



Town of

Orleans
Massachusetts

Orleans Water Quality Advisory Panel

Permeable Reactive Barrier (PRB) Stakeholder Workshop

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March 15, 2017



AECOM PRB Team Activities

We have been busy implementing projects in the field!



AECOM PRB Team Activities

Reports Produced:

- *Technical Memorandum for Eldredge Park Permeable Reactive Barrier - Demonstration Overview of Baseline Sampling, Injection Activities and Post-Injection Groundwater Monitoring - March 1, 2017*
 - *Technical Memorandum for Landfill Field Investigation Plan -February 24, 2017*
- ❖ Final Technical Memos available on Town website

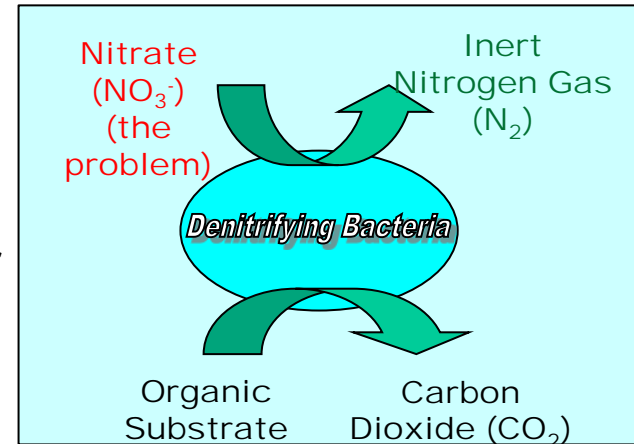
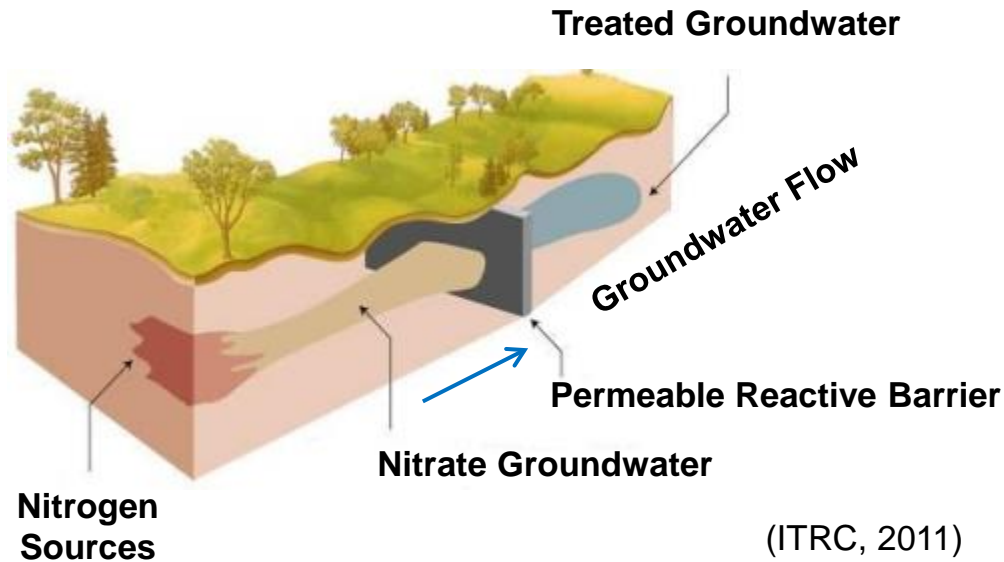


Project Locations



PRB Overview

- ❖ A PRB Consists of a Zone of Reactive Material (Amendment) Installed in the Path of a Dissolved Contaminant (e.g. nitrate) Plume



- ❖ Denitrification - Biological Process by Bacteria Ubiquitous in the Environment
 - Nitrate converted to inert nitrogen gas (N_2)
 - Requires anoxic (low oxygen conditions)

PRB Amendment – Emulsified Vegetable Oil

- ❖ Emulsified Vegetable Oil is a food-grade substrate made with soybean oil (oil-in-water emulsion with consistency similar to soy milk)
- ❖ Emulsion slowly releases dissolved organic carbon and provides a long term carbon source for denitrifying bacteria
- ❖ Emulsions are designed to be immobile once injected into groundwater
- ❖ A special formulation was used to make the emulsion “stickier” to reduce migration after injection and increase persistence



Eldredge Park Way PRB

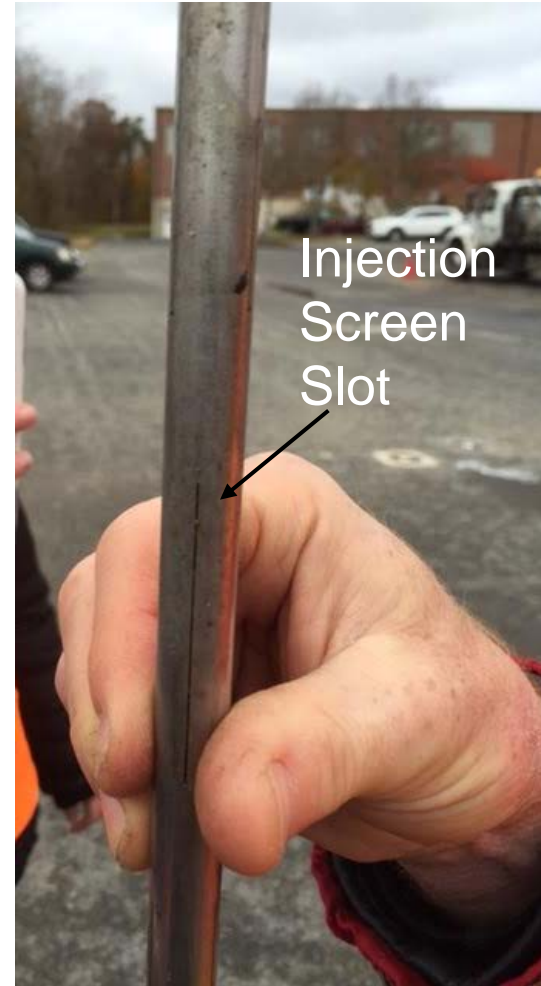
PRB –line of injection wells

Groundwater Flow



PRB Construction

PRB Injection Completed week of 14 November 2016



Eldredge Park PRB Groundwater Monitoring

- ❖ Prior to injection – baseline sampling
- ❖ During injection to monitor distribution
- ❖ Initial post-injection sampling in early January 2017
- ❖ 1st quarterly sampling round late February 2017

Field Measurements
pH (SU)
Temperature (°C)
Dissolved Oxygen (DO, mg/L)
Redox Potential (ORP; mV)
Specific Conductivity ($\mu\text{S}/\text{cm}$) ^c
Turbidity (NTU)
Laboratory Analyses
Nitrogen
Nitrate as N (mg/L)
Nitrite as N (mg/L)
Ammonia (mg/L)
Total Kjeldahl Nitrogen (TKN) (mg/L)
Total Nitrogen (mg/L)
Anions
Chloride (mg/L)
Sulfate (mg/L)
Elements
Dissolved Iron (mg/L)
Dissolved Manganese (mg/L)
Boron (mg/L)
Other
DOC (mg/L)
Methane ($\mu\text{g}/\text{L}$)
Alkalinity as CaCO ₃ (mg/L)



Groundwater Flow at Intermediate Depth



TO
WATER QUAL

SURFER
CONTOURS: IN

Legend

Eldredge Park PRB Monitoring

- ❖ Initial testing of PRB monitoring wells - baseline concentrations measured as high as 35 mg/L nitrate-nitrogen
- ❖ Wide range of nitrate concentrations at different sampling locations
- ❖ No unwanted migration of EVO detected during injection (monitoring turbidity and dissolved organic carbon 10, 20, 50 and 100 ft. downgradient)
- ❖ Initial monitoring indicates positive developments at some of the downgradient wells



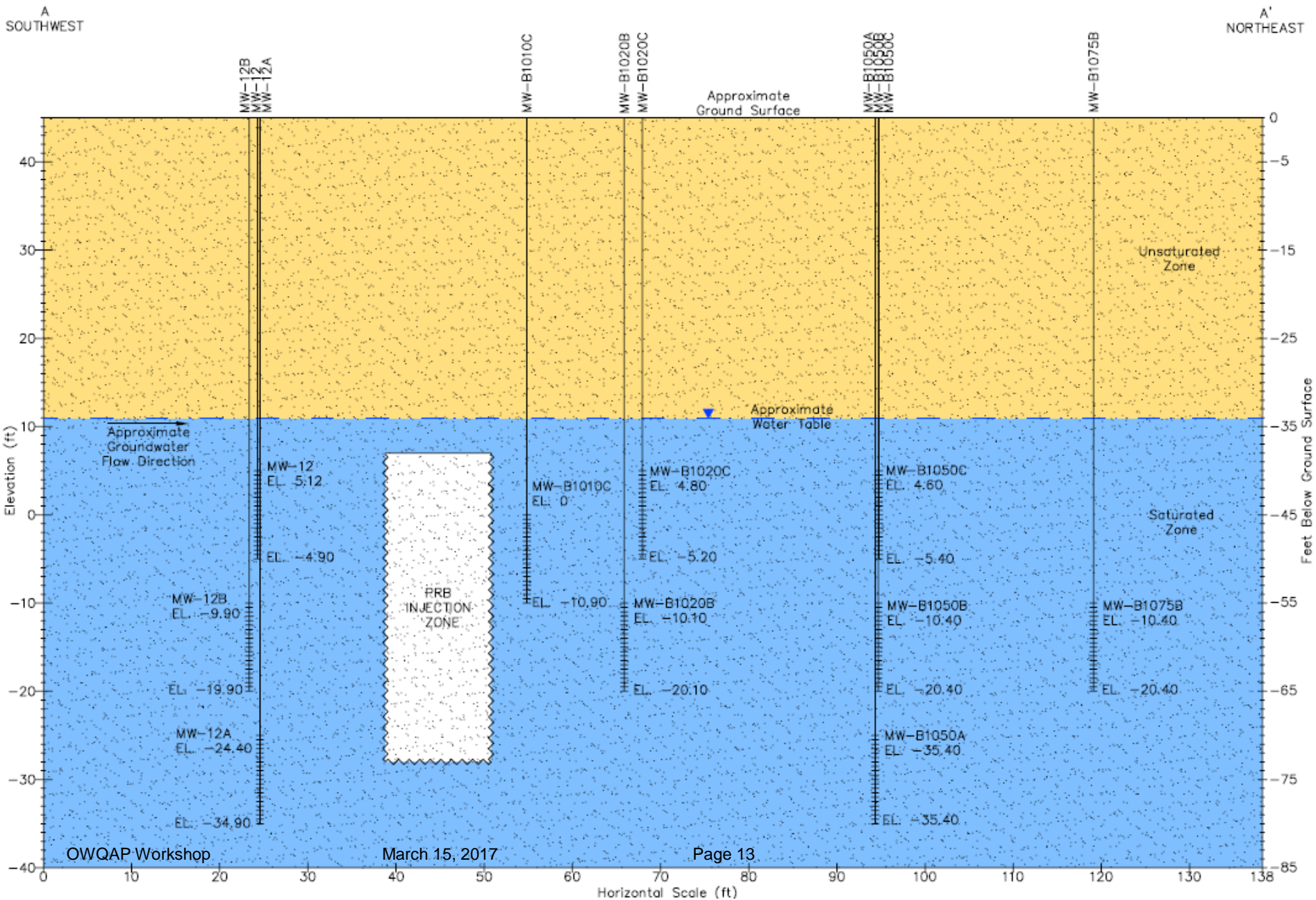
Eldredge Park Way PRB Cross Section Lines

PRB –line of injection wells

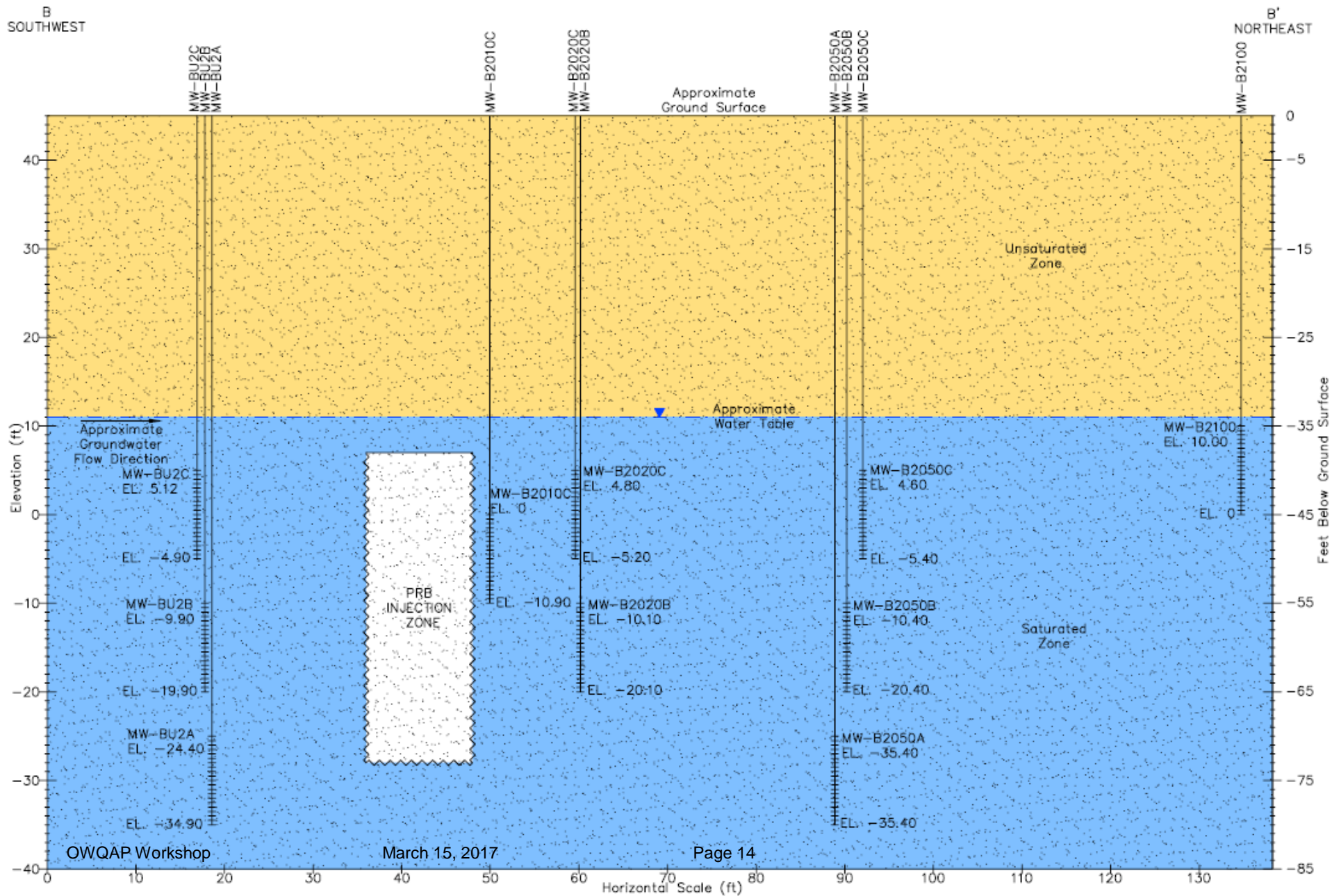
Groundwater Flow



Cross Section A-A'

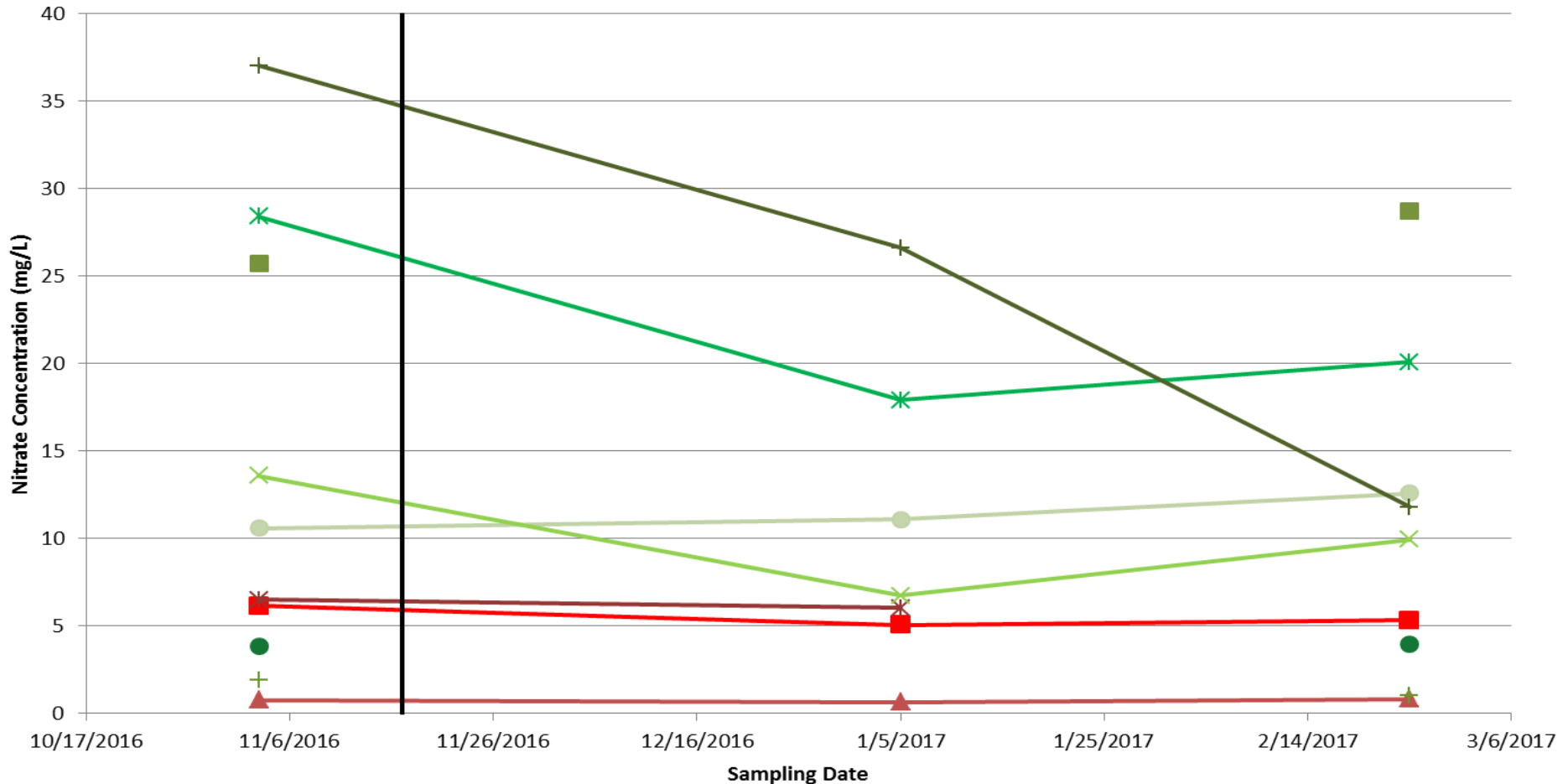


Cross Section B-B'



Eldredge Park PRB – Preliminary Data

Nitrate Concentrations at Eldredge Park Way PRB Demonstration Transect 1



MW-12A

MW-12B

MW-12 (Existing)

MW-B1020B

MW-B1020C

MW-B1050A

MW-B1010C

PRB Demonstration Injections

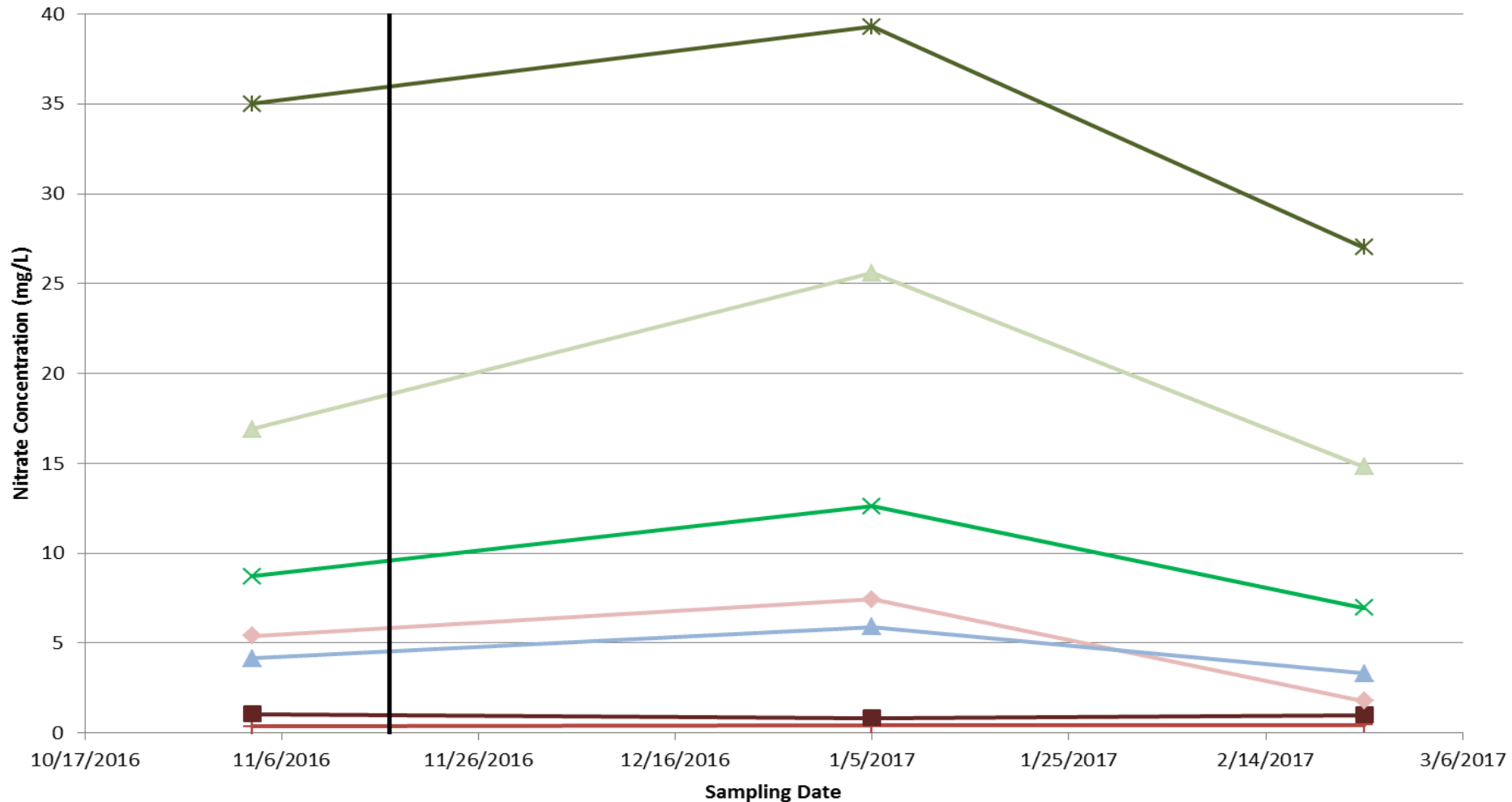
MW-B1050B

MW-B1050C

MW-B1075B

Eldredge Park PRB – Preliminary Data (cont.)

Nitrate Concentrations at Eldredge Park Way PRB Demonstration Transect 2



MW-BU2A MW-BU2B MW-BU2C MW-BC2C
MW-B2020B MW-B2020C MW-B2050A PRB Demonstration Injections

Next Steps Eldredge Park Way PRB Demonstration Test

- ❖ Evaluate PRB layout and test results to determine if modifications required
- ❖ Install four additional monitoring wells to expand range of monitoring network (completed week of 3/6/17)
- ❖ Continue Monitoring Demonstration Test at Eldredge Park – FY 2017 through FY 2019



Town Landfill – Project Objectives

- ❖ Implement Groundwater Assessment to confirm groundwater nitrogen flux based on groundwater flow and concentrations and to evaluate the distribution of 1,4-dioxane
 - Significant vertical section of aquifer potentially affected
 - Large area potentially affected
- ❖ Identify and Evaluate Response Actions for Nitrogen and 1,4-dioxane
- ❖ Conceptual Design and Cost Estimate for Response Actions



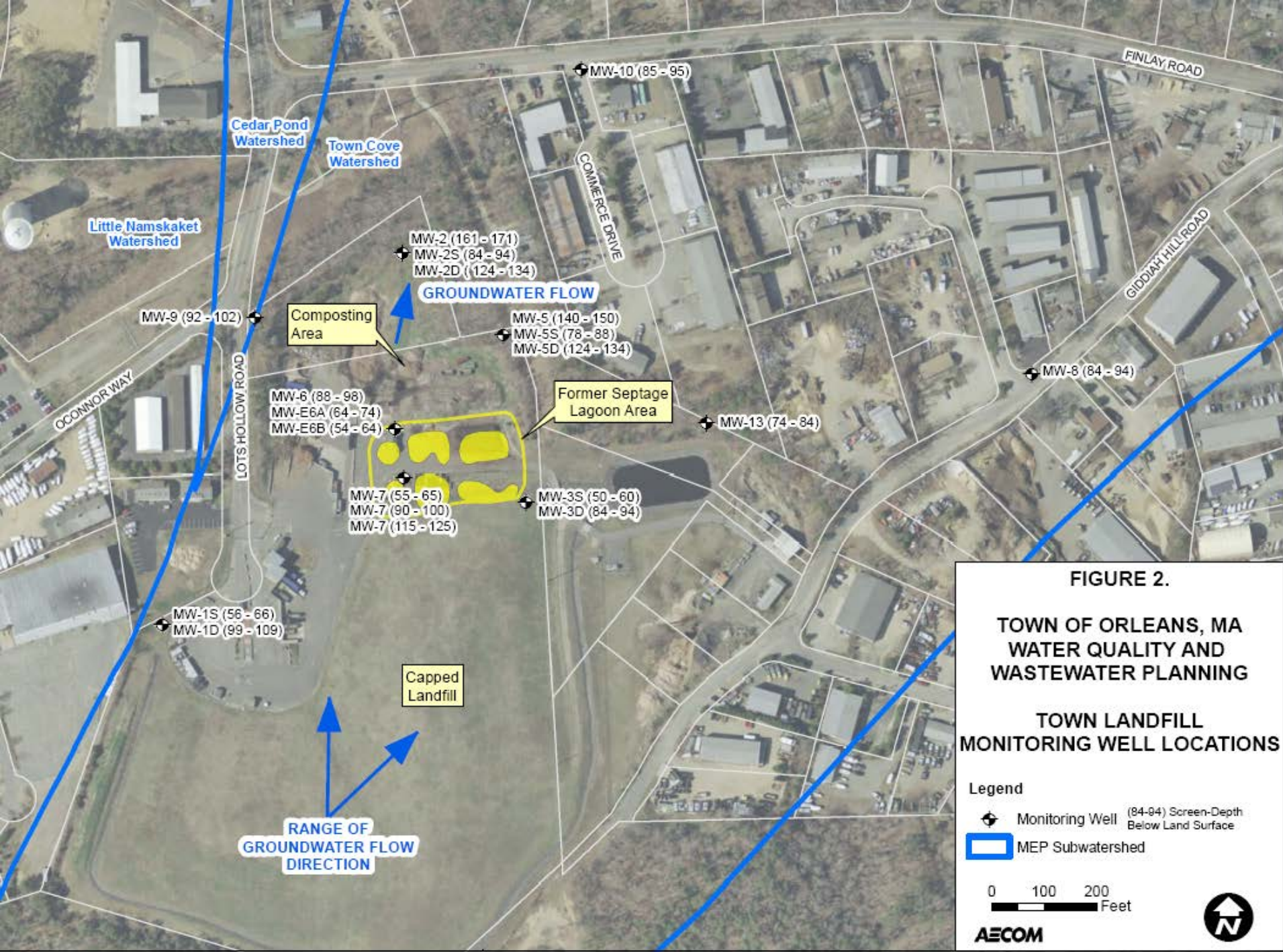





FIGURE 2.
TOWN OF ORLEANS, MA
WATER QUALITY AND
WASTEWATER PLANNING
TOWN LANDFILL
MONITORING WELL LOCATIONS

Legend

-  Monitoring Well (84-94) Screen-Depth Below Land Surface
-  MEP Subwatershed

0 100 200 Feet

AECOM



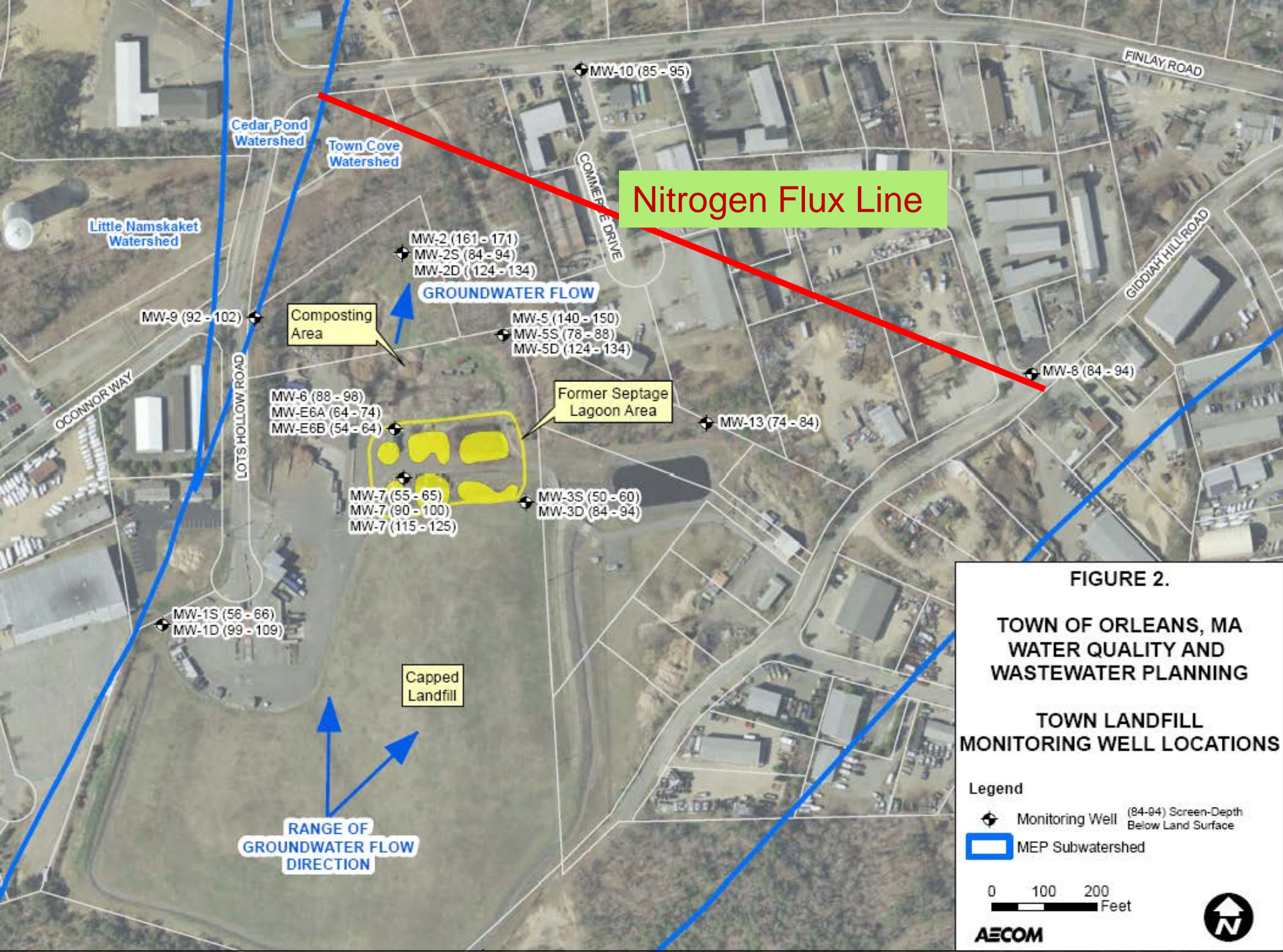


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Town of Orleans, Massachusetts
Water Quality and Wastewater Planning
Non-Traditional Technologies - Landfill Nitrogen Flux
Estimated Nitrogen flux (mass per time) from the Orleans Landfill.

Parameter	Units	Low Range Flux	High Range Flux	Mid Range Flux
Groundwater Seepage Velocity (variable) ¹	ft/d	2.00	4.00	3.00
Porosity	unitless	0.25	0.25	0.25
Darcy Velocity	ft/d	0.50	1.00	0.75
Vertical Extent	feet	60	60	60
Length of Affected Aquifer ²	feet	1,540	1,540	1,540
Groundwater Flux	ft ³ / d-ft length	30	60	45
Groundwater Flux	ft ³ / day	46,200	92,400	69,300
Groundwater Flux	L/day	1,308,236	2,616,472	1,962,354
Groundwater Flux	Gallons/min	240	480	360
Nitrate Concentration (variable) ³	mg/L	6.00	24.00	12.00
Nitrate Flux	kg /yr-ft length	1.86	14.88	5.58
Nitrate Flux	kg/year	2,865	22,920	8,595

1. Variable - sensitive to hydraulic conductivity Groundwater velocity is variable based on a range of hydraulic conductivity (Low 60 - High 250 ft./day)

2. Affected Aquifer length - line across watershed from corner Lots Hollow Rd and Finlay Rd. to Giddiah Hill Rd. at corner Industrial Way

3. Variable -sensitive to total nitrogen concentration - Data set average concentration 12 mg/L, range 1 mg/L to 27 mg/L, n=32



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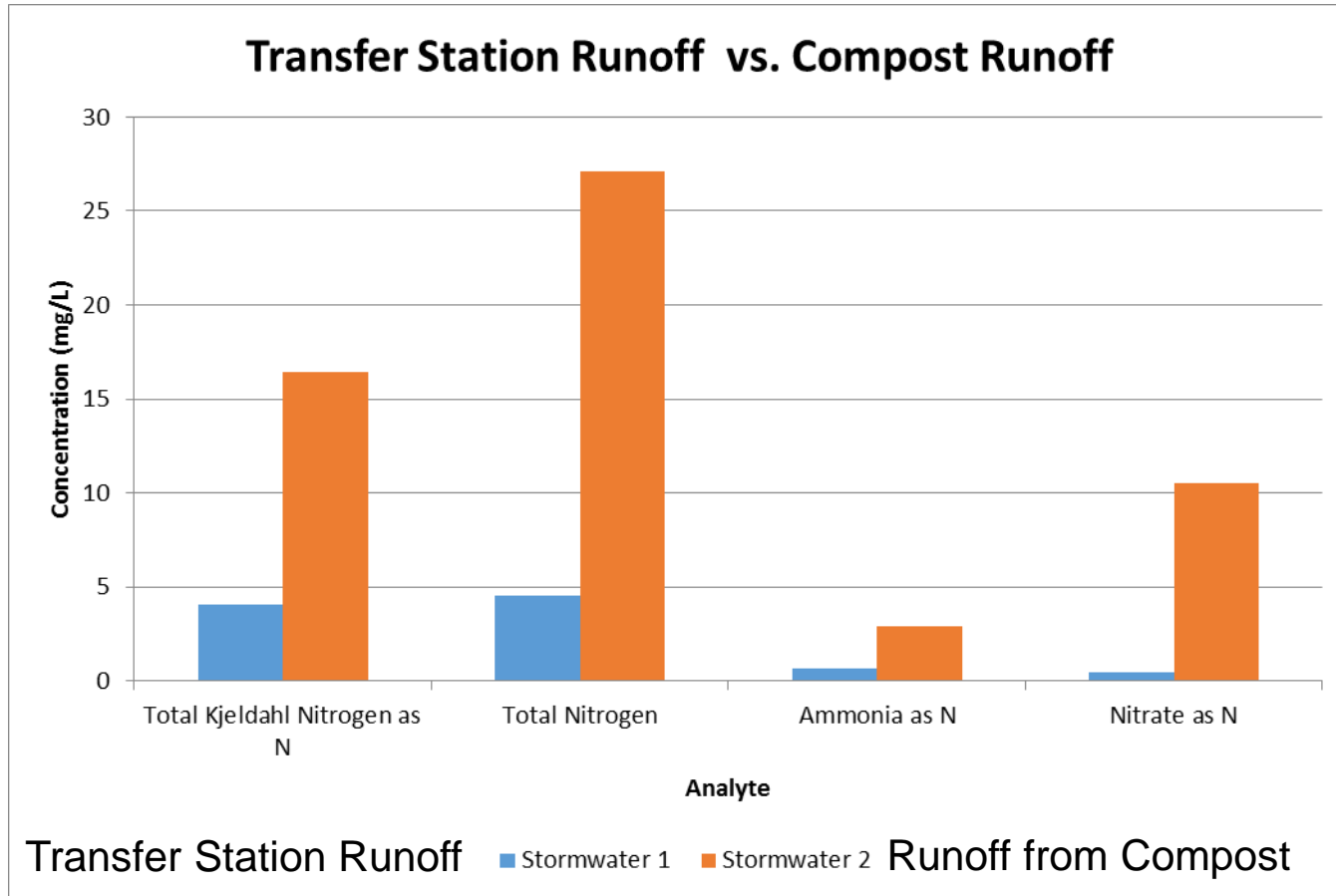
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Sources of Nitrogen at the Landfill



Compost Operation Significant Nitrogen Source



1,4-dioxane in groundwater

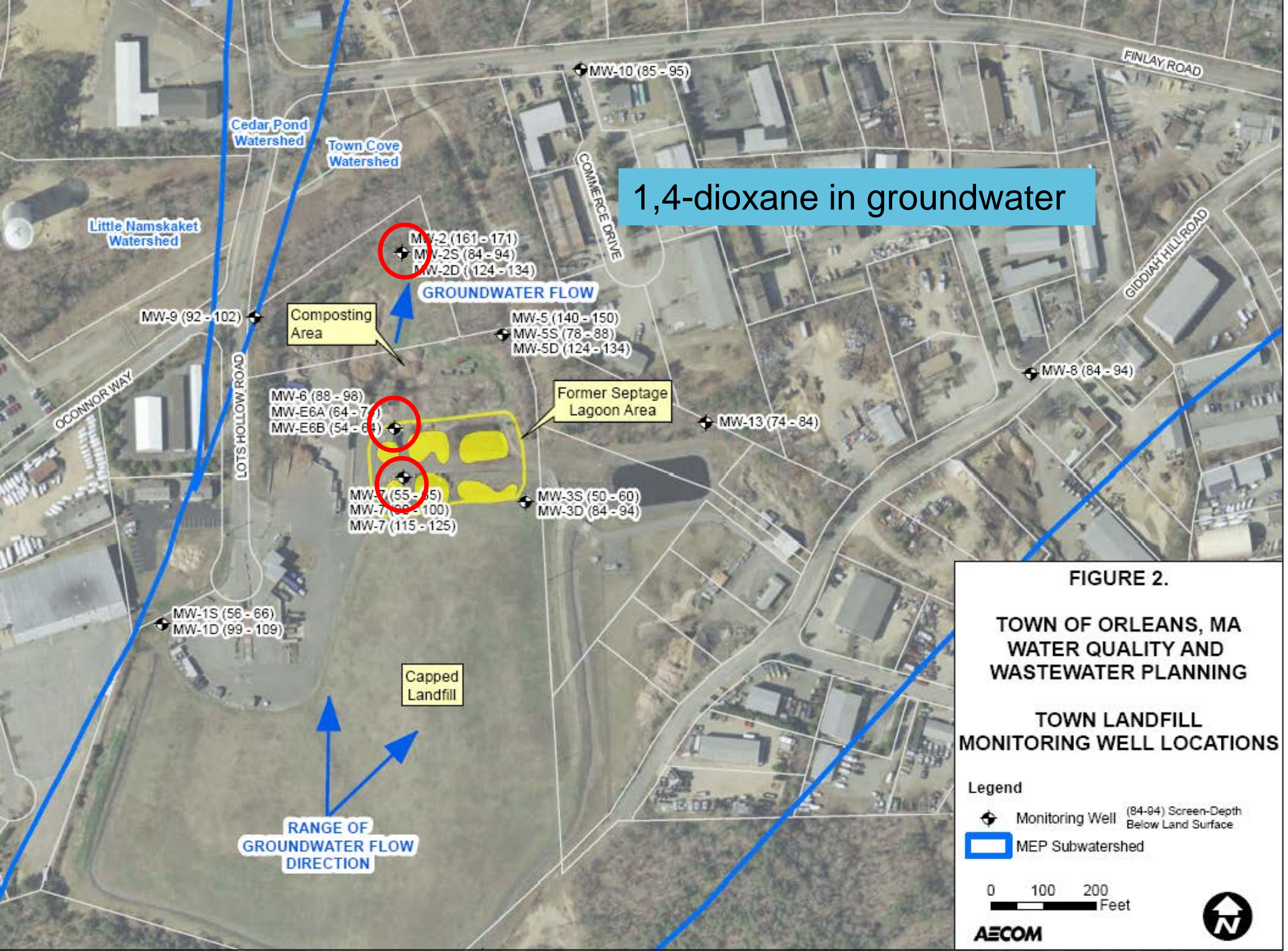


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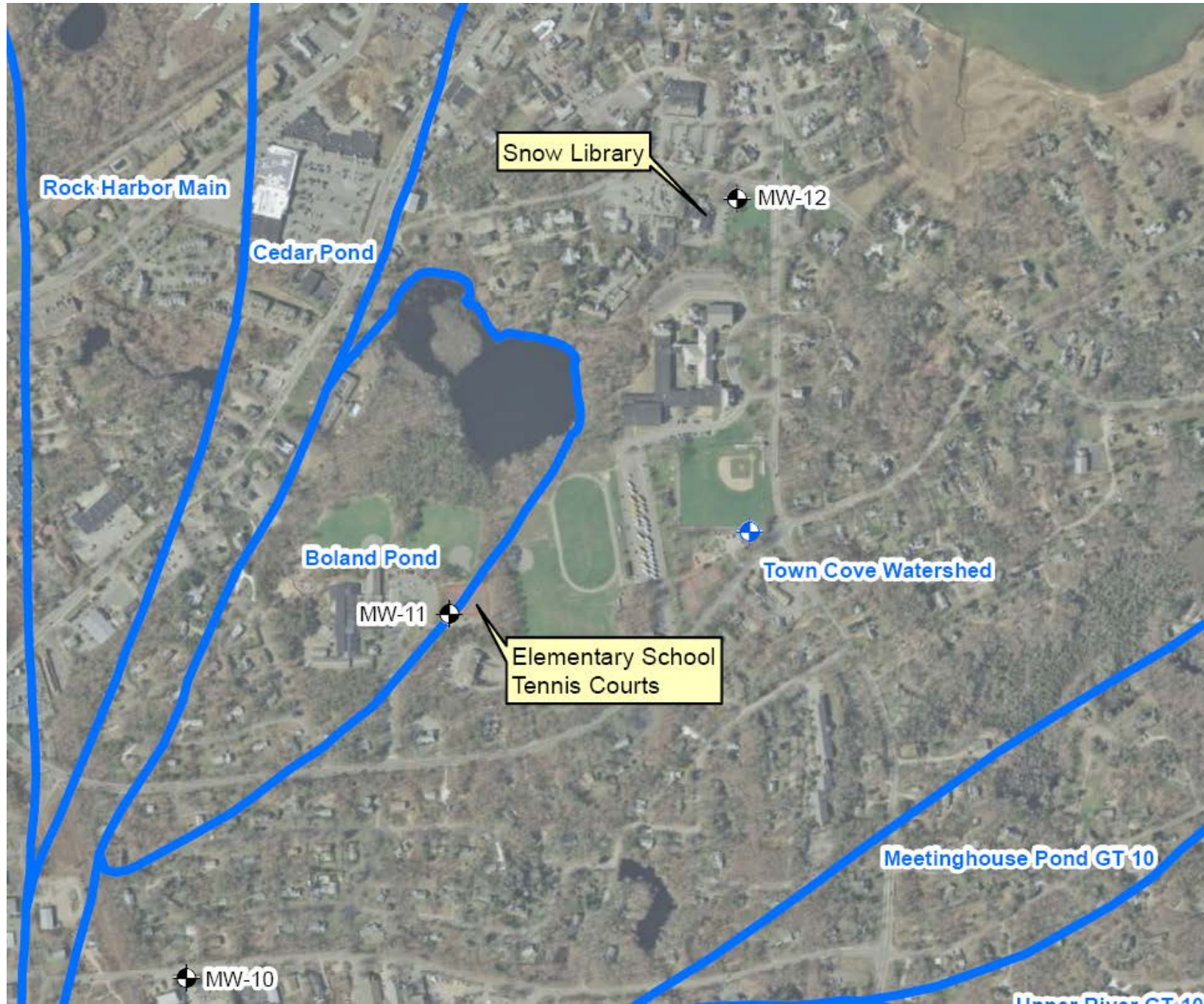
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Landfill - Summary

- ❖ Groundwater affected by significant nitrate concentrations shallow and by ammonia and 1,4-dioxane deep
- ❖ Sources of 1,4-dioxane and nitrogen identified
 - 1,4-dioxane source appears to be solid waste in the landfill
 - Nitrogen sources:
 - Landfill (mainly ammonia)
 - Septage Lagoons (ammonia and nitrate)
 - Compost operation (organic nitrogen, ammonia, and nitrate)
 - Transfer Station runoff (ammonia and nitrate)
- ❖ Landfill Area Nitrogen flux Estimated –Mid-range estimate ~ 8,500 kg/yr
- ❖ 1,4-dioxane detected in more monitoring wells > 0.0003 mg/L standard
- ❖ Potential area of downgradient migration area in watershed identified



Downgradient Watershed Wells



Landfill Potential Corrective Actions for Nitrogen - Nitrogen Flux

- ❖ Reduce/Eliminate infiltration of transfer station stormwater/landfill cap drainage through the septage lagoon area
- ❖ Move compost operation to a location with an impermeable surface (already in planning by DPW)
- ❖ Consider treatment of stormwater, landfill cap drainage and compost area runoff with best management practices to maximize denitrification
- ❖ Consider active capture and treatment of landfill area nitrogen flux with groundwater extraction and treatment with nitrification/denitrification bio-filter systems

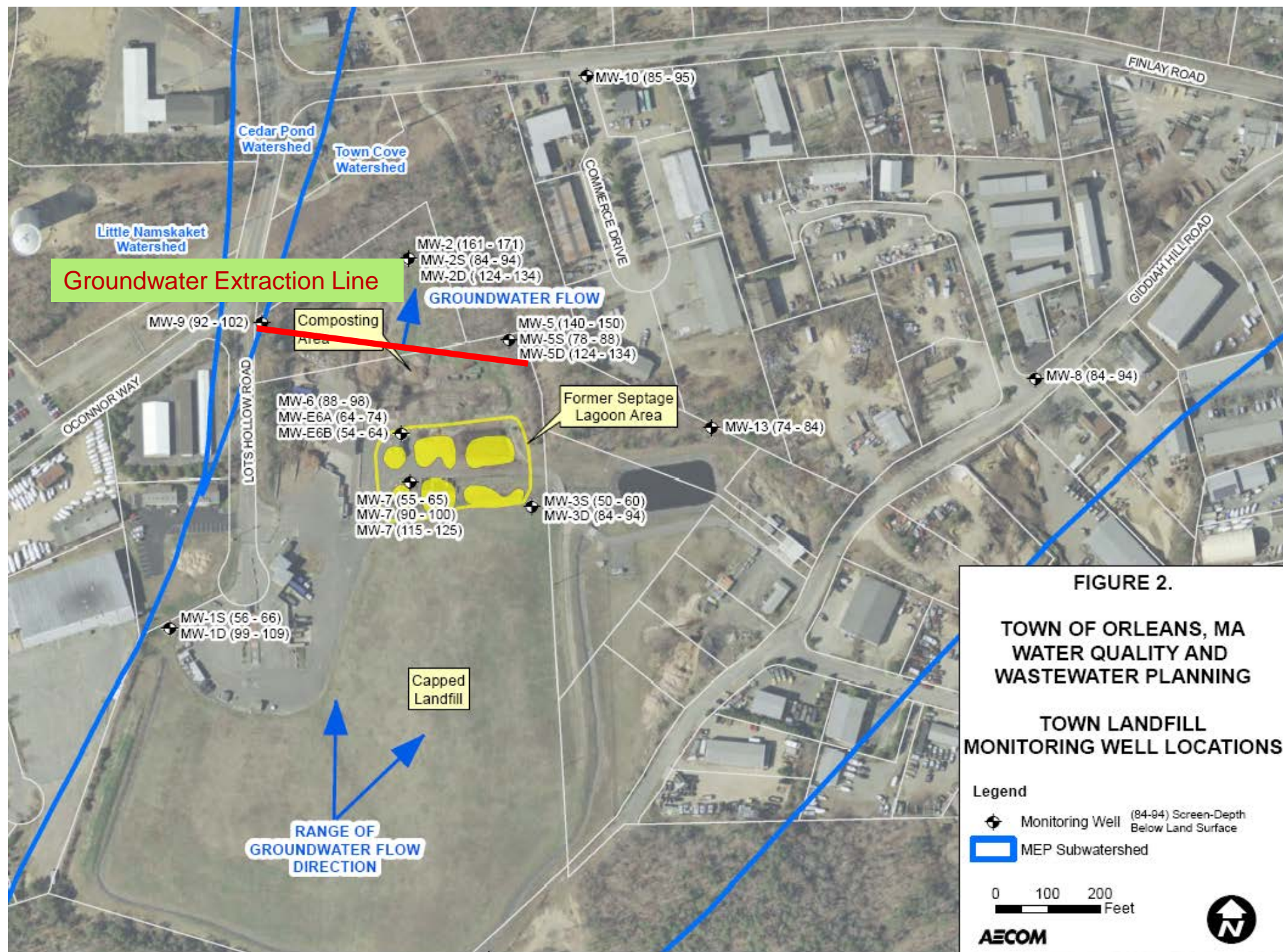


Potential Landfill Corrective Action for Nitrogen - Nitrogen Flux - Nitrification/Denitrification Bio-Filter System

❖ System Components:

- Groundwater extraction pumping system (could be solar powered)
- 1st Stage - nitrification system (convert ammonia to nitrate) with nitrification bio-filters
- 2nd stage denitrification treatment with denitrification bio-filters
- Re-infiltration to groundwater





Groundwater Extraction Line

GROUNDWATER FLOW

Composting Area

Former Septage Lagoon Area

Capped Landfill

RANGE OF GROUNDWATER FLOW DIRECTION

FIGURE 2.

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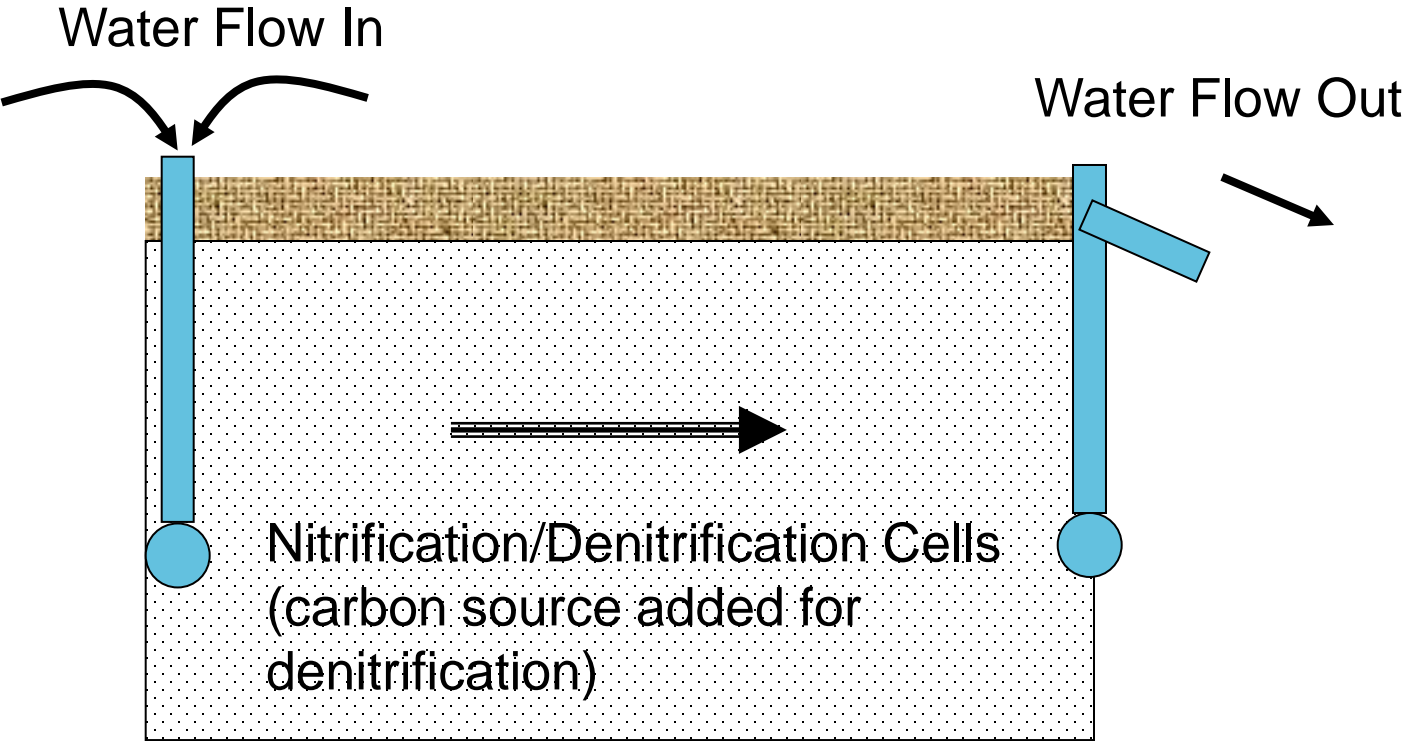
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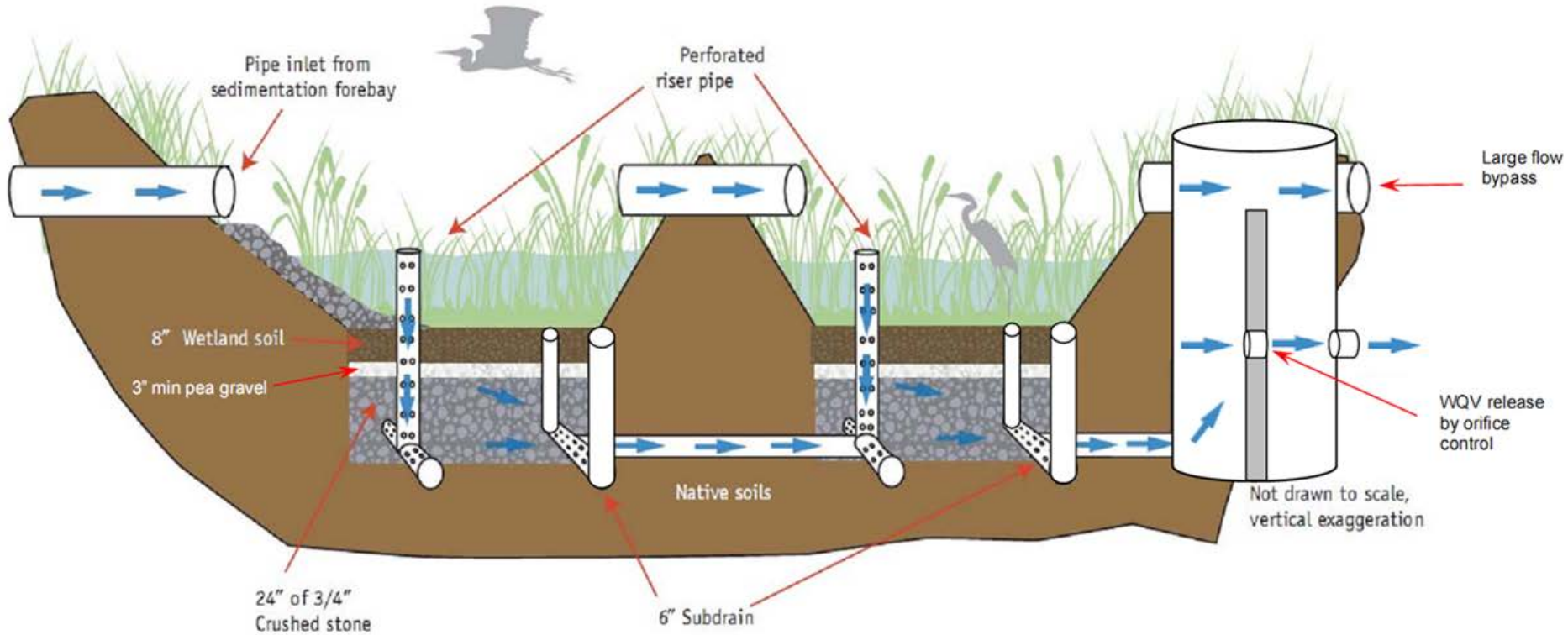
0 100 200 Feet

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Bio-Filter Treatment System Concept



Nitrification/Denitrification Bio-Filter System



Next Steps Landfill Site

- ❖ Evaluate risks associated with 1,4 –dioxane and complete initial conceptual design and cost estimate to reduce nitrogen flux
- ❖ Implement final design, permit, and construct landfill nitrogen flux corrective actions in FY-18



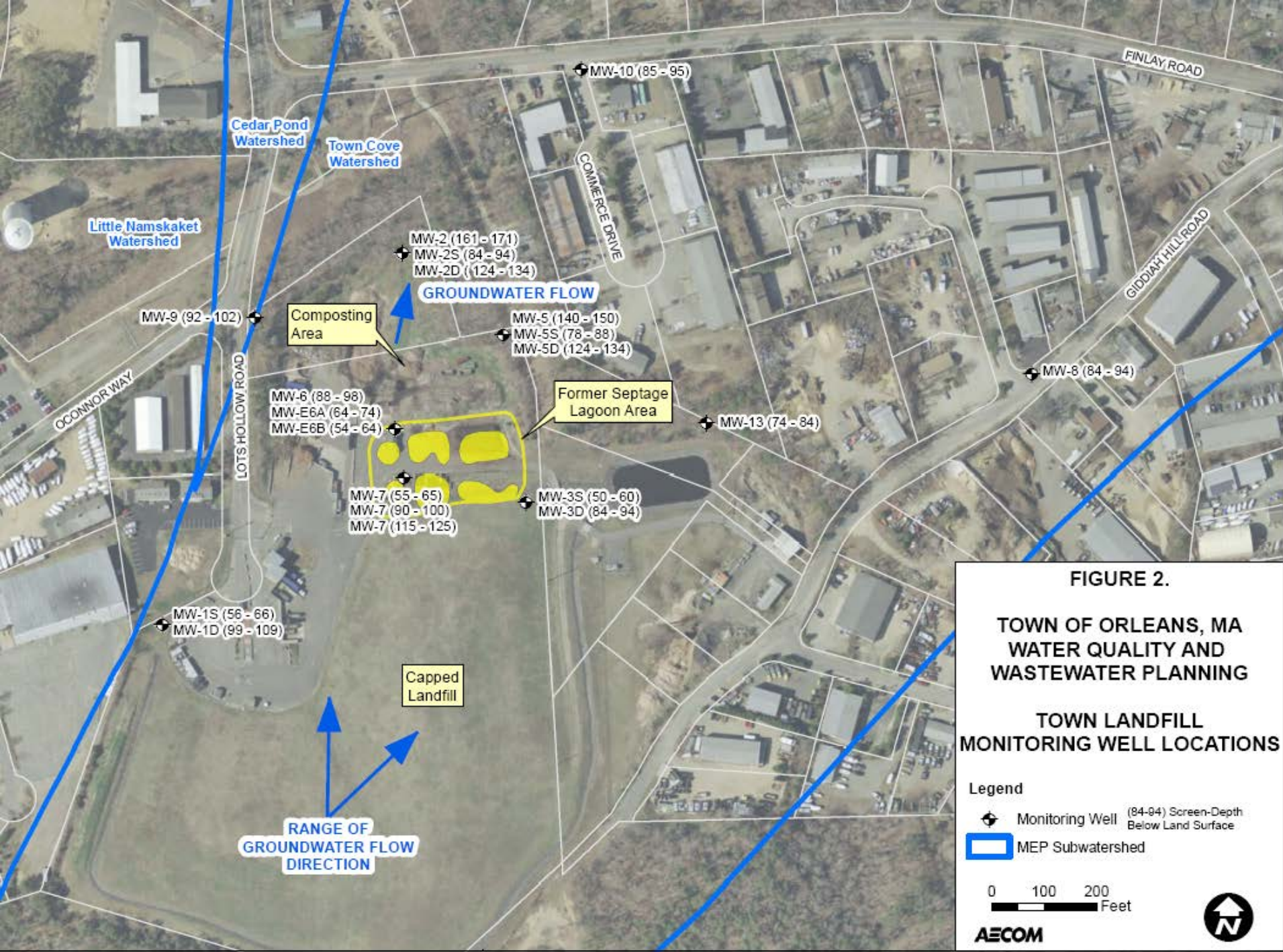




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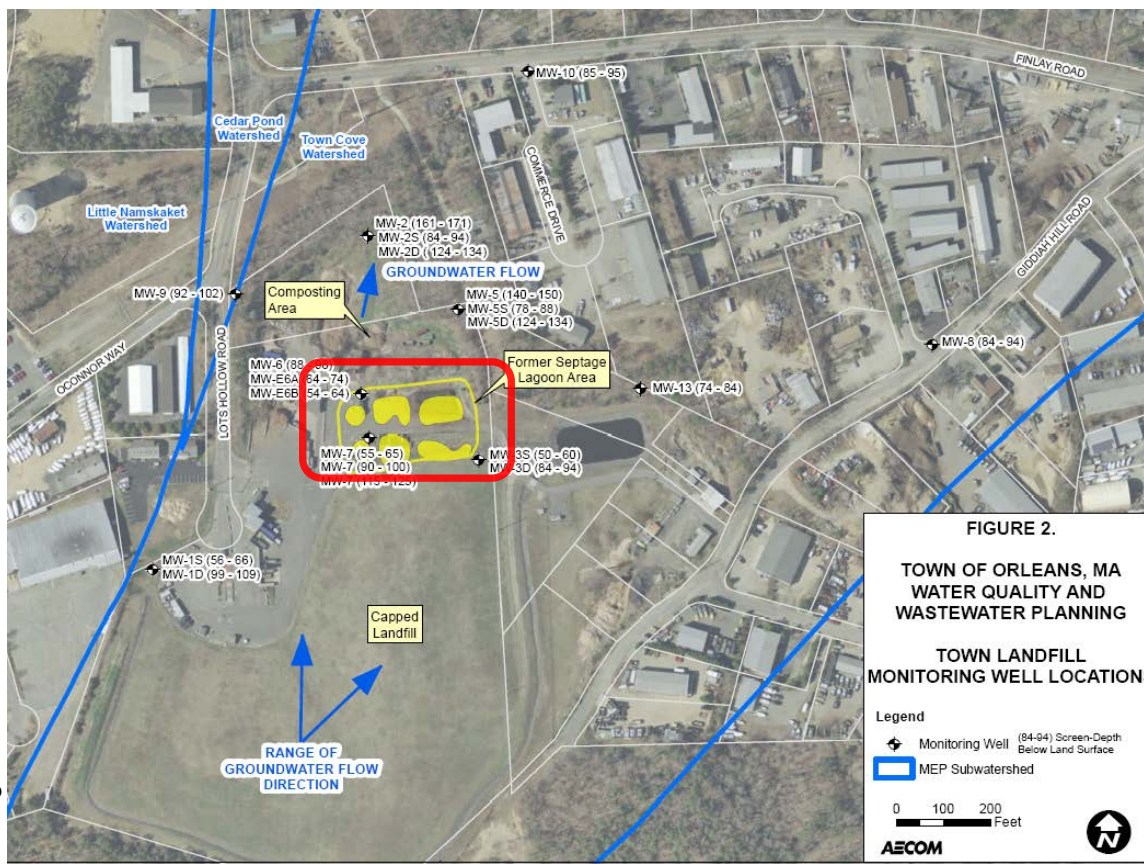
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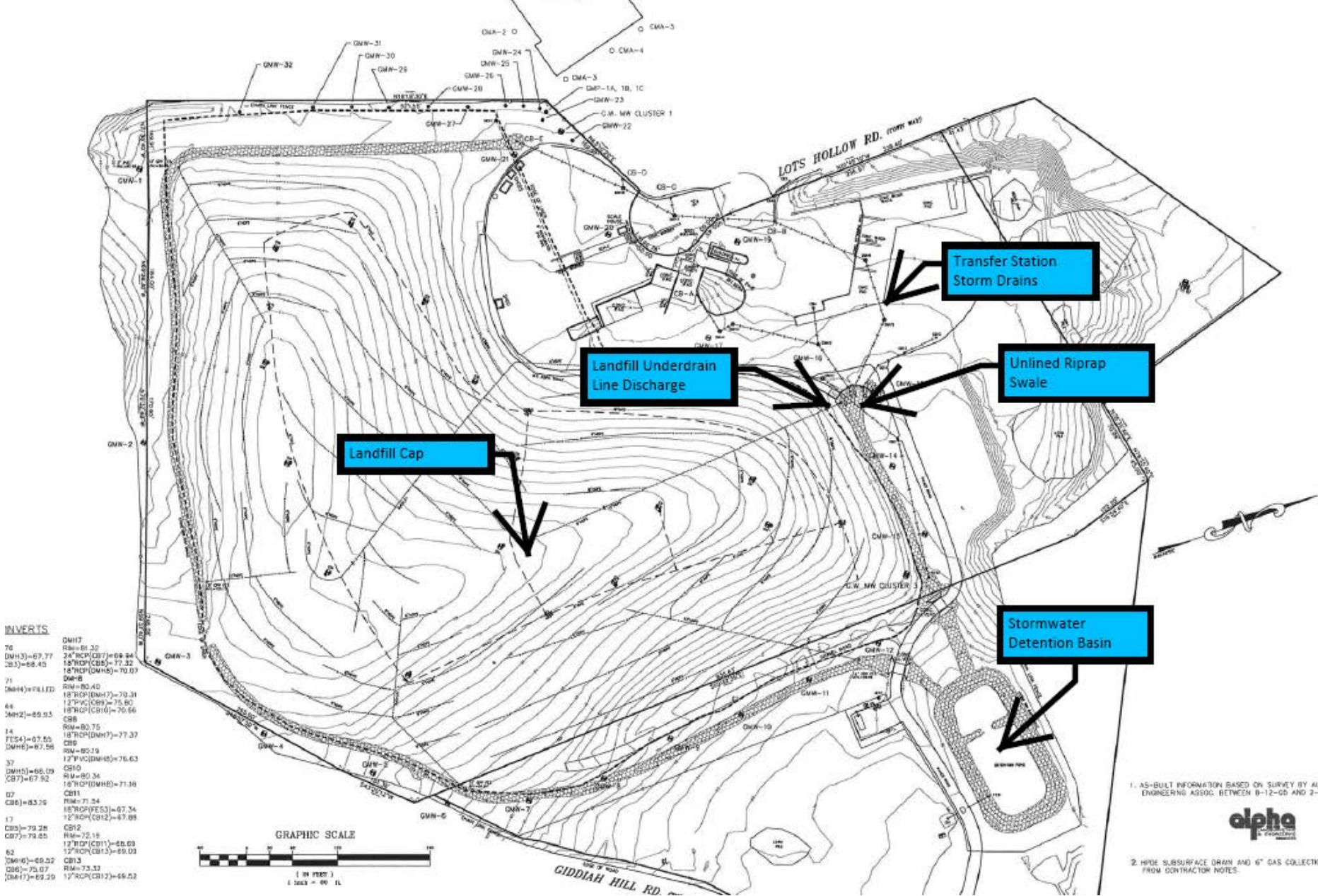
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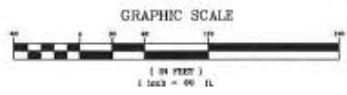
Volume and Cost estimate Landfill Septage Lagoons excavation												
		L	w	Ft2	Vertical	Volume ft2	Cubic Yards	tons	No. 18 Wheelers	Excavation Cost \$10/yd	T/Disposal \$135/ton	Total
Volume of necessary over excavation to safely reach depth (extends into cap area)												
Overburden	Footprint	500	300	150,000	12	1,800,000	66,667	106,667	5,333	\$666,667		\$666,667
Backfill										\$666,667		\$666,667
Septage soil	Footprint	300	200	60,000	2	120,000	4,444	7,111	356	\$44,444	\$960,000	\$1,004,444
											Subtotal	\$2,337,778
											Engineering	\$584,444
											Total	\$2,922,222





INVERTS

70	DMH7	RM=81.20
DMH3)=67.77	24"RCP(CB7)=68.84	18"RCP(CB5)=77.32
CB3)=68.45	18"RCP(DMH5)=70.07	
71	DMH8	RM=80.40
DMH4)=71.17	18"RCP(DMH7)=70.31	12"RCP(CB9)=75.80
64	CB8	18"RCP(CB10)=70.84
54H2)=69.93	RM=80.75	18"RCP(DMH7)=77.37
14	CB6	RM=80.19
FE54)=67.55	12"RCP(DMH6)=76.63	
DMH5)=67.58	RM=80.34	18"RCP(DMH6)=71.16
37	CB11	RM=71.54
DMH3)=66.09	18"RCP(FE53)=67.34	12"RCP(CB12)=67.88
CB7)=67.92	CB12	RM=72.18
07	CB13	12"RCP(CB13)=69.09
CB6)=65.26	RM=73.37	
17	CB14	12"RCP(CB12)=66.52
CB5)=70.28	CB15)=69.29	
CB7)=70.85		
62		
DMH6)=66.22		
CB6)=70.07		
DMH7)=69.29		



1. AS-BUILT INFORMATION BASED ON SURVEY BY ALP ENGINEERING ASSOC. BETWEEN 8-12-08 AND 2-1

alpha
ENGINEERING ASSOCIATES

2. HYD. SUBSURFACE DRAIN AND 6" GAS COLLECTOR FROM CONTRACTOR NOTES.







Thank You