Permeable Reactive Barrier as Part of an Integrated Containment Remedy at the DuPont Newport Site, Newport, DE

Steve Shoemaker
DuPont Corporate Remediation Group

John A. Wilkens
Corporate Center for Engineering Research,
DuPont Central Research and Development

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RTDF Permeable Reactive Barriers Workgroup
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Newport Superfund Site

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Newport South Landfill

Plant & Landfill History

- **Plant History**
  - Pigments plant built 1902
  - DuPont purchased, 1929; expanded product mix
  - Plant sold to Ciba-Giegy -- 1984
  - DuPont retained ownership/responsibility for landfills

- **Newport South Landfill (NSL)**
  - Slurry disposal of pigment manufacturing residues
  - Lithopone white pigment -- ZnS-$BaSO_4$
    - Roasting and acid-leaching of barium and zinc ores
  - Spent ores & wastes deposited: 1902 to 1953
  - Metal sulfate/sulfide driven geochemistry

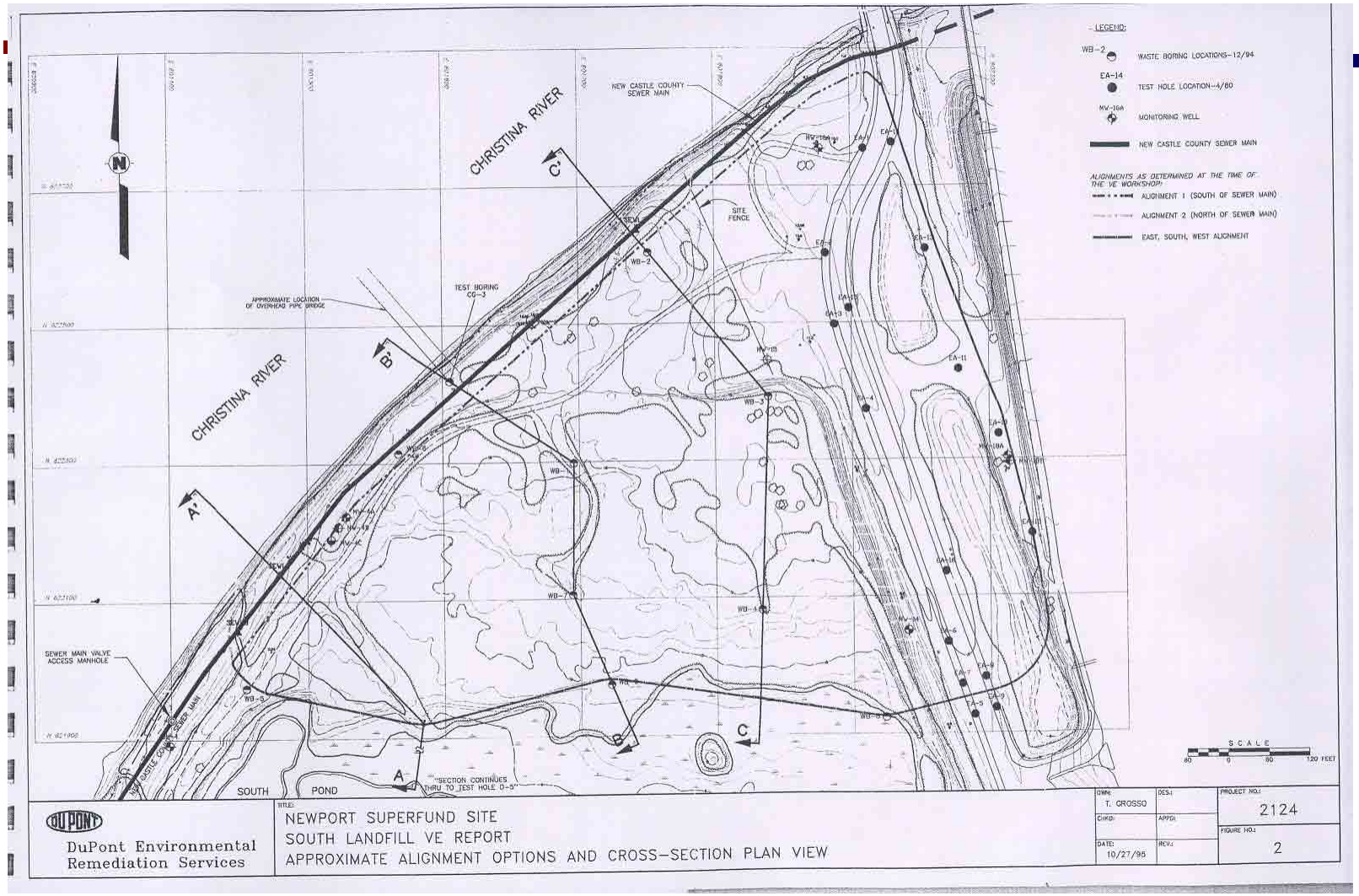
Regulatory History

- 1990 -- Landfill declared an EPA Superfund Site
  - High metals including Ba, Zn, Cu, Cd, Pb, Co, Ni, Mn
- 1993 -- EPA "Record of Decision"
  - Treat by in-situ stabilization (cement block 16 ac by 15 ft deep)
- 1995 -- EPA "ESD" -- Alternate treatment
  - Sulfate & sulfide addition to immobilize metals
    - Potential to reduce costs
- 2001 -- EPA "ESD" -- Cap with PRB approved
  - Containment-based remedy meeting Superfund preference for permanent treatment

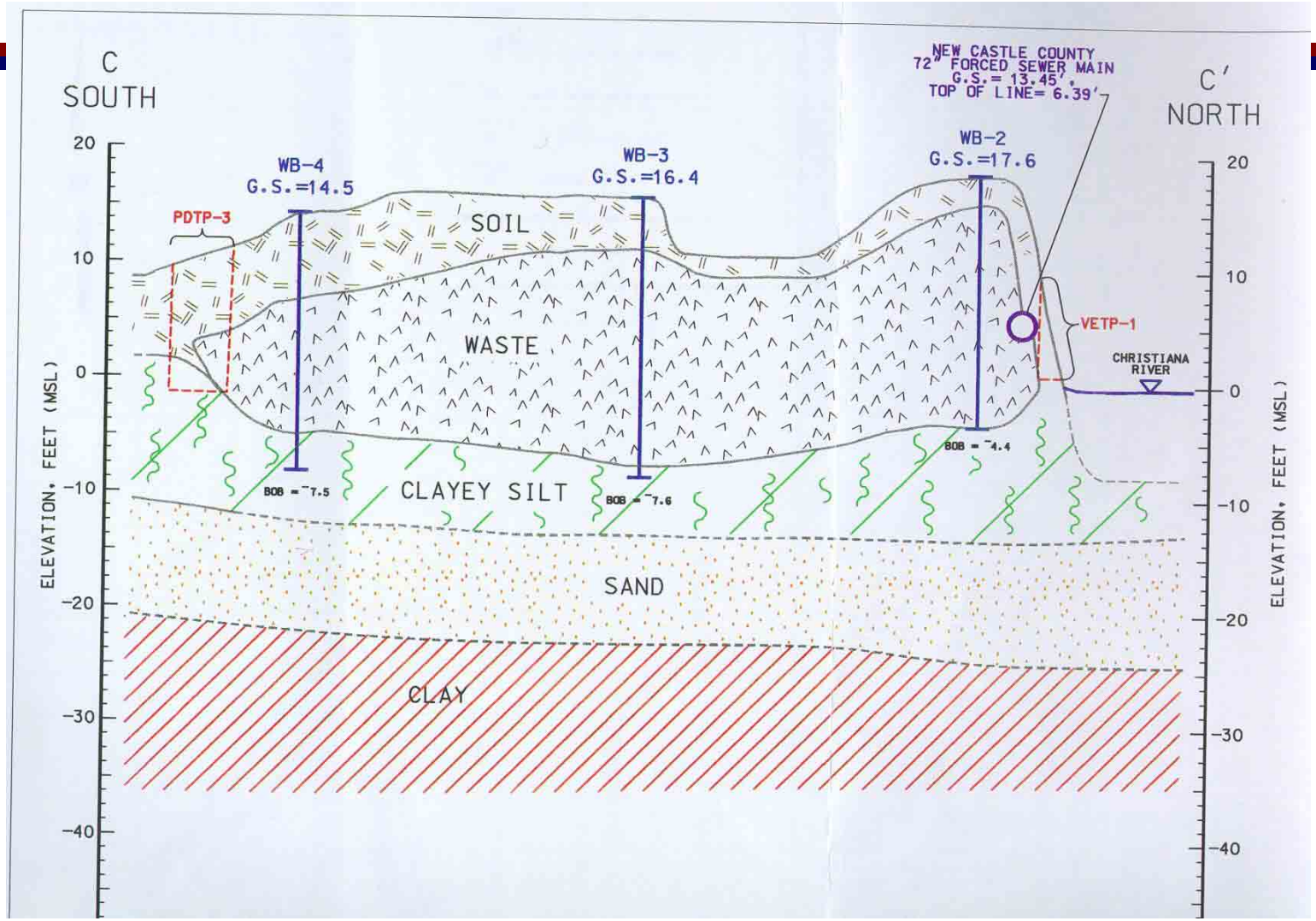
Conceptual Model

- Landfill is isolated hydrogeologically
- 16 acres of waste deposits 5 to 15 ft deep
- Waste overlain by sandy fill and underlain by low K marsh deposits
- Landfill surrounded by tidally influenced Christina River and wetlands
- Rainfall infiltration on landfill is only source of groundwater flow
  - Radial to river and wetlands

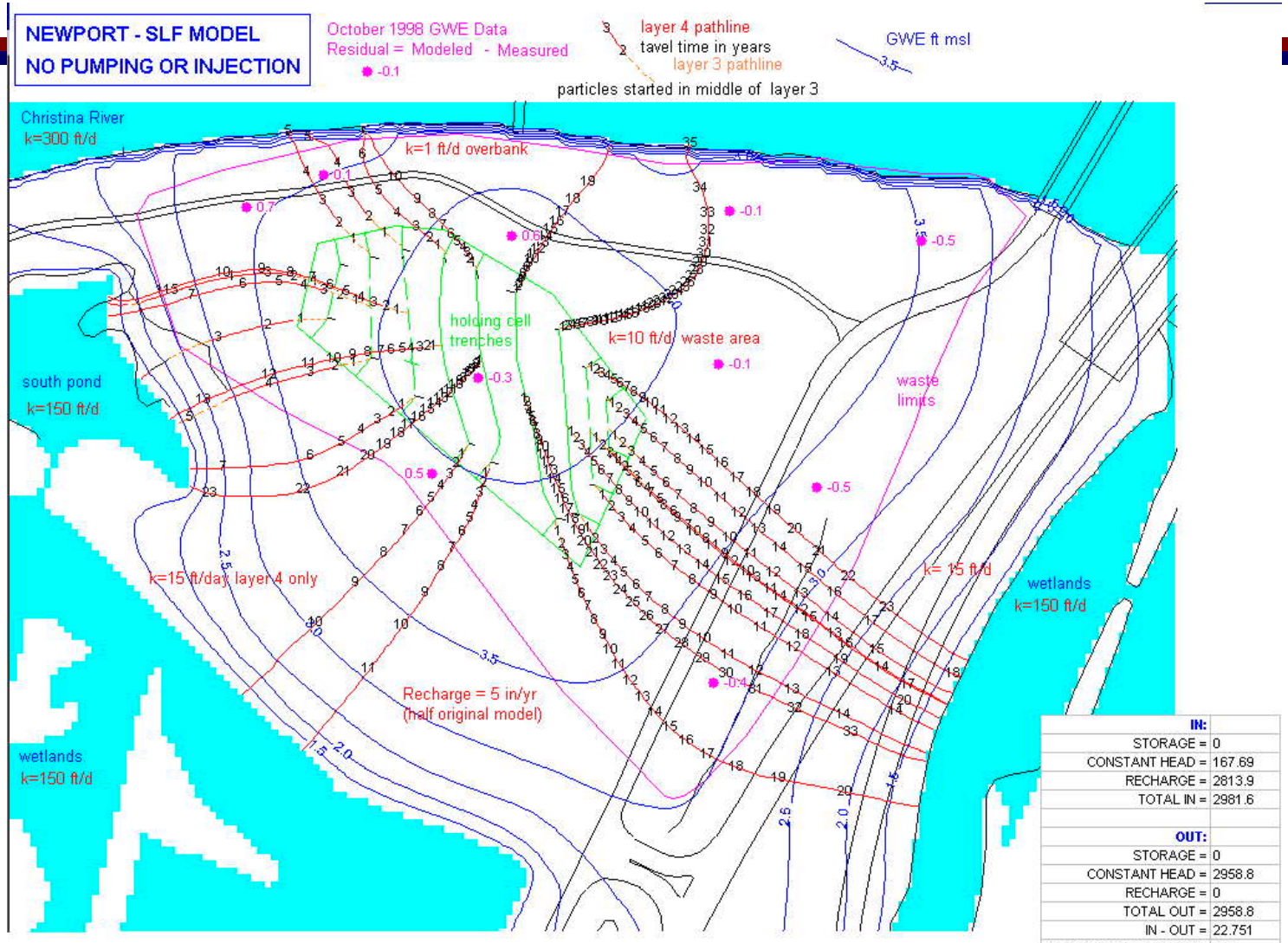
NSL Plan View



NSL Cross Section



MODFLOW results

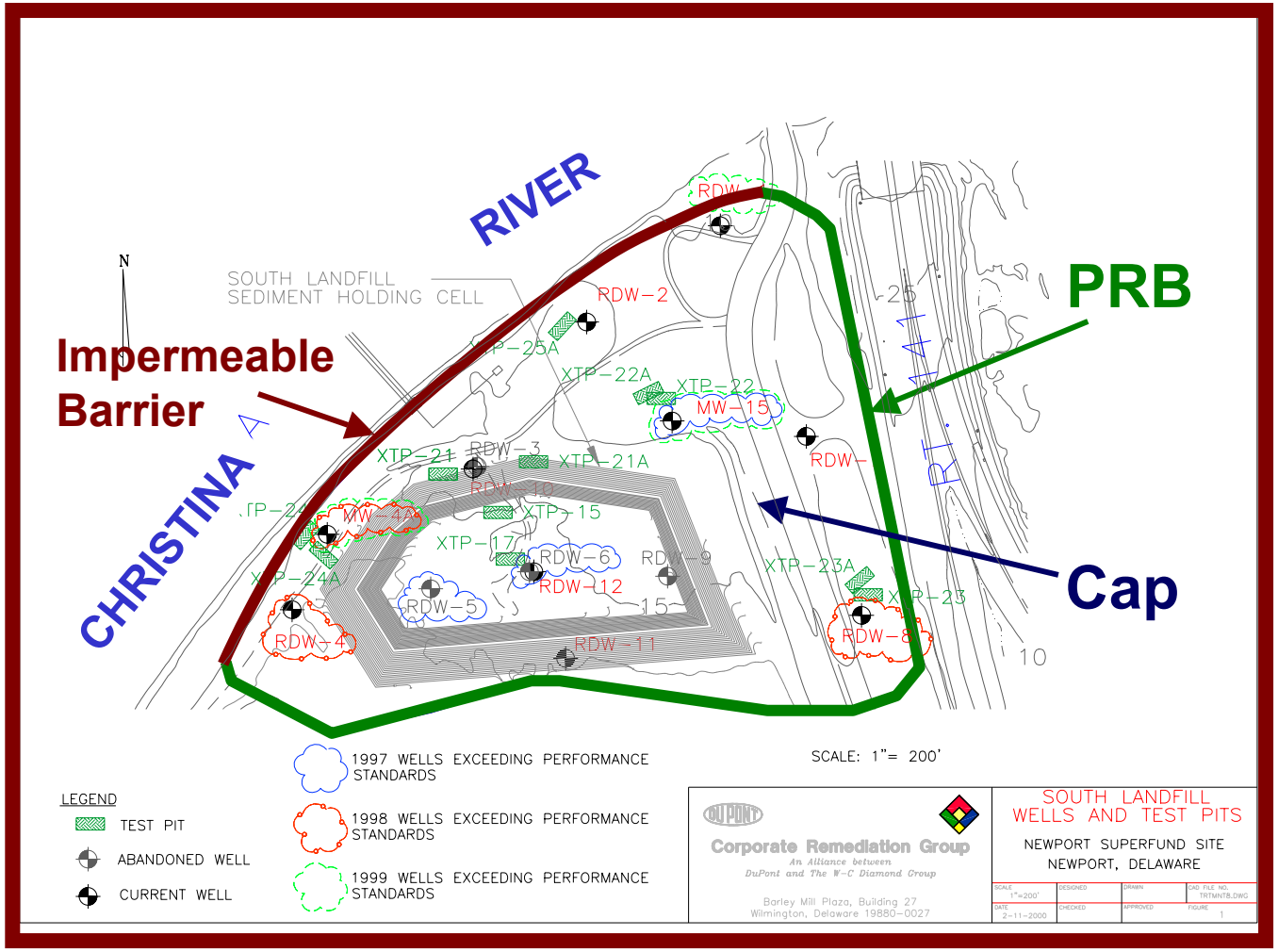


IN:	
STORAGE =	0
CONSTANT HEAD =	167.69
RECHARGE =	2813.9
TOTAL IN =	2981.6
OUT:	
STORAGE =	0
CONSTANT HEAD =	2958.8
RECHARGE =	0
TOTAL OUT =	2958.8
IN - OUT =	22.751
PERCENT DISCREPANCY =	0.77

Existing Conditions
Water Balance

- Waste K avg ~ 4 x 10^{-5} cm/sec (0.1 ft/day)
- MODFLOW calibrated GW flow in waste ~ 0.2 gpm
- Equivalent calibrated recharge ~ 0.3 in/yr
- HELP model estimated infiltration ~ 6 in/yr
  - Total infiltration over 15 acres ~ 4.6 gpm
- Conclusion: Bulk of infiltration discharges through overburden soils
  - Agrees with field observations (test pits, etc.)

Remedy Concept



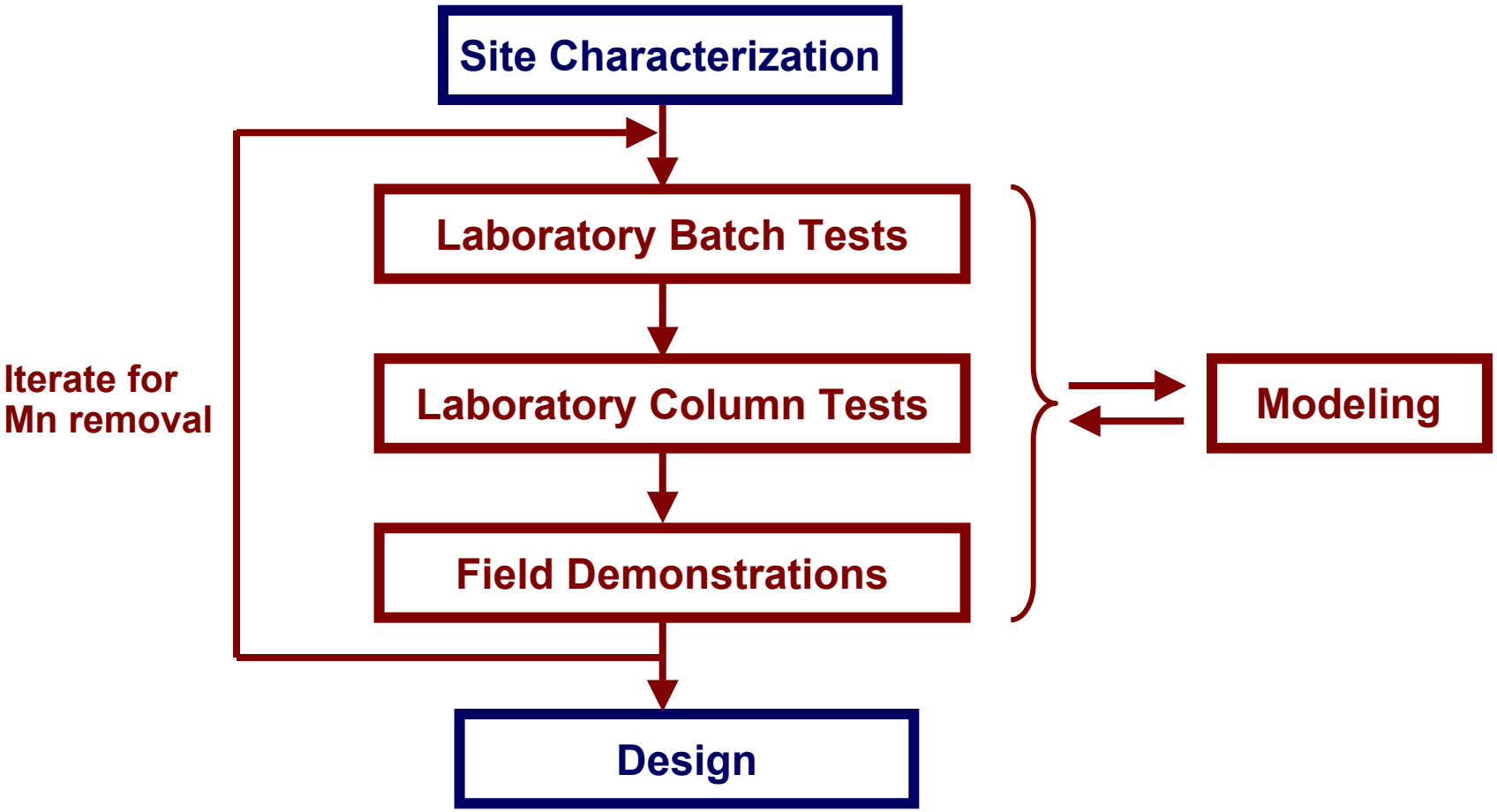
Newport S. L. -- Stake

- **Cement Block**
  - **Cost: $17 million**
  - **Original, fall-back remedy**
- **PRB (& slurry wall & cap …)**
  - **Cost: $4 million**
- **Stake for Success: $13 million**

Treatment Standards

- **Did not meet standards in groundwater**
  - Barium: 7.8 mg/l (up to 500 mg/l observed)
  - Zinc: 0.12 mg/l (up to 1 mg/l observed)
  - Manganese 1.0 mg/l (up to 20 mg/l observed)
- **Already met standards in groundwater**
  - Cadmium 0.004 mg/l
  - Lead 0.015 mg/l
  - Copper 0.018 mg/l
  - Nickel 0.73 mg/l

PRB Technical Program Flow



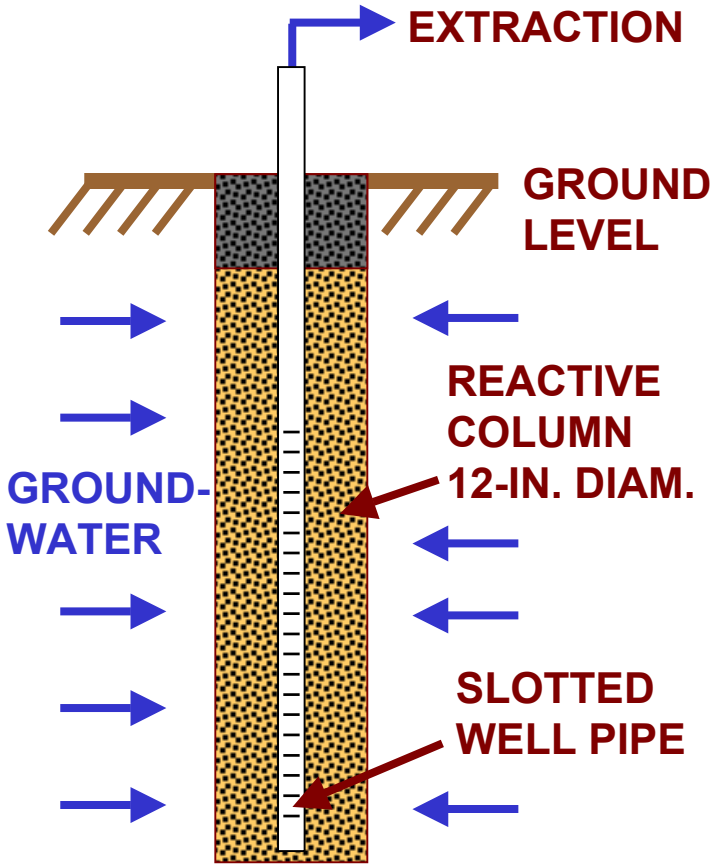
Lab Results
Final Reactive Mix

- CaSO4 identified early for Ba removal
- ZVI added for sorption of Zn
- $MgCO_3$ added to reactive mix for Mn removal
- Final formulation:

Sand : $CaSO_4$: ZVI : $MgCO_3$ :: 100 : 20 : 5 : 5

- Proceed to Field Demonstrations

Field Demonstration: In-Situ Reactive Well



- Test in proposed PRB zones
  - Consultation w/ EPA R&D
  - Ba-rich & Zn-rich zone tests
  - Used proposed treatment mix
  - Accelerated via extraction
  - All three metals reduced to below treatment standards

Capping South Landfill

- Capping the NSL to reduce infiltration and GW flow to discharge points
- With reduced infiltration, pre-existing mound will subside
- Flow will still be outward toward discharge points, but at a much lower rate
- Reduced discharge rate equates to increased PRB retention time and wall life
- Infiltration determined under various capped conditions using HELP model

Flux Calculations

CAP CASE	Infiltration Rate (in/yr)	Infiltration over SLF (gpm)	Flux (cm3/day /cm2)	Pore Velocity (cm/day)
Current Conditions (3 ft soil)	6	4.6	1.2	4
Asphalt (4-in) + Stone (8-in)	0.1	0.078	0.02	0.07
Soil (18-in) + Drain Layer + GCL	0.003	0.0023	0.0006	0.002
Topsoil (6-in) + fill (12-in) + Drainage Layer + Synthetic Liner (RCRA style cap)	0.00005	0.00004	0.00001	0.00003

- **Assumptions**
  - **All infiltration over 15 acre capped NLF flows through PRB to wetlands**
  - **PRB length = 2200 ft**
  - **PRB saturated depth = 10 ft**
  - **Slurry wall flux is negligible**

PRB Life

CAP CASE	Infiltration Rate (in/yr)	Infiltration over SLF (gpm)	Flux (cm3/day/cm2)	Pore Velocity (cm/day)	Res. Time in 3 ft wall (years)	Field Demo Simulated Time (yrs)
Current Condition (3-ft soil)	6	4.6	1.2	4	0.06	0.3
Asphalt (4-in) + Stone (8-in)	0.1	0.078	0.02	0.07	3.6	18
Soil (18-in) + Drain Layer + GCL	0.003	0.0023	0.0006	0.002	125	600
RCRA-style cap	0.00005	0.00004	0.00001	0.00003	8351	36,000

PRB Life

- Landfill cap key to PRB life
- ESD cap specification
  - Engineered cap -- maximum permeability 1 x 10^{-7} cm/sec
  - Synthetic geomembrane layer with geosynthetic clay liner, …
  - Average rain infiltration < 0.003 in/year
- PRB life
  - 600 years based on demonstrated field performance
  - Limited only by test duration
  - Calculated life based on reaction and solubility losses measured in millennia

Conclusions & Path Forward

- PRB achieves performance standards for all required metal concentration reductions
- PRB life is theoretically measured in centuries
  - Surface cap decreases infiltration entering and thus groundwater leaving landfill through the PRB.
- The PRB is an essentially permanent remedy
- Implementation scheduled for 2002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