Watershed Management Modeling with PLAT: Pollutant Loading Analysis Tool

City of Torrance

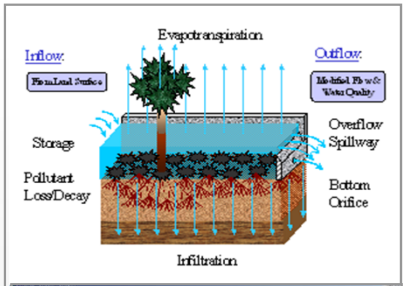
Carollo Engineers

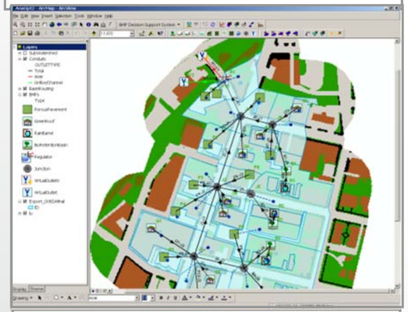
Engineers...Working Wonders With Water®

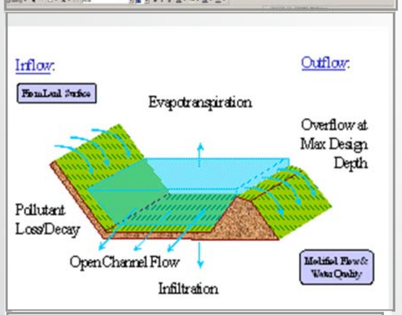
Presentation Outline

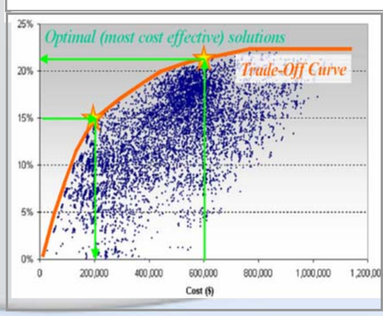
- **Project Background**
- **Water Quality Modeling with PLAT**
  - Satellite Imagery
  - PLOAD
  - P8
  - SUSTAIN
- **Conclusions**

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









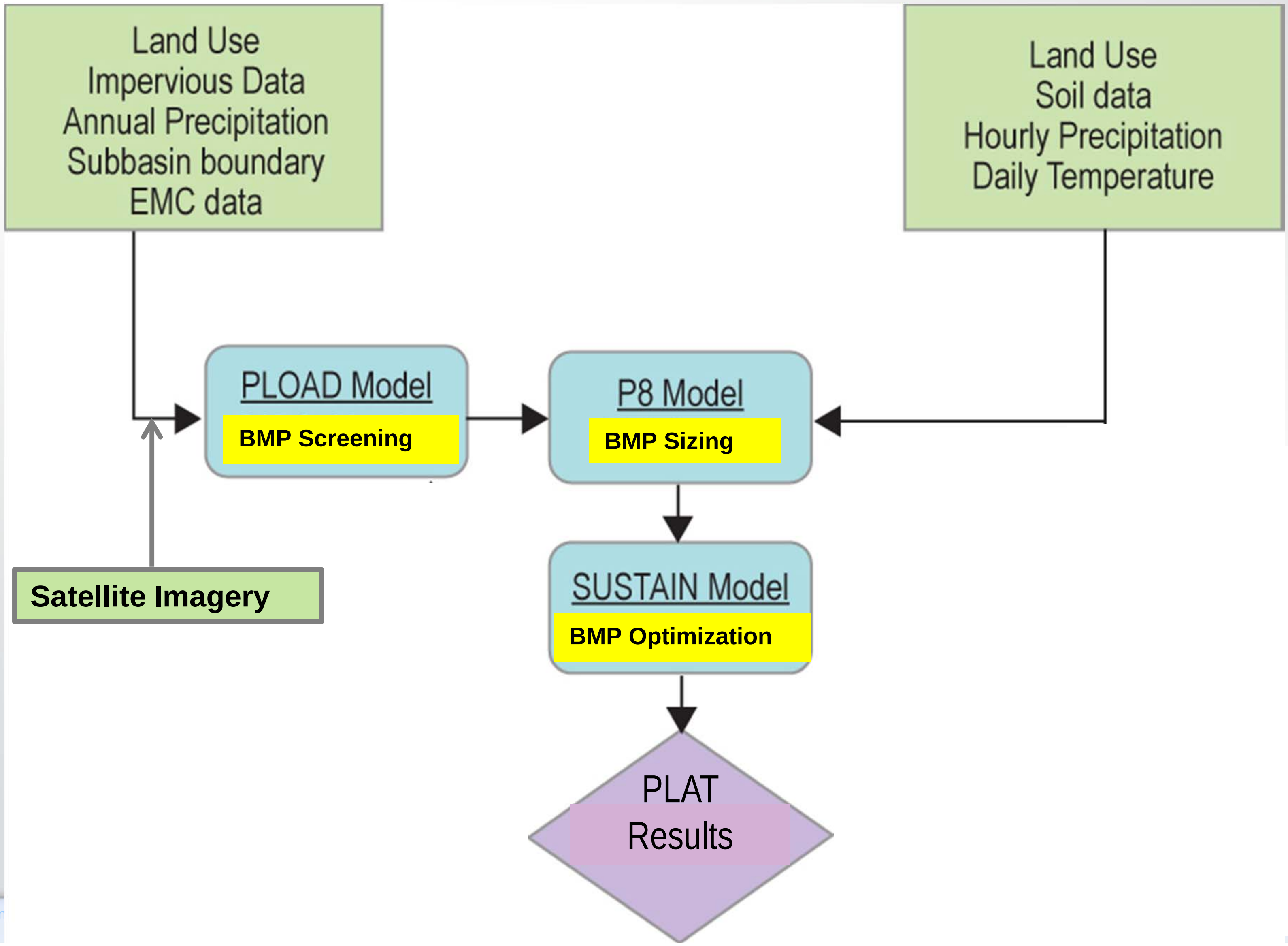
Model	Management Practice Evaluation Techniques	Water Quality Constituents
AnnAGNPS	• Sediment - RUSLE factors • Runoff curve number changes • Storage routing • Particle settling	• Sediment • Nutrients • Organic carbon
STEPL	• Sediment - RUSLE factors • Runoff curve number changes • Simple percent reduction	• 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** – **P**ollutant **L**oading and **A**nalysis **T**ool
- 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



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)

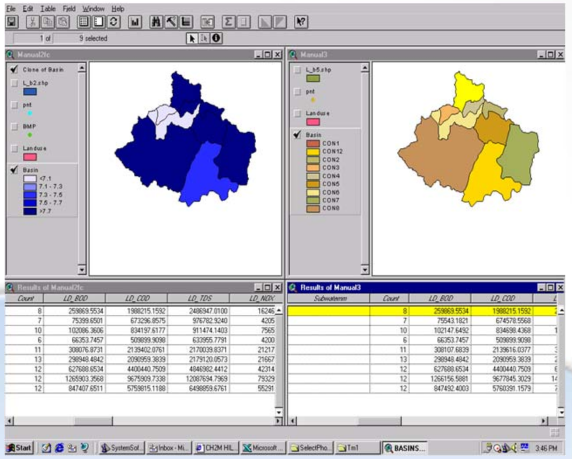
Pollutant Reduction
- Applied to base line load

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



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)

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

Impervious Surface can be readily extracted from satellite imagery

Any surface not penetrable by water

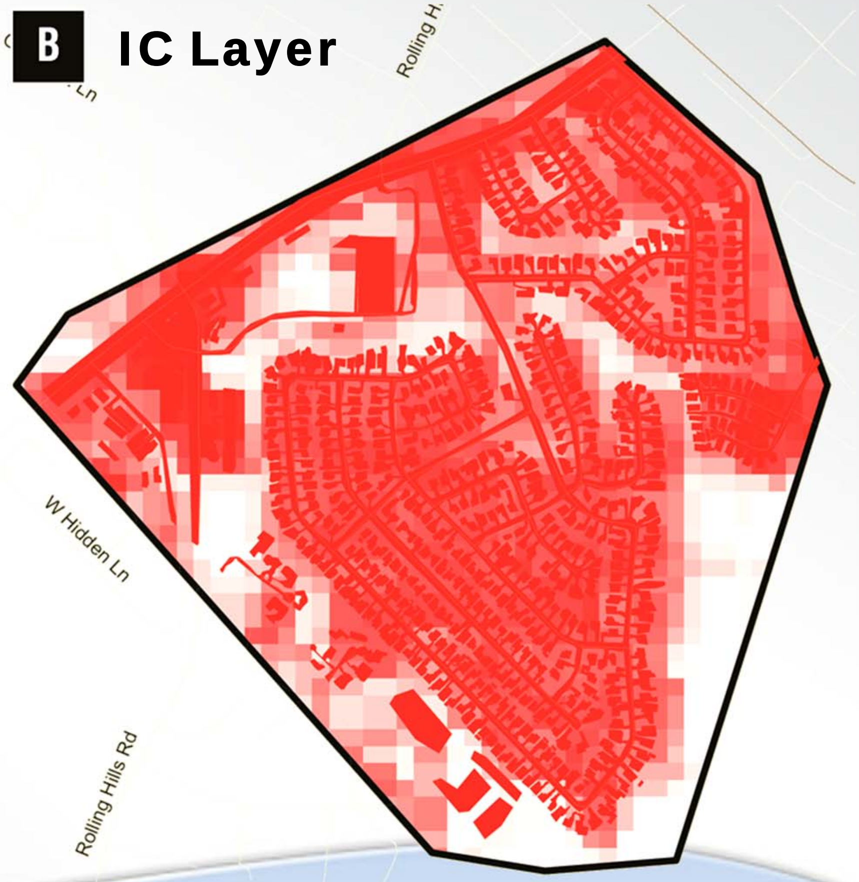
Includes streets, parking lots, side-walks and building roof tops

Transportation elements contribute the most to impervious surface area

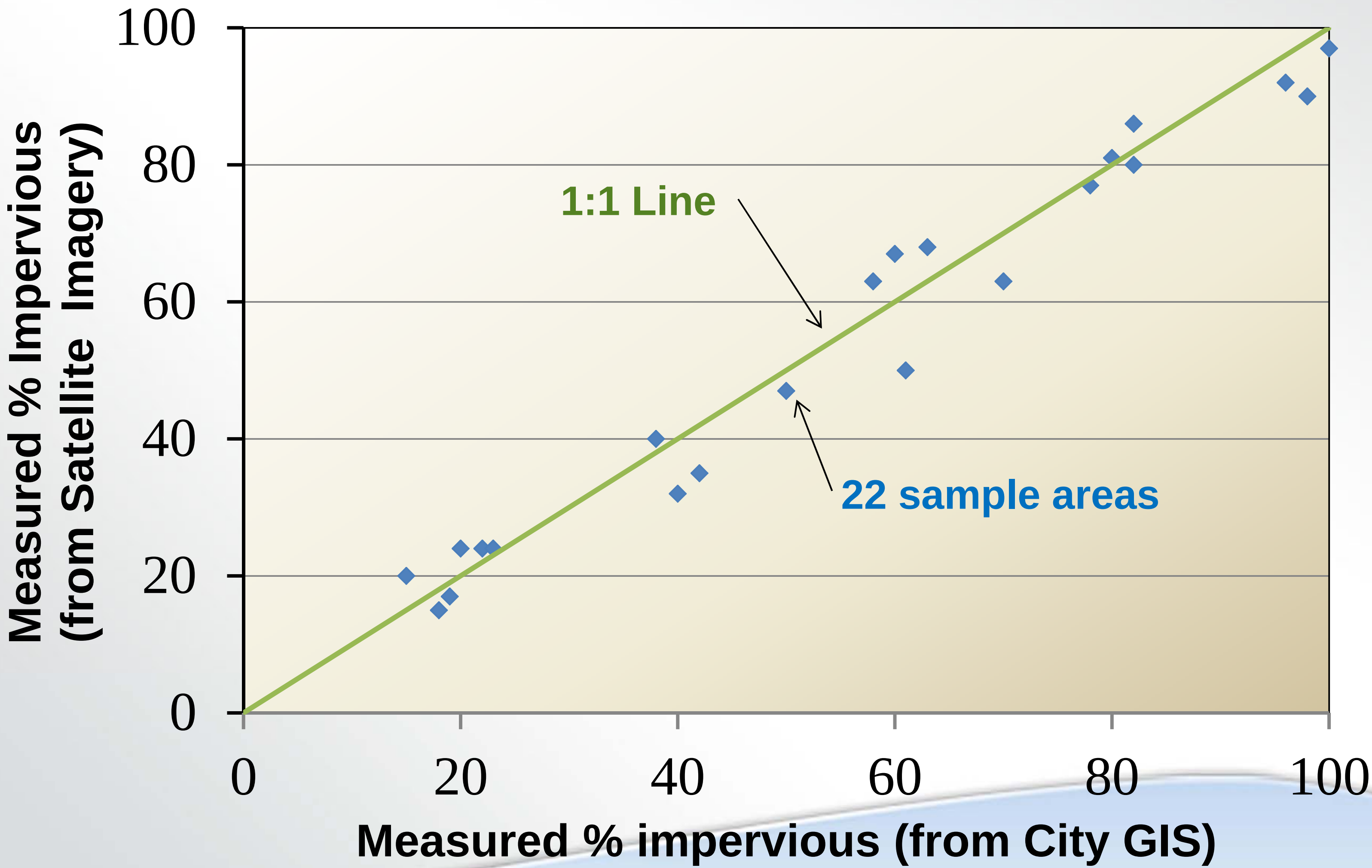
Satellite imagery allows accurate and quick estimation of impervious areas

A Raw Satellite

B IC Layer



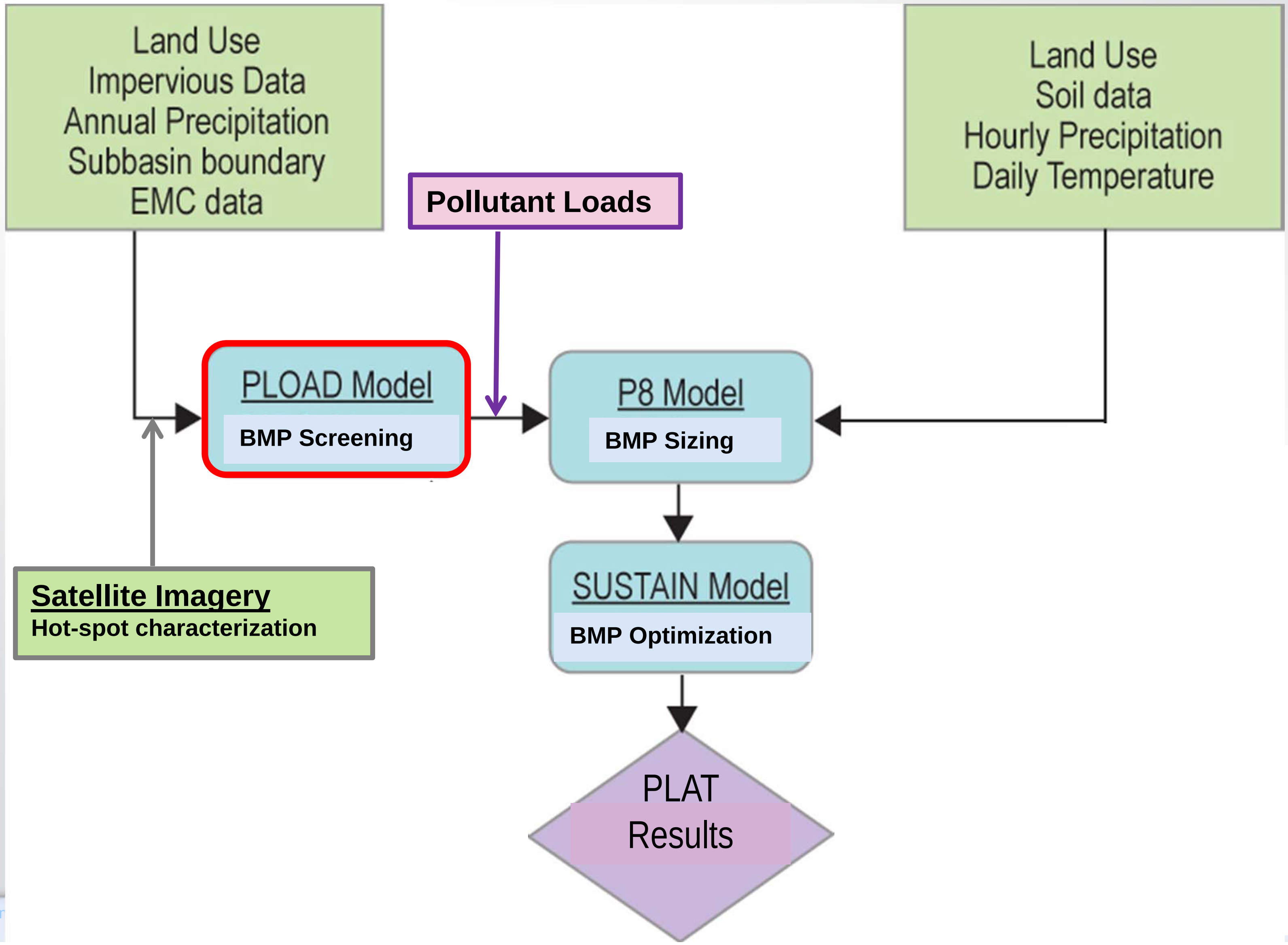
Comparison of % imperviousness of sample areas confirms accuracy of satellite imagery



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



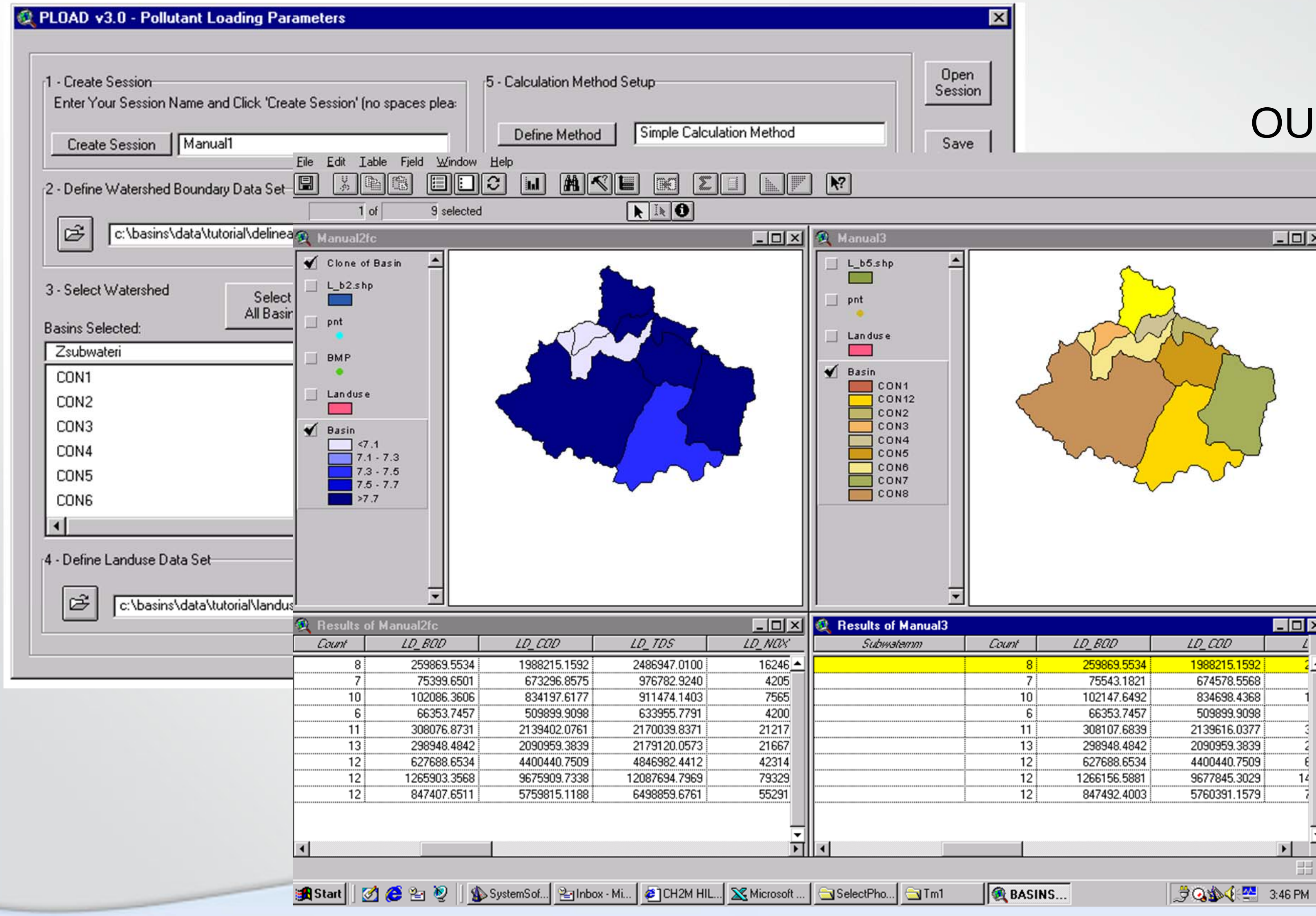
Simple Approach – PLOAD Modeling

- 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

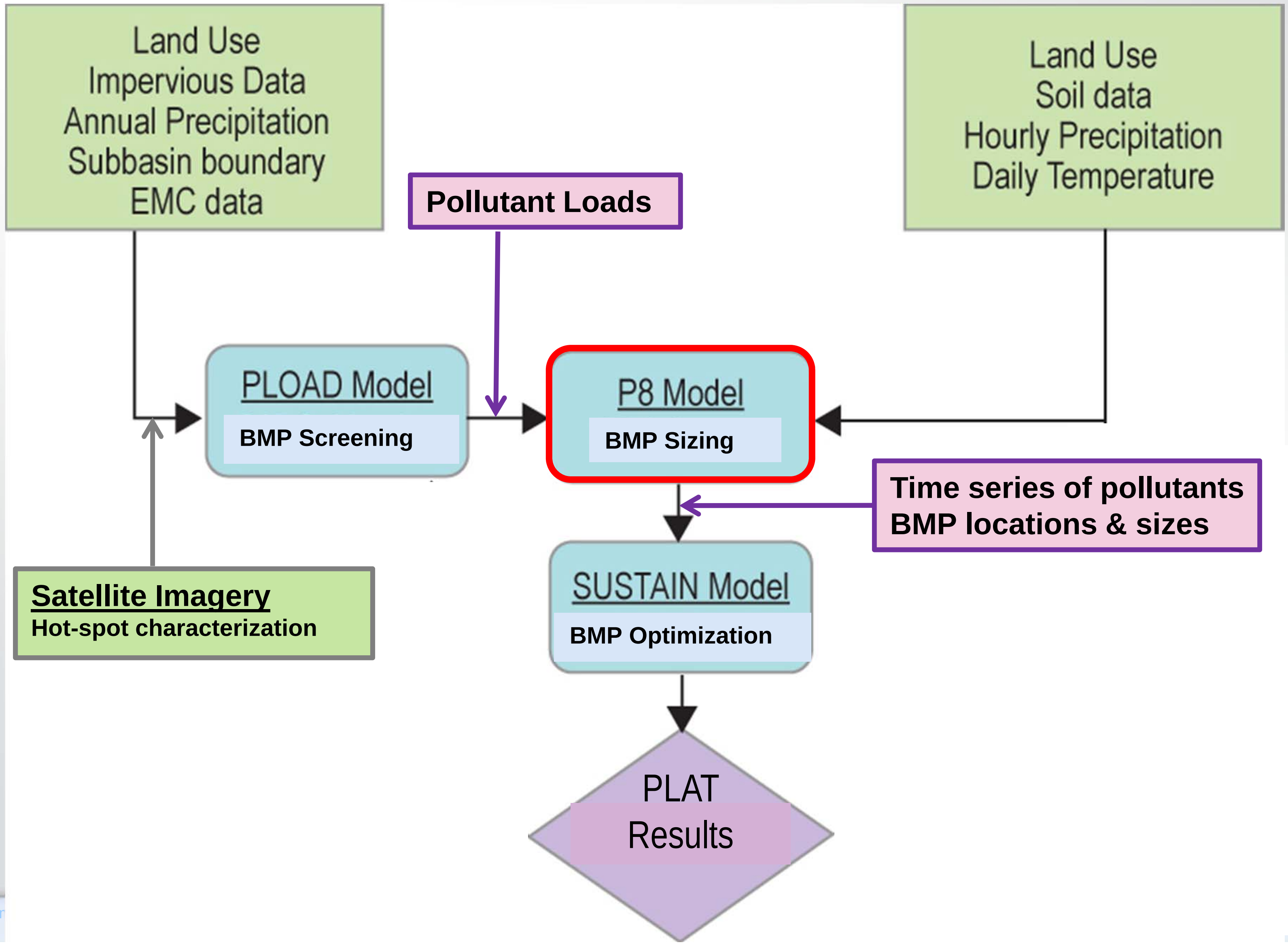
Pollutant load by subwatershed

INPUT

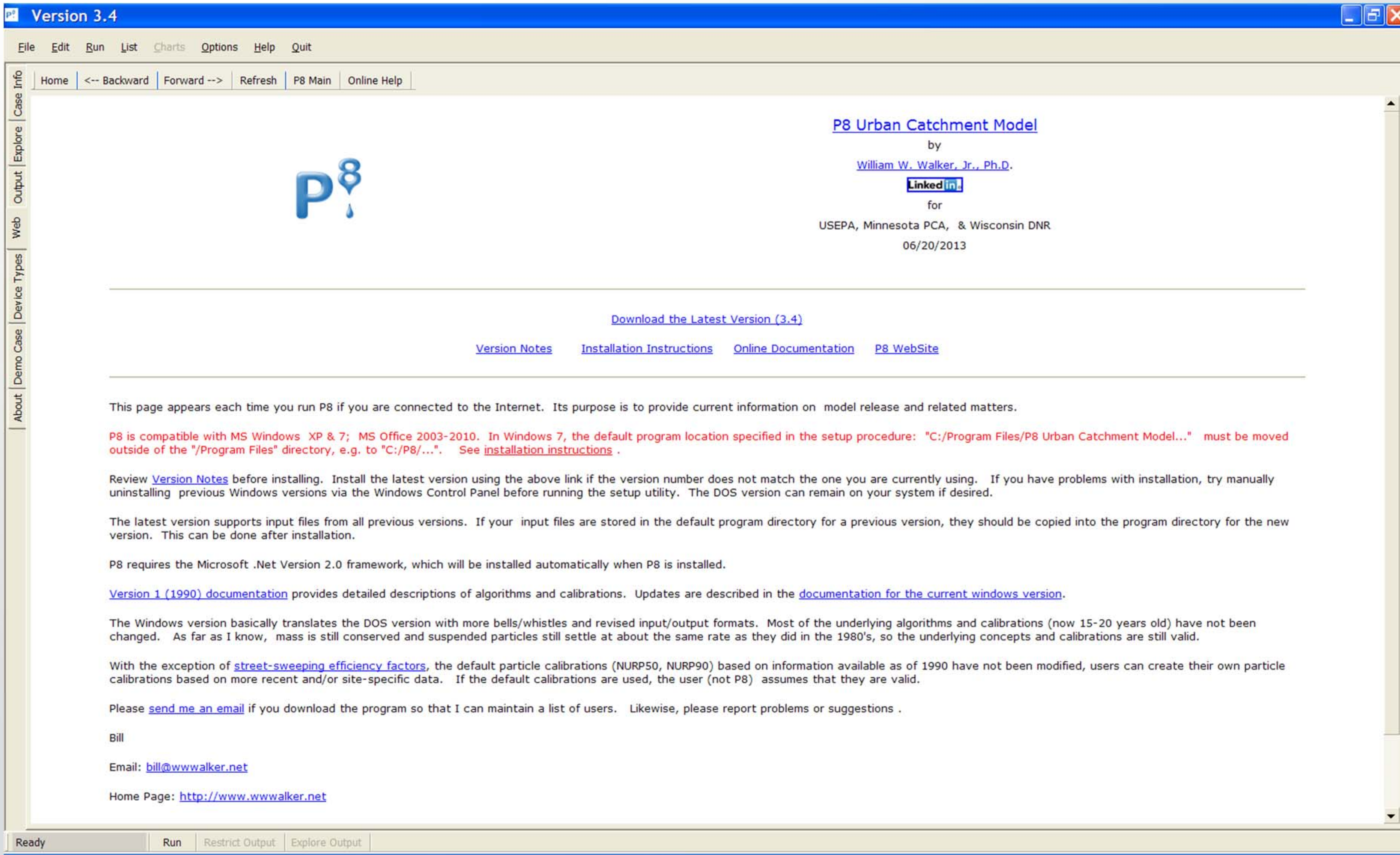
OUTPUT



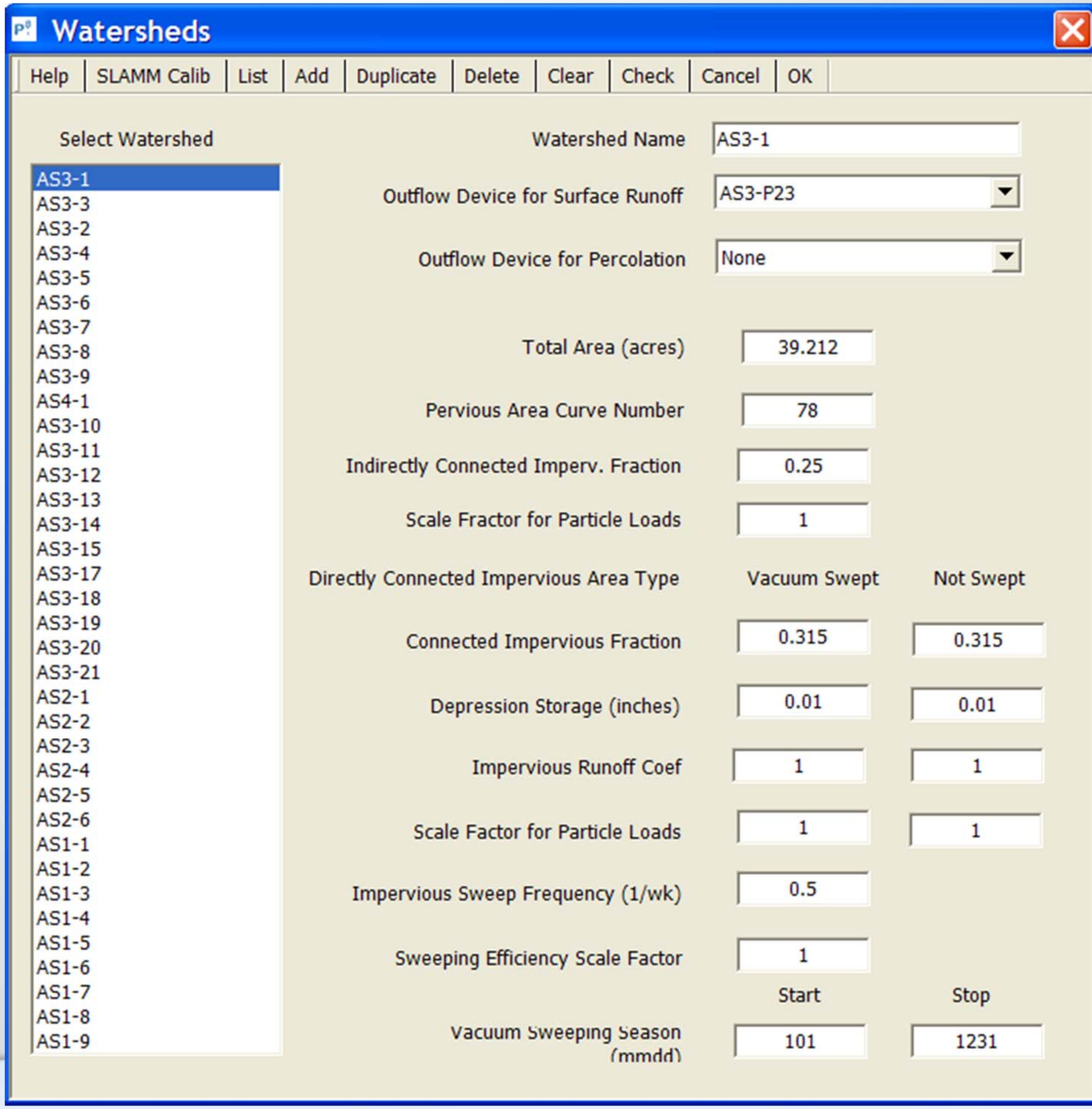
P8 calculates time-series pollutant loads by area for BMP sizing

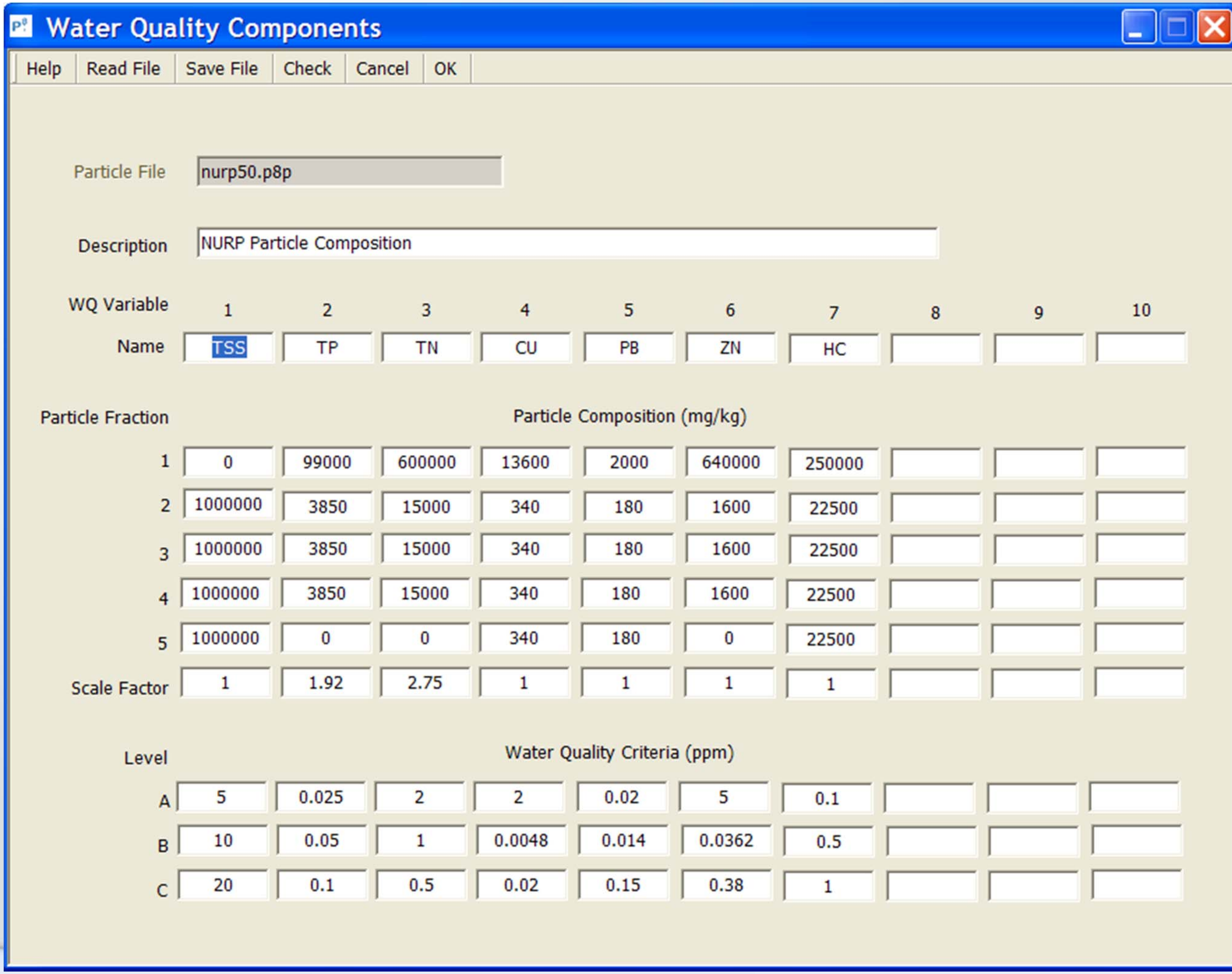


Advanced BMP Modeling with P8 (Urban Catchment Model)



Watershed input data sheet





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			

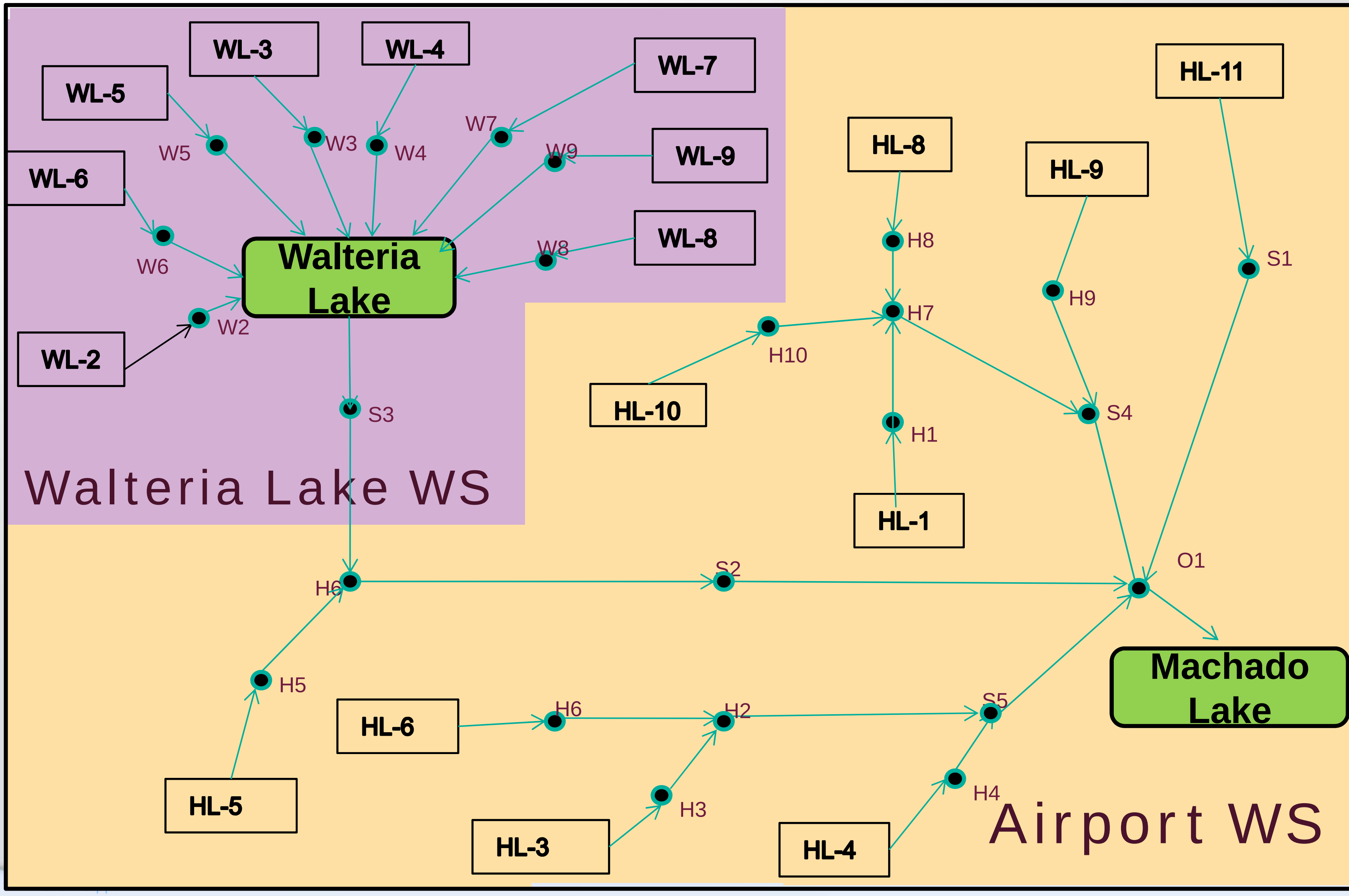
Particle Composition (mg/kg)

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)

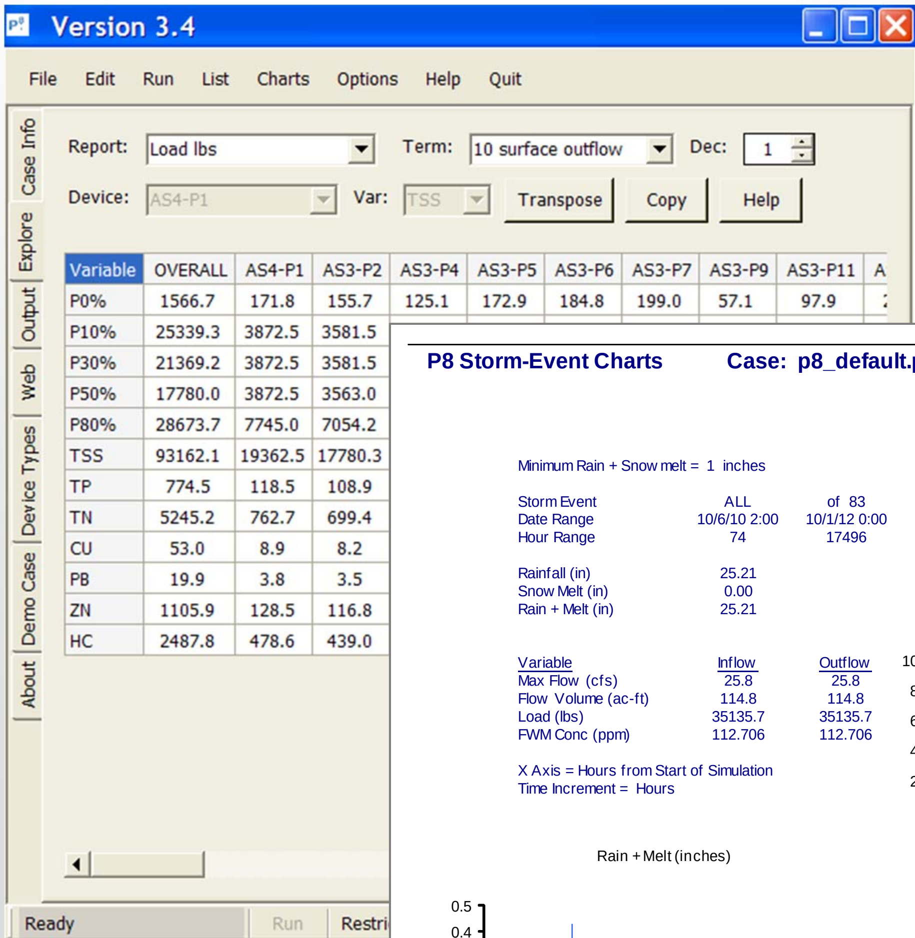
Level	1	2	3	4	5	6	7	8	9	10
A	5	0.025	2	2	0.02	5	0.1			
B	10	0.05	1	0.0048	0.014	0.0362	0.5			
C	20	0.1	0.5	0.02	0.15	0.38	1			

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



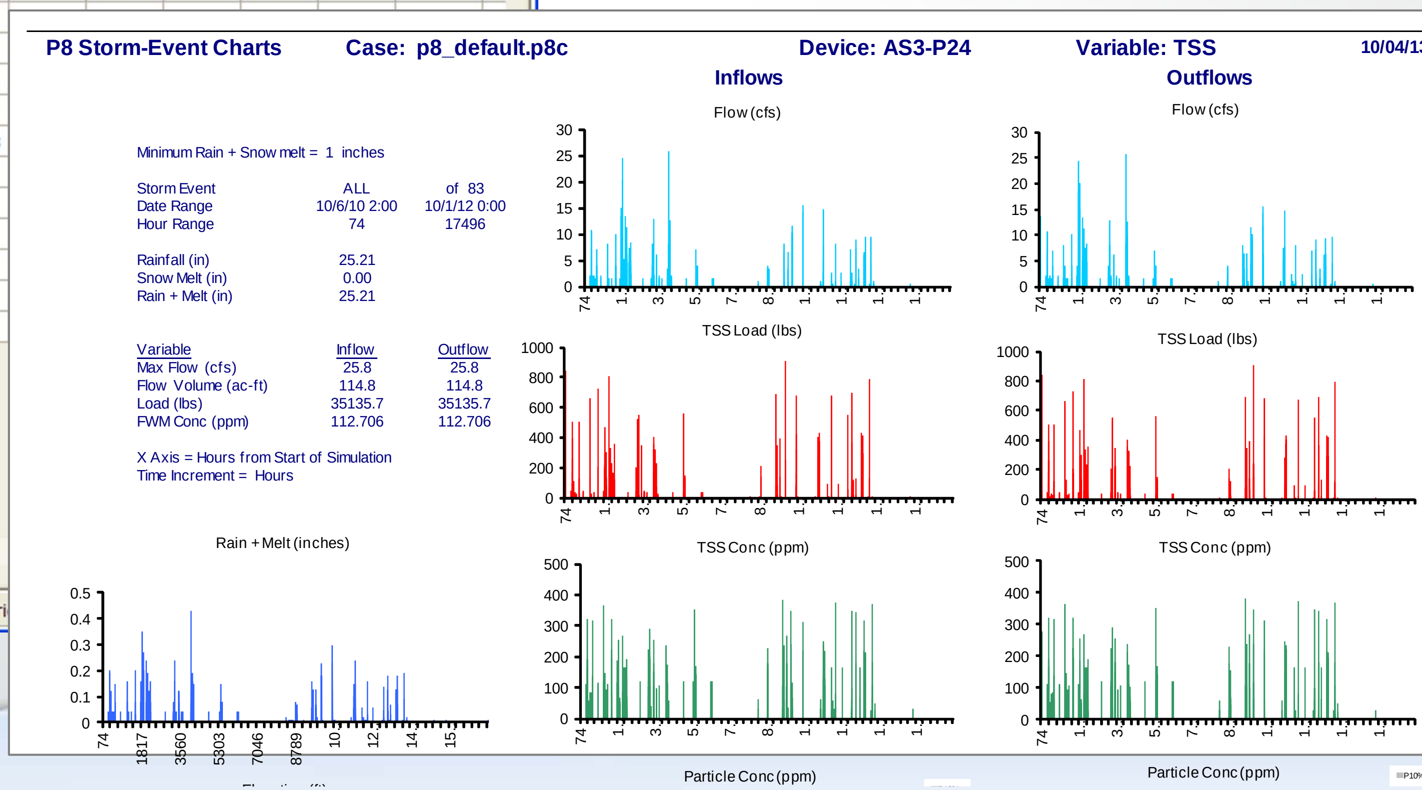
P8 Model produces time-series pollutant loads for BMP sizing and siting

INPUT



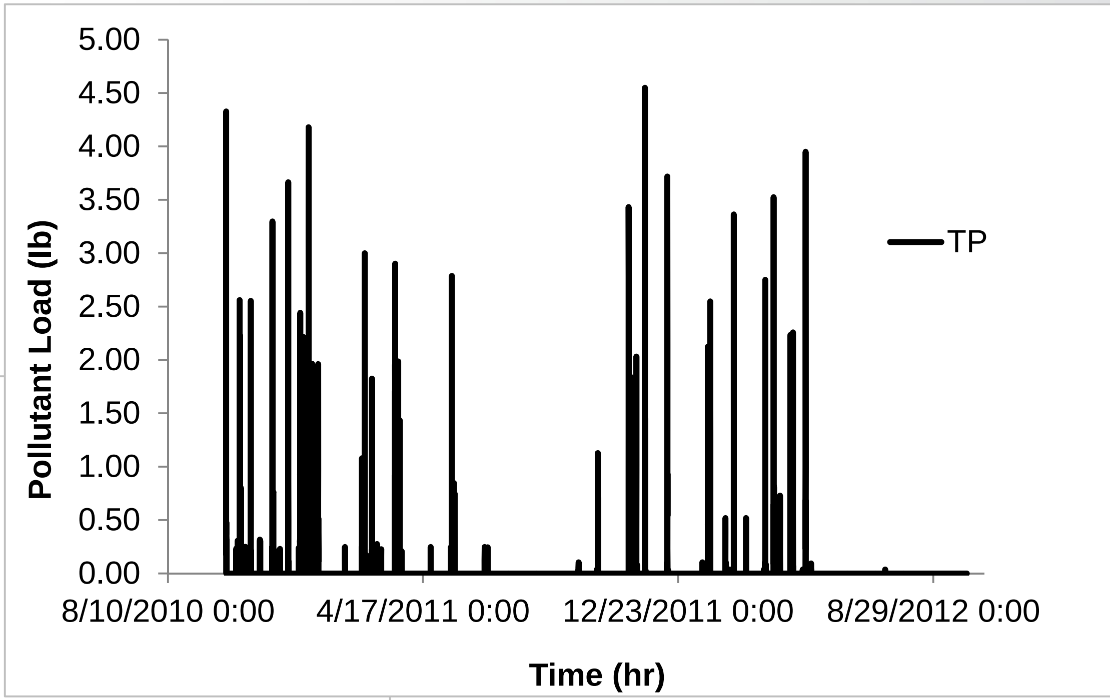
Variable	OVERALL	AS4-P1	AS3-P2	AS3-P4	AS3-P5	AS3-P6	AS3-P7	AS3-P9	AS3-P11
P0%	1566.7	171.8	155.7	125.1	172.9	184.8	199.0	57.1	97.9
P10%	25339.3	3872.5	3581.5						
P30%	21369.2	3872.5	3581.5						
P50%	17780.0	3872.5	3563.0						
P80%	28673.7	7745.0	7054.2						
TSS	93162.1	19362.5	17780.3						
TP	774.5	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						

OUTPUT

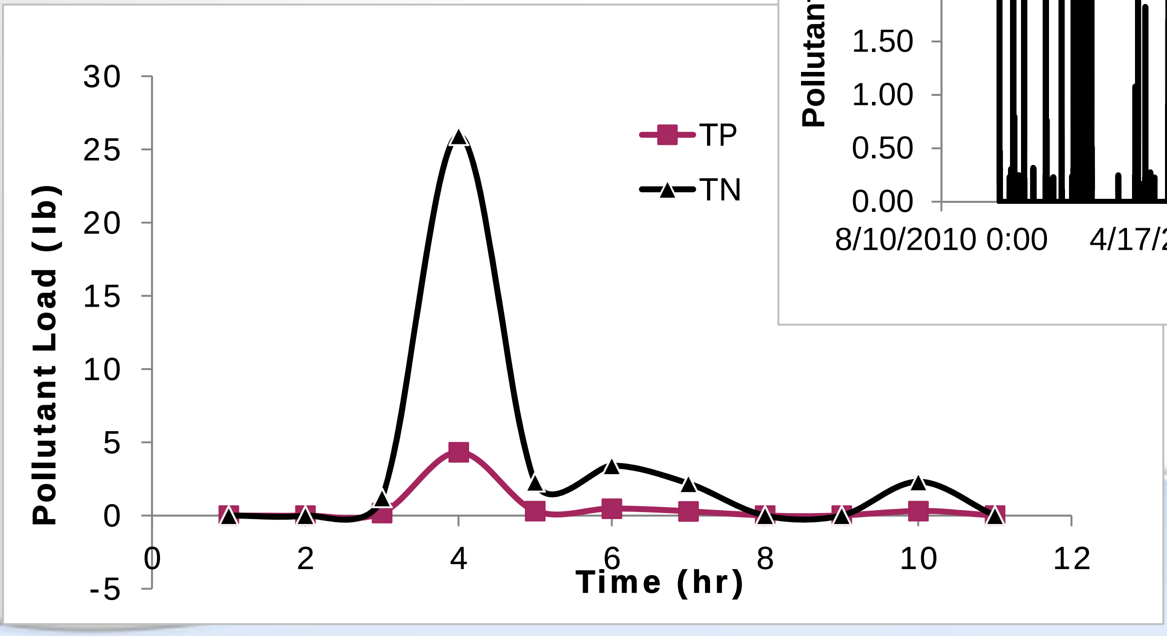


The P8 model can simulate both short-term storm events and long-term hydrology

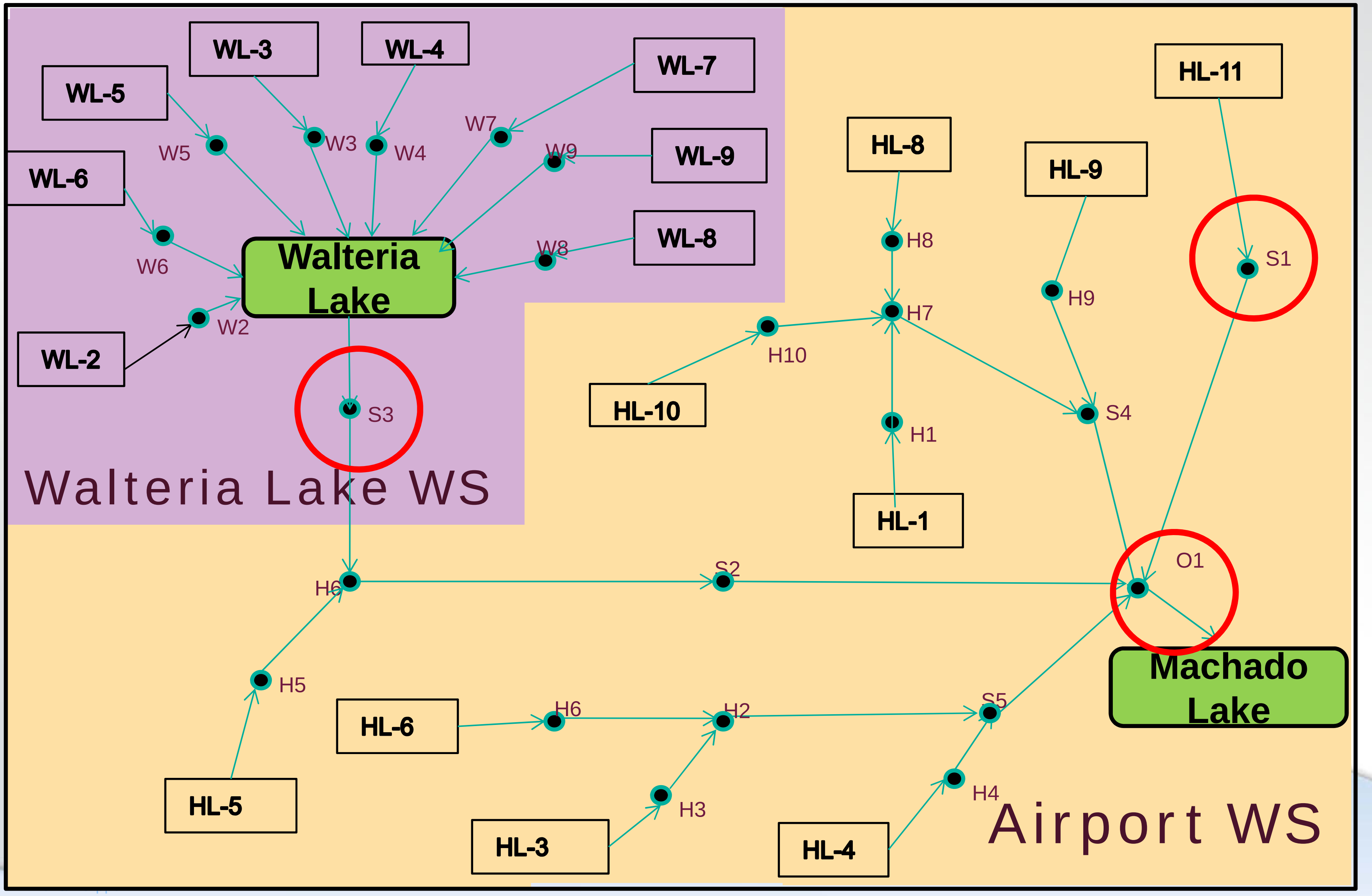
LONG-TERM
(from multiple storms to 30-yr hydrology)



SHORT-TERM
(24-hour design storm)



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



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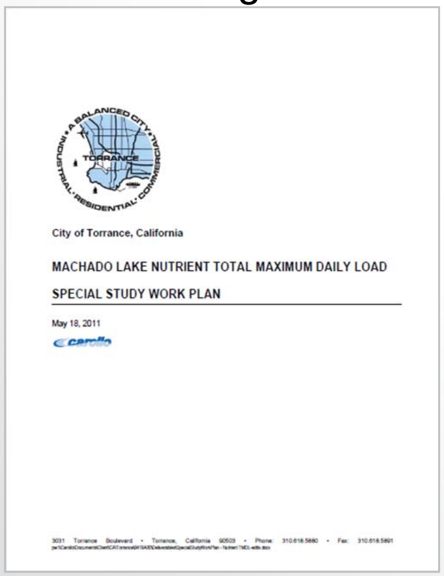
Machado Lake Nutrient TMDL Monitoring Plan

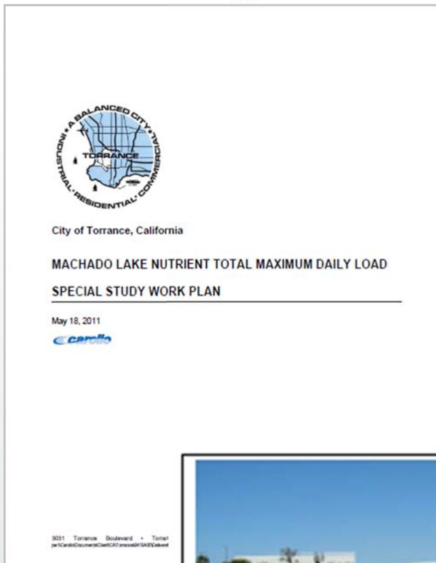

City of Torrance, California

MACHADO LAKE NUTRIENT TOTAL MAXIMUM DAILY LOAD

SPECIAL STUDY WORK PLAN

May 18, 2011

Machado Lake Toxics TMDL Monitoring Plan


City of Torrance, California

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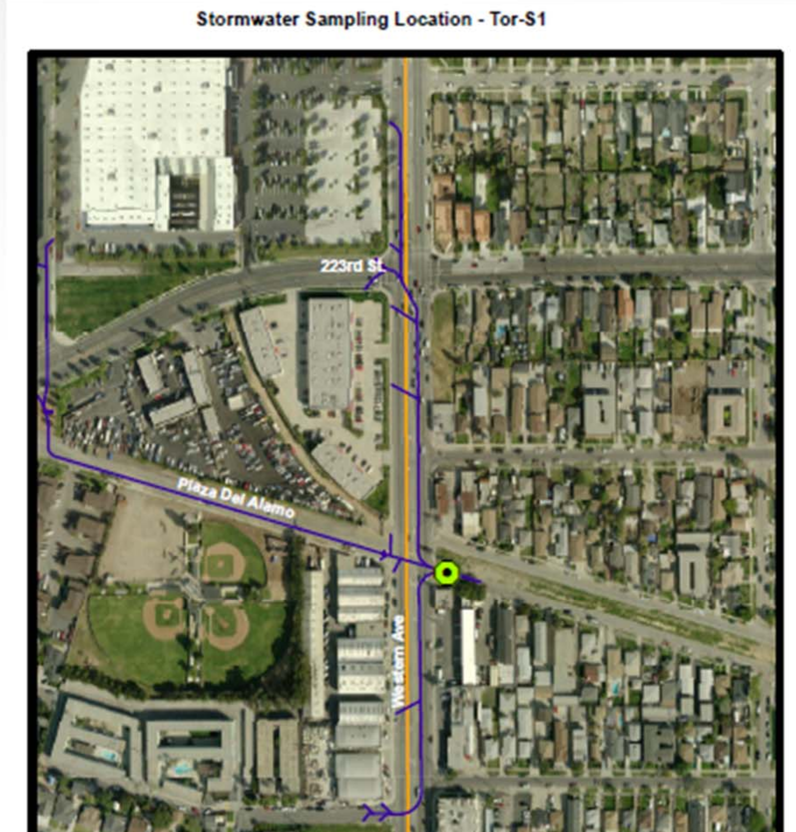
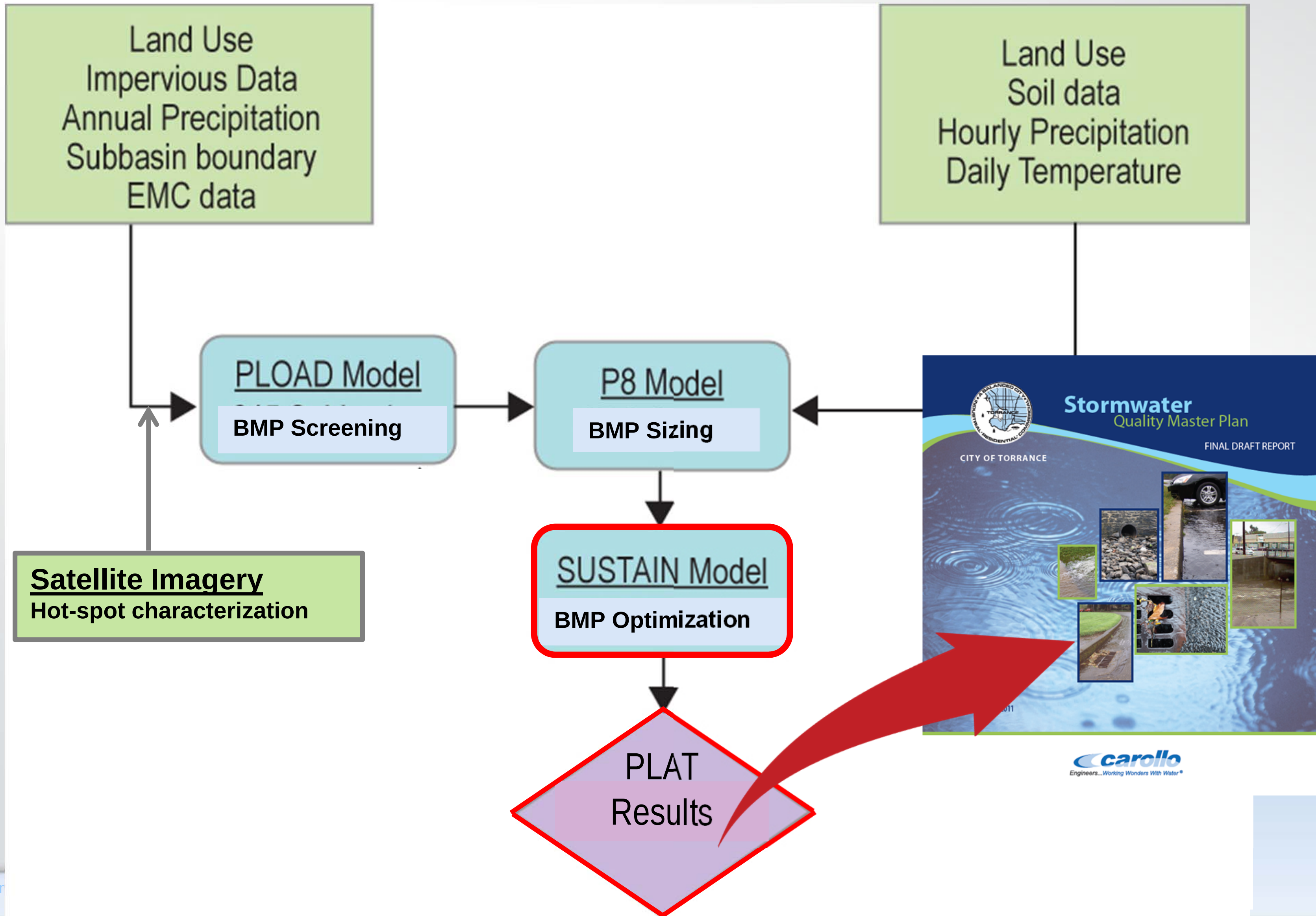
May 18, 2011



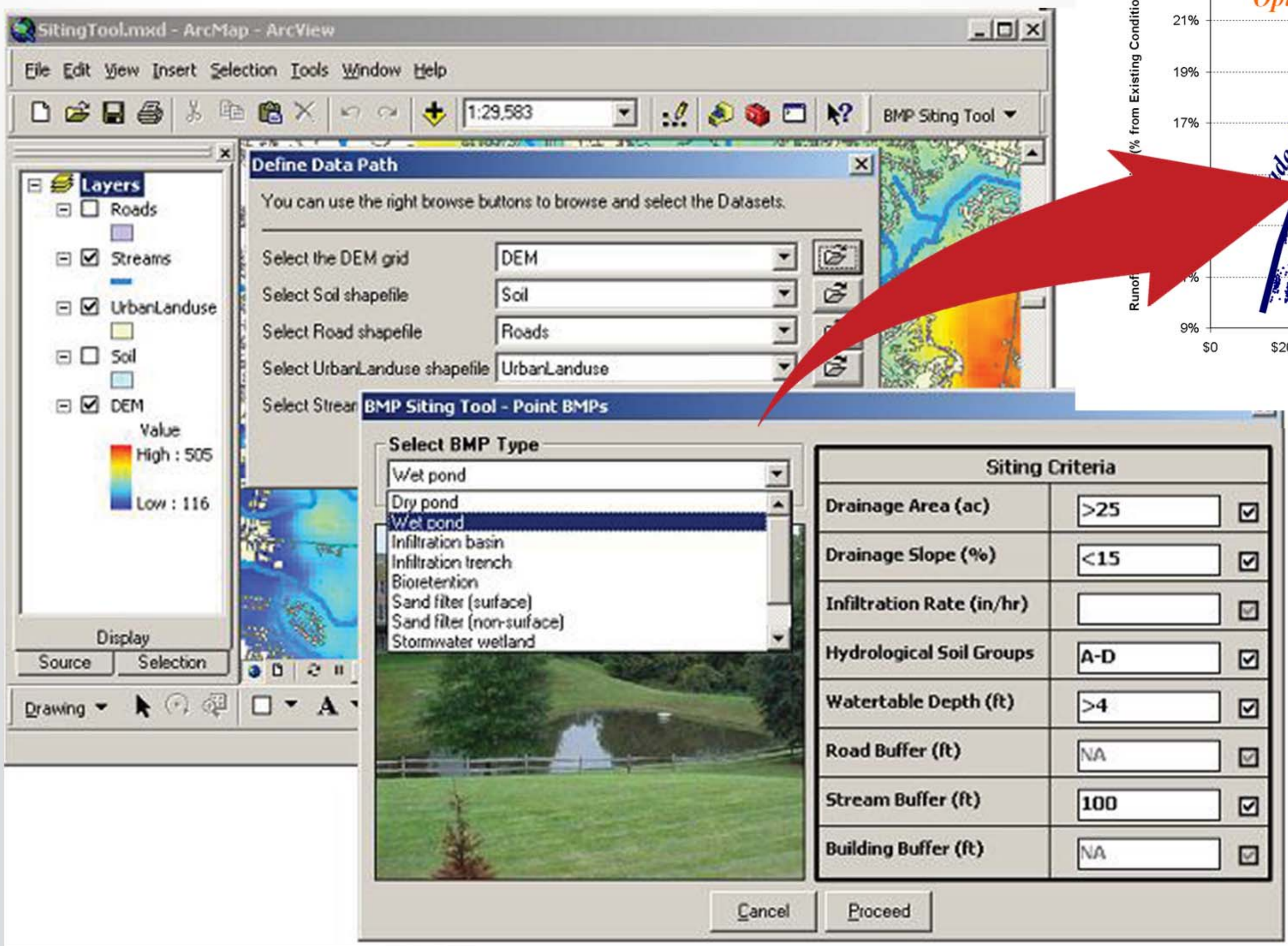
SAMPLING SITE TOR-S1

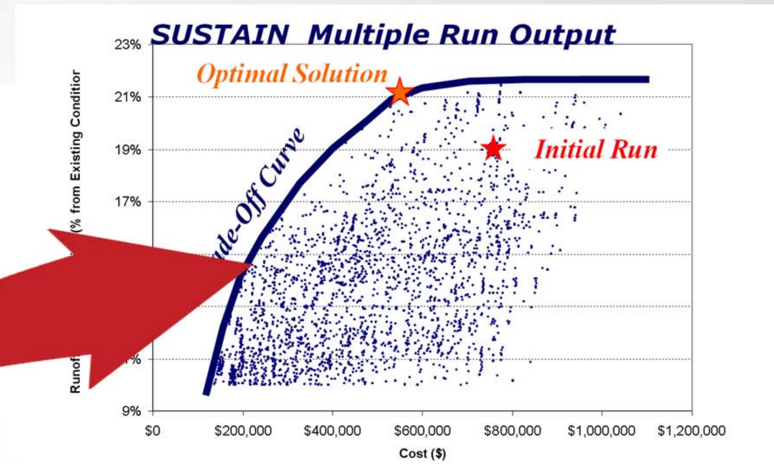
The last step of PLAT is BMP selection and optimization in SUSTAIN



The SUSTAIN Model is used to optimize sizing and minimize cost

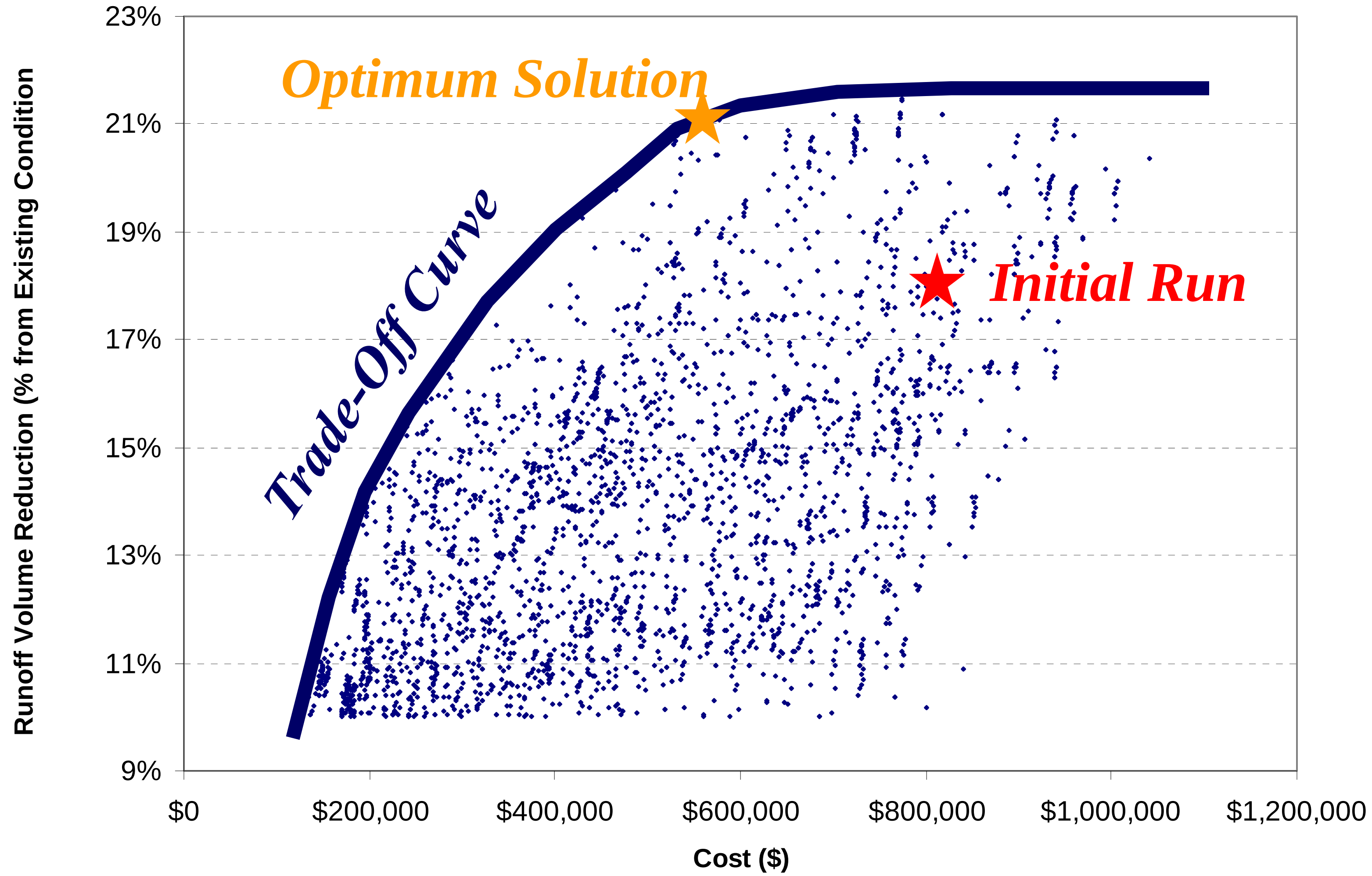
INPUT





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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