Watershed Conservation and Source Water Protection

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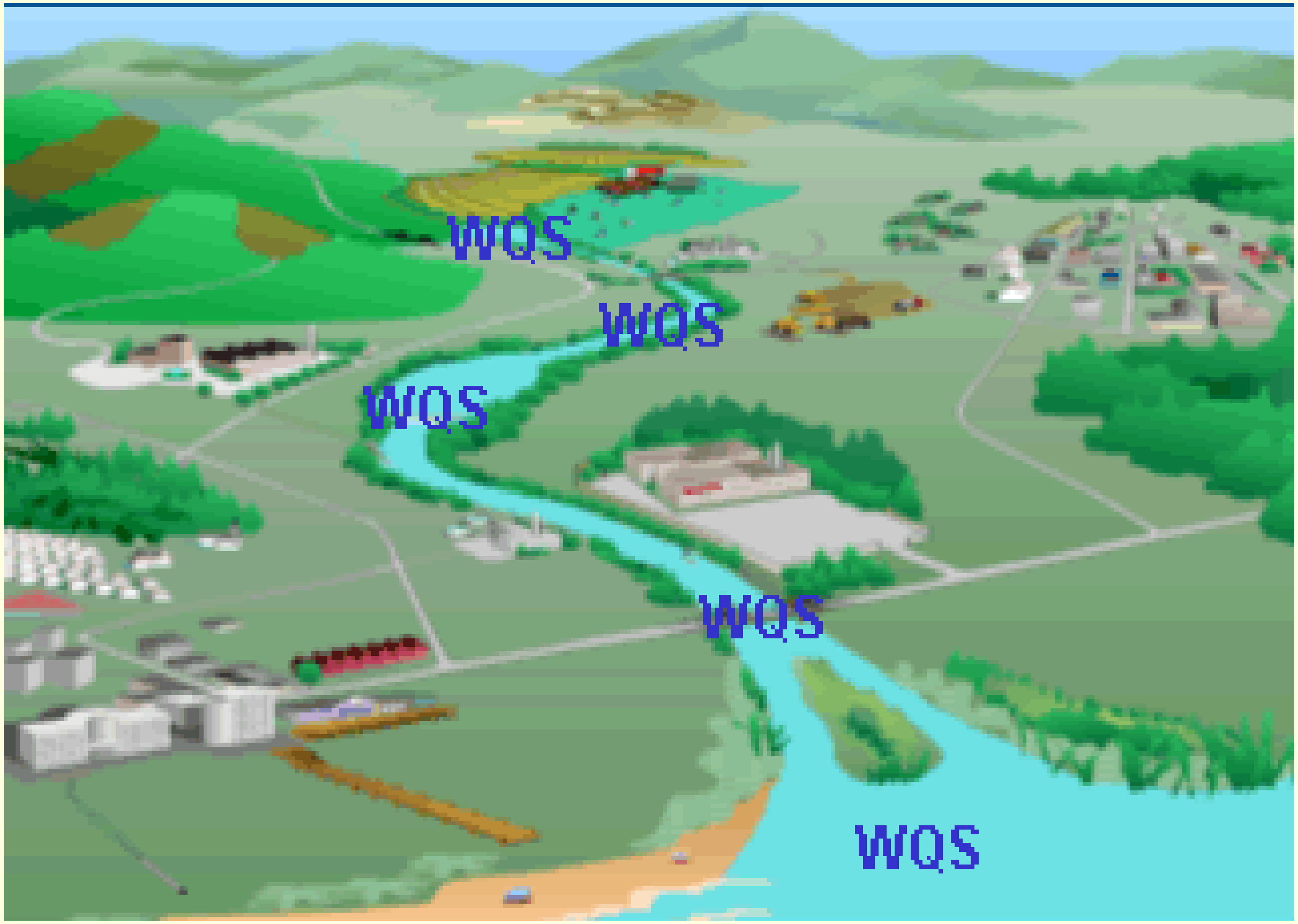
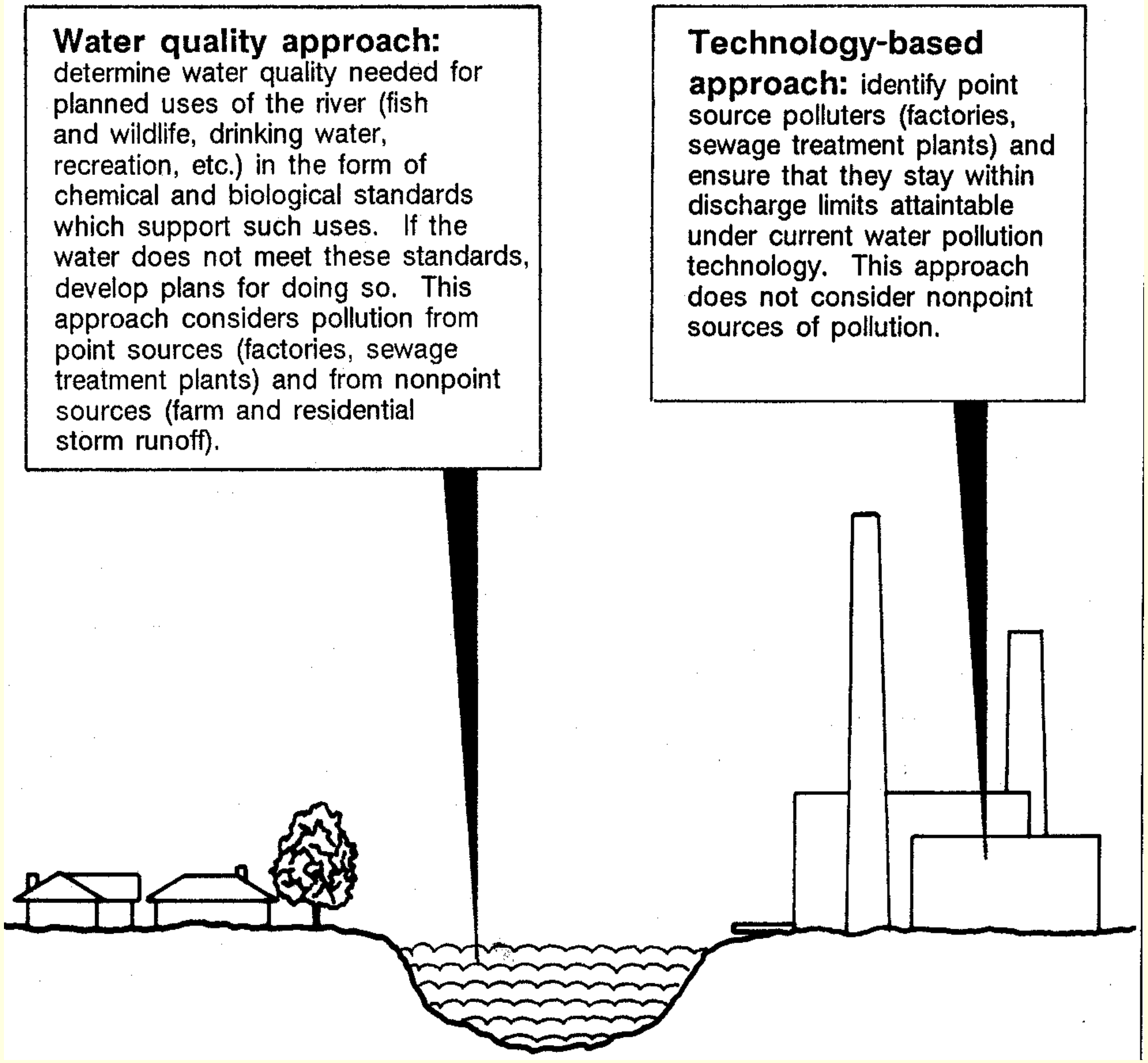
CONTENTS

1. Watershed-Based Water Quality Management

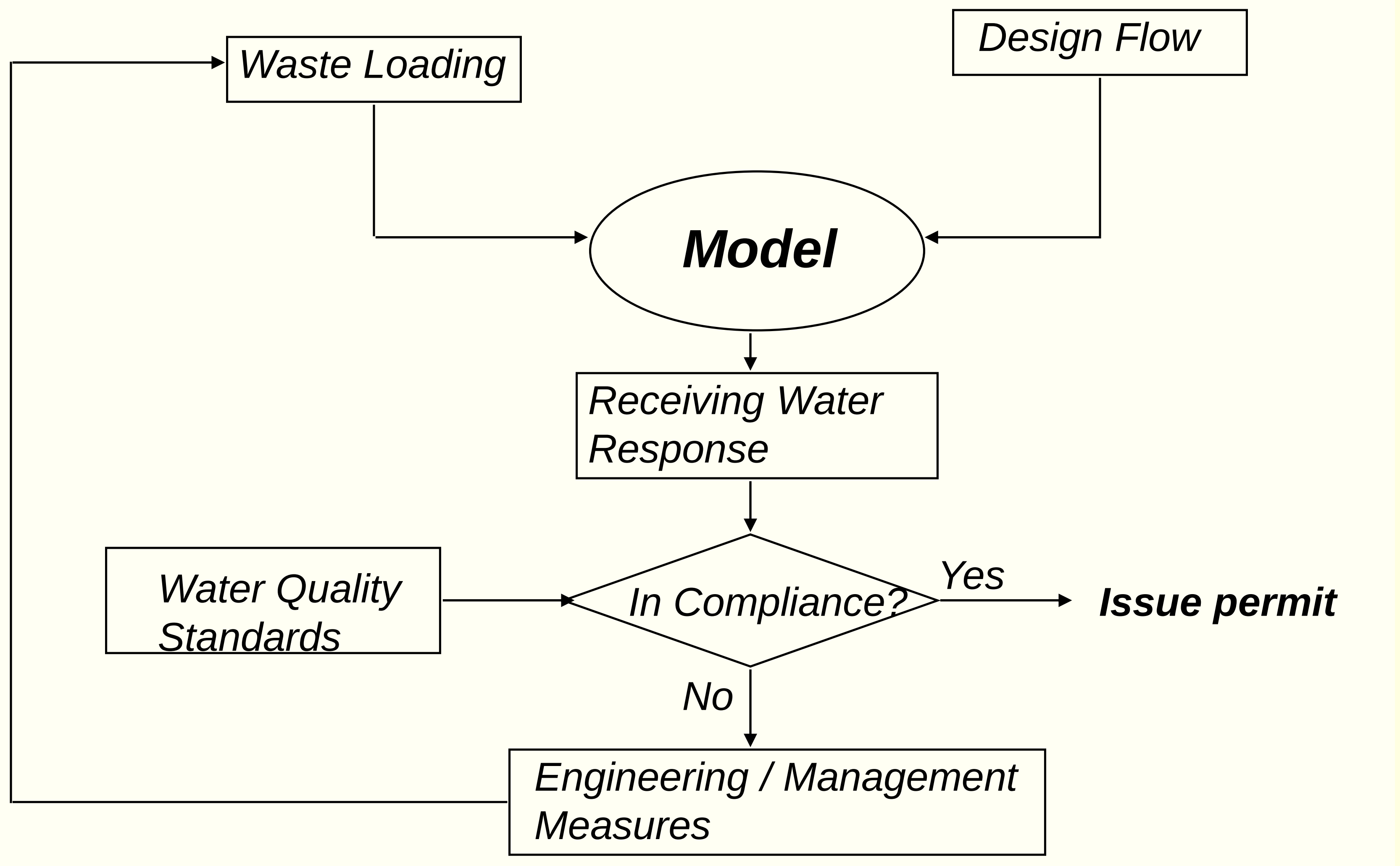
Water Quality Standards and Traditional Water Quality Management



US Clean Water Act: A Hybrid of Water Quality and Technology-Based Approaches



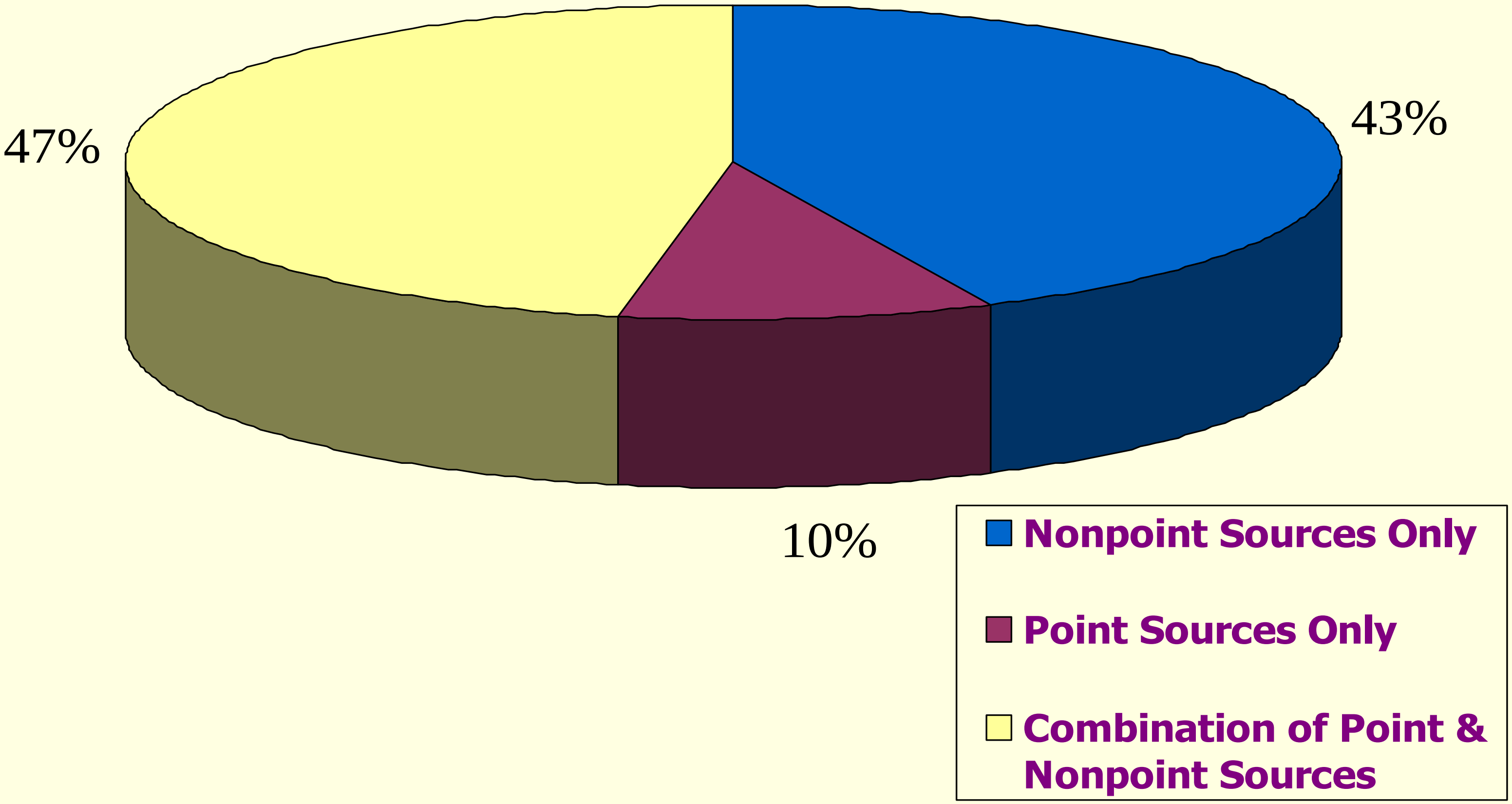
Traditional Water Quality Management



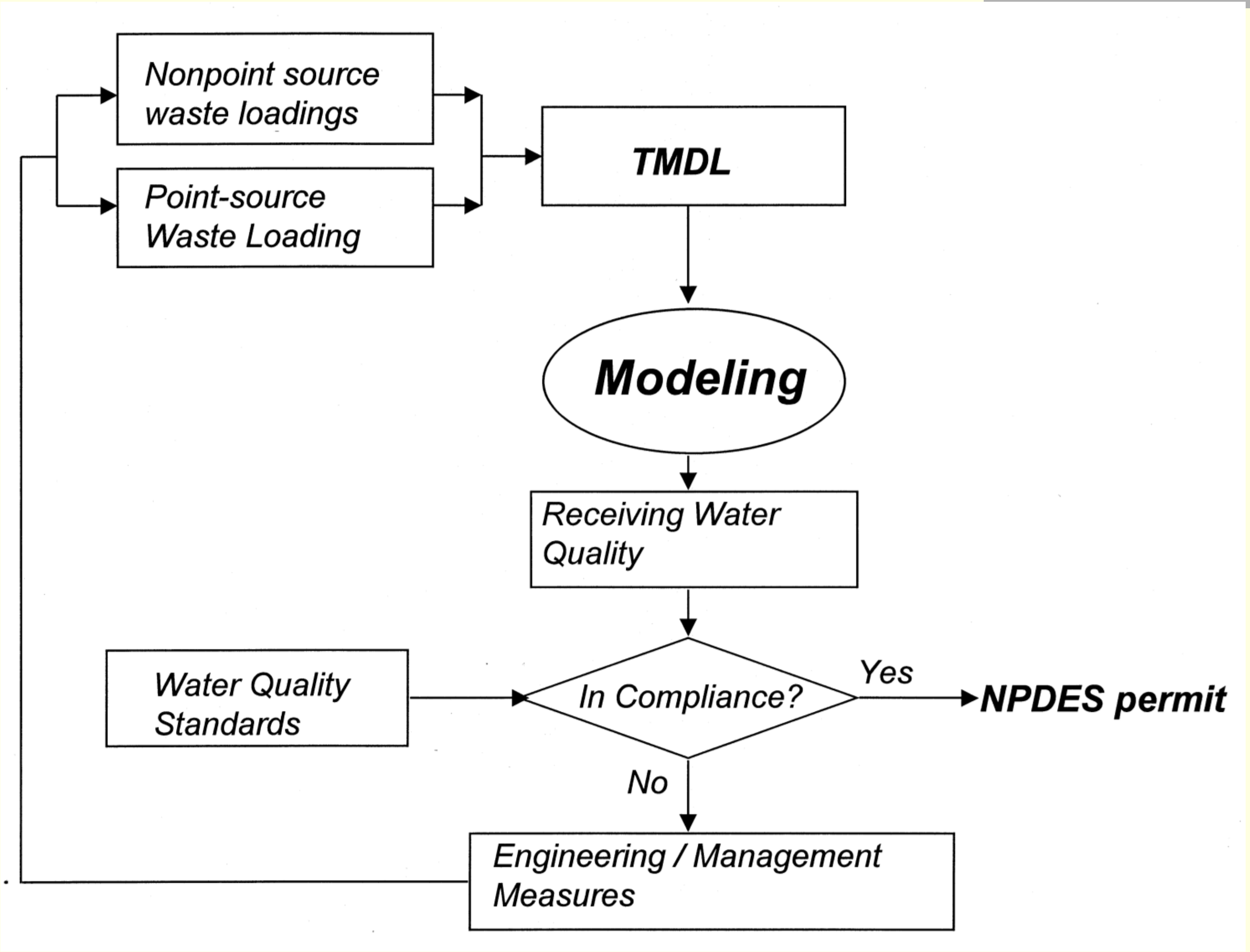
US Clean Water Act: A Partial Success

- Almost every city and village has constructed wastewater treatment facilities at secondary or advanced level.
- States report over 40 percent of assessed waters are still too polluted for fishing or swimming even after years of water pollution control efforts
- States have identified about 21,000 polluted river segments, lakes, and estuaries
  - Over 300,000 river & shore miles & 5 million lake acres
  - Excess sediments, nutrients, and harmful microorganisms are leading reasons

Causes of Impairment by Category from the 1998 Water Quality Survey



Total Maximum Daily Load and Watershed-Based Water Quality Management



THE TMDL PROGRAM

- **The TMDL program**
  - Requires states to develop TMDLs for waters on the 303(d) list
    - Section 303(d) requires the identification and prioritization of waters *not* meeting in-stream water quality standards
  - The TMDL includes a distribution of pollutant loading (allocation) that results in attainment of water quality standards
- **Five key steps to TMDL development**
  - Identify water quality-limited waters (303(d) list)
  - Prioritize water quality-limited waters
  - Develop the TMDL plan for each water quality limited stream segment
  - Implement the water quality improvement for each segment
  - Assess water quality improvement for each segment

Development of TMDL for a Water Quality Limited Segment

Citizens

Politicians and Scientists

Managers and Engineers

TMDL = WLA + LA + MOS

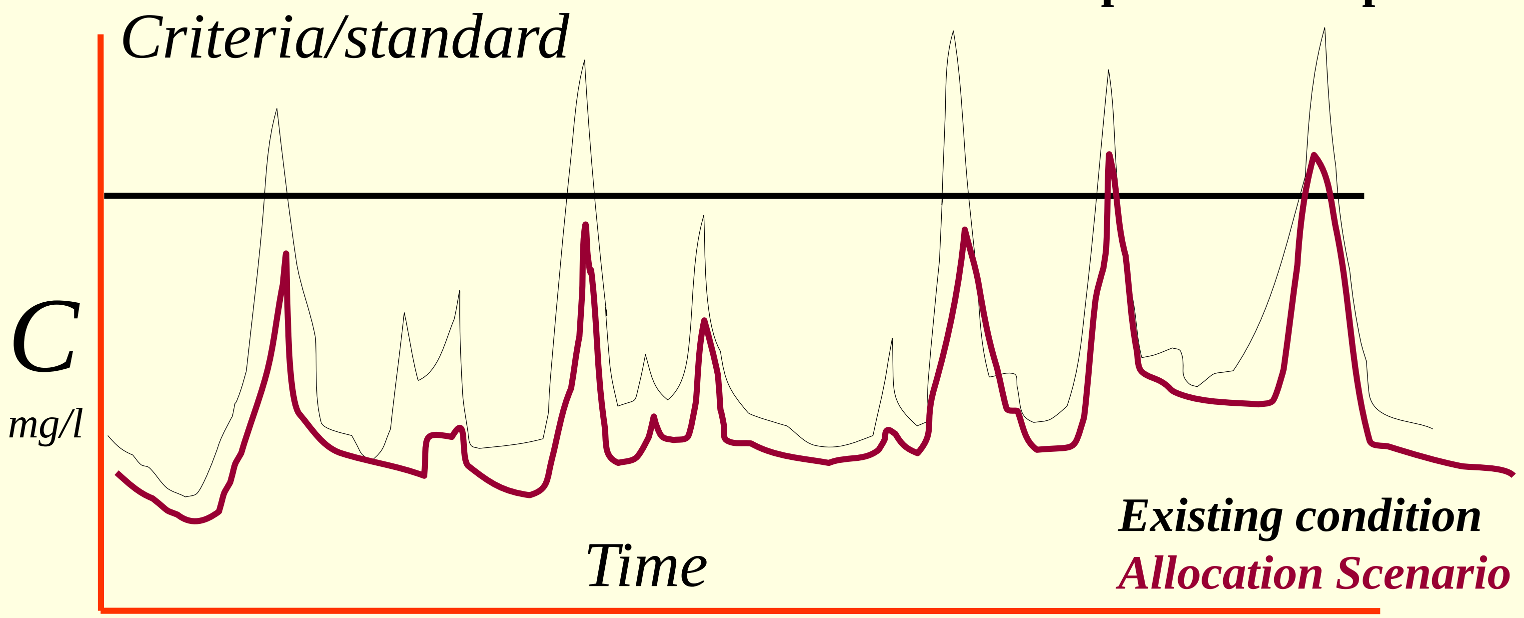
(Total max. daily load) = **(point source waste load allocation)** + **(nonpoint load allocation)** + **(margin of safety)**

↑

Water quality standard

NONPOINT SOURCE TMDLS

Modeling Approach:
Use Continuous Simulation (HSPF)
Define critical/representative period



Scenario obtained through control of:

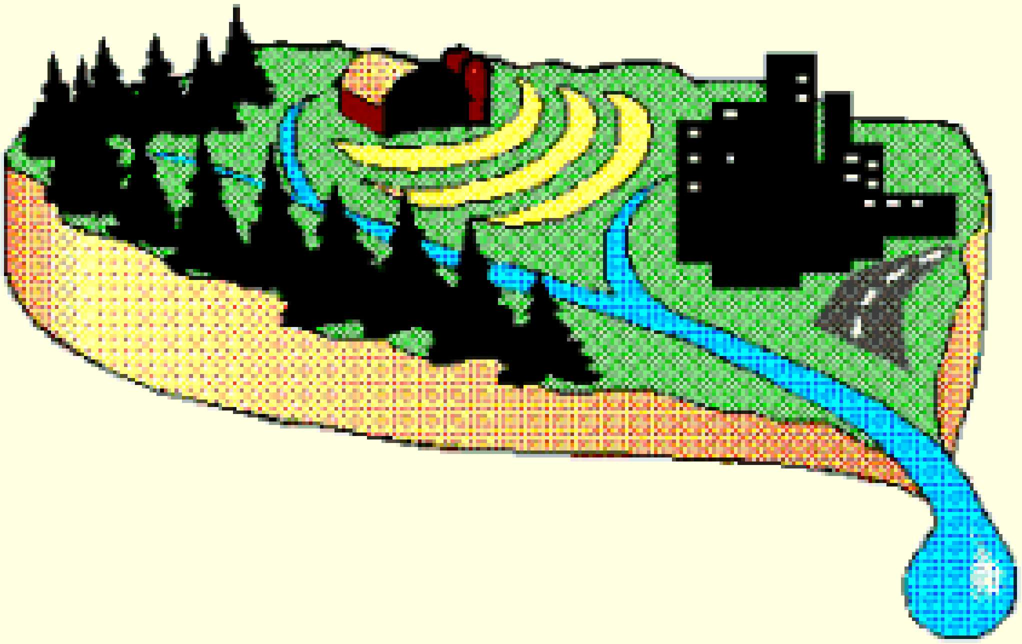
20% loading from Ag
15% from pastureland
20% urban
12% from point sources

2. Integrating BASINS and Linear Systems Modeling

Nature of Non-Point Source Pollution:

1. Wet-weather events

2. Pollutant loading = Flow x Concentration



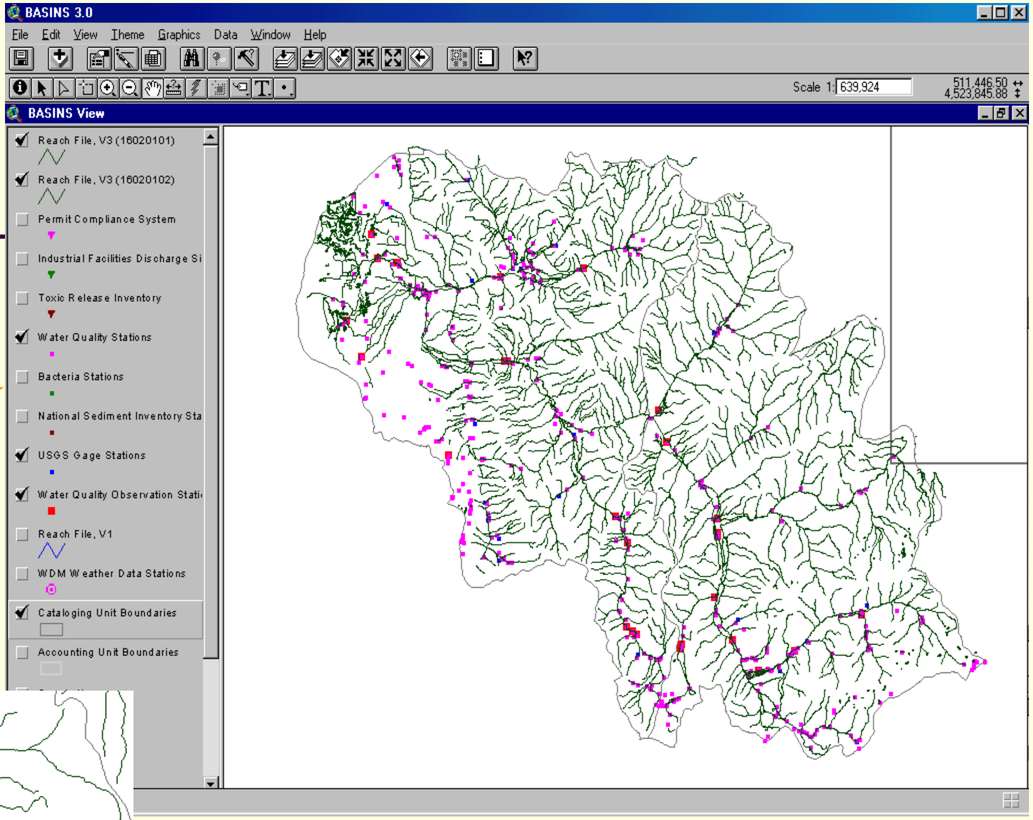
What is BASINS?

Better **A**ssessment **S**cience **I**ntegrating **P**oint and **N**onpoint **S**ources

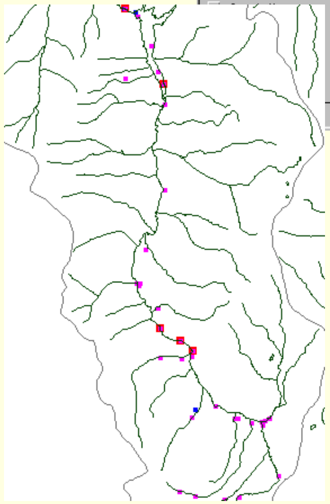
Integrated GIS, data analysis and modeling system designed to support watershed based analysis and TMDL development

- ***Data:*** national data sets with options to import local data
- ***Tools:*** provide quick access to analysis techniques for watershed assessment
- ***Models:*** provide more detailed analysis and predictive evaluations to support studies

DATA IN BASINS



Select data layers to display

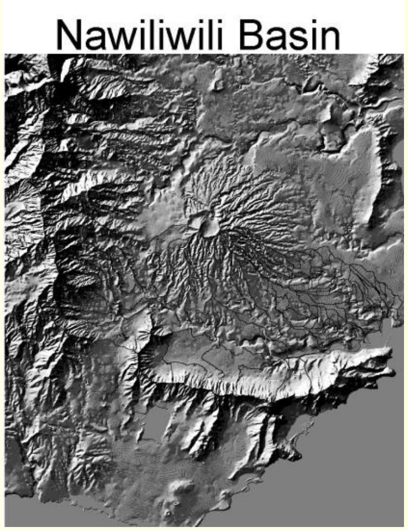


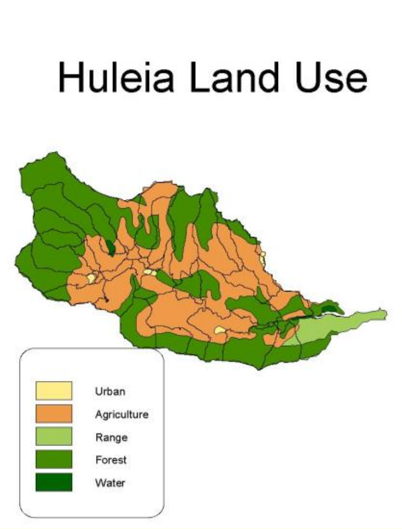
Zoom to area of interest

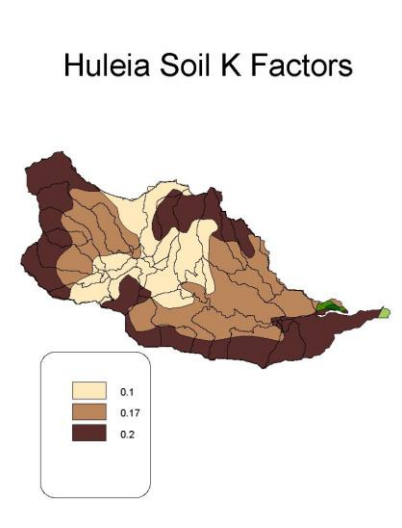
Data included:

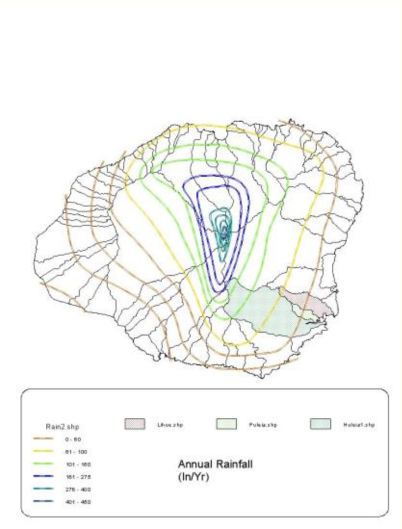
- Streams - Reach File 1, NHD
- Watershed boundaries
- Point source locations
- Monitoring locations

BASINS Application in Hawaii: Nawiliwili Watershed, Kauai









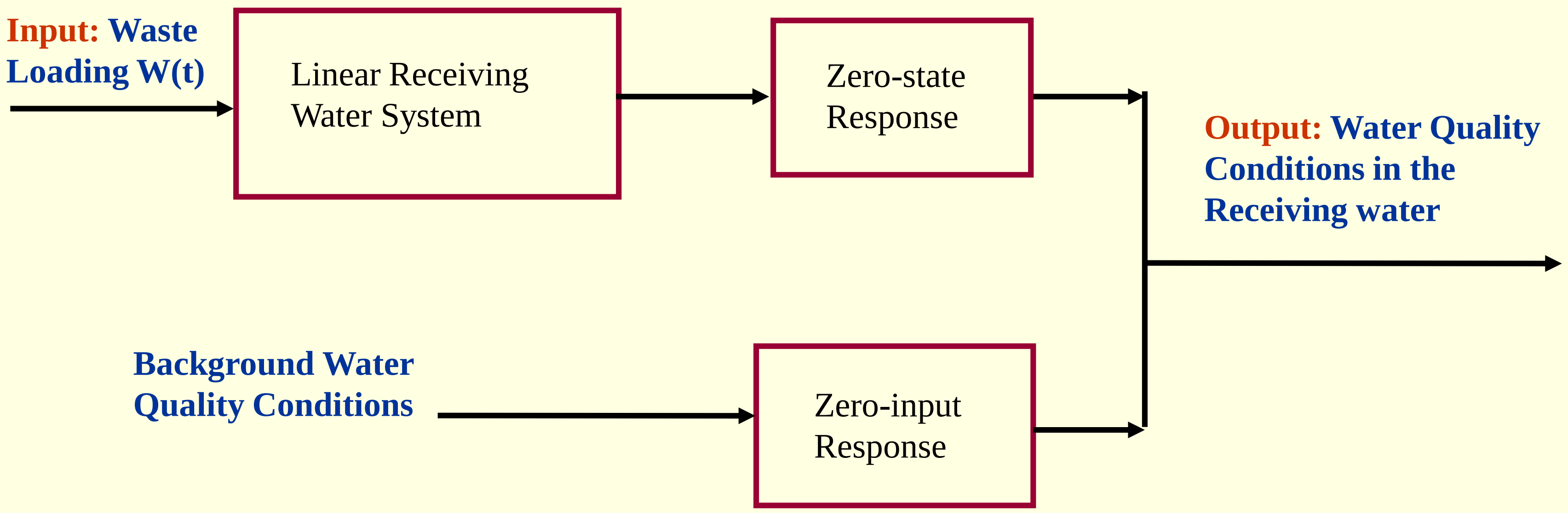
Predicted vs.Measured Values of Sediment Yield from Nawiliwili Watershed, Kauai, Hawaii

Source	Sediment Yield Ton/Acre*Yr	Rates Pertain to:
Huleia	1.59	BASINS Application
U.S.G.S., 1972, 1973, 1974, 1975 (Suspended load)	0.60 – 2.8 0.01 – 0.5 0.04 – 0.6 0.05 – 2.0	Continuous sampling Forest reserve, Kipapa Vegetated watershed, Kaneohe Undisturbed watershed, Moanalua Agricultural watershed, Waikele Stream
Jones, et. Al., 1971 (Total Load)	8.40 17.4	Makaleha Basin Niu Valley

What is Linear Systems Modeling?

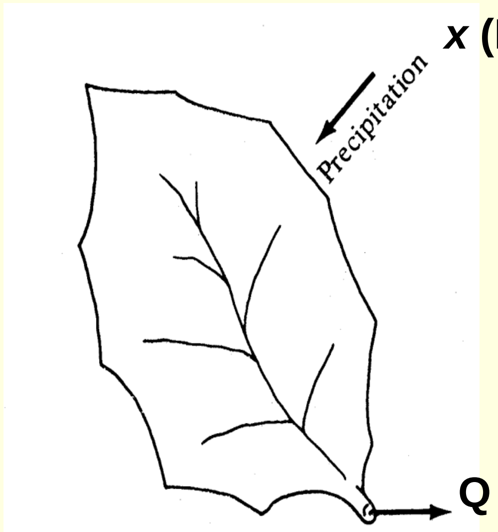
According to Linear systems theory, the system response to any input W(t) can be expressed as

$$c(t) = c_S(t) + \int_0^t h(t-\tau) W(\tau) d\tau$$



(a) BASINS

Watershed



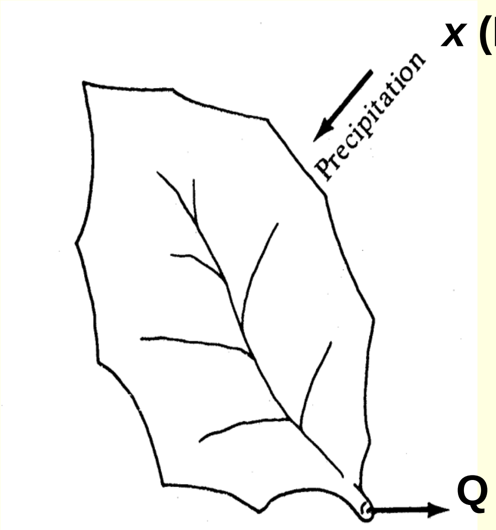
Rainfall, x → **Watershed System** / **Instantaneous Unit Hydrograph, *h*** → Runoff, Q

$$Q(t) = \int_0^t x(\tau) h(t-\tau) d\tau$$

(b) Linear Systems Watershed Rainfall-Runoff Modeling

Watershed

x (Rainfall)

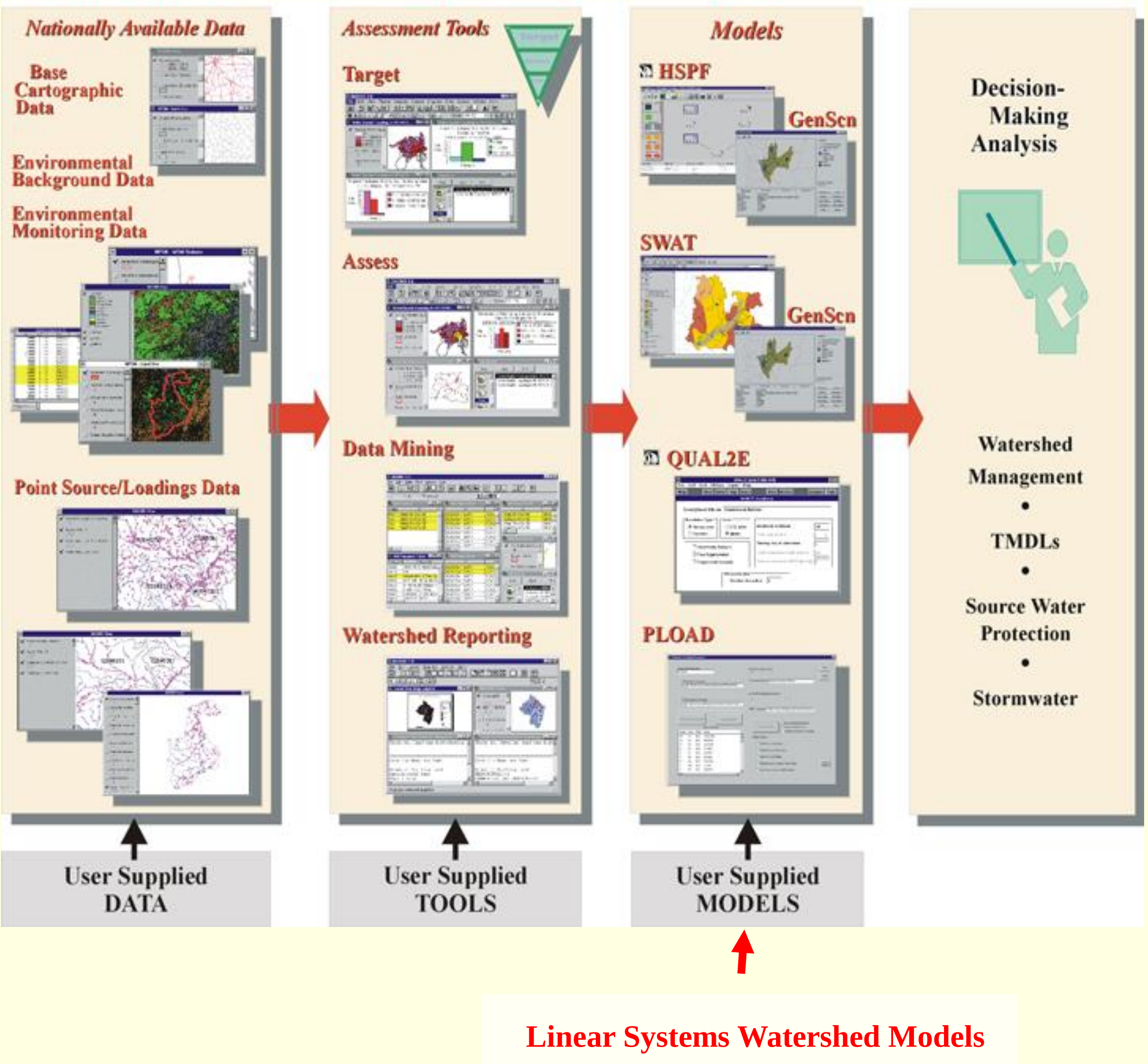


Q (Runoff)

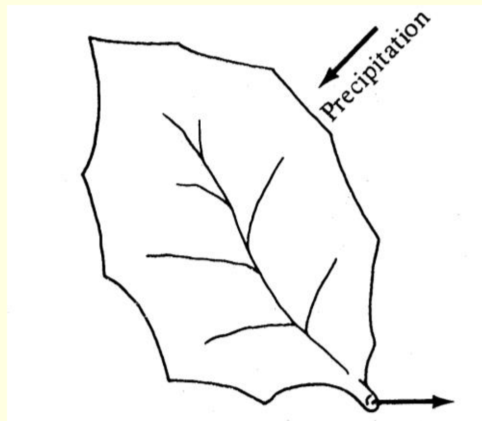
Rainfall, *x* → **Watershed System** / **Instantaneous Unit Hydrograph, *h*** → Runoff, *Q*

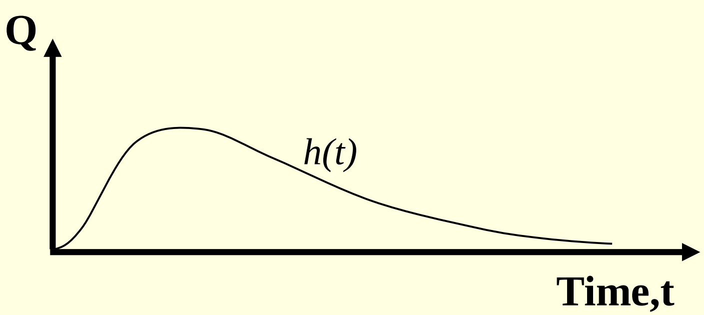
$$Q(t) = \int_0^t x(\tau)h(t-\tau)d\tau$$

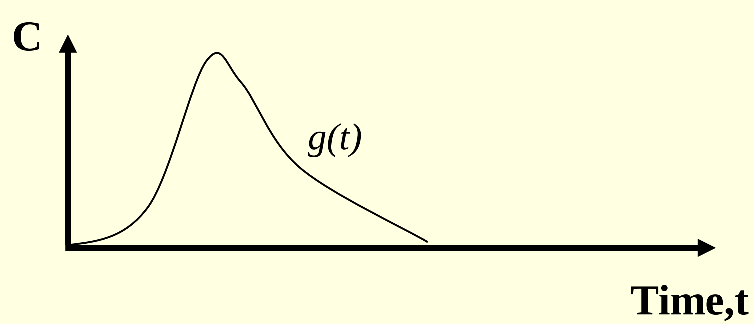
Integrating US EPA BASINS and Linear Systems Watershed Modeling



Linear Systems Modeling and Impulse Response Functions



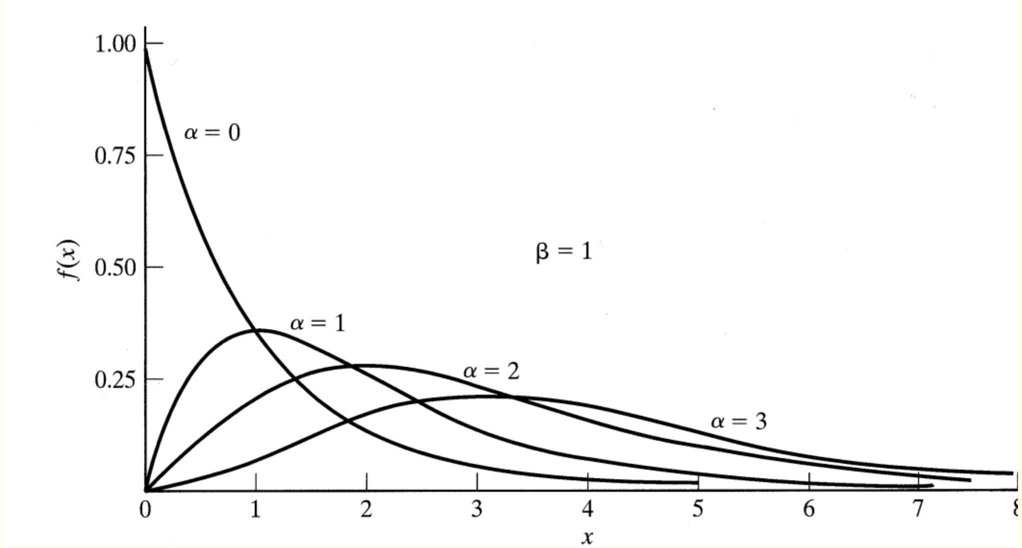




(a) Impulse Response Function of the watershed flow system (Instantaneous Unit Hydrograph)

(b) Impulse Response of the watershed pollutant transpor system (Instantaneous Unit pollutograph)

Determination of IUH by System Parameterization



Gamma function shape with various values of a and b

Gamma Function

$$h(t) = \frac{1}{\kappa} \frac{1}{\Gamma(n)} \left(\frac{t}{\kappa}\right)^{n-1} \exp\left(-\frac{t}{\kappa}\right)$$

where

$n = \alpha$ is a shape factor

and

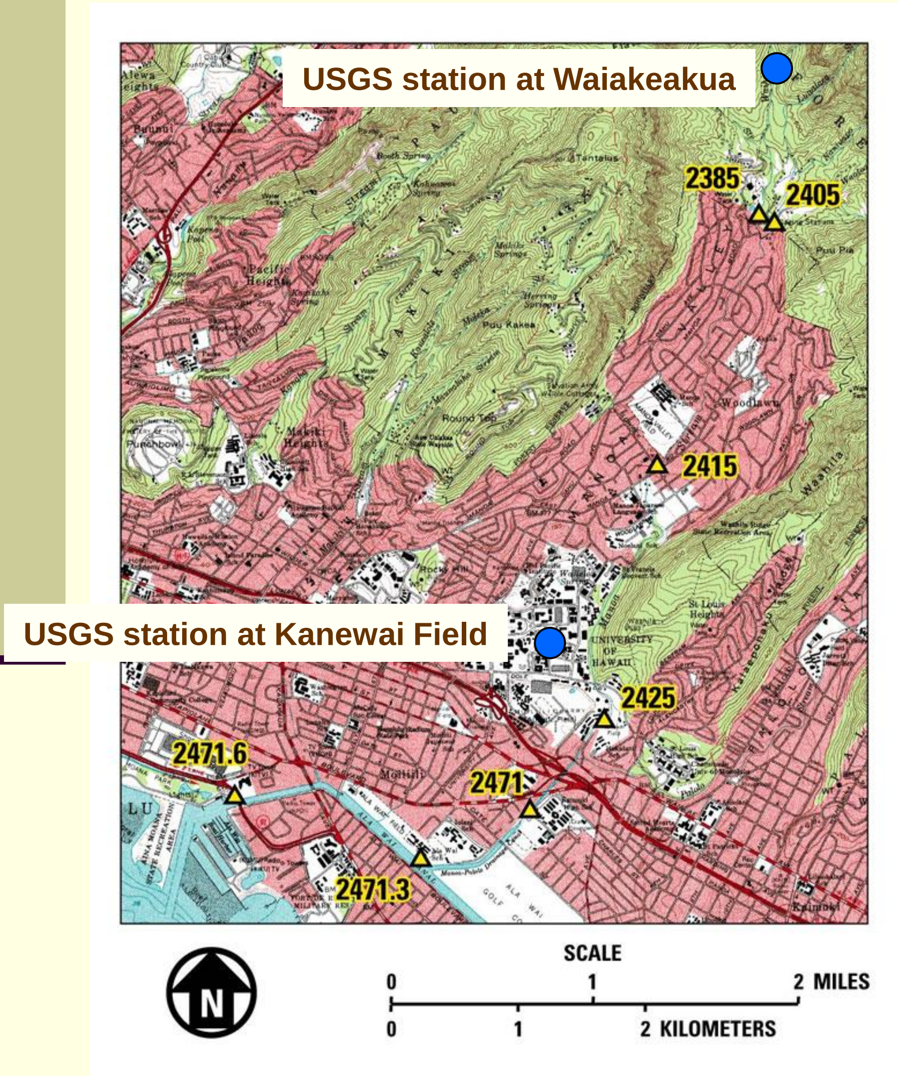
$\kappa = \beta$ is a scale factor

References

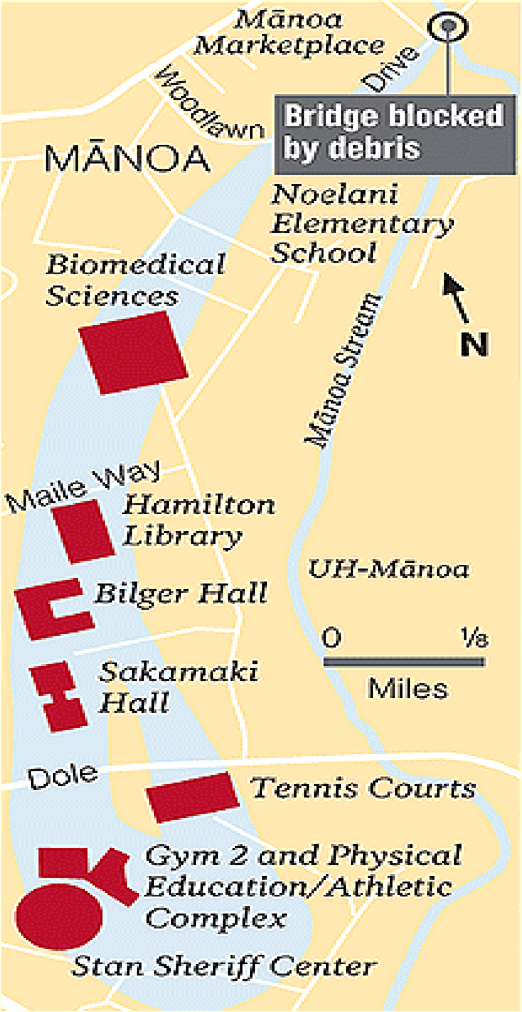
1. Nash, J.E. (1957) The form of the instantaneous unit hydrograph, Proc. Gen. Assem. Toronto, *Ins Ass. Sci. Hydrol.* 3:144-12

2. Liu, C.C.K. (1988) Solute transport modeling in heterogeneous soils: conjunctive application of physically based and system approaches, *J. Contaminant Hydrology*, 3 :97-111.

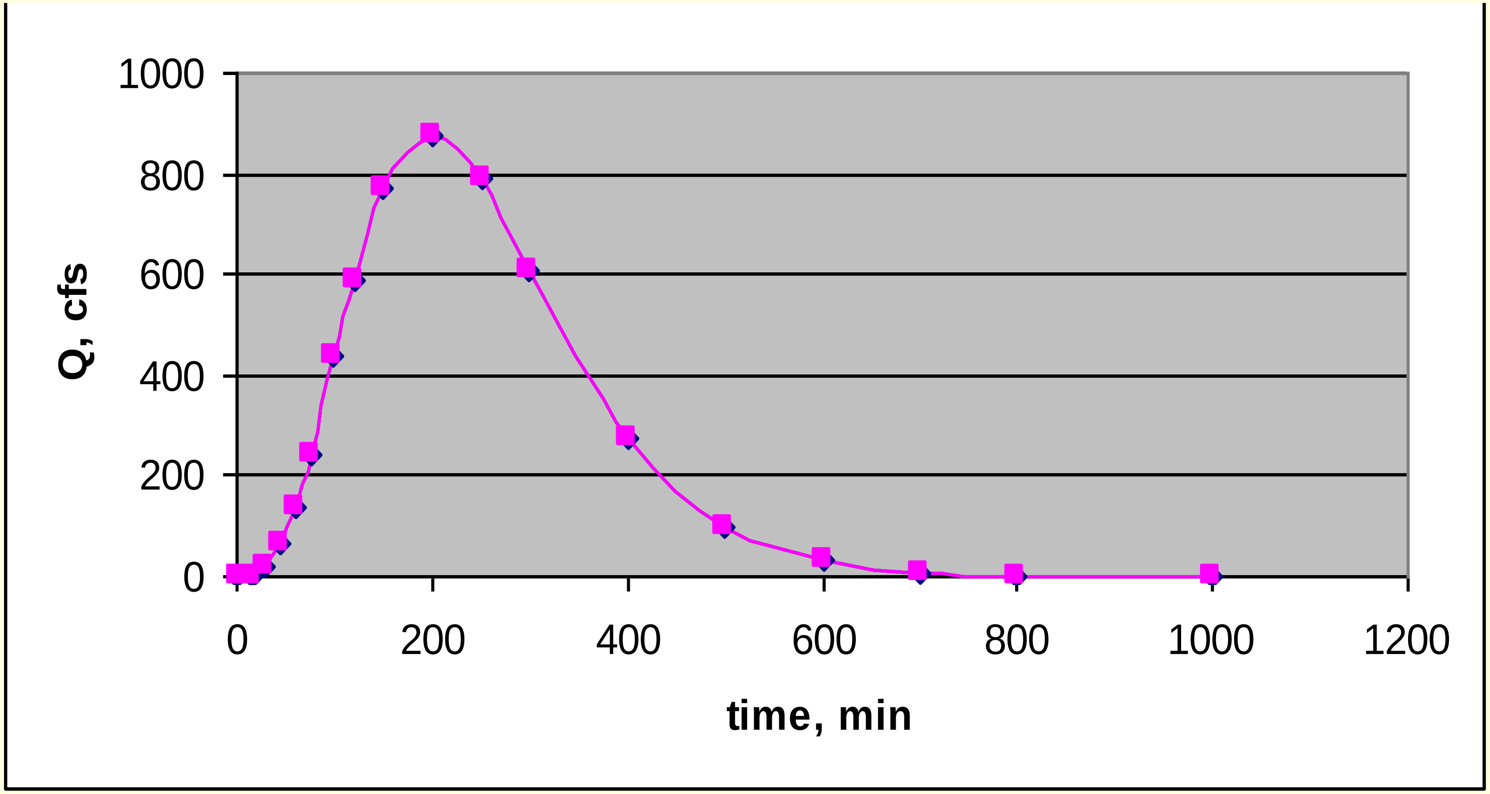
Example: Flood Hydrograph Analysis of Manoa Watershed



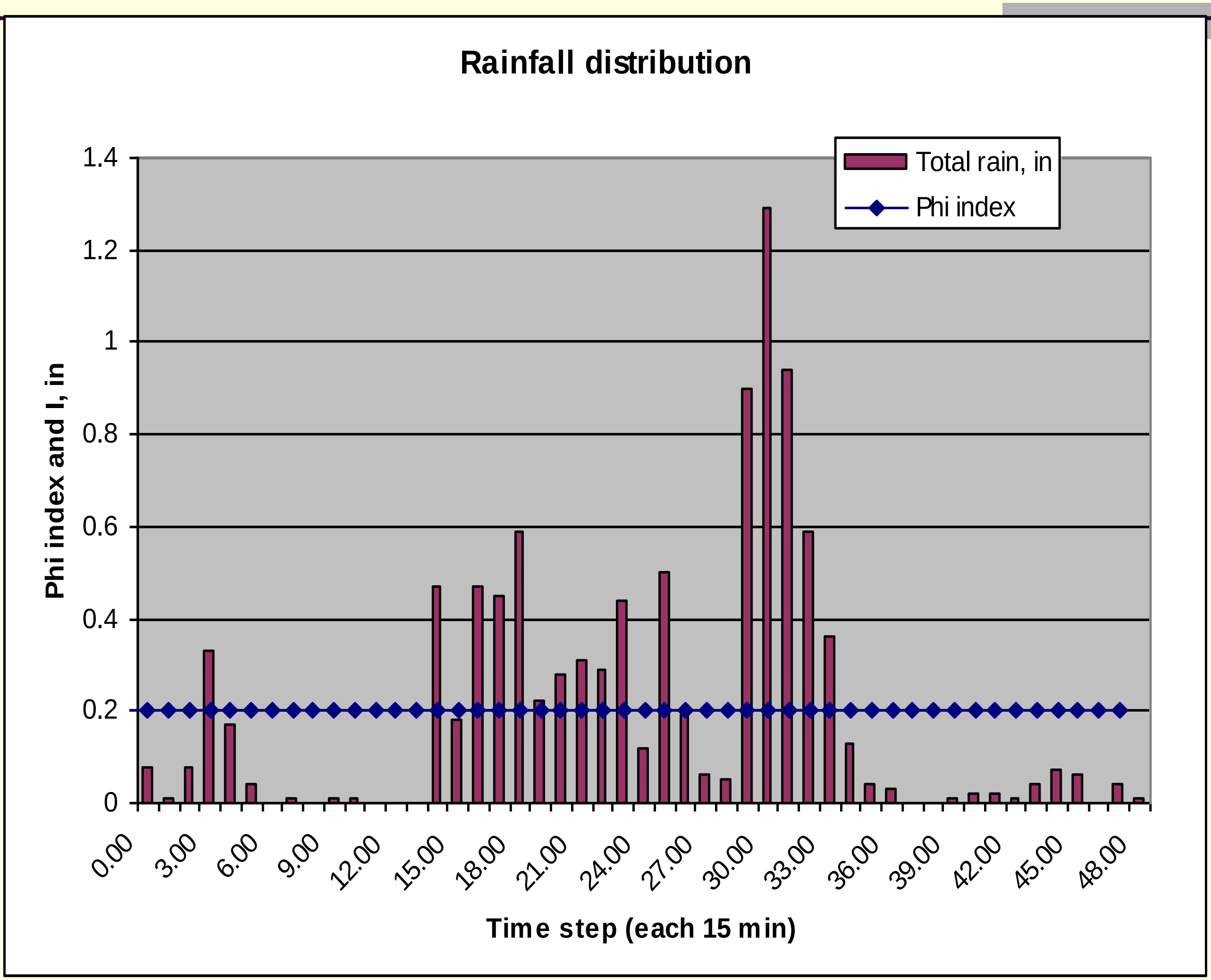
Manoa Flood of October 2004



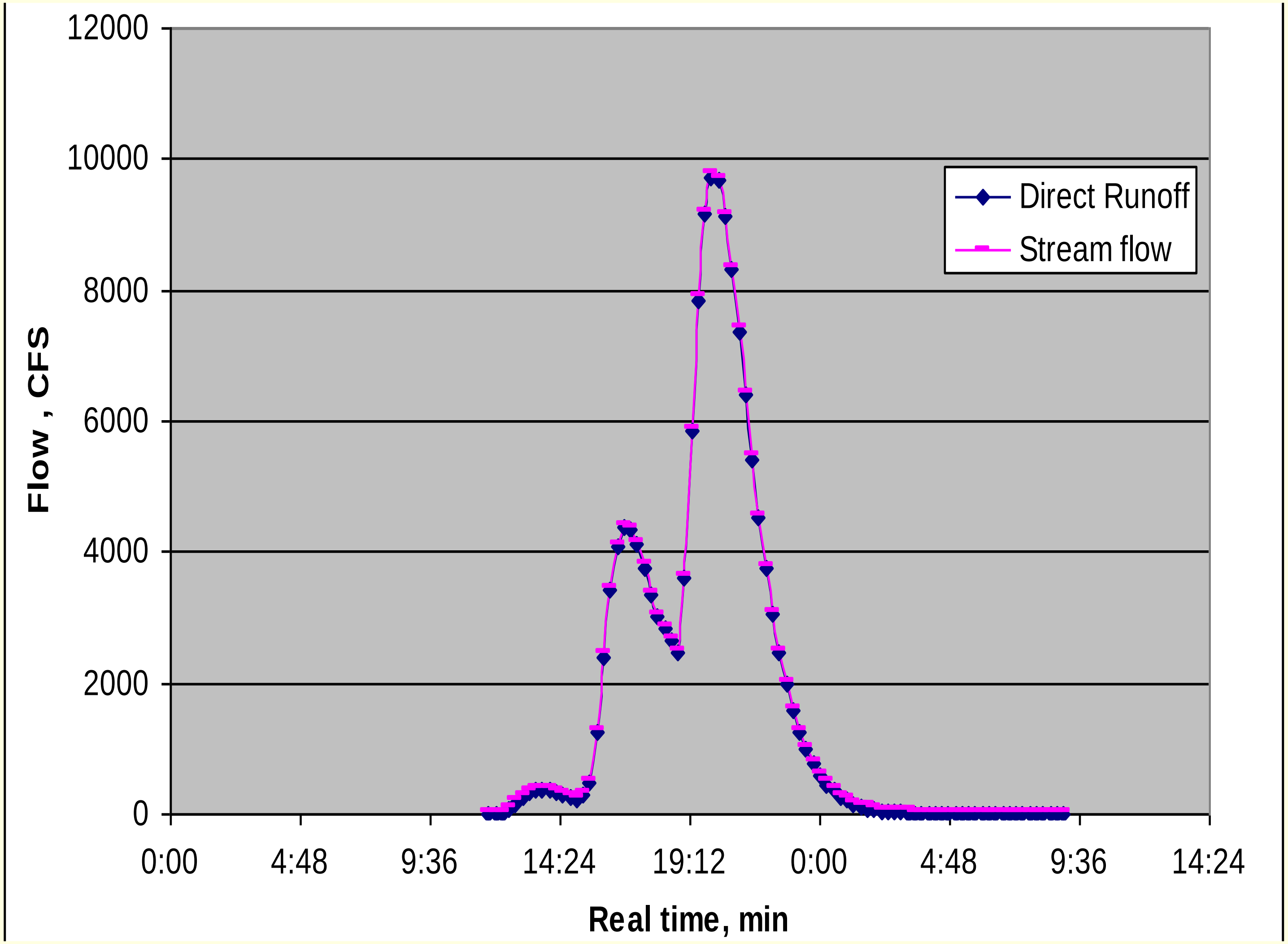
Derived Instantaneous Unit Hydrograph for Manoa Stream at Kanewai Field



Manoa Watershed Rainfall Data during October 2004 Flood



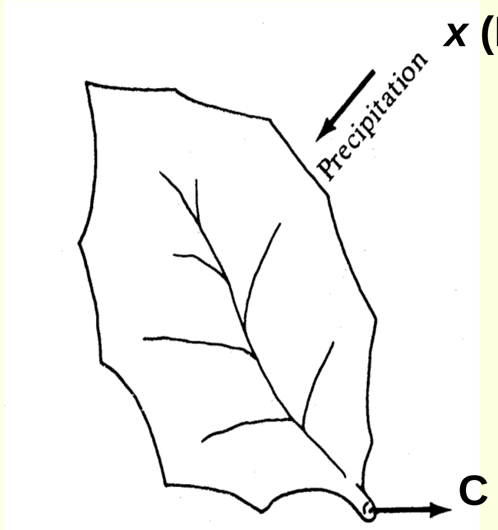
Predicted Flood Hydrograph of Manoa stream at Kanewai Park, October 30, 2004



(c) Linear Systems Watershed Pollutant Loading Modeling

x **(Rainfall)**

Watershed

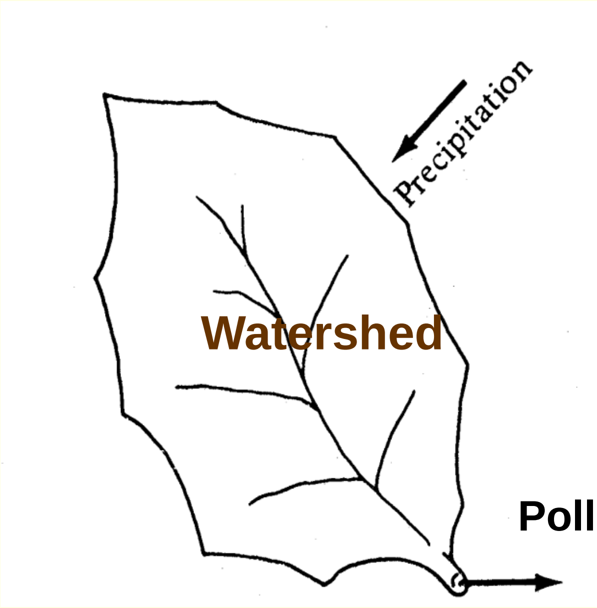


C (Pollutant Concentration)

Rainfall, *x* → **Watershed System** / **Instantaneous Unit Pollutograph, g** → Concentration, C

$$C(t) = \int_0^t x(\tau) g(t-\tau) d\tau$$

(c) Linear Systems Watershed Pollutant Generation Modeling



Pollutant Concentration, *C(t)*