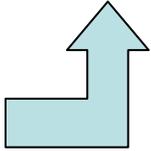
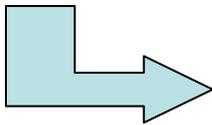


An aerial photograph of a densely populated town in Puerto Rico, nestled in a valley. The foreground is dominated by a lush green forest with a winding path. In the upper left corner, the bottom edge of a hot air balloon is visible. The sky is overcast with soft, grey clouds. The title text is overlaid in the upper right quadrant.

Erosion Control 101 for Puerto Rico

Erosion Control 101 For Puerto Rico



Erosion & Sediment Control & Puerto Rico

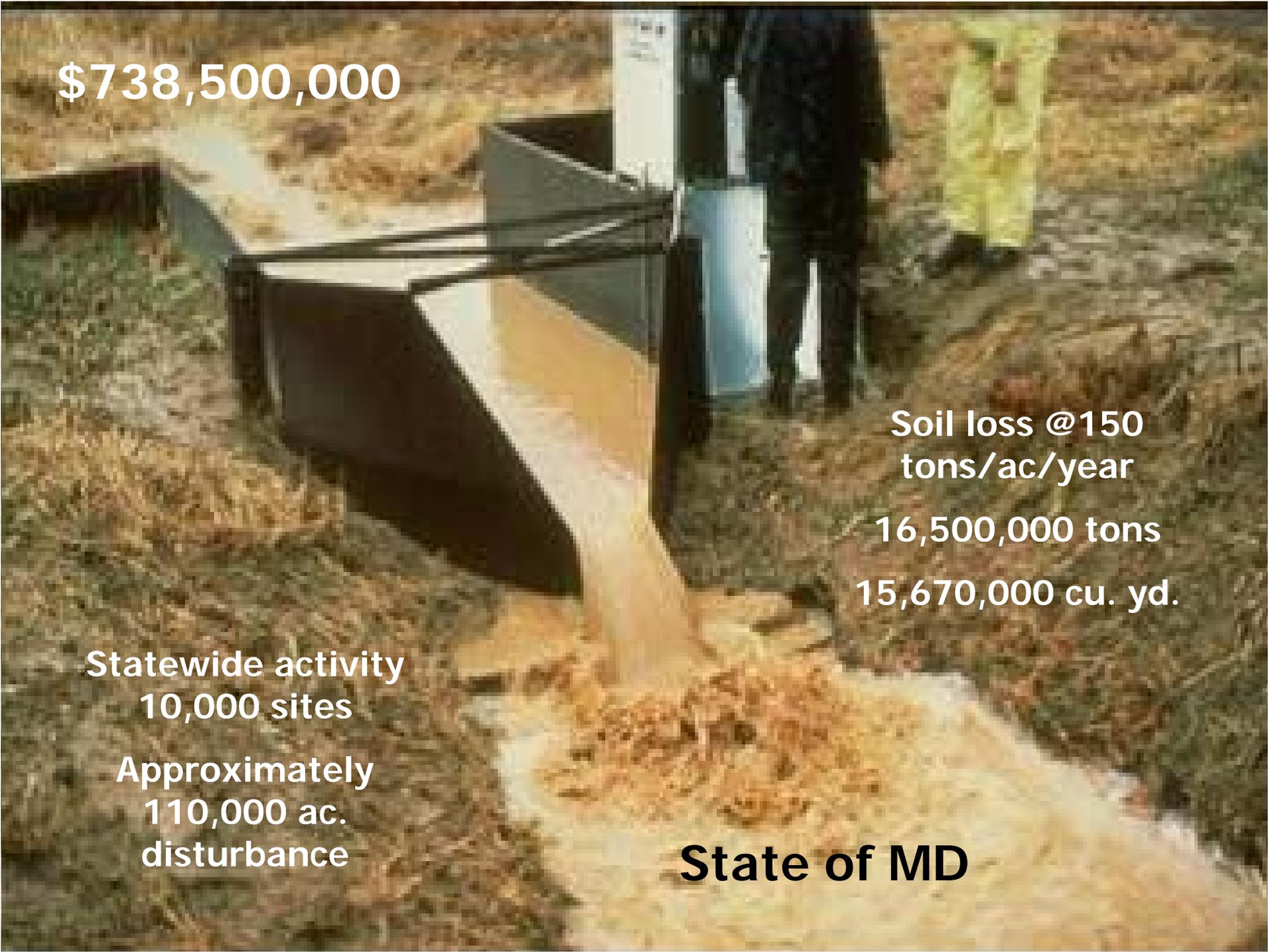
Rico

- **Needed for General Health & Economic Welfare**
- **It's Required – Regulation for the Control of Erosion & Prevention of Sedimentation + EPA Regulations**
- **Puerto Rico Erosion & Sediment Control Handbook for Developing Areas (2005 – EQB & NRCS)**

Puerto Rico is Not Alone!

Implementation is Difficult





\$738,500,000

**Soil loss @150
tons/ac/year**

16,500,000 tons

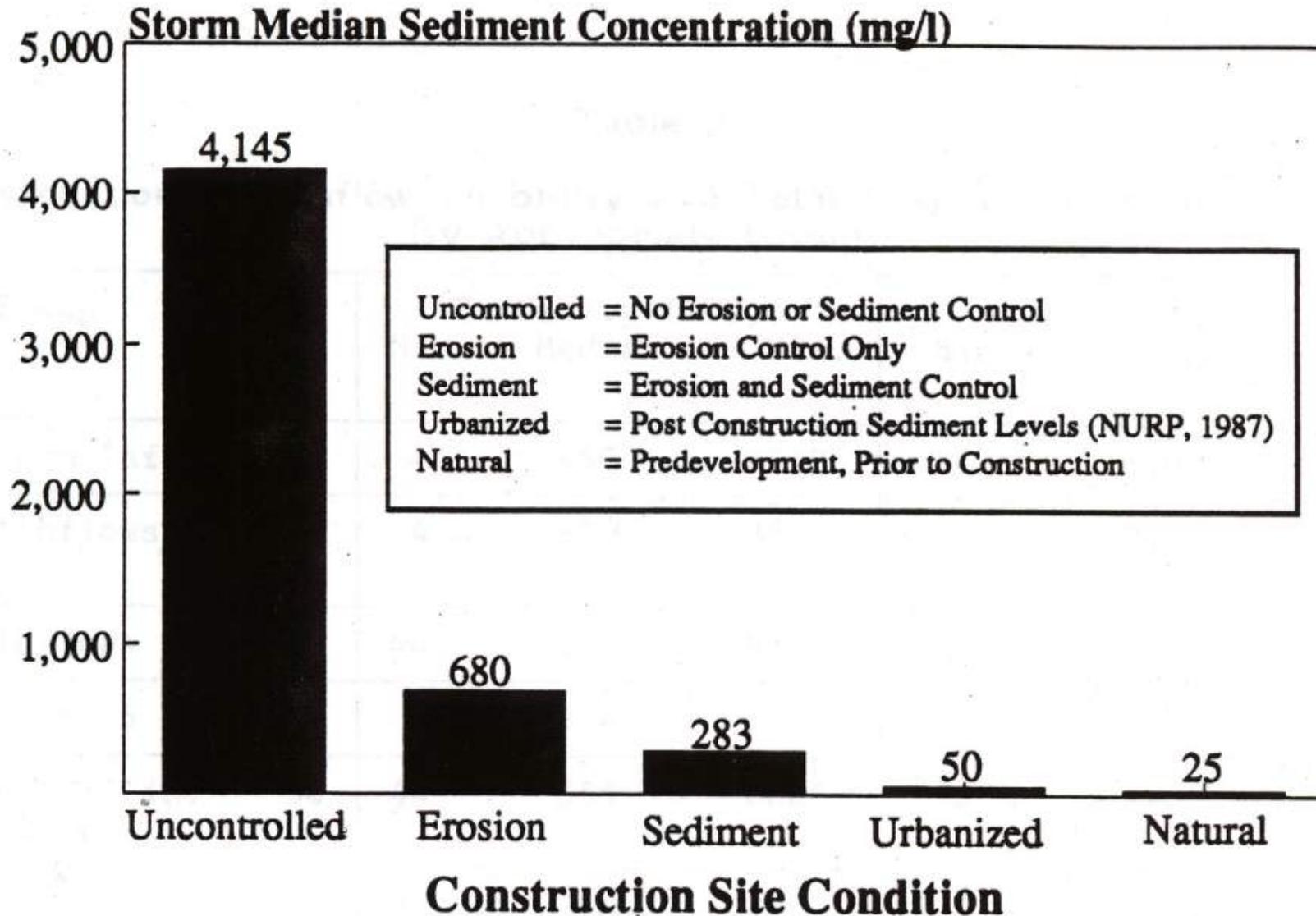
15,670,000 cu. yd.

**Statewide activity
10,000 sites**

**Approximately
110,000 ac.
disturbance**

State of MD

Effect of Erosion and Sediment Control Measures On Suspended Sediment Concentrations From Piedmont Construction Sites



Source: Schueler and Lugbill, 1990

An aerial photograph of a river. On the left side, a small boat with a white mast is visible on the water. A large, irregularly shaped area of the river is filled with a thick, yellowish-brown sediment plume, likely from an erosion control site. The surrounding water is a darker, greenish-blue color. The text of the slide is overlaid on the right side of the image.

Erosion Control Implementation?

- **Staff & Resources**
- **Politics (Enforcement)**
- **Conventional Way of Doing Things**
- **Agency Coordination**

PRIORITY ESC Practices for Puerto Rico: Not ONLY Practices. . .But Perhaps First Practices

- **Fit Island Conditions**
- **Existing Practice in Handbook**
- **Simple But Effective**
- **Good Cost/Benefit**
- **Ease of Implementation & Enforcement**



Priority ESC Practices for Puerto Rico

- **#1 – Minimize Site Clearing**
- **#2 – Construction Phasing**
- **#3 – Construction Entrance**
- **#4 – Silt Fence, Properly Installed**
- **#5 – Rapid Soil Stabilization**
- **#6 – Traps, Basins & Diversions**
- **#7 – Your Ideas!**

Other ESC Practices in Handbook: ***Vegetative, Structural, Runoff Practices***

- **Construction Sequence**
- **Topsoiling , Mulching, Matting, Sodding**
- **Permanent Seeding & Planting**
- **Filter Strip**
- **Construction Road Stabilization**
- **Straw Bales**
- **Stormwater Conveyance Channel**
- **Check Dams**
- **Inlet & Outlet Protection**
- **Level Spreader**

Priority ESC Practice #1



Minimize Site Clearing

1. Minimize Site Clearing

What It Is:

- Clearing Only Area Necessary For Construction**
- Buffering Sensitive Features**

Techniques:

- Identify Sensitive Features On Plan**
- Clearly Mark Limits of Clearing in Field**
- Keep Construction Equipment & Traffic Out of Sensitive Areas**



Photo: Delaware Sediment & Stormwater Program

Marking Sensitive Resources in Field





Silt Fence is Not Adequate Barrier

APR 28 2005

Photo: Albemarle County, Virginia

**Silt Fence + Orange Fence:
A Little Better**



Photo: Delaware Sediment & Stormwater Program

PR Erosion & Sediment Control Handbook

- **Sections 2.6 & 2.8 (Erosion Control Plan)**
 - Restrict construction to least critical areas
 - Avoid streams, flood plains, steep slopes, erodible soils
 - Physically mark limits of construction

- **Section 3.2 (Minimum ESC Practices)**
 - More conservative BMPs next to sensitive areas

PR Erosion & Sediment Control Handbook (continued)

- **Sections 3.4.1 – Tree Preservation
& Protection**
- **Section 3.4.10 – Riparian Forest
Buffer**

Implementation Issues

- **Identify Sensitive Areas on Site Plan**
- **Strong Link From Plan to Field**
- **Education of Contractor & Subcontractors**
- **Installation & maintenance of fencing or barrier**
- **\$3 - \$5/linear foot**



Priority ESC Practice #2

Phase I

Phase II

Phased Construction



2. Phased Construction

What Is It:

- Only one portion of site is disturbed at any one time
- Subsequent phases are not started until earlier phases are substantially completed
- Reduce soil erosion by minimizing the duration & area of exposed soil

Sequence Of Construction (Part of Phasing)



- Protect existing vegetation
- Stabilized construction access
- Sediment traps and barriers
- Runoff conveyance system
- Clearing and grading
- Building construction



2. Phased Construction

- Can reduce erosion by 40% over traditional mass grading

Technique:

- Requires careful planning
- Phasing plan developed early in the project planning and design stage
- Phases should correspond to existing and future drainage boundaries
- Minimum “threshold” size (15 acres)
- “Cut” soil matches “fill” requirement
- Locate temporary stockpiles and construction access
- Establish trigger for completion of each phase
- ID key ESC elements to inspect in each phase

PR Erosion & Sediment Control Handbook

- **Section 2.8 (Implementing the Plan)**
 - **Limit the size of areas exposed at any one time**
- **Section 3.3 & 3.3.1 (Construction Sequence)**
 - **Work schedule coordinates timing of construction with installation of ESC practices (sequencing is one component of phasing)**

Implementation Issues

- Can be challenging to balance cuts and fills within limited areas
- Certain equipment may need to be mobilized more than once
- Economic consequences?
- Need to coordinate with dry/rainy seasons in terms of stabilization
- Phasing can be hard to enforce
- **Cost:** variable – may entail extra costs for mobilization and stockpiling; can also save \$ by limiting structural ESC practices, repairs and maintenance

Priority ESC Practice #3



**Construction Entrance
& Wash Rack**



Mud On Roads is Public Safety Issue

P.S. Don't Wash It Off!

JAN 27 2005

Photo: Albemarle County, Virginia

3. Construction Entrance & Wash Rack

What It Is:

- **Clearly Defined & Stabilized Entrance/Exit from Construction Site to Paved Road**
- **If Needed, Water Available to Wash Tires**
- **Wash Water Goes to Sediment Trap, Dirt Bag, or Slow Release to Vegetated Area (NOT Wetland)**

Techniques:

- **6” Aggregate + Filter Fabric**
- **At Least 12’ Wide X 50’ Long**



Photo: Delaware Sediment & Stormwater Program



Wash Water To Sediment Trap



Photo: Maryland Department of the Environment

Dirt Bag For Wash Water OR Basin Dewatering

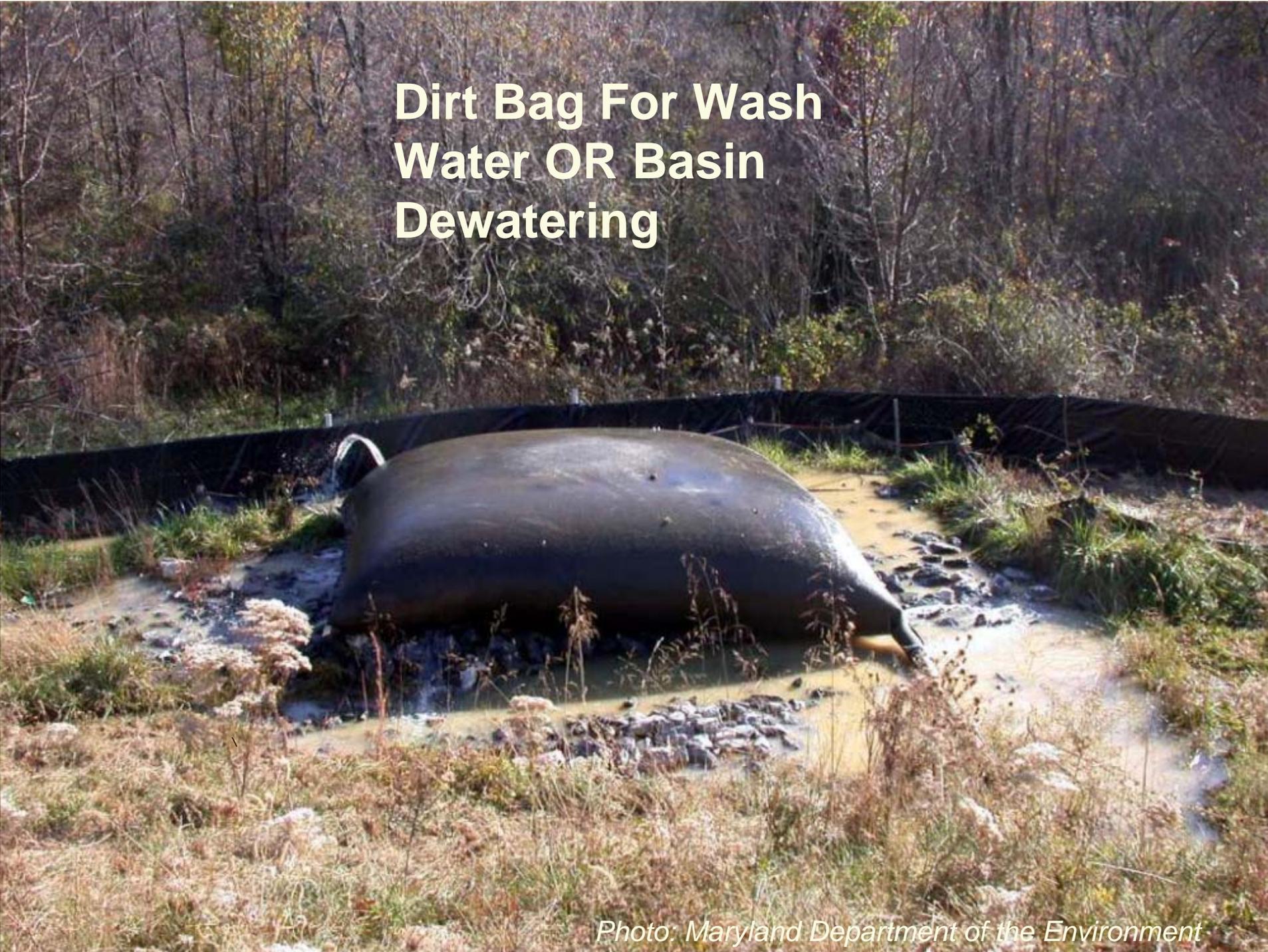


Photo: Maryland Department of the Environment

PR Erosion & Sediment Control Handbook

Section 3.2 -- Minimum ESC Practices

Section 3.5.1 – Stabilized Construction Entrance

- Don't Wash Vehicles Near Waterways**
- Define Ingress & Egress From Paved Roads**

3. Implementation Issues

- **1 st Thing To Do At Site**
- **Careful Oversight By Contractor & For Subcontractors**
- **Maintenance Can Be Frequent**
- **Wash Water Must Be Managed**
- **Cost: \$ 2 – 3 K for paved w/ wash rack**





Priority ESC Practice #4

Silt Fence

4. Silt Fence

What It Is:

- Perimeter control that filters runoff before it leaves the site**
- Settling is most important sediment removal function**

Techniques:

- Silt fence, stakes, trenching**
- Super silt fence has wire mesh backing**

4. Silt Fence

- Between 65% and 85% TSS removal in field studies.
- Ongoing maintenance can cost as much as original installation over project life

Silt fences are often poorly located, installed or maintained:

Mainland data:

- Only 67% of silt fences on the ESC plan were installed.
- Only 58% were installed correctly.
- Only 34% were adequately maintained







PR Erosion & Sediment Control Handbook

Section 3.5.4 – Silt Fence

- Designed for sheet flow**
- DA < 0.25 ac/100lf of fence (max 1 ac.)**
- Flow path < 100'**
- Slope < 50%**

4. Implementation Issues

- Installation issues
- Maintenance chief concern
- Extra time during installation for trenching
- Improper placement (concentrated flow)
- Construction traffic
- Annual maintenance is 100% of installation cost
- **Cost:** Popular practice due to low cost - \$5 per linear foot (mainland)





Priority ESC Practice #5

**Rapid Soil
Stabilization**

5. Rapid Soil Stabilization

What It Is:

- Vegetated cover and/or anchored mulch for areas that may or may not be at final grade
- Should be applied when grade will not change for minimum of 14 to 30 days
- Reduces soil erosion by minimizing the amount of time soil is exposed
- Preserves topsoil and reduces need for re-grading b/c of rill and gully formation
- Most effective erosion control



5. Rapid Soil Stabilization

- Techniques:
 - **Seeding/Hydroseeding**
 - **Mulching**
 - **Erosion control blankets/mats**
- Establish grass or mulch cover within one week of soil exposure
- Permanently stabilize disturbed areas at conclusion of construction
- Contingency line item for replacing cover that does not take
- Use native seeds and grasses

Notes on Seeding

- Poor quality of some island soils may require fertilization, liming and other soil amendments
- Take soil test
- Use only warm season grasses, with some annual ryegrass to get temporary stabilization
- Grasses vary greatly in tolerance for drought, and shade, and requirements for nitrogen and maintenance

Seeding

- Nearly 100% effective for established grass, 80% for sparse cover
- Best in combination with a mulch or erosion control blanket cover
- Native seedgrass mixes?

Straw Mulch

- Can be up to 95% effective
- Must be anchored to the soil surface
- Best if used in combination with seeding
- Best for slopes flatter than 3:1
- Island Supply?



Copyright Center for Watershed Protection, 2001

PR Erosion & Sediment Control Handbook

- **Sections 2.6 & 2.8 – Vegetate and mulch denuded areas**
- **Section 3.3.1. - Construction Sequence**
 - Temporary stabilization during extreme weather conditions
- **Section 3.4.3 - Mulching**
 - Organic mulch (grass hay, wood chips), Inorganic (landscaping fabric – mainly for weed control), hydroseeding w/ mulch. Anchored with tackifiers, emulsions, pinning, netting, crimping, etc.
- **Section 3.4.5 - Temporary Seeding**
 - Can be used up to 1 year. Species: Ryegrass, Brown Top Millet, Habichuela deterciopela, Velvet bean, Neonotonia wightii

5. Implementation Issues

- Soil compaction/
poor soils (need to
loosen, amend, scarify)
- Poor germination
- Need for irrigation
- Weed seeds and invasives
- **Cost:** Seeding - \$1,500/acres (includes
permanent seeding and stabilization)
- Can save \$ if need for structural ESC practices
is reduced or eliminated



Priority ESC Practice #6

Traps, Basins & Diversions



Photo: Delaware Sediment & Stormwater Program

6. Traps, Basins, Diversions

What It Is:

- **Perimeter Controls for Larger Cleared Areas (3 acres)**
- **Outlet Through Weir or Riser/Barrel**
- **Used in Conjunction With Diversion Dike to Limit Drainage Area**

Techniques:

- **Compacted Impoundment**
- **Outlet Structure**
- **Sized For Design Storm**



Photo: Maryland Department of the Environment



Puerto Rican Snow!

JAN 31 2005

Photo: Albemarle County, Virginia

Level Weir With Freeboard



Photo: Maryland Department of the Environment



Emergency Spillway



Riser



FEB 7 2005

Photo: Albemarle County, Virginia



JAN 14 2005

Photo: Albemarle County, Virginia



Stabilized Diversion Dike Leading To Trap or Basin

Photo: Maryland Department of the Environment



MAINTENANCE!!!

Photo: Maryland Department of the Environment



Photo: Maryland Department of the Environment

PR Erosion & Sediment Control Handbook

Section 2.6 -- Minimum ESC Practices

- **Trap Sediment Onsite**
- **Divide Up Drainage Areas**

PR Erosion & Sediment Control Handbook

Section 3.5.2 – Temporary Sediment Trap

- **Drainage Area < 5 acres**
- **Storage = 1,800 cf per acre**
- **2-year, 24-hour storm**
- **3:1 Length-Width Ratio**
- **> 20 feet from building foundations**
- **Embankments < 5 feet**
- **Clean Out at 1/3 design depth**

PR Erosion & Sediment Control Handbook

Section 3.5.3 – Sediment Basin

- **Drainage Area: 5 - 100 acres disturbed**
- **Storage = 1,800 cf per acre (& RUSLE)**
- **Possible EPA Requirements (more storage)**
- **Clean Out at 1/2 design volume**
- **Can be permanent measure**

Implementation Issues

- **Constructed Prior to Site Disturbance**
- **Proper Compaction of Embankments**
- **Access for Maintenance**
- **Periodic Clean-Out**
- **Safety/Liability**
- **Overflow**
- **\$1,000 per acre**



**Let's Work
Together for
Better ESC
Implementation**



Where Do We Go From Here?

