The Big Five Tunnel Project
Long-Term Lessons

Tom Wildeman
Colorado School of Mines, Golden, CO
twildema@mines.edu,

Jim Gusek
Golder Associates, Lakewood
jgusek@Golder.com

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Outline

- **Project Startup**
  - **Roger Olsen**
  - **Ed Bates**
- **Fumbling Around**
  - **Different configurations**
  - **Getting to the core of treatment**
- **Principles Uncovered**

Big Five Tunnel, Idaho Springs

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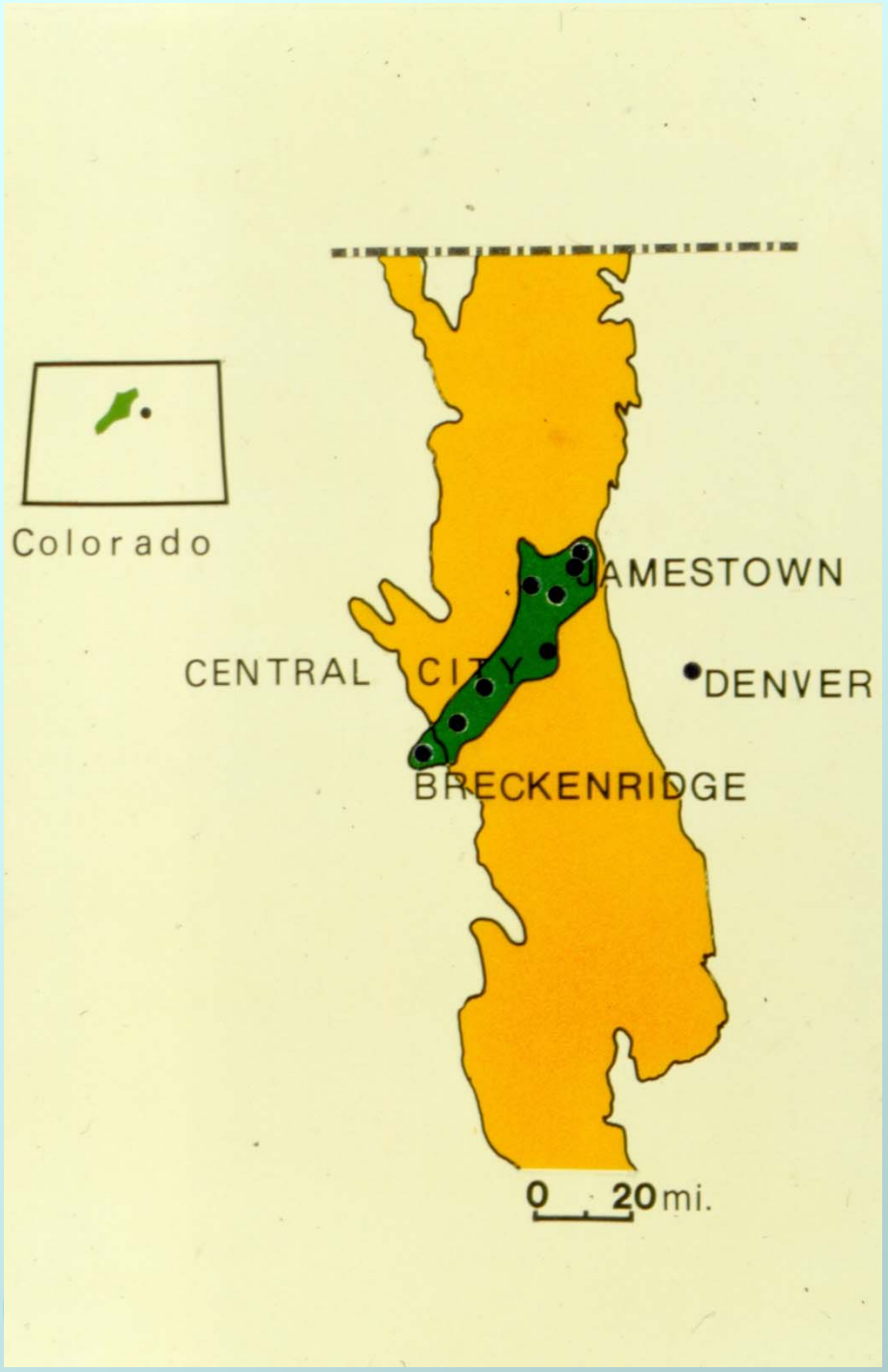

In the Front Range Mineral Belt & Part of the Central City – Idaho Springs Super Fund Site

Big Five ARD

Constituent	mg/L	Constituent	mg/L
pH	2.6	Zn	10
Al	18	Cu	1.6
Fe	50	Cd	0.03
Mn	32	Pb	0.01
SO_4=	2100	As	0.02

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What Roger Did

- **CDM in charge of Super Fund site assessment for EPA Region VIII**
- **Wanted to assess "Constructed Wetlands" as a treatment option**
- **In 1987, chose Colorado School of Mines (CSM) to start a wetlands assessment project.**
- **Roger is an alumnus of CSM and Chemistry & Geochemistry**

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Why CSM?

- **Reputation for Applied Research**
- **Collegial & Interdisciplinary**
  - **John Emerick – Plant Ecologist**
  - **Ron Cohen – Environmental Engineer**
  - **Ron Klusman – Geochemist**
  - **Dave Updegraff – Applied Microbiology**
  - **Tom Wildeman – Herder of Cats**

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Roger Also Selected Geotechnical Engineering Support

- **Gormley Consultants**
  - **John Gormley**
  - **Jim Gusek**

First Lesson

- **Need broad expertise in sciences & geotechnical engineering to understand & design passive treatment systems.**
- **Have to think broadly, not deeply**
- **Have to apply engineering “loosely,” not rigidly.**

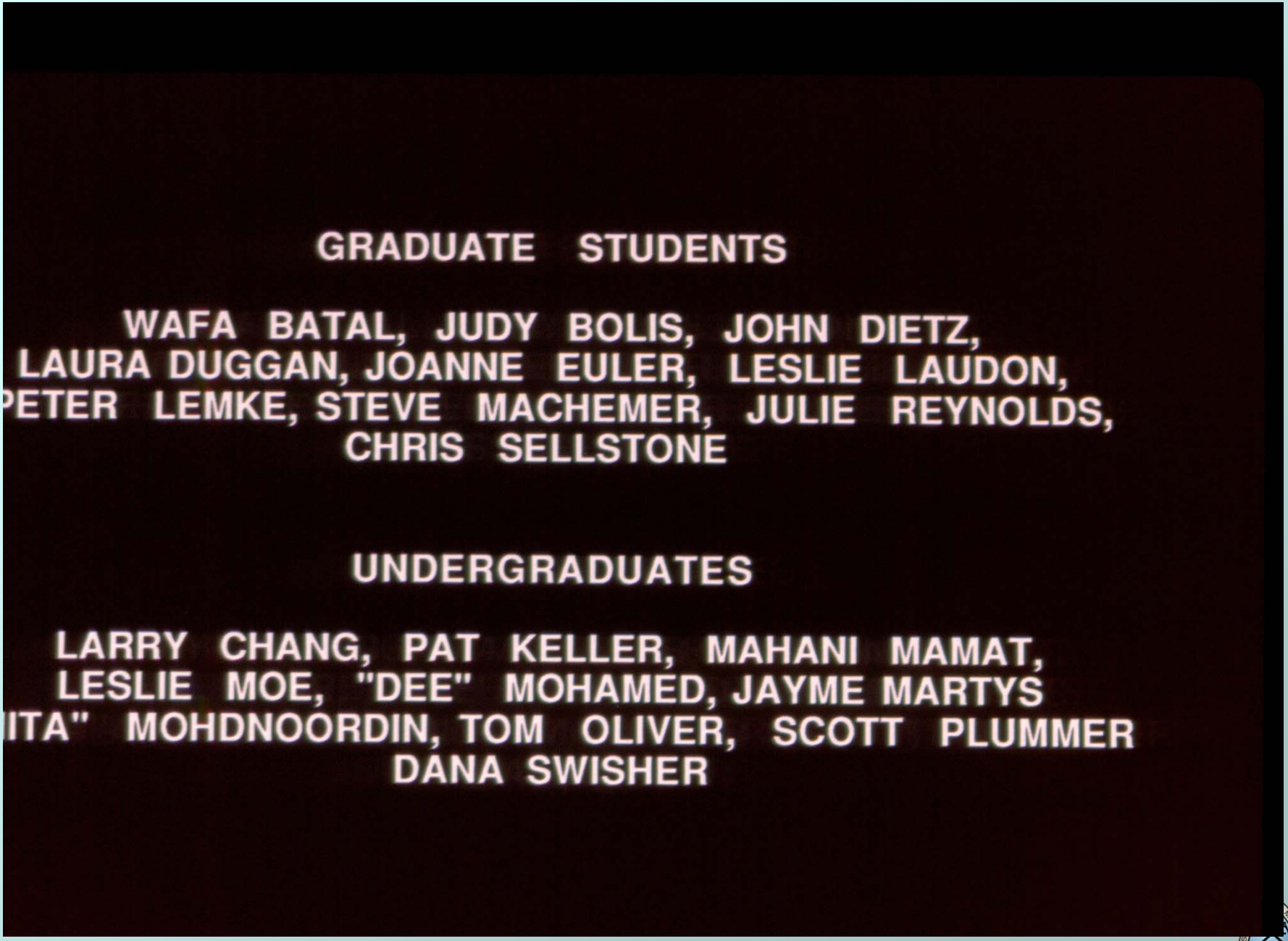
What Ed Bates Did

- **In 1988, awarded funding through the Emerging Technologies Program of the EPA Superfund Innovative Technology Evaluation (SITE) Program. Ed was program manager.**
- **Immediately banned us from our site for two months.**

We had no OSHA training and we had to write a Quality Assurance Project Plan (QAPP)

What Ed Really Did

- **Introduced us to the "real world"**
  - **Mandatory Project meetings where the students gave progress reports.**
  - **Progress & final reports**
  - **"Applied Conferences" where the industry became familiar with the technology.**
    - **Talks**
    - **"Gray literature"**


GRADUATE STUDENTS
WAFA BATAL, JUDY BOLIS, JOHN DIETZ,
LAURA DUGGAN, JOANNE EULER, LESLIE LAUDON,
PETER LEMKE, STEVE MACHEMER, JULIE REYNOLDS,
CHRIS SELLSTONE
UNDERGRADUATES
LARRY CHANG, PAT KELLER, MAHANI MAMAT,
LESLIE MOE, "DEE" MOHAMED, JAYME MARTYS
ITA" MOHDNOORDIN, TOM OLIVER, SCOTT PLUMMER
DANA SWISHER

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Original Configuration

- **Three cells 10 x 20 ft**
  - **Pennsylvania constructed wetlands criterion of 200 square ft /gal/min.**
- **Cell One: Mushroom compost**
  - **Success with this in Pennsylvania**
- **Cell Two: Peat/cow manure/saw dust**
- **Cell Three: Same as two but with a layer of limestone on the bottom.**

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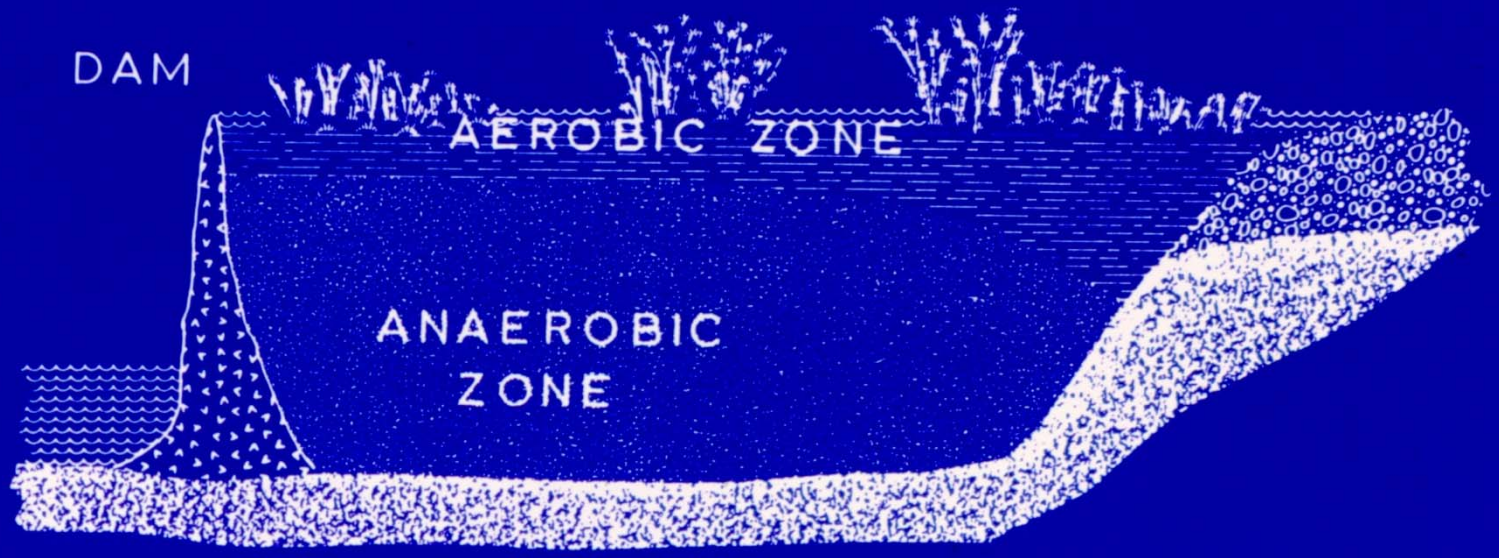
Assumed Plants Were Important

Things Happened Immediately

Fundamental Concept Picture

Gusek & Bates: Tom, you know nothing about dam construction



Problem

- **Designed for water to flow across the top.**
- **Desire to have the water flow through the substrate**

Second Lesson

- Production of sulfide is the limiting reagent for removal
- Need a volume based removal criterion, not a surface based criterion.
- A reasonable rule of thumb is that 0.3 moles of sulfide will be produced per cubic meter of substrate per day

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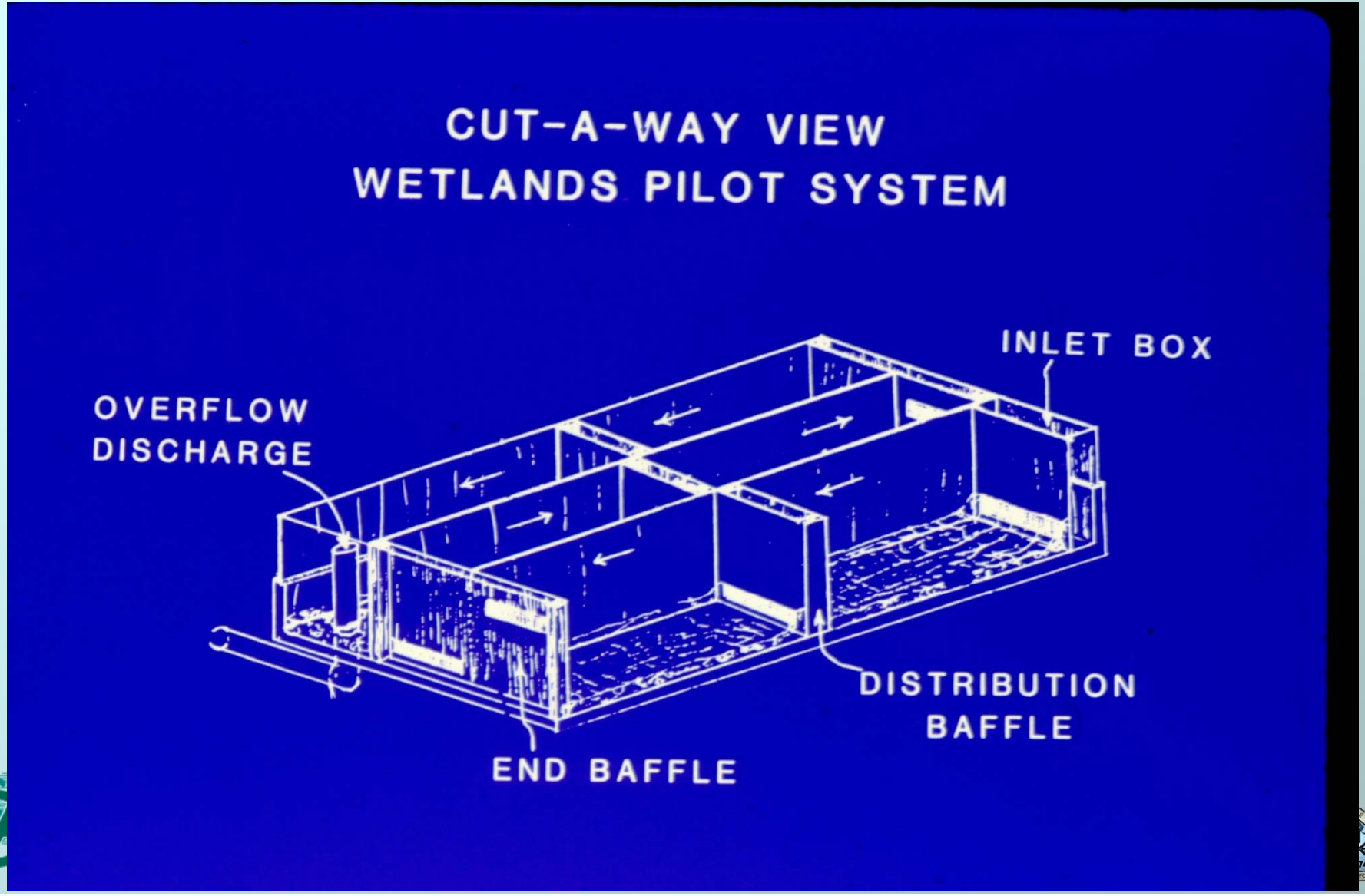
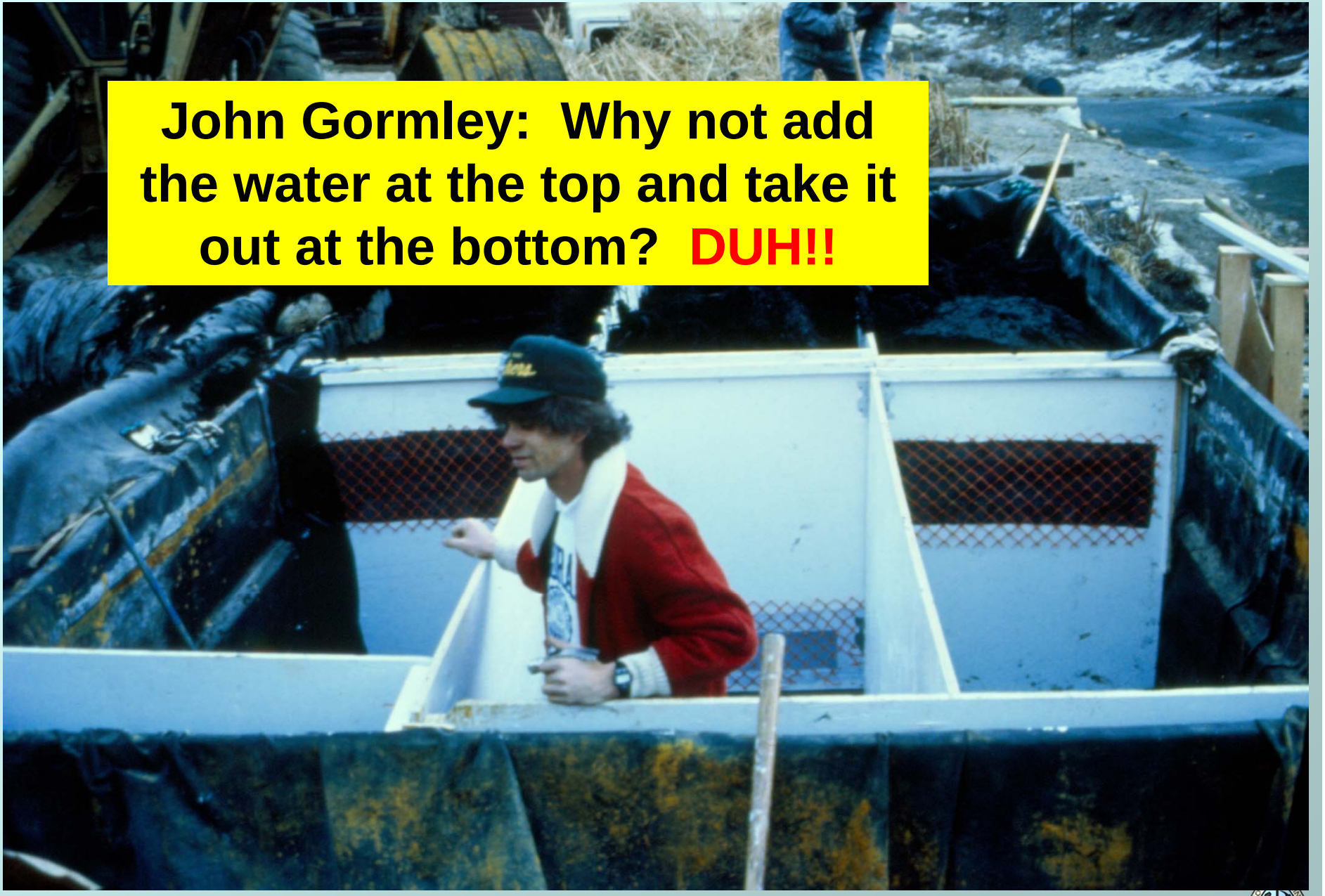
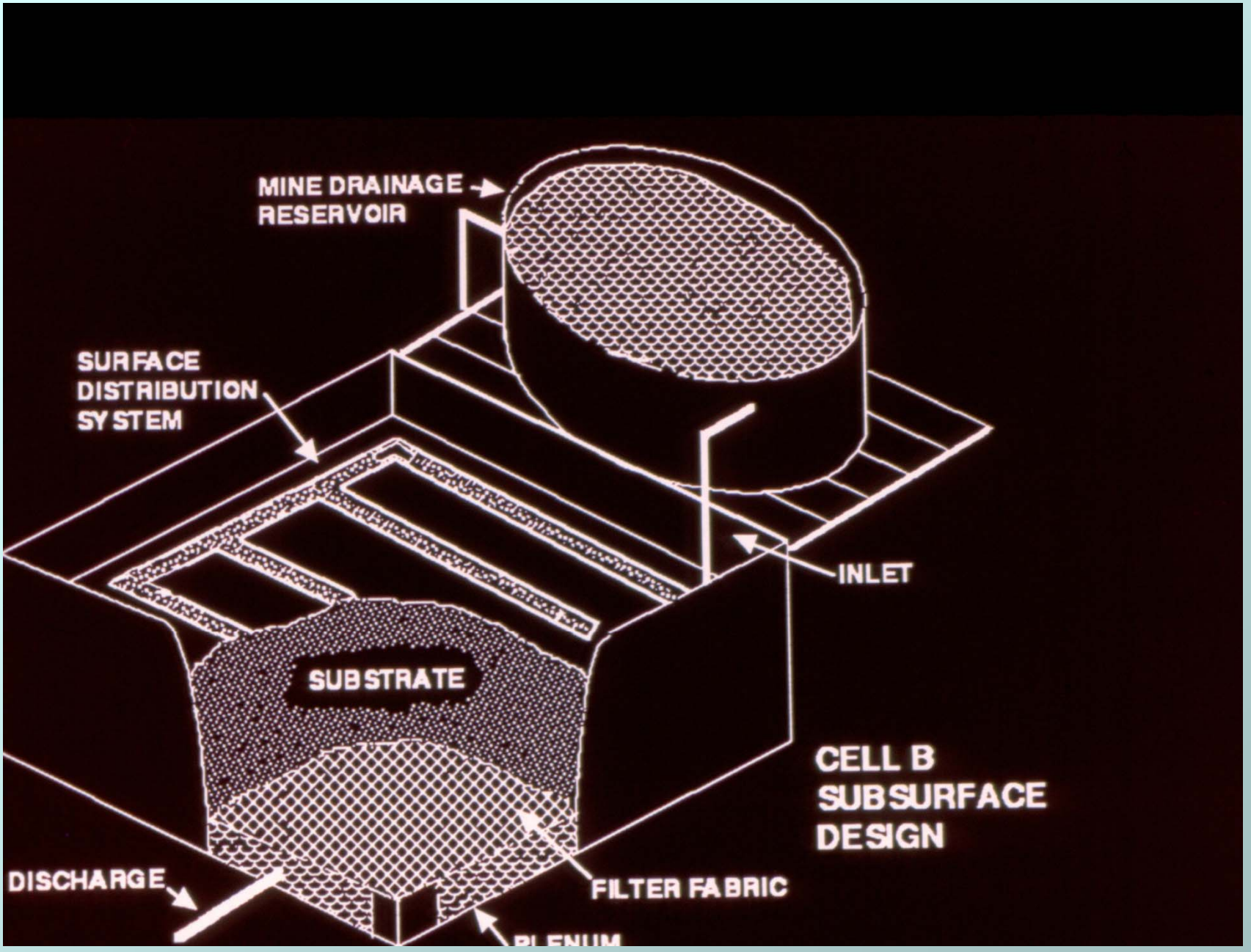
First Try to Get the Water through the Substrate




John Gormley: Why not add the water at the top and take it out at the bottom? DUH!!

2nd Try to Have Water flow through Substrate


MINE DRAINAGE
RESERVOIR
SURFACE
DISTRIBUTION
SYSTEM
INLET
SUBSTRATE
CELL B
SUBSURFACE
DESIGN
DISCHARGE
FILTER FABRIC
PLENUM

Important Picture

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Bacteria are Important

Tom, you can divide micobiologists into lumpers and splitters and I am a lumper.

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Third Lesson

- **Use bacteria found in typical aquatic environments because :**

- **1) Require the products of bacterial activity more than enzymatic use of the metals.**
- **2) A consortium of bacteria rather than a single species are generating the products.**

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Fourth Lesson

- Not designing “a thing”
- Designing a process
  - Lab studies
  - Bench-Scale Studies
  - Pilot-Scale Projects
  - Full-Scale systems

John Gormley: "Proof of Principle" Studies

Aerobic Lab Studies

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Crowning Achievement: 1200 gpm for removal of Pb

Summary

- Geochemical principles have been established and have changed little since the early 90's.
- Microbial ecosystem concept has worked well (especially for novices such as I). The ecosystem is very hardy but can be killed.
- The engineering can be tricky and development benefited considerably through failures.
- The on-site development has to go through bench- and/or pilot-scale studies. One of the primary reasons for this is because on most sites people do not know the chemistry of the MIW and how it changes with the seasons.

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Questions or Comments

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VIRGINIA
CANYON
INFLUENT
VIRGINIA
CANYON
INFLUENT
BIG FIVE
INFLUENT