Pilot Test of Nutrient Removal by Large-Scale Drip Dispersal of Tertiary-Treated Effluent, Southern Vermont

Craig Heindel, C.P.G.
Senior Hydrogeologist,
Waite-Heindel
Envir. Mgmt.
Burlington, VT

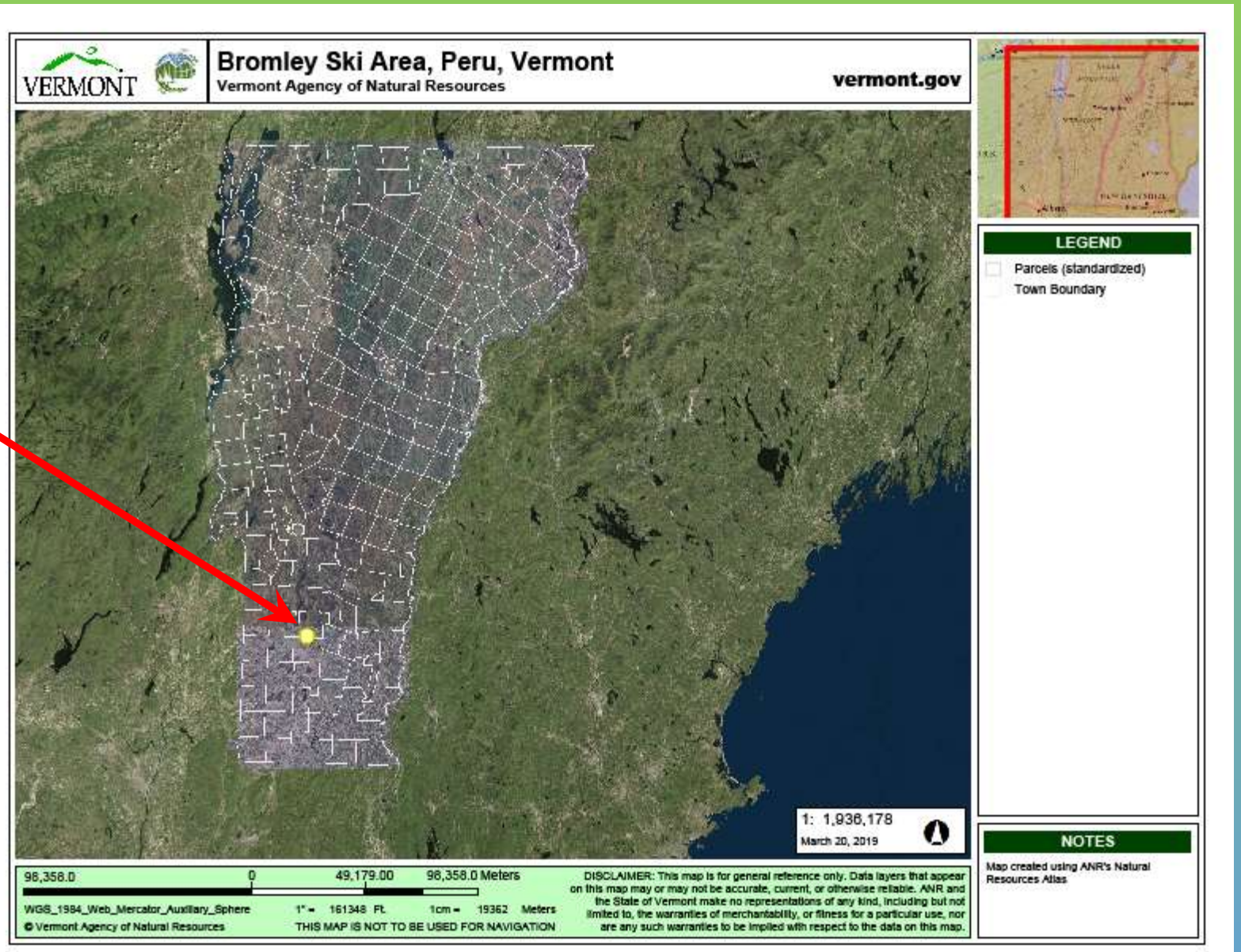
2019 NEIWPCC
Onsite Short Course

Pilot Test, Nutrient Removal by Drip Dispersal

- **Proposed Development at Bromley Ski Area, Peru, VT;**
- **Soil-based Wastewater Disposal;**
- **In-stream Nutrient Limits are set by VT regulations;**
- **Pilot Drip-Dispersal Test was conducted to evaluate nutrient removal prior to indirect discharge into stream.**

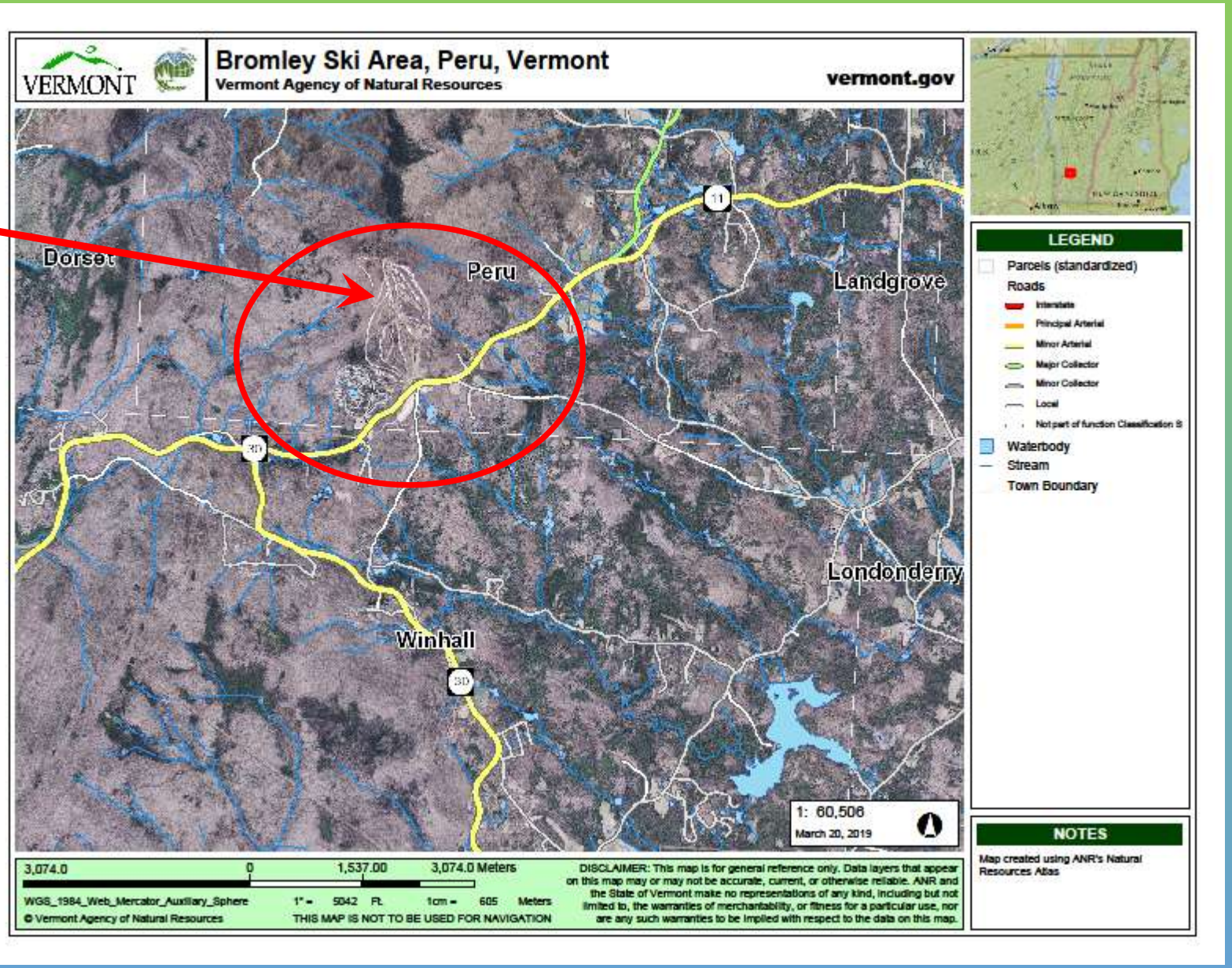
Pilot Test, Nutrient Removal by Drip Dispersal

Bromley Ski Area, Peru, VT



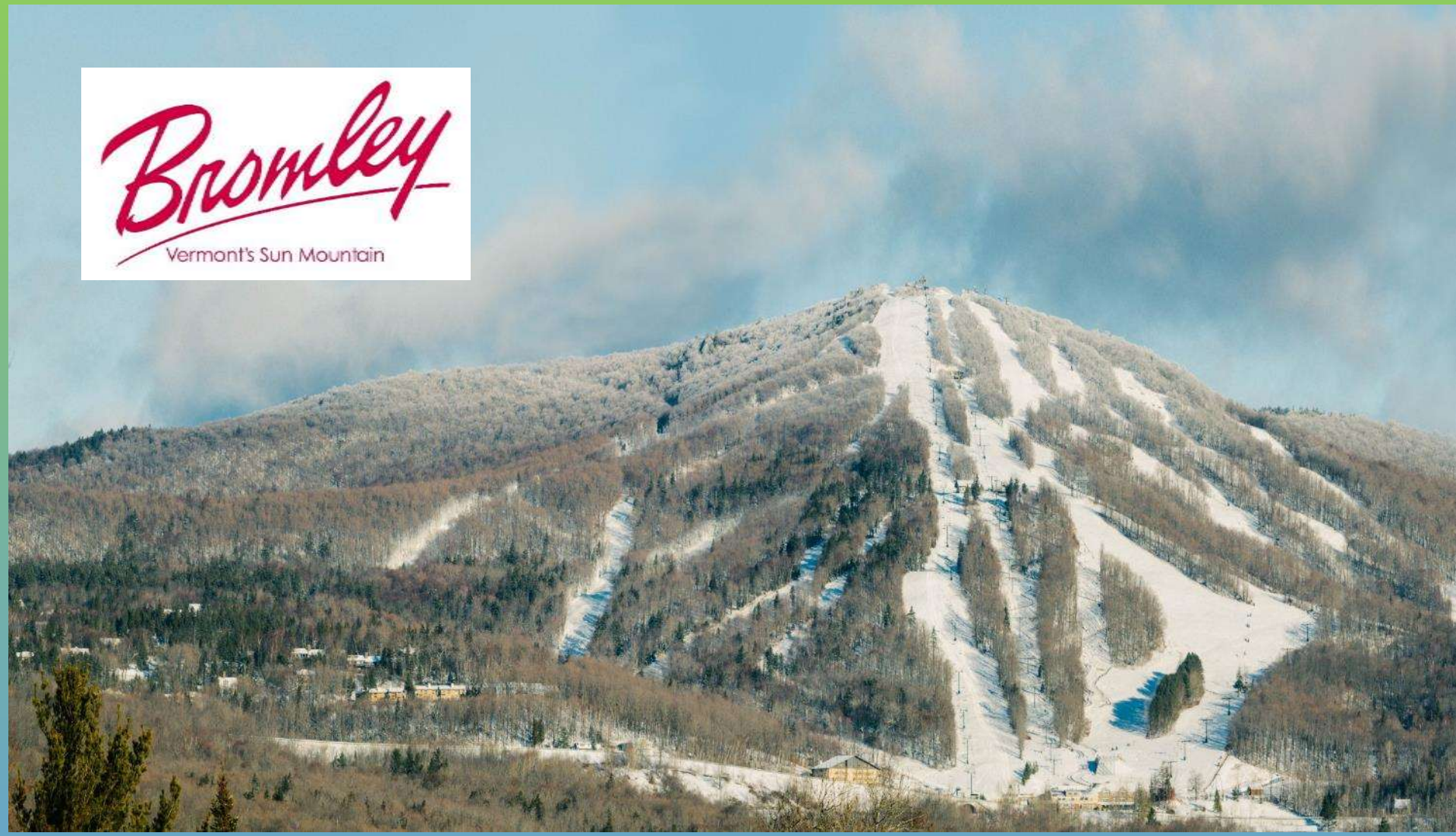
Pilot Test, Nutrient Removal by Drip Dispersal

Bromley Ski Area, Peru, VT



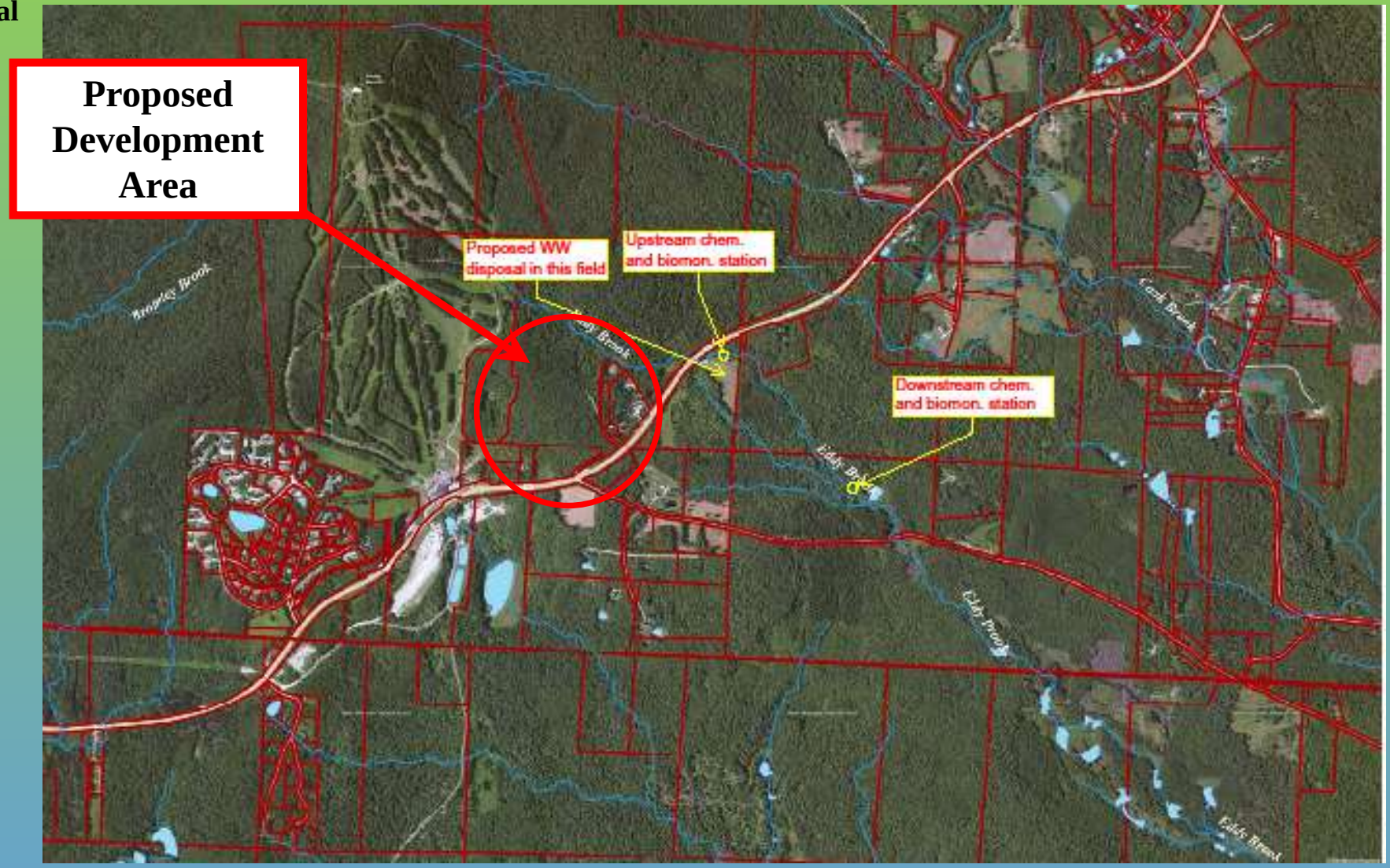
WAITE HEINDEL

Pilot Test, Nutrient Removal by Drip Dispersal



WAITE HEINDEL

Pilot Test, Nutrient Removal by Drip Dispersal



<u>Wastewater Disposal Needs</u>: about 80,000 gpd

<u>OPTIONS CONSIDERED</u>:

1. **Existing WW Treatment Plant [secondary], then disposal via spray irrigation at existing spray fields**

- **NO: not enough capacity to treat or dispose of additional 80,000 gpd**

<u>Wastewater Disposal Needs</u>: about 80,000 gpd

<u>OTHER OPTIONS CONSIDERED</u>:

2. Existing WW Treatment Plant [secondary], then disposal at new disposal area

- **NO: Indirect Discharge regulations require high degree of nutrient removal, so need tertiary treatment**

<u>Wastewater Disposal Needs</u>: about 80,000 gpd

<u>OPTION SELECTED</u>:

3. Project-specific WW Treatment [tertiary], then soil-based disposal at new disposal area

- **YES – BUT . . . Vermont's Indirect Discharge regs require field verification of predicted nutrient removal by soils at disposal area.**

VT's INDIRECT DISCHARGE REGULATIONS:

- **Three independent capacities must be evaluated:**

1. **Sufficient application area [horizontal];**

VT's INDIRECT DISCHARGE REGULATIONS:

- **Three independent capacities must be evaluated:**

1. **Sufficient application area [horizontal];**
2. **Sufficient vertical room for induced groundwater mound [maintain min. 3.0-ft. unsaturated zone below infiltrative surface];**

VT's INDIRECT DISCHARGE REGULATIONS:

- **Three independent capacities must be evaluated:**

1. **Sufficient application area [horizontal];**
2. **Sufficient vertical room for induced groundwater mound [maintain min. 3.0-ft. unsaturated zone below infiltrative surface];**
3. **Compliance with "Aquatic Permitting Criteria"**

[provides presumption of compliance with Vermont Surface Water Quality Standards].

WAITE HEINDEL

This presentation focuses on Capacity #3:

3. Compliance with Aquatic Permitting Criteria:

Two critical Nutrient parameters are addressed:

- **Total Dissolved Phosphorus: increase of no more than 0.001 mg/L above upstream location;**

This presentation focuses on Capacity #3:

3. Compliance with Aquatic Permitting Criteria:

Two critical Nutrient parameters are addressed:

- **Total Dissolved Phosphorus: increase of no more than 0.001 mg/L above upstream location;**

- **Nitrate: not exceed 2.0 mg/L.**

This presentation focuses on Capacity #3:

3. Compliance with Aquatic Permitting Criteria:

Two critical Nutrient parameters are addressed:

- **Total Dissolved Phosphorus: increase of no more than 0.001 mg/L above upstream location;**

- **Nitrate: not exceed 2.0 mg/L.**

Question: Where do these APCs apply?
Answer: At the "Compliance Point"

WAITE HEINDEL

3. [Cont.] Compliance with Aq. Perm. Crit.:

Compliance Point:

- **In "receiving water", at lowest point of flowpath from disposal system;**

- **Applies at "Low Median Monthly Flow".**

3. [Cont.] Compliance with Aq. Perm. Crit.:

Compliance Point:

- **In "receiving water", at lowest point of flowpath from disposal system;**
- **Applies at "Low Median Monthly Flow".**

LEADS TO:

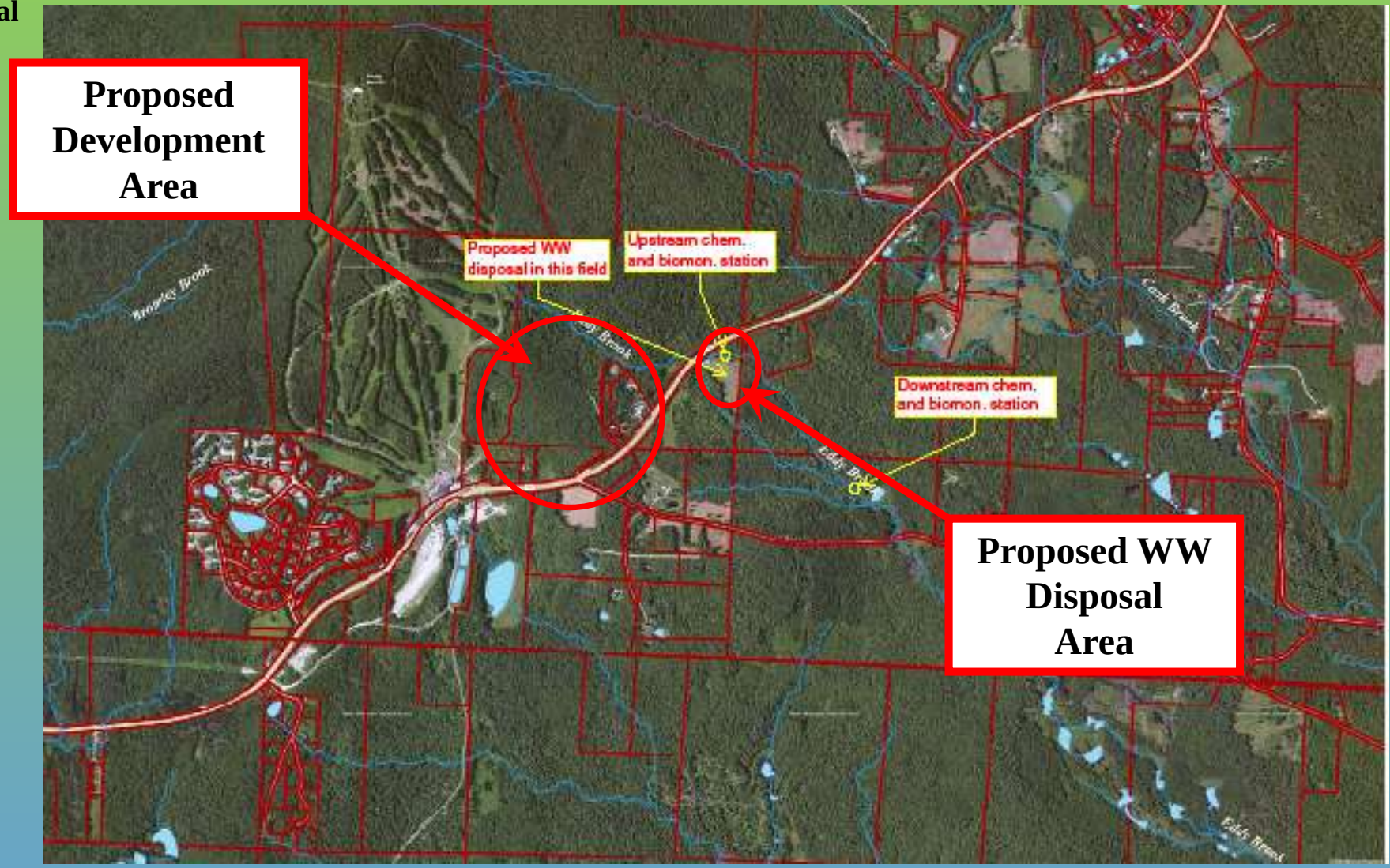
- **Choosing disposal site whose receiving water is a large stream or river [to maximize dilution];**

OR

- **Choosing treatment and disposal methods that will remove most of the nutrients [esp. TDP].**

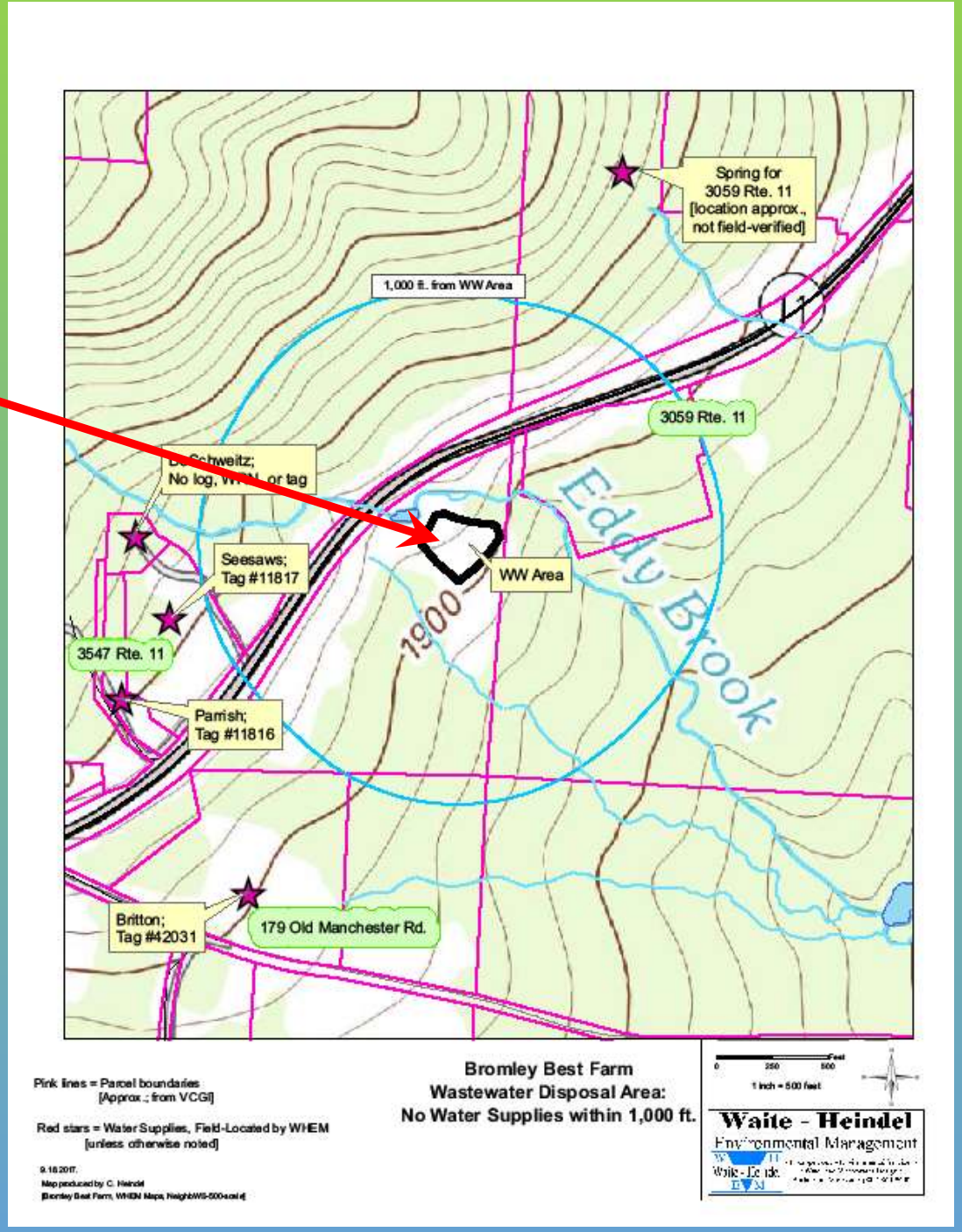
[OR BOTH]

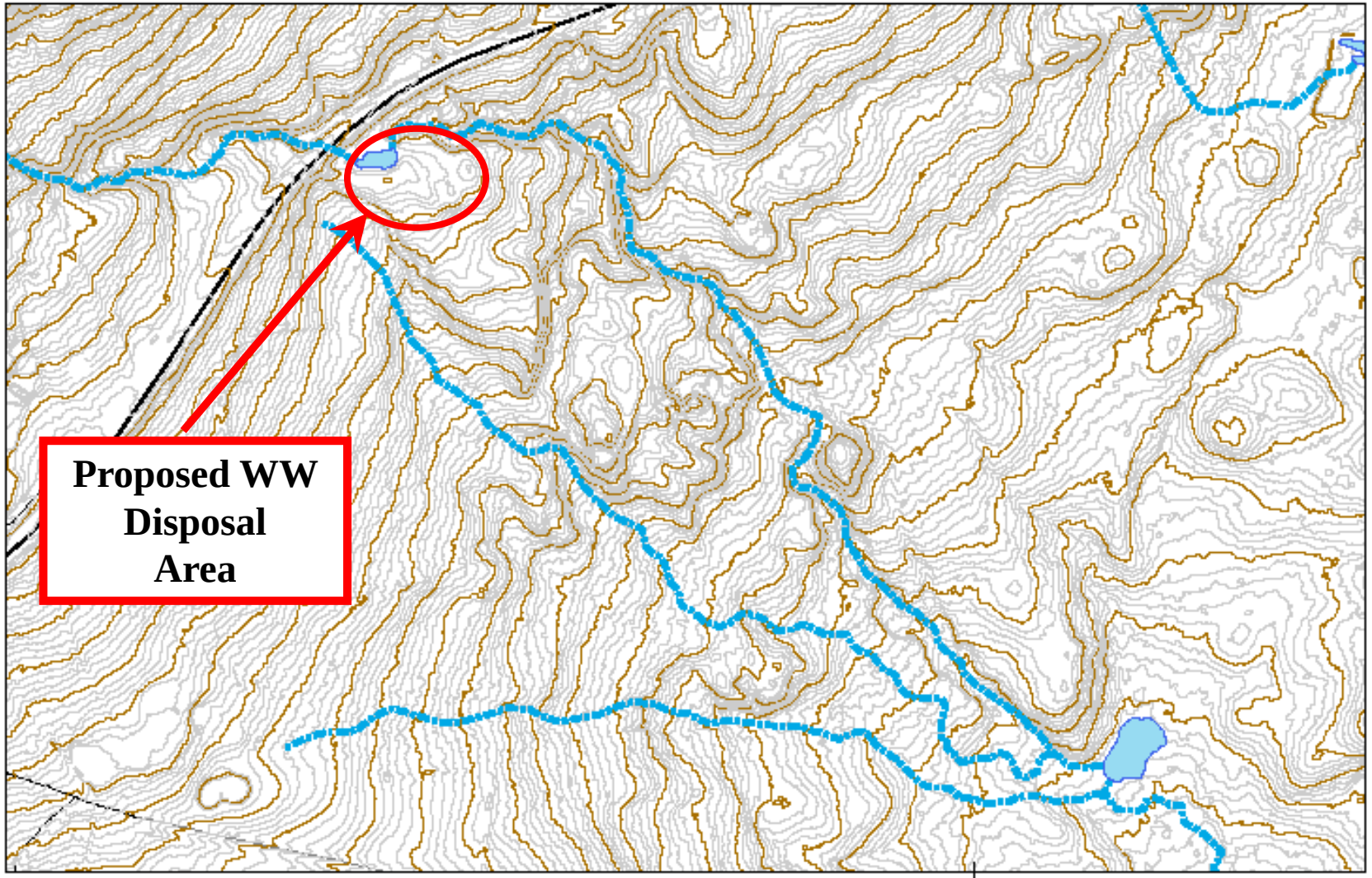
Pilot Test, Nutrient Removal by Drip Dispersal



Pilot Test, Nutrient Removal by Drip Dispersal

Proposed WW Disposal Area





Dashed Blue = "Stream", from VCGI Hydrology database.

Topography: 2-ft. Contour Interval LIDAR, from VCGI

Proposed Wastewater Disposal Area; Bromley Best Farm

0 400 800 Feet

1 inch = 400 feet

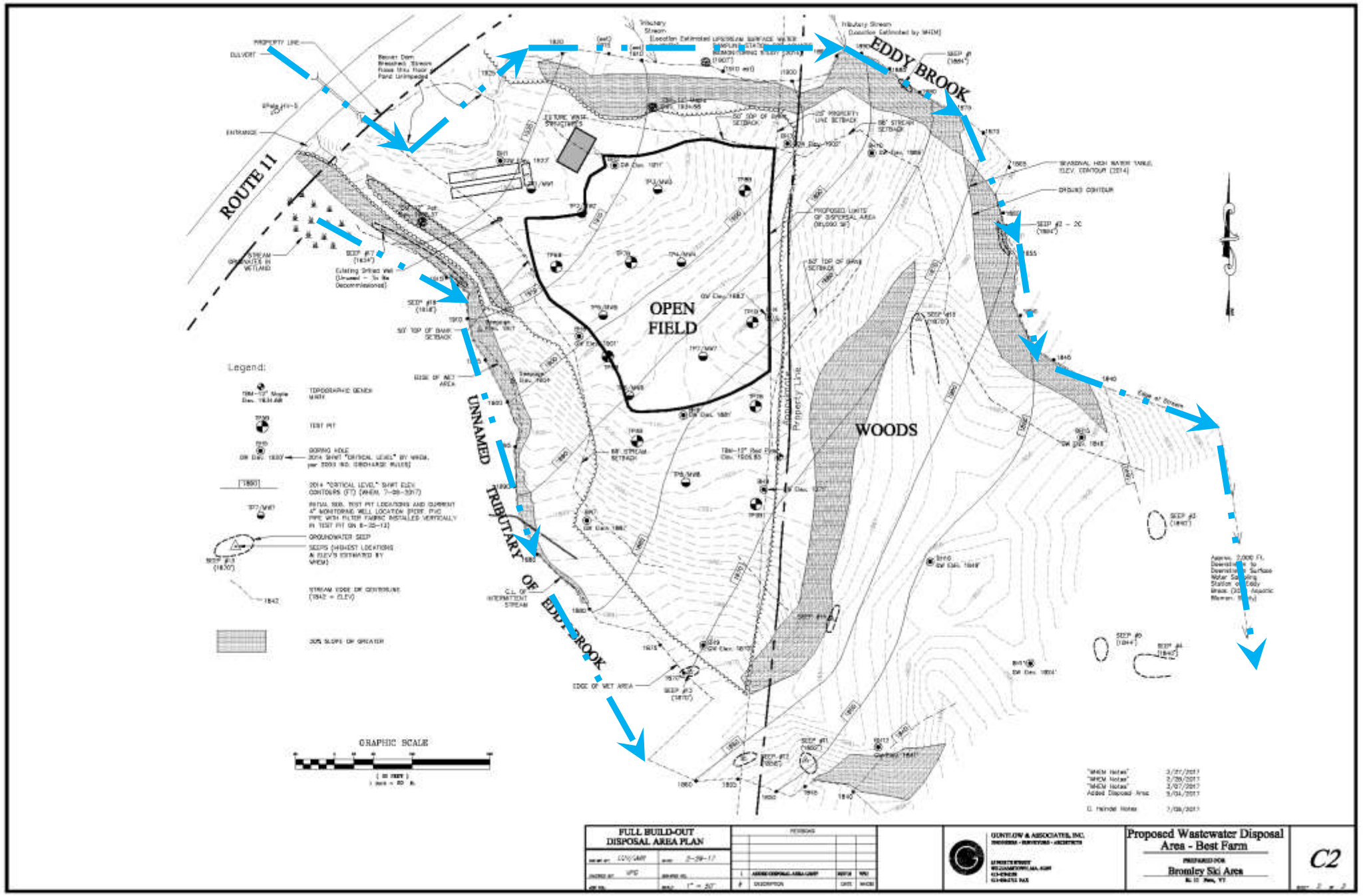
Waite - Heindel Environmental Management

March 7, 2017

Map produced by: C. Heindel

BROMLEY\Best Farm WW Area\WHEM Maps\Untitled.mxd

WAITE HEINDEL


ROUTE 11
EDDY BROOK
OPEN FIELD
WOODS
UNNAMED TRIBUTARY OF EDDY BROOK
Property Line
Legend:
GRAPHIC SCALE
FULL BUILD-OUT DISPOSAL AREA PLAN
Proposed Wastewater Disposal Area - Best Farm
Bromley Ski Area
C2

Pilot Test, Nutrient Removal by Drip Dispersal

Typical Test Pit Logs

DEEP OBSERVATION HOLE LOG* TP # 7B

Depth from Surface (Inches)	Soil Horizon	Soil Texture (USDA)	Soil Color (Munsell)	Soil Mottling	Other (Structure, Stones, Boulders, Consistency, % Gravel)
0-17'	A	SL	5YR2.5/1	-	Massive, Friable, Some "E" pockets
17-27"	Bw	LS	5YR4/6	-	Gravelly 15%
27-57"	C1	LS	2.5Y6/6	-	Gravelly 35% +/-
57-66"	C2	LS	2.5Y6/6	-	Medium Sand

Groundwater: none
Mottling: none
Ledge: >66

Parent Material: Outwash, alluvial deposits
Estimated Seasonal High Water Table: none
Perc Rate 27.48 Min/ Inch
Depth of Perc 36"

DEEP OBSERVATION HOLE LOG* TP # 8B

Depth from Surface (Inches)	Soil Horizon	Soil Texture (USDA)	Soil Color (Munsell)	Soil Mottling	Other (Structure, Stones, Boulders, Consistency, % Gravel)
0-9"	A	SL	7.5YR3/2	-	Massive, Friable, Some "E" pockets
9-33"	C1	LS	10YR4/6	-	Fine to Medium Sand
33-42"	C2	LS	2.5Y5/4	-	Gravelly 25%
42-78"	C3	LS	2.5Y6/6	-	Fine to Medium

Groundwater: none
Mottling: none
Ledge: >78

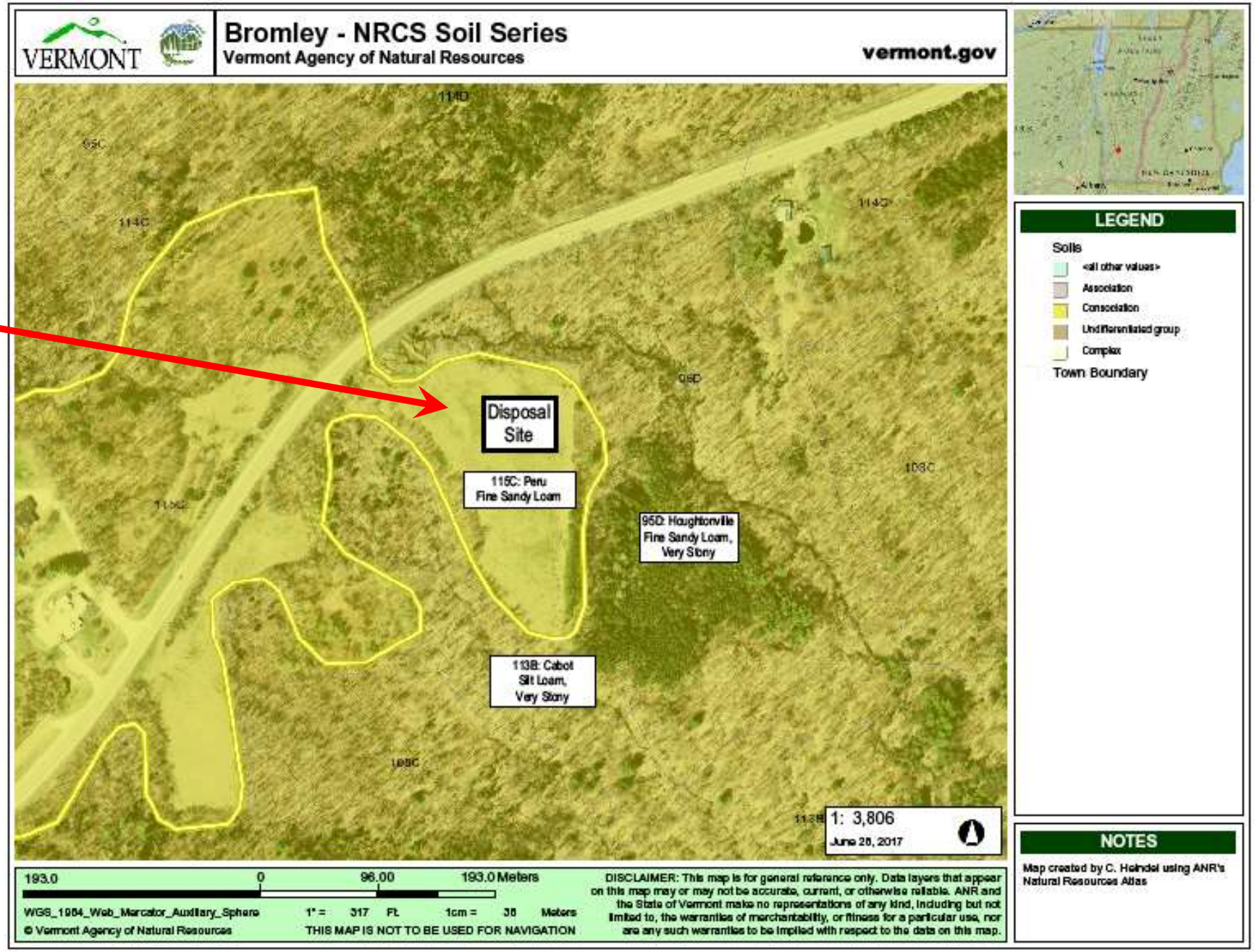
Parent Material: Outwash, alluvial deposits
Estimated Seasonal High Water Table: none

Pilot Test, Nutrient Removal by Drip Dispersal

Pilot Test, Nutrient Removal by Drip Dispersal

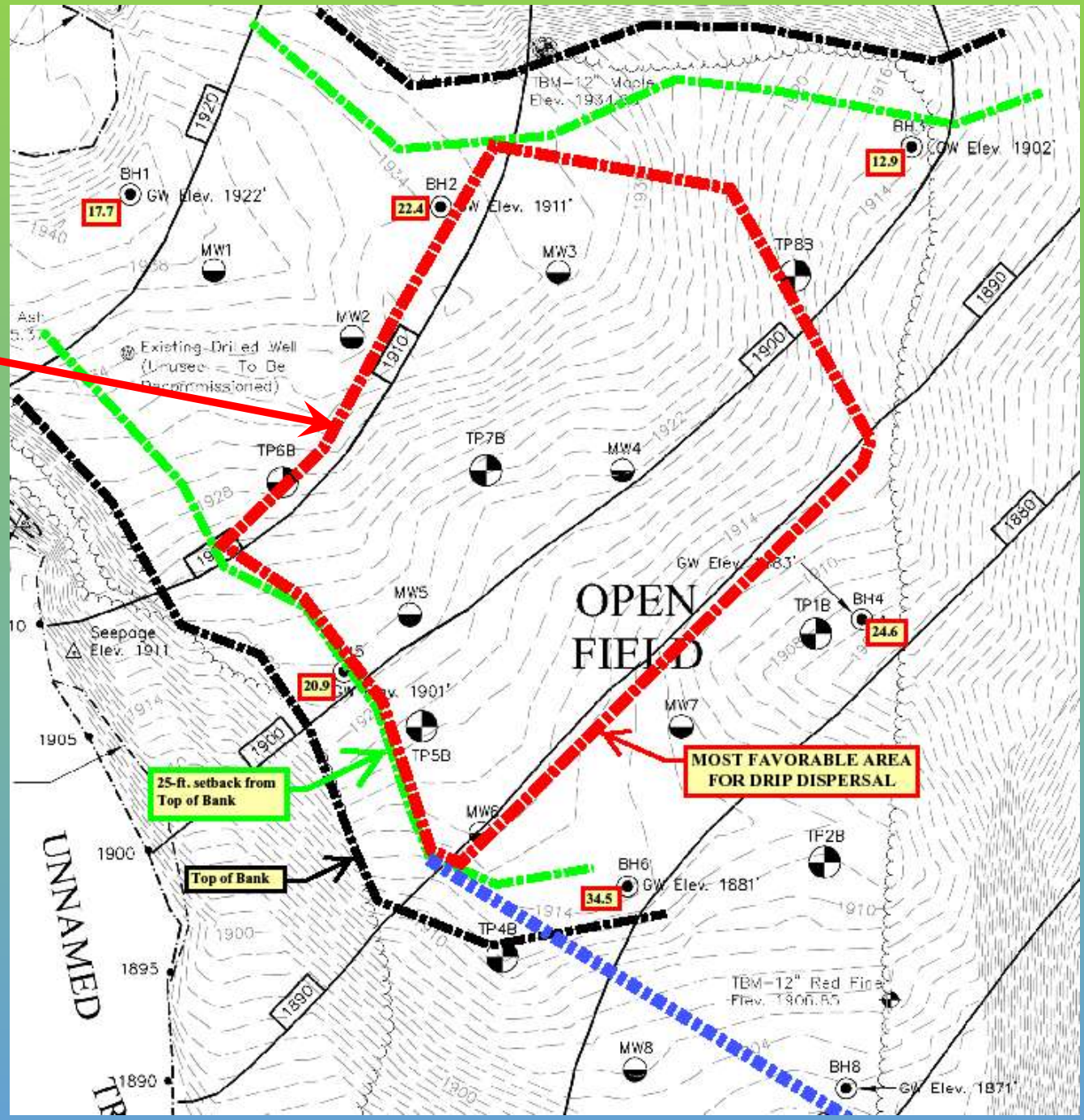
NRCS Soil Series:
Peru
Fine Sandy Loam

[parent material = loamy lodgement till]



Pilot Test, Nutrient Removal by Drip Dispersal

Favorable Area for Drip Dispersal: 50,000 to 60,000 sq.ft.



Can the site meet Criterion #3?

3. Compliance with Aquatic Permitting Criteria:

- **Total Dissolved Phosphorus: increase of no more than 0.001 mg/L above upstream location;**

Can the site meet Criterion #3?

3. Compliance with Aquatic Permitting Criteria:

- **Total Dissolved Phosphorus: increase of no more than 0.001 mg/L above upstream location;**

- **Nitrate: not exceed 2.0 mg/L;**

Can the site meet Criterion #3?

3. Compliance with Aquatic Permitting Criteria:

- **Total Dissolved Phosphorus: increase of no more than 0.001 mg/L above upstream location;**
- **Nitrate: not exceed 2.0 mg/L;**
- **Compliance is calculated at "Low Median Monthly" Stream Flow [LMMF].**

Can the site meet Criterion #3?

3. Compliance with Aquatic Permitting Criteria:

- **Total Dissolved Phosphorus: increase of no more than 0.001 mg/L above upstream location;**
- **Nitrate: not exceed 2.0 mg/L;**
- **Compliance is calculated at "Low Median Monthly" Stream Flow [LMMF].**

The Challenge at this site:
Will there be enough dilution in Eddy Brook?

WAITE HEINDEL

Pilot Test, Nutrient Removal by Drip Dispersal

3. Compliance with Aquatic Permitting Criteria:

	Total Dissolved Phosphorus	Nitrate	Total Nitrogen
	Mg/L	Mg/L	Mg/L
TARGET: ["Aquatic Permitting Criteria", per VT Indirect Discharge Regs]	in-stream increase of no more than 0.001	in-stream not to exceed 2.0	[no APC]

Pilot Test, Nutrient Removal by Drip Dispersal

3. Compliance with Aquatic Permitting Criteria:

	Total Dissolved Phosphorus	Nitrate	Total Nitrogen
	Mg/L	Mg/L	Mg/L
TARGET: ["Aquatic Permitting Criteria", per VT Indirect Discharge Regs]	in-stream increase of no more than 0.001	in-stream not to exceed 2.0	[no APC]
INPUT: Wastewater Type			
Sewage [typical domestic]	5 to 15		40 to 100

Pilot Test, Nutrient Removal by Drip Dispersal

3. Compliance with Aquatic Permitting Criteria:

	Total Dissolved Phosphorus	Nitrate	Total Nitrogen
	Mg/L	Mg/L	Mg/L
TARGET: ["Aquatic Permitting Criteria", per VT Indirect Discharge Regs]	**in-stream increase of no more than 0.001**	**in-stream not to exceed 2.0**	[no APC]
INPUT: Wastewater Type			
Sewage [typical domestic]	**5 to 15**		**40 to 100**
Secondary-treated WWTP Effluent [typical range, Bromley WWTP]	**2 to 4**		**4 to 5**

Pilot Test, Nutrient Removal by Drip Dispersal

3. Compliance with Aquatic Permitting Criteria:

	Total Dissolved Phosphorus	Nitrate	Total Nitrogen
	Mg/L	Mg/L	Mg/L
TARGET: ["Aquatic Permitting Criteria", per VT Indirect Discharge Regs]	in-stream increase of no more than 0.001	in-stream not to exceed 2.0	[no APC]
INPUT: Wastewater Type			
Sewage [typical domestic]	5 to 15		40 to 100
Secondary-treated WWTP Effluent [typical range, Bromley WWTP]	2 to 4		4 to 5
Default "In-ground Effluent" from Septic Tank Effluent [per VT Indirect Discharge Regs.]	0.14	60	

Pilot Test, Nutrient Removal by Drip Dispersal

3. Compliance with Aquatic Permitting Criteria:

	Total Dissolved Phosphorus	Nitrate	Total Nitrogen
	Mg/L	Mg/L	Mg/L
TARGET: ["Aquatic Permitting Criteria", per VT Indirect Discharge Regs]	in-stream increase of no more than 0.001	in-stream not to exceed 2.0	[no APC]
INPUT: Wastewater Type			
Sewage [typical domestic]	5 to 15		40 to 100
Secondary-treated WWTP Effluent [typical range, Bromley WWTP]	2 to 4		4 to 5
Default "In-ground Effluent" from Septic Tank Effluent [per VT Indirect Discharge Regs.]	0.14	60	
RECEIVING STREAM: Eddy Brook	0.012	1.2	

Pilot Test, Nutrient Removal
by Drip Dispersal

3. Compliance with Aquatic Permitting Criteria:

There's the CHALLENGE:

Eddy Brook is small,
does not provide much dilution

for Project Design Goal
of
80,000 gpd

	Total Dissolved Phosphorus	Nitrate	Total Nitrogen
	Mg/L	Mg/L	Mg/L
TARGET: ["Aquatic Permitting Criteria", per VT Indirect Discharge Regs]	in-stream increase of no more than 0.001	in-stream not to exceed 2.0	[no APC]
INPUT: Wastewater Type			
Sewage [typical domestic]	5 to 15		40 to 100
Secondary-treated WWTP Effluent [typical range, Bromley WWTP]	2 to 4		4 to 5
Default "In-ground Effluent" from Septic Tank Effluent [per VT Indirect Discharge Regs.]	0.14	60	
RECEIVING STREAM: Eddy Brook	0.012	1.2	

3. Compliance with Aquatic Permitting Criteria:

Calculation Method: Mass-balance, at Compliance Point in Eddy Brook

[per Vermont Indirect Discharge Rule, 2003]

Calculation Method: Mass-balance, at Compliance Point in Eddy Brook:

§14-912 Determining Compliance With Aquatic Permitting Criteria

(a) To determine compliance with the Aquatic Permitting Criteria, a mass balance equation shall be used. The resulting in-stream concentration calculated with the mass balance equation must be less than or equal to the Aquatic Permitting Criterion for each parameter to demonstrate compliance. The following mass balance equation shall be used for calculating the resulting in-stream concentration:

$$\frac{[(E_c) \times (E_q) + (D_c) \times (D_q)]}{(E_q + D_q)} = \text{Resulting in-stream concentration}$$

Where: E_c = Existing in-stream receiving water concentration
E_q = Appropriate stream flow at point of compliance and for annual or seasonal release rate.
D_c = In-ground effluent concentration (5% exc), based on site specific testing.
D_q = Proposed discharge flow (i.e. maximum design capacity) .

[VT Indirect Discharge Rule, 2003]

WAITE HEINDEL

Low Median Monthly Flow at Compliance Point in Eddy Brook:

§14-912 Determining Compliance With Aquatic Permitting Criteria

(a) To determine compliance with the Aquatic Permitting Criteria, a mass balance equation shall be used. The resulting in-stream concentration calculated with the mass balance equation must be less than or equal to the Aquatic Permitting Criterion for each parameter to demonstrate compliance. The following mass balance equation shall be used for calculating the resulting in-stream concentration:

$$\frac{[(E_c) \times (E_q) + (D_c) \times (D_q)]}{(E_q + D_q)} = \text{Resulting in-stream concentration}$$

Where: E_c = Existing in-stream receiving water concentration

E_q = Appropriate stream flow at point of compliance and for annual or seasonal release rate.

LMMF

D_c = In-ground effluent concentration (5% exc), based on site specific testing.

D_q = Proposed discharge flow (i.e. maximum design capacity) .

Low Median Monthly Stream flow [LMMF]:

- Receiving water = Eddy Brook;
- No stream gage;

- SO: use Vermont default LMMF value of 0.34 csm, at Point of Compliance

LMMF [cfs] = drainage area [sq.mi.] x 0.34 csm

where:
LMMF = Low Median Monthly Flow;
cfs = cubic ft. per second;
csm = cfs per sq.mi.

Location of Compliance Point in Eddy Brook:

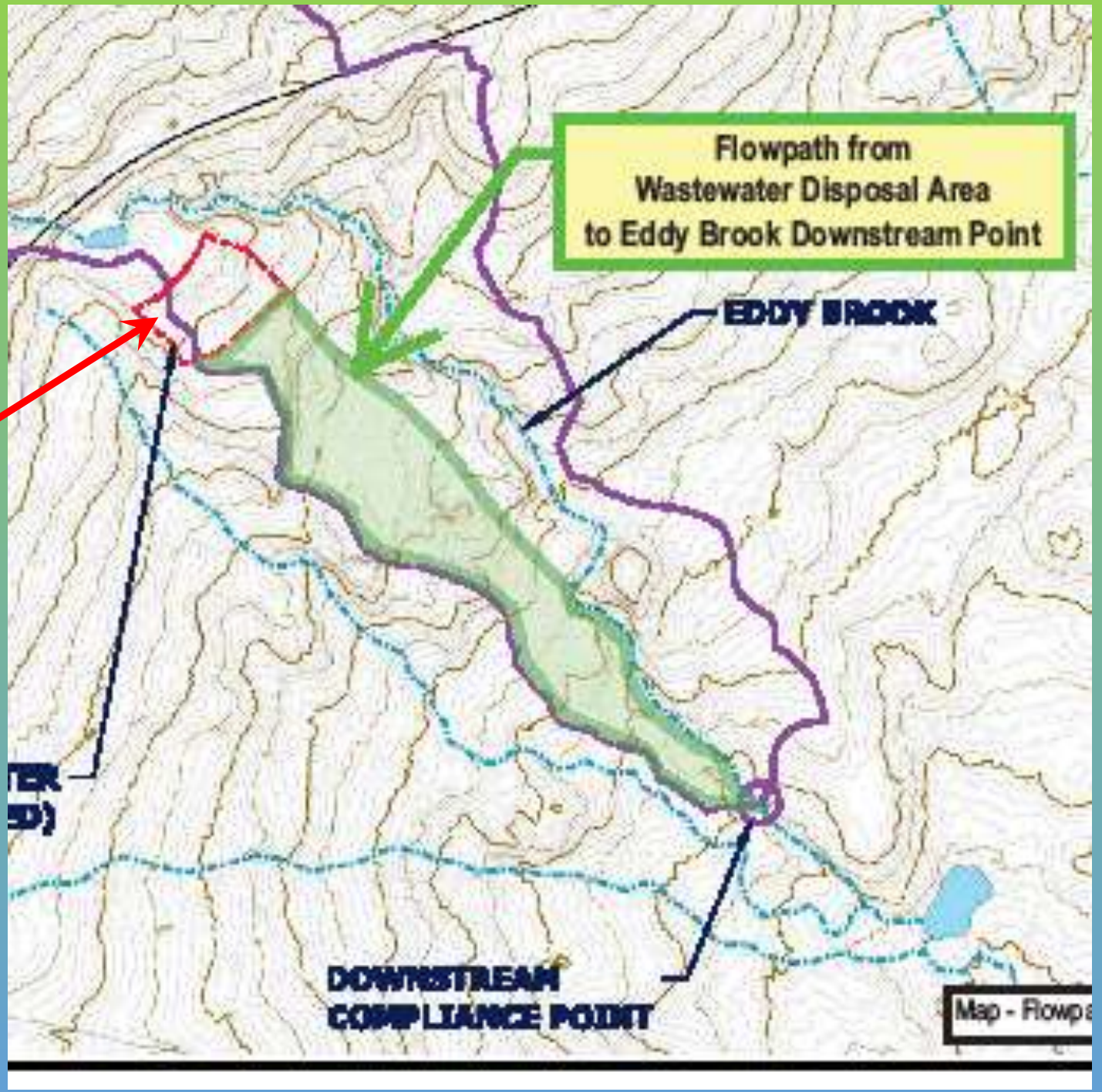
Compliance Point = Downstream point in Eddy Brook where effluent flowpath from wastewater disposal field intersects the brook.

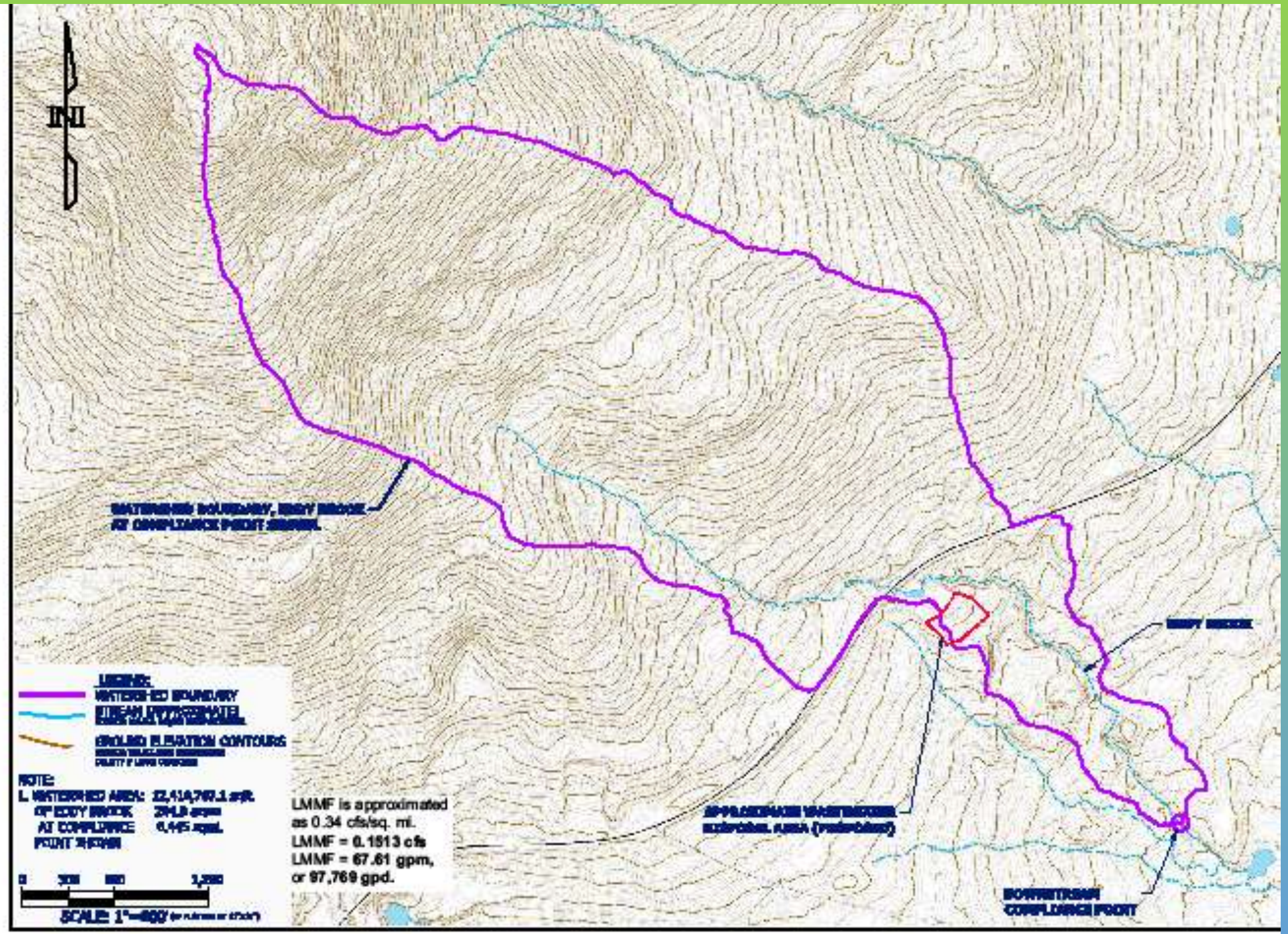
[= downstream-most point of the “Indirect Discharge”]

[per VT Indirect Discharge Regs]

Pilot Test, Nutrient Removal by Drip Dispersal

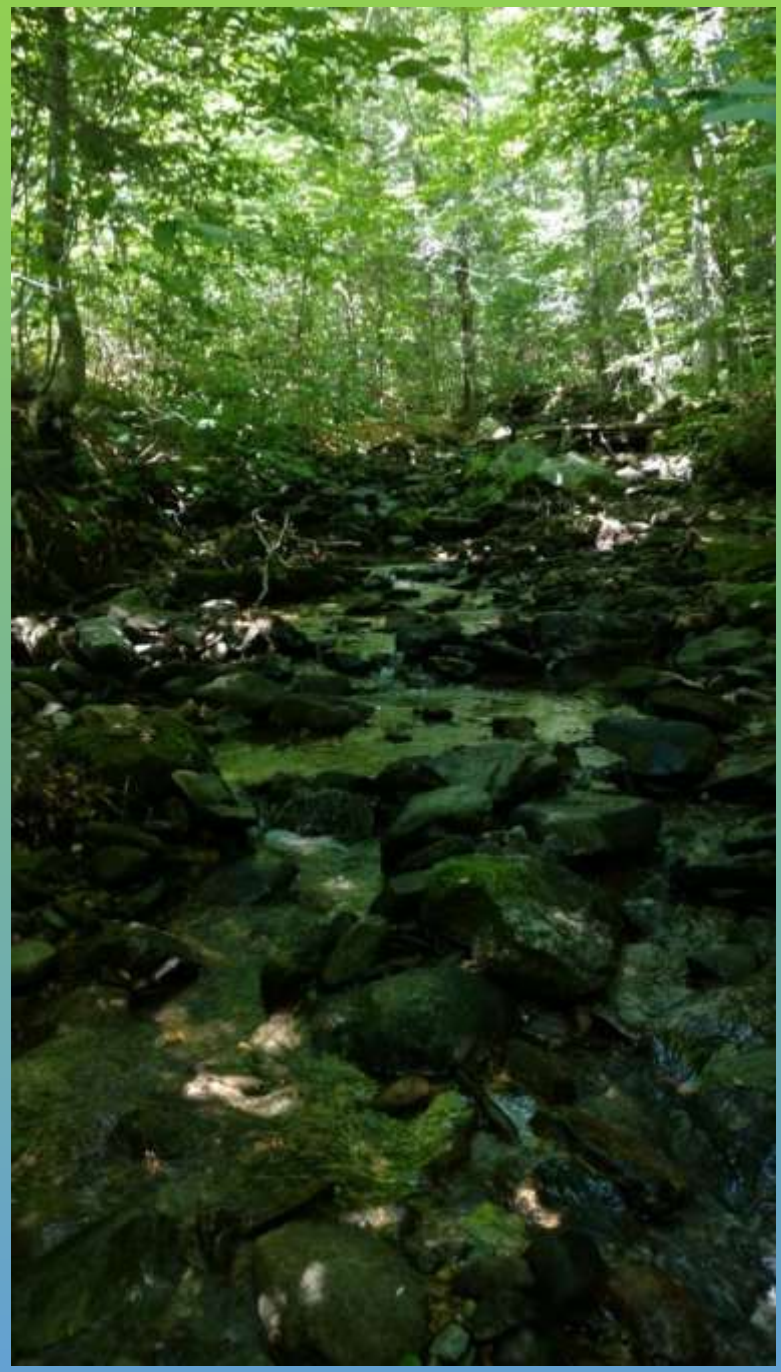
Proposed WW Disposal Area




LMMF is approximated as 0.34 cfs/sq. mi.
LMMF = 0.1513 cfs
LMMF = 67.61 gpm, or 97,769 gpd.

Compliance Point, Eddy Brook – August 2016

Upstream of Compliance Point, Eddy Brook – August 2016



Pilot Test, Nutrient Removal by Drip Dispersal

Eddy Brook: Estimation of Low Median Monthly Flow [LMMF]		
Watershed Area at Compliance Point	0.445	sq.mi.
LMMF [default]	0.34	csm [cubic feet per second per sq.mi.]
LMMF, at Compliance Point	0.1513	cfs
	97,781	gpd [conversion]

3. Compliance with Surface Water Quality Standards:

✓ **LMMF = 97,781 gpd.**

3. Compliance with Surface Water Quality Standards:

✓ **LMMF = 97,781 gpd.**

BUT . . . Remember the challenge of meeting Aquatic Permitting Criteria?

Pilot Test, Nutrient Removal by Drip Dispersal

3. Compliance with Aquatic Permitting Criteria:

There's the CHALLENGE: Eddy Brook is small, does not provide much dilution for Project Design Goal of 80,000 gpd

	Total Dissolved Phosphorus	Nitrate	Total Nitrogen
	Mg/L	Mg/L	Mg/L
TARGET: ["Aquatic Permitting Criteria", per VT Indirect Discharge Regs]	in-stream increase of no more than 0.001	in-stream not to exceed 2.0	[no APC]
INPUT: Wastewater Type			
Sewage [typical domestic]	5 to 15		40 to 100
Secondary-treated WWTP Effluent [typical range, Bromley WWTP]	2 to 4		4 to 5
Default "In-ground Effluent" from Septic Tank Effluent [per VT Indirect Discharge Regs.]	0.14	60	
RECEIVING STREAM: Eddy Brook	0.012	1.2	

LEADS TO TWO DESIGN DECISIONS:

1. Treatment is needed, to substantially reduce TDP in effluent:
= Tertiary Treatment;

2. Further nutrient removal in disposal field would be beneficial:
= Drip Dispersal.

3. Compliance with Surface Water Quality Standards:

NEXT: Need background concentrations at Compliance Point in Eddy Brook, for:

- **Total Dissolved Phosphorus;**
- **Nitrate.**

Calculation Method: Mass-balance, at Compliance Point in Eddy Brook:

§14-912 Determining Compliance With Aquatic Permitting Criteria

(a) To determine compliance with the Aquatic Permitting Criteria, a mass balance equation shall be used. The resulting in-stream concentration calculated with the mass balance equation must be less than or equal to the Aquatic Permitting Criterion for each parameter to demonstrate compliance. The following mass balance equation shall be used for calculating the resulting in-stream concentration:

$$\frac{[(E_c) \times (E_q) + (D_c) \times (D_q)]}{(E_q + D_q)} = \text{Resulting in-stream concentration}$$

Background WQ

Where: E_c = Existing in-stream receiving water concentration
E_q = Appropriate stream flow at point of compliance and for annual or seasonal release rate.
D_c = In-ground effluent concentration (5% exc), based on site specific testing.
D_q = Proposed discharge flow (i.e. maximum design capacity) .

WAITE HEINDEL

Pilot Test, Nutrient Removal by Drip Dispersal

Bromley Mountain, Best Farm WW Area

Upgradient Surface Water, Aquatic Permitting Criteria;

Eddy Brook, 2014

Date	Mon. Station	Total Dissolved Phos. (mg/l)	Nitrate Nitrogen (mg/l)	pH (s.u.)
6/19/2014	Upstream	0.008	0.2	6.47
6/24/2014		0.007	0.3	6.63
7/2/2014		< 0.005	0.3	6.59
7/17/2014		0.009	0.2	7.07
8/6/2014		0.017	0.2	7.12
8/12/2014		0.019	0.2	7.13
9/11/2014		0.026	0.2	7.23
9/17/2014		0.03	0.2	7.21
10/1/2014		0.024	0.2	7.07
10/9/2014		0.011	< 0.1	6.88
STATISTICS:				
Minimum		0.005	0.10	6.47
Maximum		0.030	0.30	7.23
Normal Distribution?		yes	yes	NA
Transformation Closest to Normal		NA	NA	NA
Does Transformation Produce Normality?		NA	NA	NA
Mean of Untransformed Data		0.0156	0.210	6.85
Mean of Transformed Data		NA	NA	NA
Std. Dev. of Untransformed Data		0.00887	0.0568	NA
Std. Dev. of Transformed Data		NA	NA	NA
n		10	10	10
Student's t-value (one-tailed)		1.833	1.833	NA
Upper 95% C.I.		**0.0207**	**0.2429**	**NA**

✓ **Background WQ in Eddy Brook**

Calculation Method: Mass-balance, at Compliance Point in Eddy Brook:

§14-912 Determining Compliance With Aquatic Permitting Criteria

(a) To determine compliance with the Aquatic Permitting Criteria, a mass balance equation shall be used. The resulting in-stream concentration calculated with the mass balance equation must be less than or equal to the Aquatic Permitting Criterion for each parameter to demonstrate compliance. The following mass balance equation shall be used for calculating the resulting in-stream concentration:

$$\frac{[(E_c) \times (E_q) + (D_c) \times (D_q)]}{(E_q + D_q)} = \text{Resulting in-stream concentration}$$

Where: E_c = Existing in-stream receiving water concentration
E_q = Appropriate stream flow at point of compliance and for annual or seasonal release rate.
D_c = In-ground effluent concentration (5% exc), based on site specific testing.
D_q = Proposed discharge flow (i.e. maximum design capacity) .

✓ **Proposed Indirect Discharge: 80,000 gpd**

Calculation Method: Mass-balance, at Compliance Point in Eddy Brook:

§14-912 Determining Compliance With Aquatic Permitting Criteria

(a) To determine compliance with the Aquatic Permitting Criteria, a mass balance equation shall be used. The resulting in-stream concentration calculated with the mass balance equation must be less than or equal to the Aquatic Permitting Criterion for each parameter to demonstrate compliance. The following mass balance equation shall be used for calculating the resulting in-stream concentration:

$$\frac{[(E_c) \times (E_q) + (D_c) \times (D_q)]}{(E_q + D_q)} = \text{Resulting in-stream concentration}$$

Where: E_c = Existing in-stream receiving water concentration
E_q = Appropriate stream flow at point of compliance and for annual or seasonal release rate.
D_c = In-ground effluent concentration (5% exc), based on site specific testing.
D_q = Proposed discharge flow (i.e. maximum design capacity) .

FINAL PARAMETER: "In-ground Effluent Concentration" [= nutrients in groundwater downgradient of drip-field]

Calculation Method: Mass-balance, at Compliance Point in Eddy Brook:

§14-912 Determining Compliance With Aquatic Permitting Criteria

(a) To determine compliance with the Aquatic Permitting Criteria, a mass balance equation shall be used. The resulting in-stream concentration calculated with the mass balance equation must be less than or equal to the Aquatic Permitting Criterion for each parameter to demonstrate compliance. The following mass balance equation shall be used for calculating the resulting in-stream concentration:

$$\frac{[(E_c) \times (E_q) + (D_c) \times (D_q)]}{(E_q + D_q)} = \text{Resulting in-stream concentration}$$

Where: E_c = Existing in-stream receiving water concentration
E_q = Appropriate stream flow at point of compliance and for annual or seasonal release rate.
D_c = In-ground effluent concentration (5% exc), based on site specific testing.
D_q = Proposed discharge flow (i.e. maximum design capacity) .

FINAL PARAMETER:
"In-ground Effluent Concentration"
[= nutrients in groundwater downgradient of drip-field]

LEADS TO PILOT TEST

PILOT TEST DETAILS:

- **Drip dispersal field: 235 ft. x 11 ft., 4 dispersal pipes; application area: 2,515 sq.ft.**

- **Test Effluent: Wastewater effluent from Bromley WWTP (secondary treatment), diluted with well water by approximately 1:4, spiked with Bromide as tracer.**

- **Application Rate of Test Effluent: 2.0 gpd/sq.ft.; 5,020 gpd for 119 days.**

- **Down-gradient groundwater quality, depth: sampled from MW-BH-3, located 35 ft. downgradient.**

- **Up-gradient groundwater [for comparison]: MW-BH-2, located 180 ft. upgradient.**

Pilot Test, Nutrient Removal
by Drip Dispersal

PILOT TEST DETAILS:

Drip dispersal field: 235 ft. x 11 ft., 4 dispersal pipes; application area: 2,515 sq.ft.

OAKSON
YOUR DRIP DISPERSAL EXPERT IN NEW ENGLAND

WAITE HEINDEL

PILOT TEST, DRIP DISPERSAL FIELD:

PILOT TEST, DRIP DISPERSAL FIELD:

PILOT TEST, DRIP DISPERSAL FIELD:

PILOT TEST, DRIP DISPERSAL FIELD:

PILOT TEST, DRIP DISPERSAL FIELD:

Perc-Rite® Drip Dispersal System, distributed by Oakson, from American Manufacturing:

- ***0.5-in. diameter***
- ***Emitters located every 2 ft.***
- ***Emitter discharge rate: 0.61 gal/hour, over wide pressure range.***

PILOT TEST, DRIP DISPERSAL FIELD:

PILOT TEST, DRIP DISPERSAL FIELD:

PILOT TEST, DRIP DISPERSAL FIELD:

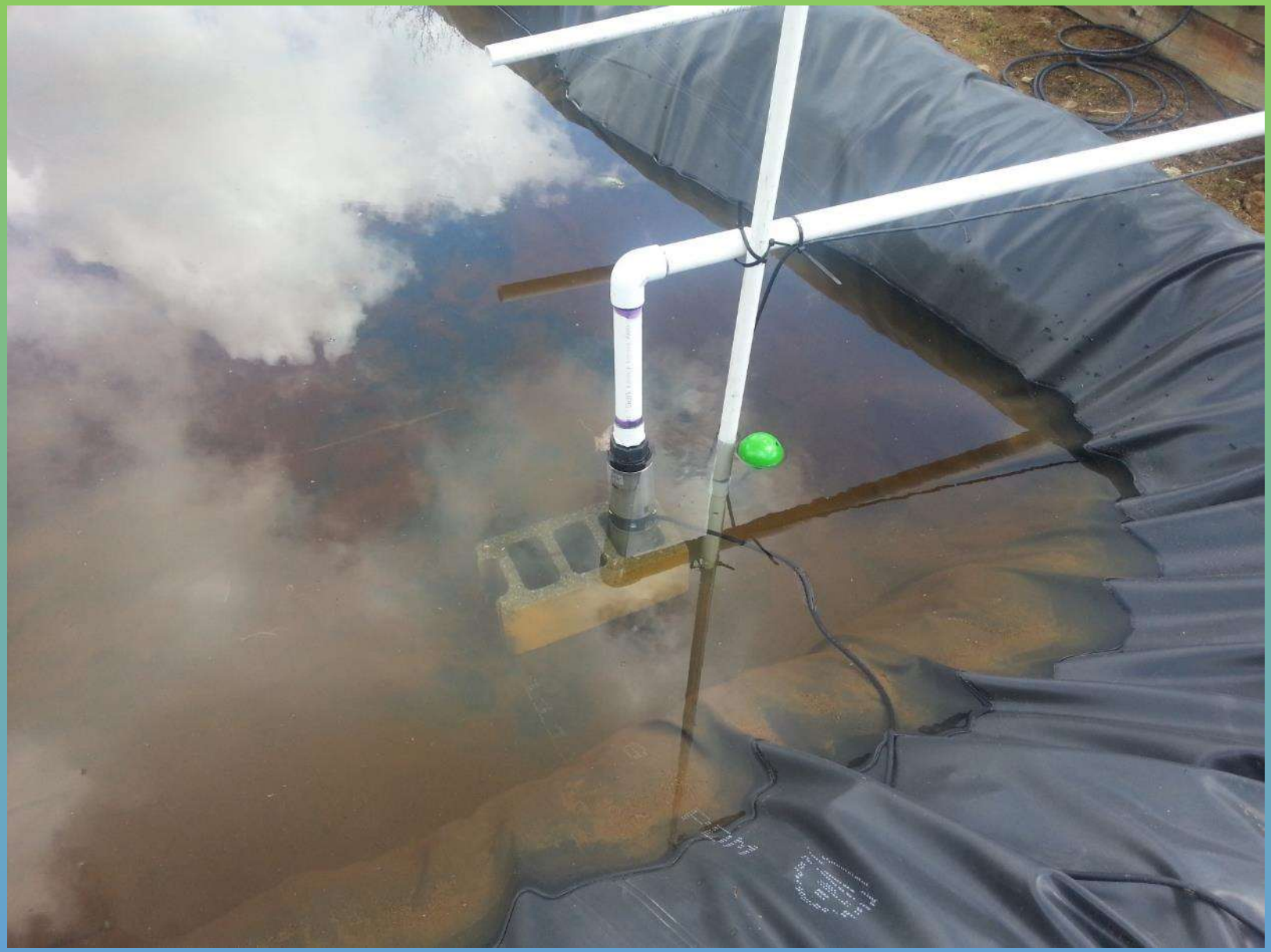
PILOT TEST, DRIP DISPERSAL FIELD:

PILOT TEST: EFFLUENT LAGOON

PILOT TEST; EFFLUENT LAGOON & PUMP

PILOT TEST; EFFLUENT LAGOON & PUMP

PILOT TEST; EFFLUENT LAGOON & PUMP



PILOT TEST; LINE TO DRIP DISPERSAL AREA

PILOT TEST: TANK OF EFFLUENT BEING UNLOADED

PILOT TEST: EFFLUENT CHEMISTRY

[Before spiking with Bromide as tracer]

Sample Date	BOD (5-Day) (mg/L)	Bromide (mg/L)	Chloride (mg/L)	Nitrate as N (mg/L)	Nitrite as N (mg/L)	NH3 as N (mg/L)	TKN (mg/L)	Total N (mg/L)	TDP (mg/L)	TSS (mg/L)	Total Sodium (mg/L)	Cond. (mS/cm)	pH (s.u.)	Temp. (^{o}C)
7/20/2016	5	< 1.0	72	1.7	< 0.2	2.2	3.5	5.4	2.7	10	39	503	7.37	19.5
7/21/2016	5	< 1.0	71	0.52	< 0.2	1.4	3.2	3.92	2.5	8	37	484	7.34	19.0
11/10/2016	< 1.0	< 0.10	64	0.55	< 0.2	2.8	4.9	5.65	2.4	18	37	477	6.31	7.3
11/15/2016	2.9	< 0.10	59	0.53	< 0.2	2.8	5.9	6.63	2.7	24	35	493	7.55	6.2
11/18/2016	< 1.1	0.11	60	0.51	< 0.2	3.4	6.2	6.91	2.7	23	34	487	7.62	8.2

WAITE HEINDEL

PILOT TEST: EFFLUENT SPIKING

- **Effluent is spiked with Pool-grade Sodium Bromide as tracer**

[2 oz. per 1,000 gallons of effluent]

[requested by personnel in VTDEC Indirect Discharge Program].

PILOT TEST: SPIKED EFFLUENT CHEMISTRY

Raw Effluent	Sample Date	BOD (5-Day) (mg/L)	Bromide (mg/L)	Chloride (mg/L)	Nitrate as N (mg/L)	Nitrite as N (mg/L)	NH3 as N (mg/L)	TKN (mg/L)	Total N (mg/L)	TDP (mg/L)	TSS (mg/L)	Total Sodium (mg/L)	Conductivity (mS/cm)	pH (s.u.)	Temp. (°C)
	7/20/2016	5	< 1.0	72	1.7	< 0.2	2.2	3.5	5.4	2.7	10	39	503	7.37	19.5
	7/21/2016	5	< 1.0	71	0.52	< 0.2	1.4	3.2	3.92	2.5	8	37	484	7.34	19.0
	11/10/2016	< 1.0	< 0.10	64	0.55	< 0.2	2.8	4.9	5.65	2.4	18	37	477	6.31	7.3
	11/15/2016	2.9	< 0.10	59	0.53	< 0.2	2.8	5.9	6.63	2.7	24	35	493	7.55	6.2
	11/18/2016	< 1.1	0.11	60	0.51	< 0.2	3.4	6.2	6.91	2.7	23	34	487	7.62	8.2

Diluted & Spiked Eff.	Sample Date	BOD (5-Day) (mg/L)	Bromide (mg/L)	Chloride (mg/L)	Nitrate as N (mg/L)	Nitrite as N (mg/L)	NH3 as N (mg/L)	TKN (mg/L)	Total N (mg/L)	TDP (mg/L)	TSS (mg/L)	Total Sodium (mg/L)	Conductivity (mS/cm)	pH (s.u.)	Temp. (°C)
	7/20/2016	5	9.1	74	1.5	< 0.020	1.5	2.5	4.02	2.1	10	38	512	7.19	18.6
	7/21/2016	5	9.3	75	1.1	< 0.020	1.4	2.8	3.92	1.9	7	39	514	7.49	19.7
	7/26/2016		11	73									508	7.36	23.1
	7/29/2016		12	72									526	7.63	25.2
	8/2/2016		11	76									535	7.52	19.8
	8/5/2016		13	80									545	7.53	25.9
	8/9/2016		12	74									522	7.64	25.3
	8/12/2016		13	75									534	7.23	26.0
	8/16/2016		12	75									549	7.22	20.6
	8/19/2016		13	75									565	7.34	23.2
	8/23/2016		13	76									568	7.36	23.0
	8/26/2016		11	72									525	7.35	24.1
	8/30/2016		11	74									539	7.12	23.1
	9/2/2016		12	76									549	6.94	21.6
	9/6/2016		13	77									539	6.82	21.5
	9/9/2016		13	78									531	7.24	25.0
	9/13/2016		12	85									563	7.04	21.6
	9/16/2016		12	78									535	7.03	19.6
	9/20/2016		11	77									526	6.82	22.8
	9/23/2016		11	78									527	6.88	19.7
	9/27/2016		12	77									515	6.89	17.8
	9/30/2016		12	79									530	6.64	14.5
	10/4/2016		12	78									525	6.22	14.8
	10/7/2016		11	77									527	6.30	16.7
	10/11/2016		11	77									527	6.78	13.4
	10/14/2016		12	74									529	6.13	11.8
	10/18/2016		10	69									515	6.82	13.9
	10/21/2016		11	71									527	6.59	12.4
	10/25/2016		11	70									498	6.41	9.3
	10/28/2016		11	66									482	6.54	6.6
	11/1/2016		10	62									265	5.96	9.8
	11/4/2016		10	65									341	6.81	9.9
	11/8/2016		11	67								34	489	5.81	10.7
	11/10/2016	1.7	12	67	0.64	< 0.20	1.7	5.2	6.04	1.7	17	34	486	6.60	7.1
	11/15/2016	4.3	13	66	0.52	< 0.20	2.1	4.2	4.92	1.9	17	34	516	6.29	5.3
	11/18/2016	3.2	12	66	0.55	< 0.20	2.4	4.6	5.35	2	20	35	522	6.64	4.4
	Mean	3.8	12	74	0.86	< 0.13	1.8	3.86	4.85	1.9	14	38	514	6.89	17.4
	Max	5	13	85	1.5	< 0.20	2.4	5.2	6.04	2.1	20	44	568	7.64	26.0
	Min	1.7	9.1	62	0.52	< 0.02	1.4	2.5	3.92	1.7	7	33	265	5.81	4.4

Twice-a-week lab analyses of:

- **Bromide,**
- **Chloride,**
- **Sodium;**

and

Field Measurements of Spec. Conductance.

WAITE HEINDEL

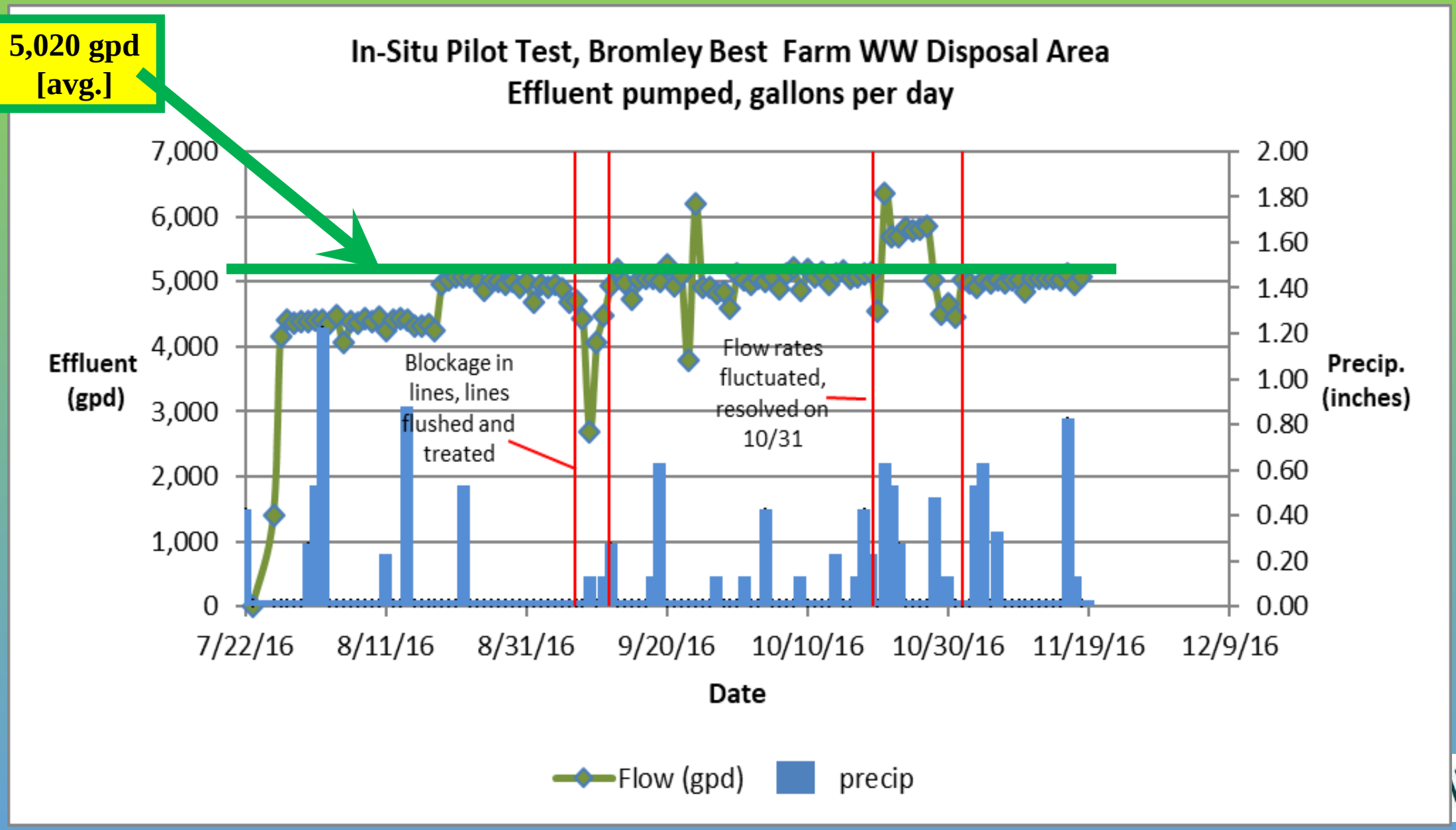
PILOT TEST: SPIKED EFFLUENT CHEMISTRY

Raw Effluent	Sample Date	BOD (5-Day) (mg/L)	Bromide (mg/L)	Chloride (mg/L)	Nitrate as N (mg/L)	Nitrite as N (mg/L)	NH3 as N (mg/L)	TKN (mg/L)	Total N (mg/L)	TDP (mg/L)	TSS (mg/L)	Sodium (mg/L)	Cond. (mS/cm)	pH (s.u.)
	7/20/2016	5	< 1.0	72	1.7	< 0.2	2.2	3.5	5.4	2.7	10	39	503	7.37
	7/21/2016	5	< 1.0	71	0.52	< 0.2	1.4	3.2	3.92	2.5	8	37	484	7.34
	11/10/2016	< 1.0	< 0.10	64	0.55	< 0.2	2.8	4.9	5.65	2.4	18	37	477	6.31
	11/15/2016	2.9	< 0.10	59	0.53	< 0.2	2.8	5.9	6.63	2.7	24	35	493	7.55
	11/18/2016	< 1.1	0.11	60	0.51	< 0.2	3.4	6.2	6.91	2.7	23	34	487	7.62

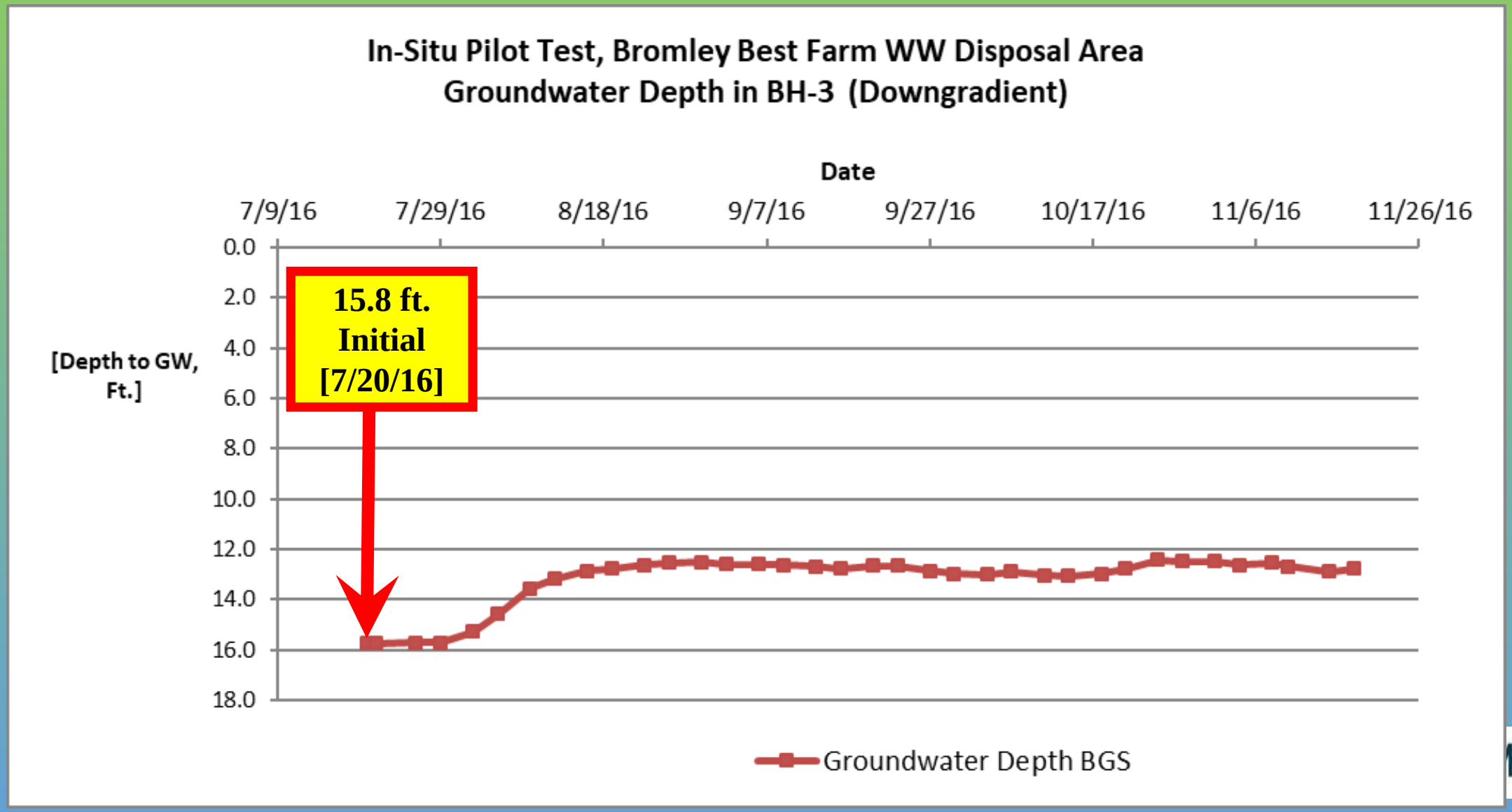
Diluted & Spiked Effluent	Sample Date	BOD (5-Day) (mg/L)	Bromide (mg/L)	Chloride (mg/L)	Nitrate as N (mg/L)	Nitrite as N (mg/L)	NH3 as N (mg/L)	TKN (mg/L)	Total N (mg/L)	TDP (mg/L)	TSS (mg/L)	Sodium (mg/L)	Cond. (mS/cm)	pH (s.u.)
	Mean	**3.8**	**12**	**74**	**0.86**	**< 0.13**	**1.8**	**3.86**	**4.85**	**1.9**	**14**	**38**	**514**	**6.89**
	Max	5	13	**85**	1.5	< 0.20	2.4	5.2	6.04	2.1	20	44	568	7.64
	Min	1.7	9.1	**62**	0.52	< 0.02	1.4	2.5	3.92	1.7	7	33	265	5.81

WAITE HEINDEL

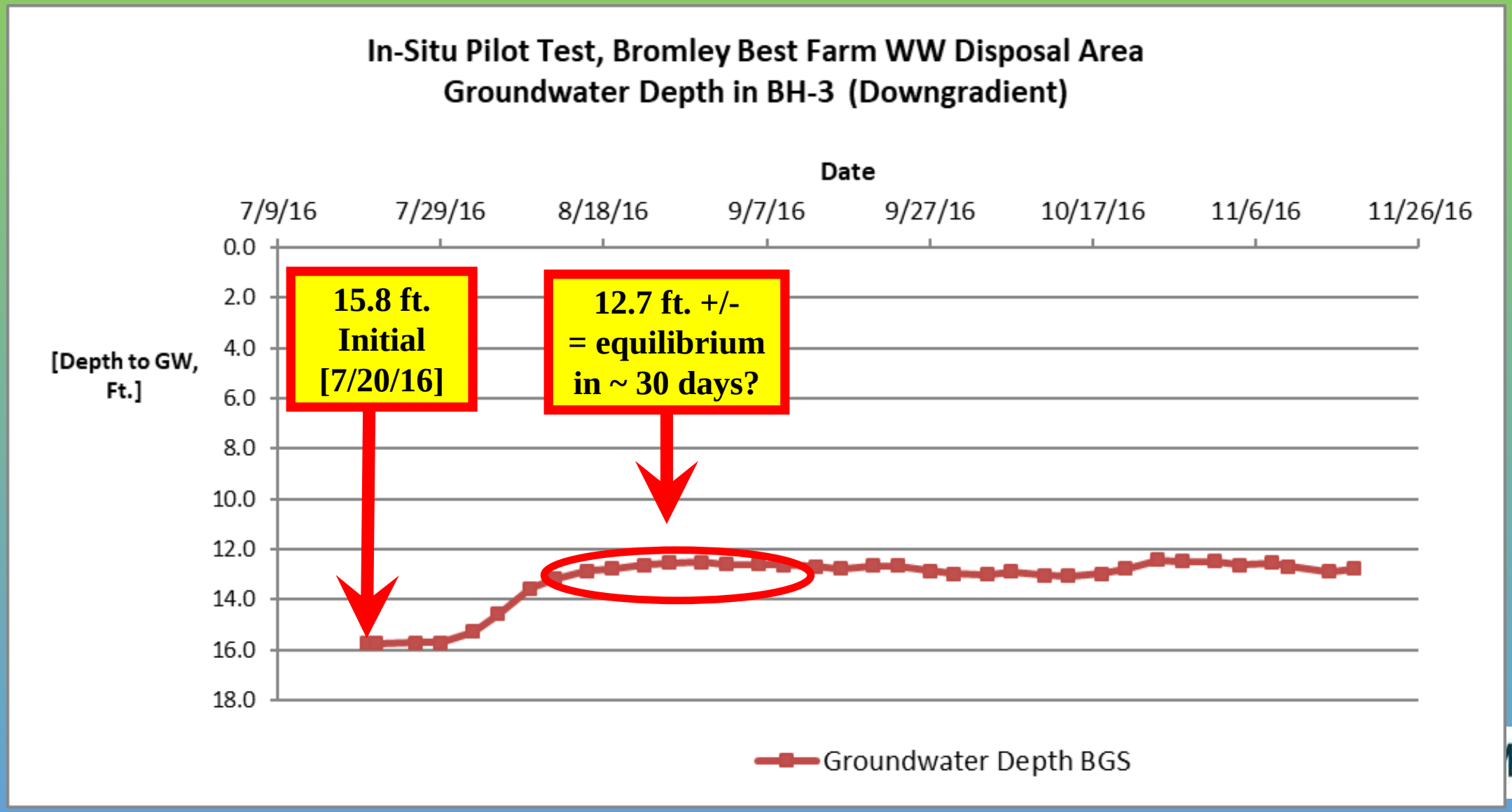
PILOT TEST: PUMPING RATE OVERVIEW



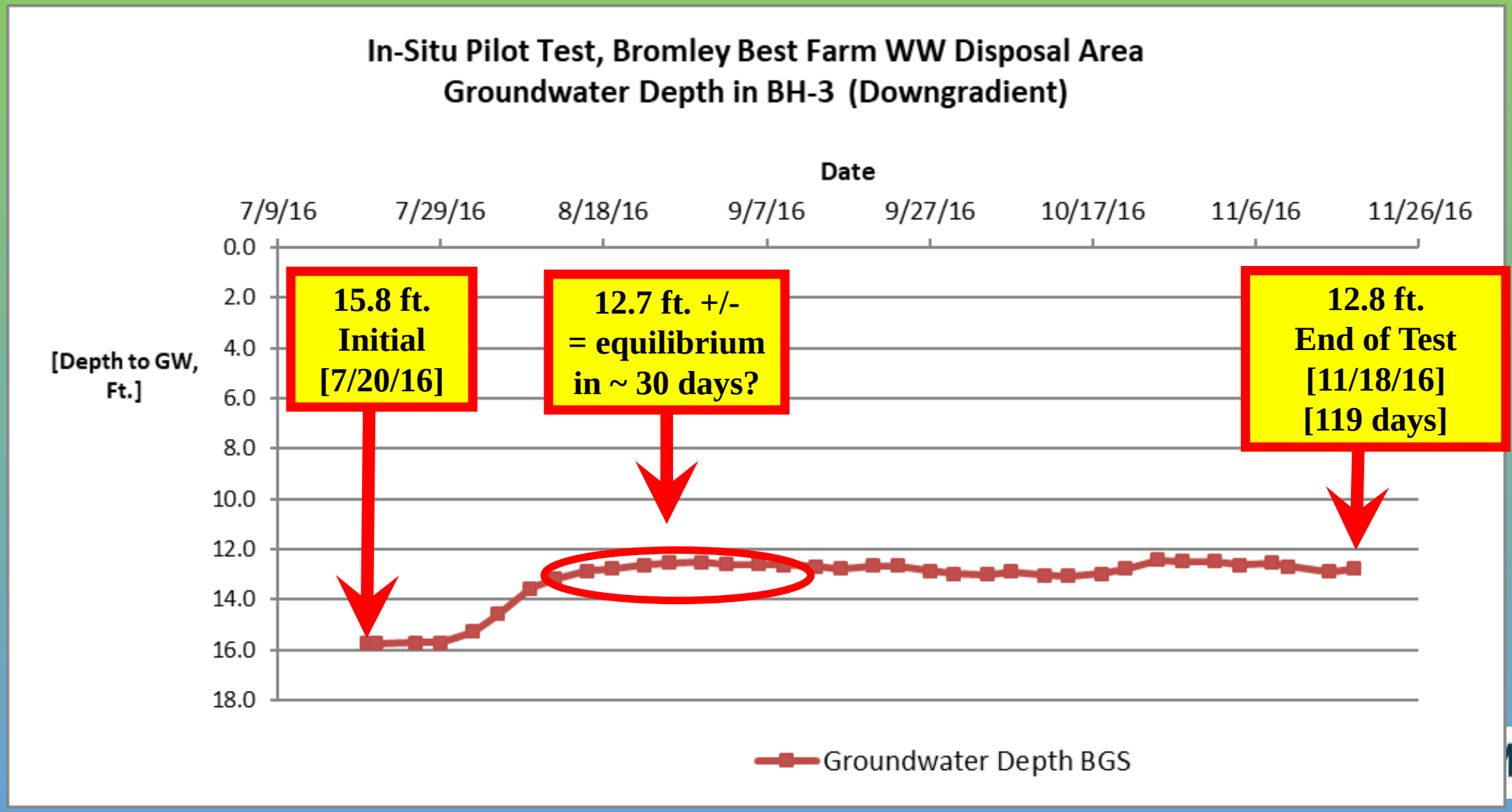
PILOT TEST: GROUNDWATER DEPTHS, DOWN-GRADIENT



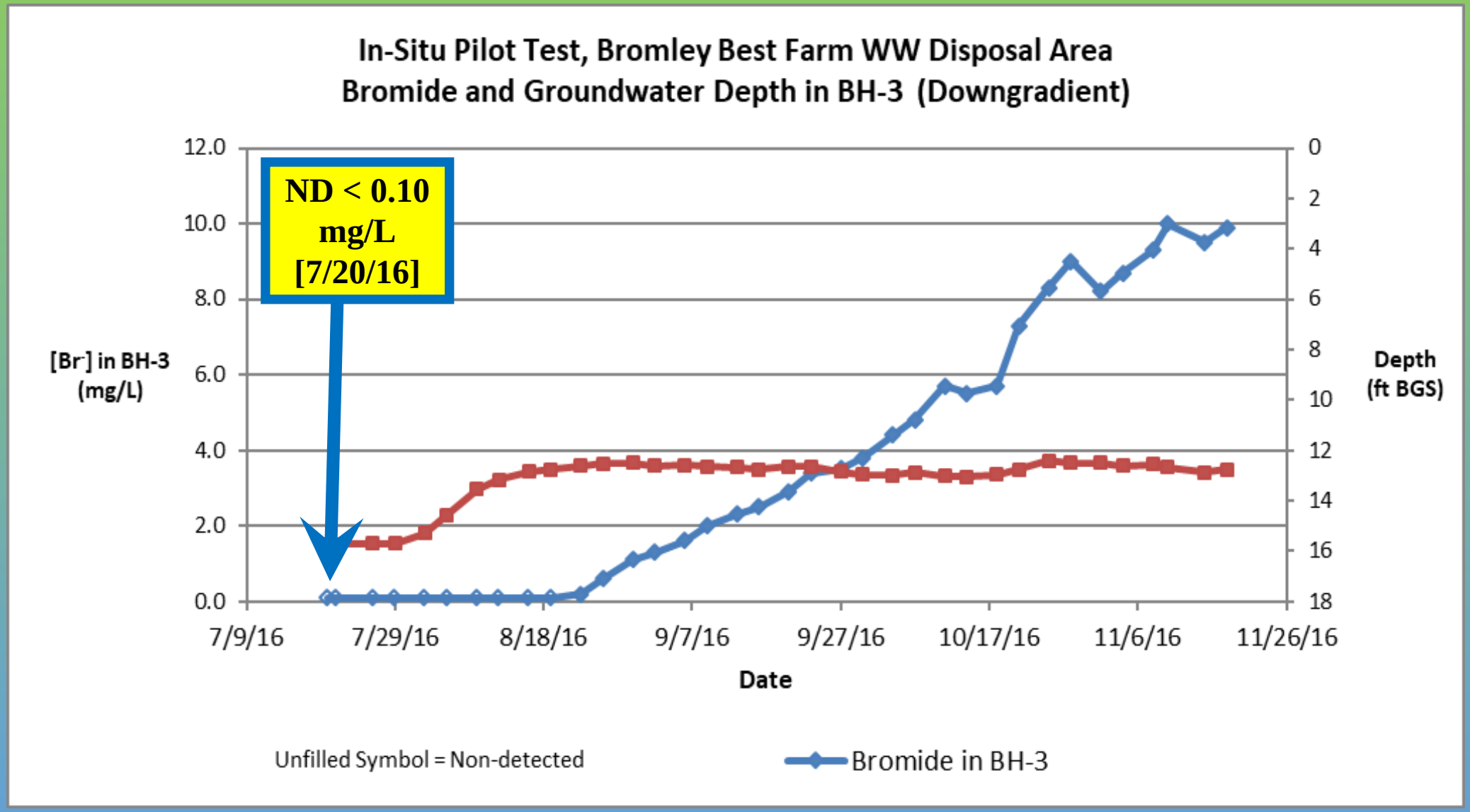
PILOT TEST: GROUNDWATER DEPTHS, DOWN-GRADIENT



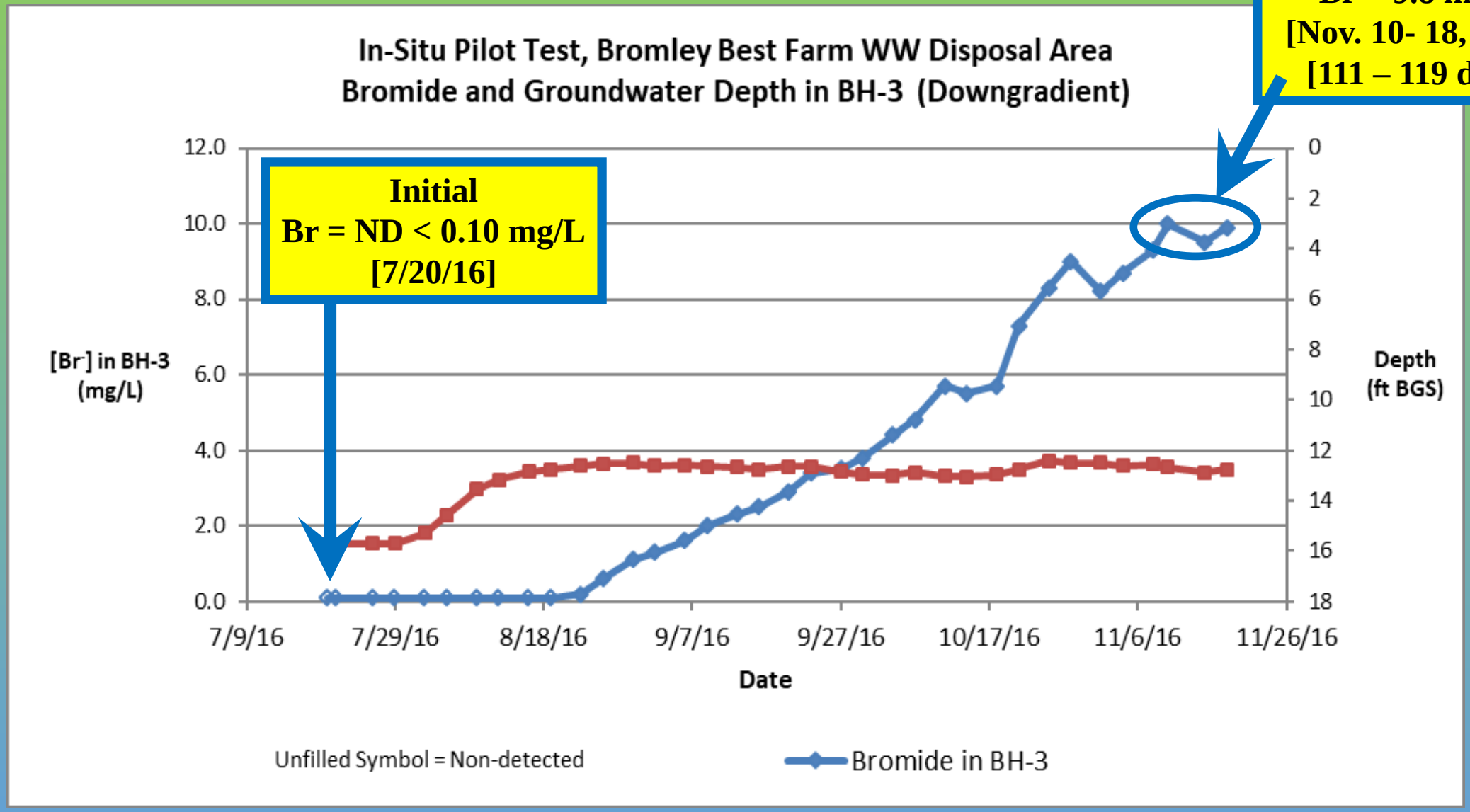
PILOT TEST: GROUNDWATER DEPTHS, DOWN-GRADIENT



PILOT TEST: BROMIDE IN DOWN-GRADIENT GROUNDWATER



PILOT TEST: BROMIDE IN DOWN-GRADIENT GROUNDWATER



PILOT TEST: NUTRIENTS IN DOWN-GRADIENT GROUNDWATER

Initial

Sample Date	Bromide (mg/L)	Nitrate as N (mg/L)	TDP (mg/L)	Depth to Water (ft BGS)
7/20/2016	< 0.10	0.23	0.018	15.75
7/21/2016	< 0.10	0.25	0.015	15.73
7/26/2016	< 0.10			15.72
11/8/2016	9.3			12.55
11/10/2016	10.0	1.2	< 0.005	12.69
11/15/2016	9.5	1.2	< 0.005	12.89
11/18/2016	9.9	1.0	0.012	12.76
Mean	3.7	0.8	0.011	13.22
Max	10.0	1.2	0.018	15.75
Min	0.1	0.2	0.005	12.43

WAITE HEINDEL

PILOT TEST: NUTRIENTS IN DOWN-GRADIENT GROUNDWATER

Sample Date	Bromide (mg/L)	Nitrate as N (mg/L)	TDP (mg/L)	Depth to Water (ft BGS)
7/20/2016	< 0.10	0.23	0.018	15.75
7/21/2016	< 0.10	0.25	0.015	15.73
7/26/2016	< 0.10	Time Gap of 110 days Waiting for Br equilibrium		15.72
11/8/2016	9.3			12.55
11/10/2016	10.0	1.2	< 0.005	12.69
11/15/2016	9.5	1.2	< 0.005	12.89
11/18/2016	9.9	1.0	0.012	12.76
Mean	3.7	0.8	0.011	13.22
Max	10.0	1.2	0.018	15.75
Min	0.1	0.2	0.005	12.43

WAITE HEINDEL

PILOT TEST: NUTRIENTS IN DOWN-GRADIENT GROUNDWATER

Sample Date	Bromide (mg/L)	Nitrate as N (mg/L)	TDP (mg/L)	Depth to Water (ft BGS)
7/20/2016	< 0.10	0.23	0.018	15.75
7/21/2016	< 0.10	0.25	0.015	15.73
7/26/2016	< 0.10			15.72
11/8/2016	9.3			12.55
11/10/2016	10.0	1.2	< 0.005	12.69
11/15/2016	9.5	1.2	< 0.005	12.89
11/18/2016	9.9	1.0	0.012	12.76
Mean	3.7			13.22
Max	10.0			15.75
Min	0.1			12.43

Final: 8-day equilibrium

Final NO3: 1.2 mg/L;

4-fold increase over initial

Final TDP: 0.007 mg/L; [avg.] decrease from initial

WAITE HEINDEL

REMEMBER WHY WE DID THE PILOT STUDY?

In-ground "Effluent" Concentration:

= PILOT TEST, to provide Groundwater data downgradient of drip-field

Calculation Method: Mass-balance, at Compliance Point in Eddy Brook:

§14-912 Determining Compliance With Aquatic Permitting Criteria

(a) To determine compliance with the Aquatic Permitting Criteria, a mass balance equation shall be used. The resulting in-stream concentration calculated with the mass balance equation must be less than or equal to the Aquatic Permitting Criterion for each parameter to demonstrate compliance. The following mass balance equation shall be used for calculating the resulting in-stream concentration:

$$\frac{[(E_c) \times (E_q) + (D_c) \times (D_q)]}{(E_q + D_q)} = \text{Resulting in-stream concentration}$$

Where: E_c = Existing in-stream receiving water concentration
E_q = Appropriate stream flow at point of compliance and for annual or seasonal release rate.
D_c = In-ground effluent concentration (5% exc), based on site specific testing.
D_q = Proposed discharge flow (i.e. maximum design capacity) .

REMEMBER WHY WE DID THE PILOT STUDY?

In-ground "Effluent" Concentration:

= PILOT TEST, to provide Groundwater data downgradient of drip-field

Calculation Method: Mass-balance, at Compliance Point in Eddy Brook:

§14-912 Determining Compliance With Aquatic Permitting Criteria

(a) To determine compliance with the Aquatic Permitting Criteria, a mass balance equation shall be used. The resulting in-stream concentration calculated with the mass balance equation must be less than or equal to the Aquatic Permitting Criterion for each parameter to demonstrate compliance. The following mass balance equation shall be used for calculating the resulting in-stream concentration:

$$\frac{[(E_c) \times (E_q) + (D_c) \times (D_q)]}{(E_q + D_q)} = \text{Resulting in-stream concentration}$$

Where: E_c = Existing in-stream receiving water concentration
E_q = Appropriate stream flow at point of compliance and for annual or seasonal release rate.
D_c = In-ground effluent concentration (5% exc), based on site specific testing.
D_q = Proposed discharge flow (i.e. maximum design capacity) .

Final "In-Ground Effluent" [Groundwater] Nutrient Concentrations:

- **NO3: 1.20 Mg/L;**
- **TDP: 0.012 Mg/L.**

WAITE HEINDEL

Calculation Method: Mass-balance, at Compliance Point in Eddy Brook:

$$\frac{[(E_c) \times (E_q) + (D_c) \times (D_q)]}{(E_q + D_q)} = \text{Resulting in-stream concentration}$$

- **Ec = Stream concentrations = 0.021 Mg/L TDP and 0.243 Mg/L NO3 [upper 95% Conf. Value];**
- **Eq = Streamflow = 97,769 gpd [LMMF];**
- **Dc = "In-ground effluent" = 0.012 Mg/L TDP and 1.20 Mg/L NO3 [max. of final 3 values of pilot test];**
- **Dq = Discharge flow = 80,000 gpd.**

Pilot Test, Nutrient Removal by Drip Dispersal

Mass-Balance Calculations & Results:

INPUT PARAMETERS:			Notes:
Chemical Name:	**TDP**		**Total Dissolved Phosphorus**
		units:	
Downgrad. GW Concentration:	0.012	mg/L	Maximum Value of 3 final Samples, Nov. 2016 in-situ pilot test
Upstream SW Concentration:	0.021	mg/L	Upper 95% C.V., from 2014 Eddy Brook Stream Sampling data
IDP Standard:	increase of 0.001	mg/L	per IDRs
Type of Discharge:	Annual		drip dispersal
Stream Name:	Eddy Brook		
LMMF:	97,769	gpd	0.445 mi^2 drainage area * 0.34 csm, converted to gpd
Disposal Rate:	80,000	gpd	
Dilution Ratio at LMMF:	**1.22**	to 1	
RESULTS:			
Stream Flow Volume at LMMF:	370,056	Liters	conversion [ltrs = gal * 3.785]
Spray Disposal Volume:	302,800	Liters	conversion [ltrs = gal * 3.785]
Mass in Stream:	7,660	mg	conc. X vol.
Mass in Groundwater:	3,634	mg	conc. X vol.
Total Downgradient Mass:	11,294	mg	sum of 2 masses
Total Downgradient Volume:	672,856	Liters	sum of 2 volumes

Predicted Downstream Surface Water Concentration, at LMMF:		
	TDP	
	0.0168 mg/L	[sum of masses] / [sum of vols]

Predicted Increase from Upstream to Downstream:		
	TDP	
	-0.0039 mg/L	**OK: < 0.001 mg/L increase**
	[decrease]	

WAITE HEINDEL

Pilot Test, Nutrient Removal by Drip Dispersal

Mass-Balance Calculations & Results:

INPUT PARAMETERS:				Notes:
Chemical Name:	**NO3**			**Nitrate**
			units:	
Downgrad. GW Concentration:	1.20		mg/L	Maximum Value of 3 final Samples, Nov. 2016 in-situ pilot test
Upstream SW Concentration:	0.243		mg/L	Upper 95% C.V., from 2014 Eddy Brook Stream Sampling data
IDP Standard:	2.0		mg/L	per IDRs
Type of Discharge:	Annual			drip dispersal
Stream Name:	Eddy Brook			
LMMF:	97,769		gpd	0.445 mi^2 drainage area * 0.34 csm, converted to gpd
Disposal Rate:	80,000		gpd	
Dilution Ratio at LMMF:	**1.22**	to 1		
RESULTS:				
Stream Flow Volume at LMMF:	370,056		Liters	conversion [ltrs = gal * 3.785]
Spray Disposal Volume:	302,800		Liters	conversion [ltrs = gal * 3.785]
Mass in Stream:	89,887		mg	conc. X vol.
Mass in Groundwater:	363,360		mg	conc. X vol.
Total Downgradient Mass:	453,247		mg	sum of 2 masses
Total Downgradient Volume:	672,856		Liters	sum of 2 volumes

Predicted Downstream Surface Water Concentration, at LMMF:		
NO3		
0.674	mg/L	[sum of masses] / [sum of vols]
		OK: < 2.0 mg/L.
Predicted Increase from Upstream to Downstream:		
NO3		
0.431	mg/L	

Pilot Test, Nutrient Removal by Drip Dispersal

Mass-Balance Calculations & Results:

Predicted Downstream Surface Water Concentrations:						
			NO3:	0.674	mg/L	OK: < 2.0 mg/L.
			TDP:	0.0168	mg/L	
Predicted Increases from Upstream to Downstream:						
			NO3:	0.431	mg/L	
			TDP:	-0.0039	mg/L	OK: < 0.001 mg/L increase

Pilot Test, Nutrient Removal by Drip Dispersal

Mass-Balance Calculations & Results:

Predicted Downstream Surface Water Concentrations:						
			NO3:	0.674	mg/L	OK: < 2.0 mg/L.
			TDP:	0.0168	mg/L	
Predicted Increases from Upstream to Downstream:						
			NO3:	0.431	mg/L	
			TDP:	-0.0039	mg/L	OK: < 0.001 mg/L increase

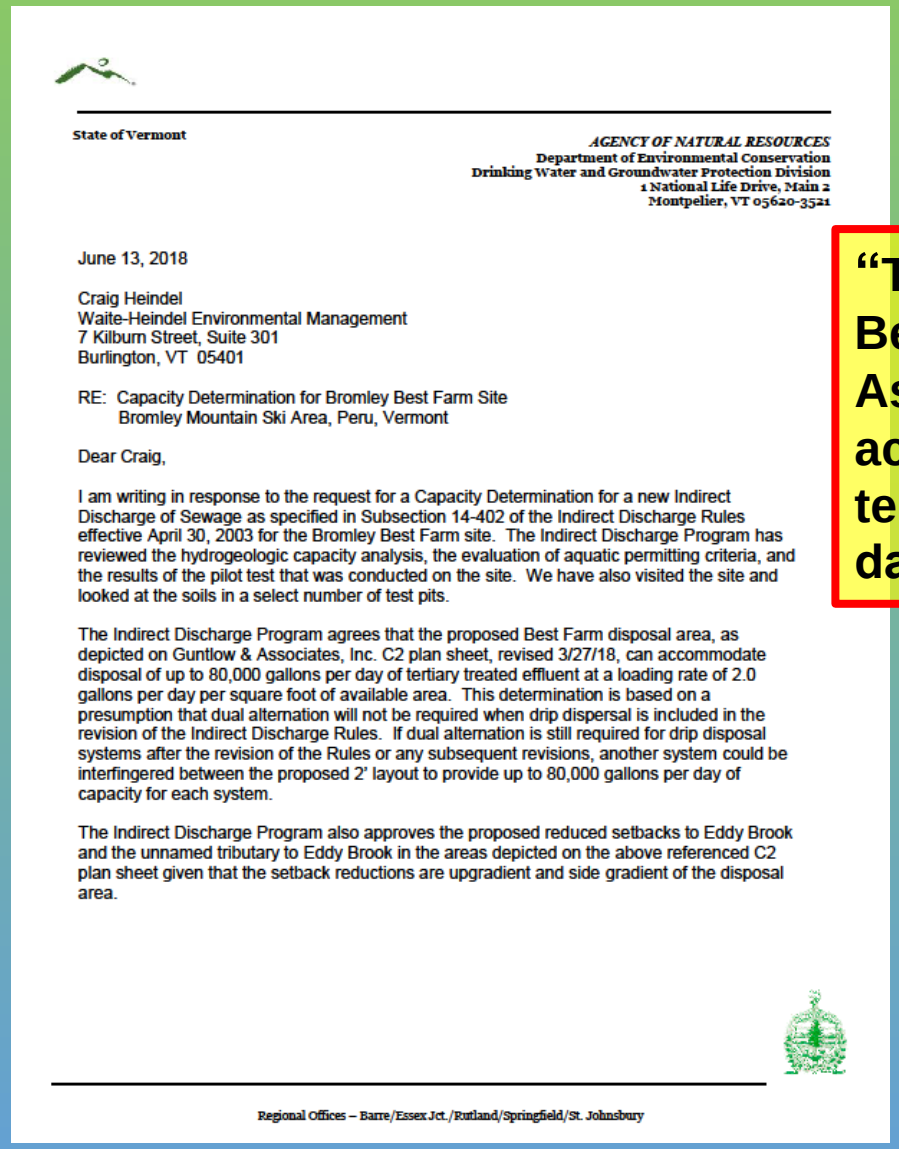
✓ **SUCCESS!**

Documentation of predicted compliance with Aquatic Permitting Criteria of Vermont's Indirect Discharge Rule.

WAITE HEINDEL

Pilot Test, Nutrient Removal
by Drip Dispersal

“Capacity Determination Letter” issued 6/13/2018



State of Vermont

AGENCY OF NATURAL RESOURCES
Department of Environmental Conservation
Drinking Water and Groundwater Protection Division
1 National Life Drive, Main 2
Montpelier, VT 05620-3521

June 13, 2018

Craig Heindel
Waite-Heindel Environmental Management
7 Kilburn Street, Suite 301
Burlington, VT 05401

RE: Capacity Determination for Bromley Best Farm Site
Bromley Mountain Ski Area, Peru, Vermont

Dear Craig,

I am writing in response to the request for a Capacity Determination for a new Indirect Discharge of Sewage as specified in Subsection 14-402 of the Indirect Discharge Rules effective April 30, 2003 for the Bromley Best Farm site. The Indirect Discharge Program has reviewed the hydrogeologic capacity analysis, the evaluation of aquatic permitting criteria, and the results of the pilot test that was conducted on the site. We have also visited the site and looked at the soils in a select number of test pits.

The Indirect Discharge Program agrees that the proposed Best Farm disposal area, as depicted on Guntlow & Associates, Inc. C2 plan sheet, revised 3/27/18, can accommodate disposal of up to 80,000 gallons per day of tertiary treated effluent at a loading rate of 2.0 gallons per day per square foot of available area. This determination is based on a presumption that dual alternation will not be required when drip dispersal is included in the revision of the Indirect Discharge Rules. If dual alternation is still required for drip disposal systems after the revision of the Rules or any subsequent revisions, another system could be interfingered between the proposed 2' layout to provide up to 80,000 gallons per day of capacity for each system.

The Indirect Discharge Program also approves the proposed reduced setbacks to Eddy Brook and the unnamed tributary to Eddy Brook in the areas depicted on the above referenced C2 plan sheet given that the setback reductions are upgradient and side gradient of the disposal area.

Regional Offices – Barre/Essex Jct./Rutland/Springfield/St. Johnsbury

“The Indirect Discharge Program agrees that the proposed Best Farm disposal area, as depicted on Guntlow & Associates, Inc. C2 plan sheet, revised 3/27/18, can accommodate disposal of up to 80,000 gallons per day of tertiary treated effluent at a loading rate of 2.0 gallons per day per square foot of available area.”

WAITE HEINDEL

Pilot Test of Nutrient Removal by Large-Scale Drip Dispersal of Tertiary-Treated Effluent, Southern Vermont

SUMMARY:

1. 5,020 GPD of treated domestic WW effluent were applied to a pilot drip-dispersal field for 119 days in July through November 2016;

2. The pilot-test drip-dispersal field was 235 ft. x 10.7 ft. [2,515 sq.ft.]. Wastewater spiked with Sodium Bromide as a tracer was applied at 2.0 gpd/sq.ft. via frequent small-volume timed doses;

WH WAITE HEINDEL

Pilot Test of Nutrient Removal by Large-Scale Drip Dispersal of Tertiary-Treated Effluent, Southern Vermont

SUMMARY:

1. **5,020 GPD of treated domestic WW effluent were applied to a pilot drip-dispersal field for 119 days in July through November 2016;**

2. **The pilot-test drip-dispersal field was 235 ft. x 10.7 ft. [2,515 sq.ft.]. Wastewater spiked with Sodium Bromide as a tracer was applied at 2.0 gpd/sq.ft. via frequent small-volume timed doses;**

2. **Soils at the drip-dispersal pipe depth [6” – 12”] are sandy loams; underlying parent material is fine-to-medium sands, with occasional lenses of gravelly coarse sand;**

WAITE HEINDEL

Pilot Test of Nutrient Removal by Large-Scale Drip Dispersal of Tertiary-Treated Effluent, Southern Vermont

SUMMARY [cont.]:

4. **Total Dissolved Phosphorus and Nitrate were analyzed in samples collected from downgradient groundwater and effluent.**

Results:

		Down-Gradient Groundwater	
	Effluent	Pre-Test	End of Test
Parameter:	Mg/L	Mg/L	Mg/L
TDP	1.9	0.017	0.012
NO3	0.86	0.24	1.2

WAITE HEINDEL

Pilot Test of Nutrient Removal by Large-Scale Drip Dispersal of Tertiary-Treated Effluent, Southern Vermont

SUMMARY [cont.]:

5. **The water table beneath the disposal field was initially at ~ 15 ft. below the drip-dispersal pipes. It rose by 2.9 ft. after ~ 30 days, then remained stable. So ~ 12 ft. of unsaturated soil was maintained below the drip-dispersal field for the final 80 days of the test.**

Pilot Test of Nutrient Removal by Large-Scale Drip Dispersal of Tertiary-Treated Effluent, Southern Vermont

SUMMARY [cont.]:

6. **The combination of drip-dispersal system with frequent small-volume timed doses of treated wastewater, plus sandy loam B-horizon and fine-to-medium sands below, plus deep unsaturated zone [12 to 15 ft.] provided more than 99% removal of Total Dissolved Phosphorus, and substantial conversion of Nitrogen to Nitrate.**

Pilot Test of Nutrient Removal by Large-Scale Drip Dispersal of Tertiary-Treated Effluent, Southern Vermont

Special thanks to the team members who participated in conducting this pilot test:

- **Bill Beideman, Phil Talbot, Pat Gordon – Bromley WWTP Operators;**
- **Bill Cairns, Michael Van Eyck – Bromley Ski Area management;**
- **Rob Sarmanian, Don Ottenheimer -- Oakson; Gloucester, MA;**
- **Vince Guntlow, P.E.; Guntlow & Associates, Williamstown, MA;**
- **Endyne Laboratories, Williston, VT; Lebanon, N.H.; Plattsburgh, N.Y.**

Pilot Test of Nutrient Removal by Large-Scale Drip Dispersal of Tertiary-Treated Effluent, Southern Vermont

Questions?

THANK YOU.

- **Craig Heindel, C.P.G.; Senior Hydrogeologist, Waite-Heindel Environmental Management, Burlington, VT;**
  cheindel@gmavt.net; www.waiteenv.com; 802-806-9400
- **Rob Sarmanian, General Manager; Oakson; Gloucester, MA;**
  rob@Oakson.com; www.Oakson.com; 978-282-1322
- **Vince Guntlow, P.E.; Guntlow & Associates, Williamstown, MA;**
  VinceG@guntlowassociates.com; www.guntlowassociates.com ; 413-458-2198;
- **Bill Cairns, General Manager; Bromley Ski Area, Peru, VT;**
  bc@bromley.com; www.bromley.com; 802-536-1686.

2019 NEIWPCC
Onsite Short Course