Development and Design of Cost-Effective, Real-Time Implementable Sediment and Contaminant Release Controls

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BIOSYSTEMS & AGRICULTURAL ENGINEERING

Design/Management Goals

- Water Quality Protection Design Storm
- Systems approach
- Positive control

Positive Control

- Enable implementation of alternative management decisions
- Availability of alternative management schemes
- Real-time decision making
- Flexibility in operation

Systems Approach

- Completely integrated components
- Integrate with natural system
  - passive/active
- During planning and design incorporate management options

Storm Size

- Excellent results for most storms
  - 1 yr design storm
- Very good results for large storms
  - 2 yr 24 hr design storm
- Structural stability for largest storms
  - Greater than 2 yr 24 hr design storm

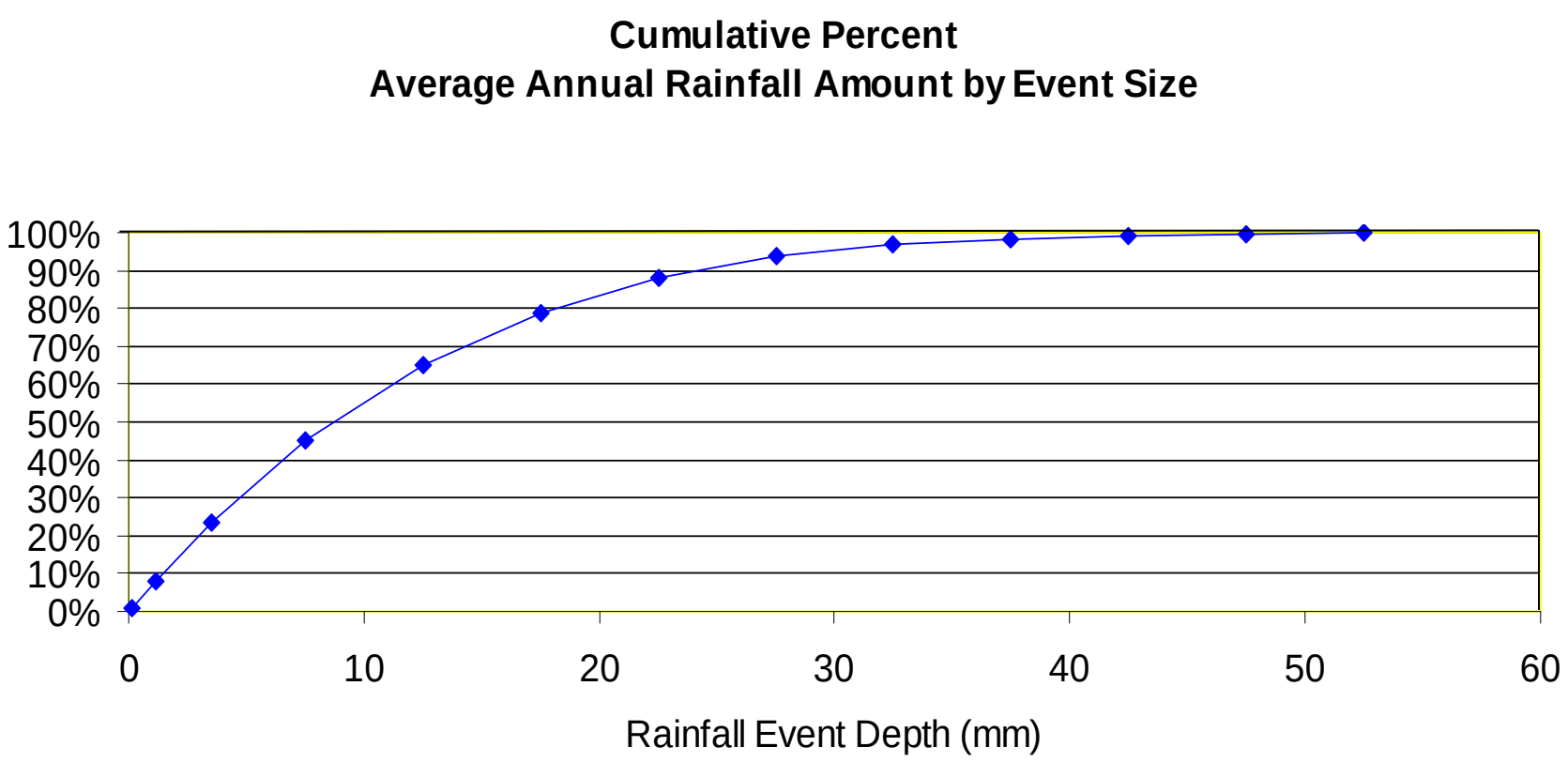
Water Quality Design Storm

- USA – Urban Nonpoint Source
- Capture and treat 90% of the runoff producing events that occur each year
- Design based on the Rainfall Frequency Spectrum (defined as the distribution of all rainfall events)

Effectiveness of Water Quality Treatment for NPS

“The effectiveness of any stormwater water quality treatment practice is a function of how much stormwater is treated by the system and how much by-passes the practice”.

Rainfall

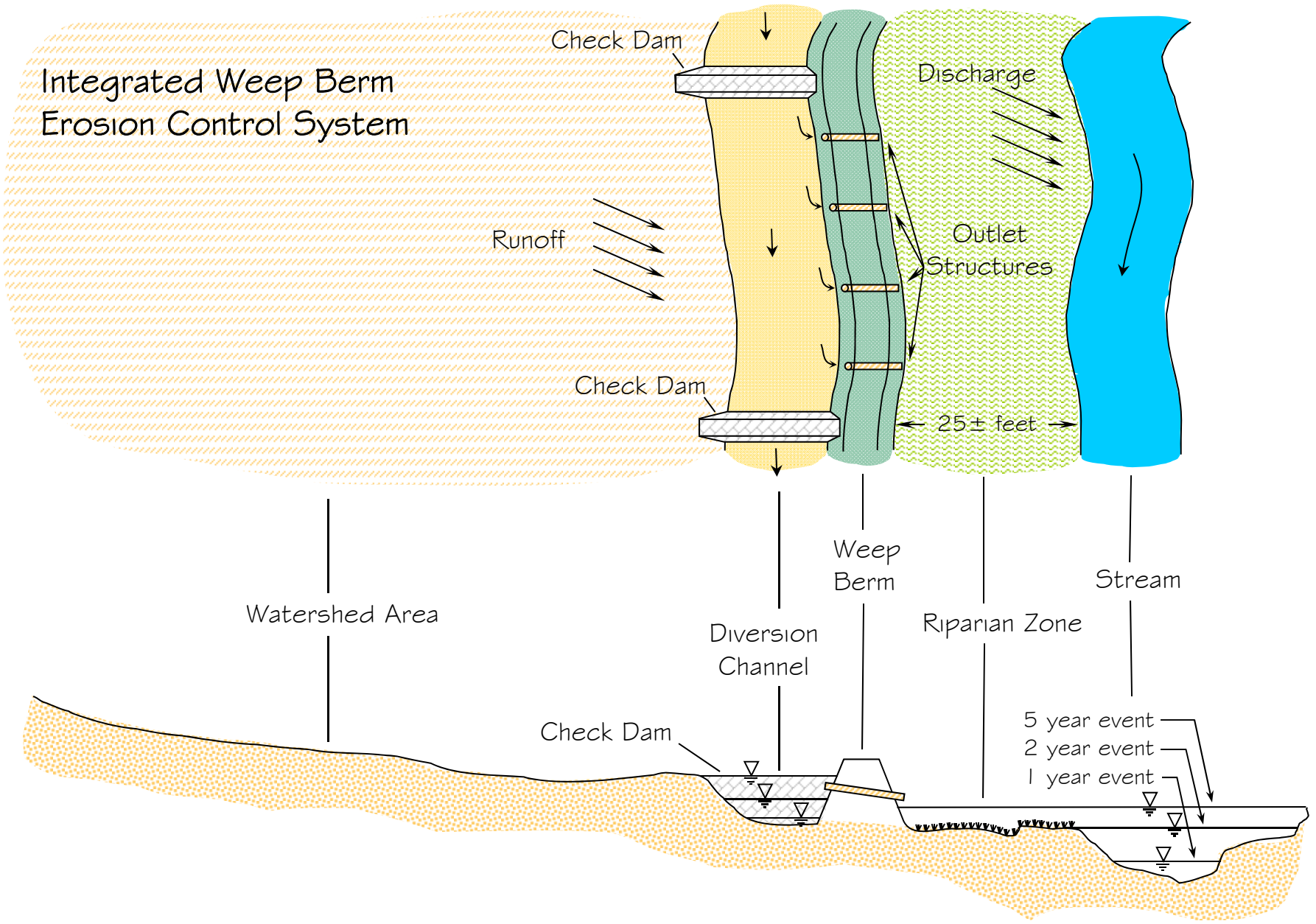

Cumulative Percent
Average Annual Rainfall Amount by Event Size
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
10
20
30
40
50
60
Rainfall Event Depth (mm)

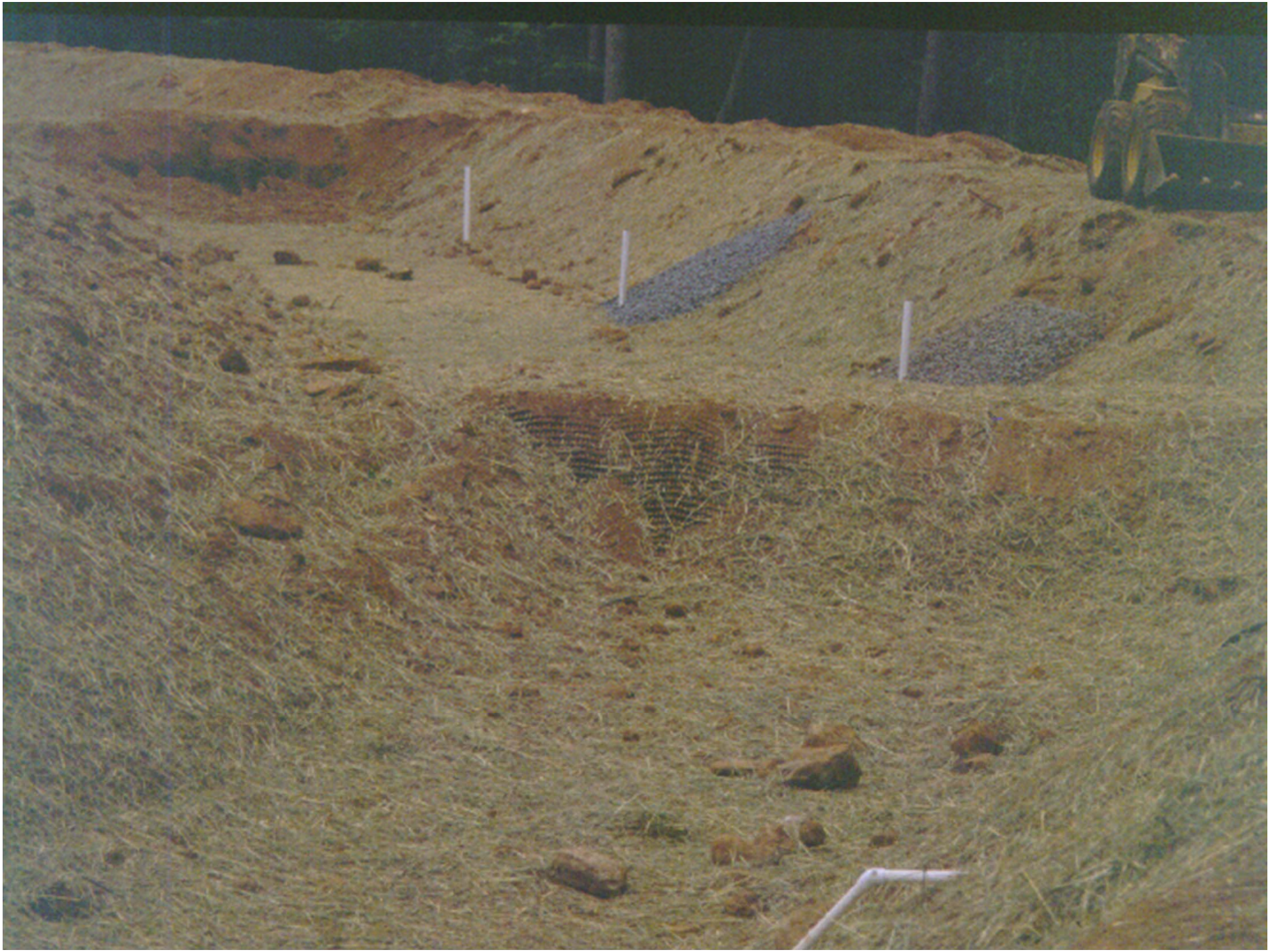
Expected System Performance

- SEDCAD analysis
  - Coagulation-flocculation system
  - Weep berms
  - Sand filters
- SEDCAD assessment
  - Incremental rainfall
  - Storm analysis (20 mm and 2 yr 24 hr)
  - NRCS Type II distribution

Weep Berm

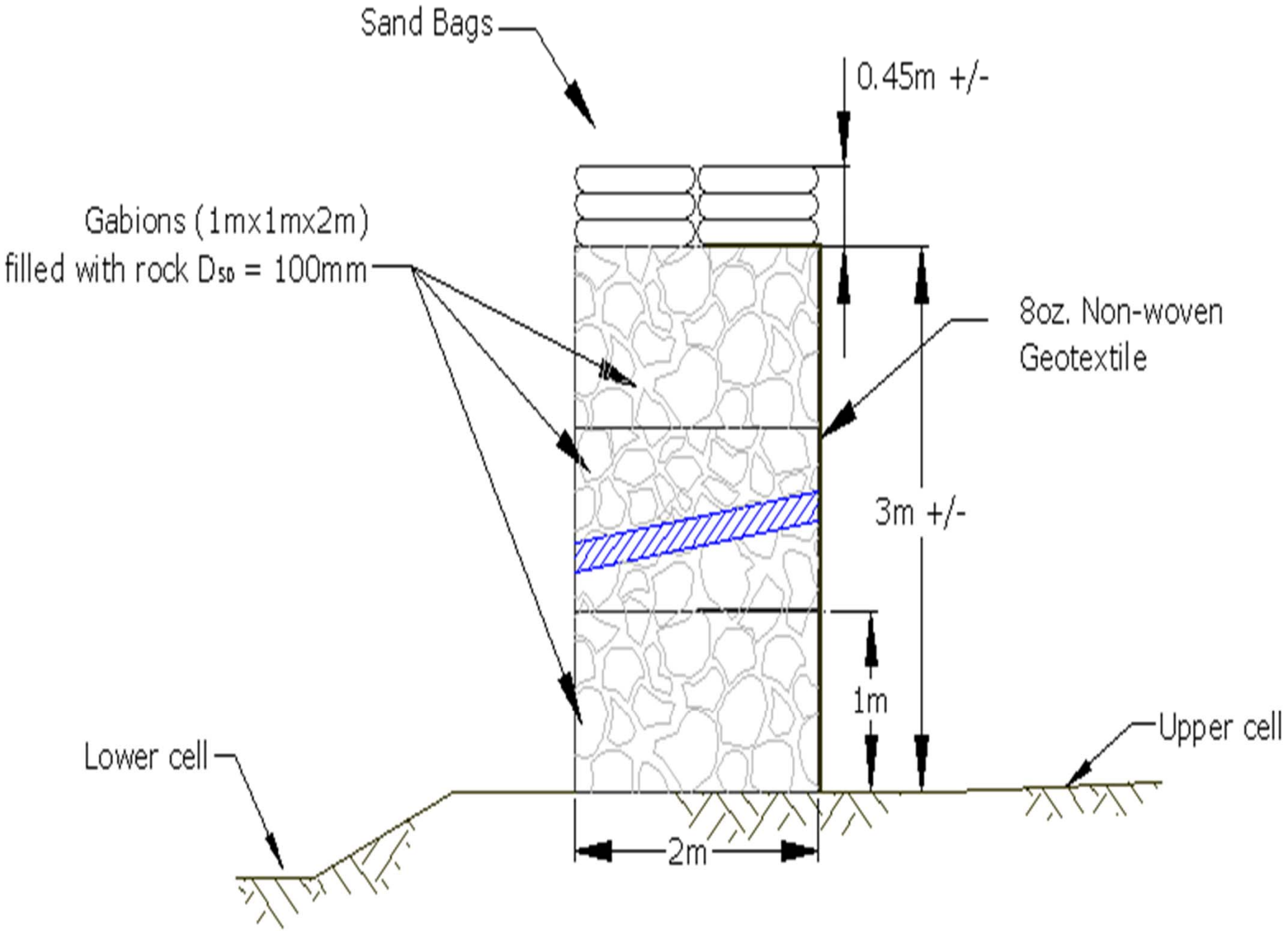
- Incorporates check dams within the diversion
  - Backwater collection at specified locations
  - Facilitates the settling of sediment
  - Temporary stormwater storage
- Low cost passive dewatering controls are used to drain backwater through the *weep berm* into the down-gradient riparian zone

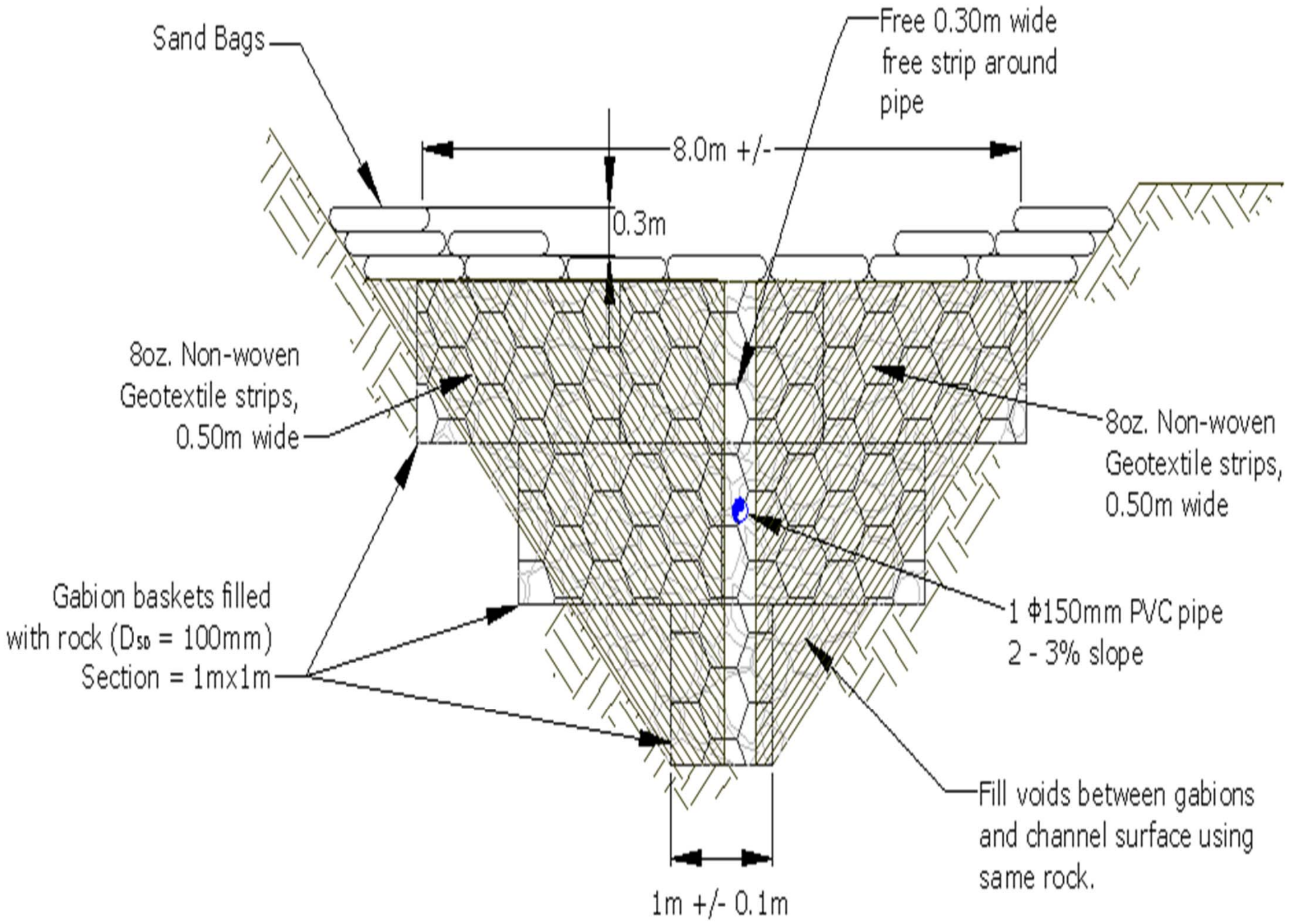

Integrated Weep Berm
Erosion Control System
Check Dam
Discharge
Runoff
Outlet
Structures
Check Dam
25± feet
Weep
Berm
Stream
Watershed Area
Diversion
Channel
Riparian Zone
Check Dam
5 year event
2 year event
1 year event



Additional Benefits

- *Weep berm* operates like many small sediment ponds in series
  - Based on design components and geometry
- Efficiently reduces effluent sediment concentration


Sand Bags
0.45m +/-
Gabions (1mx1mx2m)
filled with rock D_{50} = 100mm
8oz. Non-woven
Geotextile
3m +/-
1m
Upper cell
Lower cell
2m


Sand Bags
Free 0.30m wide free strip around pipe
8.0m +/-
0.3m
8oz. Non-woven Geotextile strips, 0.50m wide
8oz. Non-woven Geotextile strips, 0.50m wide
Gabion baskets filled with rock (D_{50} = 100mm) Section = 1mx1m
1 Φ150mm PVC pipe 2 - 3% slope
Fill voids between gabions and channel surface using same rock.
1m +/- 0.1m

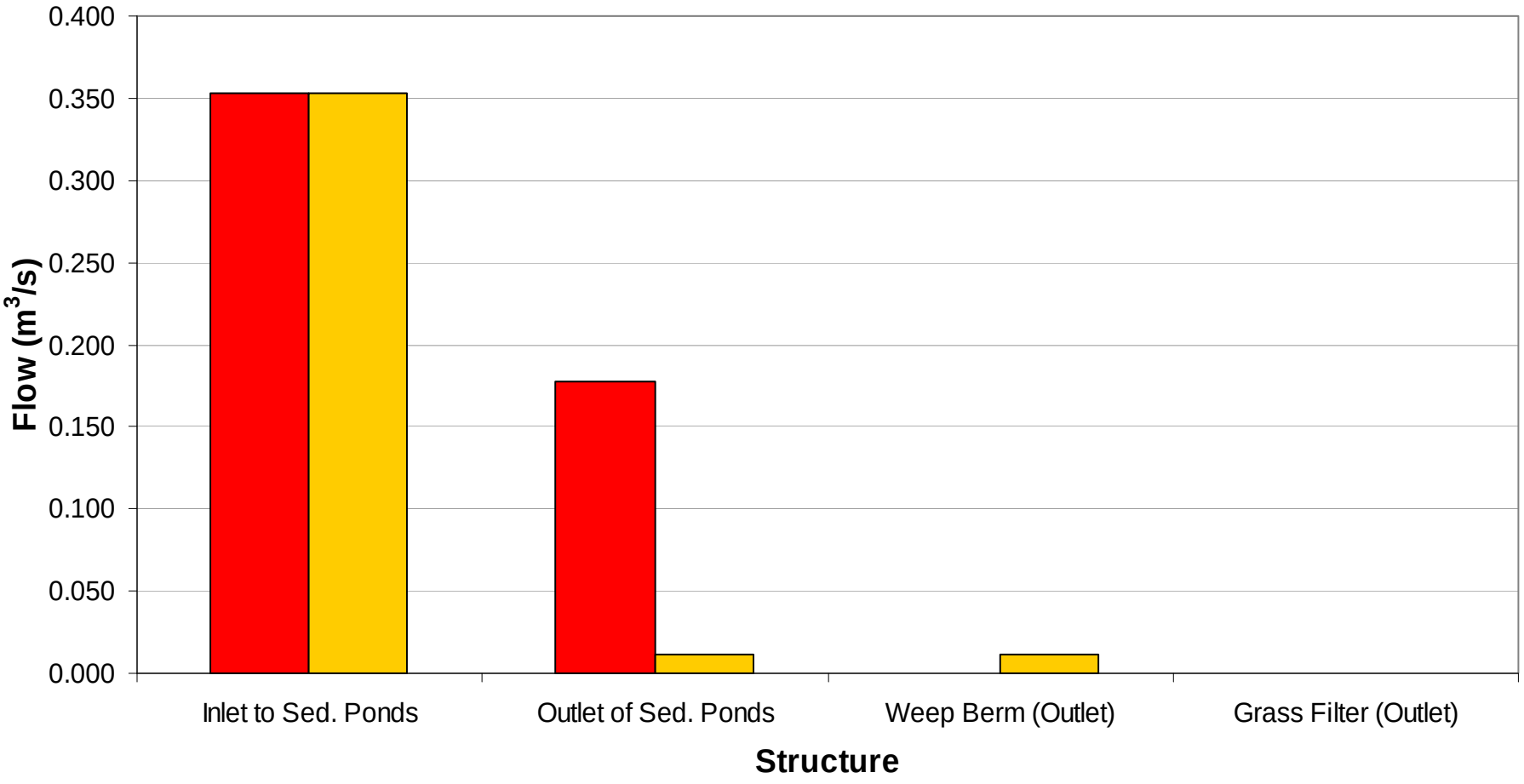
Cu Removal

- Dewatering Sediment Ponds
  - 26% all storms, 11% large storms
- Compost Filters
  - 67%
- Grass Channels
  - 46%

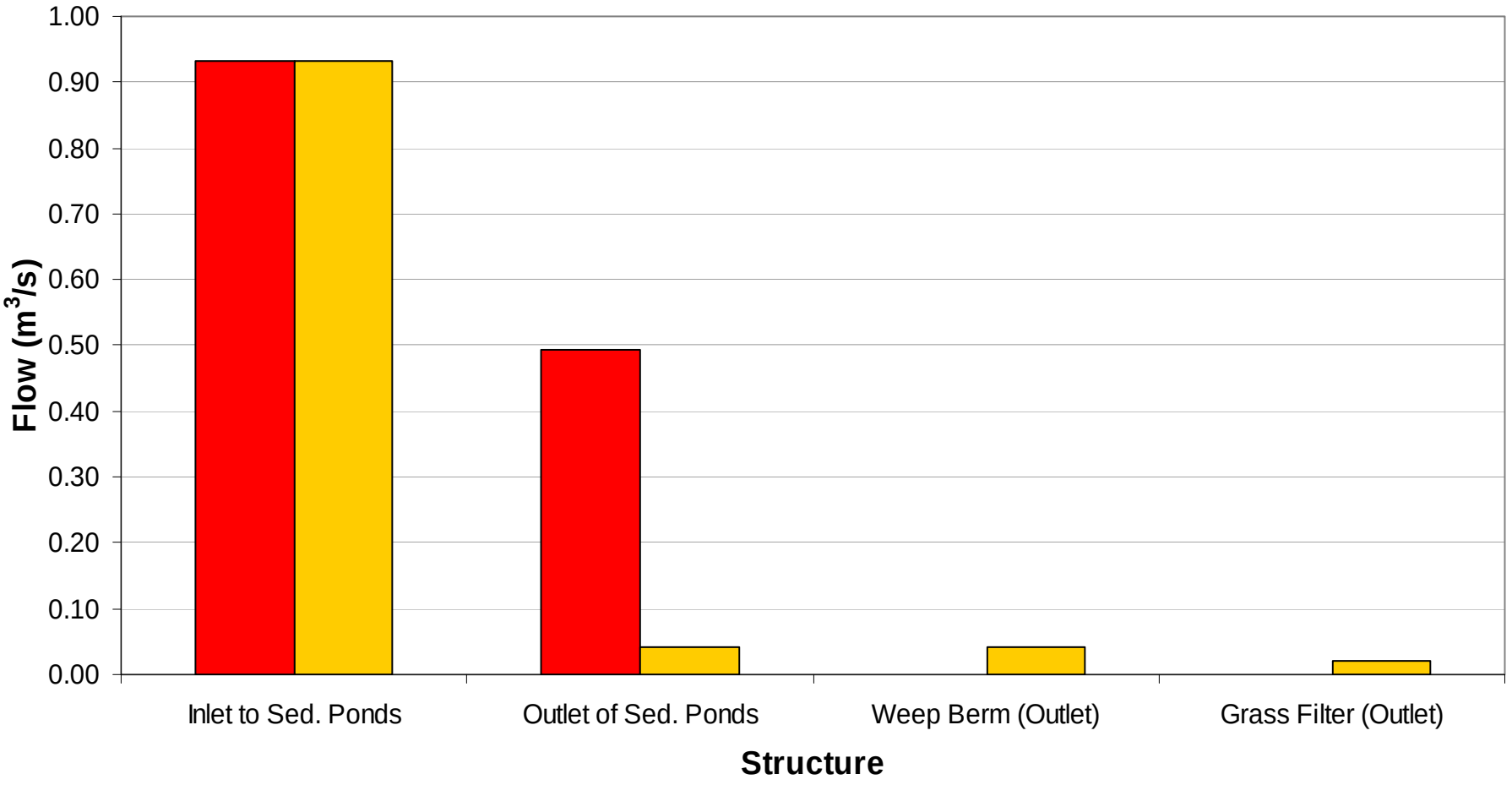
Cu and TSS Removal

- Quality swales (high infiltration)
  - Cu 46-89%
  - TSS 80-98%
- Grass filter strip (TSS)
  - 54% for 75 ft
  - 84 % for 150 ft

Preliminary SEDCAD Results
Peak Flows, 20mm Storm



Preliminary SEDCAD Results
Peak Flows, 2yr 24hr Storm

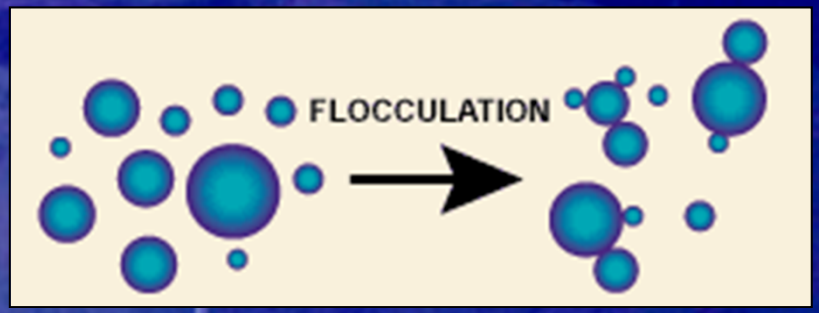


Flocculation

- Widely used in Water Treatment Plants
- Exploration of flocculant use in mining at few sites
- Enhance sediment removal efficiency of sediment detention ponds
- Many products/manufacturers available

Flocculation

- Polymers form bridges between the flocculants
- Particles are bound into large agglomerates or clumps
- Settling rates increased



Polymeric Flocculation Design Experience

- Centralia Surface Coal Mine
  - Modified system resulting in improved compliance
  - Reduced flocculation costs by ~$250,000/year
- Texas Utility Mining Company
  - Simplified $1,000,000 sophisticated system
  - Vastly increased compliance at significant cost savings

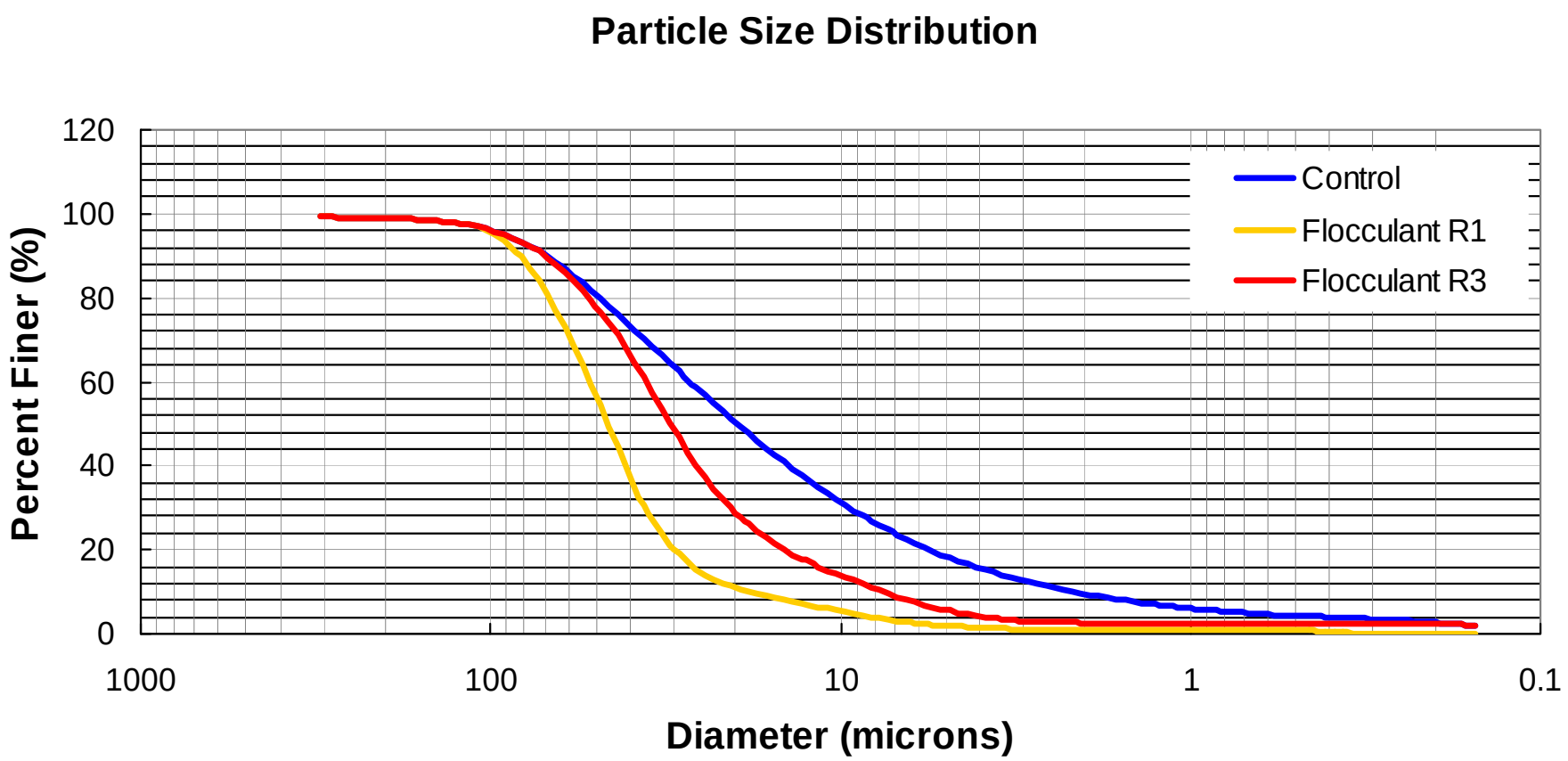
Polymeric Flocculation Design Experience

- Yanacocha (Newmont)
- Conducted flocculation analysis
  - Jar test for screening/selecting flocculent
  - 2m column testing
  - Preparation for site application/modifications

Results
Inflow 1,500 mg/L, Si and Cl

Flocculant Concentration (mg/L)	Effluent TSS (mg/L)
1	<15
2	<15
3	<15
4	20

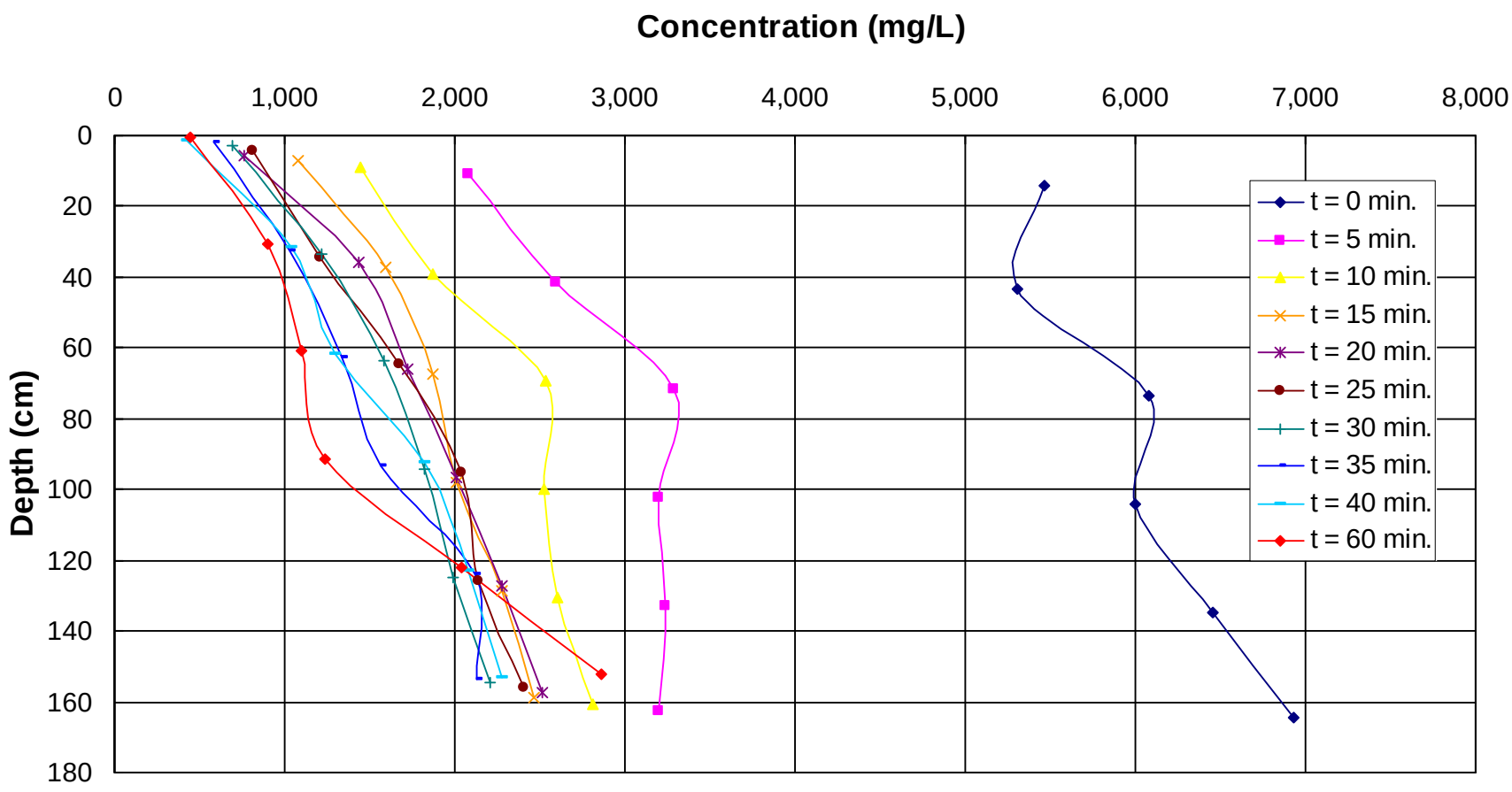
Screening Test



Column Tests

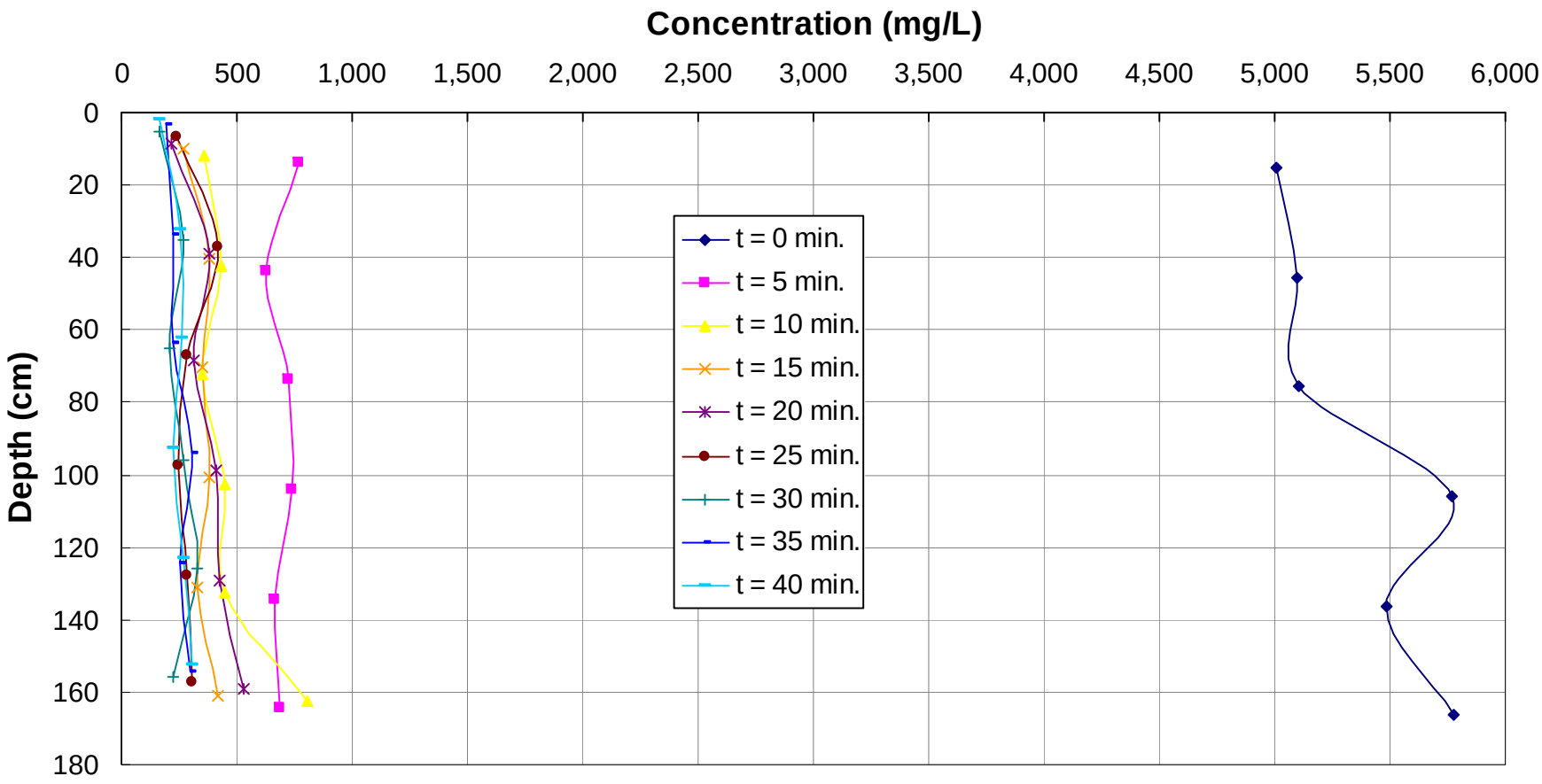
- 9, 12 in. PVC columns
- 6 ports located at 1 ft intervals
- TSS
- Sediments characterization
  - Specific gravity
  - Particle size distribution

Column Tests



Control case (Sediment Type R – Low Conc.)

Column Tests



Flocculant R1 (0.5 ppm)

System Design Components

Applicator

- Less than $100
- Function of flow

Distributor

- Less than $20
- Irrigation nozzles
  - Spatial distribution
  - Across and along channel

Both components are:

- Adjustable/automatic
- Active/passive

System Design Components Channel

- Induce flocculation
  - Particle-to-particle contact
- Create dense, large flocculants through velocity gradient
- Baffled system in channel to control velocity gradient
- Tapered velocity gradient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