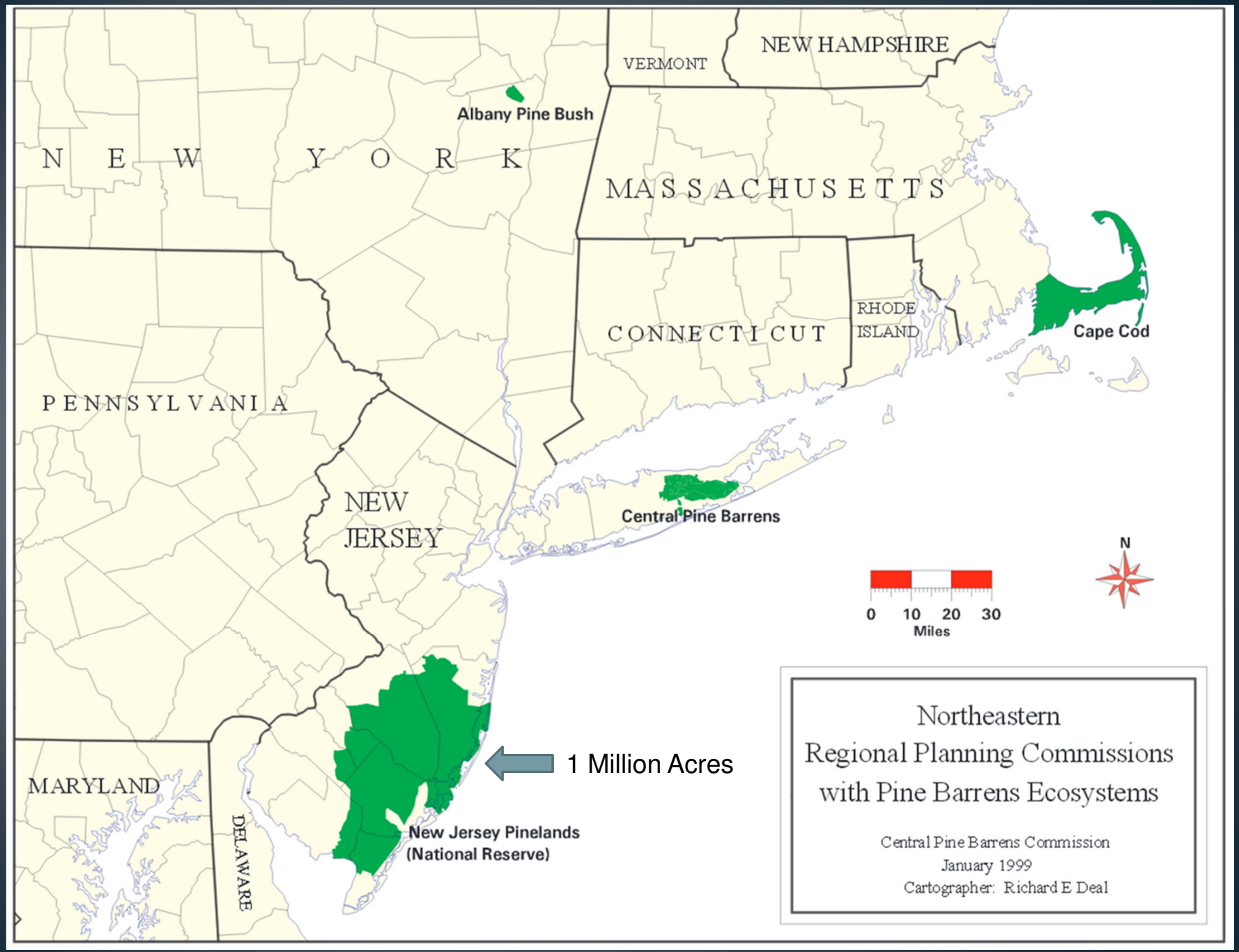
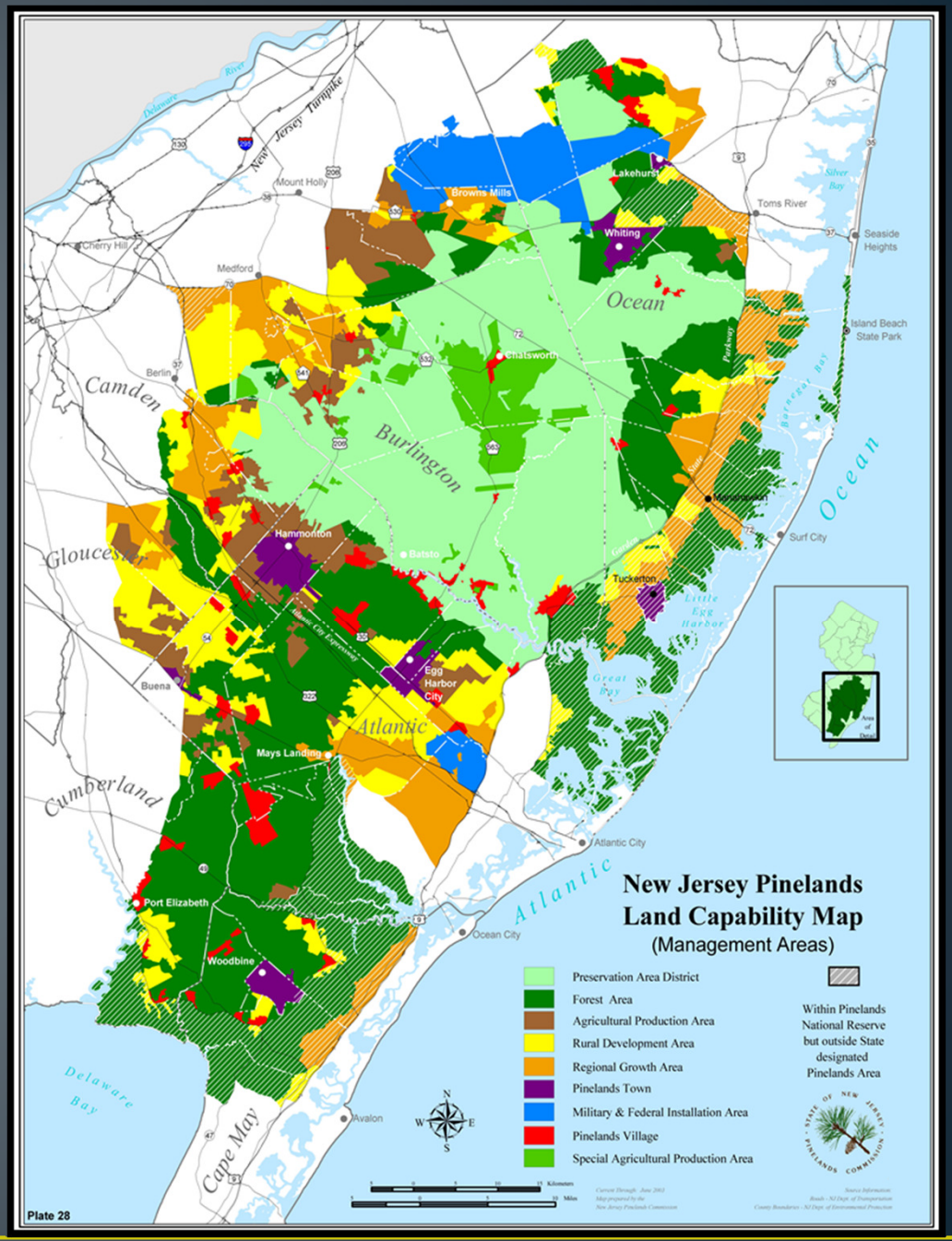
Screening Tool to Evaluate the Vulnerability of Down-gradient Receptors to Groundwater Contaminants from Uncapped Landfills

Nineteenth Annual Pine Barrens Research Forum
Brookhaven National Laboratory
October 2, 2014


VERMONT
NEW HAMPSHIRE
Albany Pine Bush
N E W Y O R K
MASSACHUSETTS
CONNECTICUT
RHODE ISLAND
Cape Cod
PENNSYLVANIA
NEW JERSEY
Central Pine Barrens
N
0 10 20 30
Miles
1 Million Acres
MARYLAND
DELAWARE
New Jersey Pinelands
(National Reserve)
Northeastern
Regional Planning Commissions
with Pine Barrens Ecosystems
Central Pine Barrens Commission
January 1999
Cartographer: Richard E Deal

NJ Pinelands Facts

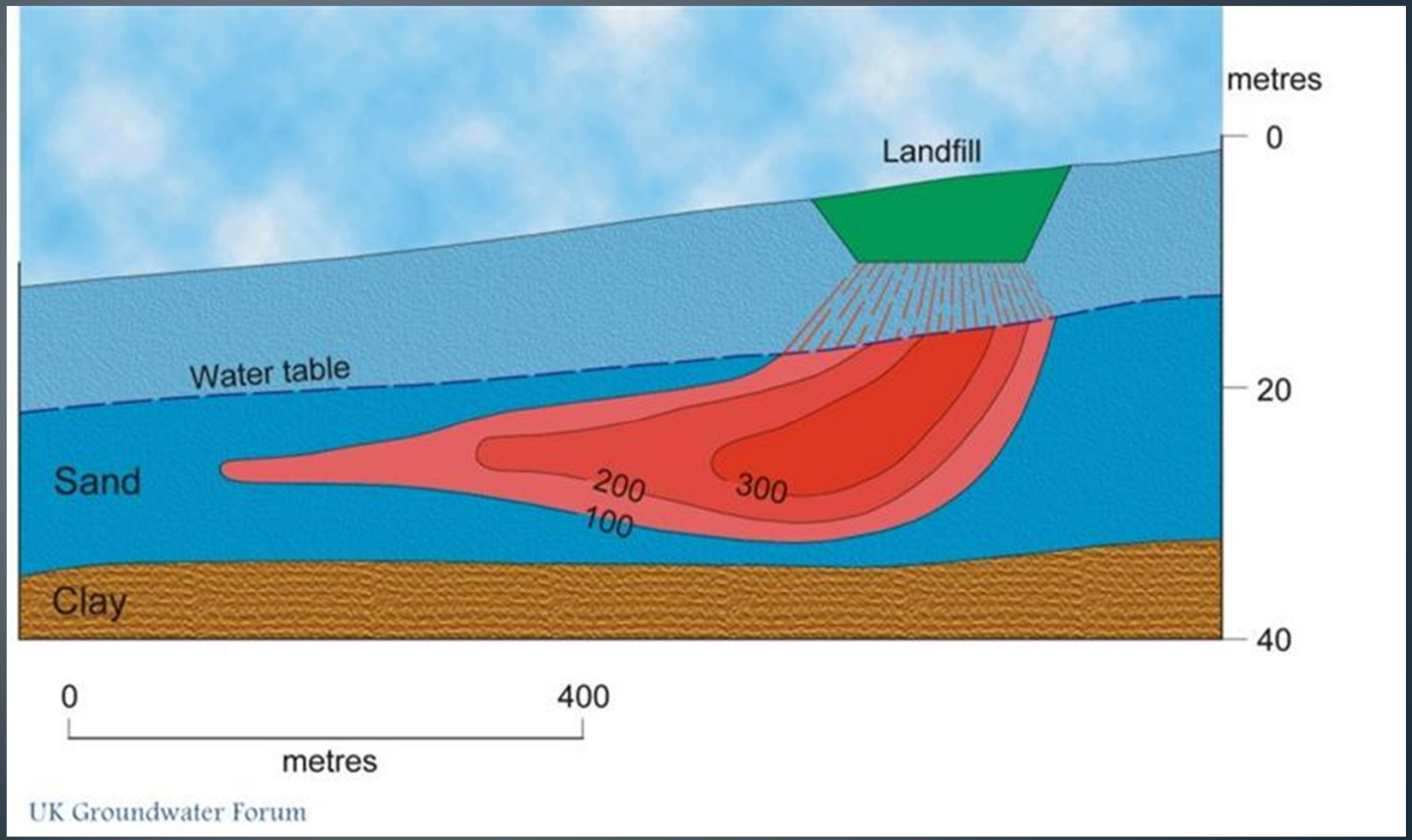
- Federal /State1978/1979
- Protected via land use controls & environmental programs
- Characterized by acidic, nutrient-poor streams fed by shallow water table aquifer
- 17.7 Trillion gallon Kirkwood-Cohansey unconfined aquifer underlies most of the region
- Subdivided into Preservation (no growth) Areas and Protection (designated growth) Areas.



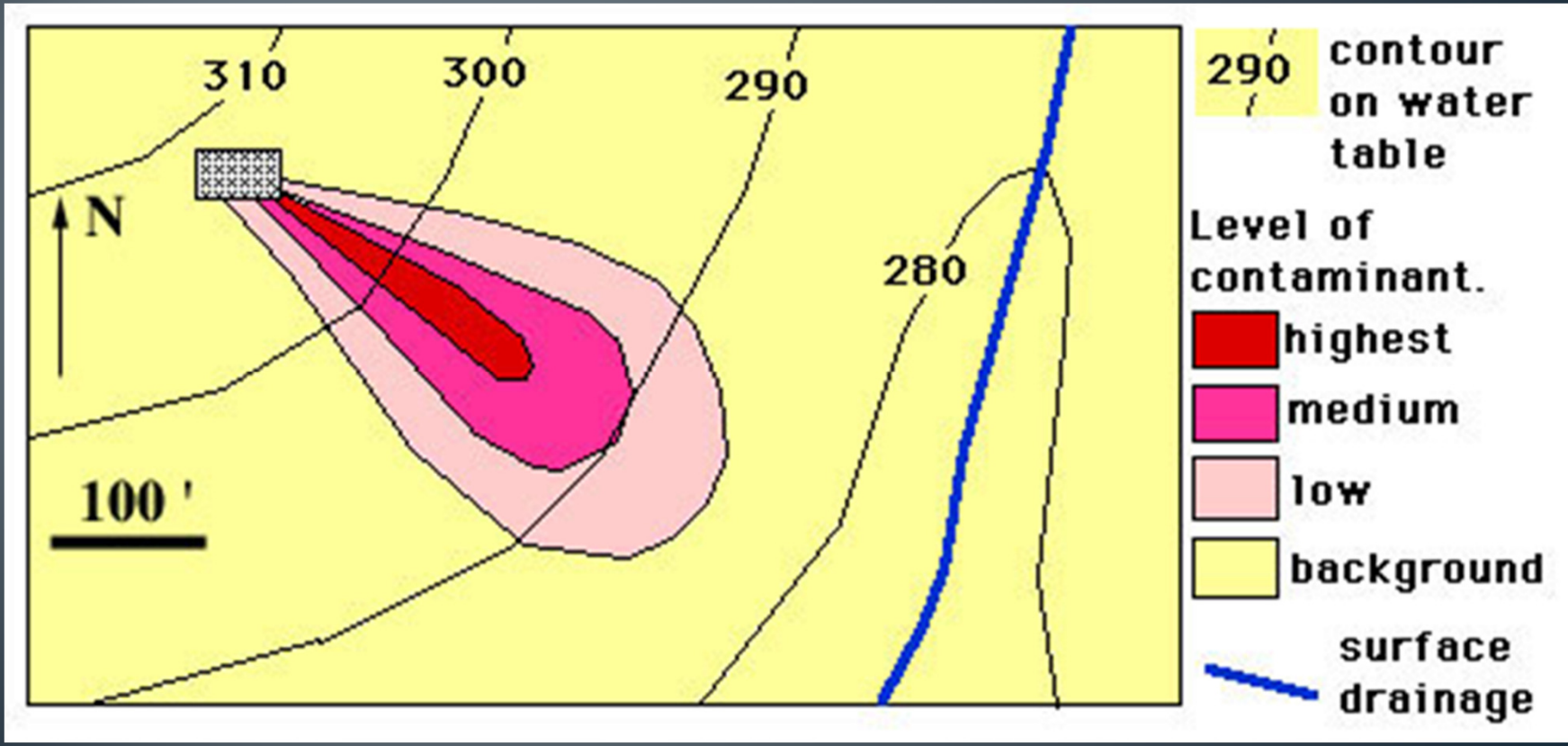
Project Background

- More than 60 (pre-1981 / pre-Pinelands Commission) legacy landfills in the region.
- Most are subject to the Commission's (**presumptive remedy**) **impermeable capping** requirement.
    - Exceptions include vegetative and construction debris "dumps" and landfills where no leachate plume exists.
- Most closed landfills still lack engineering controls beyond chain-link fencing and thin soil cover.
- High cost of mitigation controls has lead to so few capped landfills.
- Landfills in the non-growth areas of the Pinelands pose the greatest challenge due to limited re-development opportunities.

Idealized Landfill Leachate Plume cross section



Idealized Landfill Leachate Plume plan view



Project Drivers

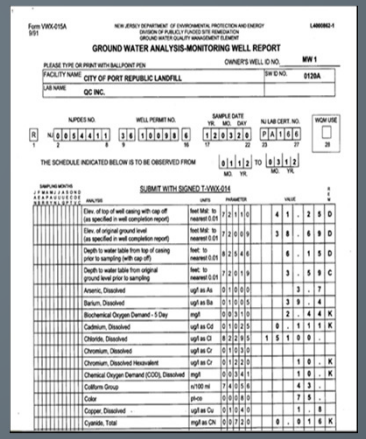
- Triage landfills to rank the threat level and refocus efforts to remediate those posing the greatest risk.

- Facilitate / expedite redevelopment on uncapped landfills where mitigation requirements are minimal.

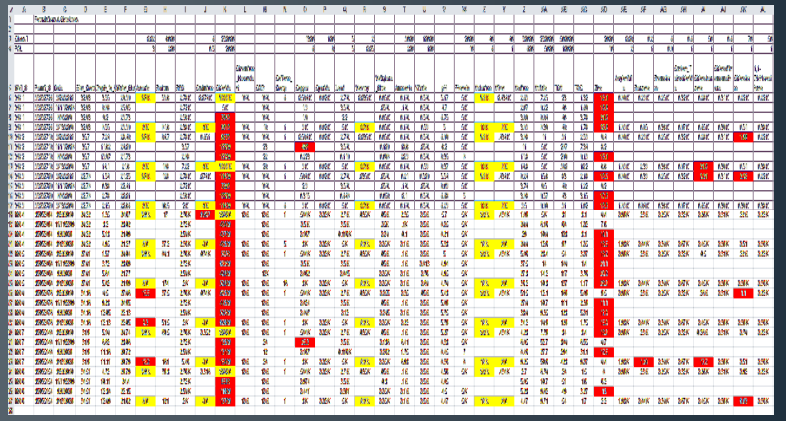
2010 Pinelands Staff- Proof of Concept Study

USGS Project Precursor

1. Consolidated and digitized archived historic landfill monitoring well data for 6 landfills



GROUND WATER ANALYSIS-MONITORING WELL REPORT

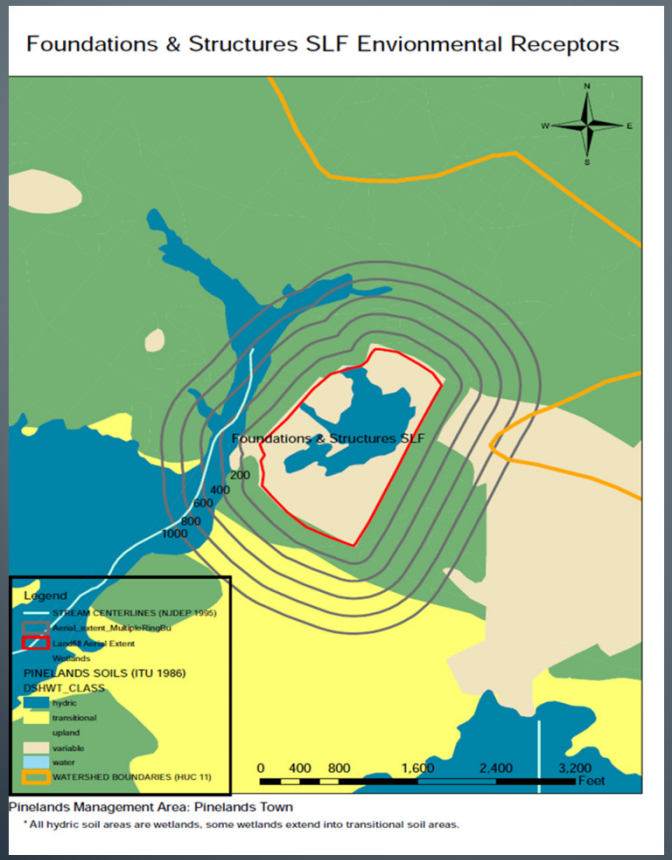


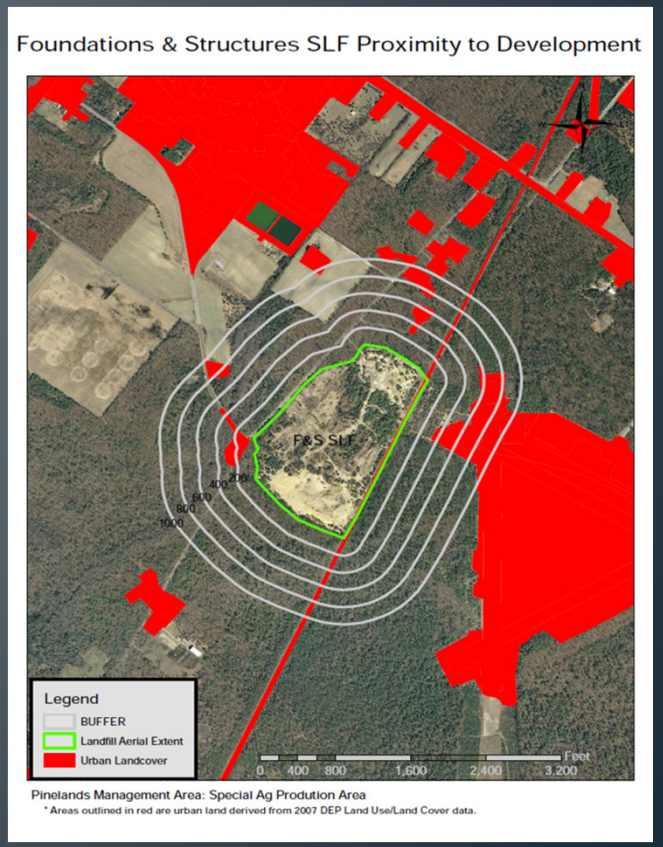
2. Compared monitoring well data to applciable water quality standards

2010 Pinelands Staff- Proof of Concept Study

USGS Project Precursor

3. Proximity to potential leachate receptors: surface water, wetlands and residences



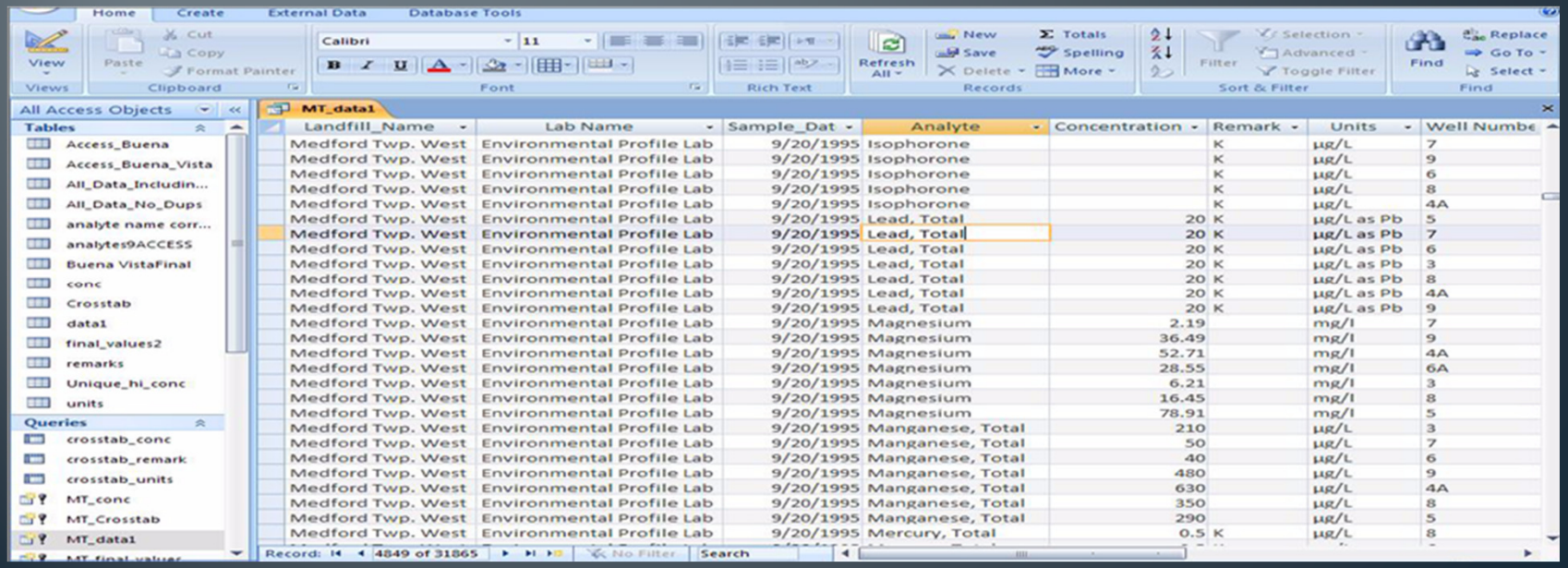


USGS – Pinelands Cooperative Agreement

- Successful proof of concept – Comprehensive assessment of monitoring well data coupled with GIS analysis
- Next step was to model the fate and transport of leachate constituents to estimate concentrations at nearby receptors.
- Lead to a USGS – Pinelands Commission Cooperative Agreement
- Total project budget of $180,000
- Project deliverables:
  - Searchable Access Database of archived records for each monitoring well sample event
  - Mathematical model to predict movement of chemicals in groundwater
  - Interpretive Report describing the leachate plume modeling methodology

Access Database (332,794 discrete data entries)

- Water quality data from monitoring wells
- Regulatory data for each contaminant
- Chemical properties of each contaminant



Solute Transport Model Selected by USGS

Domenico Transport Model (1985 and 1987)

- Screening tool
- Used to predict movement of contamination from point sources to receptors (streams, wetlands, etc).
- Supported by the USEPA.

- Supported and improved upon by Penn DEP (2008)
  - Developed Quick Domenico Spreadsheet Application
  - Added retardation factor for solute-carbon interactions
  - Limits dispersion to downward direction (below the water table).

Quick Domenico is a classic, But our new model is a Rolls Royce!

Old Model
(Quick Domenico)

USGS Model
Renovation Service
(Ron Baker's office)

New Model
(Quick Domenico
Multiscenario)

Under the hood:

- *Up to 50 simulations on a single spreadsheet*
- *Automatic calculation of time required to reach steady state*
- *Automatic calculation of contaminant dispersivity*
- *Regulatory values of contaminants for comparison to model outputs-%*

QDM: User-input parameters

Simulation Number	Receptor	Contaminant	Source Concentration (ug/L)	Decay constant Lambda ($days^{-1}$)	Source Width (ft)	Source Thickness (ft)	Hydraulic Conductivity (ft/day)	Hydraulic Gradient (ft/ft)	Porosity (dimensionless)	Soil Bulk Density (g/cm3)	KOC	Fraction Organic Carbon	←Distance to Receptor→ x(ft)	y(ft)	z(ft)	Regulatory Value (ug/L)
1	Stream	Chloride	40666.7	0	868	10	50	0.010	0.358	1.70	0.0	0.001	757	0	0	230000.00
2	Wetlands and Hydric So	Chloride	40666.7	0	868	10	50	0.010	0.358	1.70	0.0	0.001	7	0	0	230000.00
3	Residential	Chloride	40666.7	0	868	10	50	0.010	0.358	1.70	0.0	0.001	250	0	0	250000.00
4	Stream	Nitrogen, Amm	17100.0	0.1	868	10	50	0.010	0.358	1.70	3.1	0.001	757	0	0	200.00
5	Wetlands and Hydric So	Nitrogen, Amm	17100.0	0.1	868	10	50	0.010	0.358	1.70	3.1	0.001	7	0	0	200.00
6	Residential	Nitrogen, Amm	17100.0	0.1	868	10	50	0.010	0.358	1.70	3.1	0.001	250	0	0	3000.00
7	Stream	Nitrogen, Nitrat	500.0	0.001265753	868	10	50	0.010	0.358	1.70	0.0	0.001	757	0	0	320.00
8	Wetlands and Hydric So	Nitrogen, Nitrat	500.0	0.001265753	868	10	50	0.010	0.358	1.70	0.0	0.001	7	0	0	320.00
9	Residential	Nitrogen, Nitrat	500.0	0.001265753	868	10	50	0.010	0.358	1.70	0.0	0.001	250	0	0	10000.00
10																
11																
12																
13																
14																
15																
16																
17																
18																
19																
20																

- Receptor and distance
- Contaminant and source concentration
- Contaminant – soil interaction properties
- Aquifer properties
- Contaminant regulatory values

QDM: Automatically-calculated input parameters

Simulation Number	←—Dispersivity—→ Ax (ft)	Ay (ft)	Az (ft)	←Simulation Time→ Time (days)	Time (years)	Model Length (ft)	Model Width (ft)	Conc. At Steady State	Velocity (V)	% of Regulatory Value
1	15.44	1.5	0.001	1355	3.7	1136	868		1.40	
2	0.00	0.0	0.001	13	0.0	11	868		1.40	
3	8.13	0.8	0.001	448	1.2	375	868		1.40	
4	15.44	1.5	0.001	587	1.6	1136	868		1.38	
5	0.00	0.0	0.001	13	0.0	11	868		1.38	
6	8.13	0.8	0.001	248	0.7	375	868		1.38	
7	15.44	1.5	0.001	1319	3.6	1136	868	254.13	1.40	79.4
8	0.00	0.0	0.001	13	0.0	11	868		1.40	
9	8.13	0.8	0.001	441	1.2	375	868		1.40	
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

- Dispersivities, time to steady-state and model dimensions are calculated
- Contaminant concentration and % of regulatory value are calculated for the selected simulation number (in this case 7).

Quick Domenico Multi-scenario (QDM)

Quick Domenico Multi-scenario (QDM) Spreadsheet

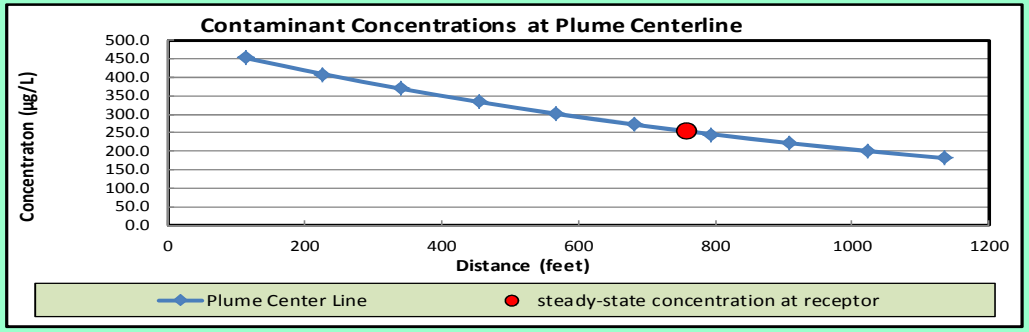
Project:	South Toms River	Password:		Date:	5/23/2014	Prepared by:	RJB

Simulation Number:	7	Contaminant:	gen, Nitrate, Disso	Receptor:	Stream

Steady-State Concentraton (ug/L)	254.13
Regulatory Value (ug/L)	320.00
Percent of Regulatory Value	79.42

Source	Dispersivity						Time to reach	Receptor Distance from Source		
Concentra	Ax	Ay	Az	Lambda	Width	Thickness	Steady State			
(µg/L)	(ft)	(ft)	(ft) >=.001	day-1	(ft)	(ft)	(days)	x(ft)	y(ft)	z(ft)
500.000	15.44	1.54	0.001	0.001266	868	10	1319	757	0	0

Hydraulic	Hydraulic		Soil Bulk		Fraction			Model Domain		
Conductivi	Gradient	Porosity	Density	KOC	Organic	Retardation	Velocity			Peclet
(ft/day)	(ft/ft)	(dec. frac.)	(g/cm^3)	(dec. frac.)	Carbon	(dec. frac.)	(ft/day)	Length (ft)	Width (ft)	Number
50	0.01	0.358	1.7	0.0	0.001	1.00	1.40	1136	868	68



	Simulated Concentrations Downgradient from Source									
	Distance from source									
Lateral	113.55	227.1	340.65	454.2	567.75	681.3	794.85	908.4	1021.95	1135.5
Distance (f	Concentration of Contaminant									
868	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
434	225.868	204.065	184.37	166.57	150.49	135.96	122.84	110.98	100.26	90.52
0	451.735	408.129	368.73	333.14	300.98	271.93	245.68	221.96	200.51	181.04
-434	225.868	204.065	184.37	166.57	150.49	135.96	122.84	110.98	100.26	90.52
-868	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Optional Field Data for model calibration: enter centerline concentrations from well sample data and distances from source to receptor										
Concentra	0	0	0	0	0	0	0	0	0	0
Distance (f	0	0	0	0	0	0	0	0	0	0

A simulation (from numbers 1-50 is selected), and all parameters and results for that simulation are shown in the spreadsheet. Result is expressed as a percent of the relevant regulatory value.

Assessing Vulnerability of Groundwater to Contaminants of Concern (COCs) from Landfills

- **Level of Concern = Unknown**
  - Data are insufficient to characterize the presence of COCs.
- **Level of Concern = Low**
  - COCs do not reach receptors at concentrations greater than the Practical Quantitation Limit (PQL).
- **Level of Concern = Moderate**
  - COCs reach receptors at concentrations greater than the PQL but less than 50% of any relevant regulatory standard.
- **Level of Concern = High**
  - COCs reach receptors at concentrations greater than or equal to 50% of one or more relevant regulatory standards.

Summary of SCREENING Model Results: Number of Landfills for Each Level of Concern

Total landfills studied:	48
Unknown level of concern (insufficient data):	18
Low level of concern:	12
Moderate level of concern:	0
High level of concern:	18

Summary of Model Results

- **Contaminant responsible for high level of concern**

• Arsenic	(2 landfills)
• Barium	(3 landfills)
• Benzene	(1 landfills)
• Cyanide	(1 landfill)
• Lead	(8 landfills)
• Mercury	(2 landfills)
• Selenium	(1 landfill)

Model adaptability

- In addition to quantifying level of concern using historic data, the model allows for additional data inputs as new data becomes available.
- Users can develop any number of simulations, changing individual parameters incrementally to reflect verified site-specific field conditions.
- Important to emphasize that the model is a screening tool, it provides conservative assessments and is likely to overestimate concentrations.
- In summary, QDM is a rapid and powerful tool for the initial assessment of level of concern for landfills and other surface and subsurface point sources of contamination.

Ed Wengrowski
Environmental Technologies Coordinator
New Jersey Pinelands Commission
ed.wengrowski@njpines.state.nj.us
609-894-7300