Load Allocations

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Topics

Part 1. Background and Basic Considerations

Part 2. Allocation methods

- Simple: Load Duration Curves
- Moderate: Decision Support System (WARMF)
- Complex: Chesapeake Bay

Summary
References

Part 1 – Background

Allocation - Defined

$$TMDL = \sum WLAs + \sum LAs + (MOS)$$

The sum of the above loads must attain the WQS.

WLA=PS waste load allocations

LAs=NPS allocations and background

MOS= Margin of safety

Source: EPA (1999)

Allocation – Basic Considerations

- Public involvement
- Economics*
- Political considerations
- Equity
- Feasibility*
  - Types of sources and management options*
  - Implementation
  - Limits of technology*
  - Variability in loads*

* Technical - Emphasized in this presentation

Source: EPA (1999)

Allocation – Technical Complexity

Affected by:

- Size of watershed (Chesapeake Bay vs small lake)
- Type of environment (free flowing, tidal, lake, etc.)
- Pollutant sources (air, groundwater, shore-line erosion, etc.)
- Pollutant transport mechanisms (e.g. groundwater)

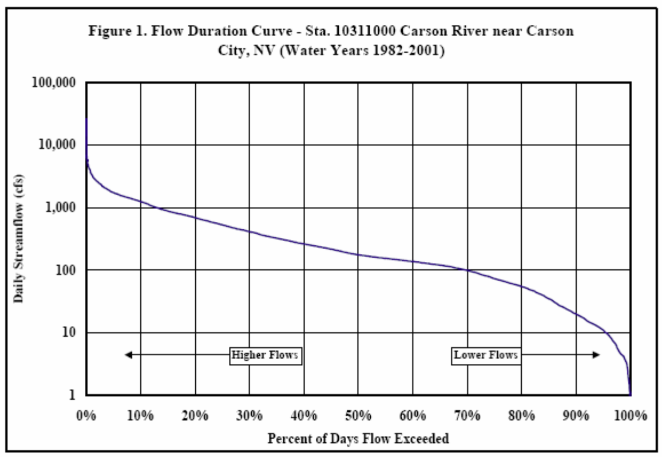
Part 2 – Allocation Methods

A. Simple: Load Duration Curves (LDC)

LDC – Step 1. Calculate Flow Duration Curve

Table 1. Flow Duration Curve Data – Sta. 10311000 Carson River near Carson City, NV (1982-2001)

Daily Streamflow (cfs)	Rank	Percent of Days Flow Exceeded
26,100	1	.01%
14,000	2	.03%
11,500	3	.04%
11,200	4	.05%
10,100	5	.07%
.	.	.
0.32	7301	99.95%
0.27	7302	99.96%
0.26	7303	99.97%
0.19	7304	99.99%
0.01	7305	100.00%



http://www.dep.nv.gov/bwqp/

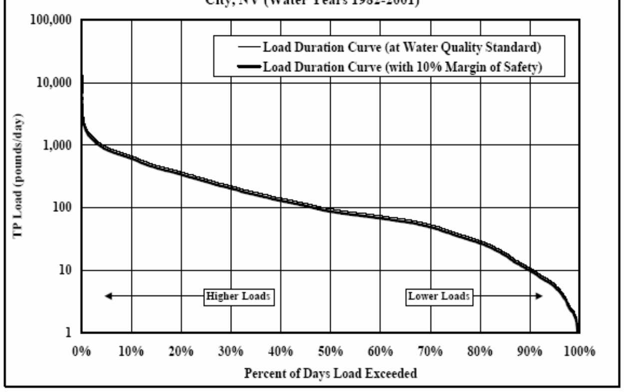
LDC – Step 2. Calculate Flow Duration Curve

Load (pounds per day) = streamflow (cfs) x 0.1 mg/l x 5.396 *[Eq. 1]*

Table 2. Load Duration Curve Data – Sta. 10311000 Carson River near Carson City, NV (1982-2001)

Daily Streamflow (cfs)	Rank	Percent of Days Flow Exceeded	Allowable Load at the Standard (#/day)	Allowable Load with 10 % Margin of Safety (#/day)
26,100	1	.01%	14,084	
14,000	2	.03%	7,554	
11,500	3	.04%	6,205	
11,200	4	.05%	6,044	
10,100	5	.07%	5,450	
. .	. .	. .	. .	. .
0.32	7301	99.95%	0.17	
0.27	7302	99.96%	0.15	
0.26	7303	99.97%	0.14	
0.19	7304	99.99%	0.10	
0.01	7305	100.00%	0.01	

Figure 2. TP Load Duration Curve - Sta. 10311000 Carson River near Carson City, NV (Water Years 1982-2001)



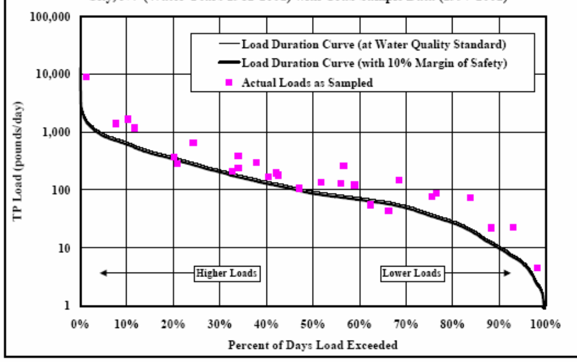
http://www.dep.nv.gov/bwqp/

LDC – Step 3. Plot WQ Data on Flow Duration Curve

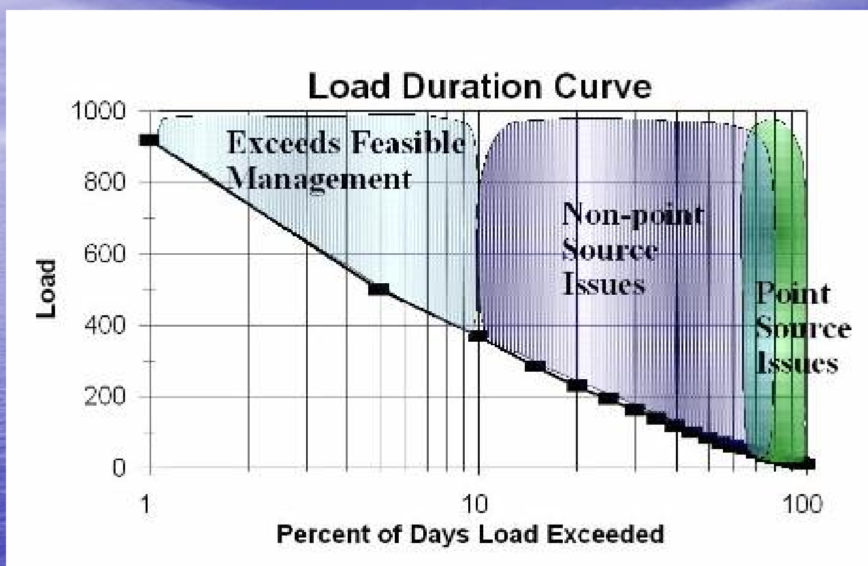
Table 3. Total Phosphorus Data for Sta. 10311000 Carson River near Carson City, NV (1997-2001)

Date	(mg/l)	Actual Load (lbs/day)	(cfs)	Percent of Days Flow Exceeded
12-Mar-97	0.08	282.32	654	20.9%
28-May-97	0.20	1,176.33	1090	11.7%
22-Jul-97	0.26	148.71	106	68.5%
16-Sep-97	0.20	76.62	71	75.5%
12-Nov-97	0.15	135.98	168	51.7%
.	.	.	.	.
9-Jan-01	0.07	43.82	116	66.2%
21-Mar-01	0.21	383.01	338	33.9%
29-May-01	0.13	237.10	338	33.9%
17-Jul-01	0.30	22.66	14	93.0%
25-Sep-01	0.18	4.47	4.6	98.2%

Figure 3. TP Load Duration Curve - Sta. 10311000 Carson River near Carson City, NV (Water Years 1982-2001) with Grab Sample Data (1997-2001)



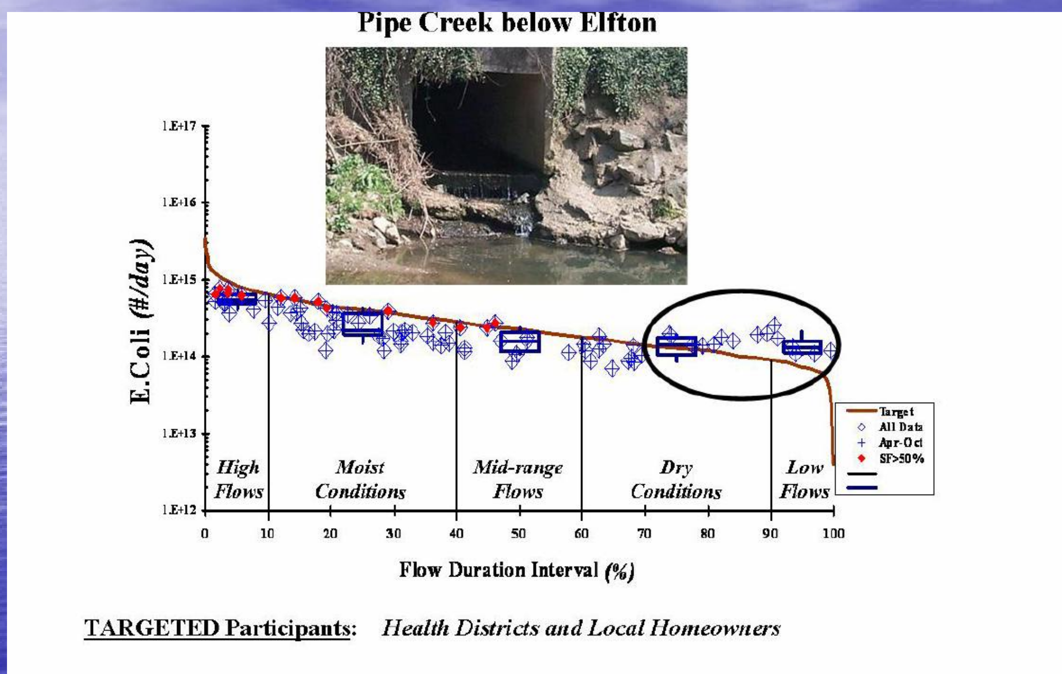
http://www.dep.nv.gov/bwqp/



LDC can help differentiate between NPS and PS exceedences

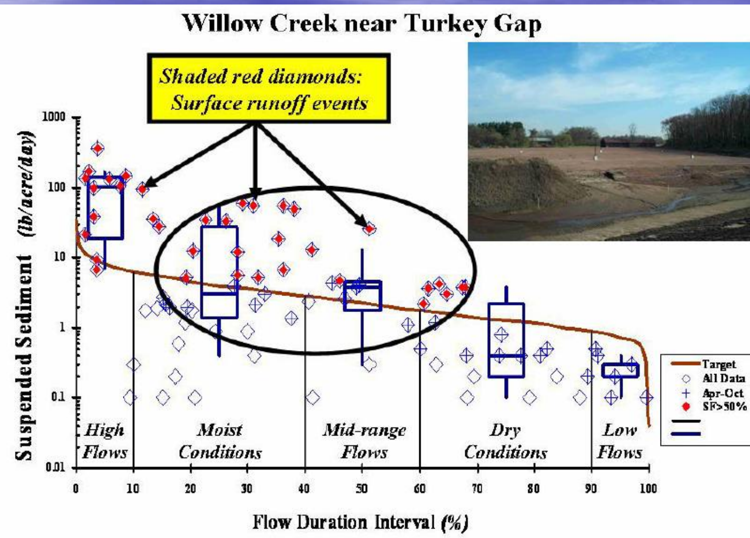
TMDL: Use to reduce samples above LDC to some percentage.

Low flow example



Source: Cleland (2007)

High to mid-flow example



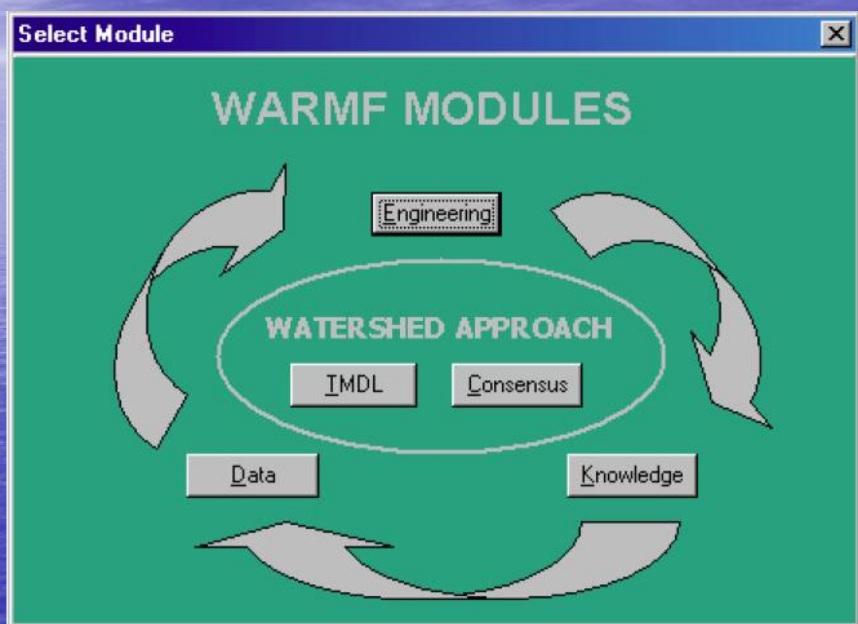
TARGETED Activities: *Construction Site Runoff Control*

Source: Cleland (2007)

Limitations / Concerns with LDC

- Statistical non-deterministic approach
- Low flow conditions (7Q10) are built into most water quality criteria for aquatic life.
- There are concerns about over-simplification.
- Single daily excursions are unlikely to cause a true impact.
- The translation into permit limits is uncertain.
- The assumed MOS is variable.

B. Moderate: Decision Support System (DSS)



Source: http://www.epa.gov/athens/wwqtsc/html/warmf.html

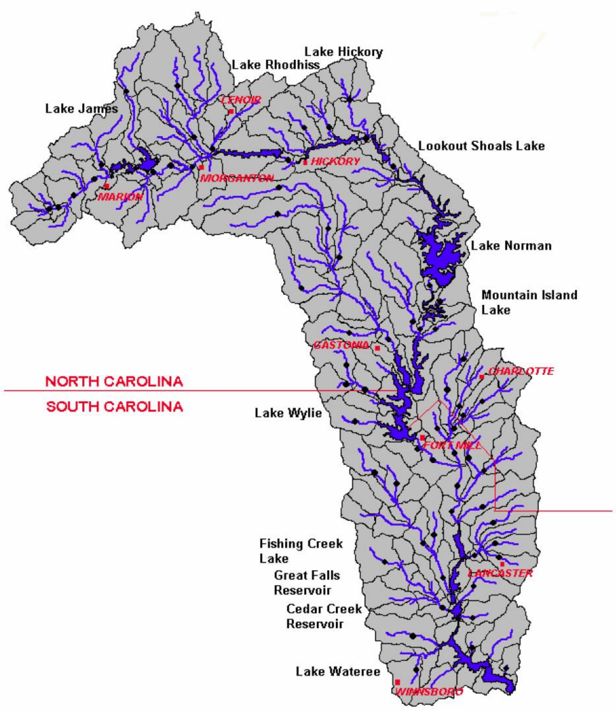


Figure 2-1
Representation of Catawba River Basin by a Network of Land Catchments, River Segments, and Reservoirs.

Users enter:

- Elevation data
- Catchment data
- Stream segment data
- Reservoir data
- System coefficients
- Meteorological data
- PS loadings
- Air Quality
- Observed data

http://www.epa.gov/athens/wwqtsc/html/warmf.html

Example data entry: Catchment data

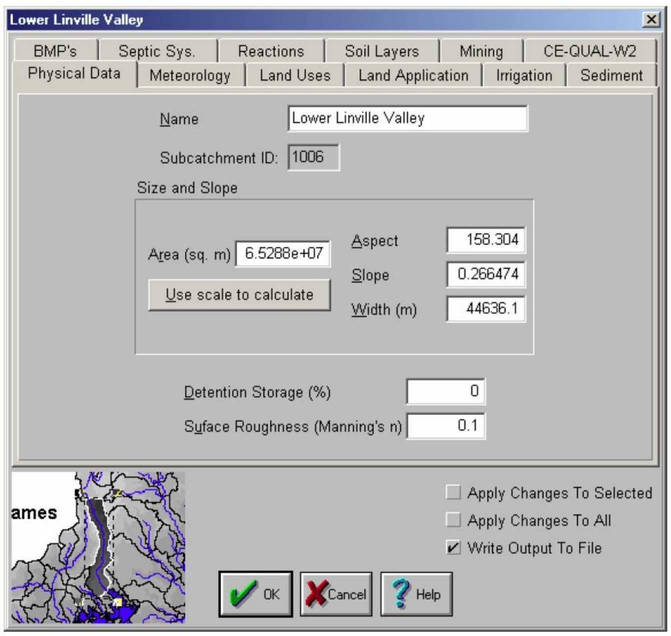


Figure 2-4
Dialog Box to Enter, Review, or Modify Catchment Data

http://www.epa.gov/athens/wwqtsc/html/warmf.html

Consensus Module

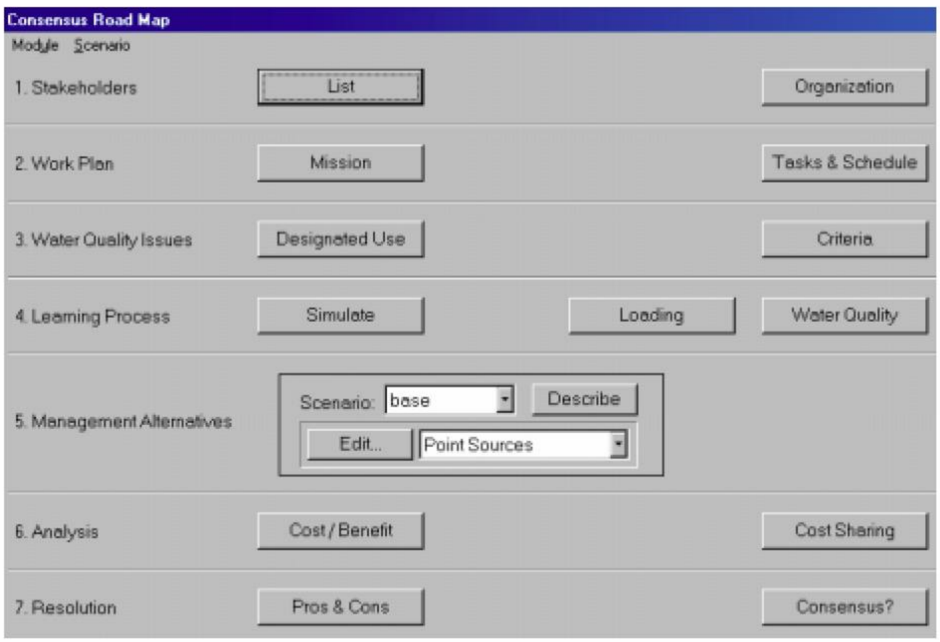


Figure 4-2
Road Map of Consensus Process.

http://www.epa.gov/athens/wwqtsc/html/warmf.html

TMDL Module

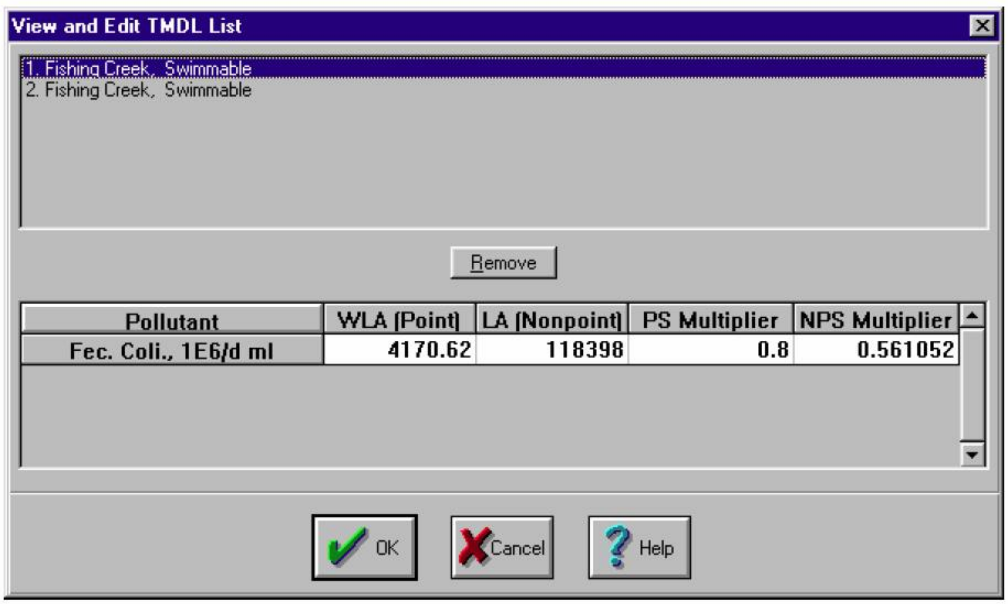


Figure 5-5
List of Saved TMDLs.

http://www.epa.gov/athens/wwqtsc/html/warmf.html

Watershed Analysis Risk Management Framework (WARMF)

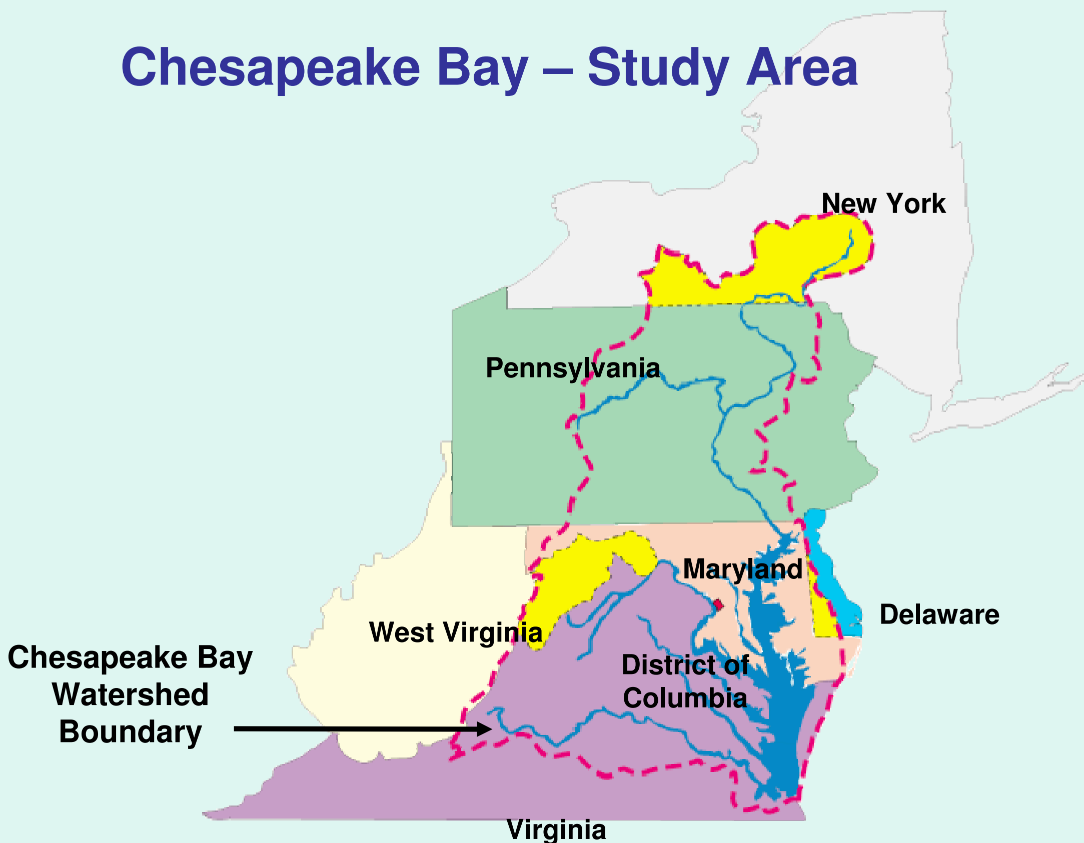
- Based on Windows GUI
- Uses commonly available data
- Predicts hydrology
- Simulates WQ
- Displays spatial distributions of PS and NPS loads
- Accounts for source controls
- Traces loadings to individual land uses
- Evaluates cost sharing and trading potential
- Others

WARMF – Case Studies

- NAPA River – CA
- Truckee River – CA
- Hangman Creek – WA
- Others

C. Complex- Chesapeake Bay

Chesapeake Bay – Study Area



Source: http://www.chesapeakebay.net/

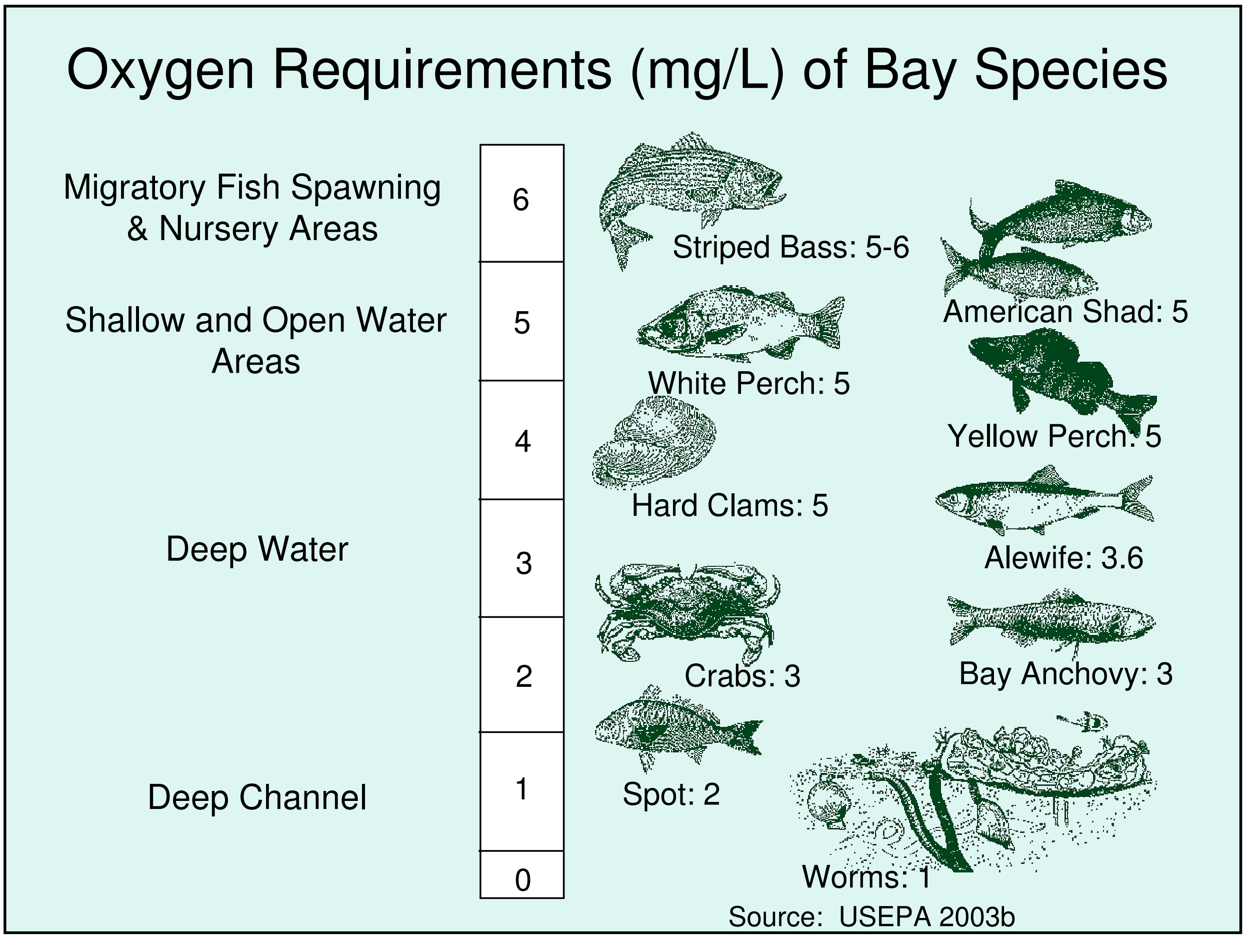
Chesapeake Bay Water Quality Criteria

- **Dissolved Oxygen –** for fish, crabs and oysters
- **Water Clarity –** light for underwater Bay grasses
- **Chlorophyll *a* –** base of the Bay food chain



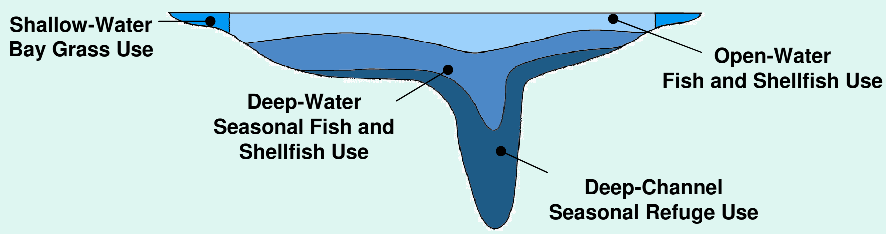
Together, these three criteria define the conditions necessary to protect the wide variety of the Bay's living resources and their habitats.

Source: USEPA. 2003a

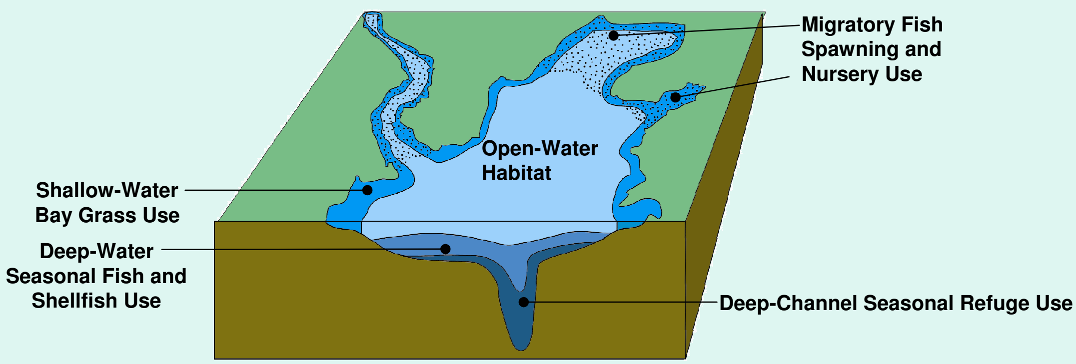

Oxygen Requirements (mg/L) of Bay Species
Migratory Fish Spawning & Nursery Areas
Shallow and Open Water Areas
Deep Water
Deep Channel
6
5
4
3
2
1
0
Striped Bass: 5-6
American Shad: 5
White Perch: 5
Yellow Perch: 5
Hard Clams: 5
Alewife: 3.6
Crabs: 3
Bay Anchovy: 3
Spot: 2
Worms: 1
Source: USEPA 2003b

Refined Designated Uses for Chesapeake Bay and Tidal Tributary Waters

A. Cross Section of Chesapeake Bay or Tidal Tributary



B. Oblique View of the “Chesapeake Bay” and its Tidal Tributaries



Source: USEPA 2003b

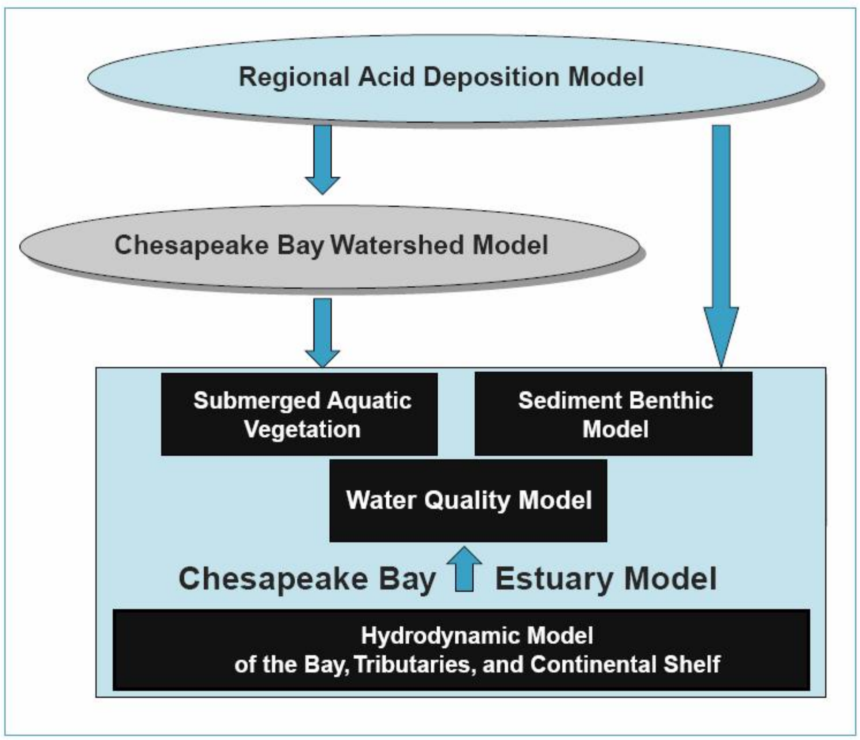


Figure II-4. Cross-media models of the Chesapeake Bay airshed, watershed and estuary.

Source: Chesapeake Bay Program website http://www.chesapeakebay.net.

Source: USEPA 2003c

“Tiered” approach to modeling and allocation

TIER	NPS ASSUMPTIONS	POTW PS ASSUMPTIONS
TIER 1	Maintain 97-2000 implementation rates	Existing NRT=8 mg/l TN and 1 mg/l TP
TEIR 2	Increase between Tier 1 and E3	8 mg/l TN and 1 mg/l TP
TEIR 3	Greater increase between Tier 1 and E3	5 mg/l TN and 0.5 mg/l TP
E3	Maximum possible	3 mg/l TN and 0.1 mg/l TP

NPS: Classifications of Ag, Urban, Mixed Open, Forestry, and Septic Sectors

PS: Also considered industrial dischargers with various levels of control

Tiers also considered various air emission controls

* Costs for the Tiers were documented and considered in the process.

Source: USEPA 2003c

Bay-wide nitrogen loads associated with various “Tiers”

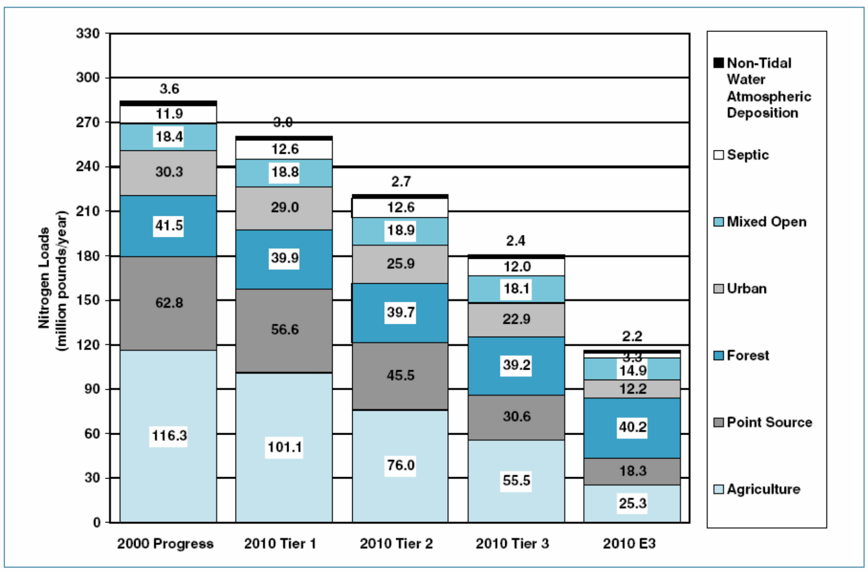
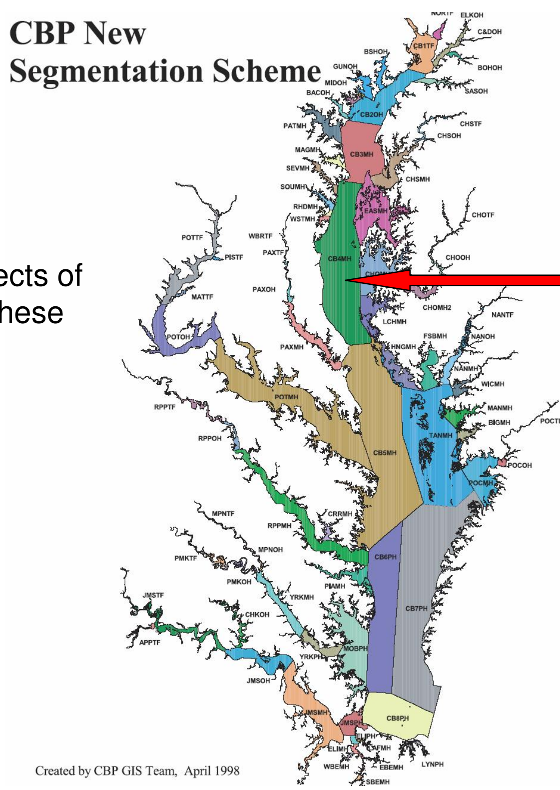


Figure C-1. Chesapeake Bay Watershed Model-estimated nitrogen loads delivered to the Chesapeake Bay and its tidal tributaries by source.

appendix C • Summary of Watershed Model Results for All Loading Scenarios

Source: USEPA 2003c

Evaluated the effects of "Tiers" on DO in these segments.



DO problem is most prevalent here (CB4 area)

Source: USEPA 2004

Segment specific responses to the loading reductions

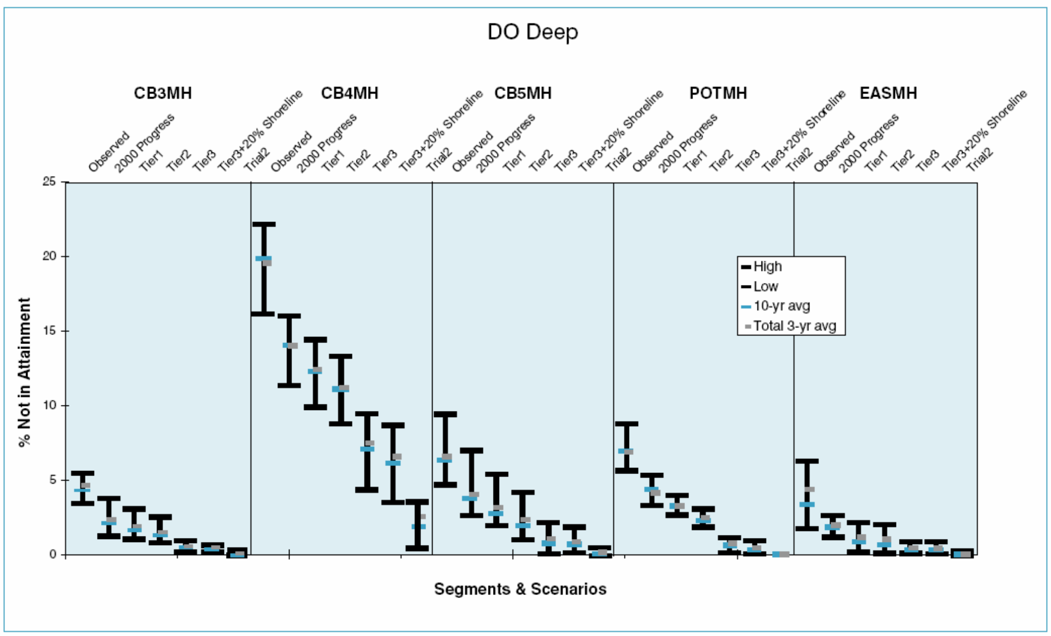
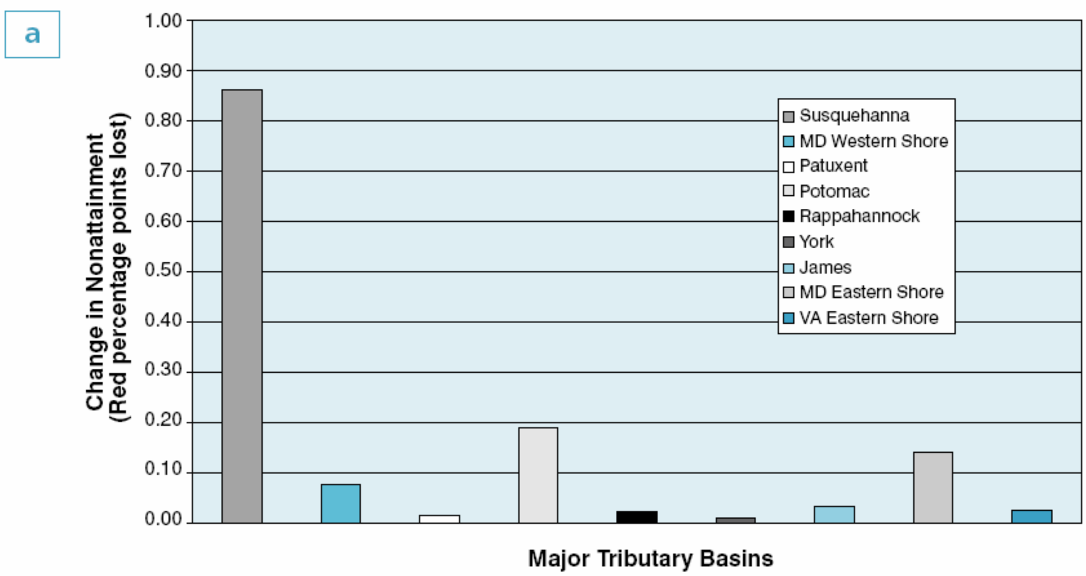


Figure III-1. Assessment of the range and mean of a three-year running average based on model estimates of dissolved oxygen criteria attainment for the deep waters of the contiguous region of CB3MH, CB4MH, CB5MH, POTMH and EASMH.

Source: USEPA 2003c

Important Geographic Considerations



Classified into low, medium, and high impact relative to upper Bay DO problem.

Source: USEPA 2003c

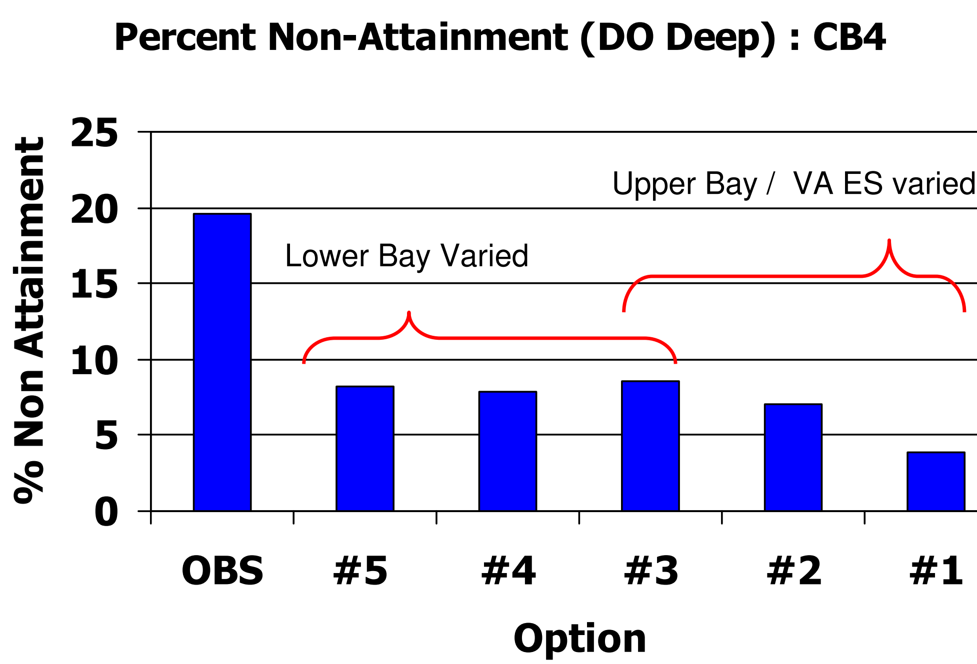
Geographic results led to additional options

Table IV-1. Basinwide nitrogen cap load options (million pounds per year) developed by the Water Quality Technical Workgroup, broken down by major tributary basin.

Basin	Option 1	Option 2	Option 3	Option 4	Option 5
Susquehanna	69.2 (T3.5)	75.9 (T3.25)	82.6 (T3)	82.6 (T3)	82.6 (T3)
Eastern Shore—MD/DE	10.6 (T3.5)	11.9 (T3.25)	13.2 (T3)	13.2 (T3)	13.2 (T3)
Western Shore—MD	8.0 (T3.5)	9.25 (T3.25)	10.5 (T3)	10.5 (T3)	10.5 (T3)
Patuxent	2.5 (T3.5)	2.8 (T3.25)	3.1 (T3)	3.1 (T3)	3.1 (T3)
Potomac	30.5 (T3.5)	34.2 (T3.25)	37.9 (T3)	37.9 (T3)	37.9 (T3)
Rappahannock	5.0 (T3)	5.0 (T3)	5.0 (T3)	5.0 (T3)	5.0 (T3)
York	5.7 (TS)	5.7 (TS)	5.1 (T3)	5.7 (TS)	8.0 (2000)
James	28.1 (TS)	28.1 (TS)	22.3 (T3)	28.1 (TS)	35.6 (2000)
Eastern Shore—VA	0.7 (T3.5)	1.9 (TS)	0.9 (T3)	1.9 (TS)	2.1 (2000)
Total	**160.4**	**174.8**	**180.8**	**188**	**198.1**

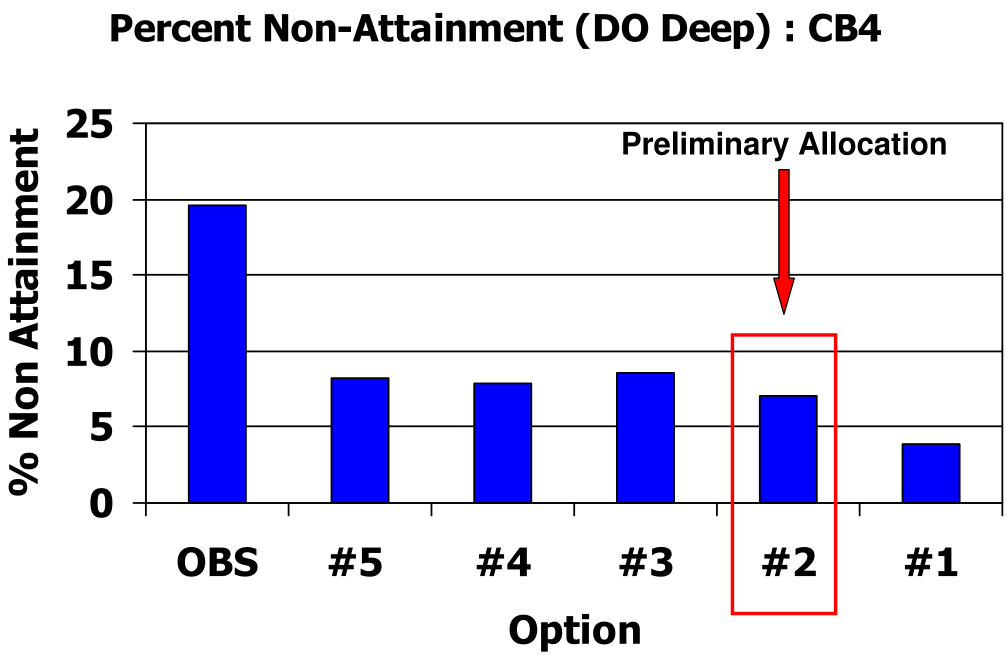
Key: T3—Tier 3 scenario loading; T3.25—loading one quarter of the way between the Tier 3 and E3 scenarios; T3.5—loading halfway between Tier 3 and E3 scenarios; TS—tributary strategy loading; 2000—2000 progress scenario loading.

Source: USEPA 2003c



#5=198, #4=188, #3=181, #2=175, #1=160 million lbs/yr TN

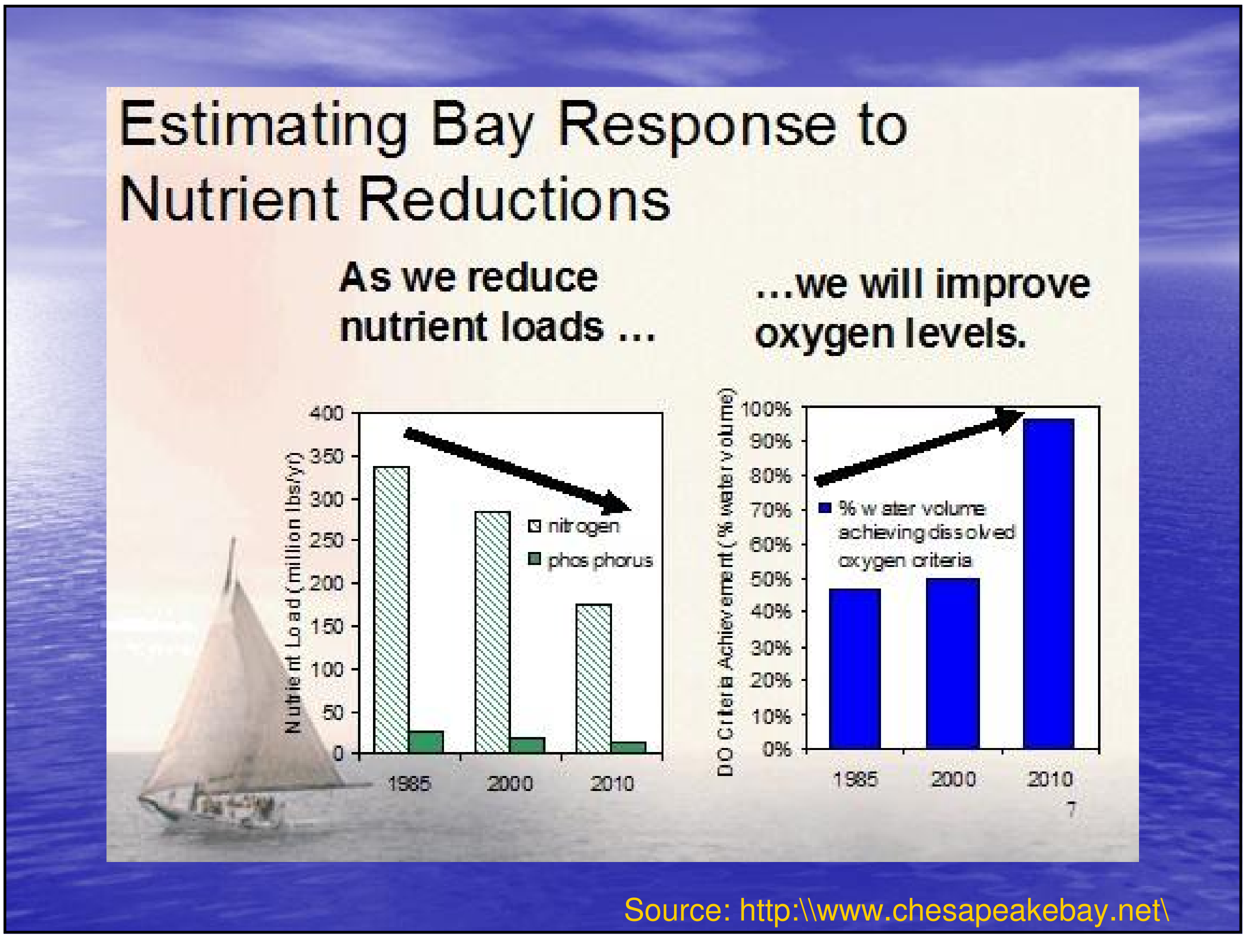
Data source: USEPA 2003c



#5=198, #4=188, #3=181, #2=175, #1=160 million lbs/yr TN

** Full Attainment was considered infeasible by Steering Committee**

Data source: USEPA 2003c


Estimating Bay Response to Nutrient Reductions
As we reduce nutrient loads …
…we will improve oxygen levels.
Nutrient Load (million lbs/yr)
400
350
300
250
200
150
100
50
0
nitrogen
phosphorus
1985
2000
2010
DO Criteria Achievement (% water volume)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
% water volume achieving dissolved oxygen criteria
1985
2000
2010
7
Source: http:\\www.chesapeakebay.net\

Chesapeake Bay Application Elsewhere

- Proper criteria, designated uses, and models are needed to apply available science.
- Technical work lays the foundation for decision making at the policy level.
- Packaging of management options into tiers facilitates modeling and testing of options.
- Geographic considerations can be important.
- Public participation and partnerships are key
- Considering costs / attainability in tiers helps incorporate costs into decisions.
- Overly stringent controls eliminate trading opportunity.

Summary

- Allocation is a policy decision but one that requires sound technical information.
  - technically feasible and reasonably fair division of the allowable loads
- Need to Consider Key Factors Influencing Complexity of Allocation Process
- There are trade-offs among TMDL Allocation Tools & Methodologies

Questions?

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