Progress on a Passive System for Turbidity Control in Construction Site Runoff

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April 7, 2011

Project Team

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Overall Objectives

- Develop a predictive flocculation model for design and permitting purposes
- Design and test a passive liquid flocculant dosing apparatus suitable for construction site implementation

Outline

- Background
- Methods and Preliminary Results
  - Passive injection/mixing system concept and modeling
    - Flocculent selection/jar tests
  - Concept for measuring flocculation constants
- Continuing work including expected finish date

Sediment Management Strategies

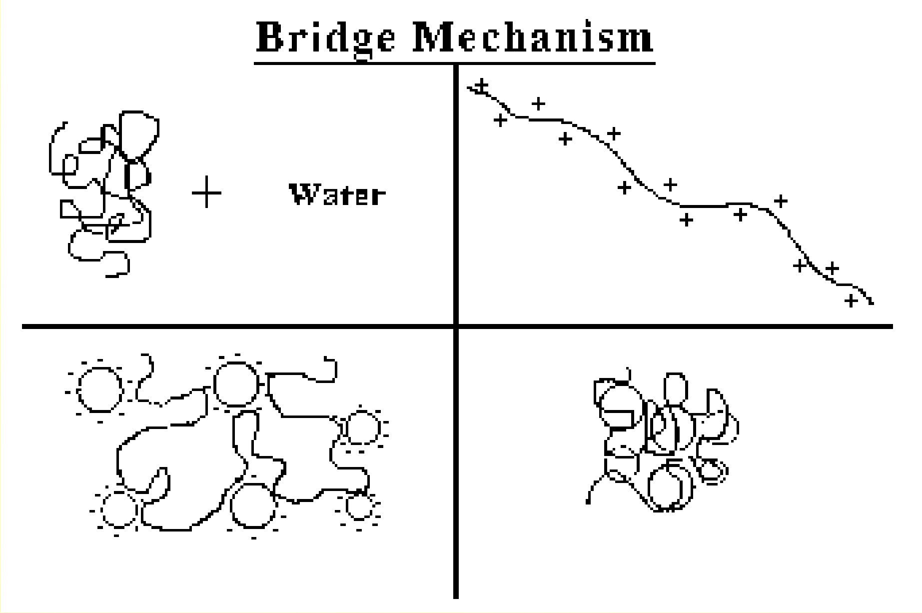
- Erosion Control
  - Surface Armoring
  - Hydraulic Energy Dissipation
- Sediment Capture
  - Sediment detention ponds

Enhanced Sedimentation Using Chemical Flocculants

- Proven technology utilized in wastewater treatment
- Potential to significantly increase onsite sediment capture
- Reduce runoff turbidity
- Decrease required sediment retention pond volume

How does flocculation work?

- Flocculation refers to the bridging between particles by a polymer chain, causing them to form flocs or larger aggregates. These flocs float (flotation) or sink (sedimentation), making them easier to remove from the system.



From: tramfloc.com

Equations for Flocculation

- Based on the binary model for flocculation based on the work done by Argaman and Kauffman (1971)
- Mathematical equations for determining the rate of floc formation and floc break up are

$$\frac{dn_p}{dt} = -\left(H_{1F}\right) + \left(B_{RF}\right)$$

Floc Formation:

$$H_{1F} = \alpha 4 \pi K_S R_F^3 n_1 n_F \overline{u'^2}$$

Floc Break-up:

$$B_{RF} = B R_F \frac{n_F}{R_1^2}$$

α = Fraction of collision resulting in successful flocculation

K_s = Flocculation constant (sec/ft^2)

B = Floc break up constant

n_1= Number of primary particles

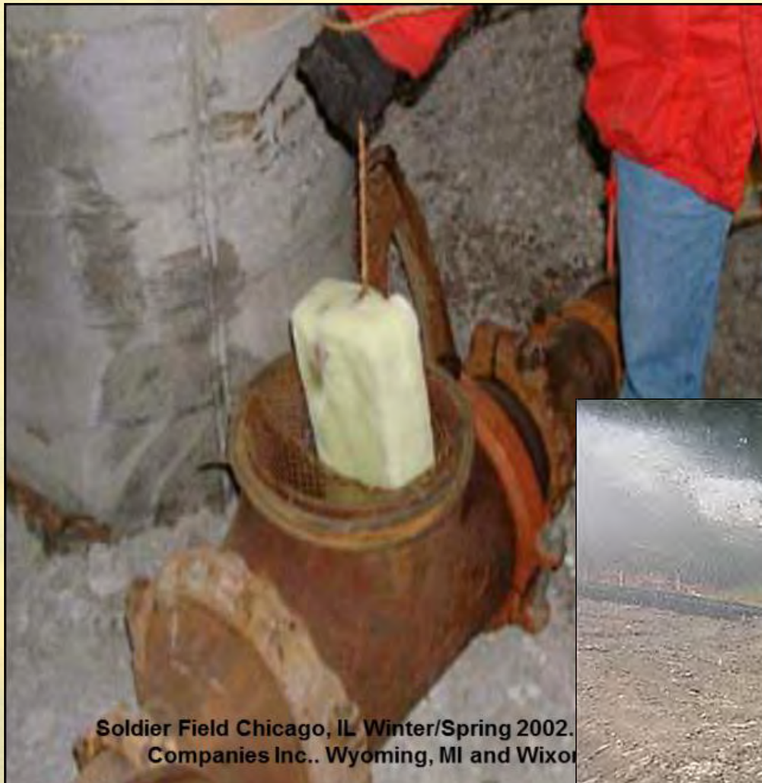
n_F= Number of flocs

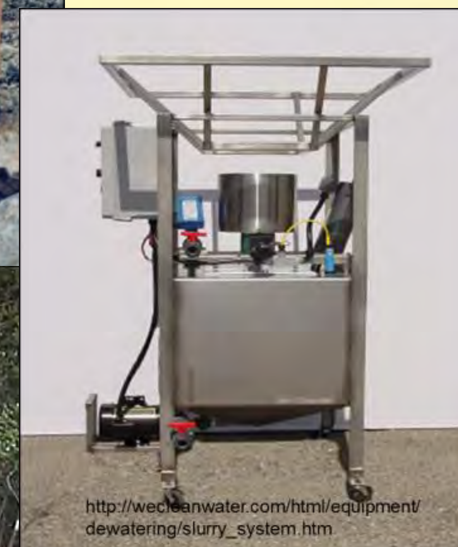
R_1= Radius of primary particles

R_f= Radius of the flocs

u'^2= Root mean square velocity

Current Onsite Flocculation Technologies





Methods and Some Preliminary Results

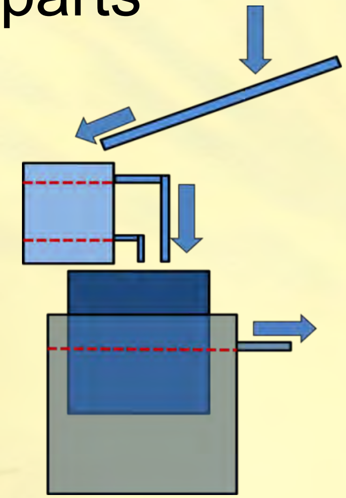
Passive Liquid Injection Devices

Floating bucket

- Rainfall controlled dosing
- Proven feasible
- Simple operating concept and construction
- No moving parts

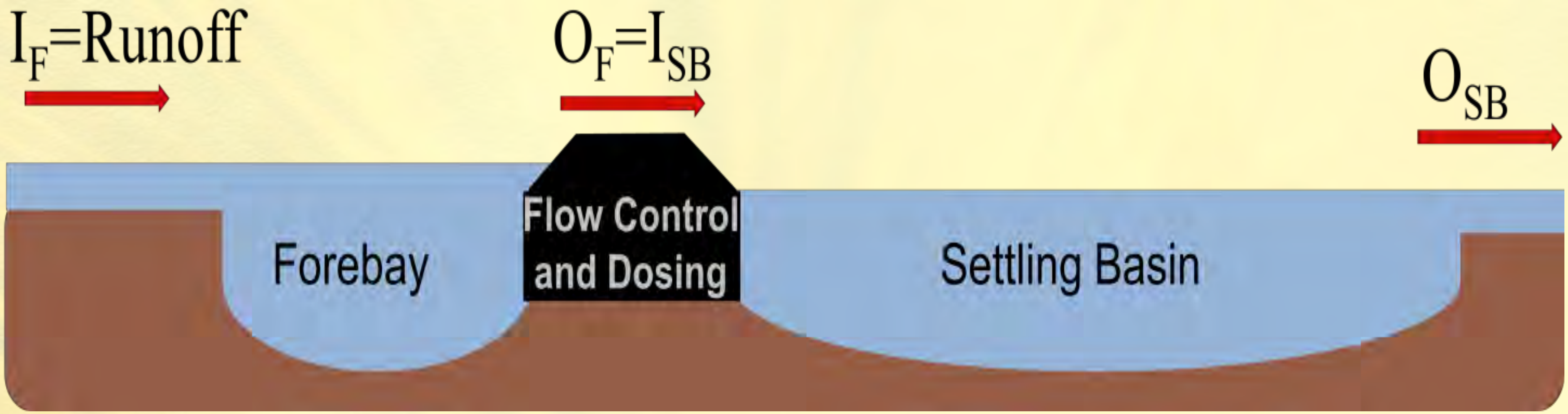
Experimental Design

- Runoff controlled dosing
- Simple design and calibration
- Simple installation



What range of dosing concentration can be achieved by each system?

Conceptual Layout of Experimental Design



Passive System Modeling

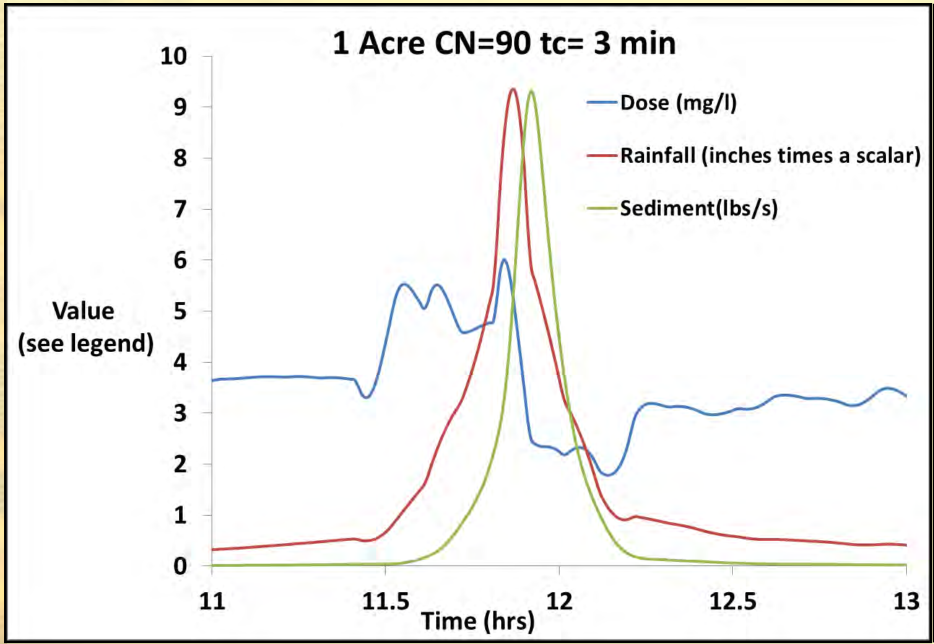
Floating bucket

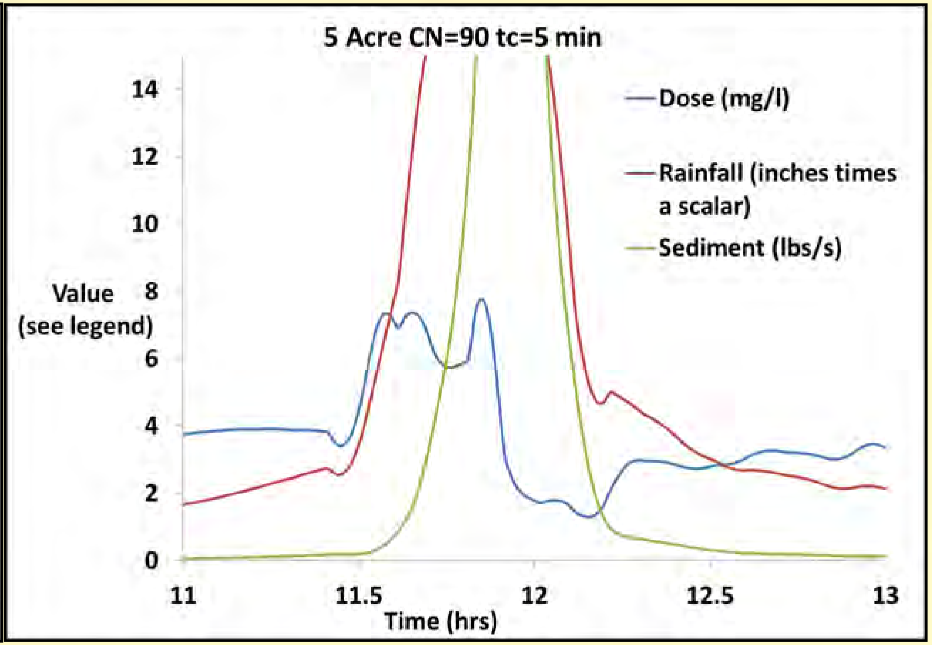
- Changing onsite characteristics impact operation
- Must rely on synthetic storm to design system
- Must be designed on a site to site basis

Experimental System

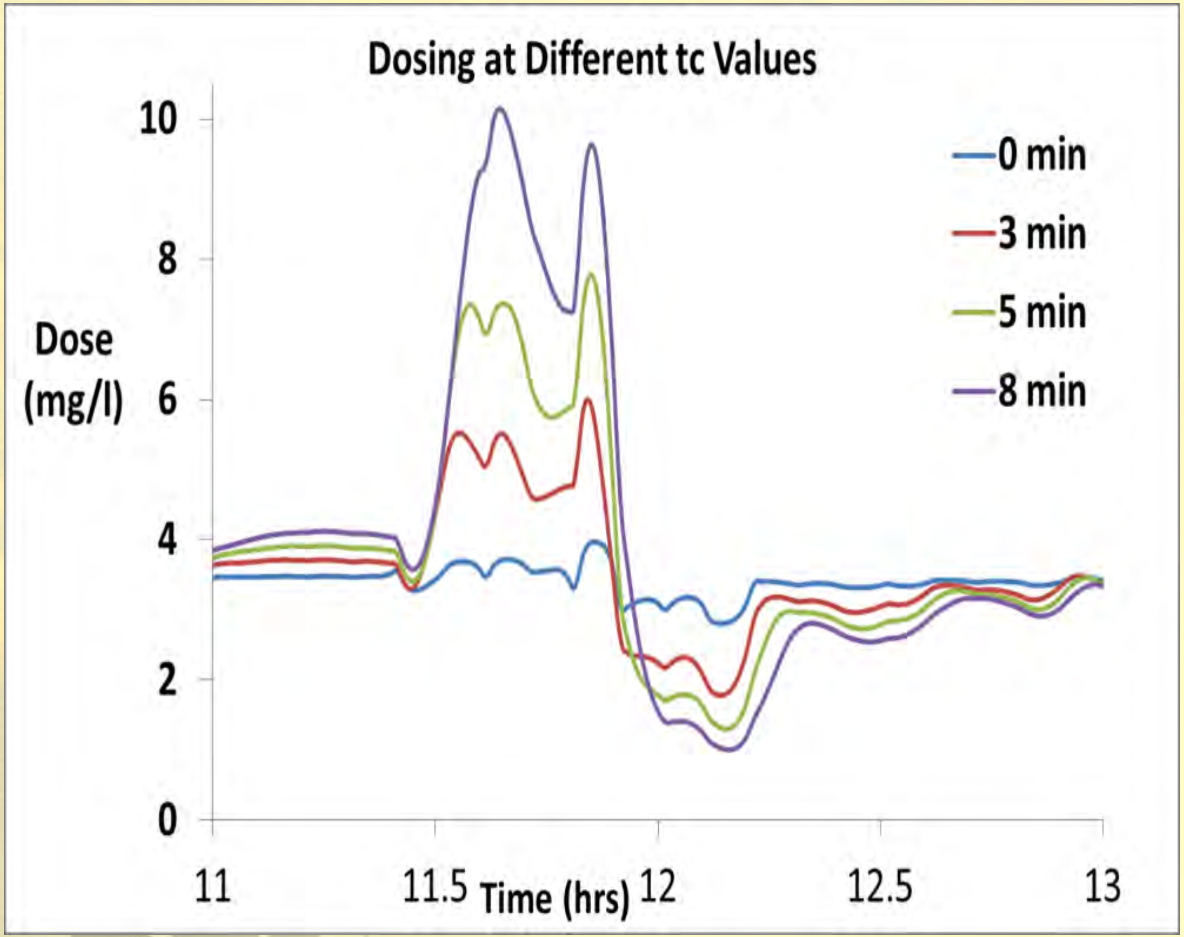
- Doses based on runoff so system is independent of site conditions
- Generalized designs are possible based on expected runoff volumes

Floating Bucket System Modeling





Floating Bucket System Modeling

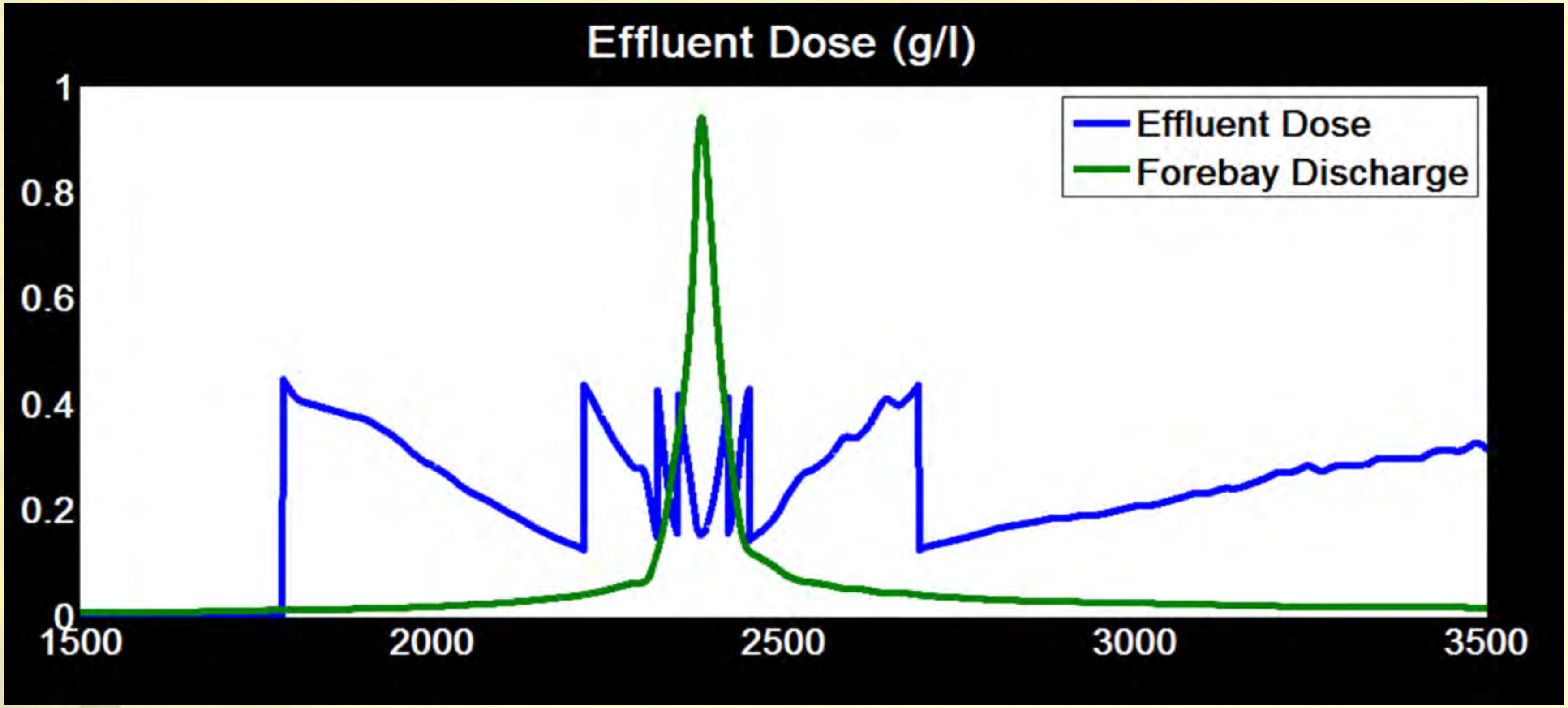


Square (1:1 l:w)

Construction Site

Acres	Minimum (min)	Maximum (min)
1	3	3
2	4	5
3	4	6
5	5	8
10	7	11

Experimental System Modeling



Jar Tests

- The behavior of each soil/flocculant combination is different
- To start with, we are completing jar tests to determine:
  - Type of flocculant to use
  - Velocity gradient to use
  - Concentration of flocculant to use

Jar Test Methods

- 66 second pre-settling (from Stokes equation)
- 5 second mixing
- 4 minute post-settling
- Turbidity measured and TSS analyzed

Jar Test Results

Floc	Pros	Cons
Hydrofloc	Greatest removal efficiency Long stability in concentrated form	Very high viscosity
Superfloc 705	High removal efficiency Moderate viscosity	Difficult to mix Very short stability
FloPam SH (solution)	Easy to mix Low viscosity High removal efficiency	Short stability Difficult to mix
FloPam VLM (solution)	High removal efficiency Moderate Viscosity	Very short stability

Flocculation Modeling

- Argaman and Kauffman (1971) showed that growth maximum size to which the flocs can grow is controlled the velocity gradient 'G' (sec^{-1})
- G is the function of the turbulence that can be generated in the sedimentation basin.
- The estimation of G values will be achieved by a set of oscillating grids in a flume with sediment flow at constant rate.
- The kinetic energy imparted by the grids will be used to estimate the G value which is given by

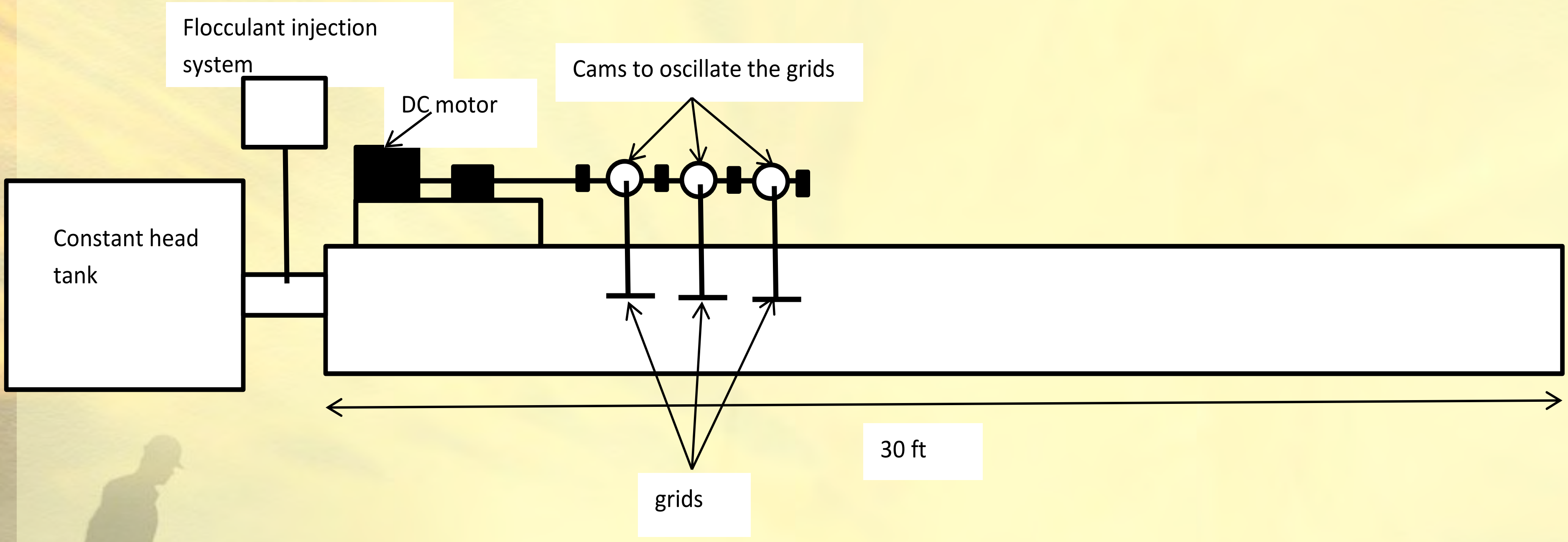
$$G = \sqrt{\frac{\varepsilon}{\vartheta}}$$

where; ε = Kinetic energy dissipated by the oscillating grids in one cycle

ϑ = Kinematic viscosity of the fluid

Flocculation Modeling

Schematic diagram for the oscillating grids:



Preliminary Conclusions

- Design for passive injection and mixing system selected
- For our preliminary design, we will be using diluted Hydrofloc as our flocculent
- Design for flocculation parameter estimation apparatus selected and under construction

Continuing work…

- Field testing of injection and mixing apparatus
- Continue jar tests on diluted Hydrofloc to estimate flocculent concentrations and velocity gradients necessary for optimum flocculation
- Testing of two soils to detemine flocculation parameters
- End date: June 30, 2011

Acknowledgements

- The research team is grateful to Greenville County, South Carolina for funding this research.

Questions???