Biodegradable Liquid Shoring

- General Characteristics and Use

Background

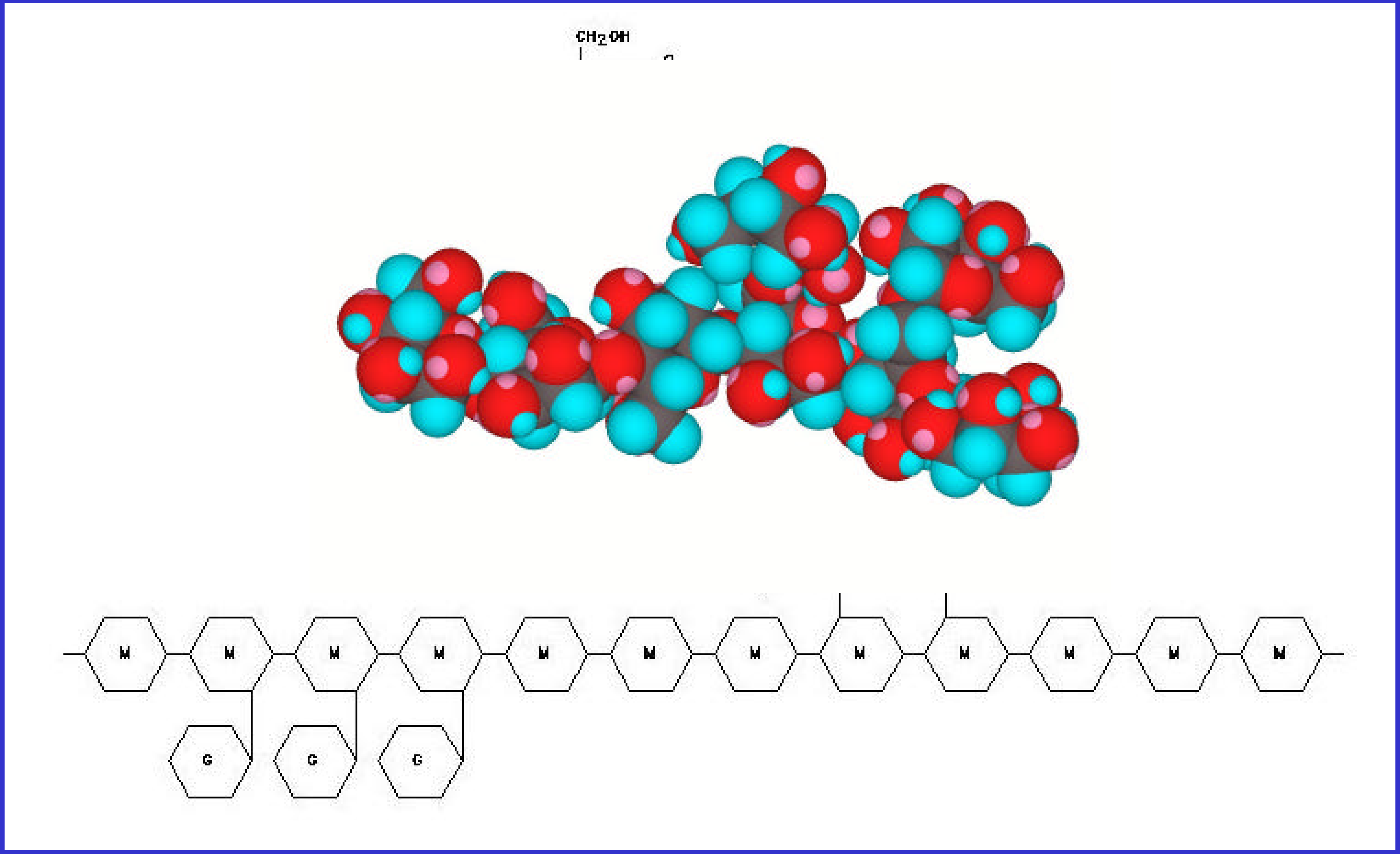
- History – Introduced in 1986 to USA
- Utility – Drains and PRB's
- In Context Biopolymer is Guar Gum
- Fluid Characteristics of Guar Gum solution

Origin and Chemistry

- **Legume – *Cyamopsis tetragonalobus***

Processed to Powder

Guar Gum Biopolymer Structure



Excavation Stability Factors

- Hydrostatic Head
- Wall Cake
- Viscosity

Hydrostatic Head

- Differential Over Groundwater
- Prevents Erosion by Groundwater Entry
- Fluid Density and Head Determine Force

Wall Cake

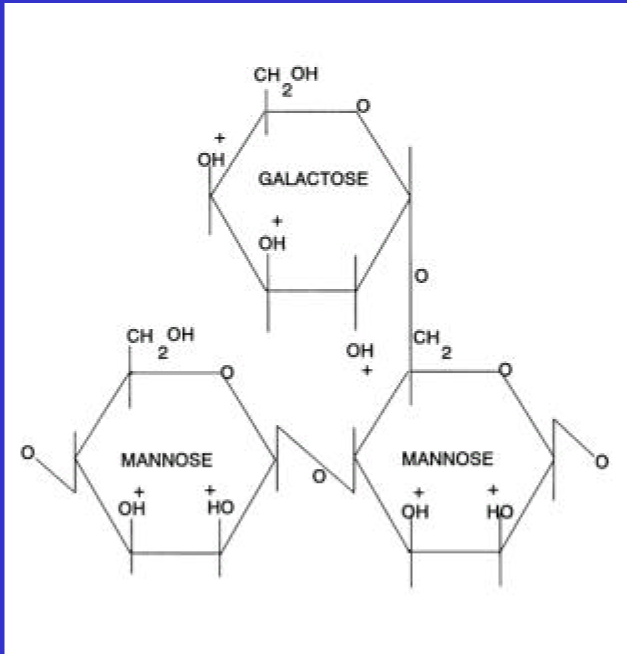
- Polymer Forms Hydrogen Bonds to Clay & Silica
- Coats Clays to Prevent Water Damage Penetration, Swelling and Dispersion
- Prevents Water Penetration Into Sand
- Completely Broken Down by Enzyme

Viscosity

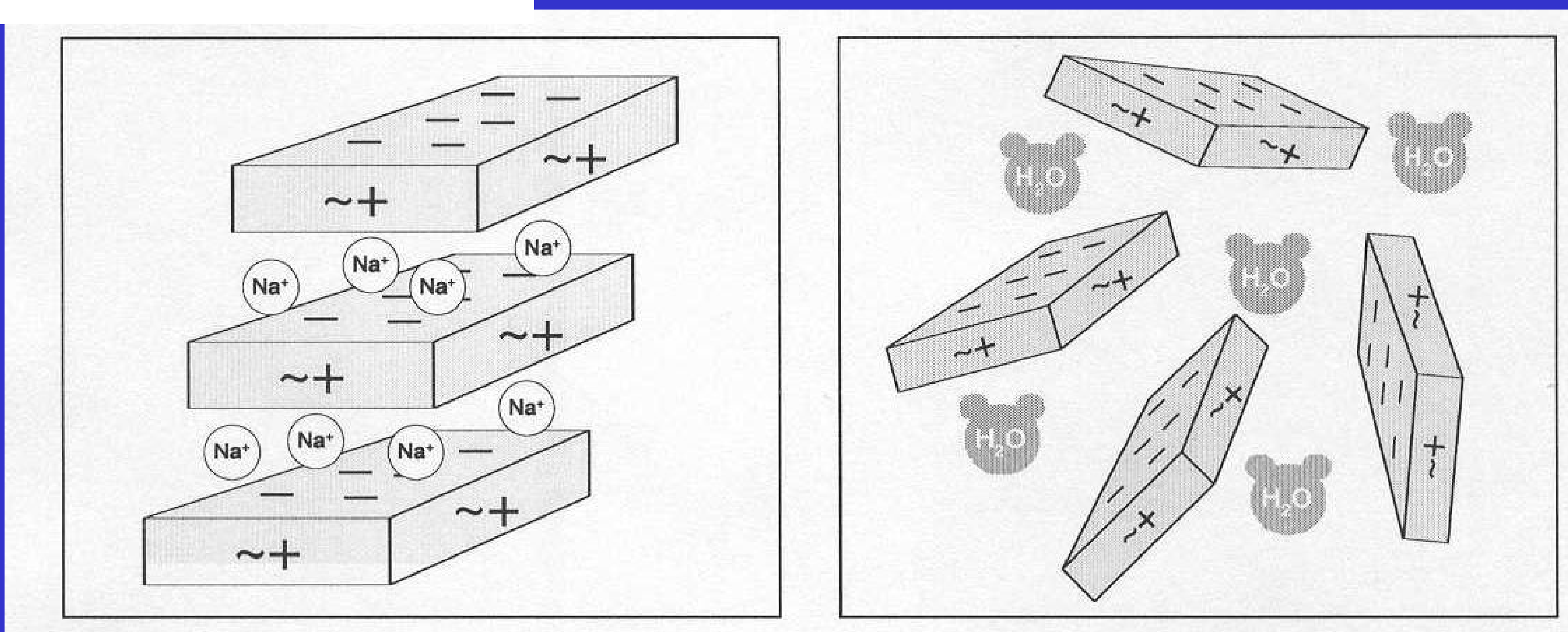
- Limits and Slows Slurry Movement, Washing
- Limits Movement of Solids

Chemical Bonding of Polymer

- Polymer Molecules Adsorb onto Soil via Hydrogen Bond -- Bridging Between Particles
- Clay Surfaces are Negatively Charged
- Silica Edges are Negatively Charged



CH2OH
O
OH
GALACTOSE
OH
O
CH2OH
OH
CH2
O
O
MANNOSE
O
MANNOSE
O
OH
HO
OH
HO



~+
Na+
H2O

Chemical Bonding of Polymer

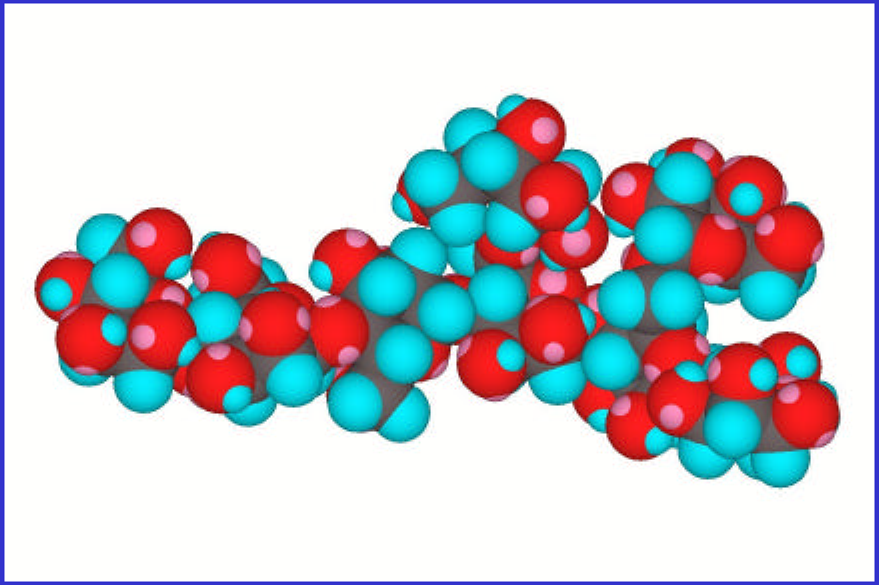
- Polymer Molecules Adsorb onto Soil via Hydrogen Bond -- Bridging Between Particles
- Clay Surfaces are Negatively Charged
- Silica Edges are Negatively Charged
- Polymer Exterior Structure is Positively Charged

Fluid Characteristics

- Non-Newtonian Rheology – Shear Thinning Allows Easier Pumping and Delivery
- Viscosity – Typically 60 to 120 Marsh Funnel Seconds
- Low Gel Strength – Solids Settle Quickly for Clean Fluid – Reduces Contamination of Media
- Unit Weight – Slurry Alone 62.4 pcf
- Unit Weight in Use – 63 to 70 pcf
  - Dependent on type of soil excavated and Time Frame
- Fluid Loss – Limited by wall cake formation – Controls Face erosion
- Clay Stabilization – Polymer Bonding Prevents Dispersion and Swelling of Contacted Clays

Polymer Biodegradability

- **Guar gum is a complex carbohydrate consisting of galactose and mannose sugars, easily broken by microbes or chemically.**



Breakdown Mechanisms Include

- Biological Consumption by Molds, Fungi, Bacterium from Air and Soil
- Enzyme Breaker
- Bleach or other oxidizing agents

Results of Breakdown

- Oligosaccharides and simple sugars
- Short-term microbial consumption of Oligosaccharides
- Carbon Dioxide and Water as Microbes Consume sugars
- Other constituents depend on additives

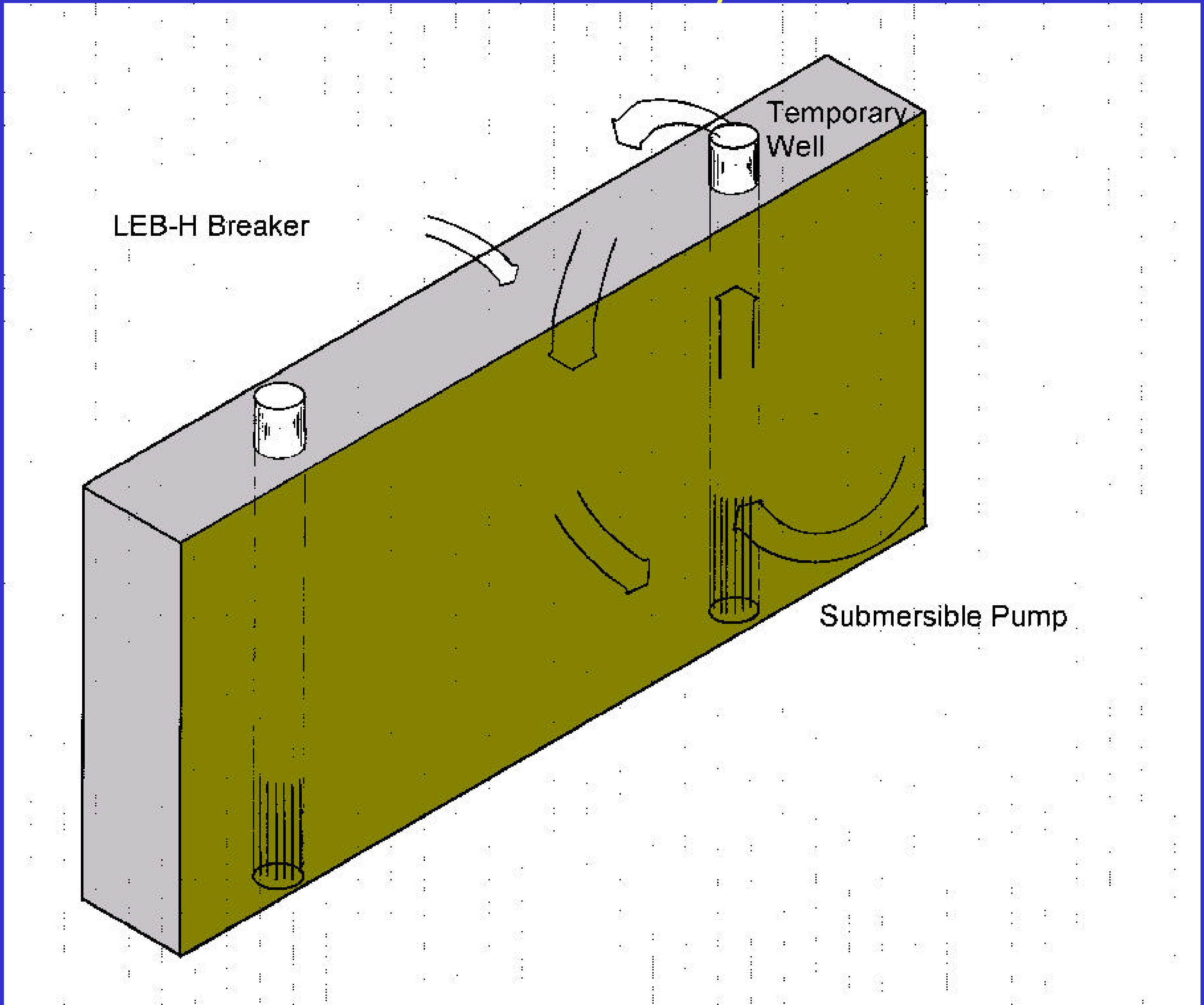
Trench Media Development Steps

- Preparation
- Chemicals for Optimum Conditions
- Circulation and Contact
- Enzyme Action
- Microbial Action
- Potential slurry Removal

Media Development

- Preparation – Means of Injection and Circulation Installed
- Chemicals – Optional pH Adjustment and Enzyme Breaker
- Circulation – Fluid is Pumped to Maximize Contact Throughout Media Zone and Walls

Circulation and Enzyme Addition



Media Development

- Enzyme Action
  - Enzyme is Specialized Protein
  - Liquid Base Water and/or Glycol
  - Enzyme Contacts Polymer Breaking Bonds
- Microbial Action –
  - Completes Degradation
  - Metabolization of Sugars
- Removal of Slurry in Special Cases

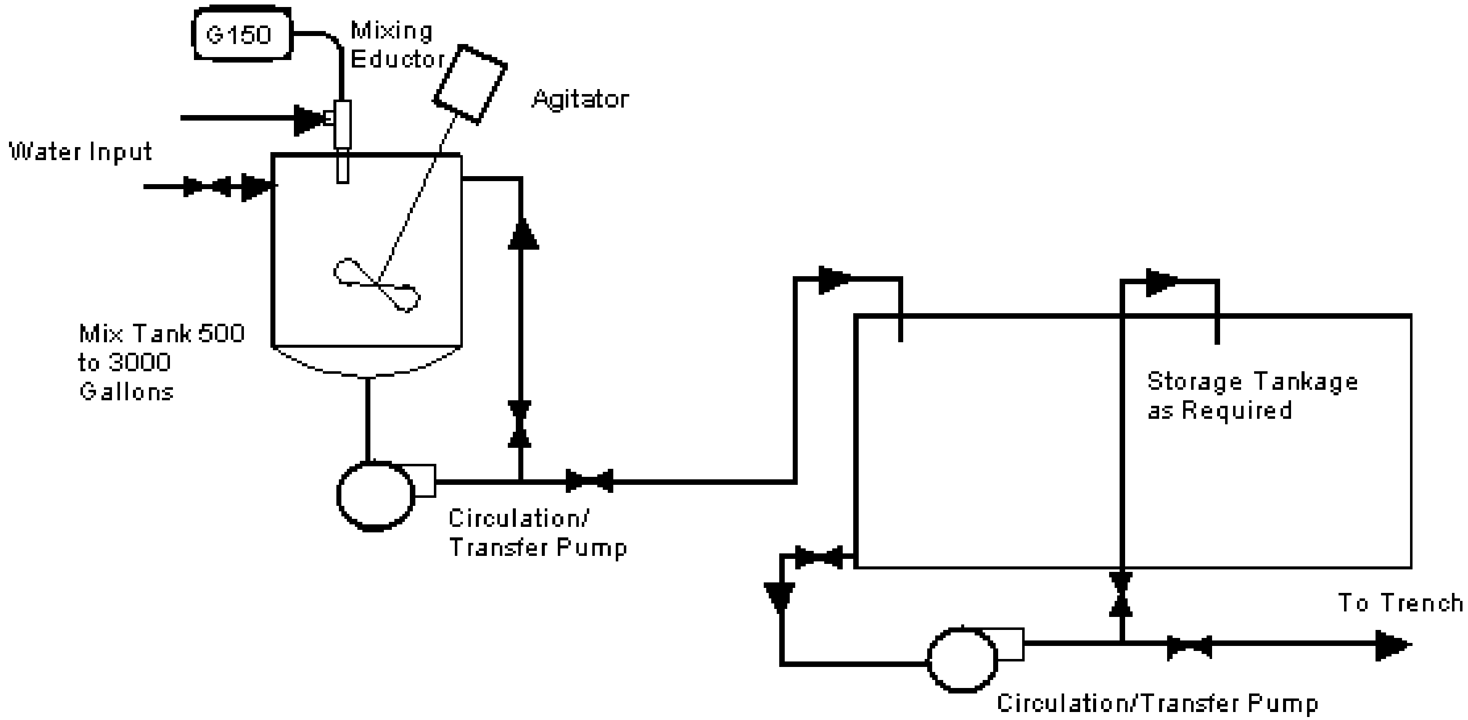
Project Planning Steps

- Consider GeoTechnical Stability
- Test Site Factors for Compatibility
- Design Mix for Adequate Stability
- Potable Water Source
- Mixing Equipment and Storage
- Clean System
- Mix, Age and Monitor Slurry
- Excavate and Install PRB
- Develop Media by Breaking Biopolymer

Mixing and Preparation

- Production Goal -- Homogenous, Stable Fluid
- Typical Mixing Equipment
  - Wets
  - Mixes
  - Ages and Hydrates

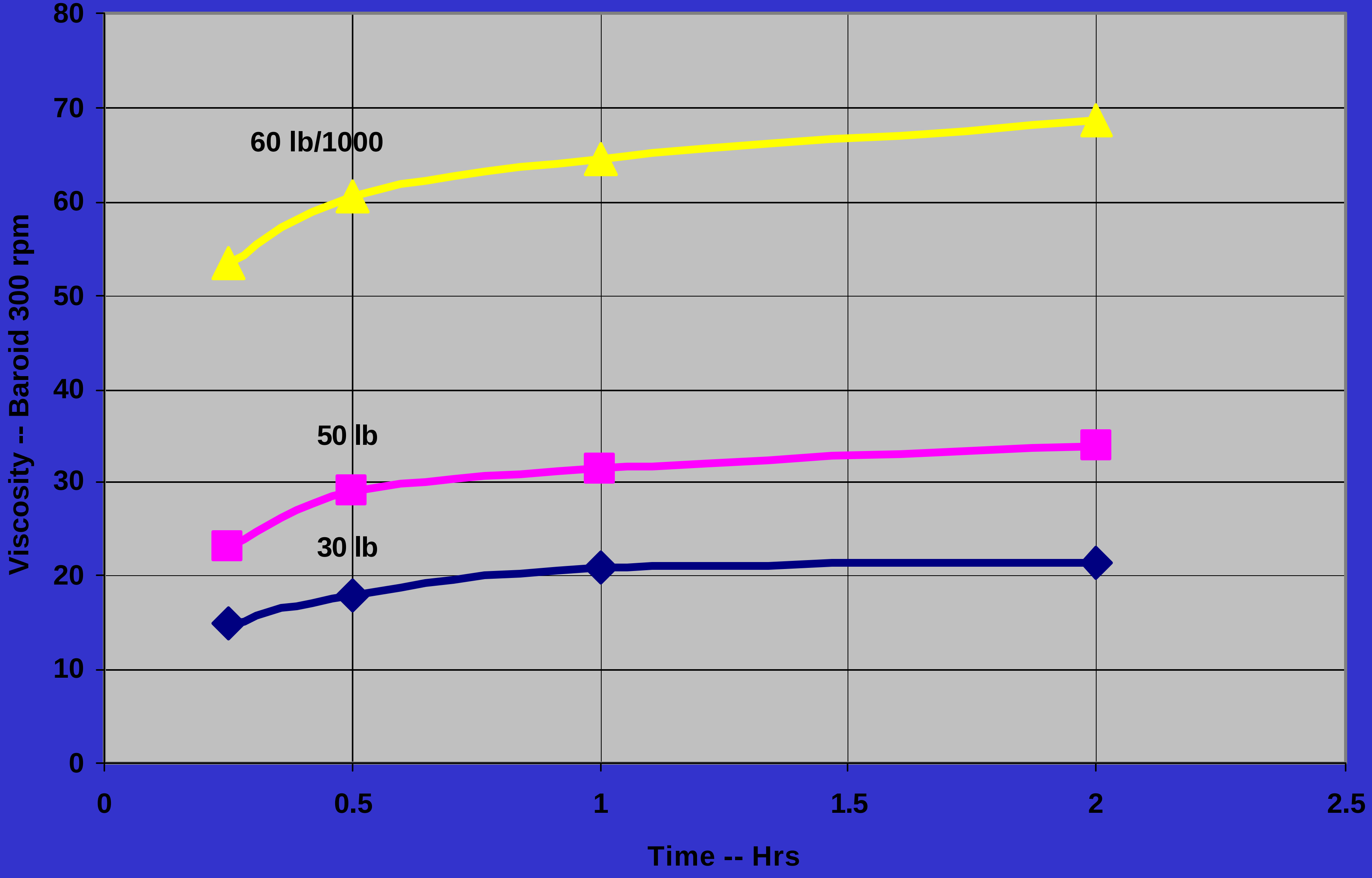
Typical Field Mixing



Mixing and Preparation

- Production Goal -- Homogenous, Stable Fluid
  - Typical Mixing Equipment
    - Wets
    - Mixes
    - Ages and Hydrates
- Storage for Adequate Hydration Time
- Proper Aging See Hydration Chart

G150 Hydration



Stabilization

- Pre-Job Site Factor Testing
- System Cleanliness – Water and Equipment
- pH Control – To Reduce Microbial Activity
- Biostat – To Slow Microbial Growth
- Preparation for Breakdown – Reversal of Stabilization Chemistry

Quality Control

- Regular Monitoring of pH and Viscosity
- Viscosity – Marsh Funnel or Baroid Rheometer


Bradley
RHEOMETER

Quality Control

- Regular Monitoring of pH and Viscosity
- Viscosity – Marsh Funnel or Baroid Rheometer
- pH – Meter or Indicator Paper
- Record Keeping – Trends of Use and Stability

Rantec Corporation

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Compatibility with Media

- Zero Valent Iron
  - ETI Testing Indicates G150 Compatible
  - Dazomet (Busan 1059WS) and Dimet Biostats Compatible
- Carbon Source Field Use in B.C. Indicates Compatibility
- G150 is Generally Compatible Due to its Biodegradability

Recent PRB Installations Using Biopolymer

Location	Depth	Year Installed
Kelly AFB, TX	32 ft.	2003
Carswell AFB, TX	40 ft.	2002
Kelly AFB, TX	30 ft.	2002
Needham, MA	46 ft.	2001
Vancouver, BC	50 ft.	2001
Somersworth, NH	47 ft.	2001
Pease AFB, NH	35 ft.	1999, 2000
Travis AFB, CA (Breaker Only)		2001