

Watershed Management Modeling with PLAT: Pollutant Loading Analysis Tool

City of Torrance

Carollo Engineers

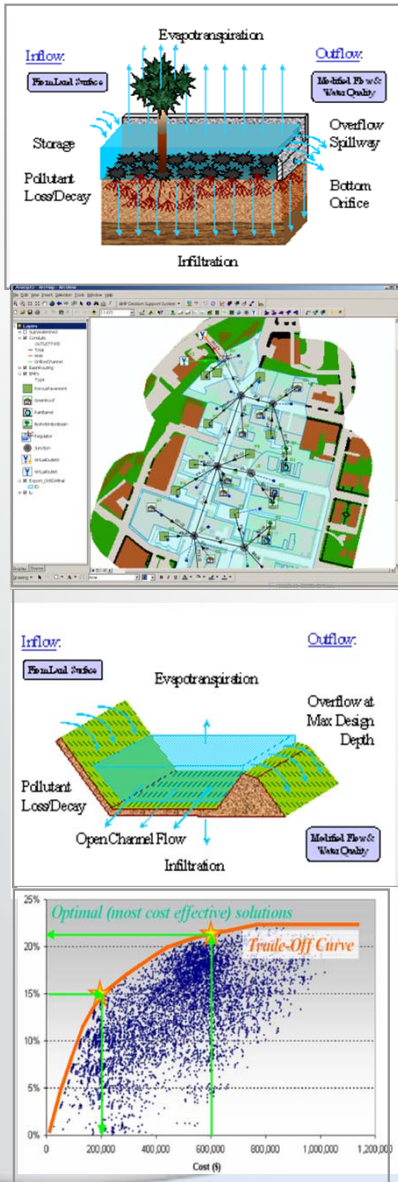


Presentation Outline

- **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)



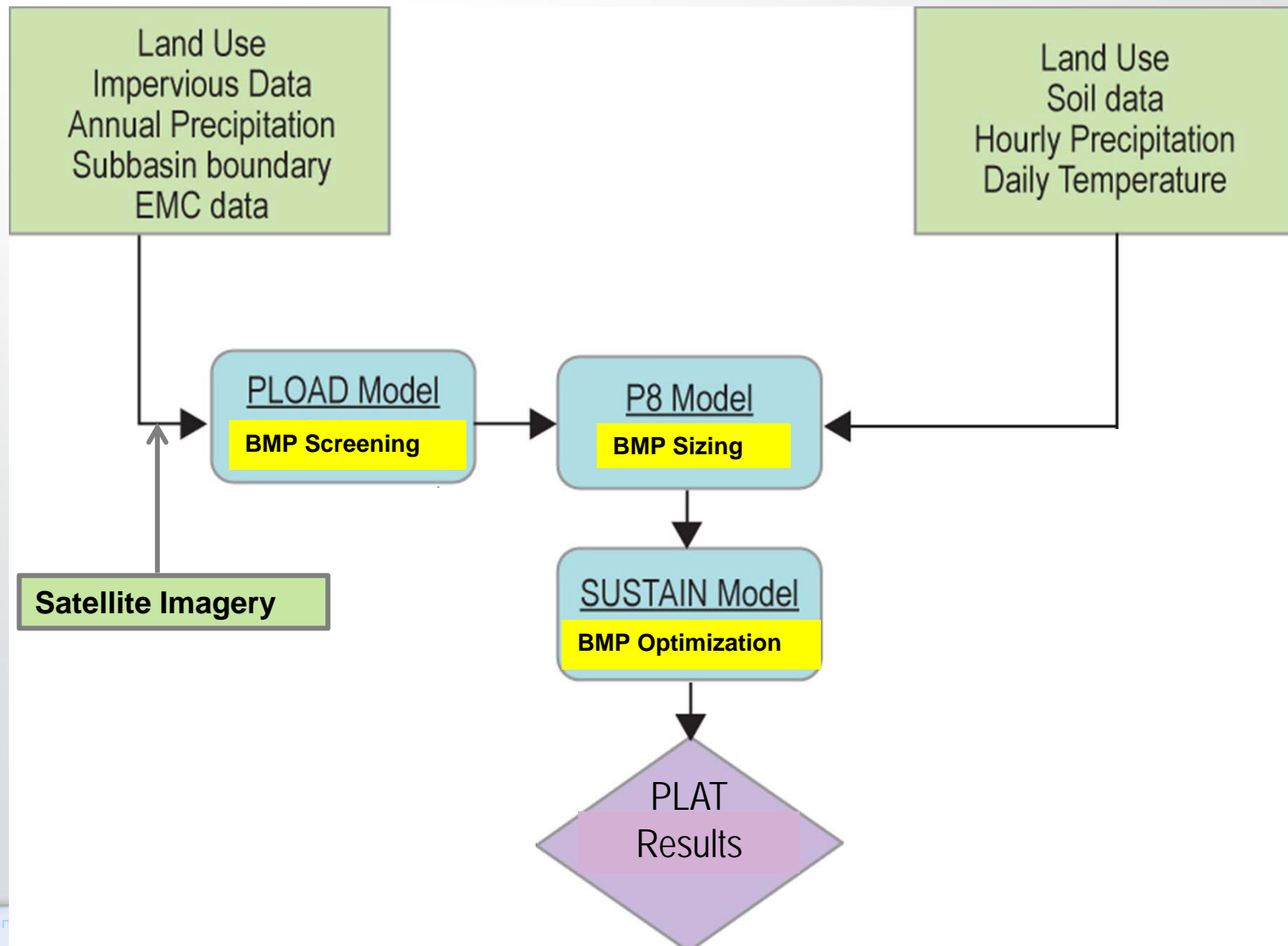
Model	Management Practice Evaluation Techniques	Water Quality Constituents
AnnAGNPS	<ul style="list-style-type: none"> Sediment - RUSLE factors Runoff curve number changes Storage routing Particle settling 	<ul style="list-style-type: none"> Sediment Nutrients Organic carbon
STEPL	<ul style="list-style-type: none"> Sediment - RUSLE factors Runoff curve number changes Simple percent reduction 	<ul style="list-style-type: none"> Sediment Nutrients
GWLF	<ul style="list-style-type: none"> Sediment - USLE factors Runoff curve number changes User-specified removal rate 	<ul style="list-style-type: none"> Sediment Nutrients
HSPF	<ul style="list-style-type: none"> HSPF infiltration and accumulation factors HSPF erosion factors Storage routing Particle settling First-order decay 	<ul style="list-style-type: none"> Sediment Nutrients
SWMM	<ul style="list-style-type: none"> Infiltration Second-order decay Particle removal scale factor Sediment - USLE (limited) 	<ul style="list-style-type: none"> Sediment User-defined pollutants
P8-UCM	<ul style="list-style-type: none"> Infiltration - Green-Ampt method Second-order decay Particle removal scale factor 	<ul style="list-style-type: none"> Sediment User-defined pollutants
SWAT	<ul style="list-style-type: none"> 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 	<ul style="list-style-type: none"> 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** – **P**ollutant **L**oading and **A**nalysis **T**ool
- Comprises of commonly used public 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



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	<ul style="list-style-type: none"> • Impervious cover • Land cover • Preliminary Pollutant ranking 	
PLOAD	<ul style="list-style-type: none"> • Pollutant loading & hot spots • Calibrate P8 model • Screen BMPs 	
P8	<ul style="list-style-type: none"> • Simulate and route pollutants • Evaluate alternatives • Preliminary BMPs sizing 	
SUSTAIN	<ul style="list-style-type: none"> • 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

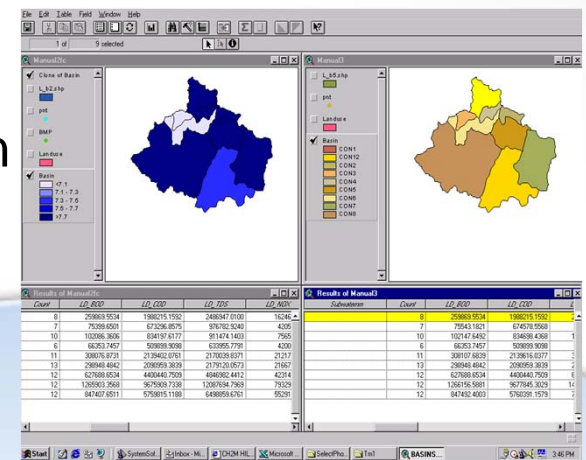


BMPs

- 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, sidewalks and building roof tops

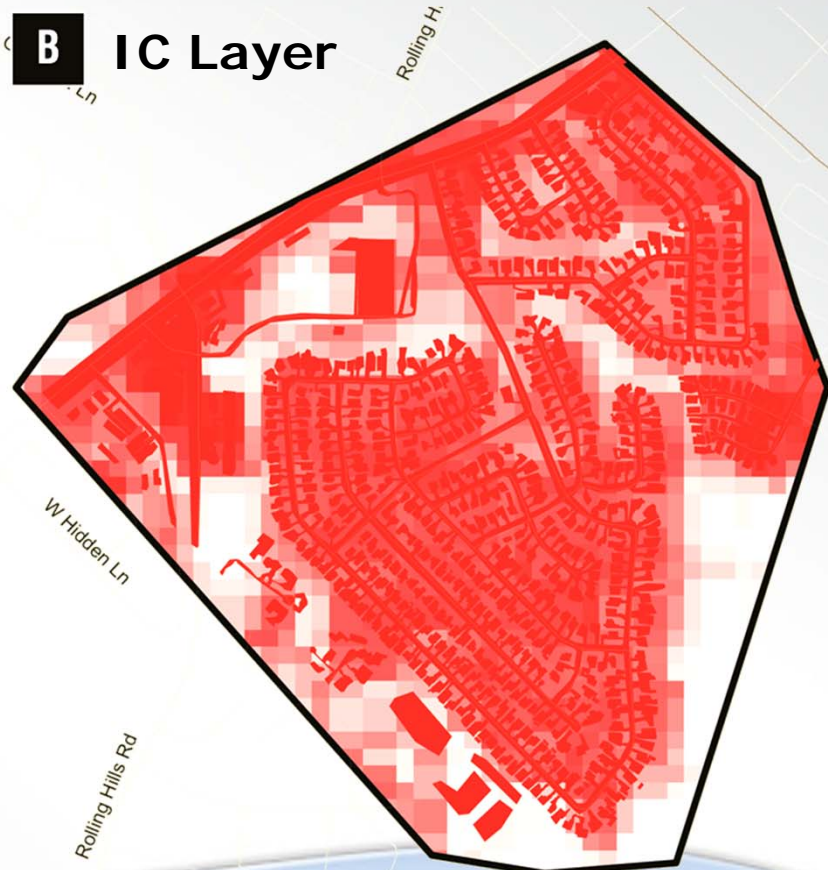
Transportation elements contribute the most to impervious surface area

Satellite imagery allows accurate and quick estimation of impervious areas

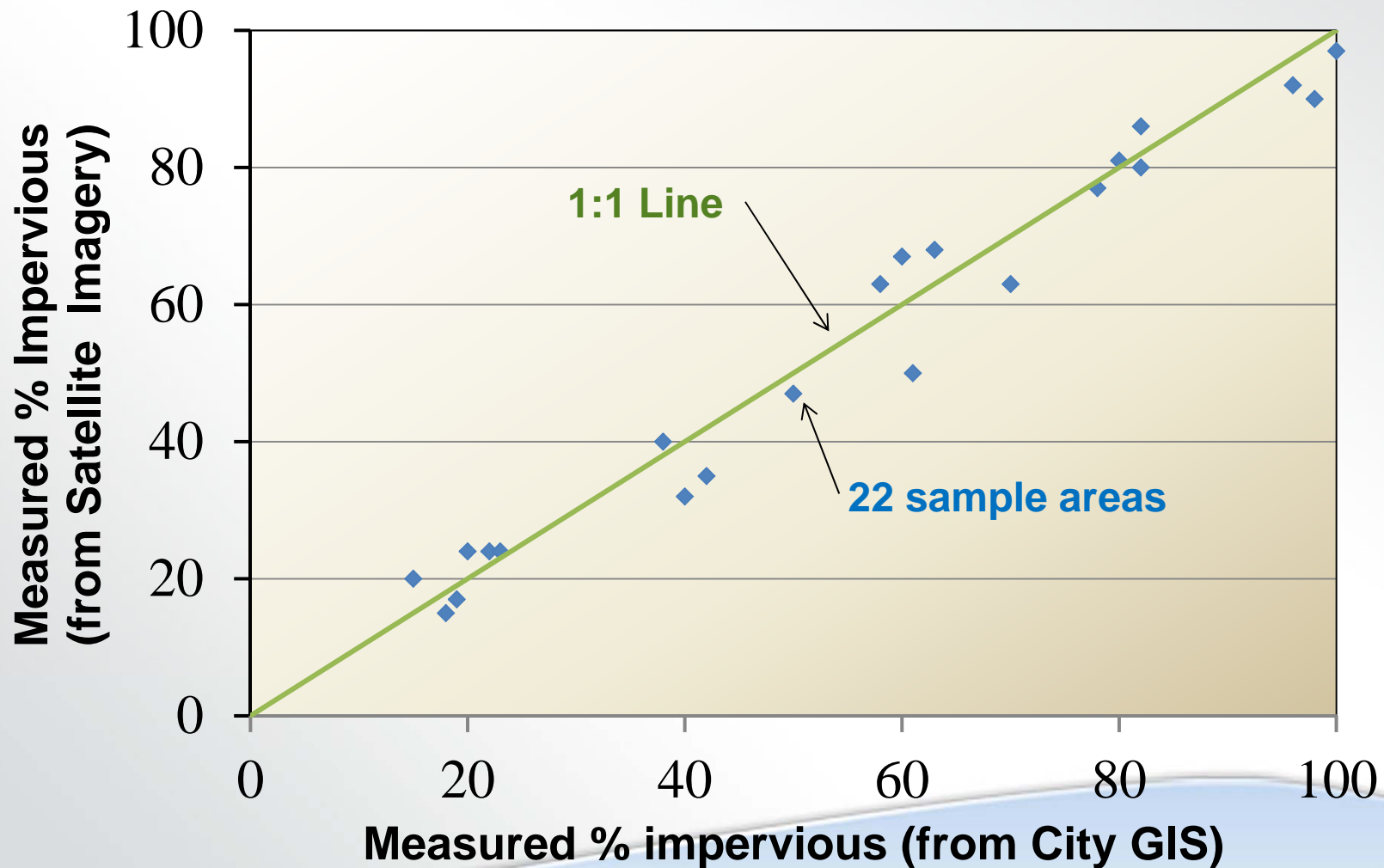
A Raw Satellite



B IC Layer



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

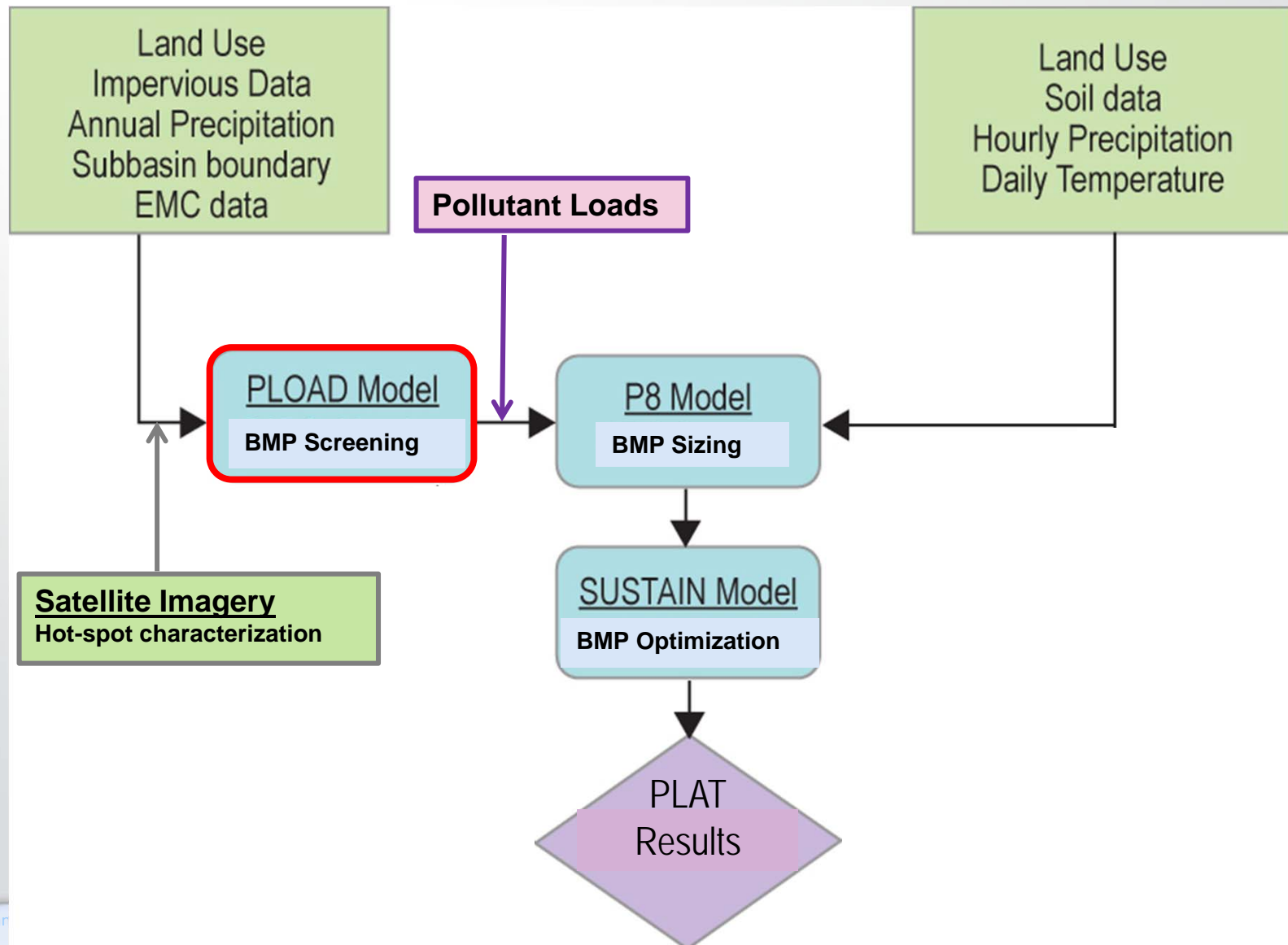


The same Satellite Imagery data can be used to quickly identify open space for BMP siting

- **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



PLOAD calculates pollutant loads by subbasin for BMP screening



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

PLOAD v3.0 - Pollutant Loading Parameters

1 - Create Session
 Enter Your Session Name and Click 'Create Session' (no spaces please)
 Create Session: Manual1

5 - Calculation Method Setup
 Define Method: Simple Calculation Method

2 - Define Watershed Boundary Data Set
 1 of 9 selected

3 - Select Watershed
 Basins Selected: Zsubwateri
 CON1
 CON2
 CON3
 CON4
 CON5
 CON6

4 - Define Landuse Data Set
 c:\basins\data\tutorial\Manual2fc

Manual2fc Legend:
 Clone of Basin
 L_b2.shp
 pnt
 BMP
 Landuse
 Basin
 Basin Legend:
 <7.1
 7.1 - 7.3
 7.3 - 7.5
 7.5 - 7.7
 >7.7

Manual3 Legend:
 L_b5.shp
 pnt
 Landuse
 Basin
 Basin Legend:
 CON1
 CON12
 CON2
 CON3
 CON4
 CON5
 CON6
 CON7
 CON8

Results of Manual2fc

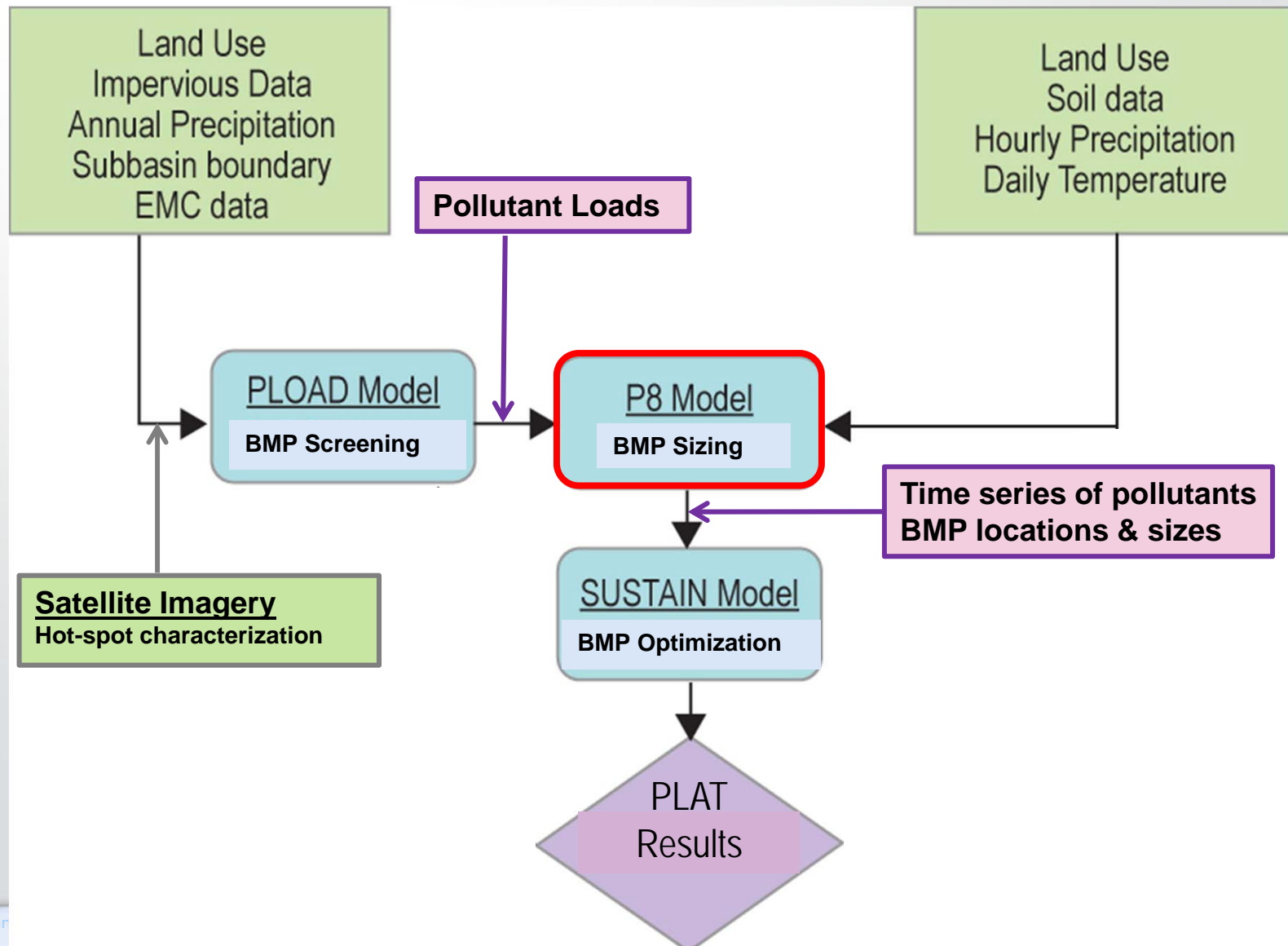
Count	LD_BOD	LD_COD	LD_TDS	LD_NOX
8	259869.5534	1988215.1592	2486947.0100	16246
7	75399.6501	673296.8575	976782.9240	4205
10	102086.3606	834197.6177	911474.1403	7565
6	66353.7457	509899.9098	633955.7791	4200
11	308076.8731	2139402.0761	2170039.8371	21217
13	298948.4842	2090959.3839	2179120.0573	21667
12	627688.6534	4400440.7509	4846982.4412	42314
12	1265903.3568	9675909.7338	12087694.7969	79329
12	847407.6511	5759815.1188	6498859.6761	55291

Results of Manual3

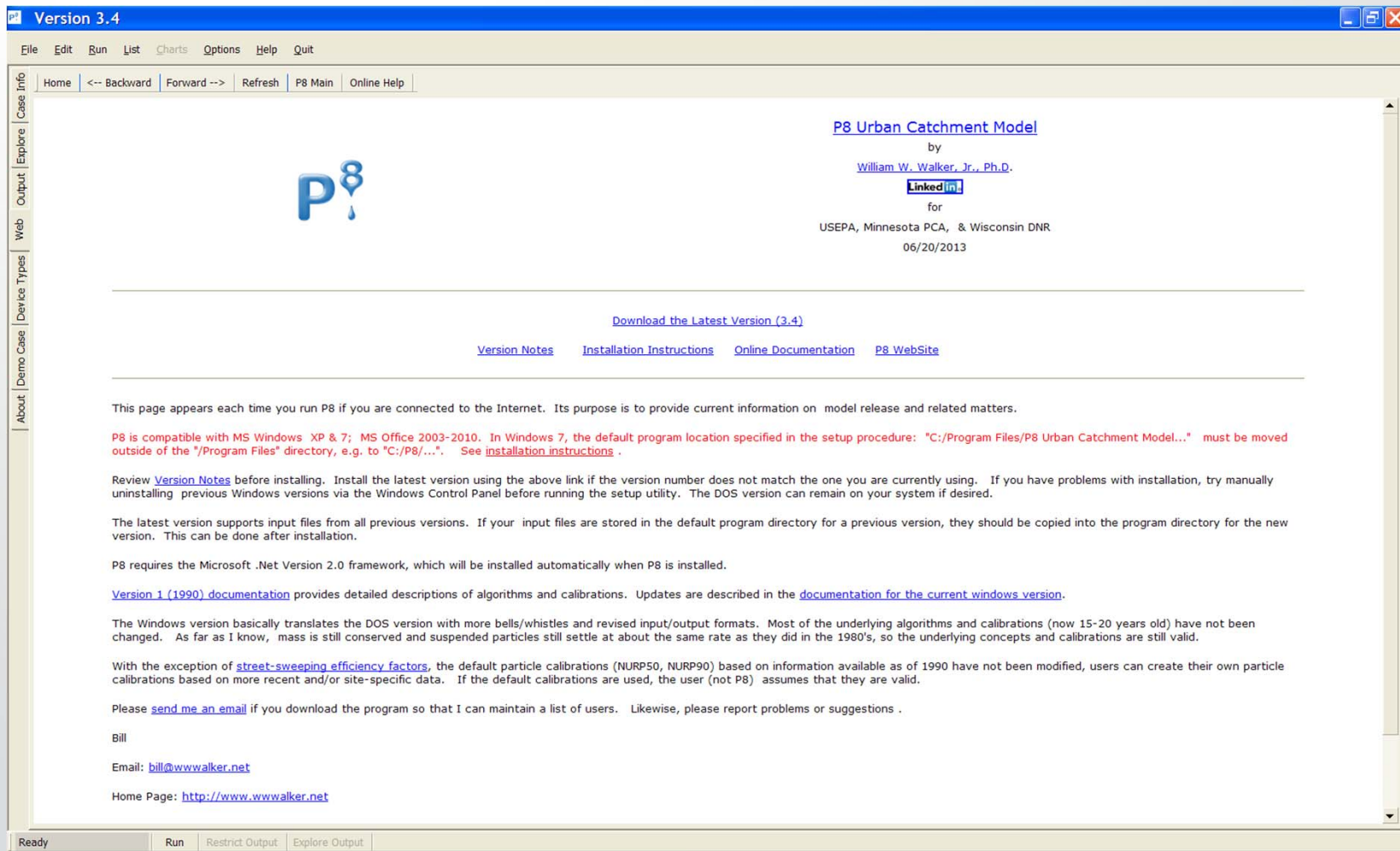
Subwater	Count	LD_BOD	LD_COD	LD_TDS	LD_NOX
	8	259869.5534	1988215.1592	2486947.0100	16246
	7	75399.6501	674578.5568	976782.9240	4205
	10	102147.6492	834698.4368	911474.1403	7565
	6	66353.7457	509899.9098	633955.7791	4200
	11	308107.6839	2139616.0377	2170039.8371	21217
	13	298948.4842	2090959.3839	2179120.0573	21667
	12	627688.6534	4400440.7509	4846982.4412	42314
	12	1266156.5881	9677845.3029	12087694.7969	79329
	12	847492.4003	5760391.1579	6498859.6761	55291

OUTPUT

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



Advanced BMP Modeling with P8 (Urban Catchment Model)



Version 3.4

File Edit Run List Charts Options Help Quit

Home <-- Backward Forward --> Refresh P8 Main Online Help

P8

[P8 Urban Catchment Model](#)
by
[William W. Walker, Jr., Ph.D.](#)
[Linked in](#)
for
USEPA, Minnesota PCA, & Wisconsin DNR
06/20/2013

[Download the Latest Version \(3.4\)](#)

[Version Notes](#) [Installation Instructions](#) [Online Documentation](#) [P8 WebSite](#)

This page appears each time you run P8 if you are connected to the Internet. Its purpose is to provide current information on model release and related matters.

P8 is compatible with MS Windows XP & 7; MS Office 2003-2010. In Windows 7, the default program location specified in the setup procedure: "C:/Program Files/P8 Urban Catchment Model..." must be moved outside of the "/Program Files" directory, e.g. to "C:/P8/...". See [installation instructions](#).

Review [Version Notes](#) before installing. Install the latest version using the above link if the version number does not match the one you are currently using. If you have problems with installation, try manually uninstalling previous Windows versions via the Windows Control Panel before running the setup utility. The DOS version can remain on your system if desired.

The latest version supports input files from all previous versions. If your input files are stored in the default program directory for a previous version, they should be copied into the program directory for the new version. This can be done after installation.

P8 requires the Microsoft .Net Version 2.0 framework, which will be installed automatically when P8 is installed.

[Version 1 \(1990\) documentation](#) provides detailed descriptions of algorithms and calibrations. Updates are described in the [documentation for the current windows version](#).

The Windows version basically translates the DOS version with more bells/whistles and revised input/output formats. Most of the underlying algorithms and calibrations (now 15-20 years old) have not been changed. As far as I know, mass is still conserved and suspended particles still settle at about the same rate as they did in the 1980's, so the underlying concepts and calibrations are still valid.

With the exception of [street-sweeping efficiency factors](#), the default particle calibrations (NURP50, NURP90) based on information available as of 1990 have not been modified, users can create their own particle calibrations based on more recent and/or site-specific data. If the default calibrations are used, the user (not P8) assumes that they are valid.

Please [send me an email](#) if you download the program so that I can maintain a list of users. Likewise, please report problems or suggestions.

Bill
Email: bill@www.walker.net
Home Page: <http://www.walker.net>

Ready Run Restrict Output Explore Output

Watershed input data sheet

Watersheds [X]

Help | SLAMM Calib | List | Add | Duplicate | Delete | Clear | Check | Cancel | OK

Select Watershed

- AS3-1
- AS3-3
- AS3-2
- AS3-4
- AS3-5
- AS3-6
- AS3-7
- AS3-8
- AS3-9
- AS4-1
- AS3-10
- AS3-11
- AS3-12
- AS3-13
- AS3-14
- AS3-15
- AS3-17
- AS3-18
- AS3-19
- AS3-20
- AS3-21
- AS2-1
- AS2-2
- AS2-3
- AS2-4
- AS2-5
- AS2-6
- AS1-1
- AS1-2
- AS1-3
- AS1-4
- AS1-5
- AS1-6
- AS1-7
- AS1-8
- AS1-9

Watershed Name: AS3-1

Outflow Device for Surface Runoff: AS3-P23

Outflow Device for Percolation: None

Total Area (acres): 39.212

Pervious Area Curve Number: 78

Indirectly Connected Imperv. Fraction: 0.25

Scale Fractor for Particle Loads: 1

Directly Connected Impervious Area Type: Vacuum Swept Not Swept

Connected Impervious Fraction: 0.315 0.315

Depression Storage (inches): 0.01 0.01

Impervious Runoff Coef: 1 1

Scale Factor for Particle Loads: 1 1

Impervious Sweep Frequency (1/wk): 0.5

Sweeping Efficiency Scale Factor: 1

Vacuum Sweeping Season (m added): Start Stop

101 1231

Water Quality Components



Help Read File Save File Check Cancel OK

Particle File

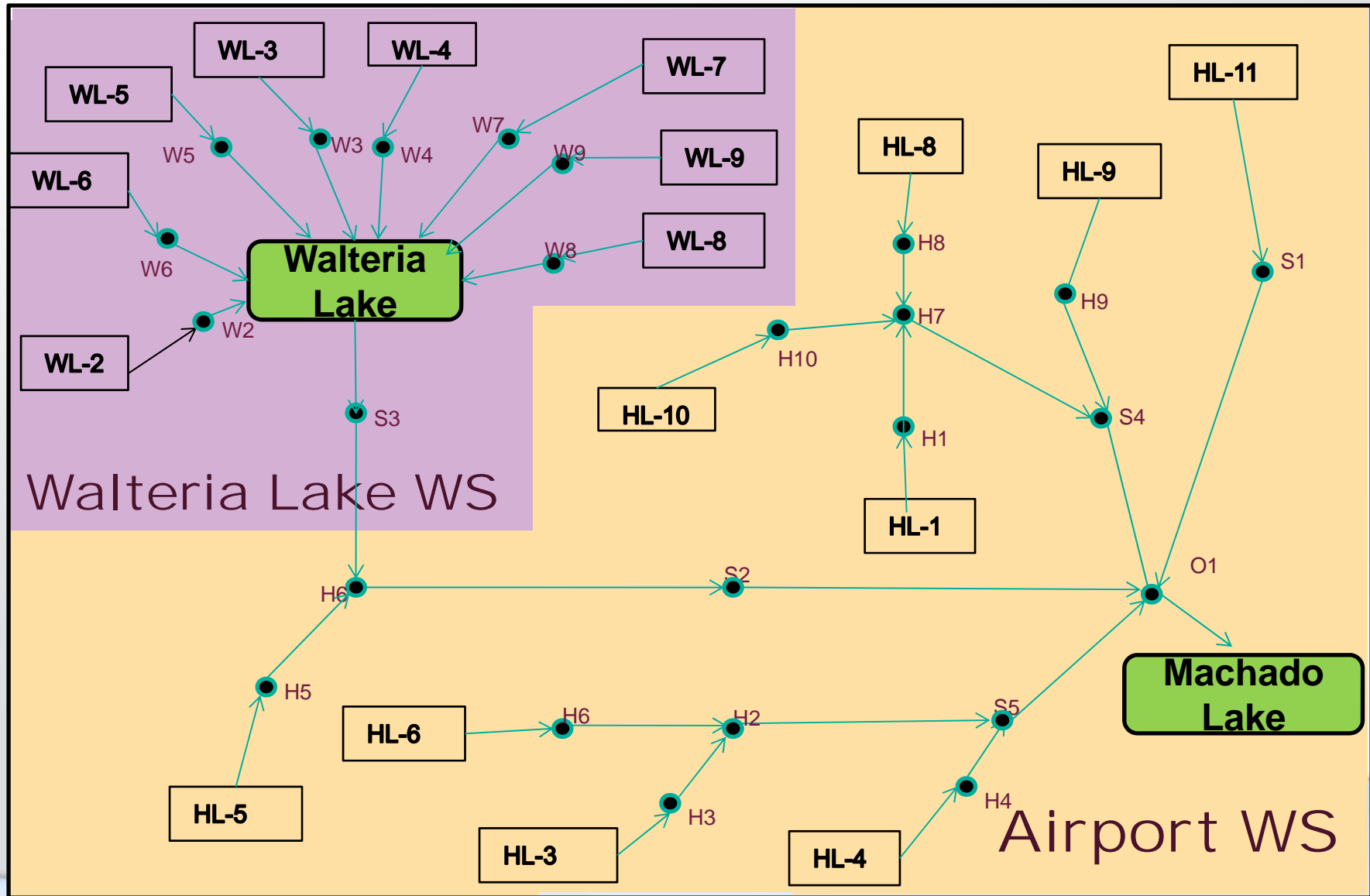
Description

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

Particle Fraction	Particle Composition (mg/kg)									
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			

Level	Water Quality Criteria (ppm)									
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

Version 3.4

File Edit Run List Charts Options Help Quit

Report: Load lbs Term: 10 surface outflow Dec: 1

Device: AS4-P1 Var: TSS Transpose Copy Help

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	
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							

Minimum Rain + Snow melt = 1 inches

Storm Event ALL of 83
Date Range 10/6/10 2:00 10/1/12 0:00
Hour Range 74 17496

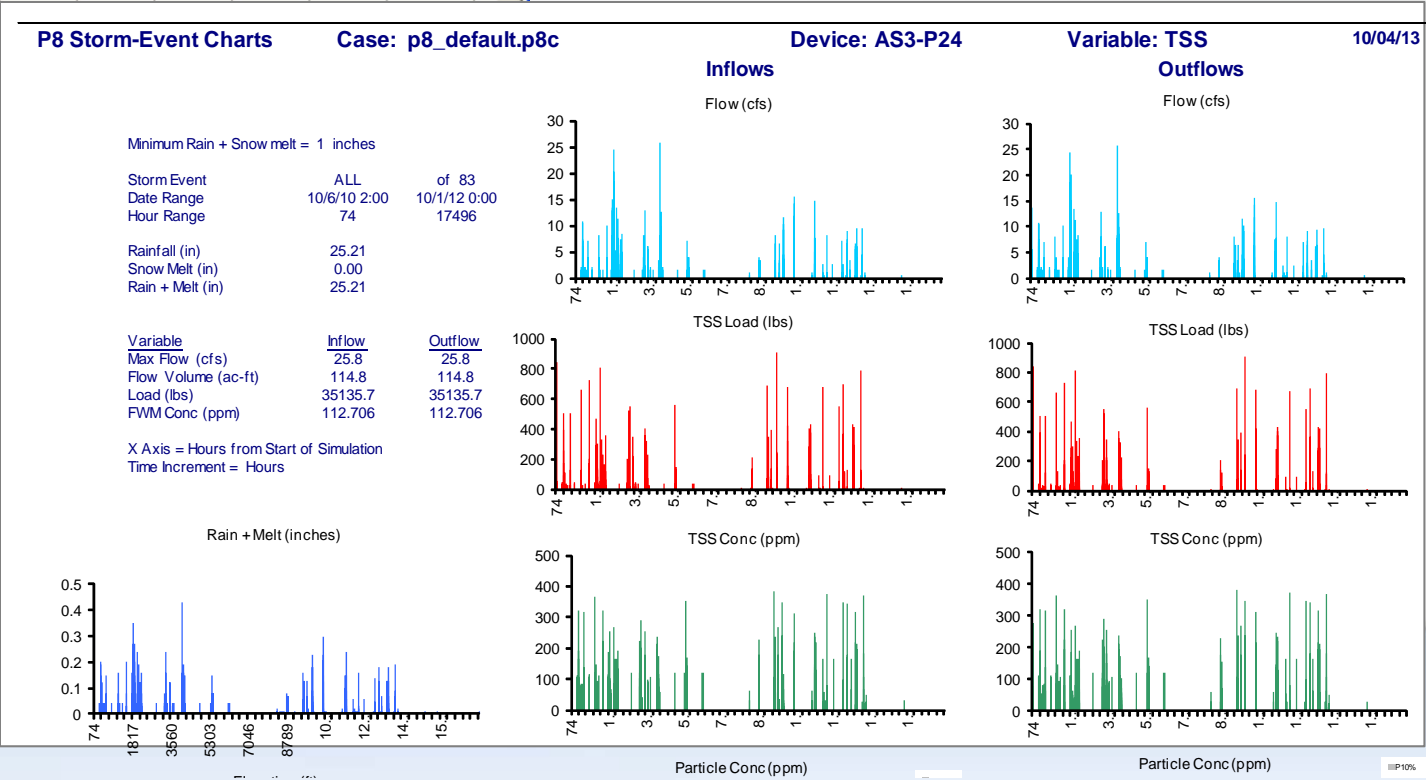
Rainfall (in) 25.21
Snow Melt (in) 0.00
Rain + Melt (in) 25.21

Variable	Inflow	Outflow
Max Flow (cfs)	25.8	25.8
Flow Volume (ac-ft)	114.8	114.8
Load (lbs)	35135.7	35135.7
FWM Conc (ppm)	112.706	112.706

X Axis = Hours from Start of Simulation
Time Increment = Hours

Ready Run Restri

OUTPUT



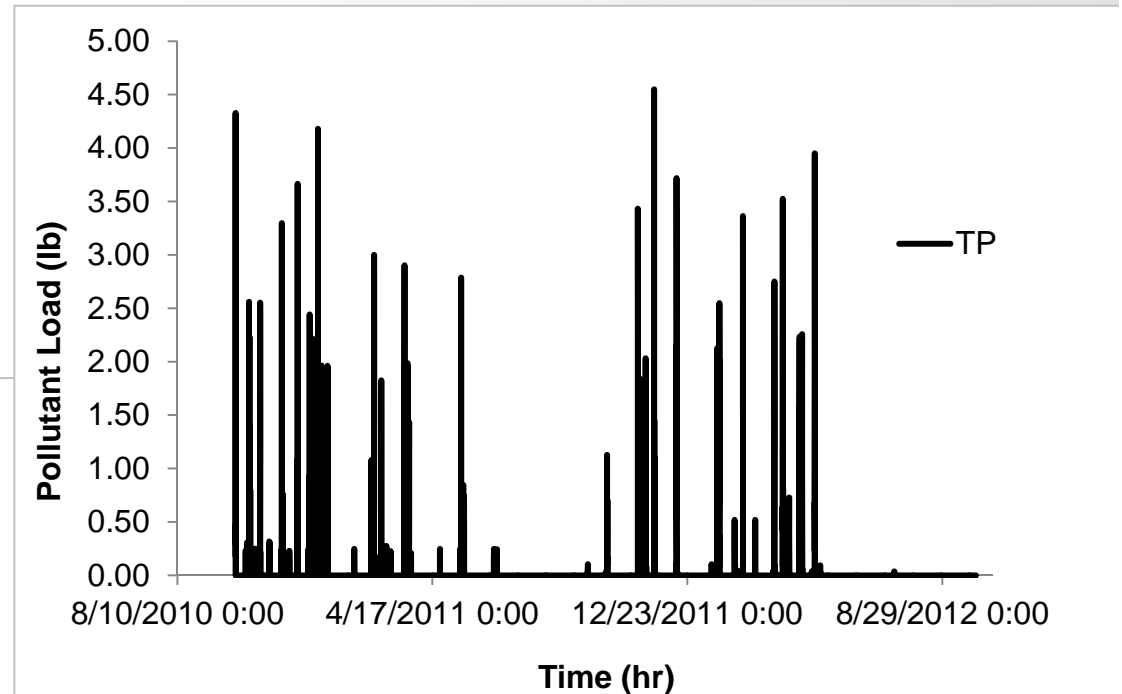
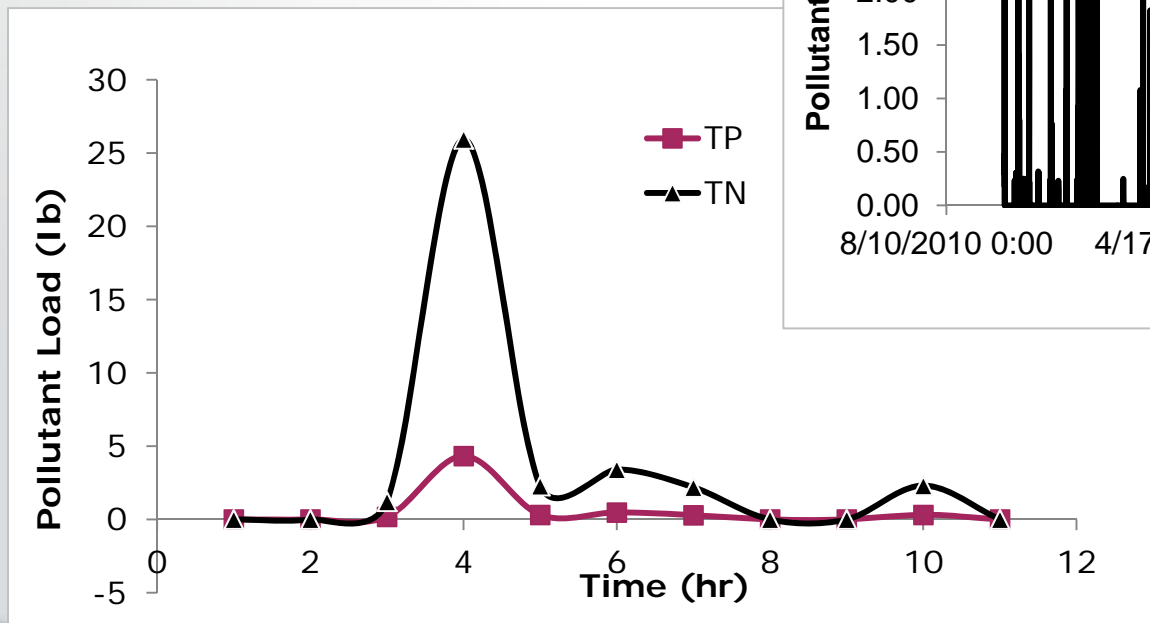
The P8 model can simulate both short-term storm events and long-term hydrology

LONG-TERM

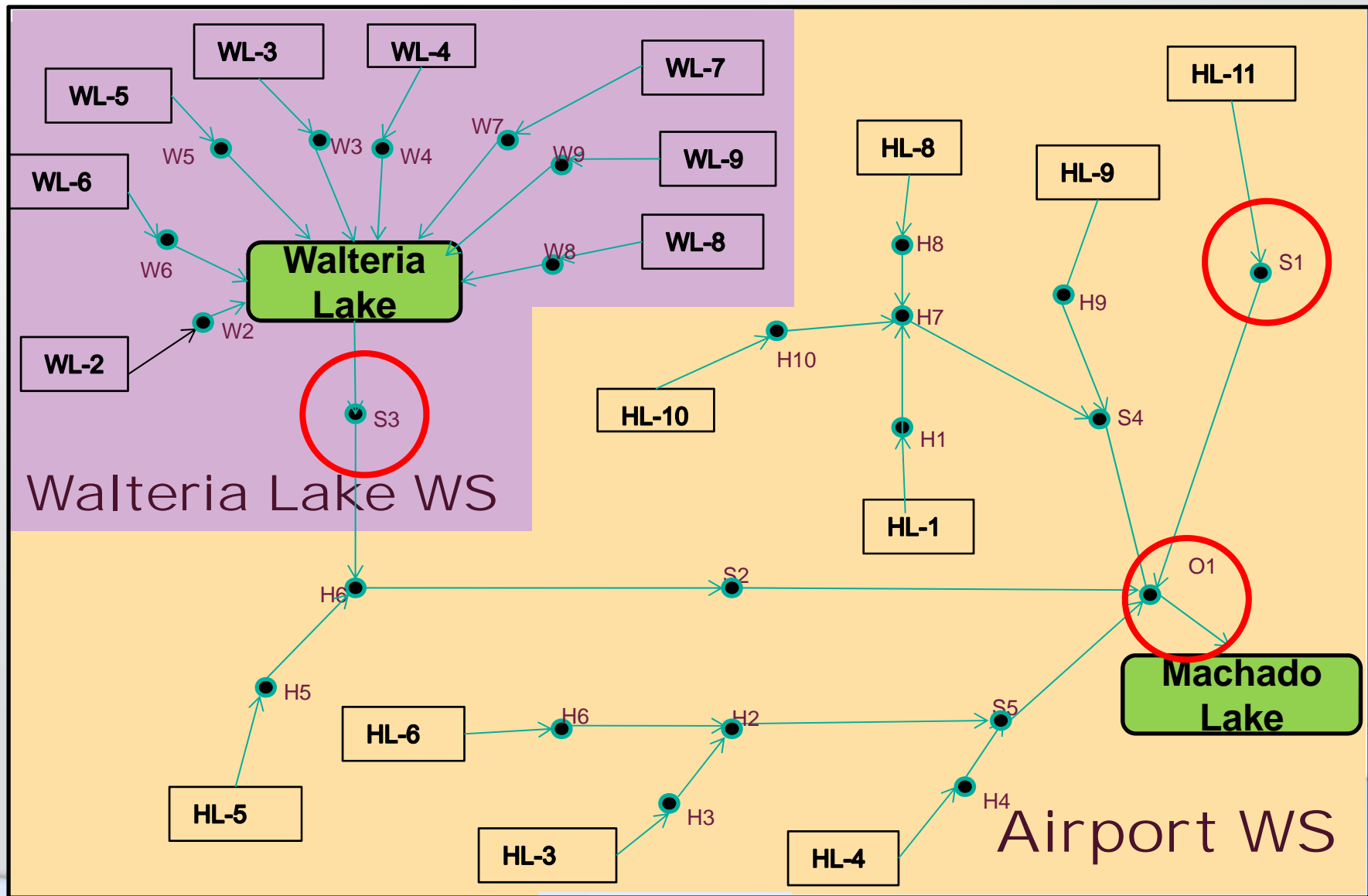
(from multiple storms to 30-yr hydrology)

SHORT-TERM

(24-hour design storm)

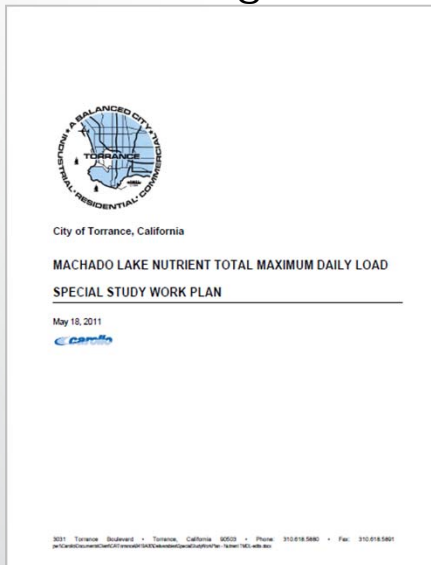


The P8 model allows for quick comparison of model and monitoring sampling data

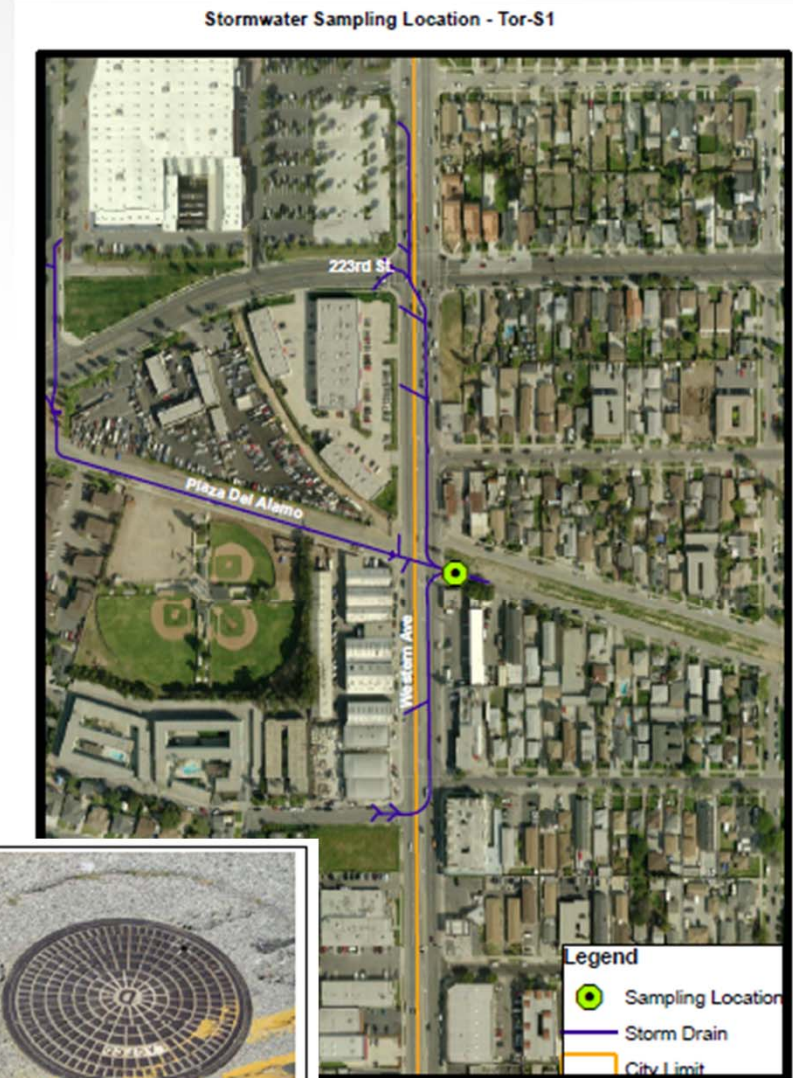
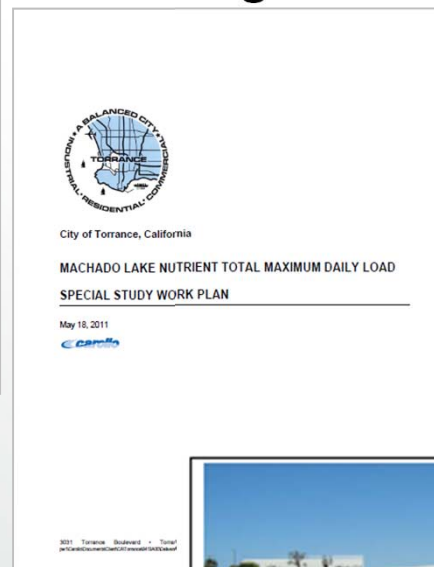


The P8 model allows for quick comparison of model and monitoring sampling data

Machado Lake Nutrient TMDL Monitoring Plan

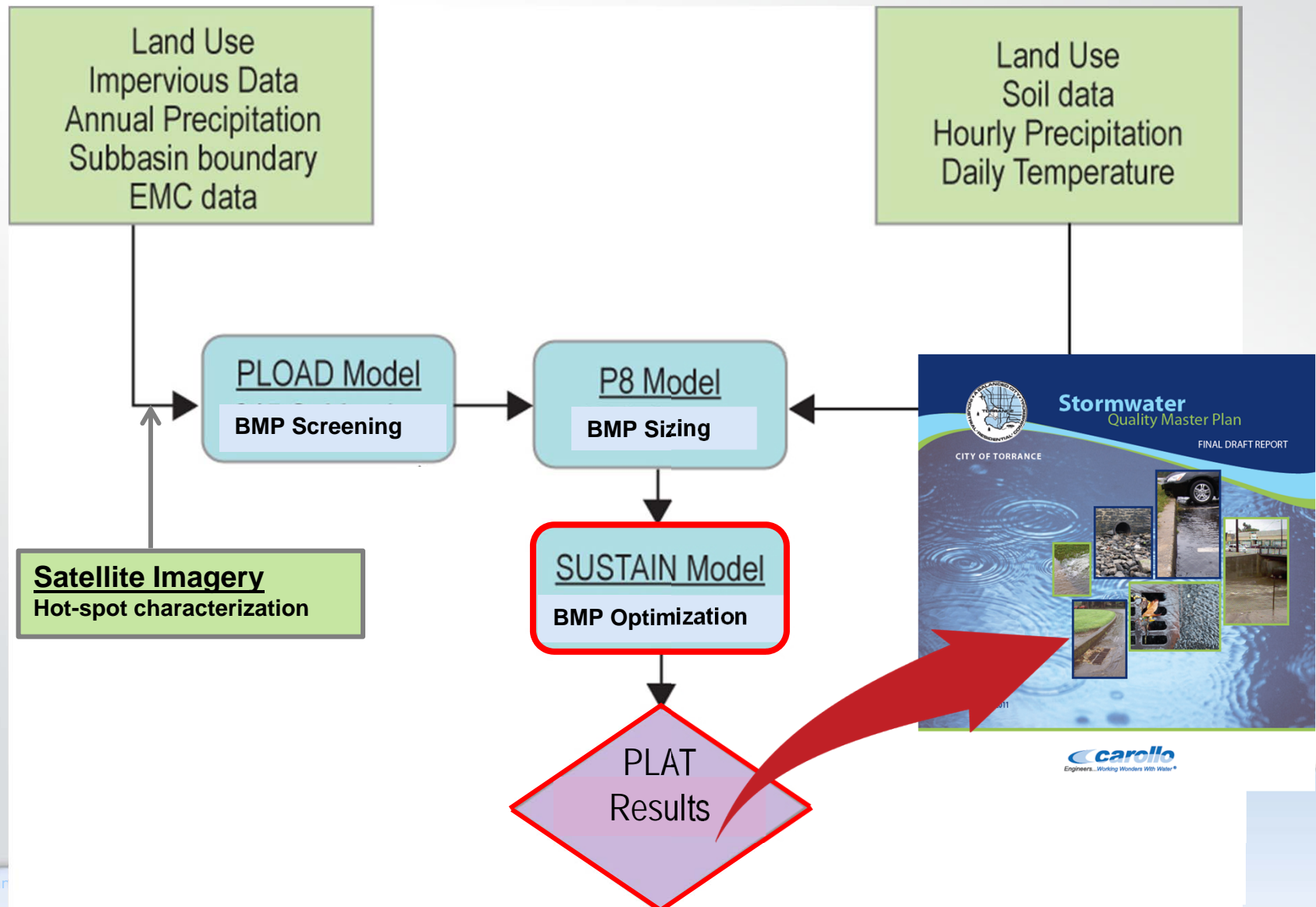


Machado Lake Toxics TMDL Monitoring Plan



SAMPLING SITE TOR-S1

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



The SUSTAIN Model is used to optimize sizing and minimize cost

INPUT

The screenshot shows the ArcMap Siting Tool interface. The 'Define Data Path' dialog box is open, with the following selections:

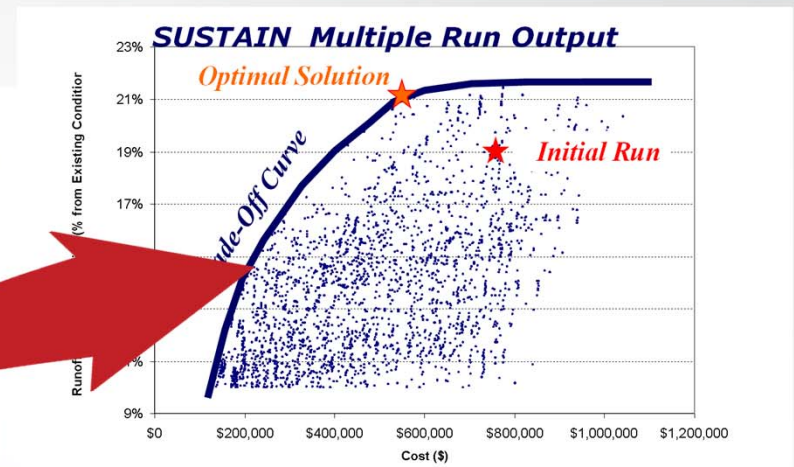
- Select the DEM grid: DEM
- Select Soil shapefile: Soil
- Select Road shapefile: Roads
- Select UrbanLanduse shapefile: UrbanLanduse
- Select Stream: (empty)

The 'BMP Siting Tool - Point BMPs' dialog box is also open, showing the following options:

- Select BMP Type: Wet pond (selected)
- Other options: Dry pond, Wet pond, Infiltration basin, Infiltration trench, Bioretention, Sand filter (surface), Sand filter (non-surface), Stormwater wetland.

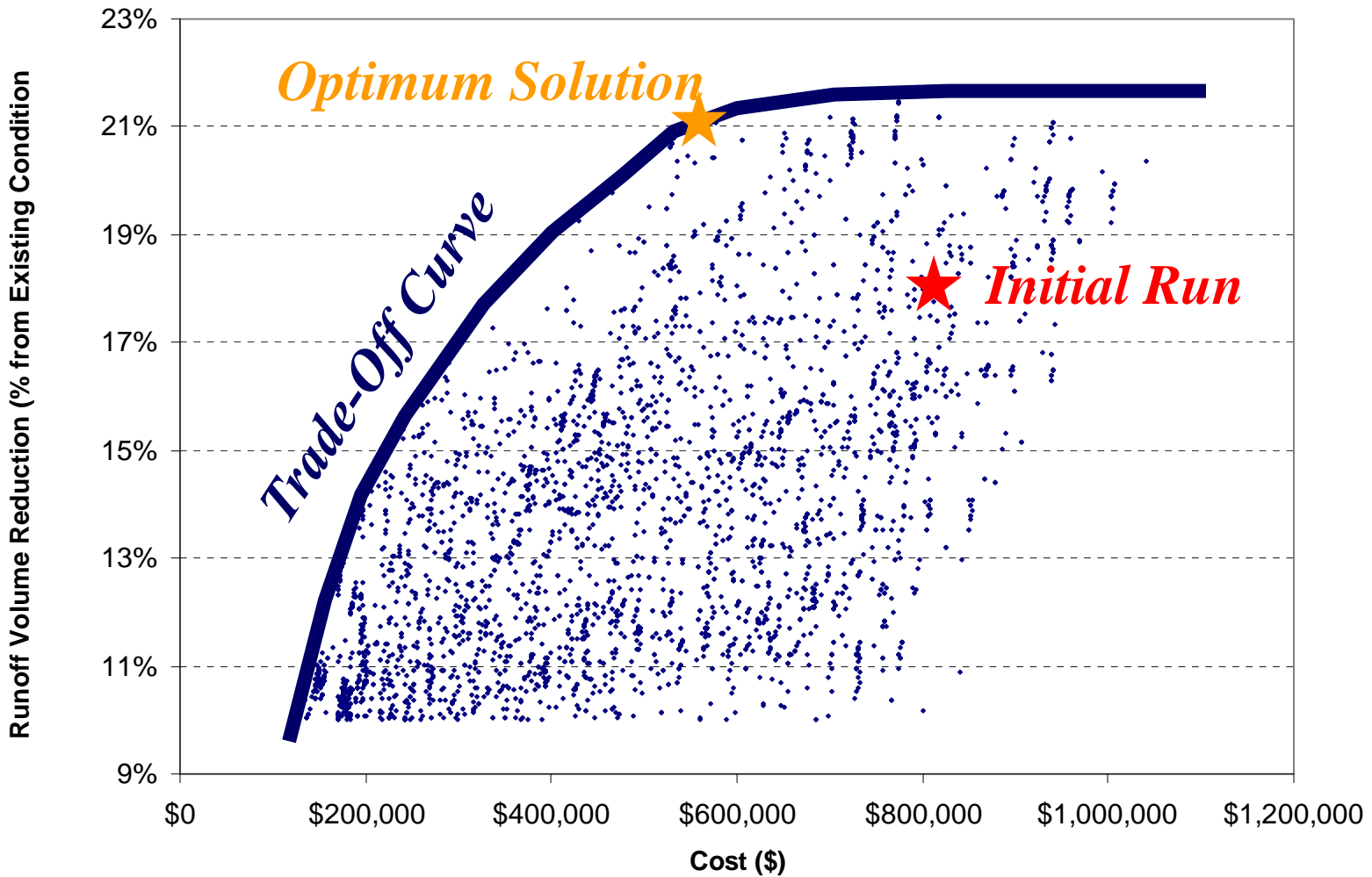
The 'Siting Criteria' table is as follows:

Siting Criteria	
Drainage Area (ac)	>25 <input checked="" type="checkbox"/>
Drainage Slope (%)	<15 <input checked="" type="checkbox"/>
Infiltration Rate (in/hr)	<input type="text"/> <input checked="" type="checkbox"/>
Hydrological Soil Groups	A-D <input checked="" type="checkbox"/>
Watertable Depth (ft)	>4 <input checked="" type="checkbox"/>
Road Buffer (ft)	NA <input checked="" type="checkbox"/>
Stream Buffer (ft)	100 <input checked="" type="checkbox"/>
Building Buffer (ft)	NA <input checked="" type="checkbox"/>



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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