# CALCULATION AND DISTRIBUTION OF WATER ENVIRONMENT CARRYING CAPACITY (WEC)

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# Contents

- Healthy Watershed Management – Define and Attributes
- What is WEC?
- WEC Target setting and allocation methods
- Water Quantity/Quality Control Strategies
- NPS Control Technology - Basic Principles, Best Management Practices (BMPs) , TMDL's
- Case Examples. – Lessons Learned, Success Stories
- Conclusions

## Quote by Theodore Roosevelt, US President 泰迪 罗斯福总统

- Conservation means development as much as it does protection. I recognize the right and duty of this generation to develop and use the natural resources of our land; but I do not recognize the right to waste them, or to rob, by wasteful use, the generations that come after us.
- **我**认可每一代人类有权利开发及运用自己的**自然**资源，但我不认可人类有权浪费或乱用资源而影响到下一代及将来人类使用的权利。

# Healthy Watershed – Define and Attributes (USEPA)

- A healthy watershed has mostly natural land cover, especially near its waters; good water quality, quantity and flow; and habitats with diverse aquatic life. Together, these components support long-term, sustainable benefits to people and the environment.
- Six essential attributes

1. Landscape condition
2. Habitat
3. Hydrology
4. Geomorphology
5. Water quality
6. Biological condition

# Proposed Rules for WEC Determination

- Maintain the sustainable utilization of environmental resources
- Maintain the relative balances of WEC in all sections of a river basin - uniform spatial strategies?
- Consider technical as well as economical feasibilities. Finding the “optimal” plan
- Incorporate new realities, e.g., climate change, sea level rises, etc.

Comply with effluent limits

# Effluent Limits to Minimize Pollutants: Example Requirement

- Effluent limits require facility to "minimize" pollutants
  - "Minimize" means "to reduce and/or eliminate to the extent achievable using control measures (including best management practices) that are technologically available and economically practicable and achievable in light of best industry practice".

  - Three types of effluent limits:

    - Non-numeric technology-based limits
    - Numeric technology-based limits
    - Water quality-based limits

# NPS Control
# Major Strategies and Technologies

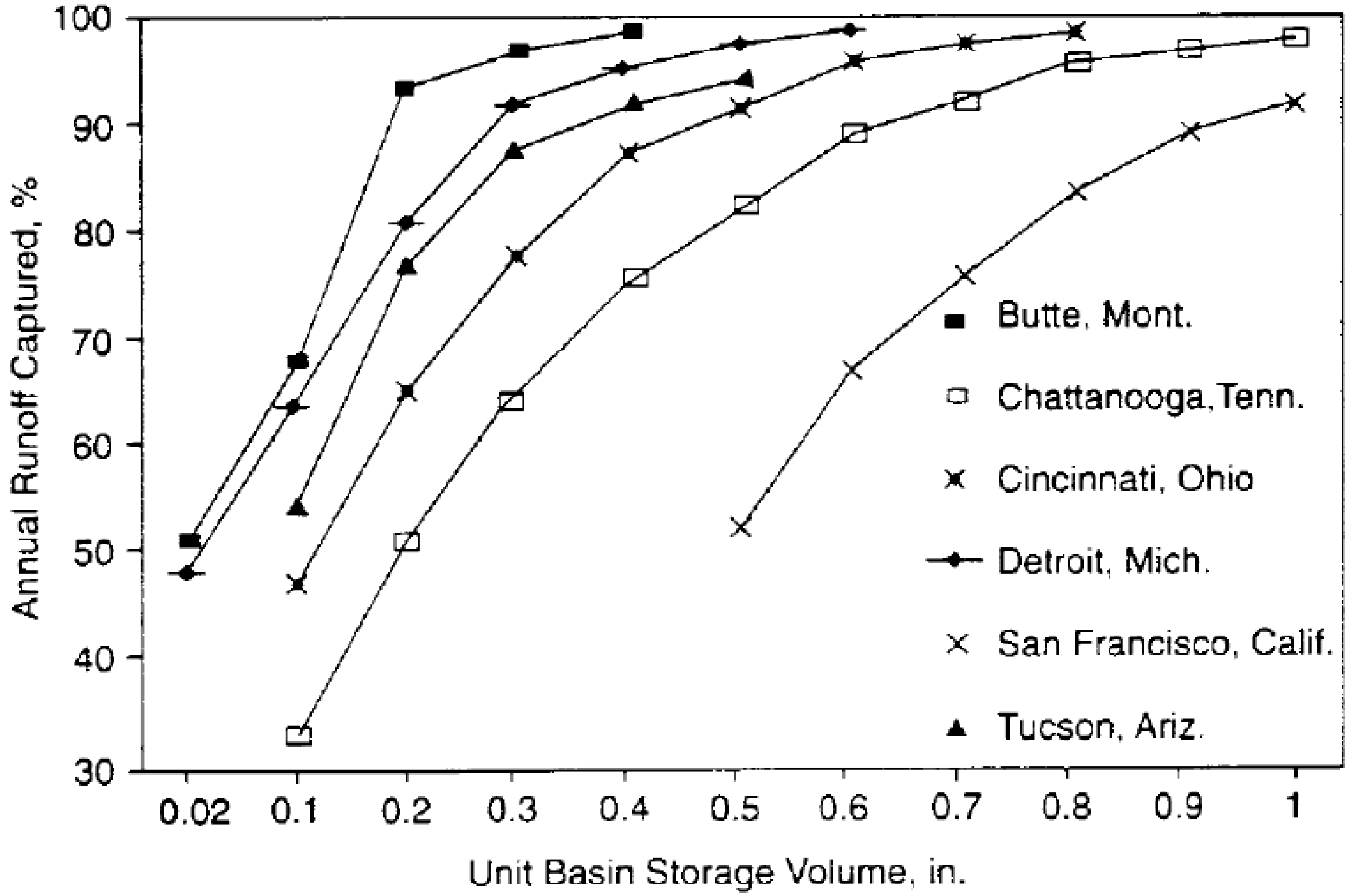
- Regulatory Framework
  - Laws, regulations, ordinances: federal, state and local
  - Most backed up by grants, cost sharing and financial incentives
  - Public education (Media !!!) and interested groups
- Control Measures – Best Management Practices (BMPs)
  - 1st Generation – Mostly ponds, infiltration and swales, etc.
  - 2nd Generation – Filtration, manufactured BMPs
  - Recent – Low impact development (LID), green infrastructure (GI) practices such as bioretention, green roof, etc.
  - New products
- Total Maximum Daily Load (TMDL) programs – Modeling required. Integrated control of point and nonpoint sources of pollution. TMDL is the basis for watershed-wide water quality improvement

# Regulatory Requirement (North Carolina)

**Town of Chapel Hill Zoning**

- **85% TSS removal for first 1 inch of precipitation**
- **Volume leaving site post-development shall not exceed volume pre-development for the 2 year 24 hour storm event (3.60 inches)**
- **Rate leaving site post-development shall not exceed rate pre-development for the**
  - **1 year storm – 3.0 inches**
  - **2 year – 3.60 inches**
  - **25 year – 6.41 inches**
  - **50 year – 7.21 inches**

# "Maximized" Water Quality Volume




Source: Roesner et al., 1991

# CASE EXAMPLES:

New York Source Water protection

Reference: New York City Department of Environmental Protection

# 生态工程：自然净化水

**尊重自然生态系统，有效地发挥生态系统服务功能，实现可持续发展目标的工程**


**14亿美元投资于**
**生态系统保护和恢复**
**或**
**60－80亿美元建水处理厂**
**加每年5亿美元的运行费**

# TMDL – INTEGRATED POINT & NONPOINT CONTROL

Main tool for restoring water quality in “impaired” streams and river segments, and lakes and reservoirs. Thousands of TMDL’s have been completed. Many success stories (listed on the USEPA website).

# Total Maximum Daily Load (TMDL)

- TMDL Define
- TMDL = WLA + NPS + MOS

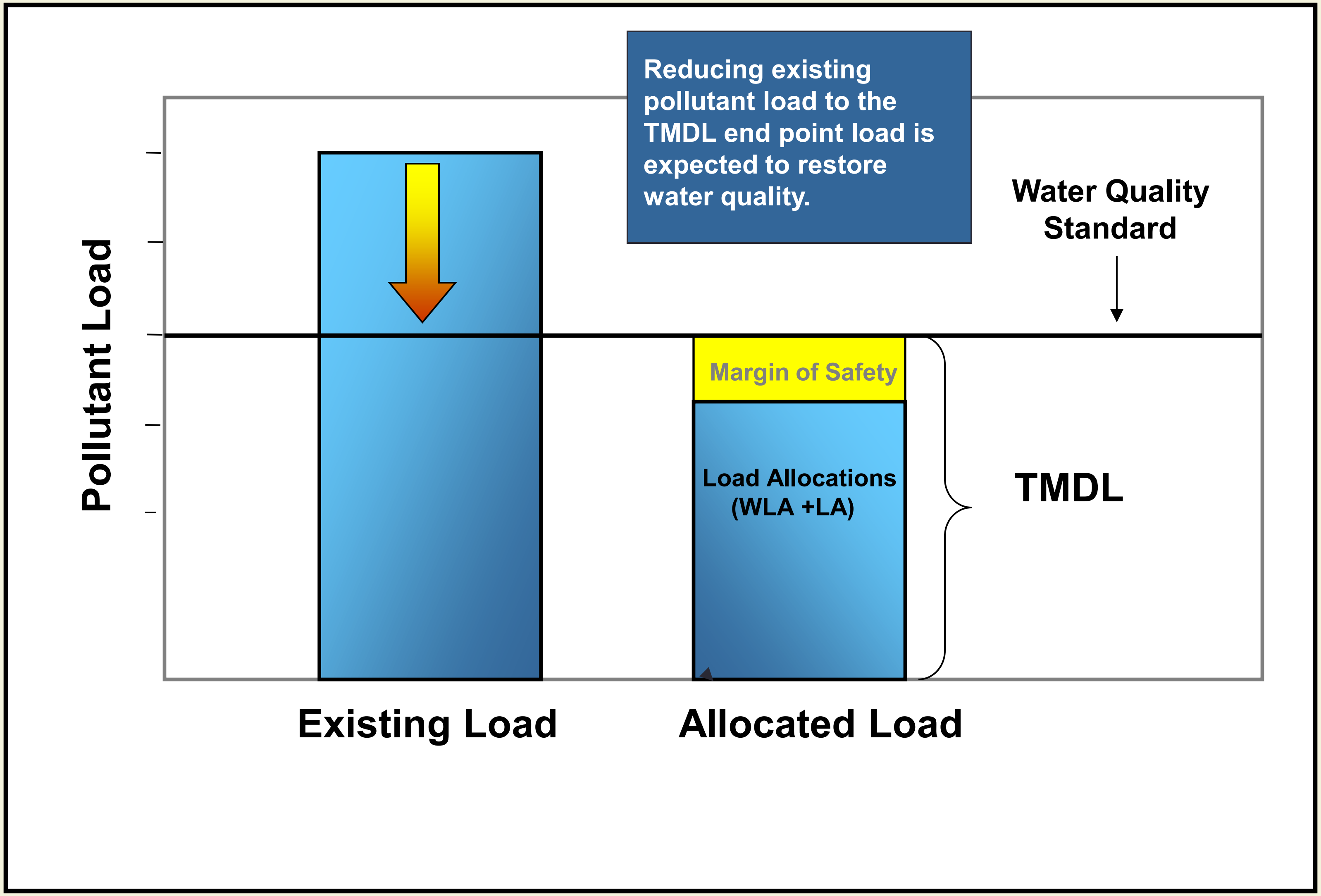
  * TMDL = Total Maximum Permissible Load

  * WLA = Point Source Allocation

  * NPS = Nonpoint Source Allocation

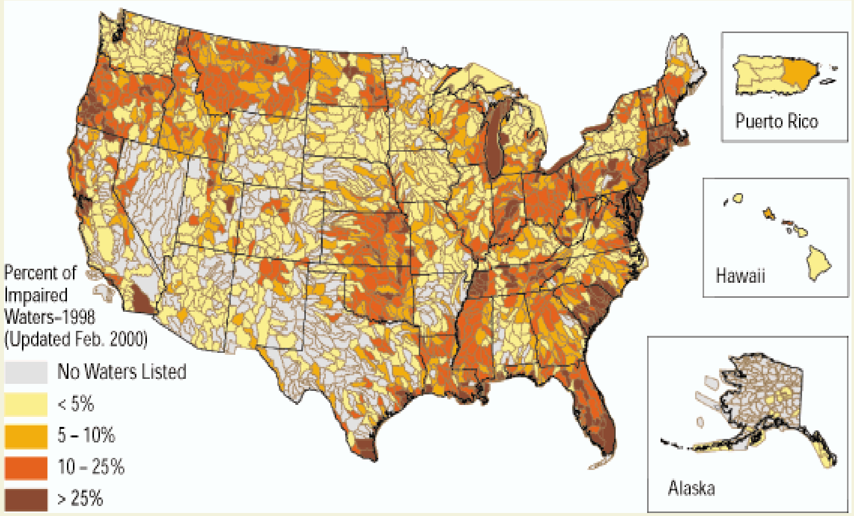
  * MOS = Margin of Safety
- TMDL is a “water-quality” based process, which is more cost-effective than “performance” based ones

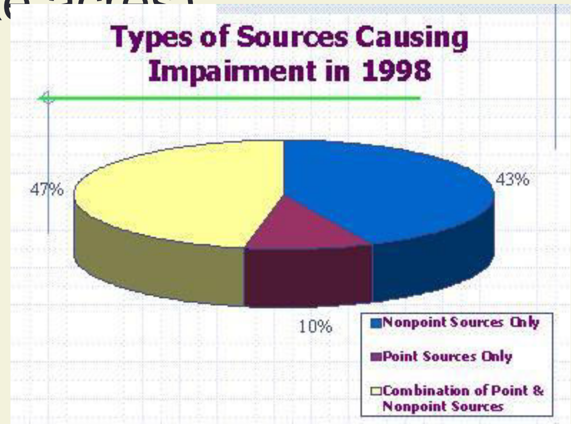
# An Example TMDL



# Background of EPA TMDL Program

- 1998 State 303(d) Lists of Polluted Waters
  - 218M live within 10 miles of a polluted waterbody
  - Over 20,000 waterbodies (300,000 river miles and 5M lake acres)




- http://www.epa.gov/owow/tmdl/

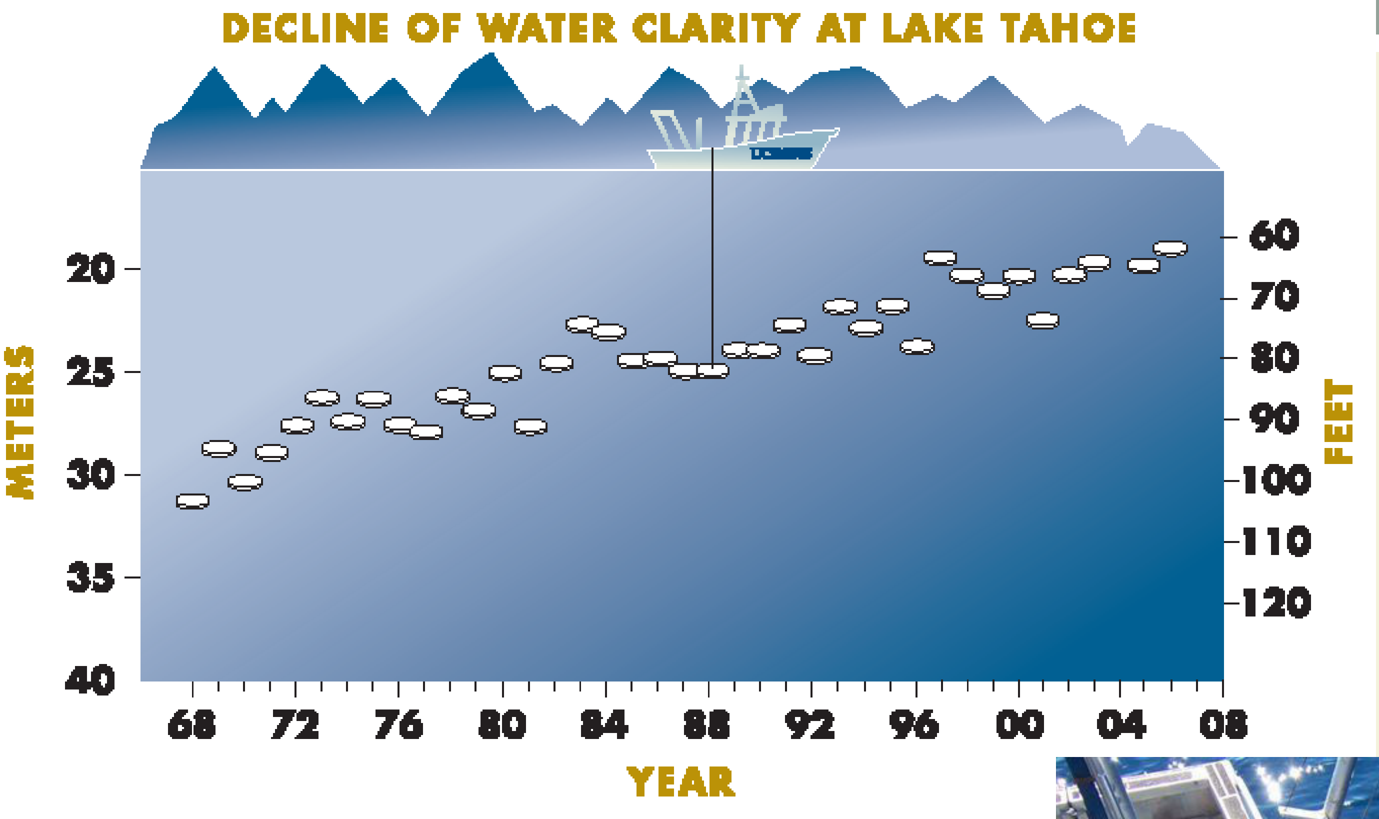
# Challenge for TMDL Implementation

- Total # of TMDLs: ~50,000 TMDLs nation-wide
- Timeframe: over the next 10-15 years
- New TMDL Final Rule April 30, 2003
- Current (2021) revision of CWA (including TMDL) is being considered, likely to be expanded with more $$$.
- TMDL Cost Study:
  - TMDL Development: $69 M/year for 15 years
  - TMDL Implementation: $0.9 – 4.3 Billion / year
- Challenge for TMDL Implementation
  - EPA does not have the breadth of authority outside Clean Water Act (TMDL is just “a plan on paper”)
  - Some Nonpoint Source Pollution control implementation relies on voluntary and incentive-based program
  - New Innovative Approach (e.g., Pollutant Trading) and “green” initiatives not well understood and face resistence.


Lake Tahoe
UC Davis
San
Francisco
Los Angeles
0
100 KM
100 Miles
© geology.com

## LAKE TAHOE BASIC FACTS

11th deepest lake in the world
Maximum Depth = 501 m
Mean Depth = 330 m
Lake Surface Area = 500 sq. km
Watershed Area = 800 sq. km
Shoreline length = 115 km
Ultra-oligotrophic
Monomictic
63 Inflowing streams
1 Outflowing stream
Mean residence time ~ 600 yrs
Altitude = 1895 m
Latitude = 39 °N



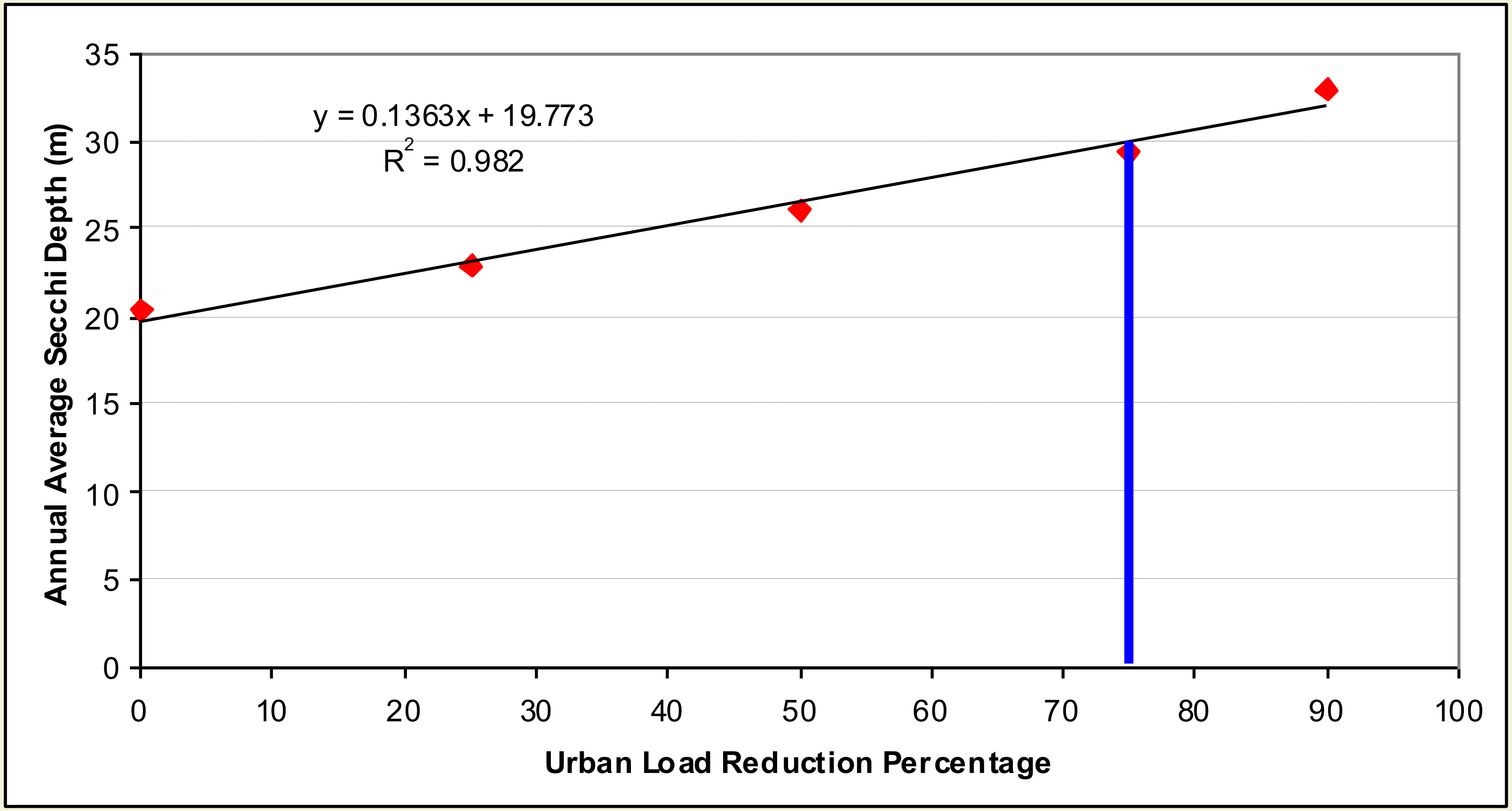

Cause for Concern
30 m (100 ft target)

UC DAVIS
TAHOE ENVIRONMENTAL
RESEARCH CENTER

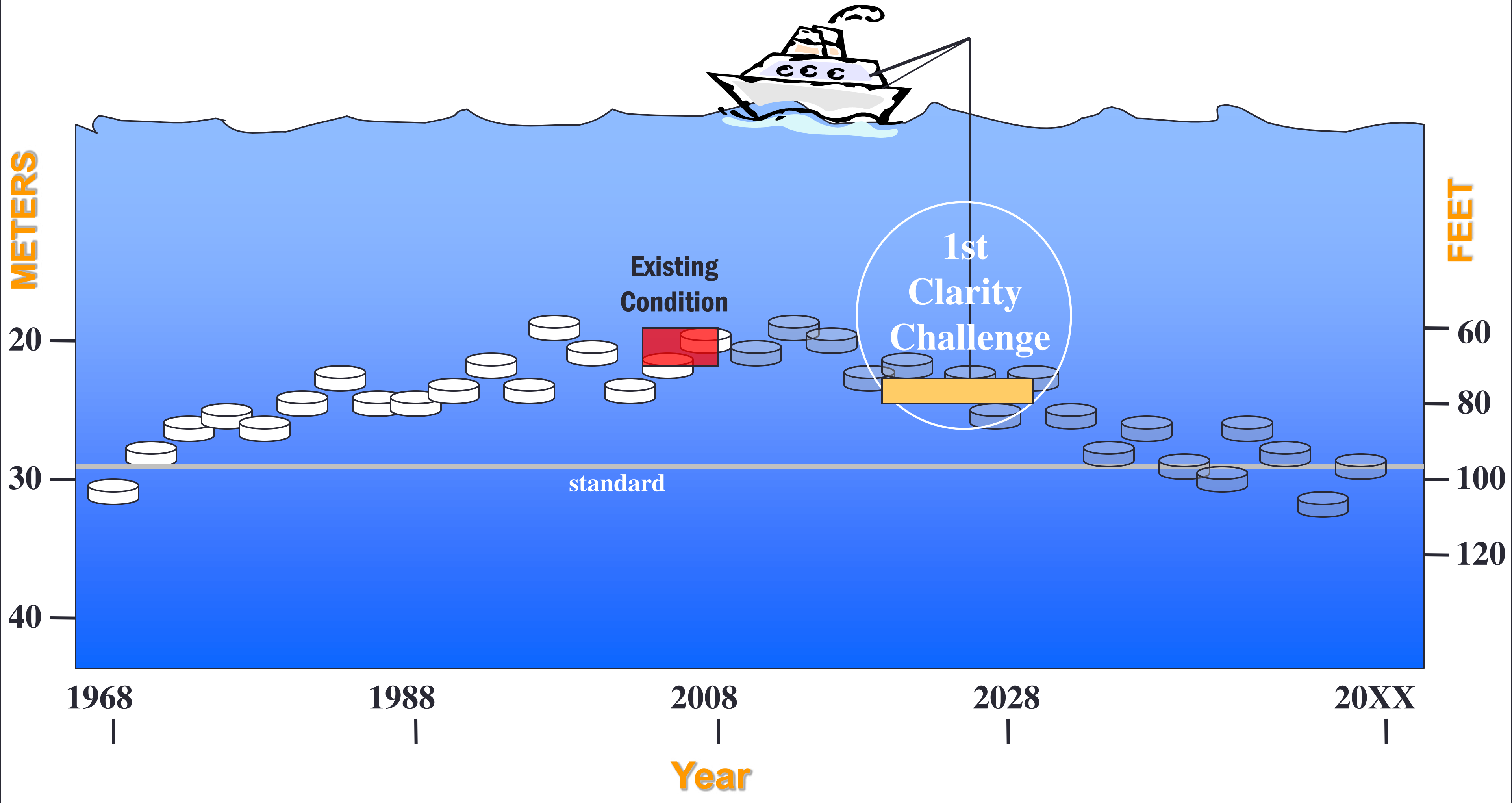
# Urban Runoff

After

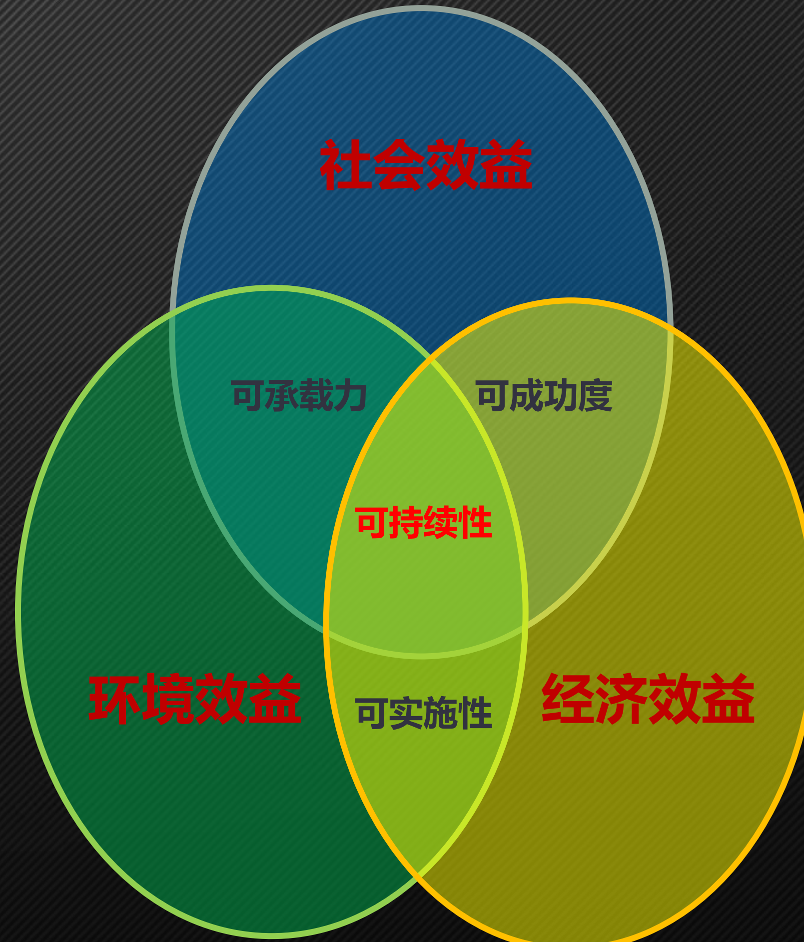
# 75% Reduction from Urban Runoff to Meet WQS of 30 m for Secchi Depth



# The Clarity Challenge: Reverse clarity decline and measurably improve clarity

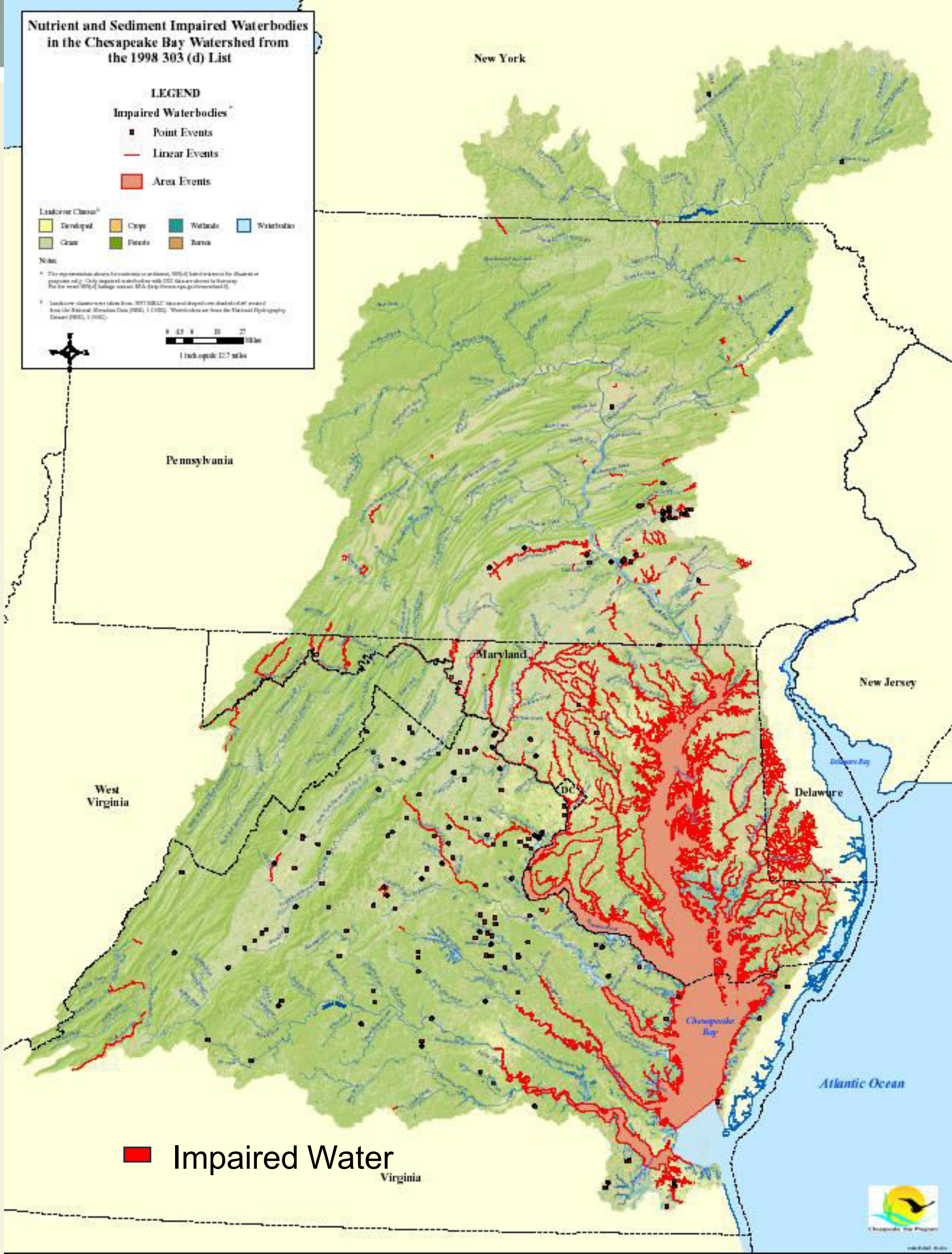


# Chesapeake Bay 佳斯匹克湾生态修复

**Over 90% of the Bay and its tidal rivers are impaired due to low dissolved oxygen levels and poor water clarity, all related to nutrient and sediment pollution.**

**Without oxygen and grasses, the Bay's crabs, oysters, and fish cannot survive and thrive.**



# Current State Target Loads

**Nitrogen**

| State | Tributary Strategy | Target Load |
|---|---|---|
| **DC** | **2.12** | **2.37** |
| **DE** | **6.43** | **5.25** |
| **MD** | **42.14** | **41.04** |
| **NY** | **8.68** | **10.54** |
| **PA** | **73.17** | **73.64** |
| **VA** | **59.30** | **59.22** |
| **WV** | **5.69** | **5.71** |
| **Total** | 197.53 | 197.76 |

**Phosphorus**

| State | Tributary Strategy | Target Load |
|---|---|---|
| **DC** | **0.10** | **0.13** |
| **DE** | **0.25** | **0.28** |
| **MD** | **2.56** | **3.04** |
| **NY** | **0.56** | **0.56** |
| **PA** | **3.10** | **3.16** |
| **VA** | **7.92** | **7.05** |
| **WV** | **0.45** | **0.62** |
| **Total** | 14.93 | 14.84 |

All loads are in millions of pounds per year.

# North River Watershed
## Water Quality Summary

| | Average violation rate | | Bacteria | Aquatic Life | Nutrients |
|---|---|---|---|---|---|
| | pre TMDL (1995-1999) | post TMDL (2000-2005) | | | |
| **Muddy Creek** | 87% | 65% | ☑ | ? | ☑ |
| **Lower Dry River** | 50% | 21% | ☑ | ☑ | ☑ |
| **Mill Creek** | 77% | 57% | ☑ | ? | ☑ |
| **Pleasant Run** | 97% | 100% | ☒ | ☒ | ☒ |
| **North River** | 61% | 25% | ☑ | ☑ | ☑ |

# CURRENT TRENDS AND FUTURE OUTLOOK

Big Data and Real Time Control

Green Infrastructure (GI)

Integrating Green, Blue and Gray

# What is Green Infrastructure？
# 绿色“水”基础建设?

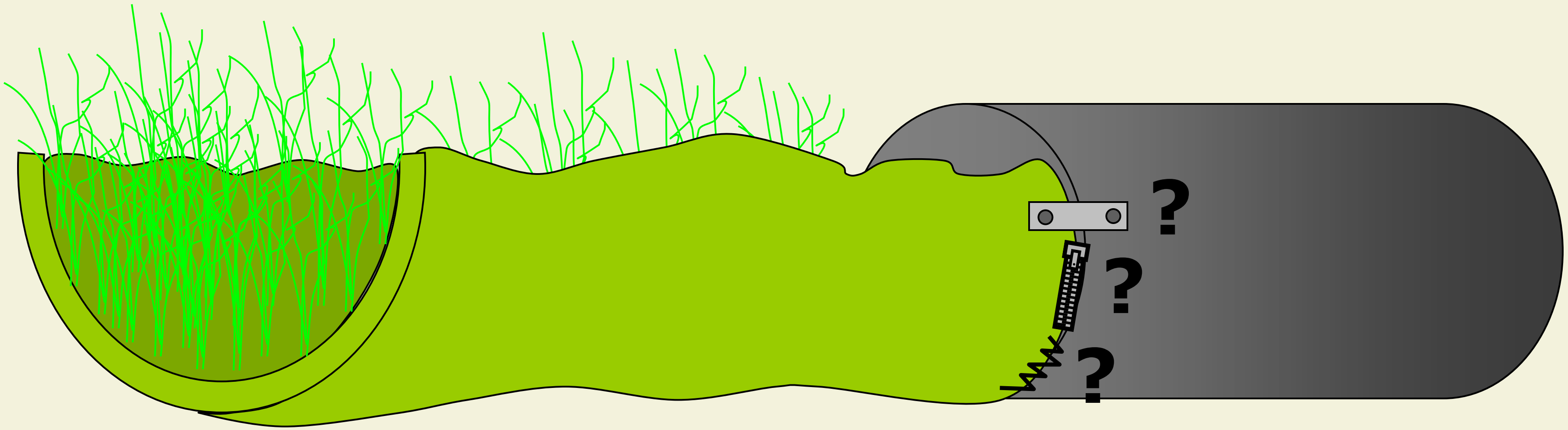
Green infrastructure is an approach that communities can choose to maintain healthy waters, provide multiple environmental benefits and support sustainable communities. Unlike single-purpose gray stormwater infrastructure, which uses pipes to dispose of rainwater, *green infrastructure uses vegetation and soil to manage rainwater where it falls*. By weaving natural processes into the built environment, **green infrastructure provides not only stormwater management, but also flood mitigation, air quality management, and much more.**

# Green infrastructure does not replace gray infrastructure.

# Can reduce the capital costs and O & M costs of gray technology.


http://www.coxconcrete.com/products/rcp/index.html

# How does Green integrate with Gray?



# Some Key Observations for future prospects

- **Point and NPS Pollution Control in general**
- **The need is obvious. However, how do we proceed with it?**
- **A "phased" strategy seems most appropriate.**
- **We need to look at "low-cost" techniques first**
- **We should try to manage "ET" (many benefits: head-island mitigation, carbon ..green.....**
- **We need data, data and more data, but good and reliable. Now we talk about Big Data and Real-Time. But remember: Garbage In - Garbage Out. Now, we may see:**
- **Gin --- G(Nth Power) Out !!!!!!!**
- **Real Time? Some parameters can't be real time!**

Thank you for your time!

谢谢大家！