Watershed Modeling for TMDL Implementation

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RAA Sub-Commitee
November 14, 2013

Representative	Sign In	Alternate	Sign In
TJ Moon County	[signature]		
Cindy Lin USEPA	[signature]		
David Smith USEPA			
Anthoney Arevalo		Ana De Anda	
Mike Antos			
Vijay Desai, City of Los Angeles			
Kirsten James	via Phone		
Richard Horner			
Liz Crosson	via Phone		
Desi Alvarez Huntington Park	[signature]		
Cameron McCullough	[signature]		
Bruce Hamamoto County	[signature]		
Noah Garrison			
Thanhloan Nguyen	via Phone		
Renee Purdy			
Ivar Ridgeway	Ivar K Ridgeway		
Hamid Tadayon City of Los Angeles			

RB-AR1567

RAA Sub-Commitee
November 14, 2013

Alfredo Magallanes City of Los Angeles			
Heather Merenda Santa Clarita			
John Dettle Torrance			
Ching-piau Lai			
Joe Bellomo			

RB-AR1568

RAA Sub-Commitee
December 4, 2013

Representative	Sign In	Alternate	Sign In
TJ Moon County	[signature]		
Cindy Lin USEPA			
David Smith USEPA			
Anthony Arevalo		Ana De Anda	
Mike Antos	[signature]		
Vijay Desai, City of Los Angeles			
Kirsten James	[signature]		
Richard Horner			
Liz Crosson			
Desi Alvarez Huntington Park	[signature]		
Cameron McCullough	[signature]		
Bruce Hamamoto County	[signature]		
Noah Garrison			
C.P. Lai	[signature]		
Thanhloan Nguyen	[signature]		
Renee Purdy			
Ivar Ridgeway	[signature]		

RAA Sub-Commitee
December 4, 2013

Hamid Tadayon City of Los Angeles			
Alfredo Magallanes City of Los Angeles			
Heather Merenda Santa Clarita			
John Dettle Torrance			
KEN SUSILO GEOSYNTEC			

RAA Subcommittee Meeting

January 9, 2014 at 1:00 PM

Los Angeles County Department of Public Works HQ

Conference Room D

I. Introductions
II. RAA Guidance Document Discussion
III. 2014 Meeting Schedule Discussion
IV. Action items and next meeting

GUIDELINES FOR CONDUCTING REASONABLE ASSURANCE ANALYSIS IN A WATERSHED MANAGEMENT PROGRAM, INCLUDING AN ENHANCED WATERSHED MANAGEMENT PROGRAM

The Regional Board adopted Waste Discharge Requirements for Municipal Separate Storm Sewer System (MS4) Discharges within the Coastal Watersheds of Los Angeles County, Order No. R4-2012-0175 (NPDES Permit No. CAS004001). As required in the permit, Part VI.C.5.b.iv.(5), permittees electing to develop a watershed management program (WMP) or enhanced watershed management program (EWMP) are required to submit a Reasonable Assurance Analysis (RAA) as part of their draft E/WMP to demonstrate that applicable water quality based effluent limitations and receiving water limitations shall be achieved through implementation of the watershed control measures proposed in the E/WMP. This guidance document is prepared to provide information and guidance to assist permittees in development of the RAA. This document provides clarification of the regulatory requirements of the RAA along with recommended criteria for the permittees to follow to prepare an appropriate RAA for Regional Board approval.

A. APPLICABLE INTERIM AND FINAL REQUIREMENTS:

Per Part VI.C.5.a of the permit, and based on an evaluation of existing water quality conditions, permittees shall classify and list water body-pollutant combinations into one of the following three categories within their draft E/WMP:

- Category 1 (Highest Priority): Water body-pollutant combinations for which water quality-based effluent limitations and/or receiving water limitations are established in Part VI.E TMDL Provisions and Attachments L through R of the MS4 Permit.
- Category 2 (High Priority): Pollutants for which data indicate water quality impairment in the receiving water according to the State Board's Water Quality Control Policy for Developing California's Clean Water Act Section 303(d) List (State Listing Policy) and for which MS4 discharges may be causing or contributing to the impairment.
- Category 3 (Medium Priority): Pollutants for which there are insufficient data to indicate water quality impairment in the receiving water according to the State's Listing Policy, but which exceed applicable receiving water limitations contained in this Order and for which MS4 discharges may be causing or contributing to the exceedance.

Permittees shall identify the water quality priorities within each watershed management area (WMA) that will be addressed by the E/WMP in order to achieve applicable water quality limitations (i.e., WQBELs and RWLs) within the timeframes established by the corresponding compliance schedules set forth in Attachments L-R, or where there is no specific compliance schedule contained in Attachments L-R, the compliance schedule set forth in the E/WMP. For watershed priorities related to addressing exceedances of RWLs in Part V.A and not otherwise addressed by Part VI.E, proposed compliance schedules must adhere to the requirements of Part VI.C.5.c.iii.(3). For watershed priorities related to achieving WLAs in USEPA established TMDLs, proposed compliance schedules must adhere to the requirements of Part VI.E.3.c.iii-v.

Permittees may choose to further subcategorize water body-pollutant combinations within the three main categories above for purposes of sequencing implementation of watershed control measures in the most effective manner possible, taking into consideration compliance deadlines and opportunities to address multiple pollutants within a water body with similar watershed control measures. This is consistent with the permit provisions in Parts VI.C.2 and VI.C.3, which group pollutants for purposes of complying with the RWLs Provisions according to whether the pollutant is being addressed by a TMDL, is similar in its fate/transport characteristics and effective implementation measures to a pollutant being addressed by a TMDL, is currently listed on the 303(d) list, or exhibits only occasional exceedances in the receiving water. For example, permittees may wish to identify which water body-pollutant combinations in Categories 2 and 3 above are similar to a water body-pollutant combination in Category 1, and could therefore be addressed simultaneously with the water body-pollutant combination in Category 1. Permittees are invited to discuss with Regional Board staff, and solicit early input on, approaches to further subcategorization of water body-pollutant combinations.

B. CURRENT/EXISTING POLLUTANT LOADING ASSOCIATED WITH CURRENT BEST MANAGEMENT PRACTICES (BMPs)/MINIMUM CONTROL MEASURES (MCMs)

- Permittees shall provide a list and map of known and suspected storm water and non-storm water pollutant sources discharging to MS4 and from the MS4 to receiving waters and any other stressors related to MS4 discharges causing or contributing to the impairments. The map must include all MS4 "major outfalls"[1], major structural controls of storm and non-storm water[2] (including, but not limited to, low flow diversions, urban runoff treatment facilities, detention and retention basins used for storm water treatment, VSS devices, other catch basin inserts/screens) that discharge to receiving waters within the watershed management area. A separate tabular list of major structural controls should also be provided. Permittees shall also provide list of non-structural controls that are currently implemented within the area(s), the results of which will be assumed to be reflected in the baseline pollutant loading.[3]
- Permittees shall provide an initial assessment of current/baseline pollutant loading for water body-pollutant combinations identified in Section A. Current/baseline pollutant loading shall based on relevant subwatershed data and the best available representative land use and pollutant loading data collected within the last 10 years. Appropriate data sources for use in assessment of baseline pollutant loading are identified in the tables below. At a minimum, baseline pollutant loadings shall be assessed and reported considering variability in pollutant loading at a spatial and temporal (including critical condition) scale consistent with that used in the TMDL and in the approved monitoring plan (i.e., for each subwatershed that was identified/analyzed/modeled in the TMDL and for each compliance monitoring location identified in the approved monitoring plan).
- Baseline loading shall be estimated using metrics derived from long-term historical data (e.g., annual rainfall, flow/runoff volume, pollutant loading, pollutant concentrations over the past 10 years) using calibrated dynamic model results for each subwatershed area. Such baseline loading estimates shall be generated for both (1) critical conditions (consistent with applicable TMDLs) and (2) average conditions for metrics related to quantity and quality (see examples of metrics, above). Critical conditions for baseline estimates shall be based on:
    - I. Baseline flow rates/runoff volumes shall be based on one of the following:
        - a) 90th percentile of long term estimated/modeled flow rates; or
        - b) Other established critical condition in the applicable TMDL; or
        - c) Runoff volume from the 85th percentile, 24-hour rainfall event (for modeled drainage areas where retention based BMPs will capture 100% of the required volume).

[1] Per definition in federal regulations.

[2] Spatial metadata must include delineation of drainage area treated where available, maximum volume of non-stormwater/stormwater treated, type of control, pollutants addressed, name and contact information of owner and, if different, operator in charge of O&M.

[3] It is assumed that these BMPs include full implementation of the 2001 Permit Storm Water Management Program elements as well as the structural BMPs identified in the first bullet.

II. Baseline pollutant loading shall be based on one of the following:

a) 90th percentile of long term pollutant loading/concentration (considering at least the most recent 10 years of available data); or

b) Long term average pollutant loading/concentration (considering at least the most recent 10 years of available data) that also incorporates the coefficient of variation so as to take the variability of pollutant loading into account. Consideration of variability must be sufficient to capture the baseline condition and required pollutant reductions under the critical condition. Where long-term average pollutant loading/concentration is used, critical conditions may be described using the long-term average loading with a coefficient of variation (CV) to take the variability of pollutant loading into account. For this type of critical condition, the reported pollutant loading in each subwatershed should be established by using a variability factor (VF) for model-predicted volumes, concentrations, and/or loads obtained from the long-term average and CV with the selected probability distribution of the pollutant loading. Procedures for the detailed calculation of variability factors for different probability distributions are described in Appendix E of the Technical Support Document for Water Quality-based Toxics Control (EPA/505/2-90-001, March 1991). It is anticipated that log-normal distributions will be assumed. If a different type of critical condition is applied (e.g. 90th percentile wet year), then CV and VF calculations are not required.

c) Pollutant event mean concentrations (EMCs) based on land use types from recommended data sources as referenced in table below may be used to estimate baseline pollutant loading; however, they must be used in combination with one of the critical conditions for flow rate/runoff volume identified in Part I, above.

- The estimated pollutant loading and/or concentrations shall be consistent with event mean concentrations (EMCs) obtained from different land use site as referenced in dependable sources, some of which are listed below:

Source No.	Reference
1.	**Sources, patterns and mechanisms of storm water pollutant loading from watersheds and land uses of the greater Los Angeles area, California, USA.** 2007. ED Stein, LL Tiefenthaler, KC Schiff. Technical Report 510. Southern California Coastal Water Research Project. Costa Mesa
2.	**Levels and patterns of fecal indicator bacteria in stormwater runoff from homogenous land use sites and urban watersheds. Request Only.** 2011. LL Tiefenthaler, ED Stein, KC Schiff. Journal of Water and Health 9:279-290
3.	Los Angeles County 2006 EMC Report

If a permittee(s) selects to use other independent sources of pollutant loading data in the RAA, the permittee(s) shall assure that the source(s) selected has appropriate documentation, is current, and is publicly available. The permittee(s) shall be required to provide the rationale used to support their selection of baseline pollutant loading data as well as the raw data and all associated QA/QC information for Regional Board review and approval.

- Baseline pollutant loading should be expressed on a pollutant-by-pollutant basis consistent with the relevant averaging period(s) / duration as expressed in the TMDL and Attachments L-Q. If the pollutant is not addressed by a TMDL, but TMDLs for that pollutant exist for other water bodies, permittees should express pollutant loading in terms of averaging period(s) / duration consistent with those other TMDLs.

C. ESTIMATED REQUIRED POLLUTANT REDUCTIONS TO MEET THE INTERIM AND/OR FINAL ALLOWABLE POLLUTANT LOADING(S)

- Permittees shall provide estimated allowable loadings from MS4 discharges expressed as concentration-based or mass-based in consideration of critical conditions. Mass-based allowable loading will be calculated based on a permittee's proportion of the watershed management area for required WQBELs. Mass-based allowable loading should be calculated for each subwatershed area identified in Section B, above.
- The difference between the current and allowable pollutant loading at each implementation deadline is the required pollutant reduction at each implementation deadline. The required pollutant reduction should be calculated based on both long-term average annual condition and the selected critical condition (as described in Section B). For modeled drainage areas where 100% of the runoff volume from the 85th percentile, 24-hour storm event is not retained, the required pollutant reduction shall be used to set targets/goals for BMPs/watershed control measures within that subwatershed area. The percent reductions to be used to set targets/goals will be dependent on the phase(s) of implementation to be addressed, as described in Section E.
- Estimated allowable loading and required reductions should be expressed on a pollutant-by-pollutant basis consistent with the relevant averaging period(s)/duration (including the selected critical condition) consistent with the TMDL and Attachments L-Q. Where a TMDL has not been developed for the water body-pollutant combination, permittees should select an averaging period/duration/critical condition consistent with that used in other TMDLs that have been developed for the pollutant in other water bodies within the region.

D. SELECTED IMPLEMENTATION/BMPs OPTIONS

Permittees shall identify strategies, control measures, and BMPs to implement through their selected storm water management programs as listed below. As a starting point, selected control measurements should be designed and maintained to treat storm water runoff from the 85th percentile, 24-hour storm where feasible and necessary to achieve applicable WQBELs and receiving water limitations.

I. ENHANCED WATERSHED MANAGEMENT PROGRAM (EWMP)

a) DETAILED DESCRIPTION OF DRAINAGE AND RETENTION SYSTEMS

If the permittees select to develop a EWMP that includes projects that retain all non-storm water runoff and all storm water runoff from the 85th percentile, 24-hour storm event for the drainage areas tributary to the projects, the permittees are required to provide a detailed description of each regional multi-benefit retention system including type (bioretention system, sub-surface chamber, etc.), drainage area addressed, storage volume, and approximate system size as well as a description and quantification, where possible, of other benefits (e.g., amount of water recharged to groundwater for water supply, etc.).

b) PROPOSED WATERSHED CONTROL MEASURES TO CONTROL STORM AND NON-STORM WATER DISCHARGES

In drainage areas within the EWMP area where retention of 85th percentile, 24-hour storm event is not pursued, the permittees are required to identify watershed control measures that will be implemented in addition to existing BMPs to prevent or eliminate non-storm water discharges that are a source of pollutants to receiving waters, and to achieve all applicable interim and final water quality-based effluent limitations and all receiving water limitations. Watershed control measures may include:

- **i.** Structural and/or non-structural controls and operation and maintenance procedures that are designed to achieve applicable water quality-based effluent limitations and receiving water limitations;
- **ii.** Retrofitting areas of existing development known or suspected to contribute to the highest water quality priorities with regional or sub-regional controls or management measures; and
- **iii.** Stream and/or habitat rehabilitation or restoration projects where stream and/or habitat rehabilitation or restoration are necessary for, or will contribute to, demonstrable improvements in the physical, chemical, and biological receiving water conditions and restoration and/or protection of water quality standards in receiving waters.

c) STORM WATER MANAGEMENT PROGRAM MINIMUM CONTROL MEASURES (MCMs), NON-STORM WATER DISCHARGE CONTROLS, AND OTHER STRUCTURAL CONTROL MEASURES

Per Part VI.C.5.b.iv.(1), permittees shall assess the MCMs as defined in Part VI.D.4, Part VI.D.5, Part VI.D.6, Part VI.D.8, Part VI.D.9 and Part VI.D.10 of the MS4 Permit and potential modifications that will most effectively address priority issues in each watershed. Based on this assessment, permittees may choose to propose customized actions and corresponding schedules within each of the abovementioned minimum control measure categories. (Alternatively, permittees may choose to implement the baseline provisions within one or more of the abovementioned MCM categories.)

Per Part VI.C.5.b.iv.(2), where non-storm water discharges from the MS4 are identified as source of pollutants, permittees shall identify and list control measures, BMPs, and other strategies to effectively eliminate the source of pollutants consistent with the requirements of Part III.A and Part VI.D.4.d (for the LACFCD) and Part VI.D.10 (for all other permittees).

For TMDL related control measures, per Part VI.C.5.b.iv.(3), permittees shall also compile a list of control measures that have been identified in TMDLs and corresponding implementation plans, and identify those control measures within these TMDLs/implementation plans to be modified, if any, to most effectively address TMDL requirements in Part VI.E and Attachments L-Q. If actions identified in the E/WMP are wholly replacing the control measures identified in the TMDL implementation plan, it can be noted as such and this list is not necessary. If not sufficiently identified in previous documents (TMDLs/implementation plans), the permittees shall evaluate and identify the control measures that will be implemented to achieve the applicable WQBELs/WLAs/RWLs associated with these TMDLs. Initially, control measures should be designed to address the volume within the drainage area associated with the 85th percentile, 24-hour storm event at the correspondence compliance point.

II. WATERSHED MANAGEMENT PROGRAM (WMP)/INDIVIDUAL WMP

a) PROPOSED WATERSHED CONTROL MEASURES TO ADDRESS CONTRIBUTIONS OF STROM WATER DISCHARGES TO RECEIVING WATER

The permittees are required to identify watershed control measures that will be implemented in addition to existing BMPs to prevent or eliminate non-storm water discharges that are a source of pollutants to receiving waters, and to achieve all applicable interim and final water quality-based effluent limitations and all receiving water limitations. (See section D.I.b. for detail.)

b) STORM WATER MANAGEMENT PROGRAM MINIMUM CONTROL MEASURES (MCMs)

See section D.I.c. for detail.

E. SPECIFIED SCHEDULE OF SELECTED WATERSHED MANAGEMENT STRATEGIES

Permittees shall translate corresponding schedules for selected BMPs into a combined schedule for achievement of the applicable interim and final water quality-based effluent limitations and/or receiving water limitations per the water body classification/prioritization above. Permittees shall align the combined schedule with interim milestones and interim and final compliance deadlines specified in the permit and demonstrate that the required loading reduction and timeline specified are expected to be achieved.

- Permittees shall identify interim milestones and dates for their achievement to ensure adequate progress toward achieving interim and final water quality-based effluent limitations and/or receiving water limitations deadlines identified in TMDL provisions in Part VI.E and attachments L - Q. If selected BMPs will address multiple pollutants then BMPs must be implemented within time frame that is consistent with the most critical/closest deadline.
- Where the TMDL does not include interim or final water quality-based effluent limitations and/or receiving water limitations with compliance deadlines *during the permit term*, Permittees shall identify interim milestones and dates for their achievement to ensure adequate progress toward achieving interim and final water quality-based effluent limitations and/or receiving water limitations with deadlines beyond the permit term.
- For interim WQBELs and/or receiving water limitations, the percent reduction based on annual average baseline loading may be used to set targets/goals for BMPs/watershed control measures where such percent reduction based on the annual average baseline loading is consistent with interim requirements as set forth in Part VI.E and Attachments L-Q. A gradual phasing of percent load reduction for interim WQBELs/RWLs to final WQBELs/RWLs shall be applied over the course of the implementation schedule. For areas to be addressed through retention of the runoff volume from the 85^{th} percentile, 24-hour storm, volume reductions over time shall be related to the interim and final deadlines.
- Permittees shall demonstrate that the activities and control measures identified in the Watershed Control Measures will achieve applicable receiving water limitations for water body-pollutant combinations not addressed by TMDLs as soon as possible. Per Part VI.C.5.c.ii and Part VI.C.4.c.iii.(3), Permittees must propose milestones based on measurable criteria and a schedule with dates for achieving the milestones that will allow progress to be measured once every two years.

F. POLLUTANT REDUCTION PLAN

a) COMPLIANCE DETERMINATION

- Compliance points shall be located at all compliance points required in the TMDLs that are within the area covered by the E/WMP.
- For a Permittee implementing an individual WMP, appropriate compliance point(s) within their jurisdiction shall be identified for Regional Board approval.

- Permittees shall include an appropriate compliance point(s) to assess the MS4 discharge(s) from the area covered by the Watershed Management Program to the Receiving Water(s)

b) EVALUATION OF SELECTED MANAGEMENT PROGRAM/BMPs PERFORMANCE

- Permittees shall provide a detailed description of individual BMPs performance and /or suite of selected BMPs performance to reduce pollutant loadings that are used as model inputs. Data on performance of watershed control measures shall be drawn only from peer-reviewed sources.
- The estimated effectiveness of BMPs in pollutant removal and/or reduction will served as a default value that can be updated through the adaptive management process with BMP monitoring data and outfall monitoring data when they become available.

c) ANALYSIS TO DEMONSTRATE SELECTED BMPs HAVE REASONABLE ASSURANCE TO MEET INTERIM/FINAL REQUIREMENTS

Based on the analysis of BMP performance using the selected modeling system, Permittees shall demonstrate that:

- Implementation of current/selected activities and control measures identified in section D above will achieve applicable water quality-based effluent limitations and/or receiving water limitations in Part VI.E and Attachments L-Q.

  Although the Permit only requires the RAA to consider WQBELs and receiving water limitations with interim and final deadlines/milestones that fall within the Permit term, it is strongly recommended that the RAA assess WQBELs and RWLs with deadlines occurring between program approval and December 28, 2022. Additionally, Where the TMDL does not include interim or final water quality-based effluent limitations and/or receiving water limitations with compliance deadlines *during the permit term*, Permittees must identify interim milestones and dates for their achievement to ensure adequate progress toward achieving interim and final water quality-based effluent limitations and/or receiving water limitations with deadlines beyond the permit term and must include these in the RAA.

- For water-body pollutant combinations not addressed by TMDLs, the activities and control measures identified in the Watershed Control Measures will achieve applicable receiving water limitations per Part V.A.

Permittees shall provide model output for each deadline specified in Attachments L-Q within the permit term to demonstrate compliance with each deadline will be achieved.

d) PROCESS OF INCORPORATING ADDITIONAL BMPs IF MILESTONE ARE NOT MET AS SCHEDULED

- Permittees in each WMA shall develop an integrated monitoring program or coordinated integrated monitoring program to assess progress toward achieving the water quality-based effluent limitations and/or receiving water limitations per the compliance schedules, and progress toward addressing the water quality priorities for each WMA.
- Permittees in each WMA shall implement an adaptive management process every two years after program approval to assess progress toward (i) achieving interim and/or final water quality-based effluent limitations and/or receiving water limitations; (ii) achievement of interim milestones; (iii) re-evaluation of the water quality priorities identified for the WMA based on more recent water quality data and reassessment of sources of pollutants in MS4 discharges; and (iv) evaluation of effectiveness of the control measures based on new information and data.

- Permittees shall report and then implement any modifications to the WMP or EWMP based on the results of the adaptive management process to improve the effectiveness of WMP or EWMP in reducing pollutant loading upon approval by the Regional Executive Officer, or within 60 days of submittal if the Regional Water Board Executive Officer expresses no objections.

G. MODELING REQUIREMENTS FOR REASONABLE ASSURANCE ANALYSIS TO SUPPORT ESTIMATION OF CURRENT LOADINGS, REQUIRED LOAD REDUCTIONS AND ANALYSIS OF WATER QUALITY OUTCOMES OF SELECTED BMPs OPTIONS

Permittees shall provide a modeling system to support the estimation of baseline loadings, required load reductions that are used to set targets/goals for selected BMPs/watershed control measures, and to demonstrate that the activities and watershed control measures identified/selected in the E/WMP will achieve applicable water quality-based effluent limitations and receiving water limitations.

The models appropriate for conducting the required RAA described above are listed in **Table 1.** These models are selected based on the following model capabilities:

(1) Dynamic continuous long-term simulation for modeling pollutant loadings, flows, and concentrations in receiving water from lands in a watershed system.
(2) Can represent rainfall and runoff processes above soil surface, and baseflow contributions in subsurfaces of urban and natural watershed systems.
(3) Can represent variability in pollutant loadings, based on land use, soil hydrologic group, and slope.
(4) BMP process based approach or empirically based BMP approach.
(5) Decision support to evaluate BMP performance
Permittees may select a combination of the models listed in model type 1.1-1.3 of Table 1 for land/watershed, receiving water, and BMP performance models, or select one of the modeling systems from integrated modeling systems listed in model type 1.4 of Table 1.

Table 1. List of Available Models

Model Type	Available Models
1.1 Land/Watershed Models	
	HSPF, LSPC, SWMM, WARMF
1.2 Receiving Water Models	
	EFDC, CE-QUAL-ICM/TOXI, QUAL2K, WASP, HSPF, LSPC, SWMM
1.3 BMP Performance Models	
* Process based models	SWMM BMP model BASINS BMP model EPA SUSTAIN model
* Empirically based models	International Stormwater BMP Database

Model Type	Available Models
1.4 Integrated BMP Modeling Systems	
* Process based models	EPA SUSTAIN model Los Angeles County WMMS model EPA TMDL Modeling Toolbox
* Empirical based models	City of Los Angeles SBPAT model

The modeling requirements consist of four primary components which are described as in the following Tables. The four components of modeling requirements are general model input data (Table 2), model parameters (Tables 3.1-3.3), BMP performance parameters (Tables 4.1-4.2), and model output (Table 5). For model parameters and BMP performance parameters, two separate tables are provided for a process based BMP model and an empirically based BMP model. It should be noted that the model requirements are the minimum requirements for a BMP performance evaluation since the specific performance measures vary depending on the designated use of the water body and the condition of the water body. Permittees shall cover all necessary requirements for a BMP performance evaluation based on input and recommendations from the TAC as approved by the Regional Board. With regard to the spatial scale, the highest resolution GIS layers should be used to satisfy the homogeneous assumption in a computational/modeled subwatershed. For temporal scale, the model should use varying time steps with a minimum 1-hour or shorter time step during rainfall events to capture peak flow and a daily or shorter time step between rainfall events.

The RAA associated with the permittee(s) draft E/WMP should include a detailed description/itemization of model inputs and outputs as indicated in Table 2 through Table 5 and should include model input files (in an electronic format that can be manipulated) as part of the draft E/WMP package submitted to Regional Board for review and approval.

Table 2. General Model Input Data for Both Process Based BMP Models and Empirically Based BMP Models

For General Model	Data Source	Data Period
2.1 Geometric Data		
• GIS Data Layer	State of California GeoPortal, Cal-Atlas Geospatial Data Library (previously CalSIL – California Spatial Information Library)/CERES and other public agencies	Most recent
• Topography Layer (DEM Data)	USGS National Elevation Dataset (NED) or	Most recent

For General Model	Data Source	Data Period
	locally derived data	
• Land Use/Land Cover Layer[5]	SCAG Land use data; Multi-Resolution Land Characteristics Consortium (MRLC) National Land Cover Database (NLCD) or locally derived data	SCAG Land use data (2005 or most recent); NLCD (2006 or most recent)
• Stream Network	USGS National Hydrography Dataset (NHD) or locally derived data	Most recent
• Drainage areas	USGS Watershed Boundary Dataset (WBD) or locally derived data	Most recent
2.2 Meteorological Data		
• Precipitation	NOAA National Climatic Data Center (NCDC) or locally derived data	at least 10 years hourly
• Evaporation	NCDC or locally derived data	at least 10 years daily/monthly
2.3 Soil Hydrologic Data		
• Hydrologic soil groups	USDA/NRCS - Soil Survey Geographic Database (SSURGO)/ STATSGO2 or locally derived data	Most recent
• Percent of area distribution for different soil groups.	SSURGO or locally derived data	Most recent
• Fraction of sand, silt, and clay for different soil groups.	SSURGO or locally derived data	Most recent
• Average Slope	SSURGO or locally derived data	Most recent
• Vegetative cover for different soil groups.	SSURGO or locally derived data	Most recent

[5] Satellite imagery may be utilized but is not required.

For General Model	Data Source	Data Period
2.4 Hydrologic Data		
• In-stream Flow	USGS and locally derived data	Daily/monthly/hourly based on availability
• In-stream Depth	USGS and locally derived data	Daily/monthly/hourly based on availability
2.5 Point Source Data		
• Point Source Location	EPA STORET data CIWQS/SMARTS or local sampling	All available data
• Point Source Discharge	EPA STORET data CIWQS/SMARTS or local sampling	Daily/monthly
• Point Source Concentration	EPA STORET data CIWQS/SMARTS or local sampling	Daily/monthly

To demonstrate the ability to predict the effect of watershed processes and management on land, soil, and receiving water body, model calibration and validation are necessary and critical steps in model application. The acceptable model calibration criteria as listed in Table 3.0 are provided to ensure the calibrated model properly assesses all the model parameters and modeling conditions that can affect model results. In addition, some valuable sources of initial starting values for many of the key calibration parameters are provided in Table 3.1 through Table 4.2 to facilitate model calibration efforts.

Table 3.0 Model Calibration Criteria

Model calibration is necessary to ensure that the calibrated model properly assesses all the variables and conditions in a watershed system. Calibration should result in model parameter values that produce the best overall agreement between simulated and observed values throughout the calibration period. Table 3.0 is a list of model calibration tolerances for different levels of agreement or accuracy based on extensive past experience with the HSPF model. The lower bound of “fair” level of agreement listed in Table 3.0 is considered a target tolerance for the model calibration process. If model calibration results do not satisfy the target tolerances, additional efforts should be completed to investigate possible errors in, and the accuracy of, input data, model formulations, and field observations. The findings of this investigation should be presented in the RAA description, along with any immediate remedial actions to address the issues and/or recommended approaches to improve the calibration in the future. Permittees are strongly encouraged to engage Regional Board staff prior to the draft E/WMP submittal, in order to facilitate review and approval.

Model parameters	**% Difference between simulated and observed values**		
	Very Good	**Good**	**Fair (lower bound, upper bound)**
Hydrology/Flow	<10	10-15	15-25
Sediment	<20	20-30	30-45
Water Temperature	<7	8-12	13-18
Water Quality/Nutrients	<15	15-25	25-35
Pesticides/Toxics	<20	20-30	30-40

Based on HSPF experience by A.S. Donigian, Jr., prepared for USEPA (2000)

Table 3.1 Model Parameters for Process Based BMP Models

Model Parameters	Data Source[6]	Range of Initial Values
3.1.1 Hydrology Parameters		
• Fraction forest cover	EPA BTN#6	0-0.95
• Interception storage capacity (in)	EPA BTN#6	0.01-0.40
• Retention storage capacity (in)	EPA BTN#6	0.01-0.30
• Manning's n for overland flow	EPA BTN#6	0.01-0.15
• Upper zone nominal soil moisture storage (in)	EPA BTN#6	0.05-2.0
• Saturated hydraulic conductivity (in/hr)	Green-Ampt Parameters	0.01-4.74
• Wetting front suction head (in)	Green-Ampt Parameters	1.93-12.6
• Upper zone soil porosity (fraction)	Green-Ampt Parameters	0.398-0.501
• Field capacity (fraction)	Green-Ampt Parameters	0.062-0.378

6 EPA BTN # : EPA Basins Technical Note #

• Wilting point (fraction)	Green-Ampt Parameters	0.024-0.265
• Temp below which ET is reduced by half (°F)	EPA BTN#6	32.0-48.0
• Temp below which ET is set to zero (°F)	EPA BTN#6	30.0-40.0
• Fraction of GW inflow to deep recharge	EPA BTN#6	0.0-0.50
• Fraction of remaining ET from baseflow	EPA BTN#6	0.0-0.20
• Fraction of remaining ET from active GW	EPA BTN#6	0.0-0.20
• Lower zone nominal soil moisture storage (in)	EPA BTN#6	2.0-15.0
• Interflow inflow parameter	EPA BTN#6	1.0-10.0
• Interflow recession parameter	EPA BTN#6	0.3-0.85
• Lower zone ET parameter	EPA BTN#6	0.1-0.9
3.1.2 Water Quality Parameters		
• Initial storage of water quality constituent on land surface (lb)	LA County Report[7]	0.0-0.0005
• Wash-off potency factor for sediment associated constituent (lb/ton)	EPA BTN#6	0.0-10.0
• Scour potency factor for sediment associated constituent (lb/ton)	EPA BTN#6	NA
• Accumulation rate of water quality constituent of land surface(lb/acre/day)	EPA BTN#6	0.0-0.0005
• Maximum storage of water quality • constituent on land surface(lb/acre/day)	EPA BTN#6	0.0-0.0005
• Rate of surface runoff that removes 90% of stored water quality constituent (in/hr)	EPA BTN#6	0.0-0.5
• General first order in-stream loss rate of constituent (1/day)	SUSTAIN manual	0.2-0.2
3.1.3 Sediment Parameters		

[7] LA County Report*: "Evaluation of Existing Watershed Models for the County of Los Angeles", August 29, 2008

• For pervious land		
• Coefficient in the soil detachment equation	EPA BTN#8	0.05-0.75
• Exponent in the soil detachment equation	EPA BTN#8	1.0-3.0
• Coefficient in the sediment wash-off equation	EPA BTN#8	0.1-10.0
• Exponent in the sediment wash-off equation	EPA BTN#8	1.0-3.0
• Coefficient in the sediment scour equation	EPA BTN#8	0.0-10.0
• Exponent in the sediment scour equation	EPA BTN#8	1.0-5.0
• For impervious land		
• Coefficient in the solids wash-off equation	EPA BTN#8	0.1-10.0
• Exponent in the solids wash-off equation	EPA BTN#8	1.0-3.0
• Solids accumulation rate on the land surface (lb/ac-day)	EPA BTN#8	0.0-30.0
• Fraction of solids removed from land surface per day (1/day)	EPA BTN#8	0.01-1.0

Table 3.2 Model Parameters for Empirically Based BMP Models

Model Parameters	Data Source	Range of Values
3.2.1 Hydrology Parameters		
• Interception storage capacity (in)	EPA BTN#6	0.01-0.40
• Retention storage capacity (in)	EPA BTN#6	0.01-0.30
• Manning's n for overland flow	EPA BTN#6	0.05-0.5
• Upper zone nominal soil moisture storage (in)	EPA BTN#6	0.05-2.0
• Saturated hydraulic conductivity (in/hr)	Green-Ampt Parameters	0.01-4.74
• Wetting front suction head (in)	Green-Ampt Parameters	1.93-12.6
• Upper zone soil porosity (fraction)	Green-Ampt Parameters	0.398-0.501
• Field capacity (fraction)	Green-Ampt Parameters	0.062-0.378
• Wilting point (fraction)	Green-Ampt Parameters	0.024-0.265
• Temp below which ET is reduced by half (^{o}F)	EPA BTN#6	32.0-48.0
• Temp below which ET is set to zero (^{o}F)	EPA BTN#6	30.0-40.0
• Fraction of remaining ET from baseflow	EPA BTN#6	0.0-0.20
• Lower zone nominal soil moisture Storage (in)	EPA BTN#6	2.0-15.0
• Interflow inflow parameter	EPA BTN#6	1.0-10.0
• Interflow recession parameter	EPA BTN#6	0.3-0.85
• Lower zone ET parameter	EPA BTN#6	0.1-0.9
B.3.2.2 Water Quality Parameters		
• Event Mean Concentration (EMC)	SBPAT User's Guide t	See Table 3.3
B3.2.3 Sediment Parameters		
For pervious land		

• Coefficient in the soil detachment equation	EPA BTN#8	0.05-0.75
• Exponent in the soil detachment equation	EPA BTN#8	1.0-3.0
• Coefficient in the sediment wash off equation	EPA BTN#8	0.1-10.0
• Exponent in the sediment wash-off equation	EPA BTN#8	1.0-3.0
• Coefficient in the sediment scour equation	EPA BTN#8	0.0-10.0
• Exponent in the sediment scour equation	EPA BTN#8	1.0-5.0
For impervious land		
• Coefficient in the solids wash-off equation	EPA BTN#8	0.1-10.0
• Exponent in the solids wash-off equation	EPA BTN#8	1.0-3.0
• Solids accumulation rate on the land surface (lb/ac-day)	EPA BTN#8	0.0-30.0
• Fraction of solids removed from land surface per day (1/day)	EPA BTN#8	0.01-1.0

Table 3.3 Suggested Average[i] EMC by land use for selected pollutants

Land Use	Nitrate (mg/L)	Total Copper (µg/L)	Total Lead (µg/L)	Total Zinc (µg/L)	Fecal Coliform (MPN/100ml)	TSS (mg/L)
Agriculture	34.4	100.1	30.2	274.8	6.03E+4	999
Commercial	0.55	31.4	12.4	237.1	7.99E+4	67.0
Educational	0.61	19.9	3.6	117.6	7.99E+4	99.6
Industrial	0.87	34.5	16.4	537.6	3.76E+3	219
Transportation	0.74	52.2	9.2	292.9	1.68E+3	77.8
Open Space	1.17	10.6	3.0	26.3	6.31E+3	216.6
SF Residential	0.78	18.7	11.3	71.9	3.11E+4	124.2
MF Residential	1.51	12.1	4.5	125.1	1.18E+4	39.9

Source: Technical Appendices "A User's Guide for the Structural BMP Prioritization and Analysis Tool (SBPAT v1.0)" for Los Angeles City, County, and Heal the Bay, December 2008

Note: These suggested average EMC values can be adjusted based on calibration studies by using more recently collected Southern California data.

Table 4.1 Suggested BMP Performance Parameters for Process Based BMP Model

4.1 BMP Performance Parameters	Rain Barrel	Bio-Retention	Porous Pavement	Dry Infiltration Basin
• Media final constant infiltration rate (in/h)	NA	0.5-0.5	0.5-1.0	1.0-1.0
• Substrate layer porosity	NA	0.4-0.5	0.45-0.5	0.3-0.4
• Substrate layer field capacity	NA	0.25-0.3	0.055-0.2	0.06-0.3
• Substrate layer wilting point	NA	0.1-0.15	0.05-0.05	0.02-0.15
• Underdrain gravel layer porosity	NA	0.5	0.5	0.5
• Vegetative parameter, A	NA	0.6-1.0	1.0	0.6
• Underdrain background infiltration Rate (in/hr)	NA	0.1-0.3	0.1	0.25-0.3
• TSS 1st order decay rate (1/day)	0.2-0.8	0.2-0.8	0.2-0.8	0.2-0.8
• Fecal Coliform 1st order decay rate (1/day)	0.5	0.5	0.5	0.5
• TSS Filtration removal rate (%)	NA	85	60	85

* Source: PA Report "SUSTAIN-A Framework for Placement of Best Management Practices in Urban Watersheds to Protect Water Quality, September 2009, EPA/600/R-09/095
Note that values in this Table can be adjusted based on calibration studies with recently collected Southern California data.

Table 4-2: Suggested BMP Performance Parameters for Empirically Based BMP Model

Median (95% Conf. Interval) Statistics of BMP Effluent Concen.	Bio-Retention	Bio-Swale	Detention Basin	Filter Strip	Manu-fractured Device	Media Filter	Porous Pavement	Retention Pond	Wetland Basin	Wetland Channel
Fecal Coliform # Per 100 mL	NA	2600-6200	500-1900	300-39600	(10,20)-D (200-3000)-F (1400-5000)-P	200-625	NA	200-1160	230-11800	NA
Enterococcus # Per 100 mL	58-437	NA	NA	NA	(10,10)-D (1750-12000)-F NA-P	NA	NA	NA	56-300	NA
E. Coli # Per 100 mL	6-137	1200-5900	82-720	NA	NA	NA	NA	31-387	199-1160	NA
TSS (mg/L)	5.0-9.0	11.8-15.3	19.0-26.0	16.0-21.5	15.0-19.9	7.4-10.0	11.0-14.4	12.0-15.0	7.0-10.9	10.0-16.0
Total Phosphorus	0.07-	0.17-	0.19-0.24	0.15-	0.10-0.13	0.08-	0.08-0.09	0.12-0.14	0.07-	0.13-

Median (95% Conf. Interval) Statistics of BMP Effluent Concen.	Bio-Retention	Bio-Swale	Detention Basin	Filter Strip	Manu-fractured Device	Media Filter	Porous Pavement	Retention Pond	Wetland Basin	Wetland Channel
(mg/L)	0.1	0.20		0.20		0.10			0.09	0.17
Dissolved Phosphorus (mg/L)	0.05-0.18	0.05-0.11	0.08-012	0.16-0.26	0.04-0.07	0.06-0.09	0.04-0.05	0.06-0.07	0.03-0.06	0.07-0.10
Total Nitrogen (mg/L)	0.74-0.99	0.63-0.82	1.75-2.69	1.0-1.23	1.90-2.41	0.68-0.99	1.28-1.65	1.19-1.36	1.04-1.21	1.05-1.56
Total Kjeldahl Nitrogen (mg/L)	0.46-0.72	0.50-0.70	1.16-1.78	0.97-1.12	1.32-1.55	0.50-0.61	0.74-0.90	0.98-1.10	0.92-1.09	1.10-1.30
NOx(NO2+NO3,andNO3) (mg/L)	0.19-0.25	0.20-0.28	0.24-0.45	0.24-0.31	0.35-0.44	0.46-0.57	0.59-0.77	0.15-0.20	0.05-0.11	0.15-0.22
Total Copper (µg/L)	4.6-9.85	5.7-7.7	4.0-6.80	6.4-7.9	7.94-11.0	5.1-6.6	6.8-8.1	4.06-5.0	3.0-4.0	3.61-5.20
Total Lead (µg/L)	2.5-2.5	1.8-2.29	2.15-4.3	1.3-2.2	3.8-5.16	1.3-2.0	1.38-2.21	2.0-3.0	1.0-1.55	1.40-3.11
Total Zinc (µg/L)	7.7-25.0	20-26.6	17.1-38.2	16.0-26.0	52.8-63.5	15.0-20.0	12.5-16.8	20.0-23.0	16.7-24.3	11.0-20.0
Total Arsenic (µg/L)	NA	0.95-1.30	1.29-1.80	0.55-1.20	1.0-2.4	0.61-1.0	2.5-2.5	0.54-1.15	NA	NA
Total Cadmium (µg/L)	0.25-1.0	0.27-0.34	0.25-0.35	0.09-0.20	0.20-0.31	0.1-0.2	0.25-0.25	0.20-0.29	0.10-0.20	0.19-0.50
Total Nickel (µg/L)	NA	2.3-4.2	2.2-3.75	2.4-3.1	3.11-5.0	2.0-2.6	1.40-1.80	2.0-2.60	NA	2.0-2.40

Source: International Stormwater BMP Database (BMPDB), July 2012
Note that for bacteria, manufactured devices are broken down into three subcategories: disinfection devices (Manufactured Device – D), inlet insert/filtration devices (Manufactured Device – F), and physical settling/straining devices (Manufactured Device – P)
Note that values in this Table can be adjusted based on calibration studies with recently collected Southern California data.

Table 5: Model Output for both Process Based BMP Models and Empirically Based BMP Models

Model Output	Output Content	Output Format
5.1 Current/Existing Pollutant Loadings		
	Current pollutant loadings at each modeled sub-watershed and each land use, under range of temporal conditions (i.e., average and critical conditions)	Tables
5.2 Load Reduction Output		
	Pollutant load reduction at each modeled sub-watershed for each BMP scenario (corresponding to applicable compliance deadlines) in dry and wet weather conditions (i.e., average and critical conditions)	Tables
	Time series plots of pollutant load reduction for each BMP scenario at compliance points	Graphics
5.3 Surface Runoff Output		

Model Output	Output Content	Output Format
	Surface runoff volume at each modeled subwatershed for each BMP scenario in dry and wet weather conditions (i.e., average and critical conditions)	Tables
	Absolute and percent reduction in runoff volume at each modeled subwatershed for each BMP scenario	Tables
5.4 Hydrographs and Pollutographs		
	Flow hydrographs at compliance points within the EWMP/WMP for each BMP scenario	Graphics
	Pollutographs at compliance points within the EWMP/WMP for each BMP scenario	Graphics
5.5 BMP Performance Summary		
	Load comparison for with and without BMPs and graphs for each BMP scenario	Tables and Graphics
	BMP storage distribution for each BMP scenario	Tables and Graphics

[i] Log-transformed arithmetic mean values shown