GUADALUPE WATERSHED MODEL

SUPPORT TOOL FOR REGIONAL HG AND PCBS MANAGEMENT

RMP Special Study
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Background

San Francisco Bay is listed as impaired for mercury (Hg) and PCBs, and the associated TMDLs call for improved regional loads estimates, greater than 50% load reductions from urbanized small tributaries in general and over 90% load reduction in the Guadalupe River watershed over the next 20 years. In order to address this call, managers need improved information on which best management practices (BMPs) may be effective and what magnitude of application will be needed to see measurable loads reductions at the watershed and regional scales. To inform the management questions, the Regional Monitoring Program for Water Quality in San Francisco Estuary funded a pilot study to develop a dynamic watershed model of the Guadalupe River Watershed. This watershed offers a unique opportunity to study legacy Hg from the largest-producing former Hg mine in North America as well as legacy PCBs from the manufacturing industries of the 1950s and 1960s. In addition, an abundance of local water, sediment, and contaminant data make the Guadalupe River Watershed an ideal study area.

Objectives

The aim of the Guadalupe Watershed Model project is to understand the source, release, and transport of sediment and contaminants from a large mixed land-use, highly urbanized watershed. The first phase of the project was to develop the underlying hydrological model in the EPA's watershed modeling software suite BASINS/HSPF. An accurate model (R^2=0.97 for mean daily flow) was developed despite challenges due to the high degree of watershed hydromodification including numerous reservoirs and percolation ponds. The second phase, currently underway, is to add sediment, Hg and PCBs into the model. The final model will serve to improve the accuracy of Hg and PCB load calculations, to investigate inter-annual load variability due to climate, and to allow scenario testing for optimizing management practices. This project will also establish model input and calibration parameters for regional application, thereby assisting in development of other local watershed models.

Model Usage

- Estimate/confirm Hg and PCB loads
- Determine propotional loads
  - when, and from where, are constituents transported
- Investigate impacts of climate on sediment, Hg and PCB loads
- Assess potential effects of land-based management practices, land use change and climate change

Model Overview

Software: Hydrological Simulation Program - FORTRAN (HSPF)

Key Processes:

- Hydrology Model (Figure 1)
- Sediment Model (Figure 2)
- Contaminant Model (Figure 3)

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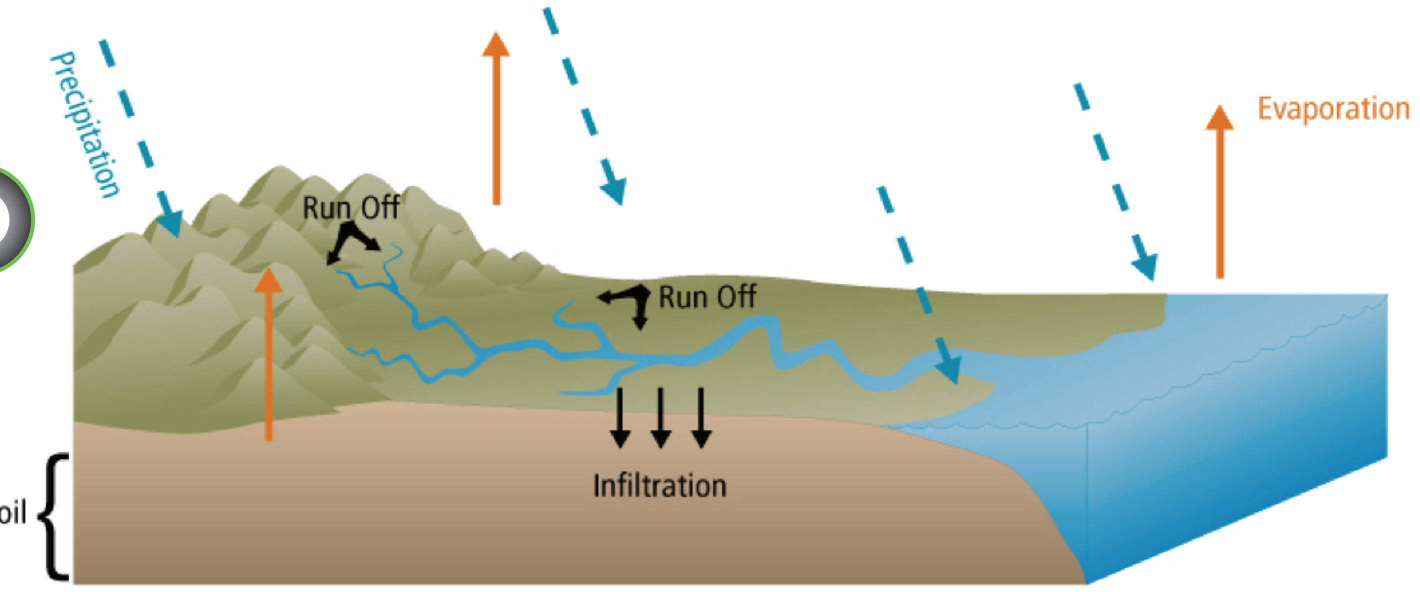

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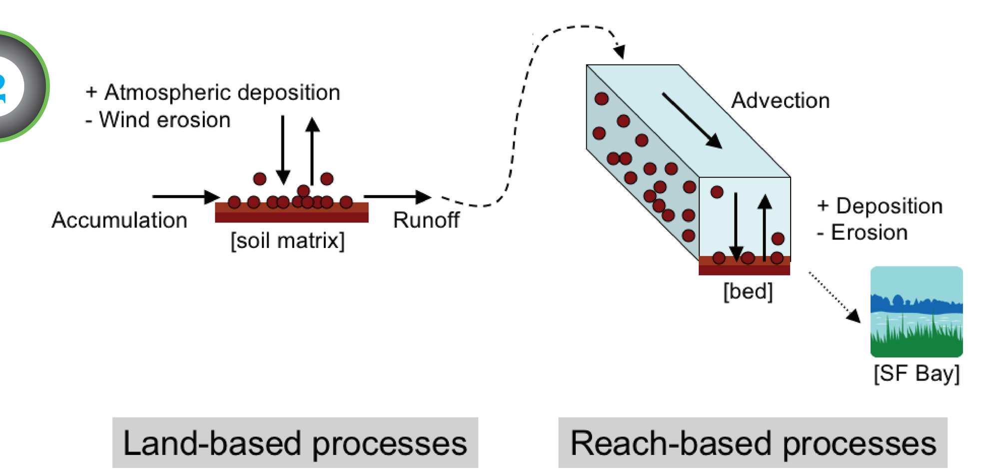

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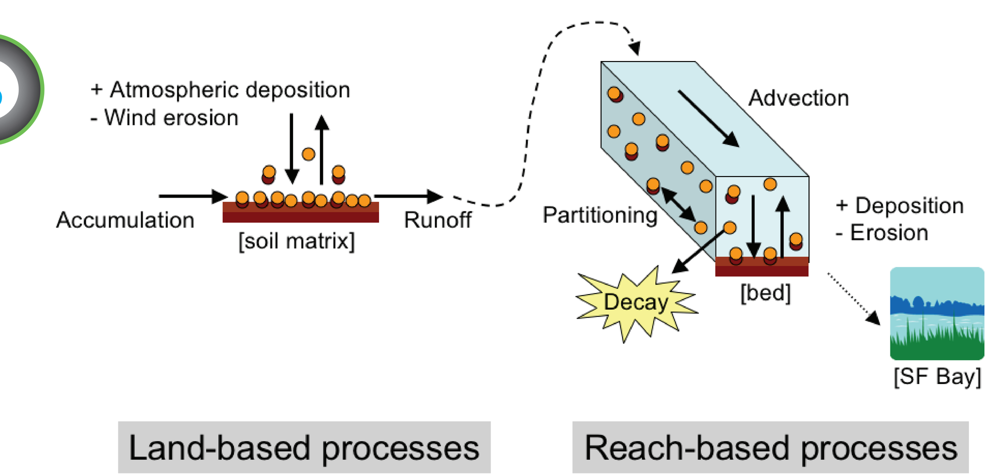

Model Setup

The entire Guadalupe River Watershed consists of approximately 172 sq. miles in Santa Clara County (Figure 4). The modeled portion is the downstream two-thirds of the overall watershed (103 sq. miles subset). The modeled watershed extends from the set of reservoirs in the San Jose foothills, north though San Jose, to drain into Lower South San Francisco Bay. The watershed is highly gauged for both precipitation (Figure 5) and streamflow (Figure 6). Suspended sediment concentration (SSC) measurements have been taken on a 15-minute basis in Guadalupe River (Figure 6) since 2002. Hg concentration data have been collected in over 100 sites across the watershed. PCBs concentration data have been collected in about 20 sites, mostly in urban areas, which are concentrated in the downstream portion of the watershed.

The process of watershed segmentation divides the modeled area into logical segments, called subbasins (Figure 6), based on topography, drainage patterns, meteorological variability, and soil types. Other boundary considerations for subbasins include locations of dams/reservoirs and flow gauges, as well as model objectives, e.g. delineating particular areas of interest to answer specific questions. The purpose of segmentation is to allow for parameterization and model output of local conditions within a watershed. The segmentation process also includes assigning precipitation stations to regions of the model (Figure 5).

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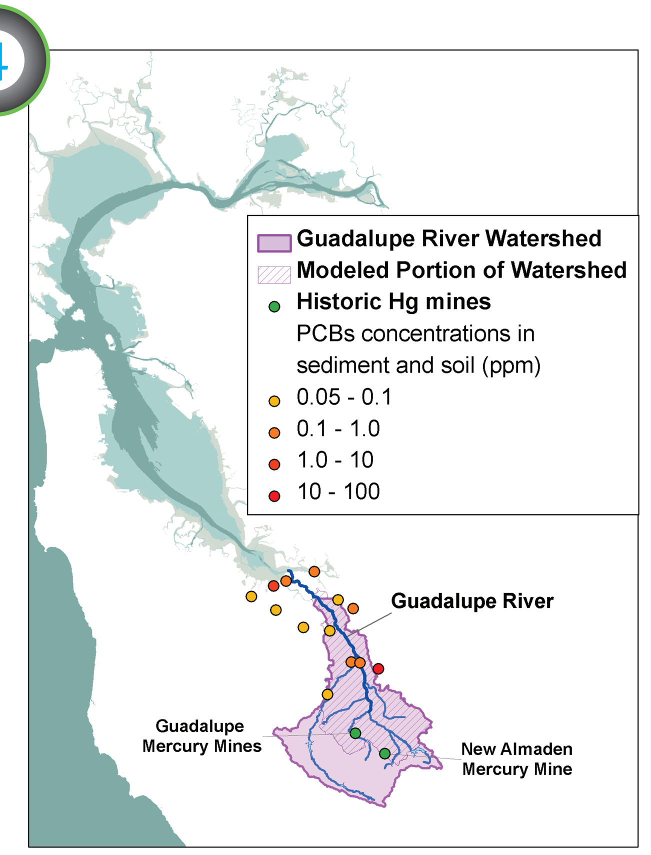

Guadalupe Watershed with Known Contaminated Sites

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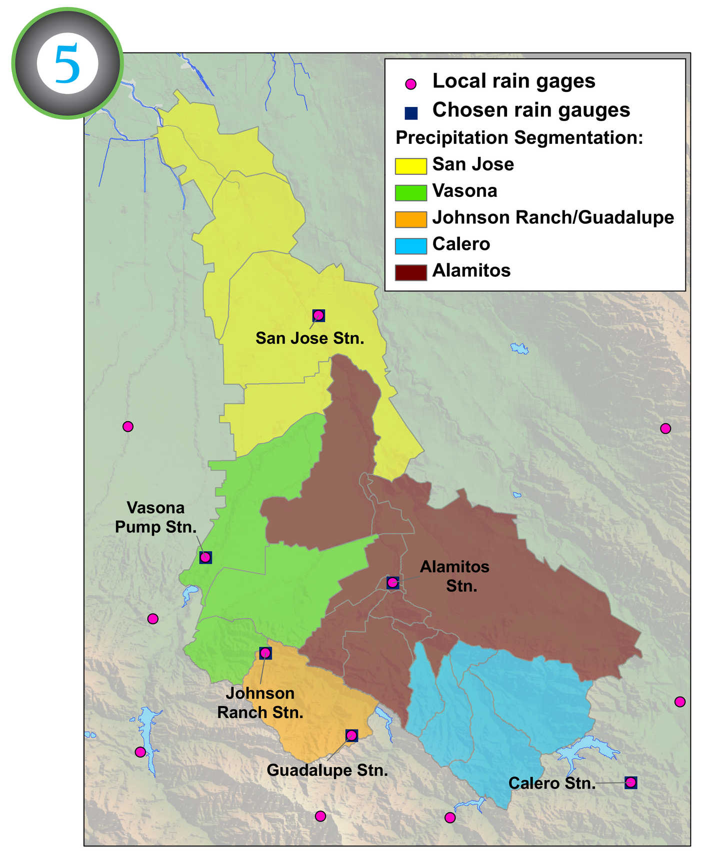

Precipitation Gauges and Model Segmentation

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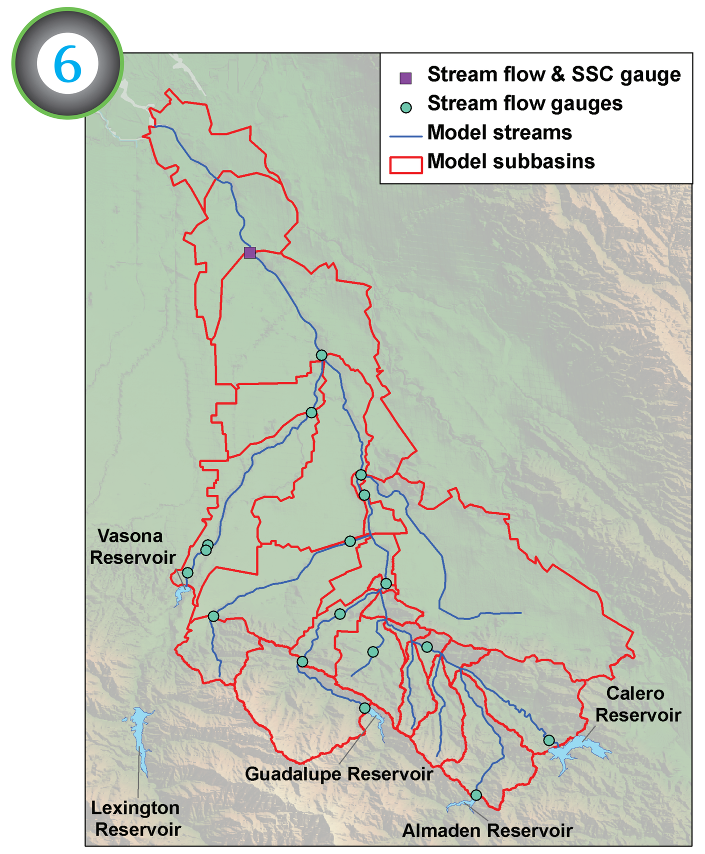

In-Stream Gauges (Flow and SSC) and Model Set-up

Calibration and Validation

Hydrology

Calibration of the hydrologic model generally involves adjusting soil moisture storage parameters and evapotranspiration parameters until the simulated flow matches the observed flow. However, calibration can also require more major changes such as re-evaluating the model segmentation (e.g. is the appropriate precipitation gauge assigned to a watershed region) or tracking down a diversion removing water from the system being modeled. The validation process evaluates the calibrated portions of the model by seeing how well the model performs as a whole.

The model was calibrated to numerous upstream locations (data not shown) before being validated on the most downstream gauge (USGS #11169025) for WY1995-2007 (Figure 7). The model generally captured annual flow volumes well; however, it performs poorly on extremely dry years (Table 1). The scatter plot of observed versus simulated daily mean flows showed a very high degree of correlation (R^2=0.97) (Figure 8). The flow duration curve (Figure 9) showed that, on average, the model simulated high- and medium-flows accurately, but slightly underestimated baseflow.

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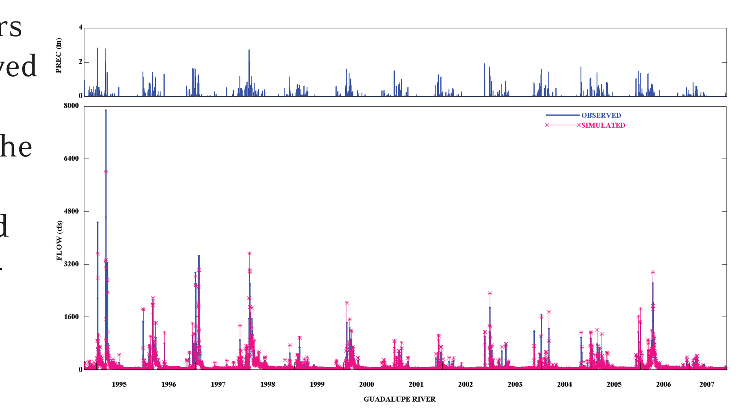
Observed and Simulated Flow for Guadalupe River with Alamitos Station Precipitation (WY 1995-2007)



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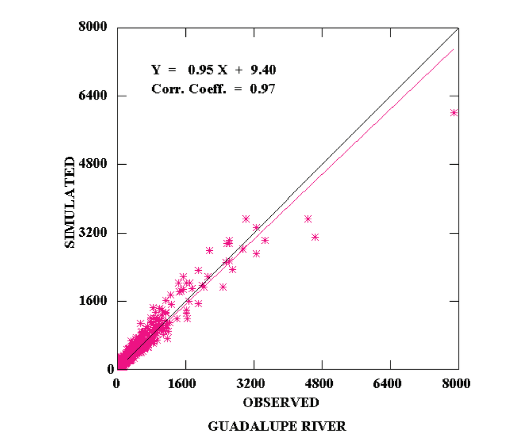
Observed Versus Simulated Daily Mean Flow for Guadalupe River (WY 1995-2007)



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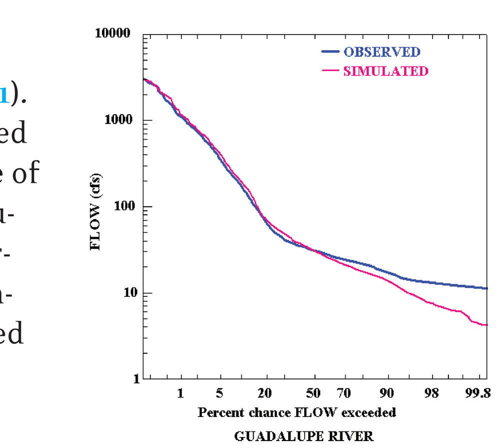
Flow Duration Curve Observed and Stimulated Flow for Guadalupe River (WY 1995-2007)



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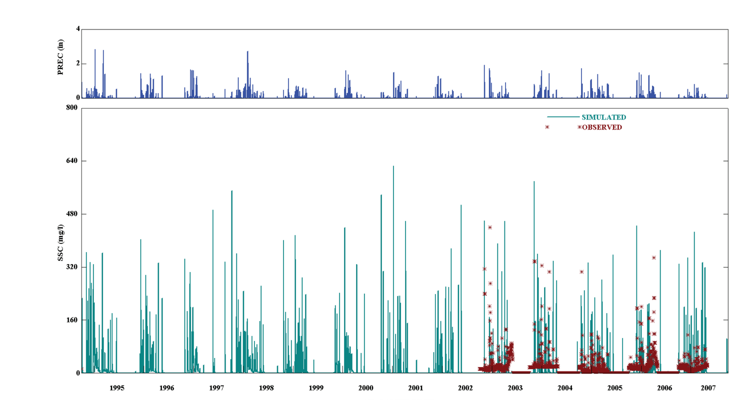
Observed and Simulated Daily Mean SSC for Guadalupe River with Alamitos Station Precipitation (WY 1995-2007)



Sediment

Calibration of the land-based sediment model generally involves adjusting accumulation and removal (including erosion) rates to meet target sediment yields for different land use types and recreate expected build-up and wash-off processes. Calibration of the reach-based sediment model involves adjusting shear stress parameters to obtain expected erosion and deposition behavior. The sediment model is then validated by comparing the simulated suspended sediment concentration (SSC) to the observed SSC. Preliminary results shown in Figure 10.

Table 1. Annual Simulated and Observed Flow Volumes for Guadalupe River and Annual Precipitation for Alamitos Weather Station

Water Year	Prec. (in)	Observed Vol. (10^6 cf)	Simulated Vol. (10^6 cf)	% Difference	Rating
1995	26.8	5,651	5,636	-0.3%	Very Good
1996	17.9	3,297	3,609	9.5%	Very Good
1997	16.6	4,188	4,000	-4.5%	Very Good
1998	27.2	5,349	5,905	10.4%	Good
1999	11.6	1,508	1,561	3.5%	Very Good
2000	14.5	2,615	2,681	2.5%	Very Good
2001	12.4	1,394	1,552	11.3%	Good
2002	9.3	968	1,320	36.4%	Poor
2003	17.6	2,148	2,313	7.7%	Very Good
2004	13.1	1,874	1,773	-5.4%	Very Good
2005	20.4	2,590	3,007	16.1%	Good
2006	16.6	4,474	5,000	11.8%	Good
2007	7.1	1,260	1,016	-19.4%	Fair

Next Steps

Once the sediment model has been calibrated and validated, the contaminant model will be parameterized and calibrated for Hg and for PCBs. Then the model will be used to investigate inter-annual load variability and to test scenarios such as changing management practices, land use and climate.

Acknowledgements

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