Stormwater Master Planning for Urban and Rural Communities

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Project Goal:

Create a stormwater master plan (SWMP) to identify and prioritize stormwater best management practices (BMPs) to improve water quality

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Where in the world?

Vermont - Lake Champlain Basin

Basin: 8,234 sq. miles

56% of the Basin is in Vermont

Basin population: 571,000 (68% in Vermont)

Important resource for the area:

- ~200,000 people (~35% of Basin's population) depend on lake for drinking water
- 99 public water systems draw water from Lake Champlain
- Tourism (billions of $s)

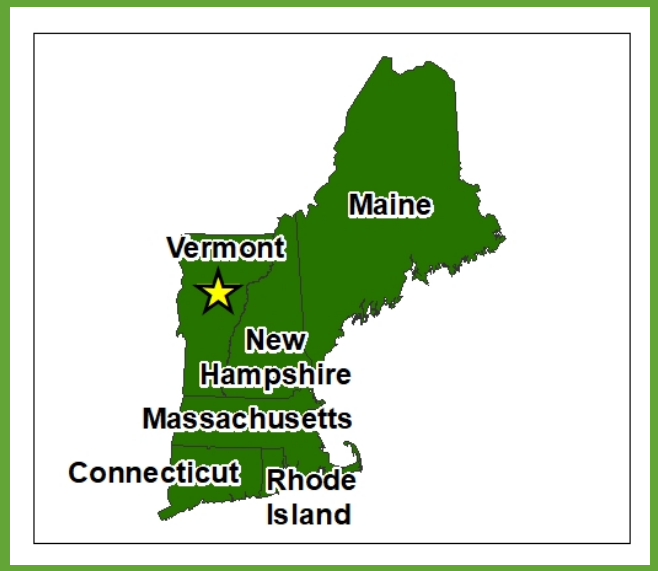
Lake Champlain Phosphorus TMDL - 2016

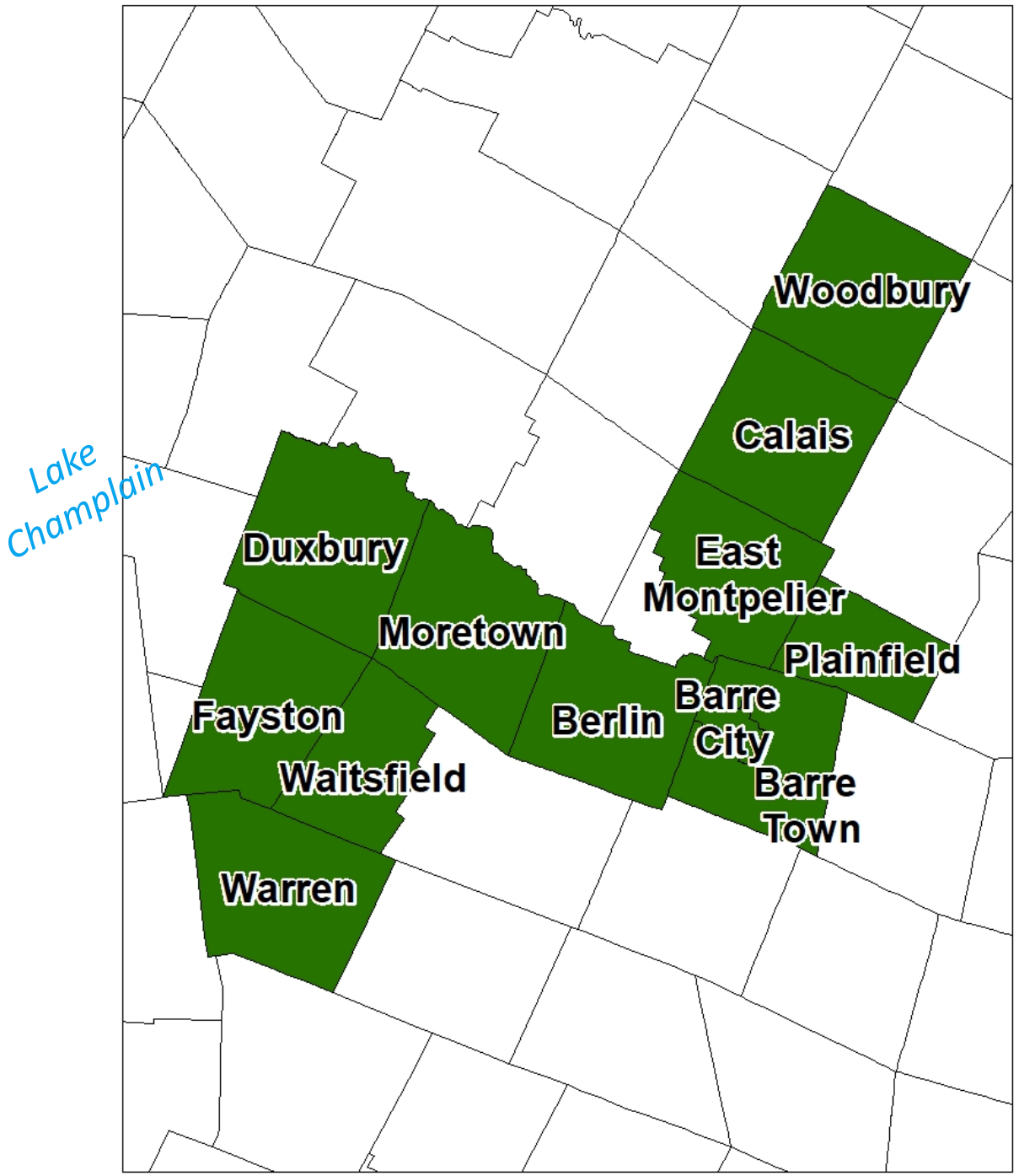
Algae Photos: http://www.lcbp.org/water-environment/human-health/cyanobacteria/cyanobacteria-health-advisories/2008-blooms-gallery/

Lake Champlain Facts Source: http://www.lcbp.org/about-the-basin/facts/

Study Area

- 12 municipalities in the Winooski River watershed
- Winooski River drains west to Lake Champlain
- 388 mi^2
- ~5,500 acres impervious





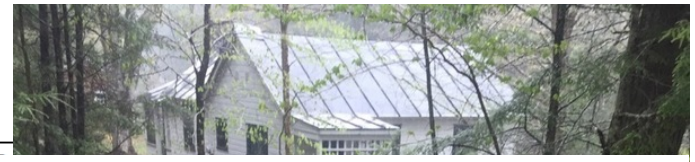
Stormwater problem areas

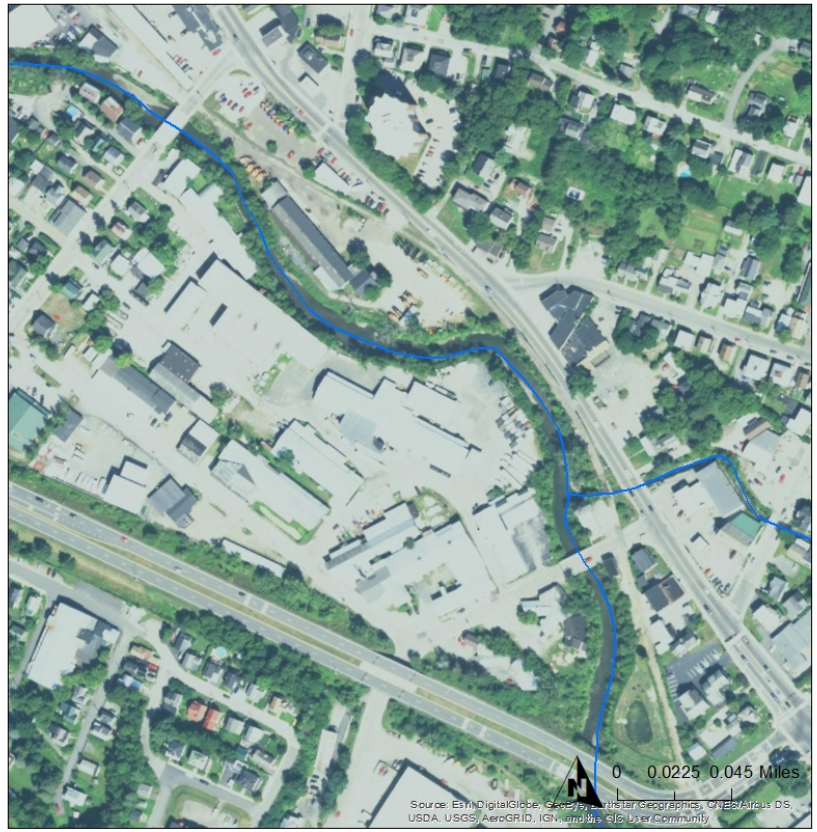
Large developments that predate stormwater regulations

Sub-jurisdictional developments

Steep rural roads

Constrained development along rivers





Stormwater Master Planning

Problem:

- Limited funding
- Public and private properties
- Large area

Approach:

- Targeting practices based on:
  - Where pollution is generated
  - Where pollution can be captured and removed efficiently
- Developing master plans:
  - With public involvement
  - As comprehensive as possible
  - Listing all known problems
  - Based on a prioritized list of projects

Goal:

- Develop a comprehensive plan for addressing stormwater runo
  - Mitigate impacts before they create problems
  - Avoid creation of new problems
- A strategic approach to make implementation more likely

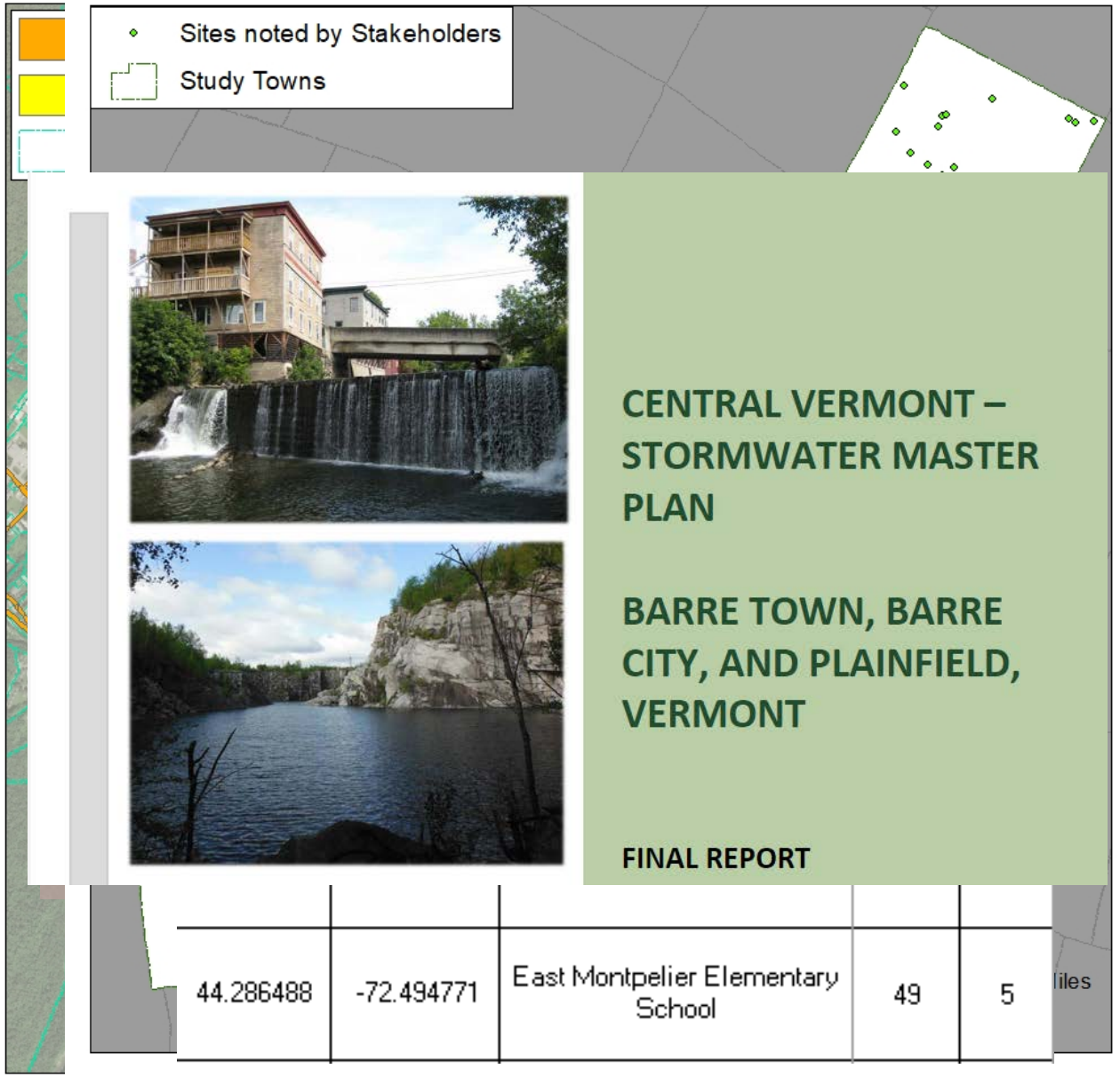


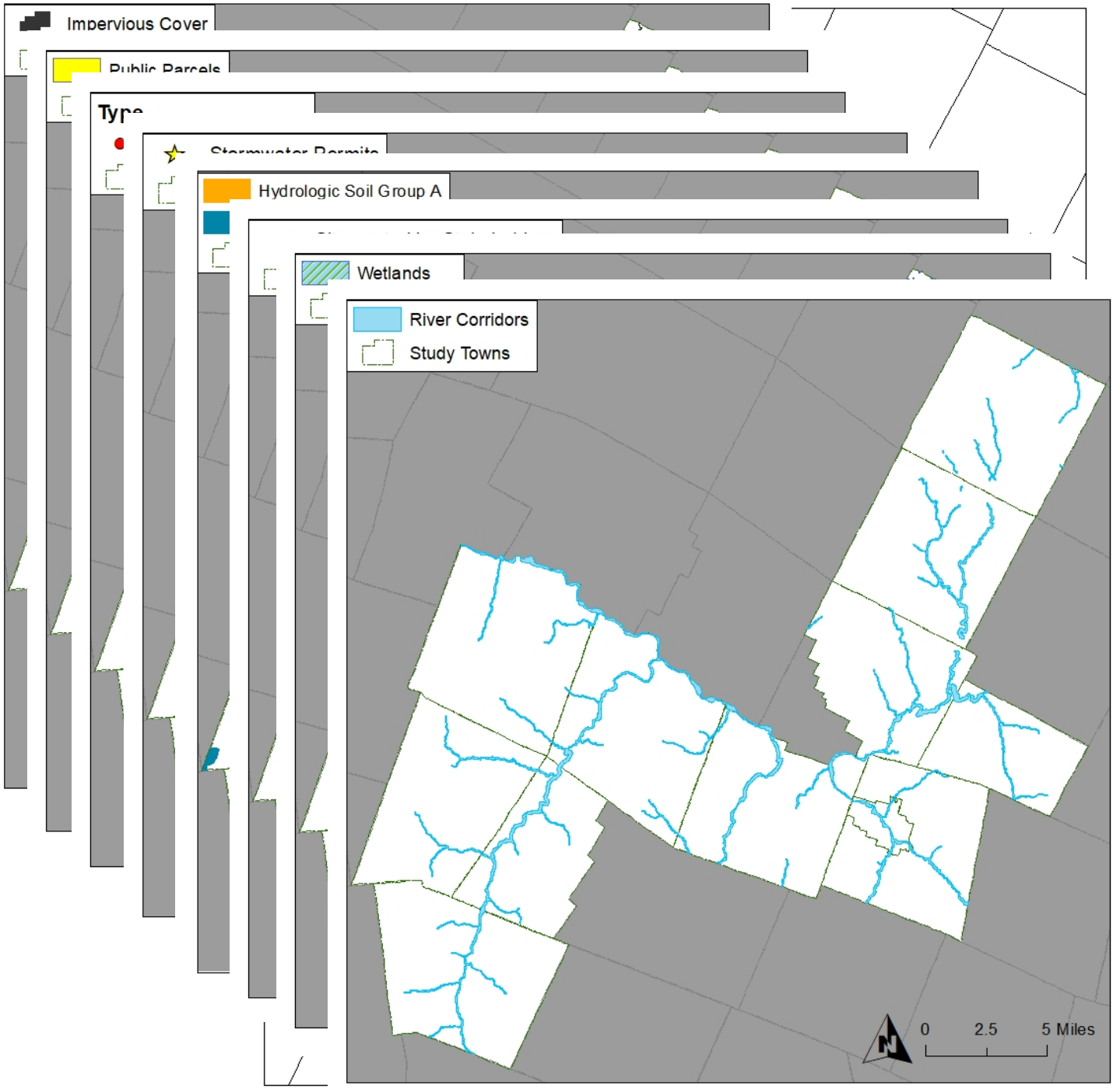
Image: https://www.wvnews.com/prestoncountyjournal/opinion/highway-funding/image_df5c12c1-4f07-5f2e-a2c1-878ab659178b.html

Targeting BMP Identification

How to prioritize?

GIS overlay analysis focusing on:

- ✓ High-percentage of impervious coverage
- ✓ Publicly owned parcels
- ✓ Large stormwater outfalls
- ✓ Areas with existing stormwater permits
- ✓ Possible infiltration sites (NRCS Hydrologic Soil Group A or B soils)
- ✓ Problem areas identified by Stakeholders
- ✓ Areas not in conflict with wetlands
- ✓ Practices compatible with river corridor regulations



Targeting BMP Identification

Green Streets identification

Methodology: Adapted from “Promoting Green Streets” 2016 report

1. Road Right-of-Way (ROW) Width - Wide
2. Road Slope - Flat
3. Hydrologic Soil Group - Good infiltration

Using a custom GIS model:

- Segment ROW polygons
- Assign soil group
- Assign slope
- Assign ROW Width
- Score each segment

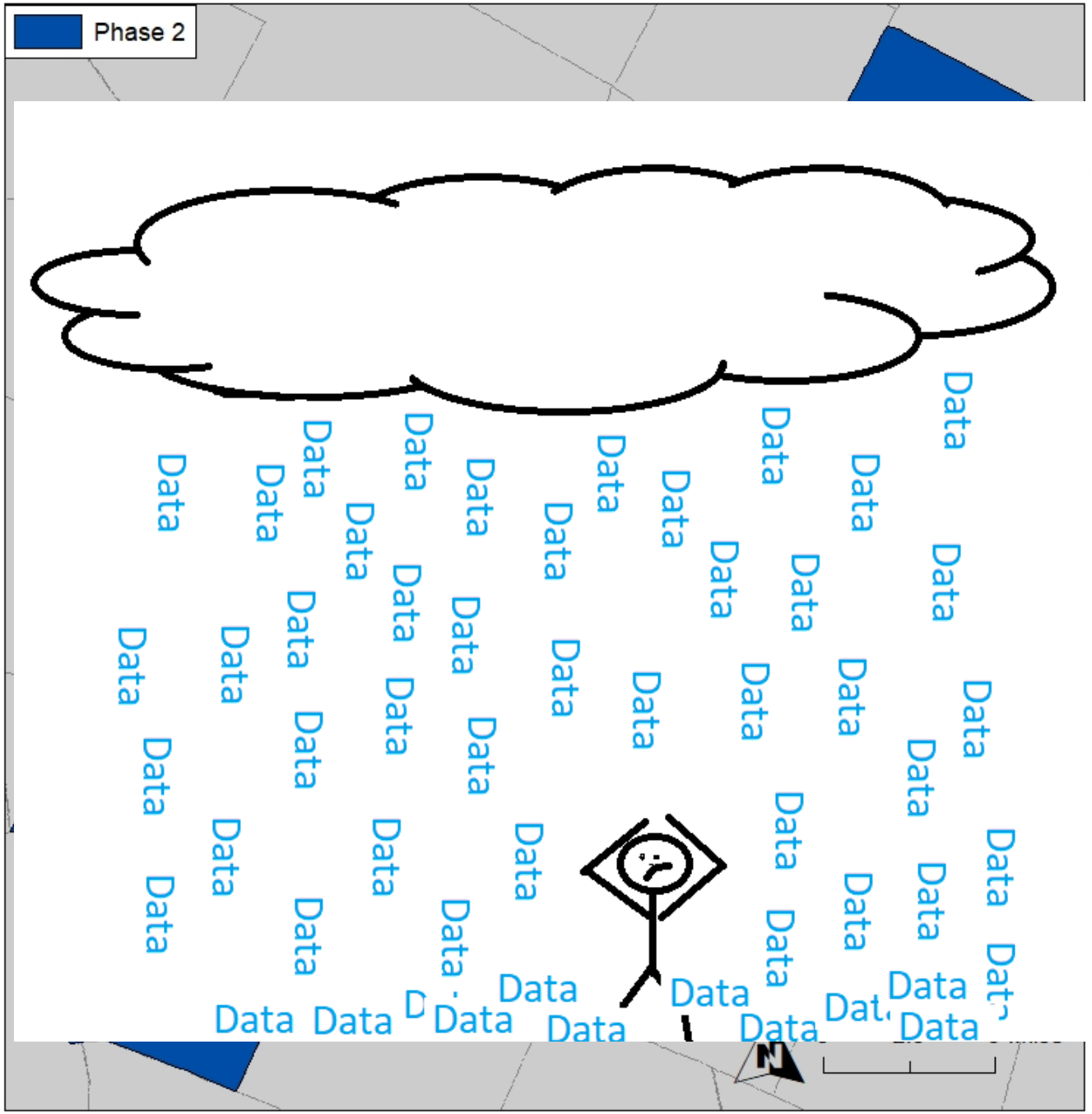
Targeting Priority Areas

768 sites to field investigate

Two Phase approach:

- Phase 1: Field season 2017
- Phase 2: Field season 2018

…. Leads to a data deluge

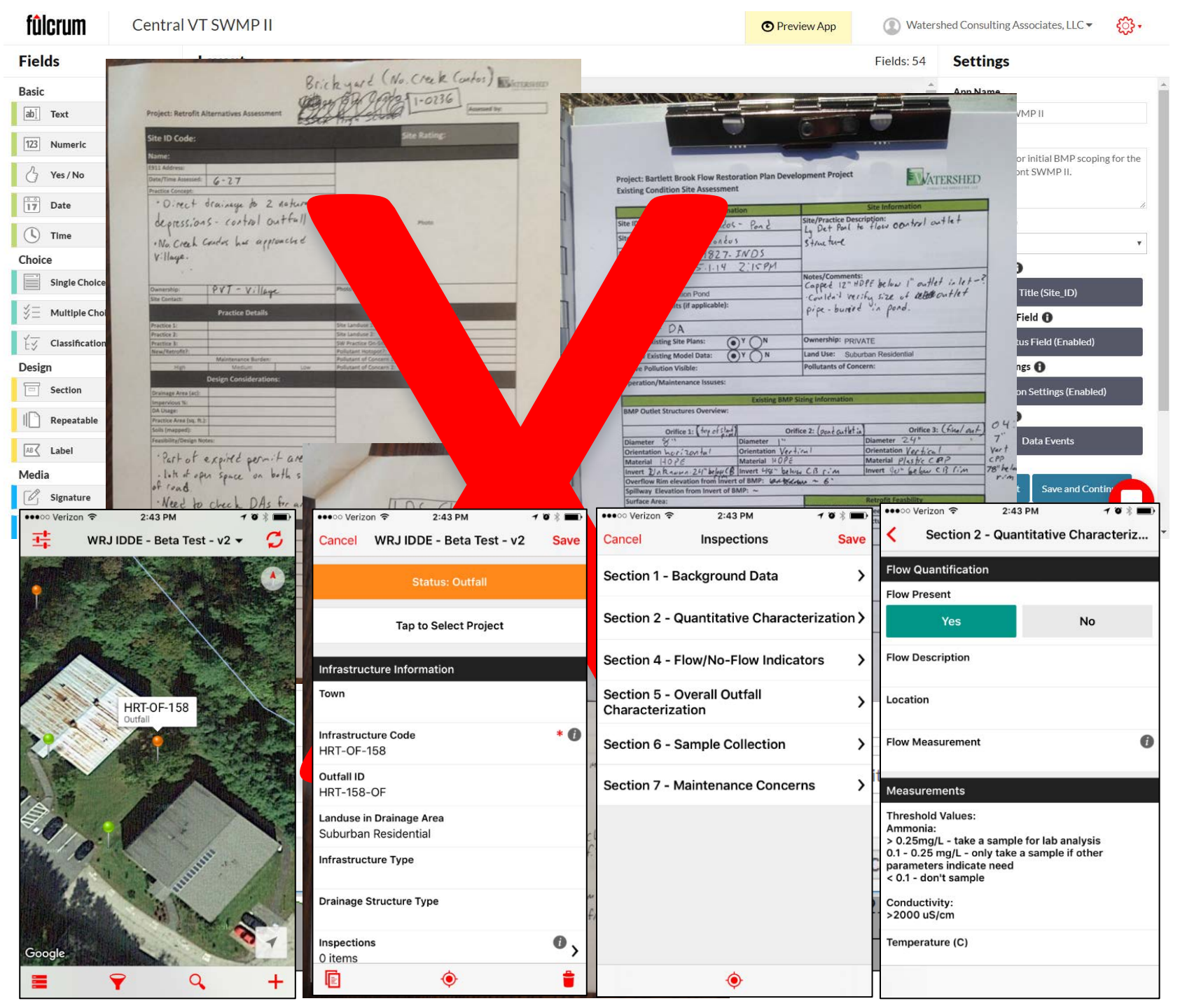


Dealing with the Data Deluge

More than **760** sites to field assessed

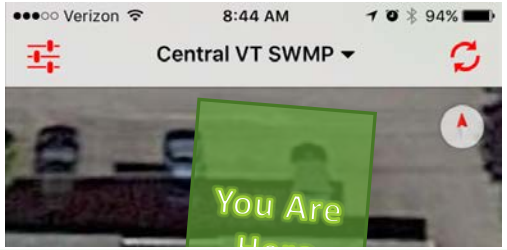
Our workflow:

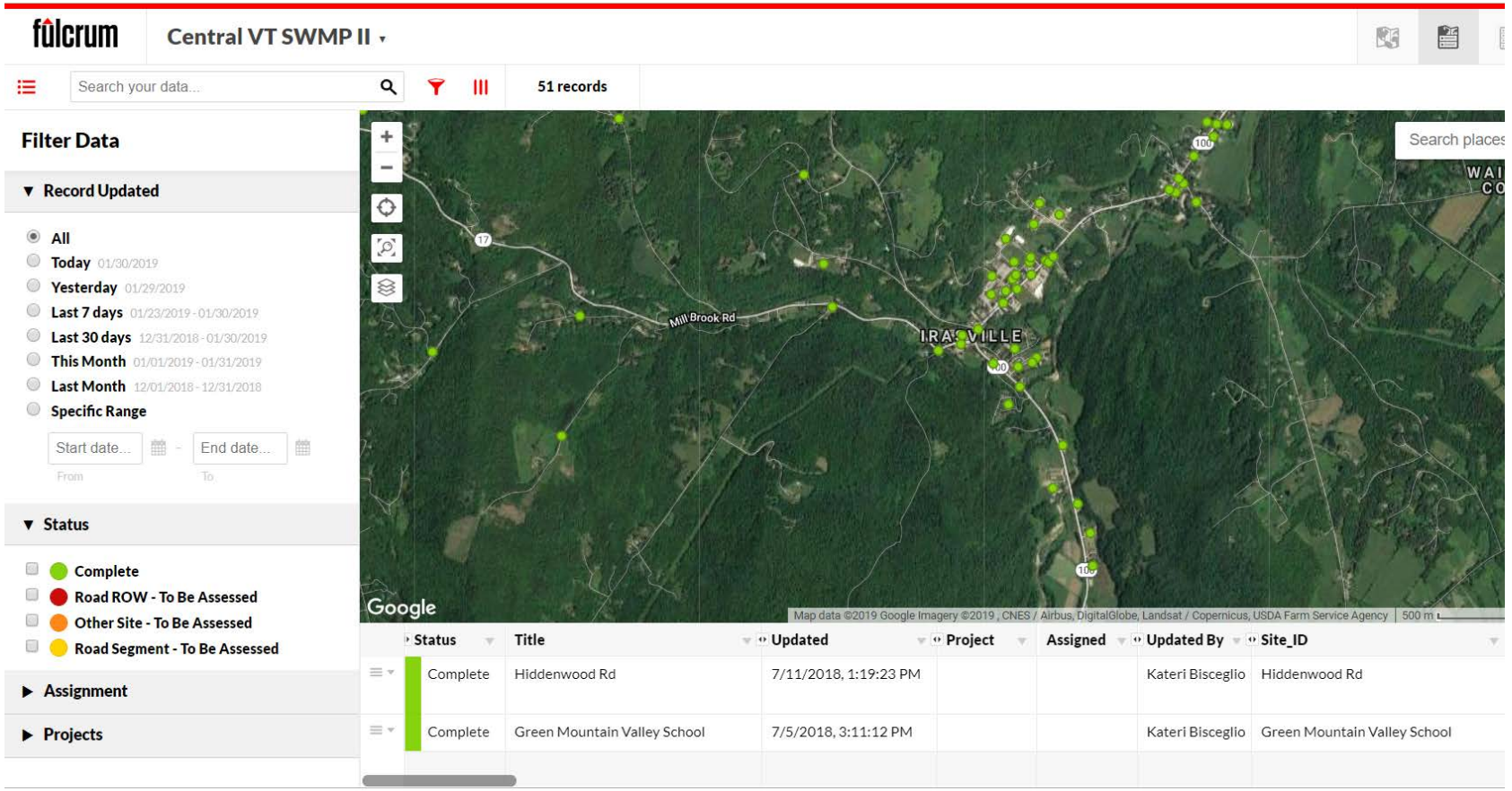
- Identify potential BMP point locations
- Use established template in GIS to record site specific information
- ~~Lots of paper forms~~
- Customize mobile app
- Upload GIS point layer to mobile app

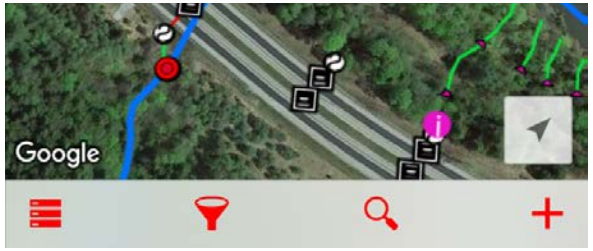


Dealing with the Data Deluge

- Field investigation using mobile app
- Data collection:
  - BMP concept
  - Photos
  - Follow-up notes or questions
  - Confirming existing infrastructure
  - If existing BMP, confirm specifications
- Upload to the Cloud
- Download in .gdb format
- Update as projects progress







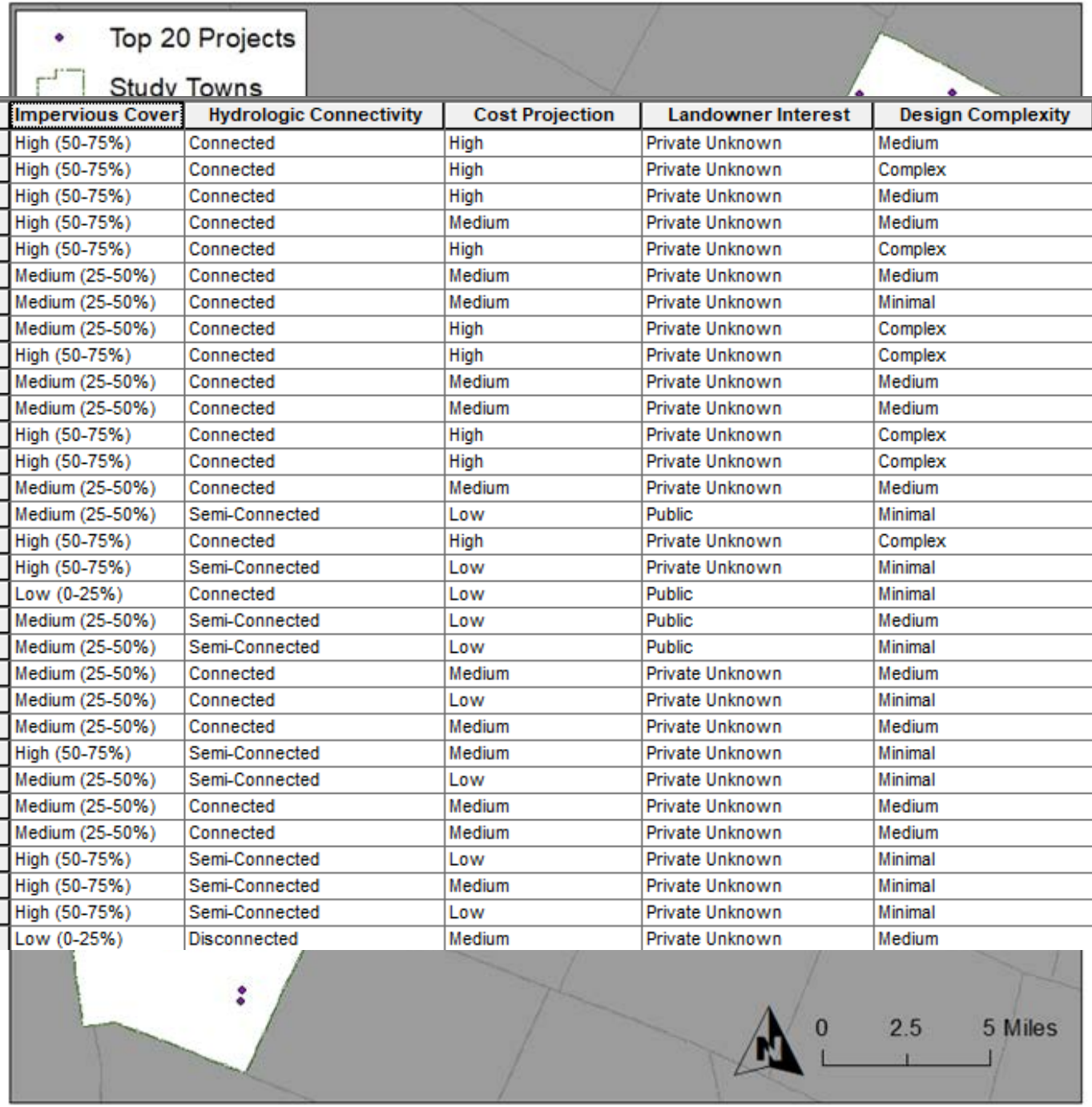
Prioritization

Goal:

- Prioritize and rank 775 projects

Our workflow:

- Standardized to ensure consistency
- Score and rank projects based on:
  - drainage area size
  - pollutant load reduction potential
  - hydrologic connectivity
  - ownership
  - feasibility issues
- Identify top 20 projects per municipality (240 projects total)



Site ID	Impervious Cover	Hydrologic Connectivity	Cost Projection	Landowner Interest	Design Complexity
	High (50-75%)	Connected	High	Private Unknown	Medium
	High (50-75%)	Connected	High	Private Unknown	Complex
	High (50-75%)	Connected	High	Private Unknown	Medium
	High (50-75%)	Connected	Medium	Private Unknown	Medium
	High (50-75%)	Connected	High	Private Unknown	Complex
	Medium (25-50%)	Connected	Medium	Private Unknown	Medium
	Medium (25-50%)	Connected	Medium	Private Unknown	Minimal
	Medium (25-50%)	Connected	High	Private Unknown	Complex
	High (50-75%)	Connected	High	Private Unknown	Complex
	Medium (25-50%)	Connected	Medium	Private Unknown	Medium
West Street Outfall	Medium (25-50%)	Connected	Medium	Private Unknown	Medium
	High (50-75%)	Connected	High	Private Unknown	Complex
	High (50-75%)	Connected	High	Private Unknown	Complex
	Medium (25-50%)	Connected	Medium	Private Unknown	Medium
	Medium (25-50%)	Semi-Connected	Low	Public	Minimal
Rotary Park Outfall	High (50-75%)	Connected	High	Private Unknown	Complex
	High (50-75%)	Semi-Connected	Low	Private Unknown	Minimal
	Low (0-25%)	Connected	Low	Public	Minimal
	Medium (25-50%)	Semi-Connected	Low	Public	Medium
	Medium (25-50%)	Semi-Connected	Low	Public	Minimal
Field Avenue Outfall	Medium (25-50%)	Connected	Medium	Private Unknown	Medium
	Medium (25-50%)	Connected	Low	Private Unknown	Minimal
	Medium (25-50%)	Connected	Medium	Private Unknown	Medium
	High (50-75%)	Semi-Connected	Medium	Private Unknown	Minimal
	Medium (25-50%)	Semi-Connected	Low	Private Unknown	Minimal
Giorgetti Arena Parking Lot	Medium (25-50%)	Connected	Medium	Private Unknown	Medium
	Medium (25-50%)	Connected	Medium	Private Unknown	Medium
	High (50-75%)	Semi-Connected	Low	Private Unknown	Minimal
	High (50-75%)	Semi-Connected	Medium	Private Unknown	Minimal
	High (50-75%)	Semi-Connected	Low	Private Unknown	Minimal
	Low (0-25%)	Disconnected	Medium	Private Unknown	Medium

Hydrologic and Pollutant Load Modeling

- Delineate drainage areas
- Model in HydroCAD and WinSLAMM

SWMPs include 240 projects that will:

- Reduce TSS load by 6,474,202 lbs annually
- Reduce TP load by 1,019 lbs annually

Outfall Output Summary

	Runoff Volume (cu. ft.)	Percent Runoff Reduction	Runoff Coefficient (Rv)	Particulate Solids Conc. (mg/L)	Particulate Solids Yield (lbs)	Percent Particulate Solids Reduction
Total of All Land Uses without Controls	193124		0.05	181.3	2185	
Outfall Total with Controls	805.0	99.58 %	0.00	106.8	5.369	99.75 %
Current File Output: Annualized Total After Outfall Controls	147.1	Years in Model Run:	5.47		0.9813	

Pollutant	Concentration - No Controls	Concentration - With Controls	Concentration Units	Pollutant Yield - No Controls	Pollutant Yield - With Controls	Pollutant Yield Units	Percent Yield Reduction
Particulate Solids	181.3	106.8	mg/L	2185	5.369	lbs	99.75 %
Total Solids	542.1	504.4	mg/L	6535	25.35	lbs	99.61 %
Total Phosphorus	0.4202	0.3610	mg/L	5.066	0.01814	lbs	99.64 %

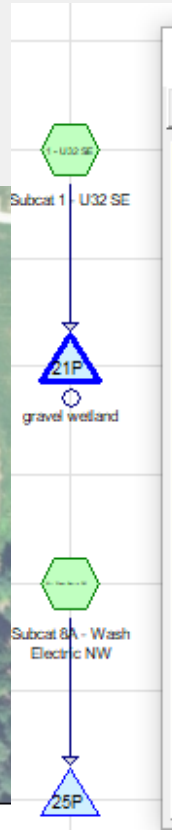
Print Output Summary to .csv File
Print Output Summary to Text File
Print Output Summary to Printer

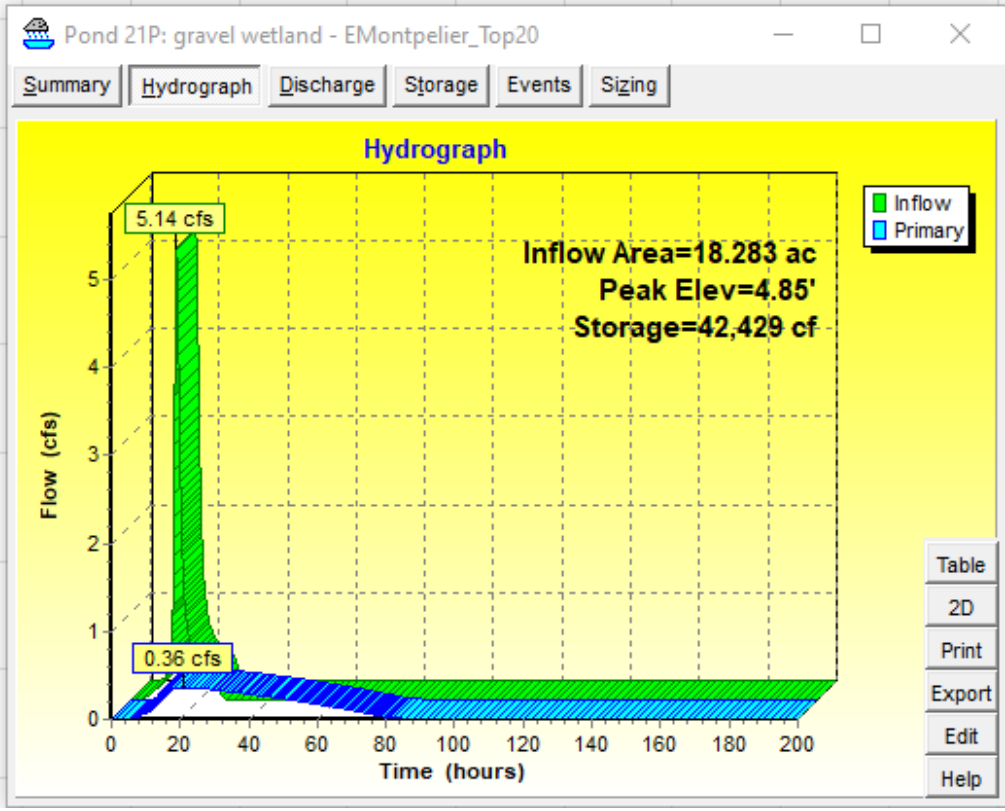
Total Area Modeled (ac): 5.558

Receiving Water Impacts Due To Stormwater Runoff

Total Control Practice Costs

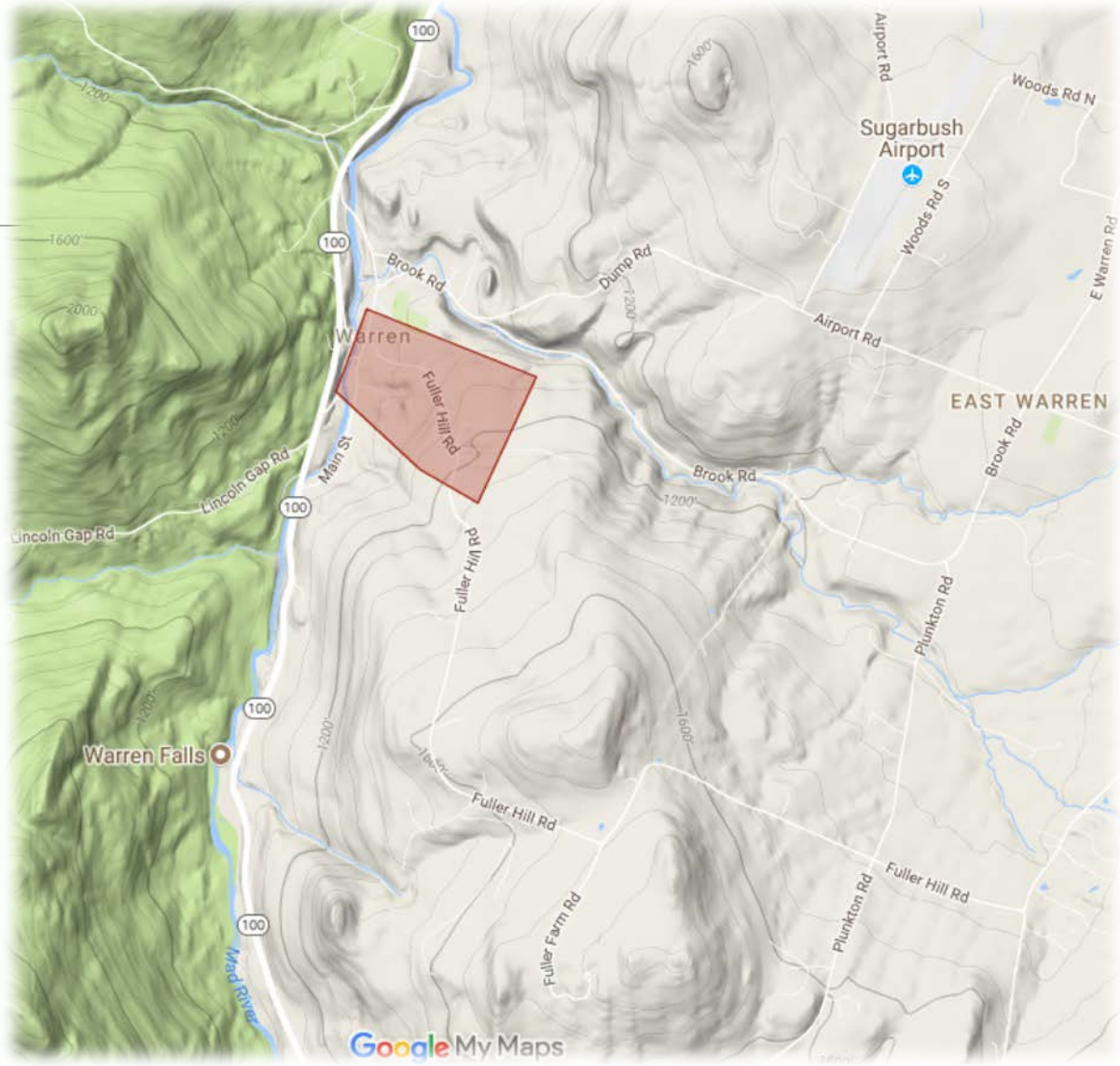
Capital Cost	N/A
Land Cost	N/A
Annual Maintenance Cost	N/A
Present Value of All Costs	N/A
Annualized Value of All Costs	N/A





Rural Case Study

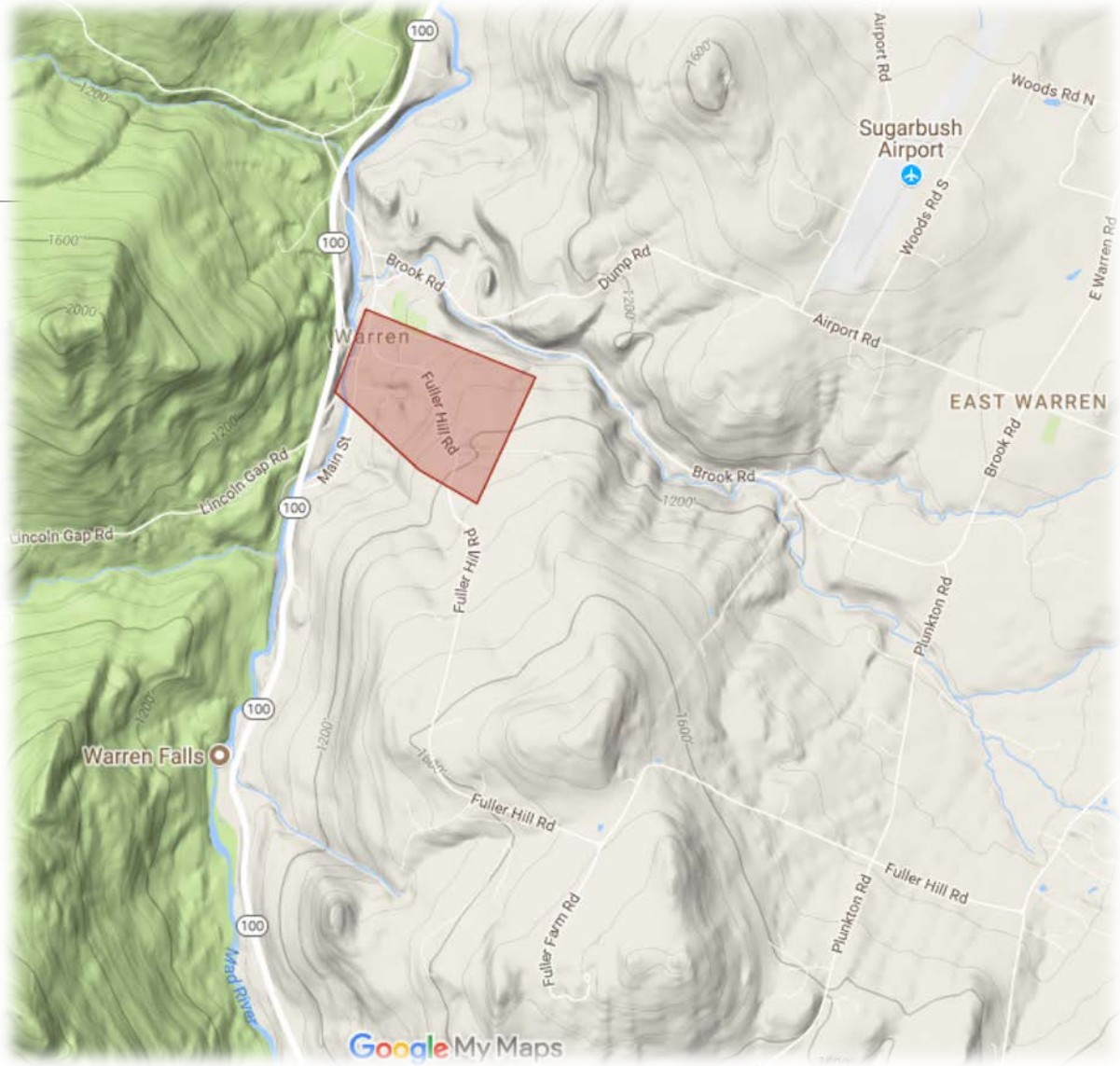
Fuller Hill Road, Warren, VT



Overview

Project Area –

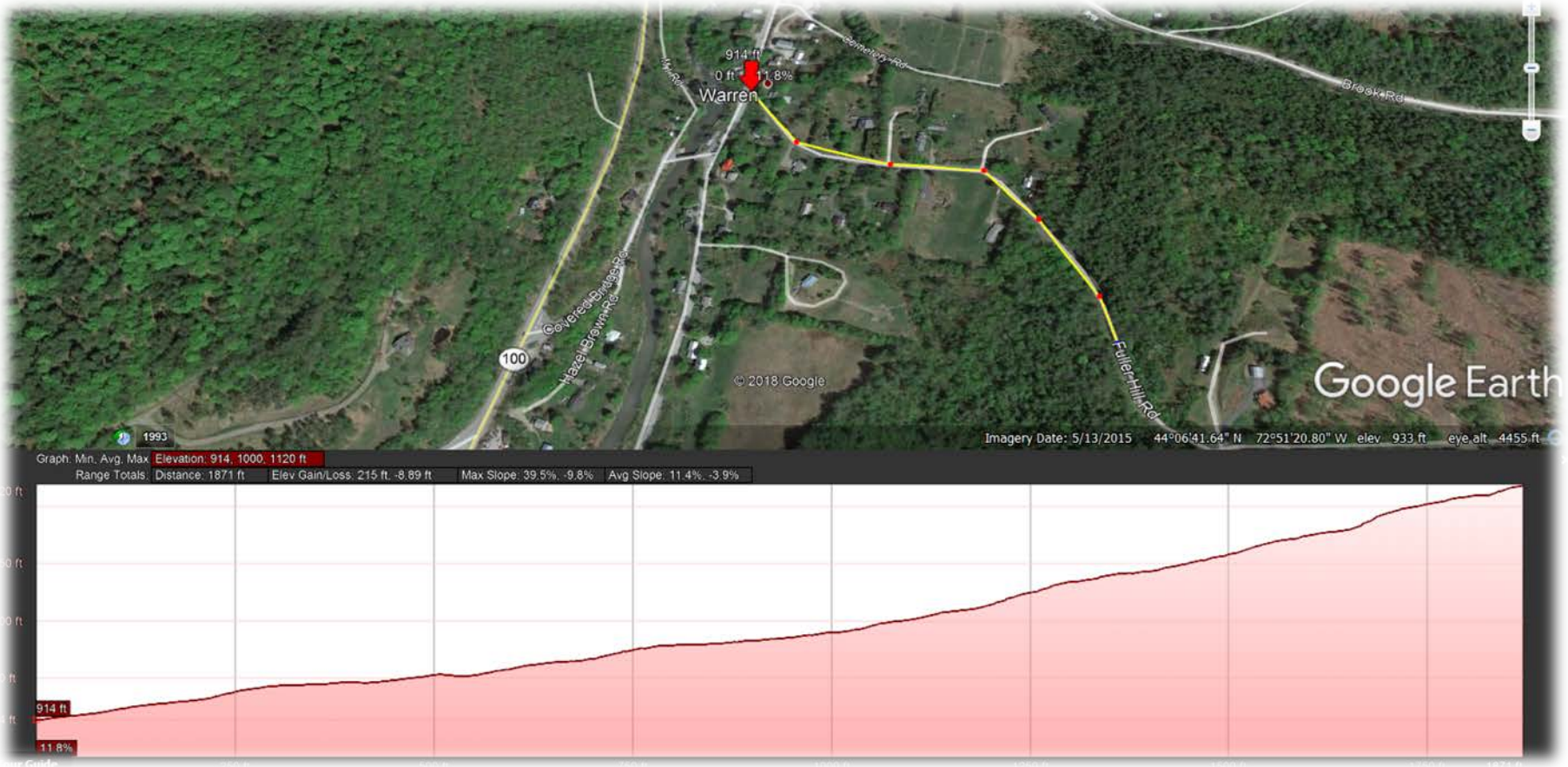
- Lowest section of a long steep dirt road



Overview

Project Area –

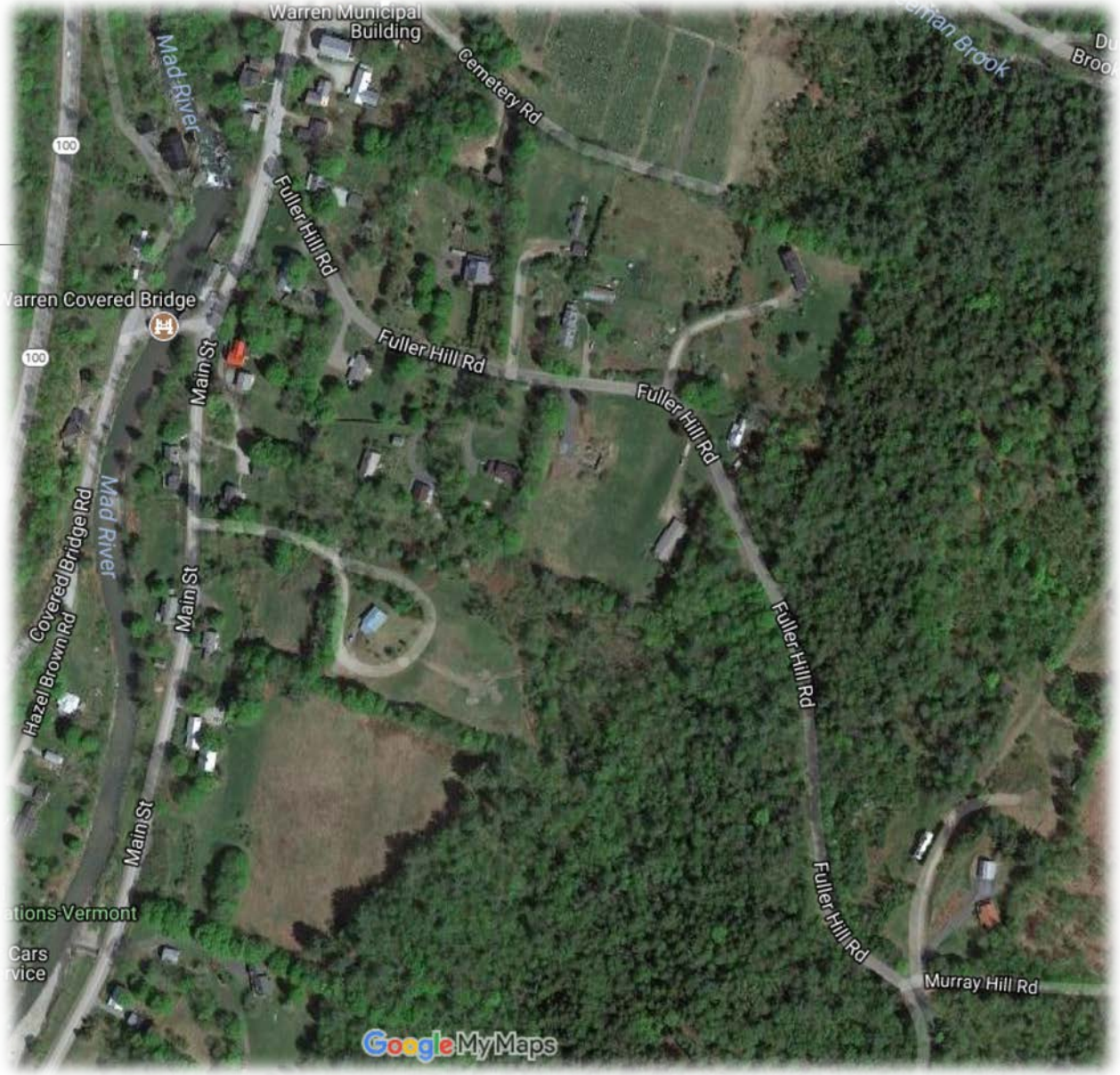
- Steep – avg 11.4%



Overview

Project Area –

- Extensive residential development surrounding it
- Why does this matter?
  - Because you can't just turn the ditches out – there's nowhere to go.



Overview

Project Area –

- Wicked confined
  - Utility poles in the ditch
  - Steep side slopes
  - Mature trees
  - Aesthetic fences

Overview

Project Area –

- Directly hydrologically connected to the Mad River

Solution Selection Process

How do we go beyond the typical rock-lined ditch to do something more?

GOALS:

- **Get water into the ground**
- **Return mobilized P to soils**
- **Reduce runoff volume for long-term ditch/outfall stability**

Solution Selection Process

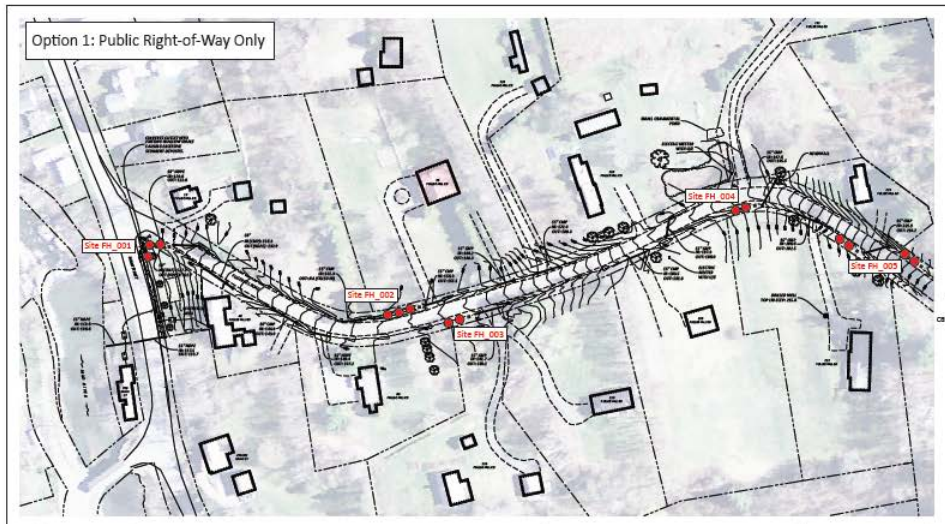
Process

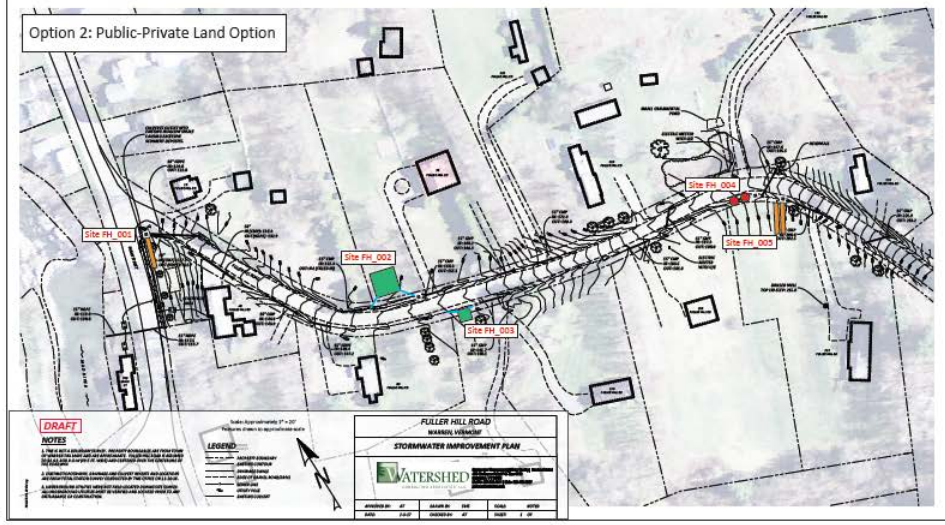
- **Extensive Mapping of Drainage Area**
- **Classification of Land Use and Soils For Modeling**

Solution Selection Process

Process

- **Development of Two Options**

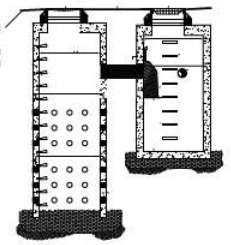




Option 1 - Public Right-of-Way Only

Drainage Area	Practice Description	Drainage Area (acres)	Impervious Cover (acres)	CPv Controlled (Y/N)	CPv Volume (cu. Ft.)	TP Reduction	TSS Reduction	Fecal Bacteria Reduction (%)	Cost	Cost / lbs. TP
FH_001	3 8'x8' concrete dry wells.	0.831	0.279	Y	2,050	2.70	2,184	93%	$ 13,800	$ 5,121
FH_002	3 8'x8' concrete dry wells.	1.453	0.279	Y	2,050	4.43	3,249	88%	$ 13,800	$ 3,119
FH_003	1 8'x8' concrete dry wells.	1.317	0.122	Y	1,350	3.10	2,169	59%	$ 4,600	$ 1,482
FH_004	2 8'x8' concrete dry wells.	5.81	0.242	Y	5,300	4.28	3,521	57%	$ 9,200	$ 2,150
FH_005	4 8'x8' concrete dry wells.	2.659	0.274	Y	4,600	1.92	2,223	87%	$ 18,400	$ 9,583
TOTAL		12.07	1.196		15,350	16.424	13,346	77%	$ 59,800	$ 3,641.01

Dry well section view shown with catch basin to inlet runoff to dry well



Pre-cast concrete dry well example

Option 2 - Public / Private Land Option

Drainage Area	Practice Description	Drainage Area (acres)	Impervious Cover (acres)	CPv Controlled (Y/N)	CPv Volume (cu. Ft.)	TP Reduction	TSS Reduction	Fecal Bacteria Reduction (%)	Cost	Cost / lbs. TP
FH_001	1x4 MC-4500 StormTech Chambers	0.831	0.279	Y	2,050	2.80	2,281	98%	$ 5,000	$ 1,786
FH_002	Infiltration basin - 20'x20' @ 3' deep with 3:1 sides	1.453	0.279	Y	2,050	4.73	3,477	94%	$ 4,000	$ 846
FH_003	Infiltration basin - 10'x10' @ 3' deep with 3:1 sides	1.317	0.122	Y	1,350	4.11	2,876	78%	$ 3,000	$ 730
FH_004	2 8'x8' concrete dry wells.	5.81	0.242	Y	5,300	4.28	3,521	57%	$ 9,200	$ 2,150
FH_005	2x4 MC-4500 StormTech Chambers	2.659	0.274	Y	4,600	2.03	2,377	91%	$ 9,500	$ 4,689
TOTAL		12.07	1.196		15,350	17.946	14,532	84%	$ 30,700	$ 1,710.69

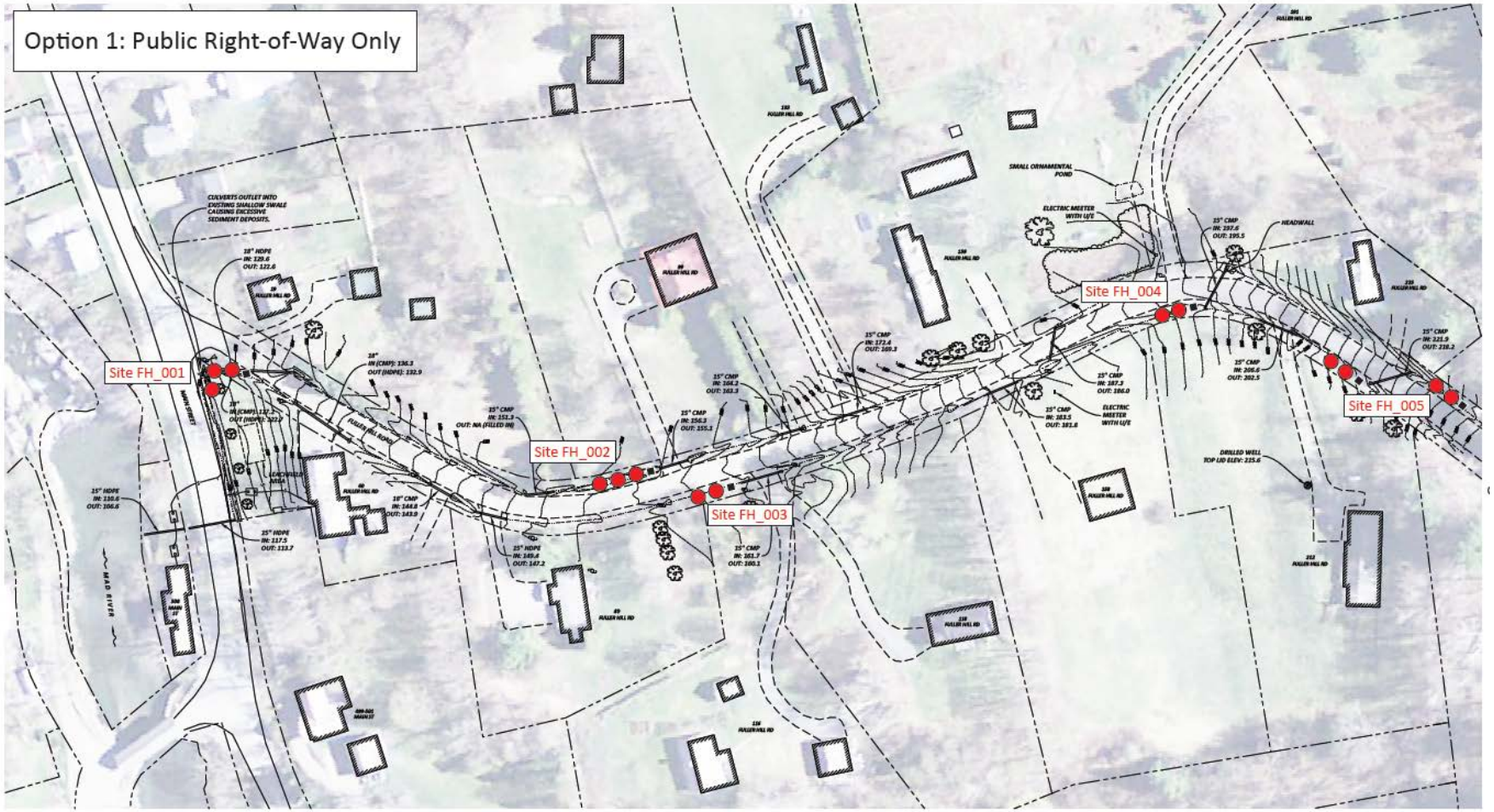
StormTech MC-4500 Infiltration Chambers installed under a parking lot.

Grass infiltration basin in a residential setting.

Solution Selection Process

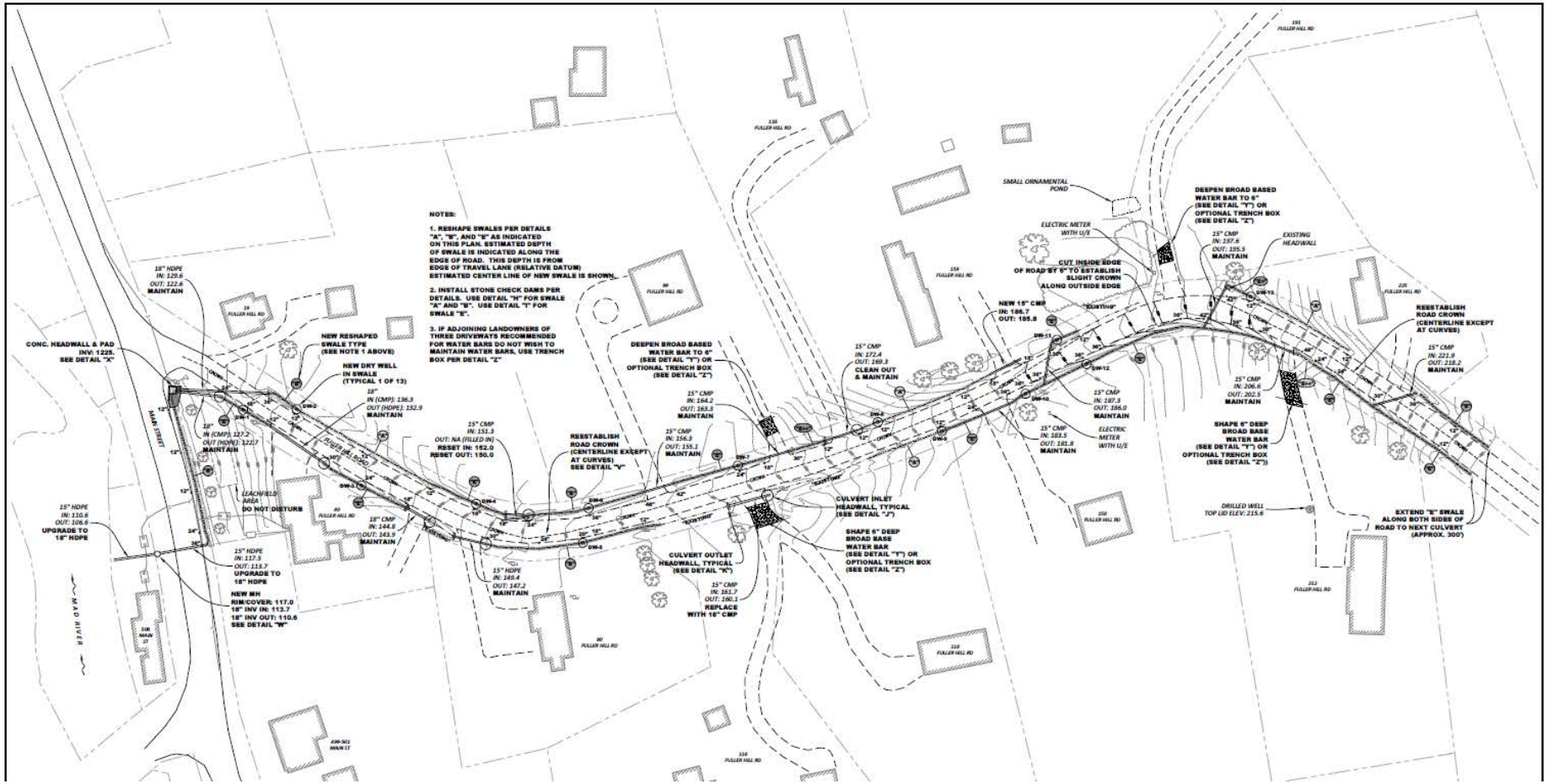
Process

- **Public ROW Option**
  - **Dry wells & ditch/road improvements**



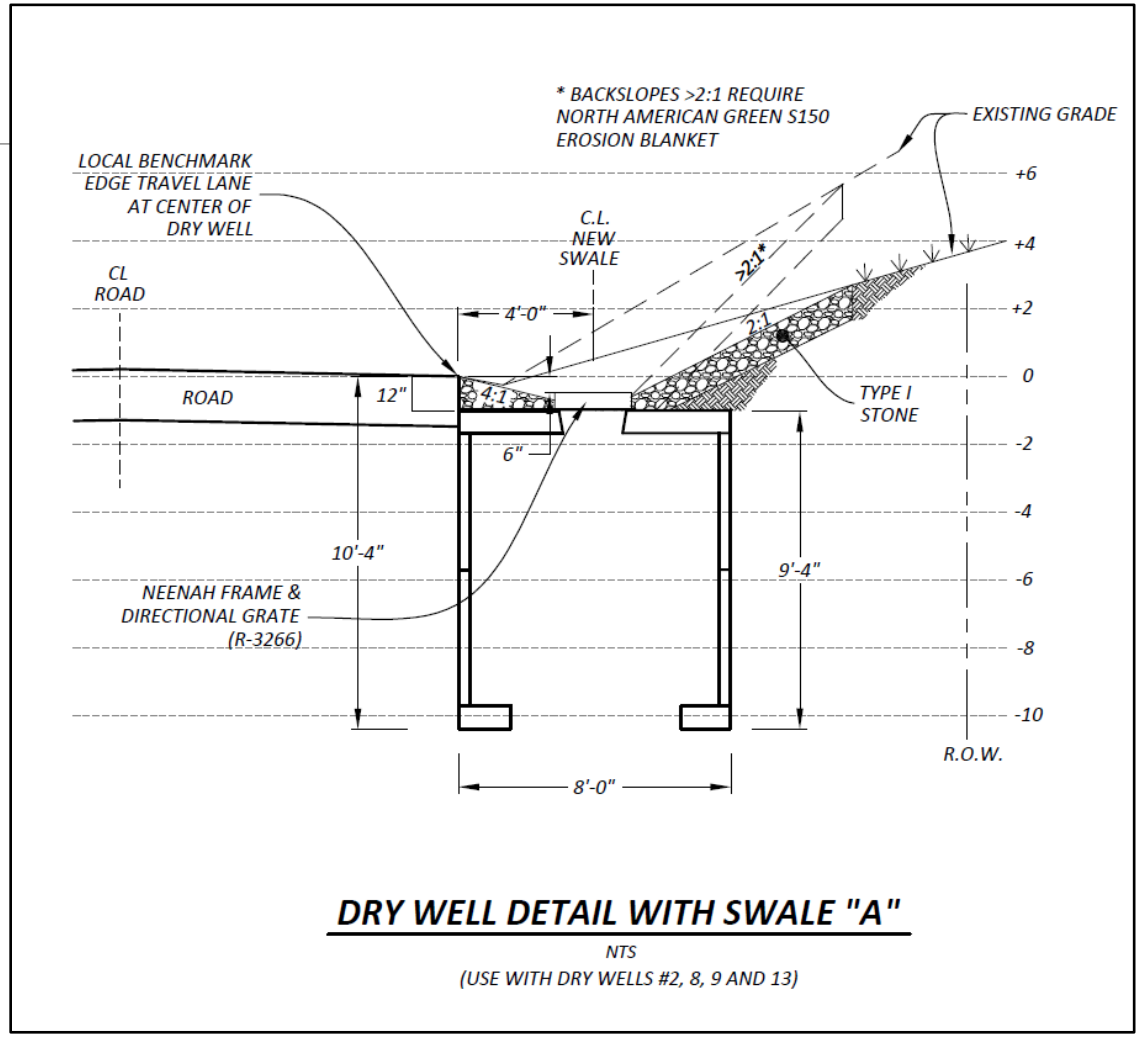
Solution Descriptions

The Final Design



Solution Descriptions

Dry Wells



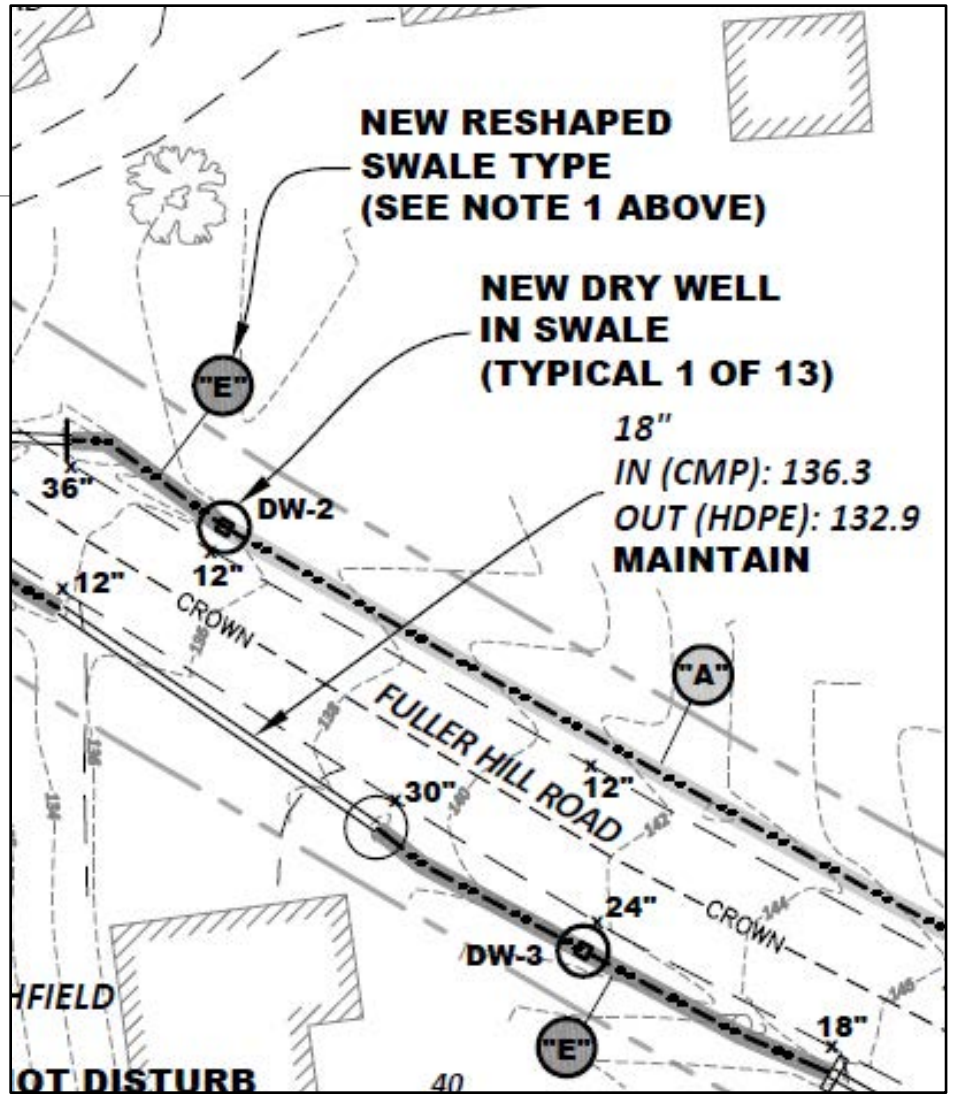
DRY WELL DETAIL WITH SWALE "A"

NTS

(USE WITH DRY WELLS #2, 8, 9 AND 13)

Solution Descriptions

Ditch Re-shaping and armoring



Solution Descriptions

Road Improvements

- **Proper Crowning**
  - **Constrained to re-shaping road**
  - **No surface improvements (i.e. pavement) – residents didn't want that**

Construction

Before:

After:

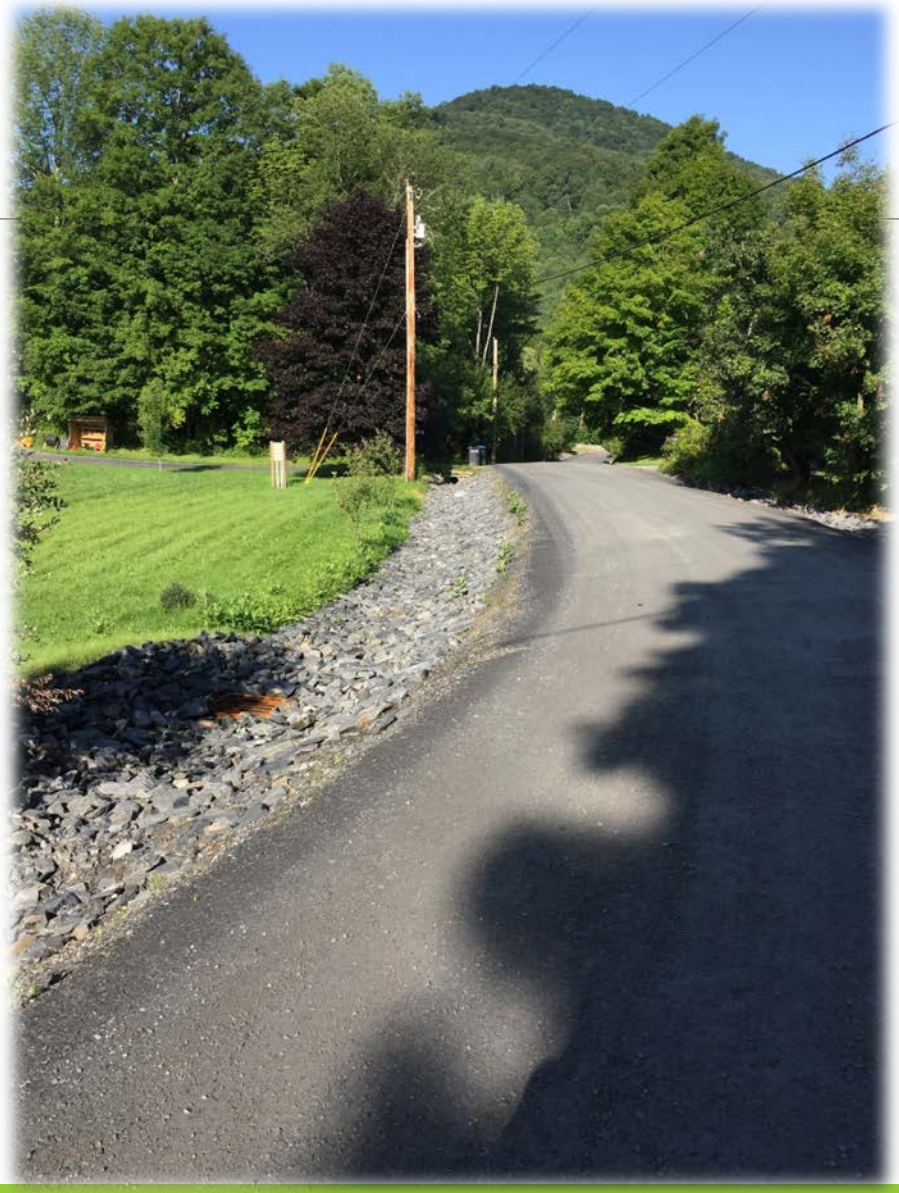
Construction

Construction

Before & After Photos

Before & After Photos

Before & After Photos



Summary

Design Fully Infiltrates 1-year storm (~2.25” / 24 hours)

Reduces Phosphorus Loading by ~16 lbs. annually (modeled)

Reduces TSS Loading by 13,000 lbs. annually (modeled)

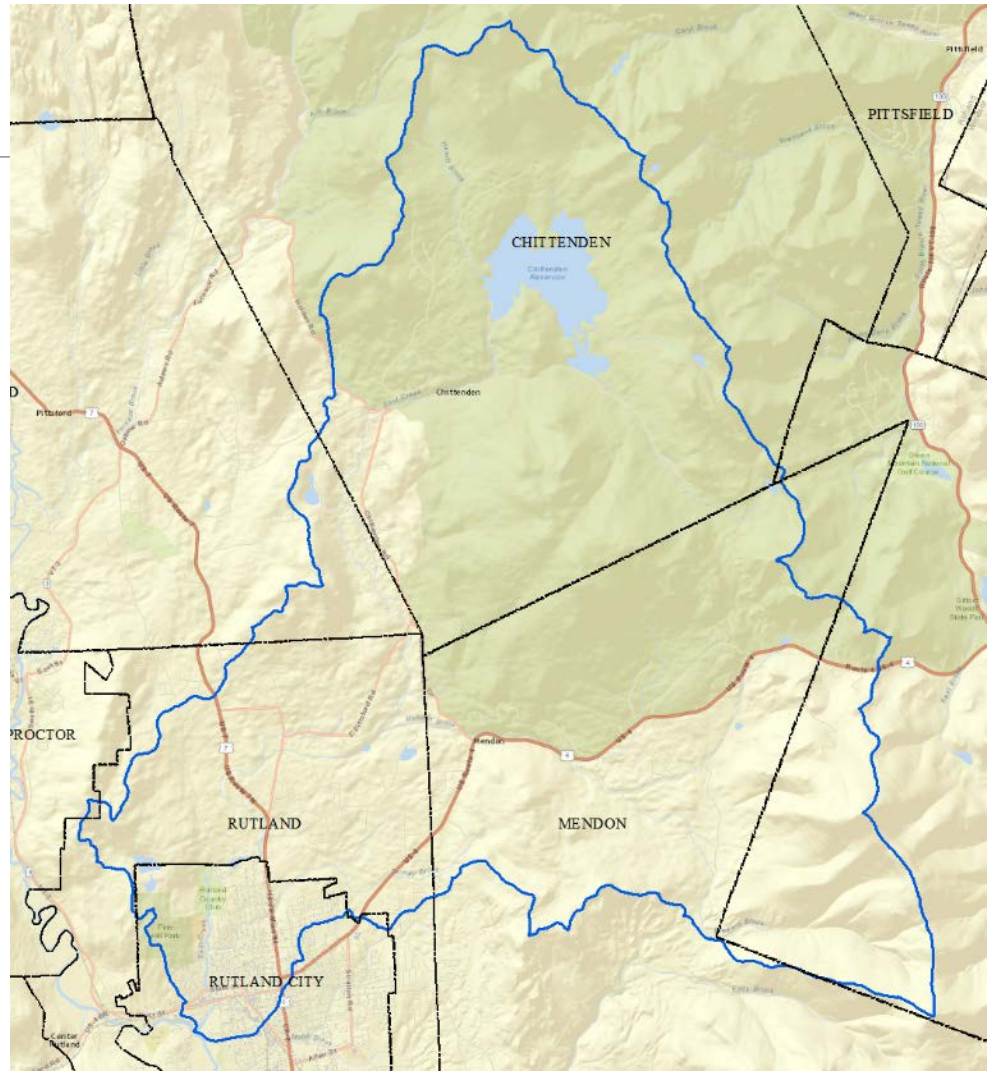
Requires no private land use

Installation Cost: ~$150,000

- **$9,375/lbs. P Removed**

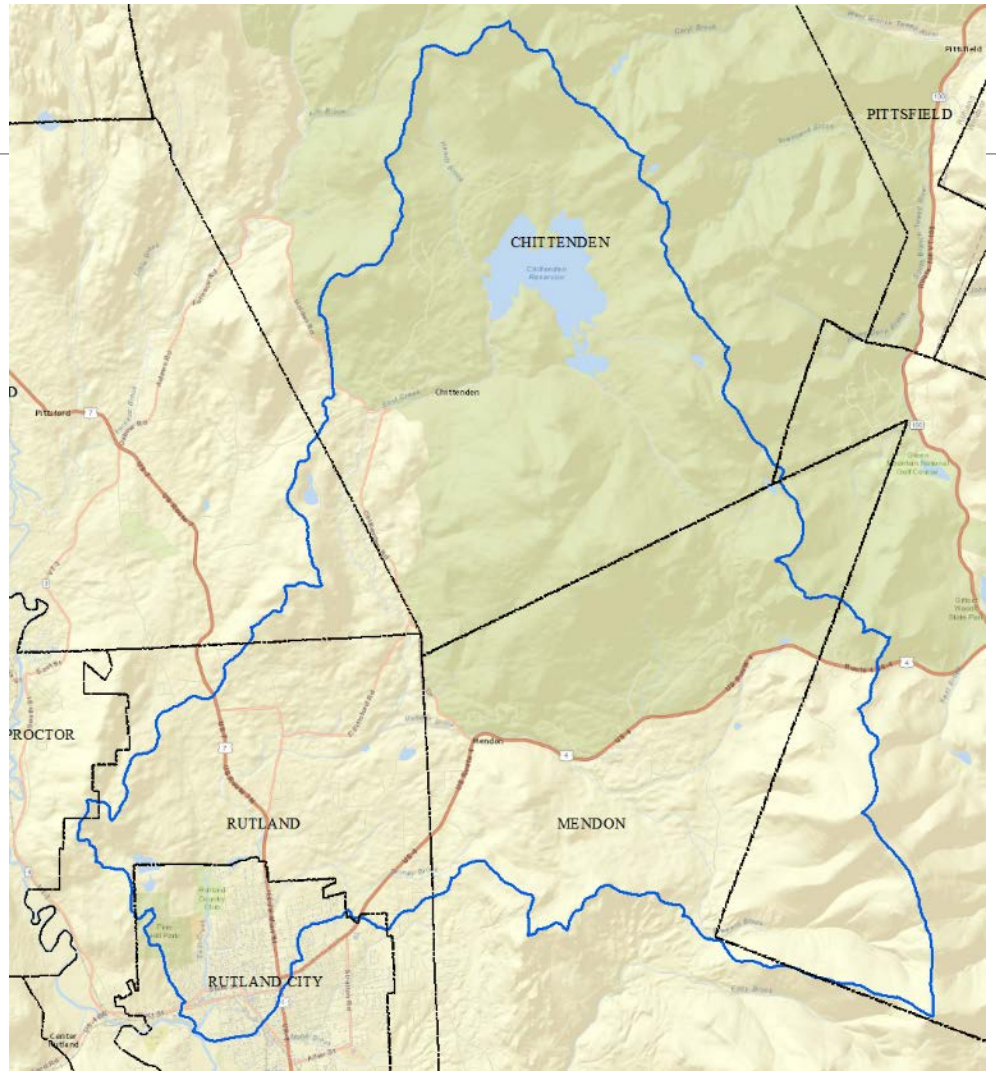
Urban Case Study

Rutland City, VT



East Creek – Tenney Brook SWMP

- Large Watershed within Lake Champlain Basin
  - TMDL for P
- Teetering on the brink of stormwater impairment
  - Sediment/Bacteria due to development
- Area is prone to CSOs



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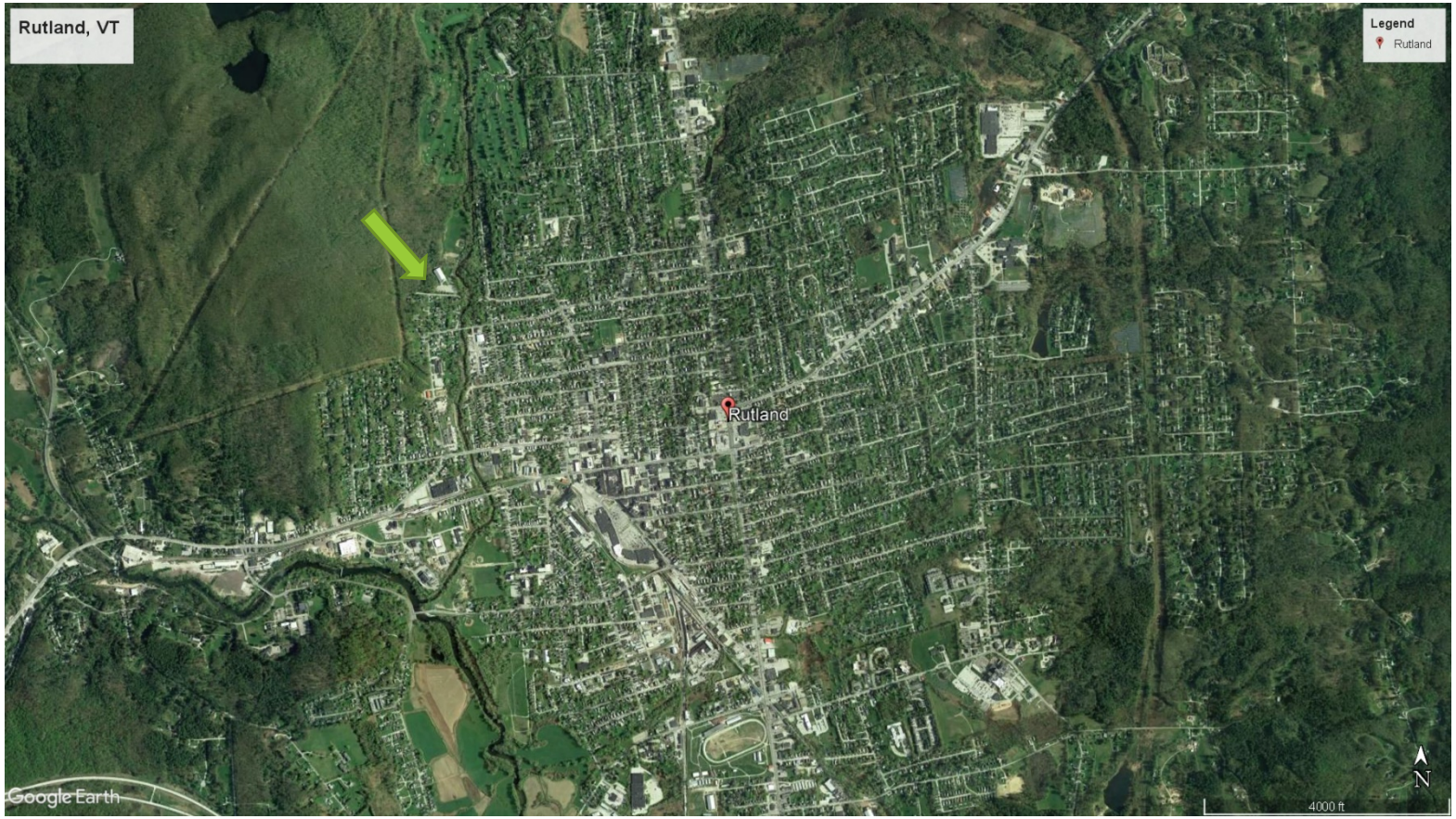


Overview

Giorgetti Arena

- Large block of impervious cover
- Directly hydrologically connected
- High-use
- High-visibility

Giorgetti Arena Bioretention

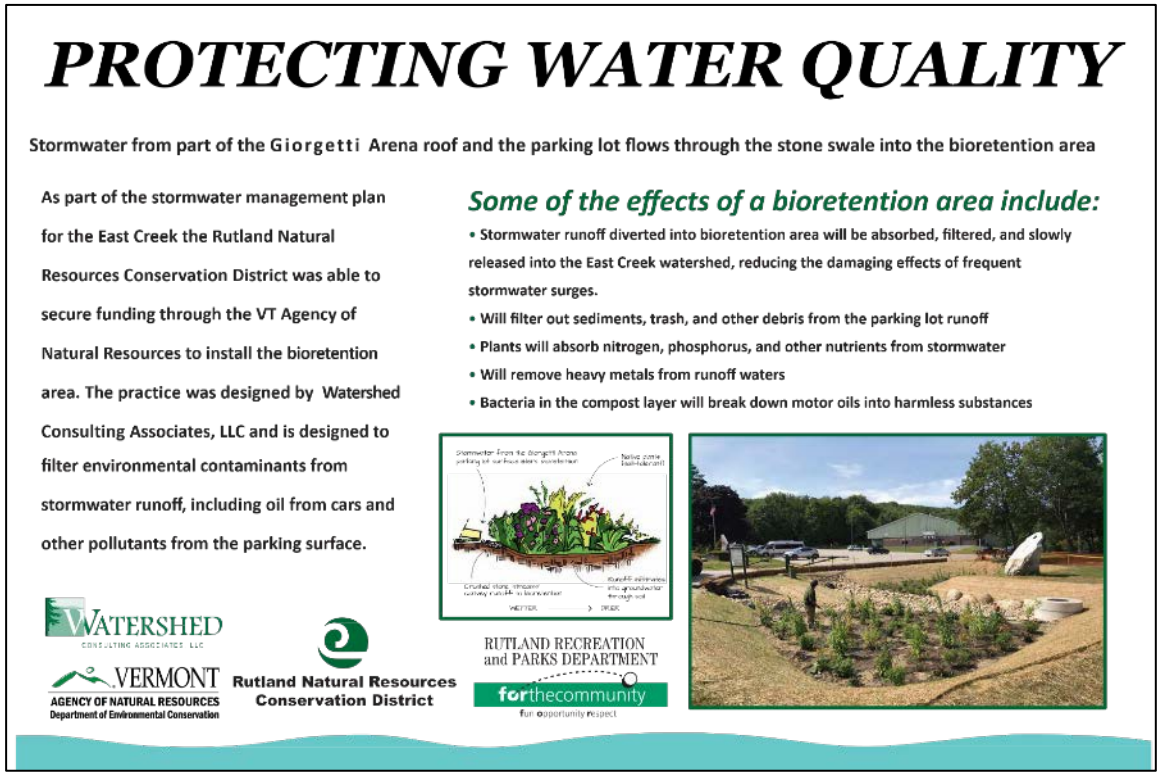
- 3,763 ft^2 bioretention practice
- 2 ft of ponding
- Fed by 4.43 acres of runoff from the parking lot, arena roof, and a portion of the adjacent street
- Infiltrates the 1-year Channel Protection volume(CPv) storm

- Annual pollutant load reductions:
  - Total Solids: ≈1,000 lbs
  - Total Phosphorus: 0.8 lbs

Giorgetti - Aesthetic Improvement

Giorgetti - Educational Outreach

- Installation of an educational sign by the Bioretention practice
- These projects are important because they engage the community in learning about, and supporting, stormwater management



Existing Conditions

Proposed Conditions

A WCA story map

Edit ×

Stormwater Master Plan for the Town of Berlin

No issues detected ×

Preliminary BMP Opportunities

Explore the photo tour to the right to visit each potential BMP location. Click each photo to be zoomed to the site's location on the map. You can pan and zoom around on the map to look at the site in more detail.

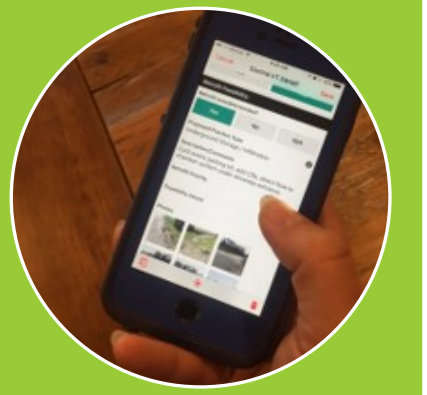
A preliminary ranking system was utilized to prioritize these 74 projects.

This prioritization was accomplished by completing an assessment of:

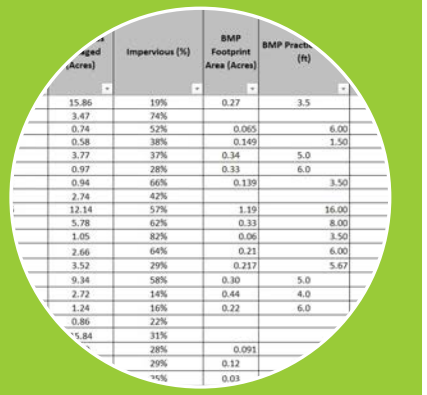
- benefit
- drainage area size
- pollutant load reduction potential
- proximity to water
- ownership
- feasibility issues.

The goal of this ranking was to identify the 20 sites that would provide the greatest water quality benefit and have a high likelihood of implementation.

Targeted desktop assessment



Data collection using custom mobile app



Ranking and prioritization

Watershed-wide plan for maximum stormwater management

Final SWMPs for 12 urban and rural communities

Questions?

Funding for the development of these Stormwater Master Plans was obtained by the Central Vermont Regional Planning Commission via the Vermont Department of Environmental Conservation Clean Water Fund grants.

CVRPC
CENTRAL VERMONT REGIONAL PLANNING COMMISSION

VERMONT
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