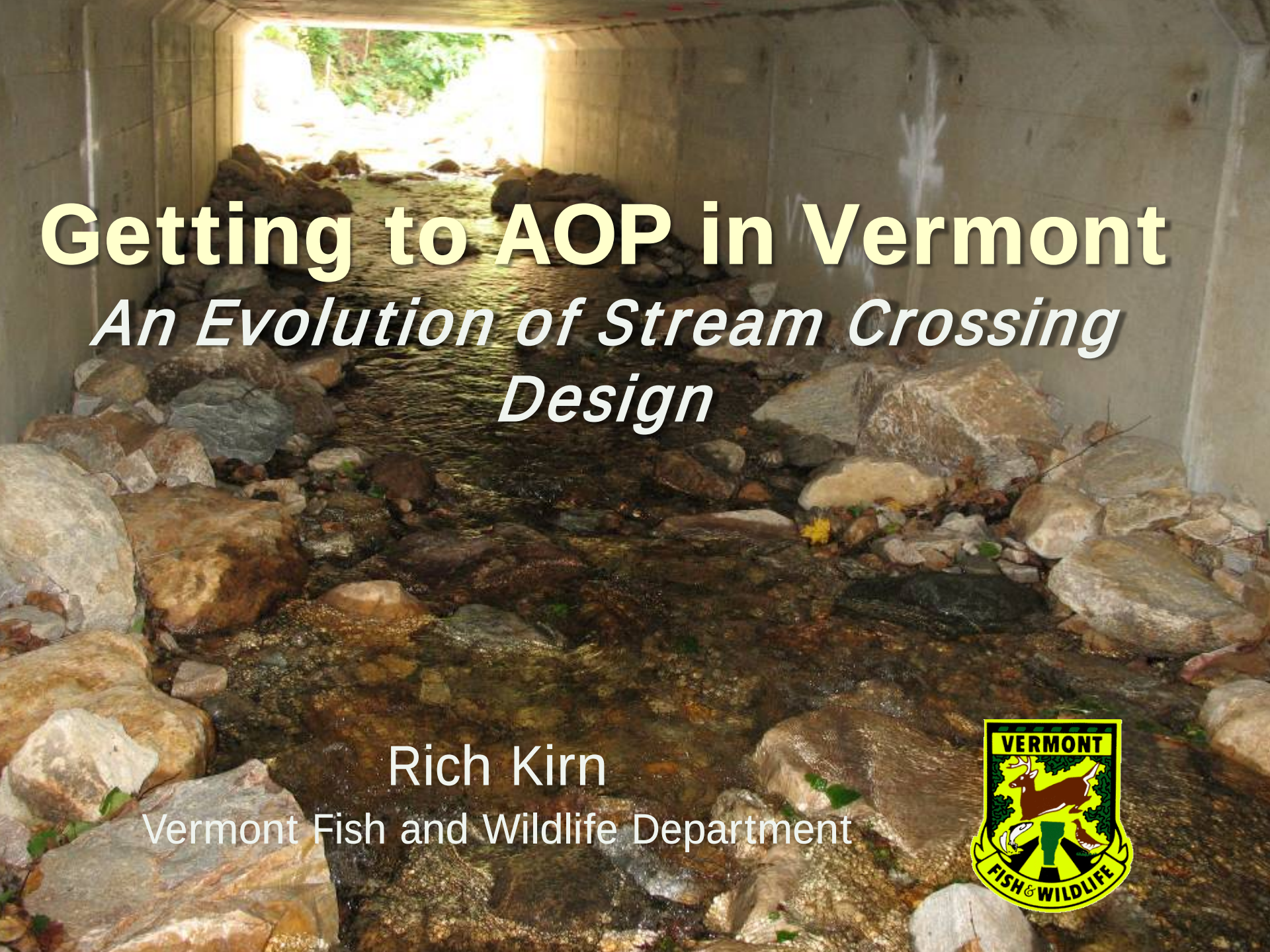
AOP Summit

March 19, 2014 Royalton, VT

- Getting to AOP in Vermont – Rich Kirn VDFW
- Assessments & Project Identification - Rich Kirn, VDFW
- Missisquoi Watershed AOP Analysis – Rose Paul, TNC
- AOP Project Management – Ann Smith, FWR
- AOP Design – Roy Schiff, MMI
- AOP Project Construction – Greg Russ, WRP;
  Brian Austin, USFS; Madeleine Lyttle, USFS
- AOP Project Costs – Jamie Masterson, USFWS
- AOP Funding



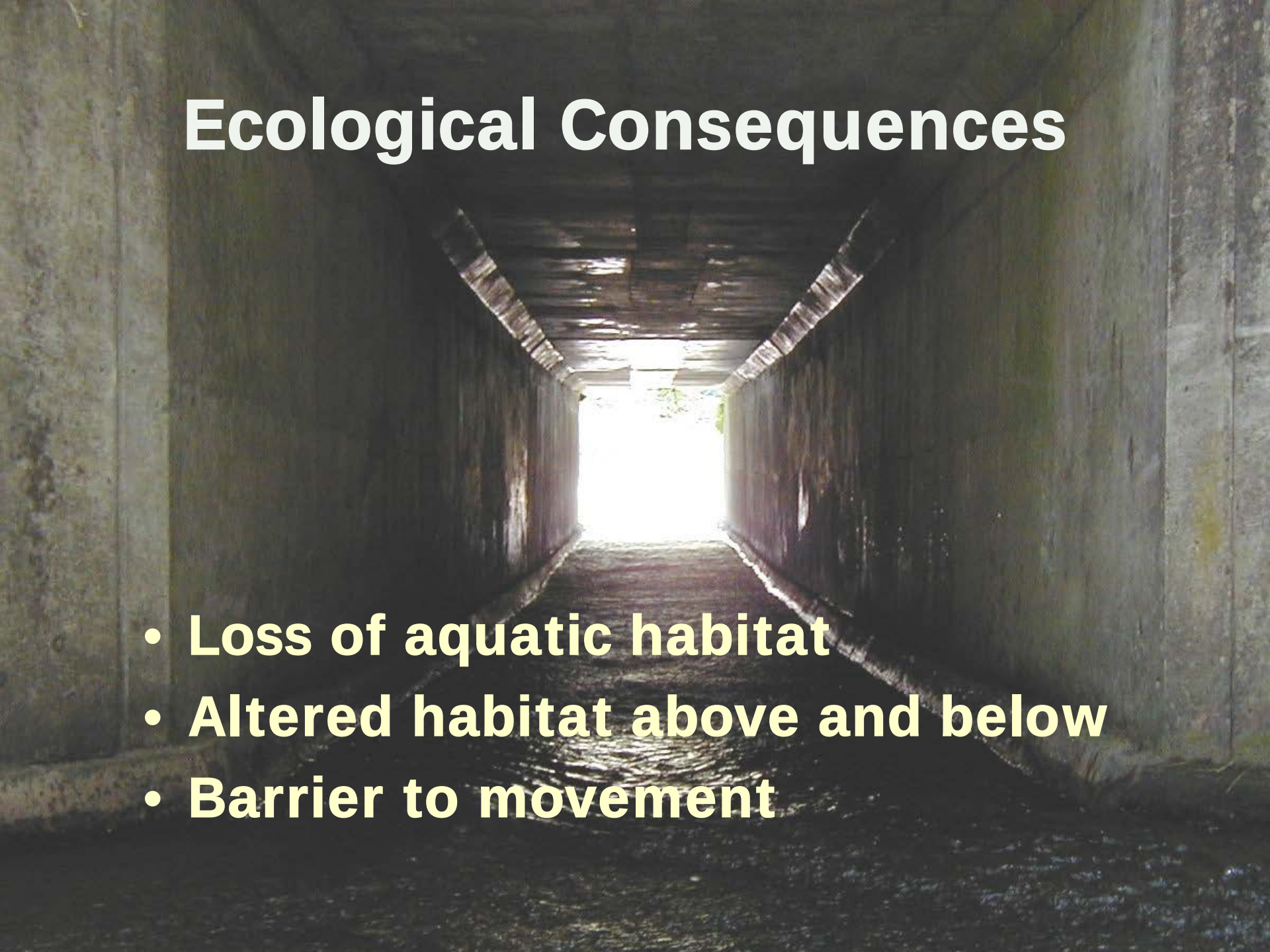
Getting to AOP in Vermont

An Evolution of Stream Crossing Design

Rich Kirn

Vermont Fish and Wildlife Department

Ecological Consequences



- Loss of aquatic habitat
- Altered habitat above and below
- Barrier to movement

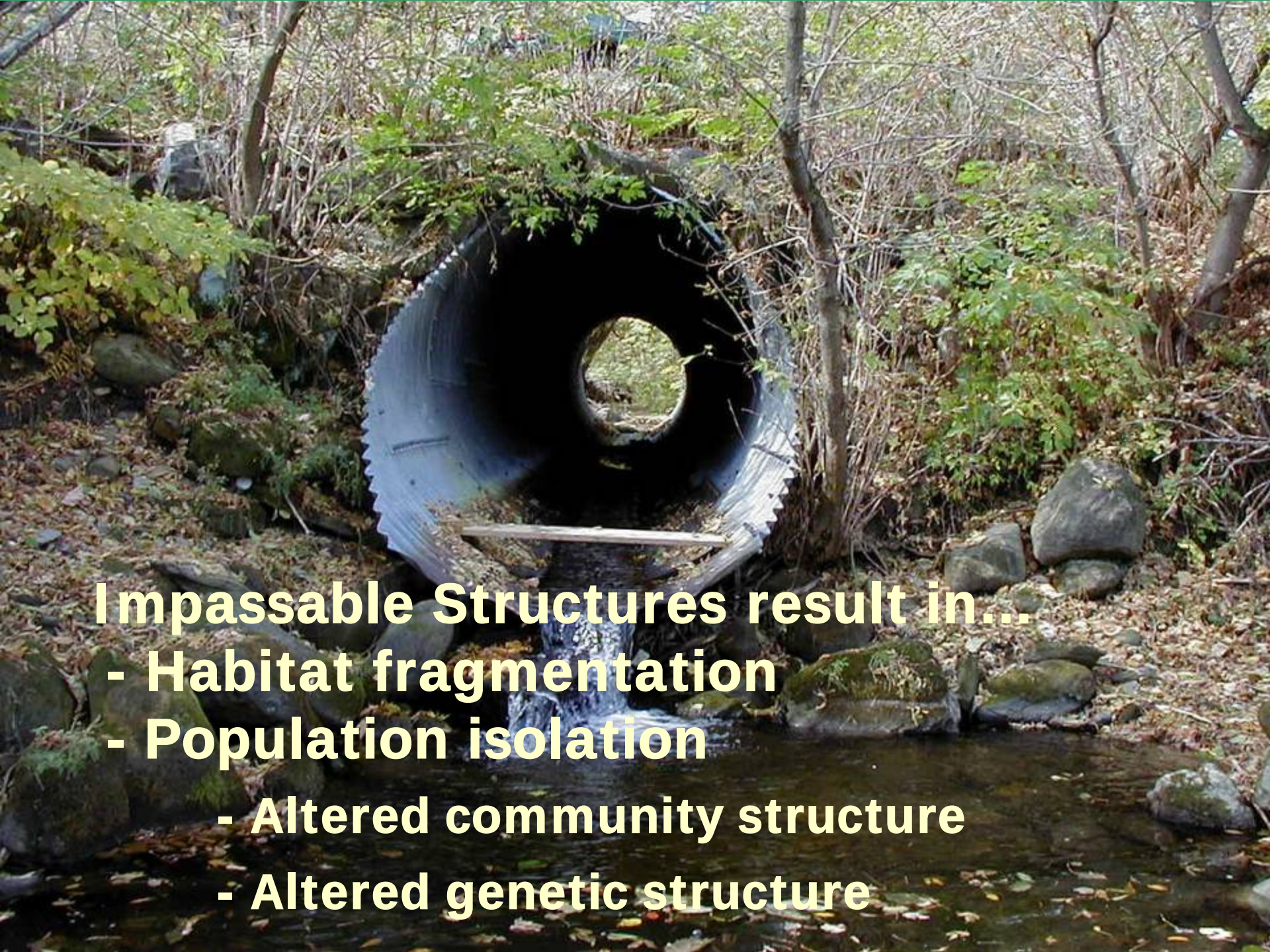
Aquatic Organism Movement

- **Daily**
  - feeding
  - resting

- **Seasonal**
  - reproduction
  - changing habitat conditions or lifestage

Aquatic Organism Movement

Recolonize Habitat



Impassable Structures result in...

- **Habitat fragmentation**
- **Population isolation**
  - **Altered community structure**
  - **Altered genetic structure**

Barriers impact more than just trout:

VT Fishes with Greatest Potential of being Impacted by Culverts

- Brook trout*
- Rainbow trout
- Brown trout
- Atlantic salmon: land-locked & sea-run*
- Rainbow smelt
- American eel*
- White sucker
- Longnose sucker
- Northern brook lamprey*
- Silver lamprey*
- American brook lamprey*
- Sea lamprey (CT River)*
- Minnows, shiners, etc.: 15 species*

* Species of Greatest Conservation Need

T&E Species

Periods of Movement for Selected Vermont Fishes

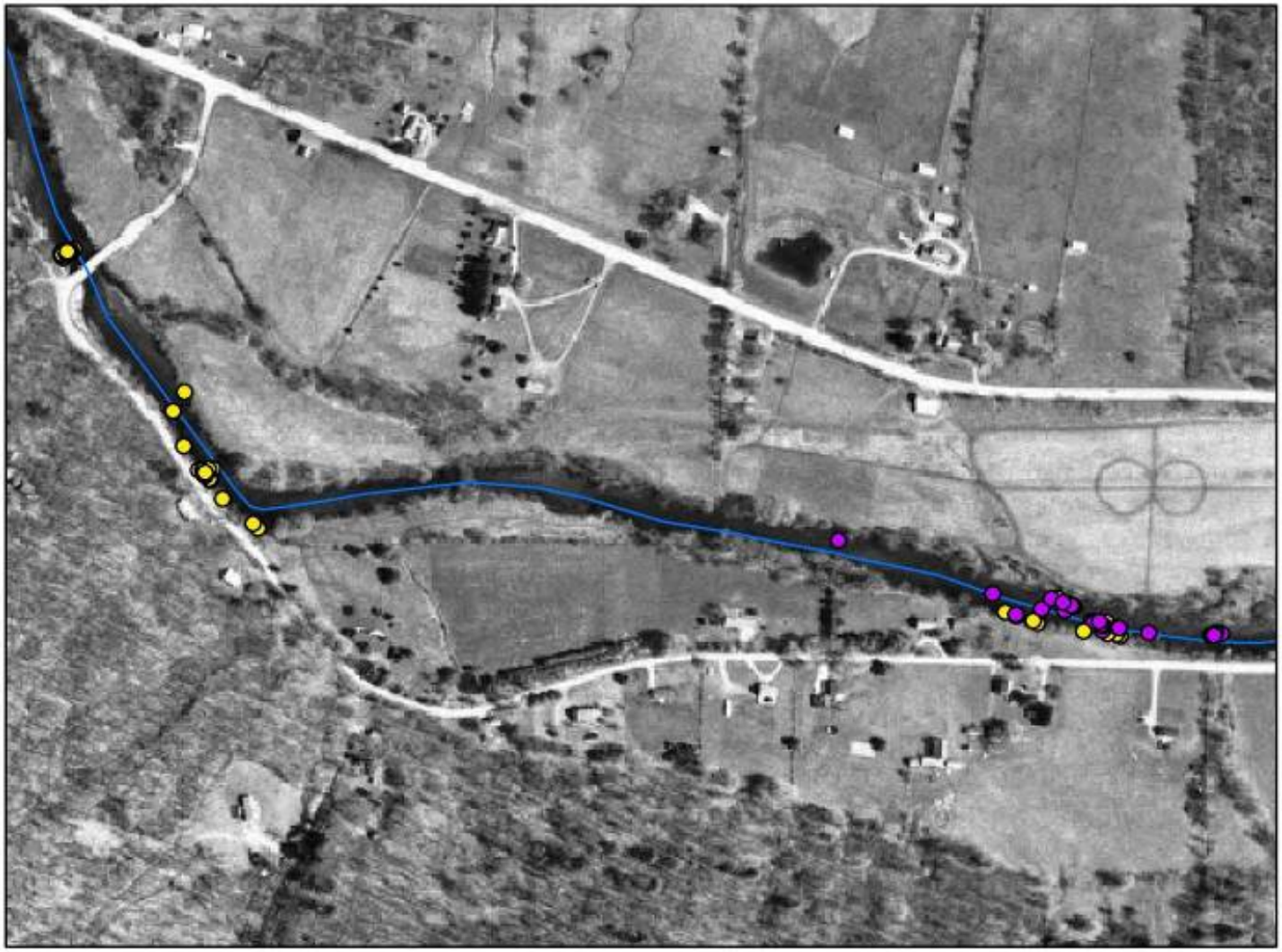
Species	Life Stage	Movement	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Brook trout	All	UD									
Rainbow trout	All	UD									
Brown trout	All	UD									
Atlantic salmon	Adult	UD									
	Juvenile	UD									
	Smolt	D									
Rainbow smelt	Adult	UD									
American eel	Adult “Silver” eel	D									
	Juv. “Yellow” eel	U									
White sucker	Adult	UD									
Other resident fishes	All	UD									

Movement Direction: U, upstream; D, downstream; UD, both.

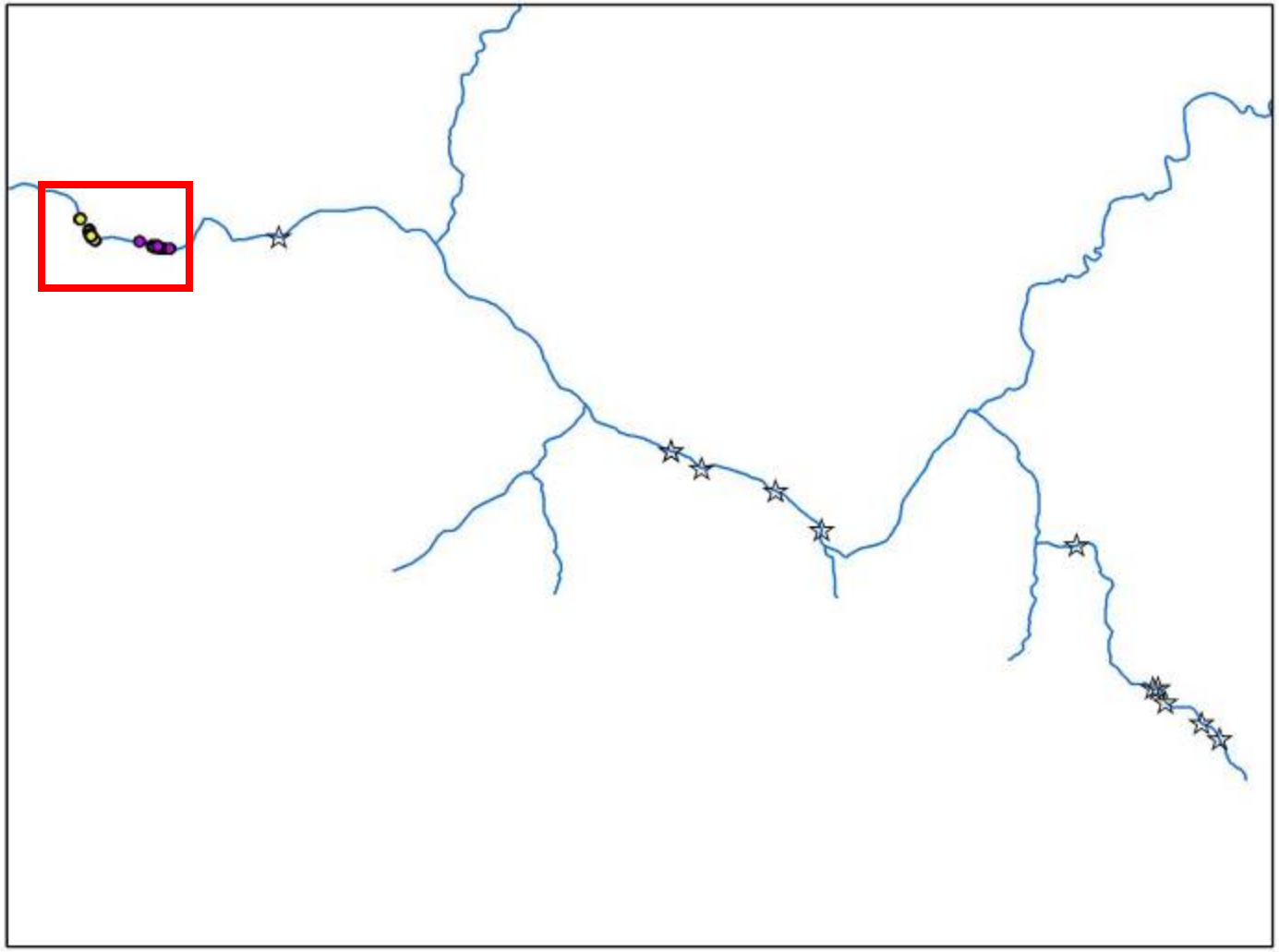
Spawning General

Batten Kill Brown Trout Radiotracking Study

Study 2 - Fish 12 - Summer and Winter range locations in Batten Kill Main Stem.



Study 2 - Fish 12 - Locations in Batten Kill Main Stem and Roaring Branch

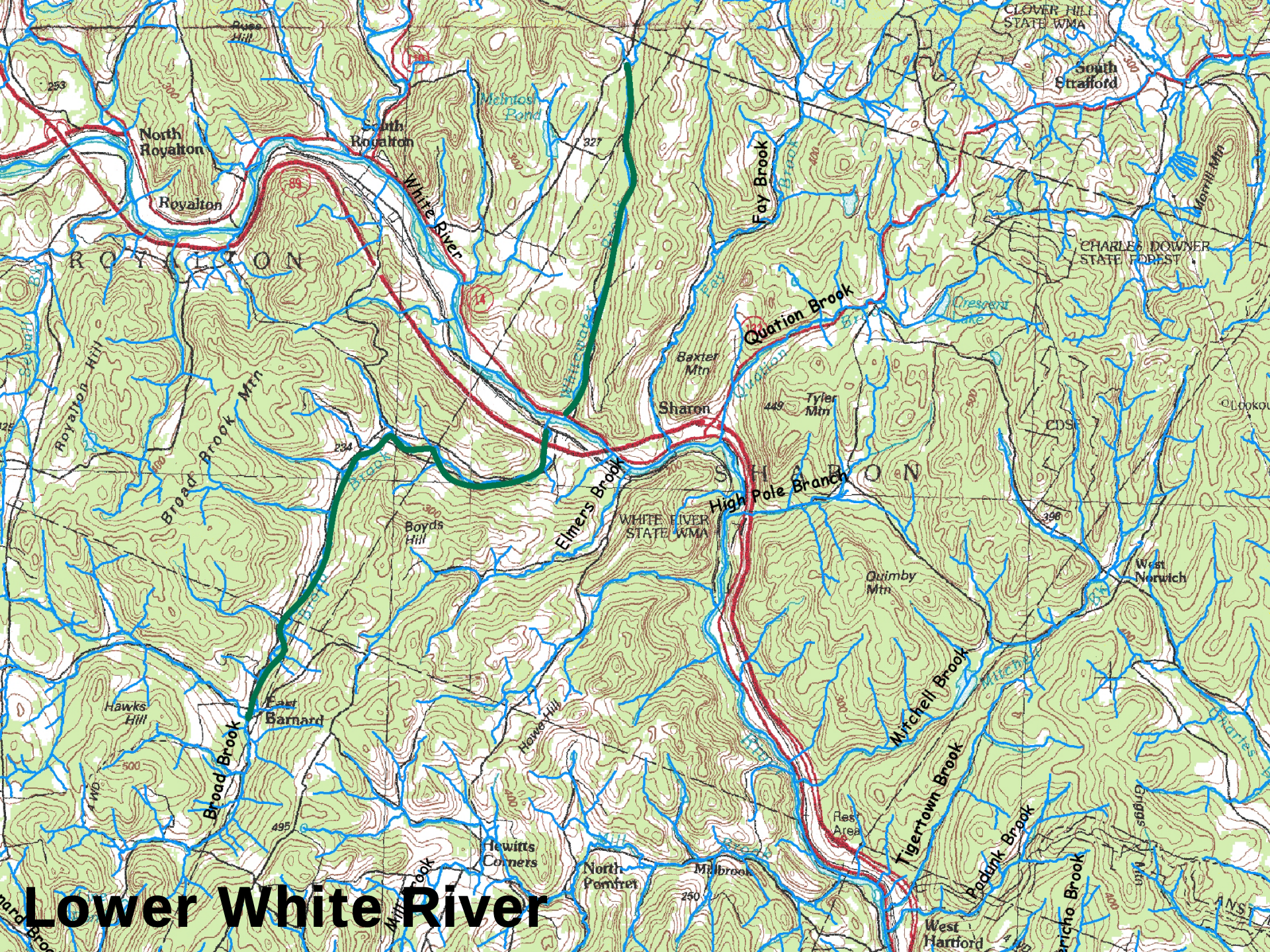


Fish 12

- Summer range
- Spawning movement
- Winter range

0 6,250 12,500 25,000 Feet

N


Lower White River
ROYALTON
SHARON
North Royalton
South Royalton
Royalton
White River
Fay Brook
Quaton Brook
Baxter Mtn
Sharon
Tyler Mtn
Elmers Brook
High Pole Branch
WHITE RIVER STATE WMA
Broad Brook Mtn
Royalton Hill
Boyds Hill
Quimby Mtn
West Norwich
Mitchell Brook
Tigertown Brook
Podunk Brook
East Barnard
Broad Brook
Hawks Hill
Howard Hill
Hewitts Corners
North Pomfret
Millbrook
West Hartford
Rest Area
CLOVER HILL STATE WMA
South Strafford
CHARLES DOWNER STATE FOREST
Melmoth Pond
Cresent Lake

State & Federal Regulatory Obligations

- US Army Corps of Engineers GP
- Clean Water Act: Nationwide Roads Exemption BMP 40CFR 232.3 c(6)
- VSA Title 10, Chapter 041 §1023 Regulation of Streamflow
- VSA Title 10, Chapter 111 § 4607. Obstructing streams

Bridge =

Passage

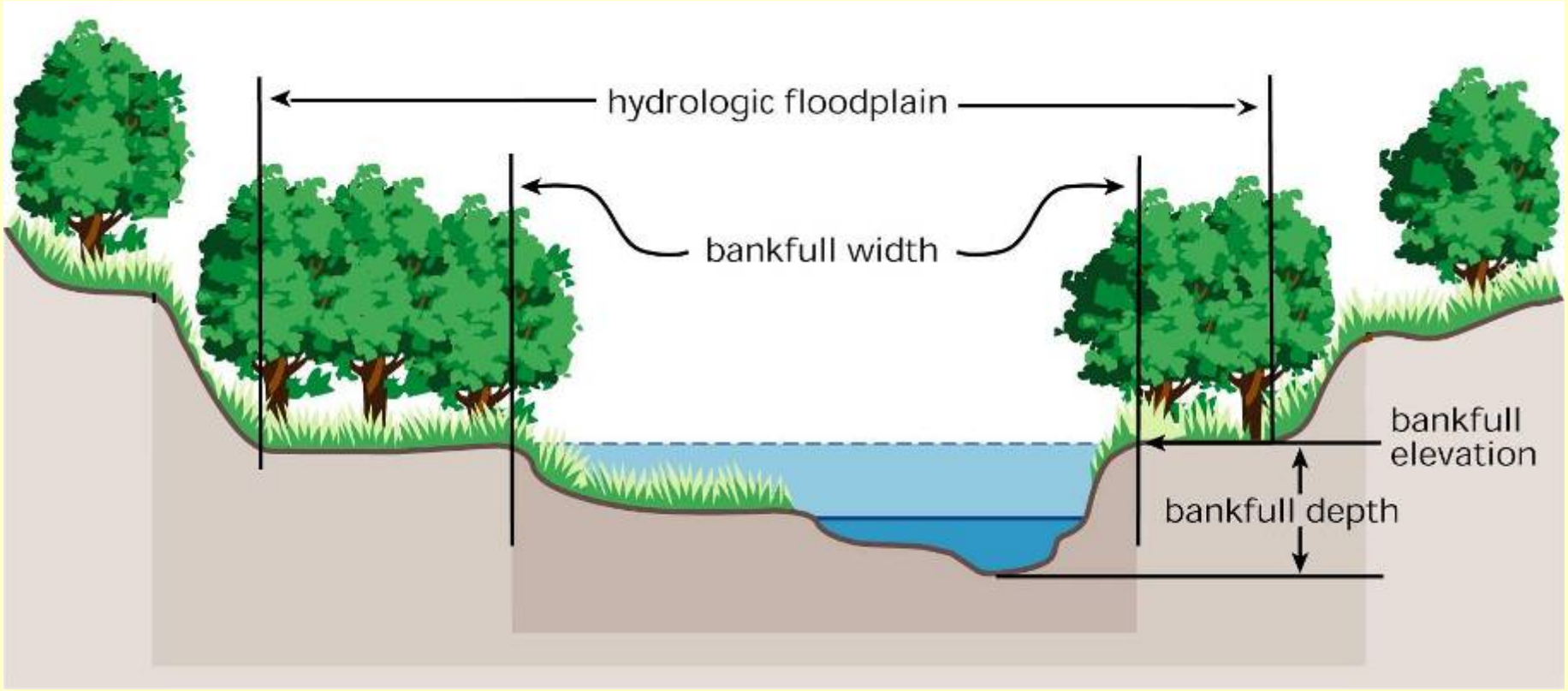
Culvert =

Barrier

Culvert Treatments
• Baffles / sills
• “Oversize”
• Buried

Past structure design considered hydraulic capacity but did not always consider other stream functions – most importantly the transport of *sediment* and *debris!*

Bankfull Width



approximately equivalent to 1.5 – 2 year event

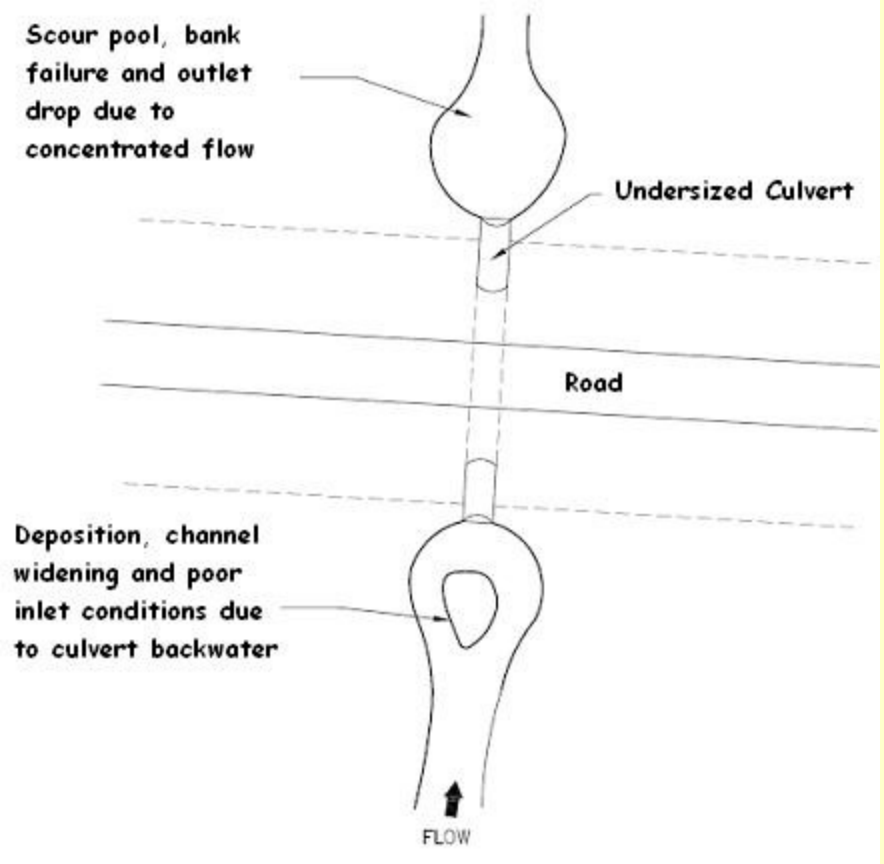
Undersized Structures

Interruption of stream sediment/debris transport – *aggradation above*

Undersized Structures

Interruption of stream sediment/debris transport – *degradation below*

Hourglass Syndrome



Hourglass Syndrome

Chase Brook Oct 1, 2010

Hourglass Syndrome

Chase Brook Oct 1, 2010

Undersized Structures

Habitat impacts above and below structure

Undersized Crossings

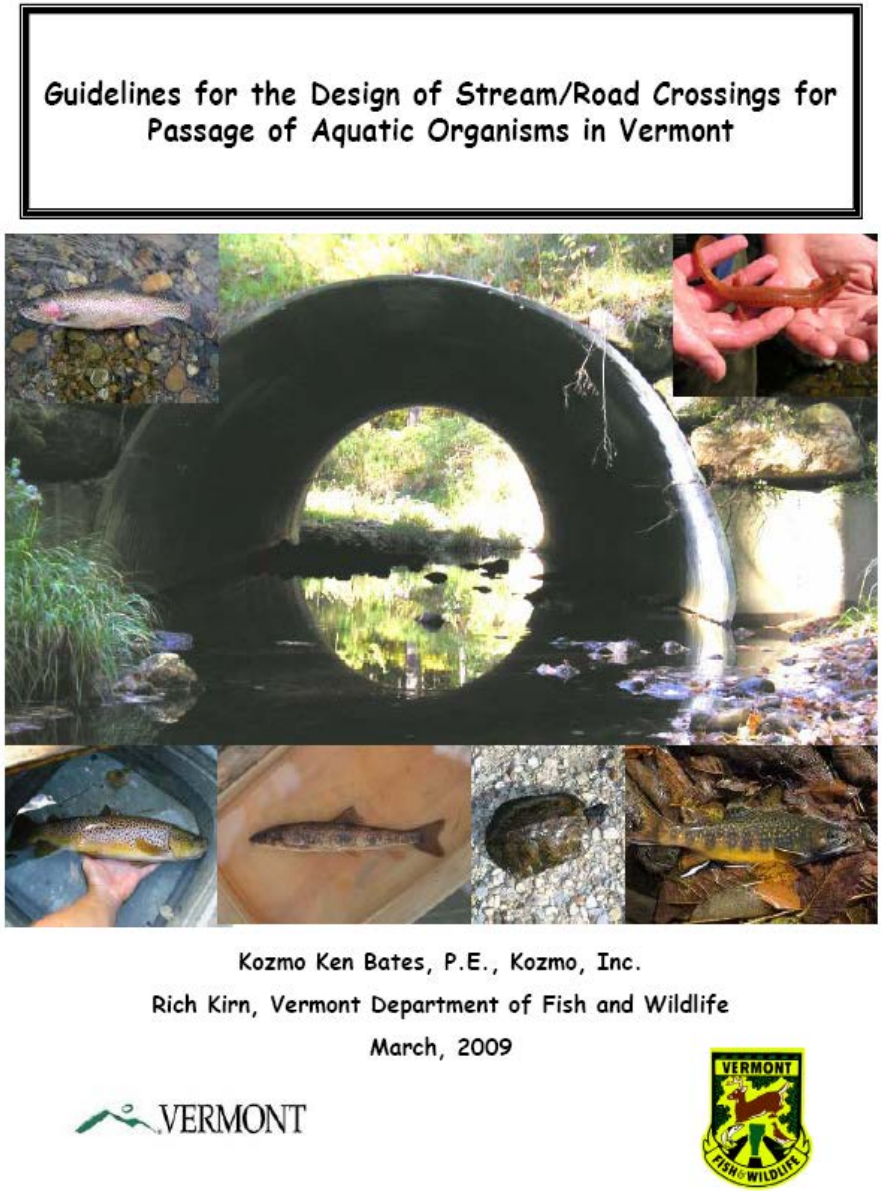
Increased maintenance

Undersized Crossings

Risk of Catastrophic Failure

Undersized Crossings

Risk of Catastrophic Failure



AOP Guidelines

- Technical engineering document
- Developed with VTrans & VDEC
- VT specific biology & hydrology
- Design workshops

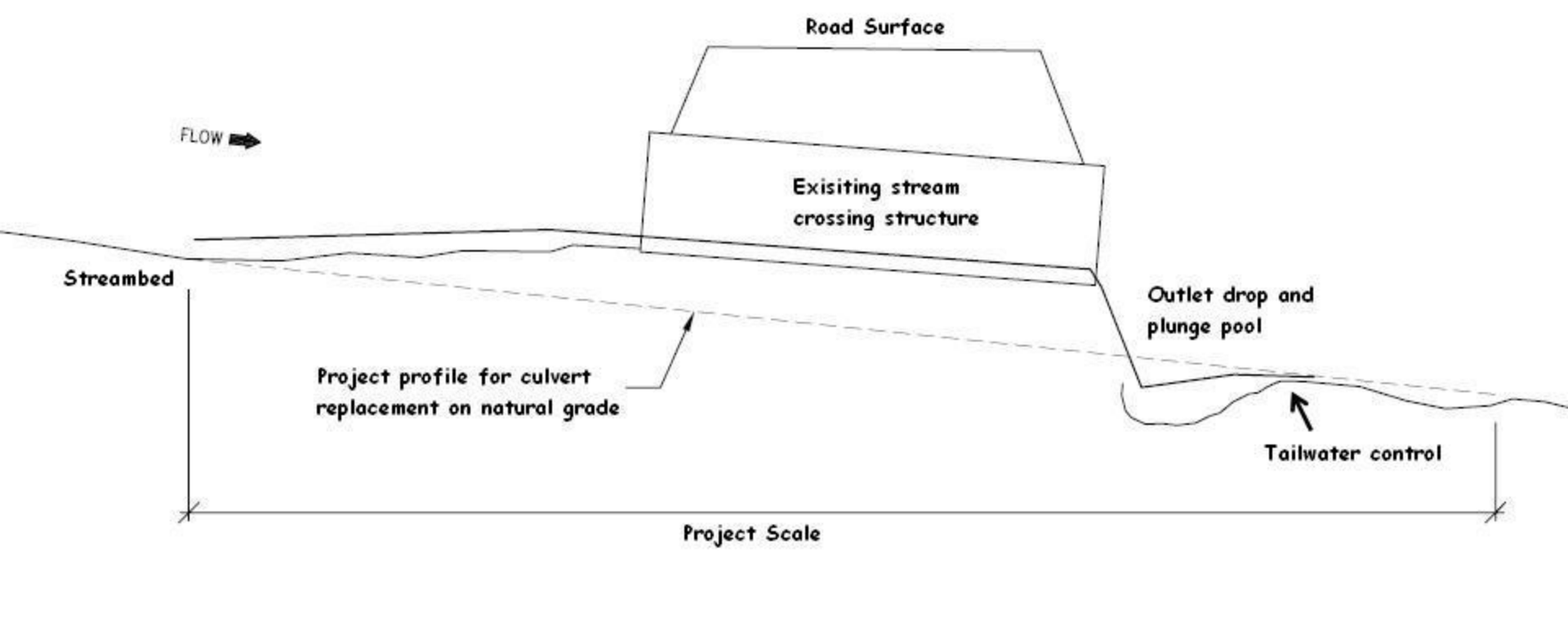
VT Stream Alteration General Permit Requirements

- **AOP**
- **Structure Width** *(1.0 BFW with exceptions for 1.2 or <1.0)*
- **Structure Embedment**
- **Structure Height**
- **Structure Profile**
- **Streambed Material Sizing**

AOP Design – Key Principles

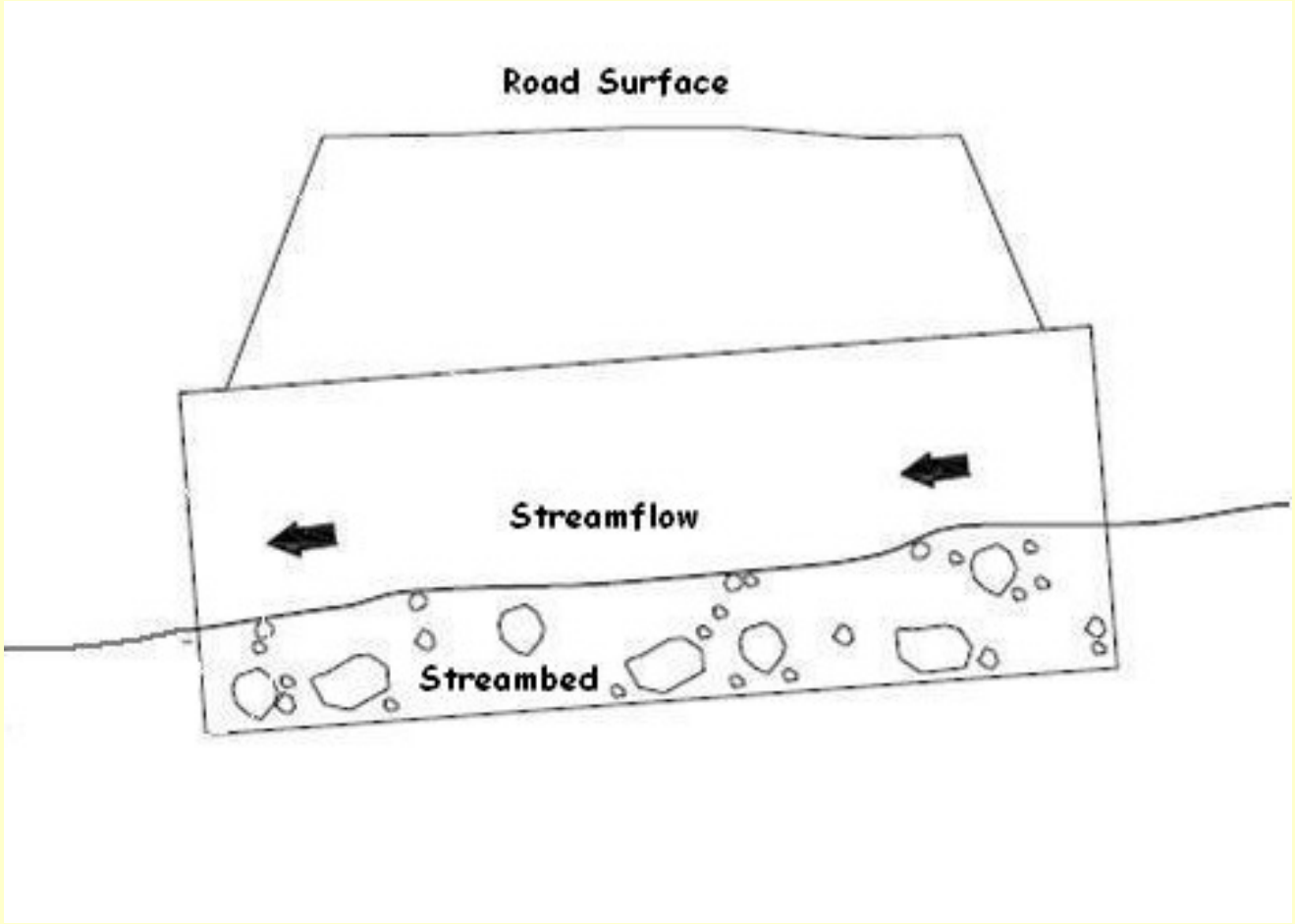
AOP Design – Key Principles

Long Project Profile



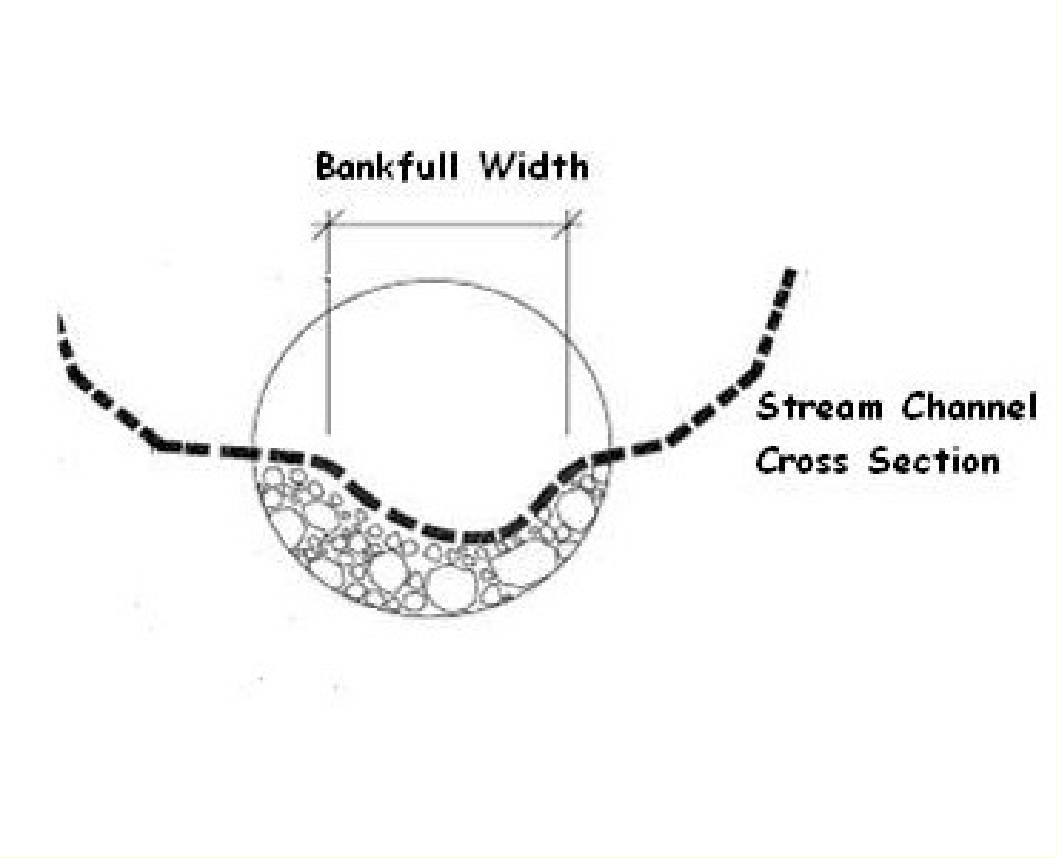
AOP Design – Key Principles

Embedment / Stone sizing



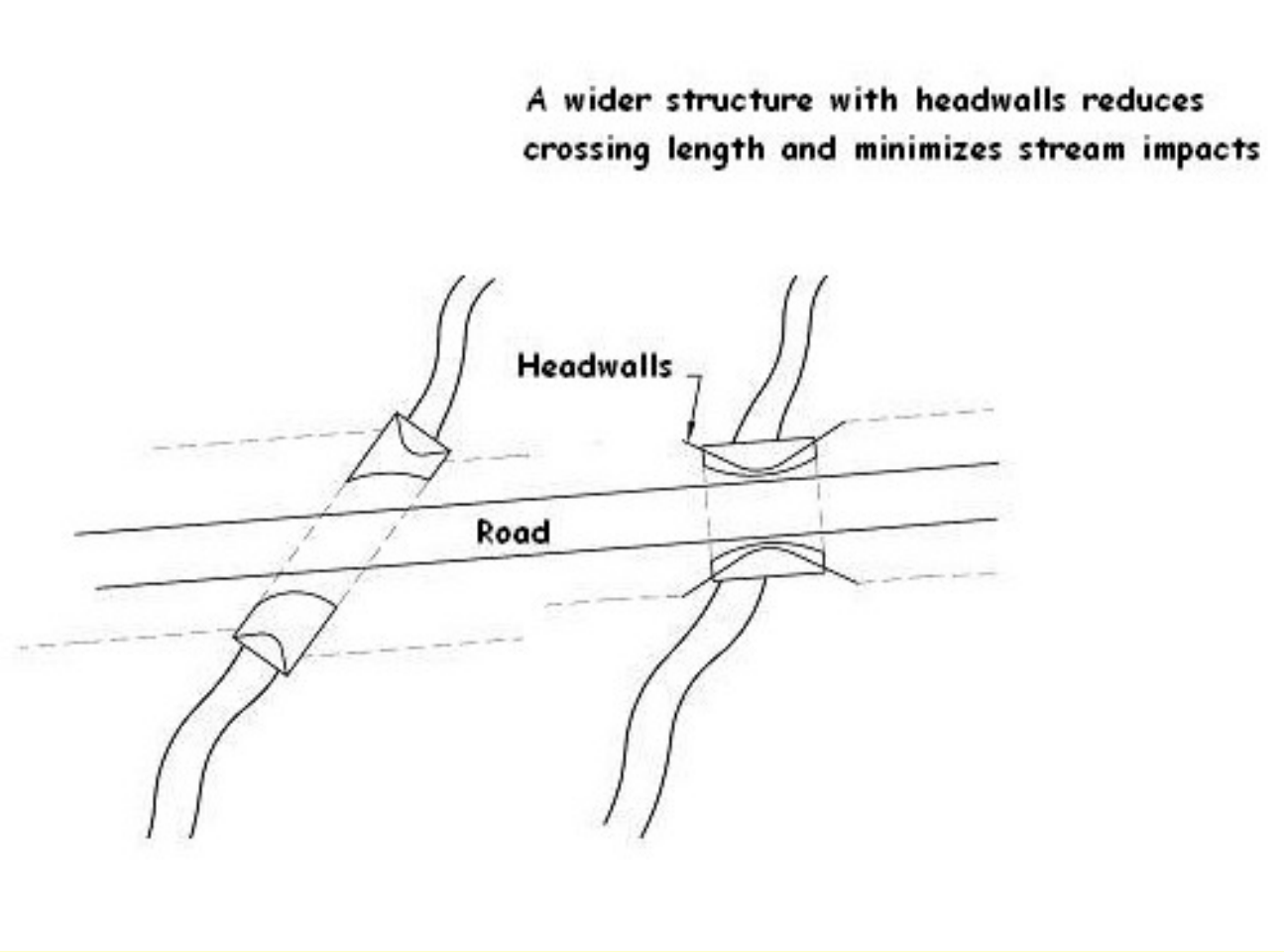
AOP Design – Key Principles

Bankfull Width



AOP Design – Key Principles

Stream Channel Alignment



Whitingham VT 100 BR30

Whitingham VT 100 BR30

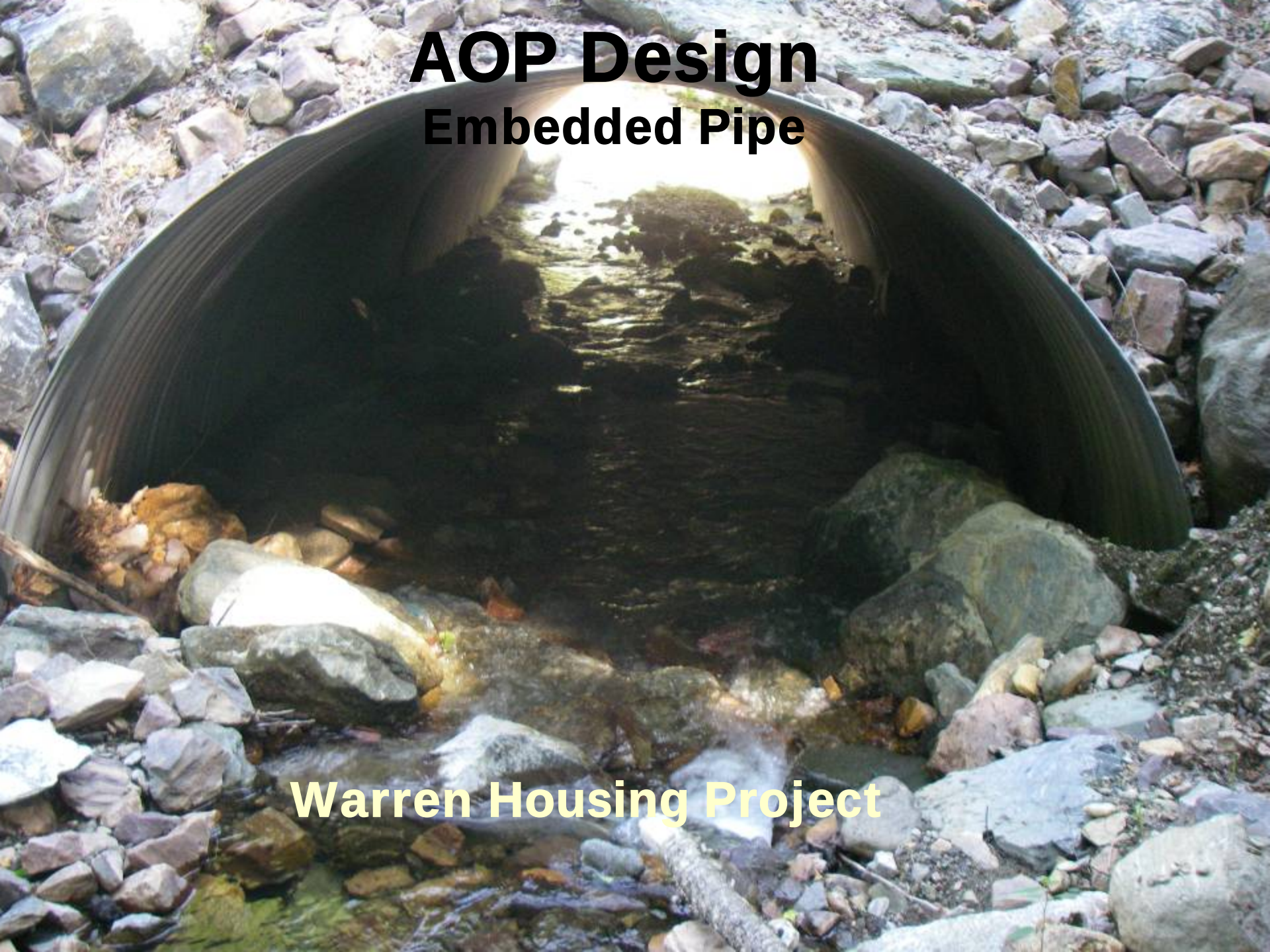
- Constrained by underground utilities
- Adjacent landowners
- Small substrate
- No Downstream grade control

AOP Design

Open Bottom Structure

AOP Design

Embedded Pipe



Warren Housing Project

AOP Design

Box with constructed bed

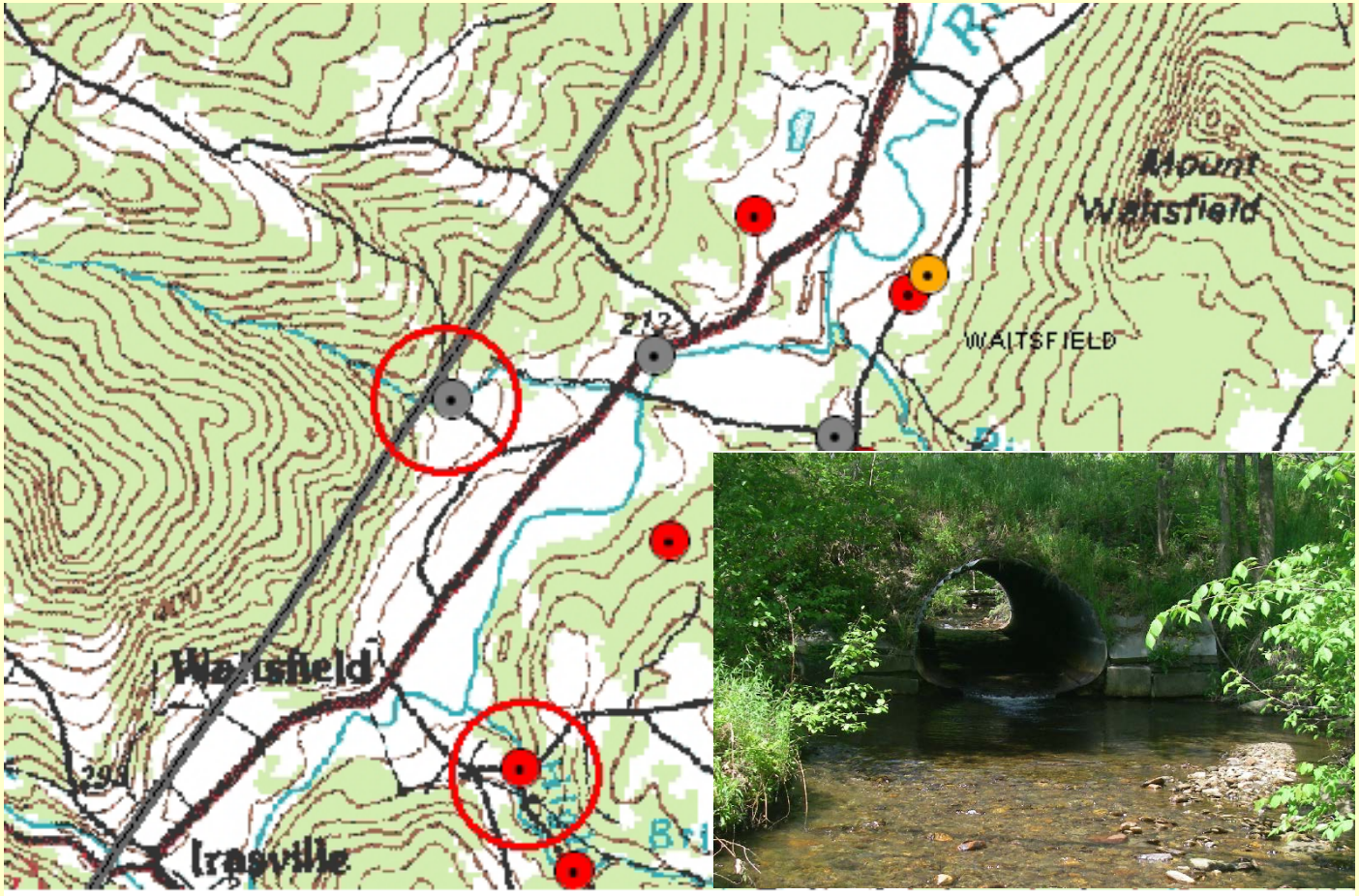
Bed retention sills and constructed streambed

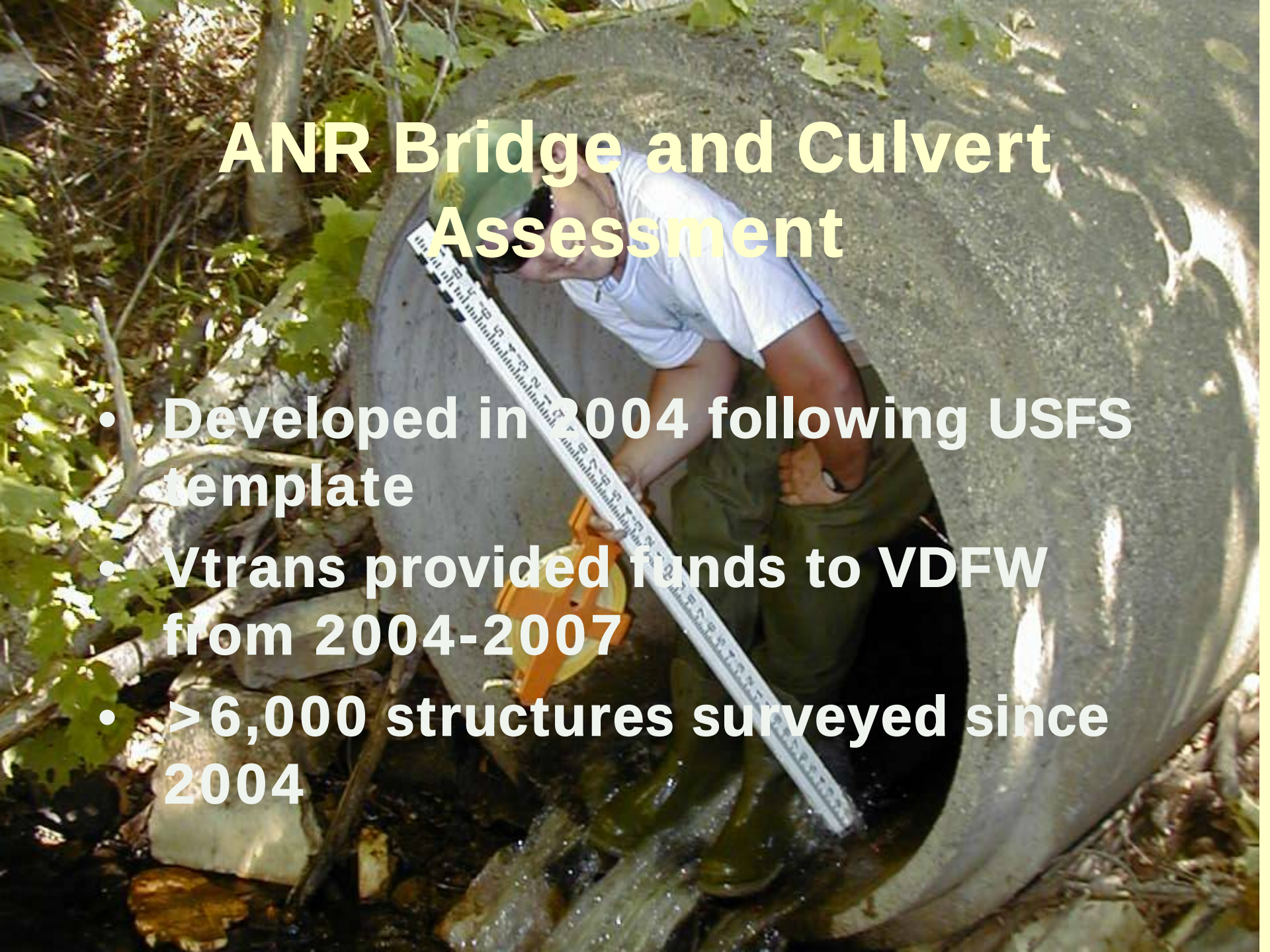
Downstream grade control structure

Chase Brook, Berlin

New Life
for
Undersized
Culverts

Culvert Assessments & Project Identification





ANR Bridge and Culvert Assessment

- Developed in 2004 following USFS template
- Vtrans provided funds to VDFW from 2004-2007
- >6,000 structures surveyed since 2004

2014:

Otter Creek

Southeast VT?

ANR Culvert Assessments

Aquatic Organism Passage Coarse Screen Criteria

- Outlet configuration
  - free-fall, cascade, at grade
- Height of outlet drop
- Outlet Pool
- Water depth
- Stream substrate within structure
- Inlet obstruction

Full Passage (Green)

Reduced (Grey)

Impassable (Red)

AOP Screen

VT Aquatic Organism Passage Coarse Screen	Full AOP	Reduced AOP	No AOP	
Updated 2/25/2008	**for all aquatic organisms**	**for all aquatic organisms**	**for all aquatic organisms except adult salmonids**	**for all aquatic organisms including adult salmonids**
AOP Function Variables / Values	**Green (if all are true)**	**Gray (if any are true)**	**Orange**	**Red**
Culvert outlet invert type	at grade **OR** backwatered	cascade	free fall **AND**	free fall **AND**
Outlet drop (ft)	= 0		> 0 , < 1 ft **OR**	≥ 1 ft **OR**
Downstream pool present			= yes (= yes **AND**	= no **OR** (= yes **AND**
Downstream pool entrance depth / outlet drop			n/m ≥ 1)	n/a < 1) **OR**
Water depth in culvert at outlet (ft)				< 0.3 ft
Number of culverts at crossing	1	> 1		
Structure opening partially obstructed	= none	≠ none		
Sediment throughout structure	yes	no		

Notes:

Assessment completed during low flows.

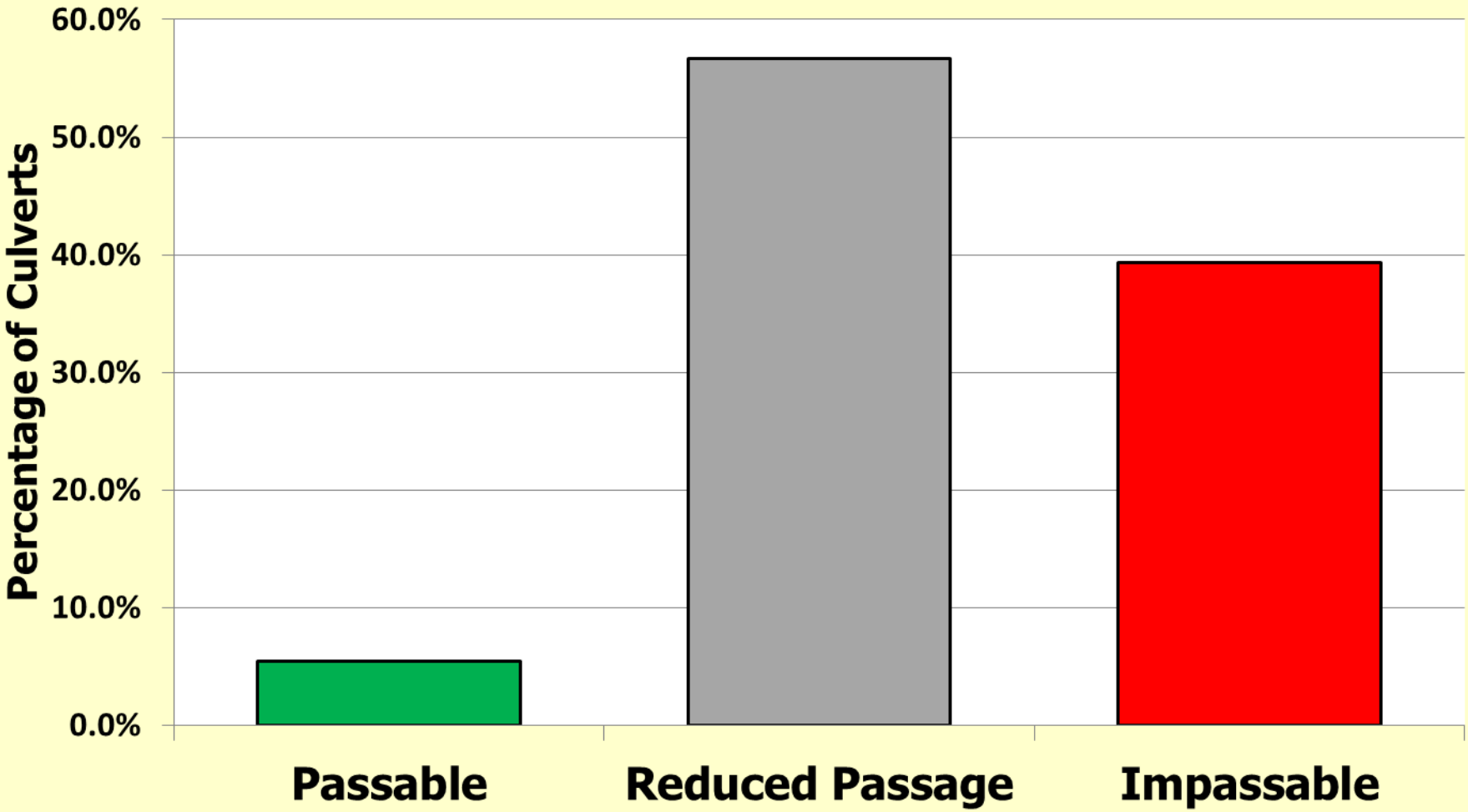
Outlet drop = invert of structure to water surface.

Pool present variable is used alone if pool depths are not measured.

n/m = not measured.

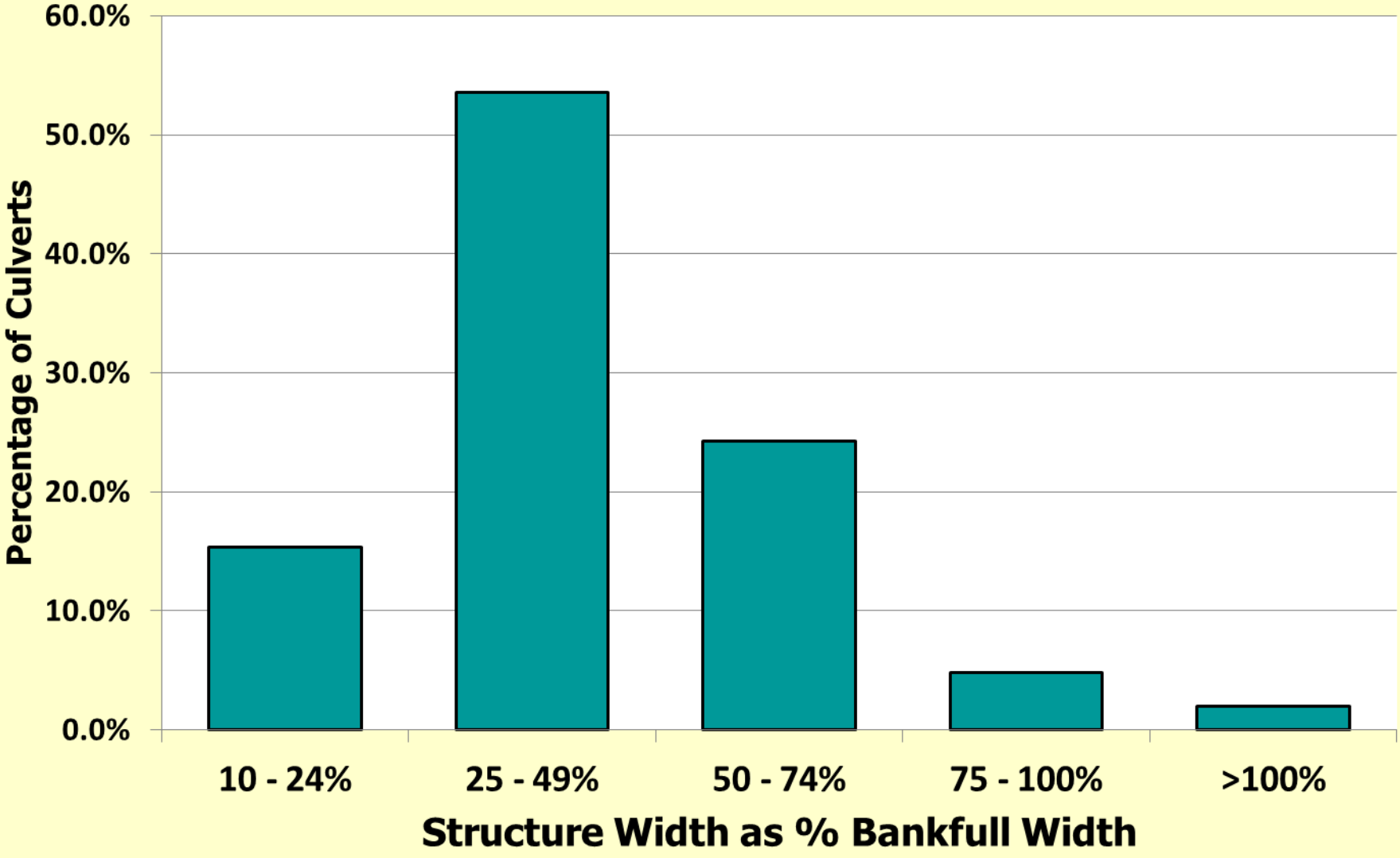
n/a = not applicable.

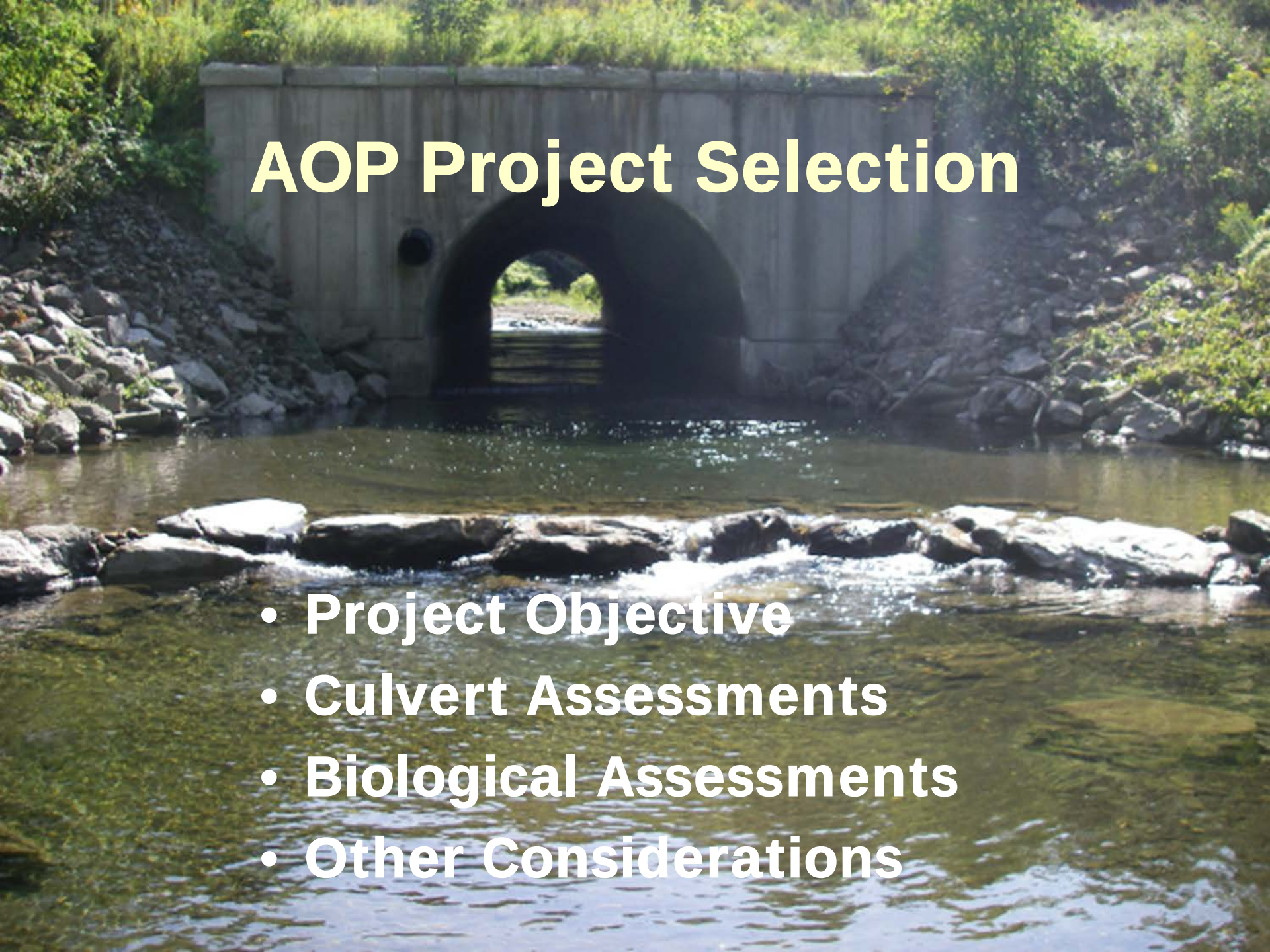
ANR Culvert Assessments
AOP Ratings



ANR Culvert Assessments

BFW ≥ 10 feet (N = 3331)





AOP Project Selection

- Project Objective
- Culvert Assessments
- Biological Assessments
- Other Considerations

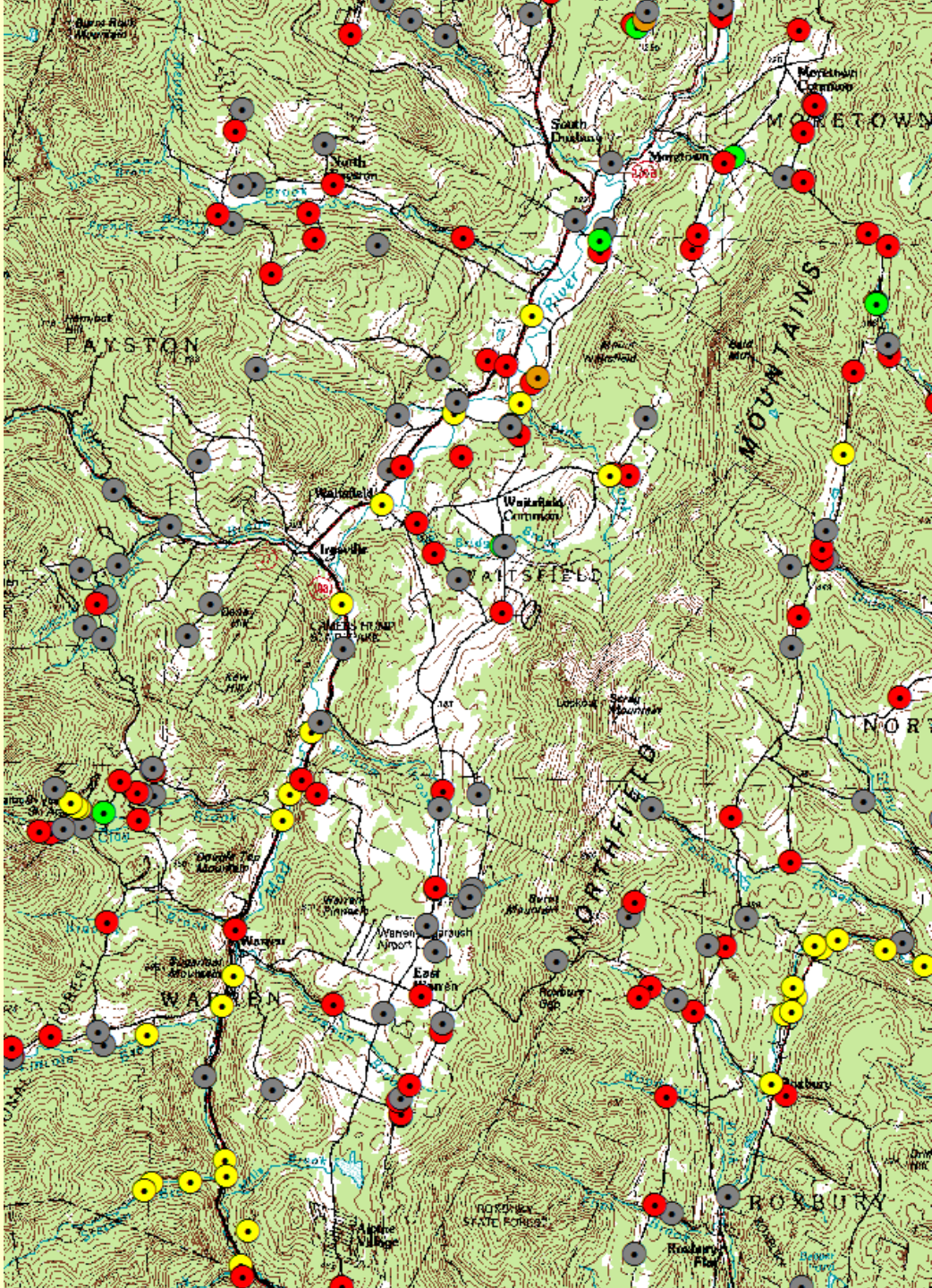
Project Objective

- Target Watershed
  - Funding, Partners?
- AOP or Target Species
- Retrofit or Replacement
- Flood Resiliency

AOP Project Selection

ANR Culvert Assessments

- AOP Rating
  - Red (Impassable)
  - Gray (Reduced Passage)



Retrofit Potential Screen

A) RPS Ranges and Variable Thresholds for Screen

	Strong Swimmers/Leapers	*Moderate Swimmers/Leapers*	*Weak Swimmers/Leapers*
Low	%BFW < 30 **OR**	%BFW < 50 **OR**	%BFW < 75 **OR**
	[(L_{NBW} ≥ 200) **OR** (L ≥ 200 **AND** D < 1)] **OR**	[(L_{NBW} ≥ 100) **OR** (L ≥ 100 **AND** D < 1)] **OR**	[(L_{NBW} ≥ 100) **OR** (L ≥ 100 **AND** D < 1)] **OR**
	Od ≥ 2.5 **OR**	Od ≥ 1.5 **OR**	Od ≥ 1.0 **OR**
	0 ≤ RPS < 5	0 ≤ RPS < 5	0 ≤ RPS < 5
Medium	5 ≤ RPS < 9	5 ≤ RPS < 10	5 ≤ RPS < 12
High	%BFW ≥ 75 **AND**	%BFW ≥ 75 **AND**	%BFW ≥ 100 **AND**
	[(L_{NBW} < 100) OR (L < 100)] **AND**	[(L_{NBW} < 100) OR (L < 100)] **AND**	[(L_{NBW} < 100) OR (L < 100)] **AND**
	Od < 1.5 **AND**	Od < 1.0 **AND**	Od < 0.5 **AND**
	RPS ≥ 9	RPS ≥ 10	RPS ≥ 12

B) Aquatic Organism Groups Based on Swimming/Leaping Ability

Strong Swimmers/Leapers	*Moderate Swimmers/Leapers*	*Weak Swimmers/Leapers*
adult trout	juvenile trout	rainbow smelt
adult salmon	suckers	sculpin
American eel	shad	minnows
	lamprey	bass and sunfish
		pike, pickerel
		darters, perch, walleye
		stickleback
		aquatic salamanders

C) RPS Variable Scoring

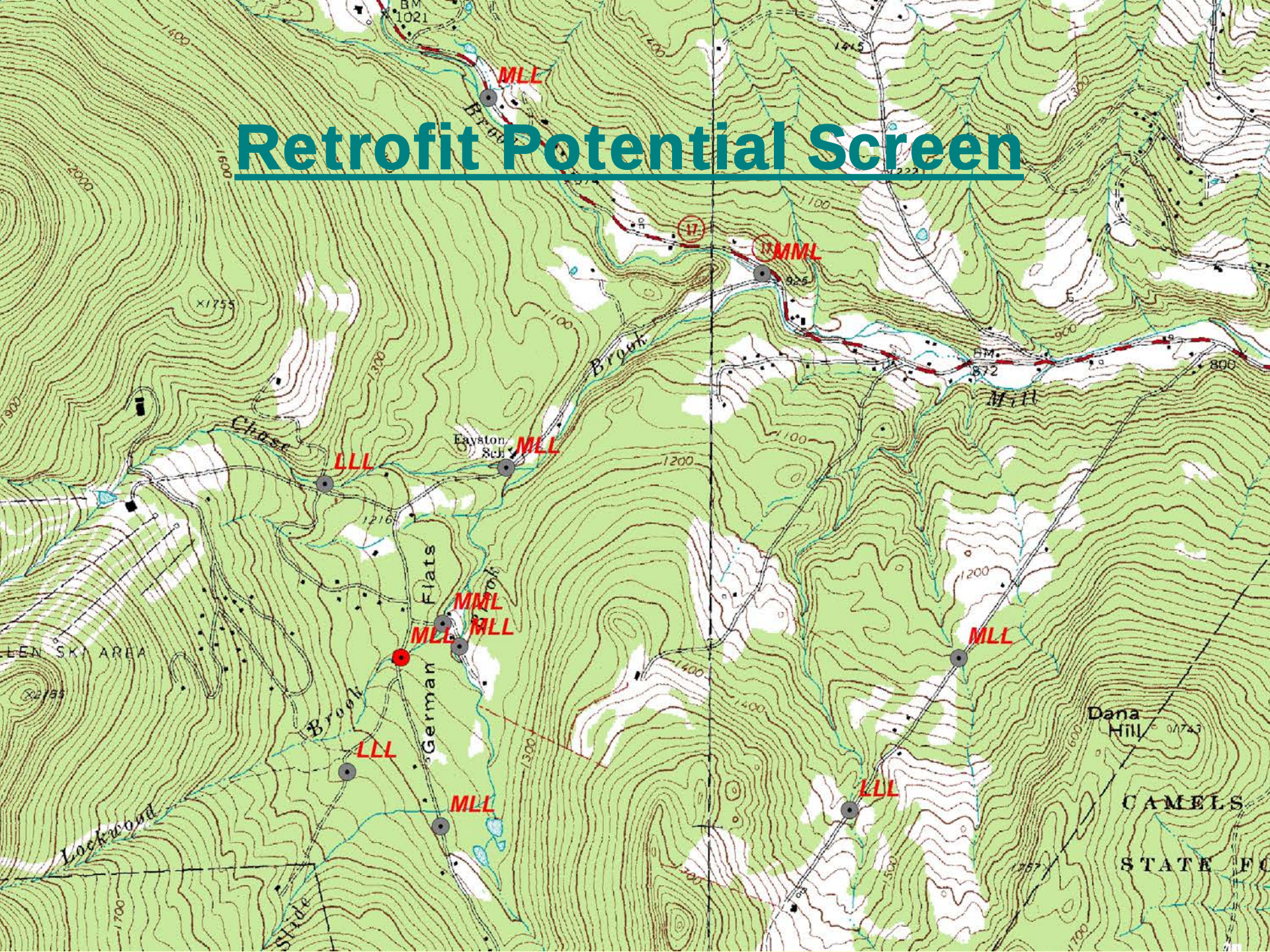
Percent structure width of channel width		*Non-backwatered structure length (ft)* †		*Outlet drop height (ft)*	
Score	*Values*	*Score*	*Values*	*Score*	*Values*
0	%BFW < 30	0	L_{NBW} ≥ 300	0	Od ≥ 2.5
1	30 ≤ %BFW < 50	1	200 ≤ L_{NBW} < 300	1	2.0 ≤ Od < 2.5
2	50 ≤ %BFW < 75	2	100 ≤ L_{NBW} < 200	2	1.5 ≤ Od < 2.0
3	75 ≤ %BFW < 100	3	40 ≤ L_{NBW} < 100	3	1.0 ≤ Od < 1.5
4	100 ≤ %BFW < 120	4	25 ≤ L_{NBW} < 40	4	0.5 ≤ Od < 1.0
5	%BFW ≥ 120	5	L_{NBW} < 25	5	Od < 0.5

Notes

%BFW = (culvert width/channel width)*100; L_{NBW} = non-backwatered structure length (ft); L = culvert length (ft); D = water depth in culvert at outlet (ft); Od = outlet drop height (ft); RPS = sum of scores for %BFW, L, and Od.

†Use culvert length (L) if non-backwatered length (L_{NBW}) not measured.

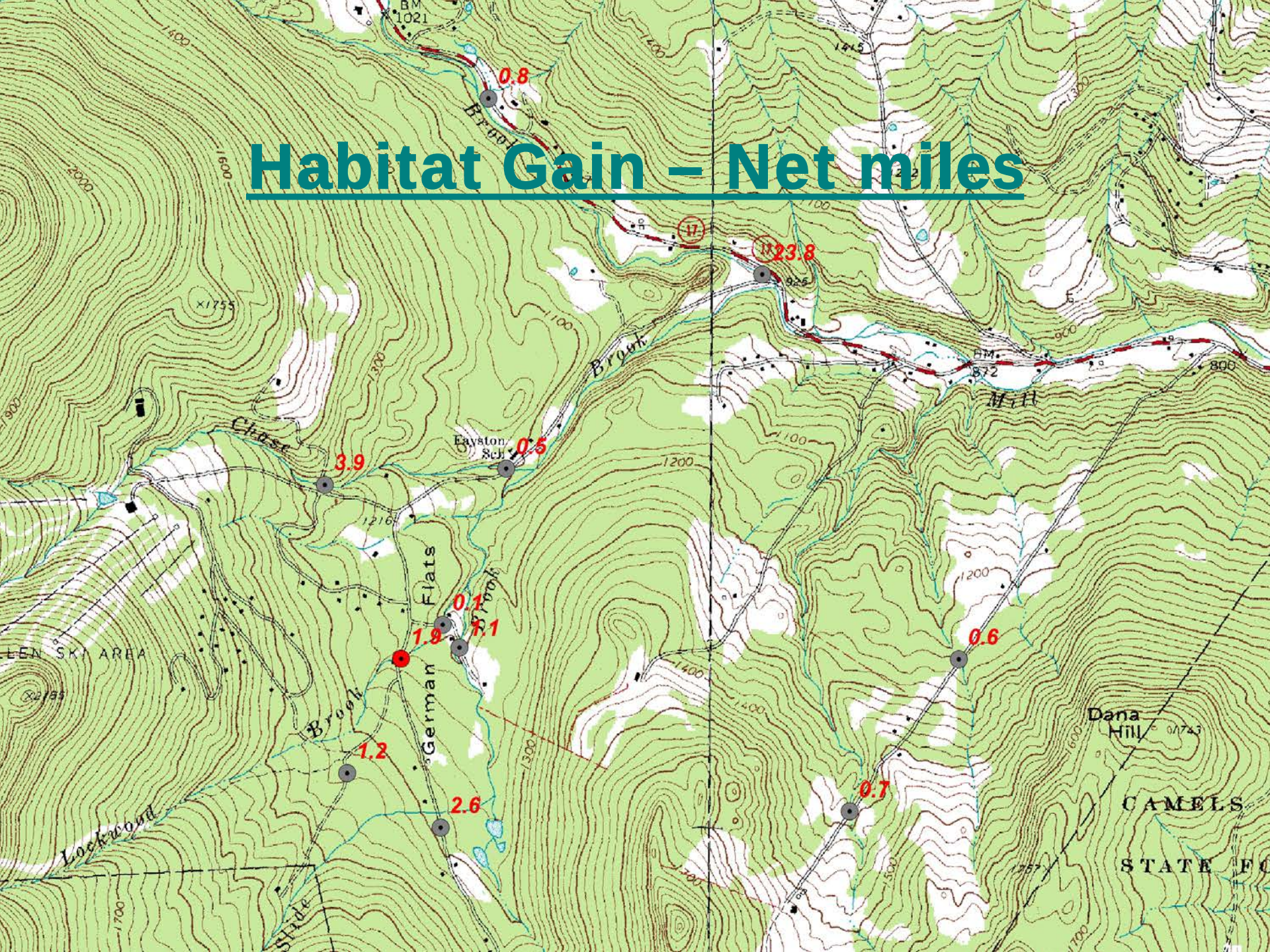
Retrofit Potential Screen



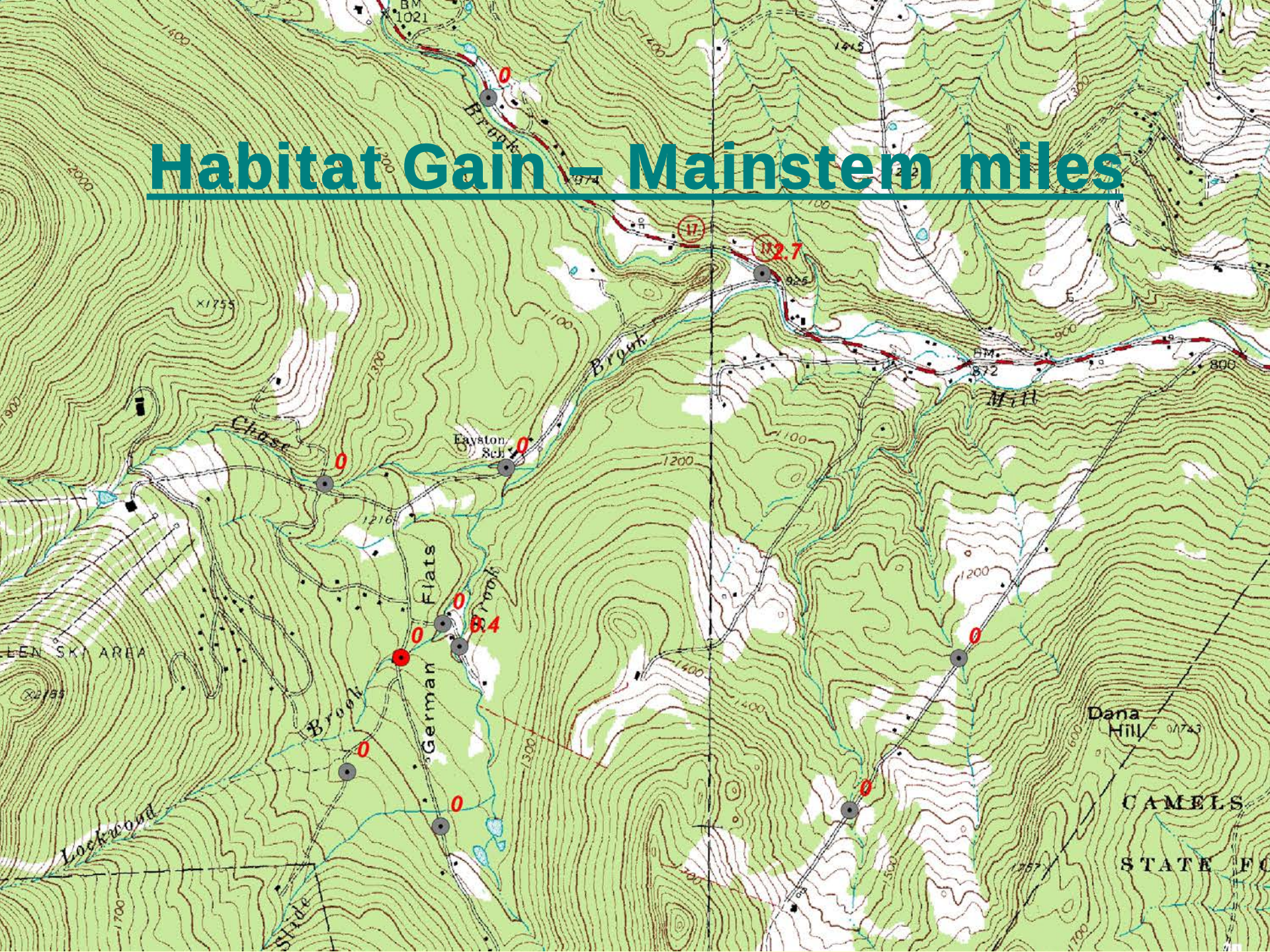
Barrier Assessment Tool (BAT)

Metric	Definition
UPSTREAM NETWORK LENGTH	Estimates the potential habitat gain (miles) upstream to the next stream crossing barrier within all stream orders.
UPSTREAM MAINSTEM NETWORK LENGTH	Estimates the potential habitat gain (miles) upstream to the next stream crossing barrier within third order or larger streams.
UPSTREAM LENGTH	Estimates the total upstream network length (miles) including tributaries and ignoring barriers.
UPSTREAM BARRIER COUNT	Estimates the number of stream crossing barriers upstream of the structure, including tributaries.
DOWNSTREAM BARRIER COUNT	Estimates the number of stream crossing barriers downstream of the structure, excluding tributaries.

Habitat Gain – Net miles



Habitat Gain – Mainstem miles

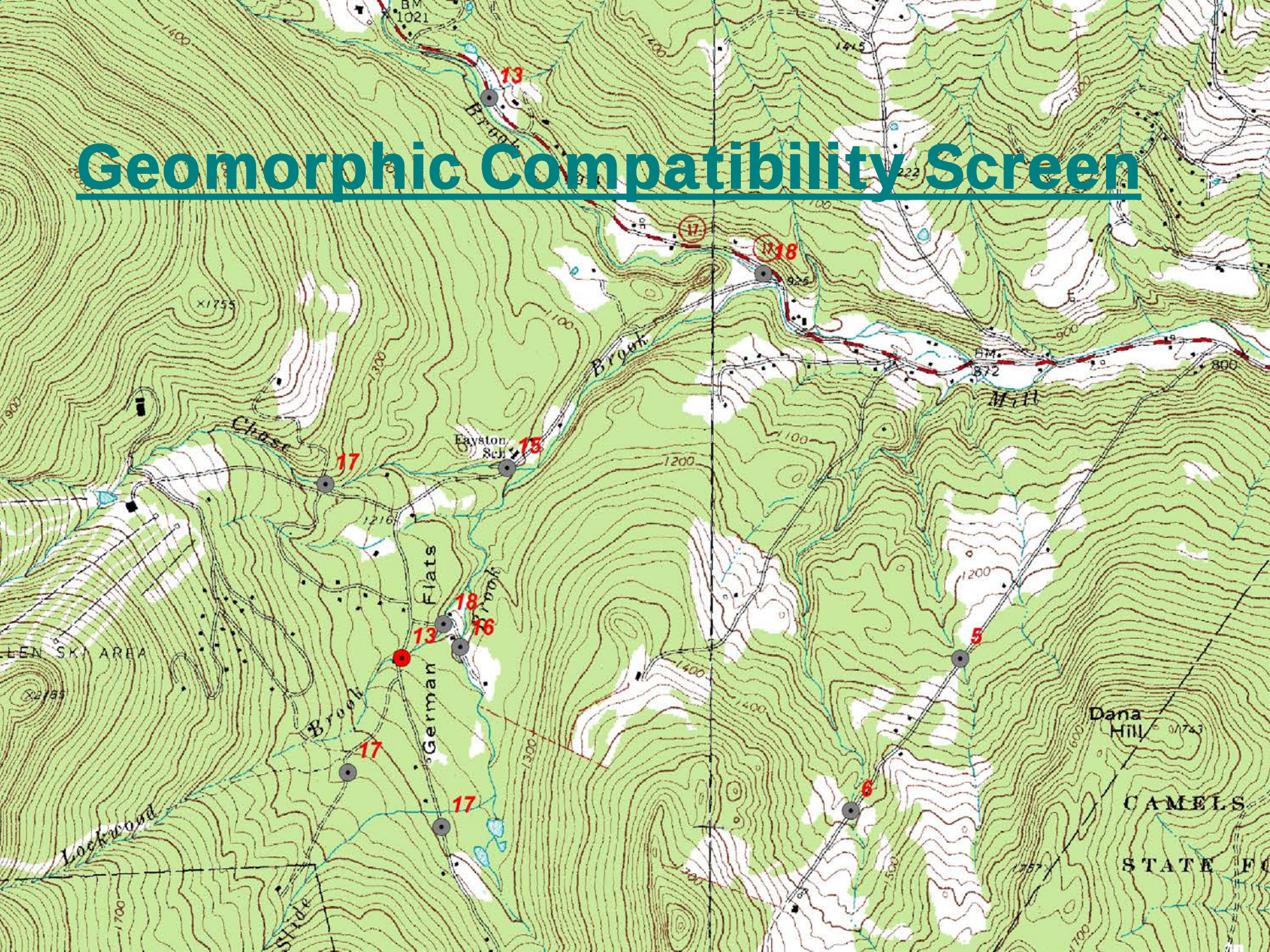


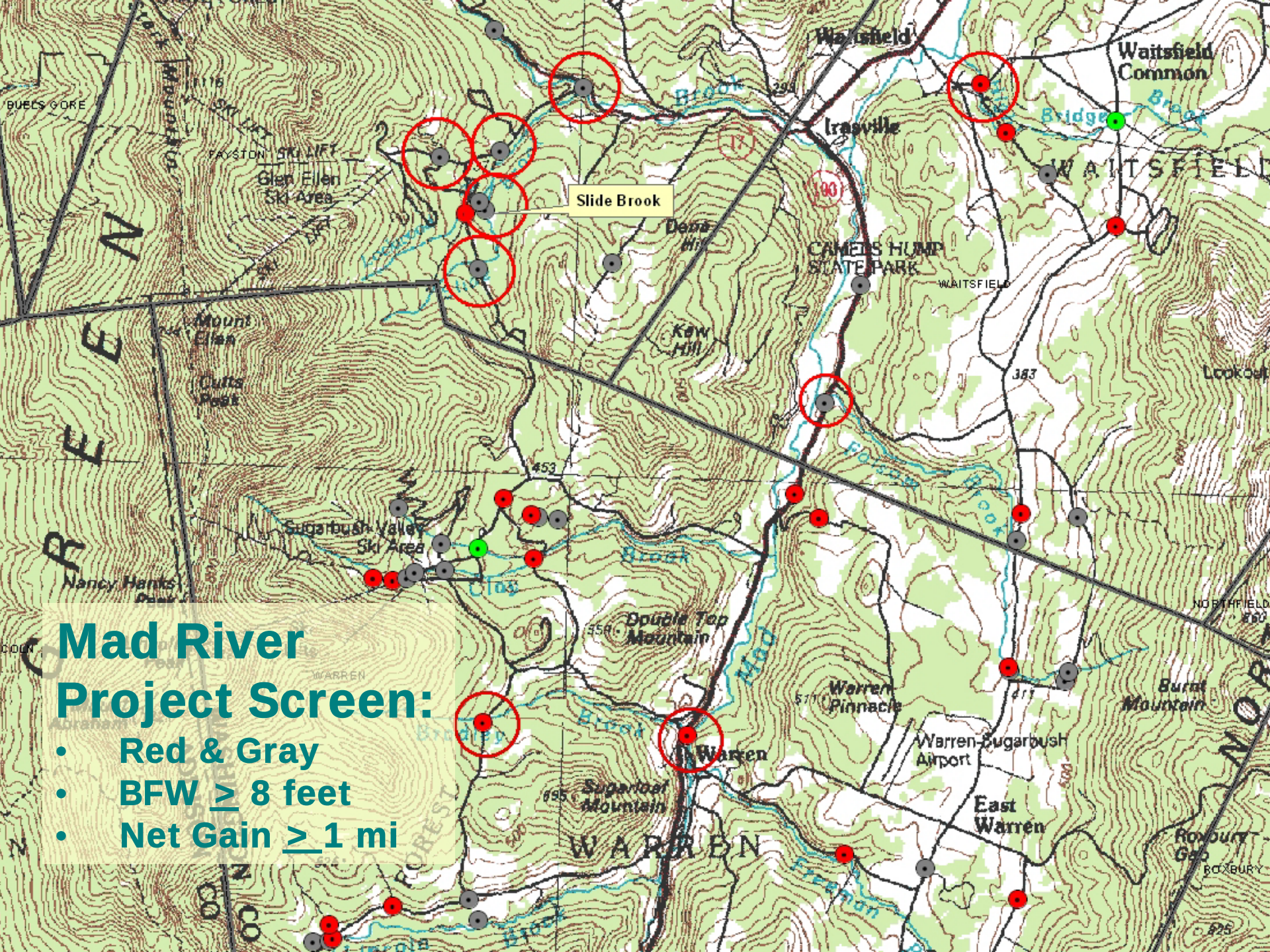
Geomorphic Compatibility Screen

TABLE 2-1
Summary of Overall Screen Score

Category Name	Screen Score	Threshold Conditions	Description of structure-channel geomorphic compatibility
Fully compatible	20<GC≤25	n/a	Structure fully compatible with natural channel form and process. There is a low risk of failure. No replacement anticipated over the lifetime of the structure. A similar structure is recommended when replacement is needed.
Mostly compatible	15<GC≤20	n/a	Structure mostly compatible with current channel form and process. There is a low risk of failure. No replacement anticipated over the lifetime of the structure. Minor design adjustments recommended when replacement is needed to make fully compatible.
Partially compatible	10<GC≤15	n/a	Structure compatible with either current form or process, but not both. Compatibility likely short term. There is a moderate risk of structure failure and replacement may be needed. Re-design suggested to improve geomorphic compatibility.
Mostly incompatible	5<GC≤10	% Bankfull Width + Approach Angle scores ≤ 2	Structure mostly incompatible with current form and process, with a moderate to high risk of structure failure. Re-design and replacement planning should be initiated to improve geomorphic compatibility.
Fully incompatible	0≤GC≤5	% Bankfull Width + Approach Angle scores ≤ 2 **AND** Sediment Continuity + Erosion and Armoring scores ≤ 2	Structure fully incompatible with channel and high risk of failure. Re-design and replacement should be performed as soon as possible to improve geomorphic compatibility.

Geomorphic Compatibility Screen



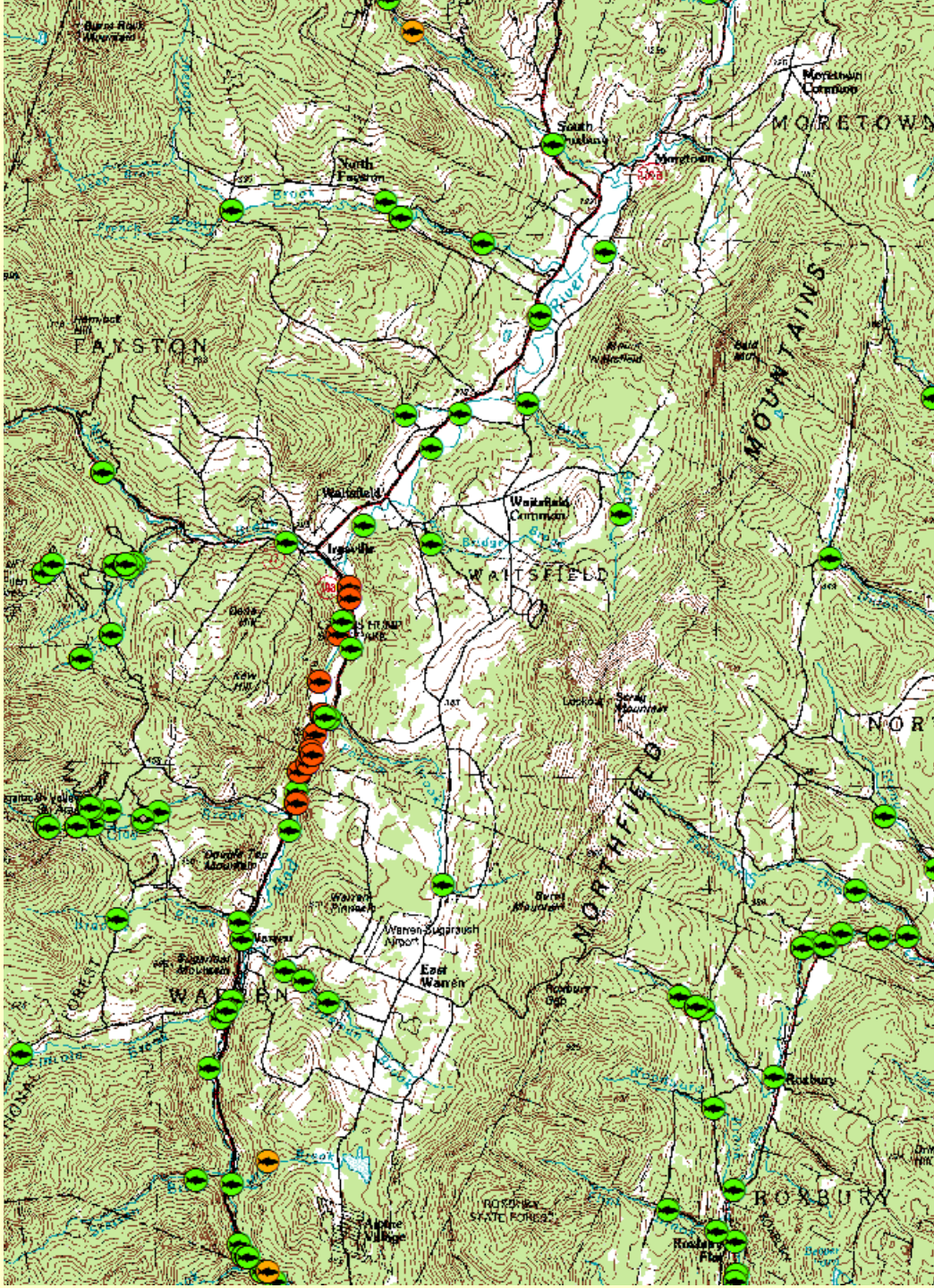

Slide Brook
Waitsfield
Waitsfield Common
Irasville
Glen Ellen Ski Area
Mount Ellen
Cutts Peak
Kew Hill
CAMELS HUMP STATE PARK
Sugarbush Valley Ski Area
Nancy Hanks
Double Top Mountain
Warren
Warren Pinnacle
Warren-Sugarbush Airport
Sugarloaf Mountain
East Warren
Burnt Mountain
WARREN
Mad River
Project Screen:
• Red & Gray
• BFW ≥ 8 feet
• Net Gain ≥ 1 mi

Additional Assessments

- **These are *Coarse* screens!!!!**
- **Ground-truth**
  - Other barriers (natural & manmade)
  - Aquatic community & abundance
  - Habitat quality
- **Feasibility**
  - Outlet drop, fill, access, utilities, etc.

Biological Assessments
(VDFW, USFS, USFWS, VDEC)

- **Species / Aquatic Community**
- **Habitat Quality**
- **Habitat Quantity (stream size)**



Biological Assessment
(above and below structure)

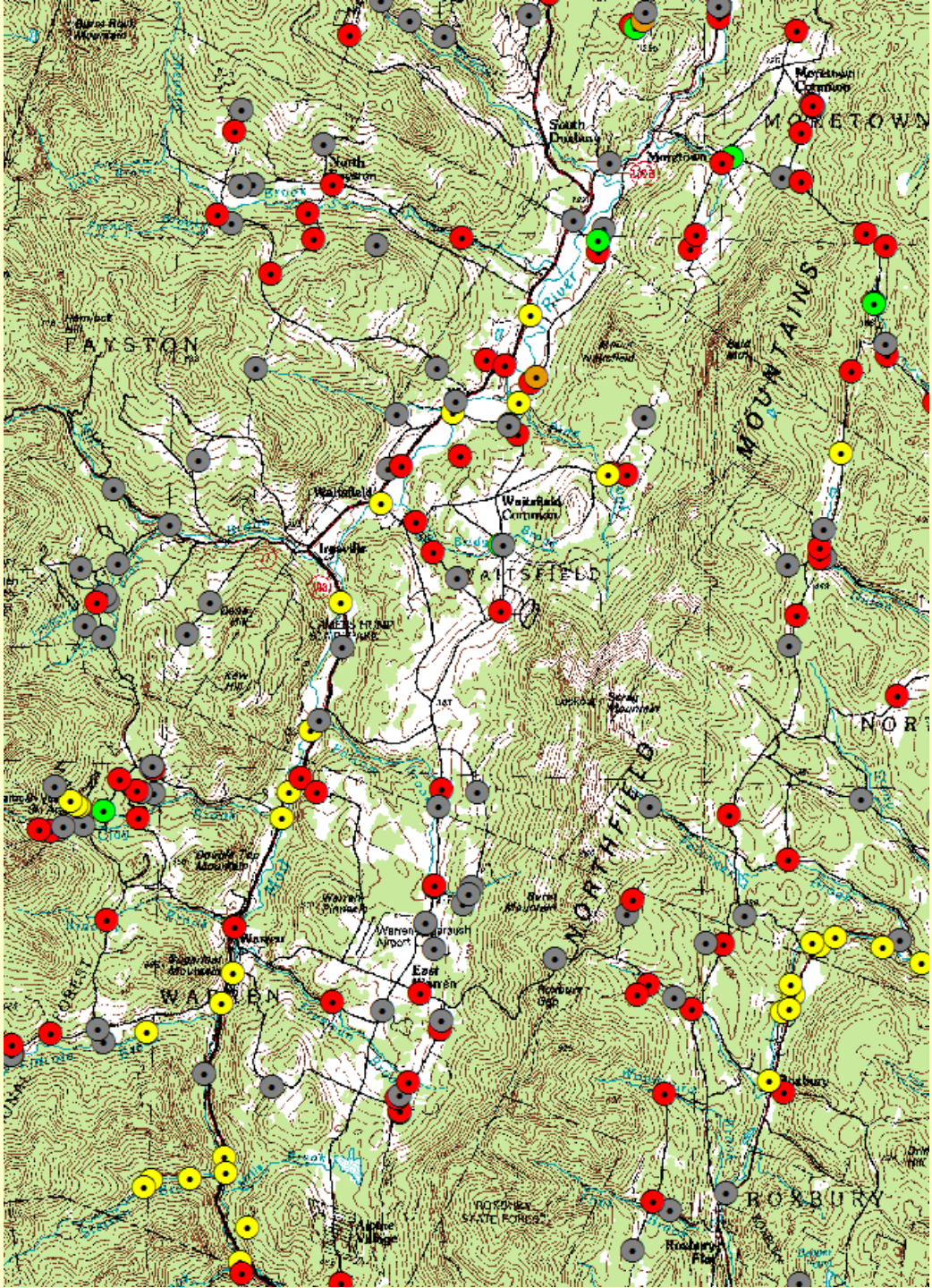
- Species composition
- Species abundance

Biological Assessment

- **Can confirm or contradict other assessments.**
- **May need to sample beyond the structure.**

Other Considerations

- **Structure Ownership**
  - **State (Vtrans protocol)**
  - **Town, private**
- **Structure Condition**
  - **Replacement schedule**
- **Focus or spread projects?**

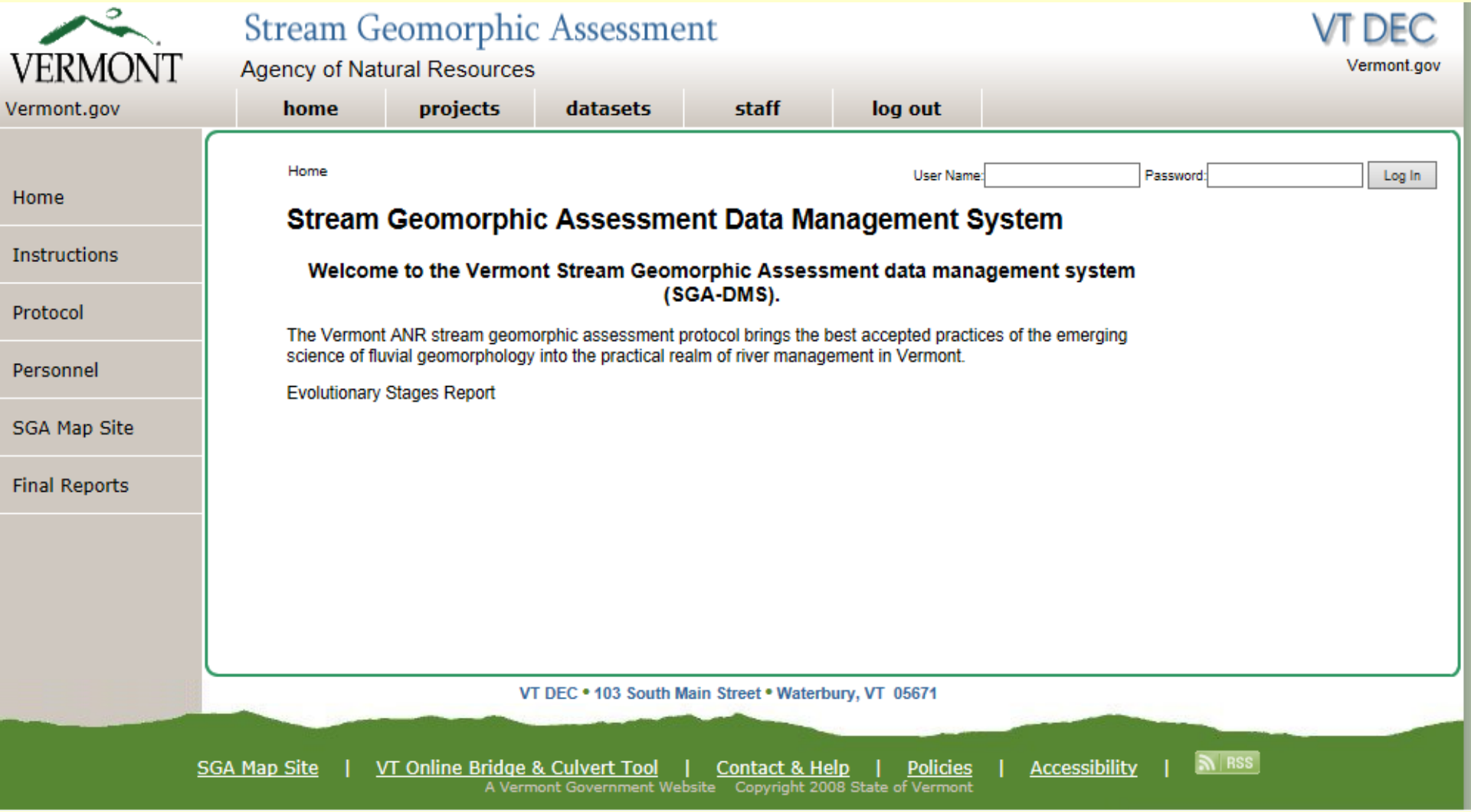


Permit Requirements

- US Army Corps of Engineers GP
- Stream Alteration Permit
  - VDFW Biologist Review
- Federal funding requirements
  - Archeological assessment
  - T&E
  - ???

AOP Technical Resources

- General AOP
- Design Guidelines
- Stream Crossing Handbook
- Culvert Assessment & Screening Tools
- Regulations
- Stream Alteration & VDFW Fisheries Contacts
- Project Implementation Process



https://anrnode.anr.state.vt.us/SGA/

Datasets List
Structures
Select Reports
Search
Export Tables
Fields List
VOBCIT Reports

Bridge and Culvert Export Table

○ dbf ○ excel ○ access

Get Table

Please provide an email address for us to contact you if there are changes to the data

Select Columns

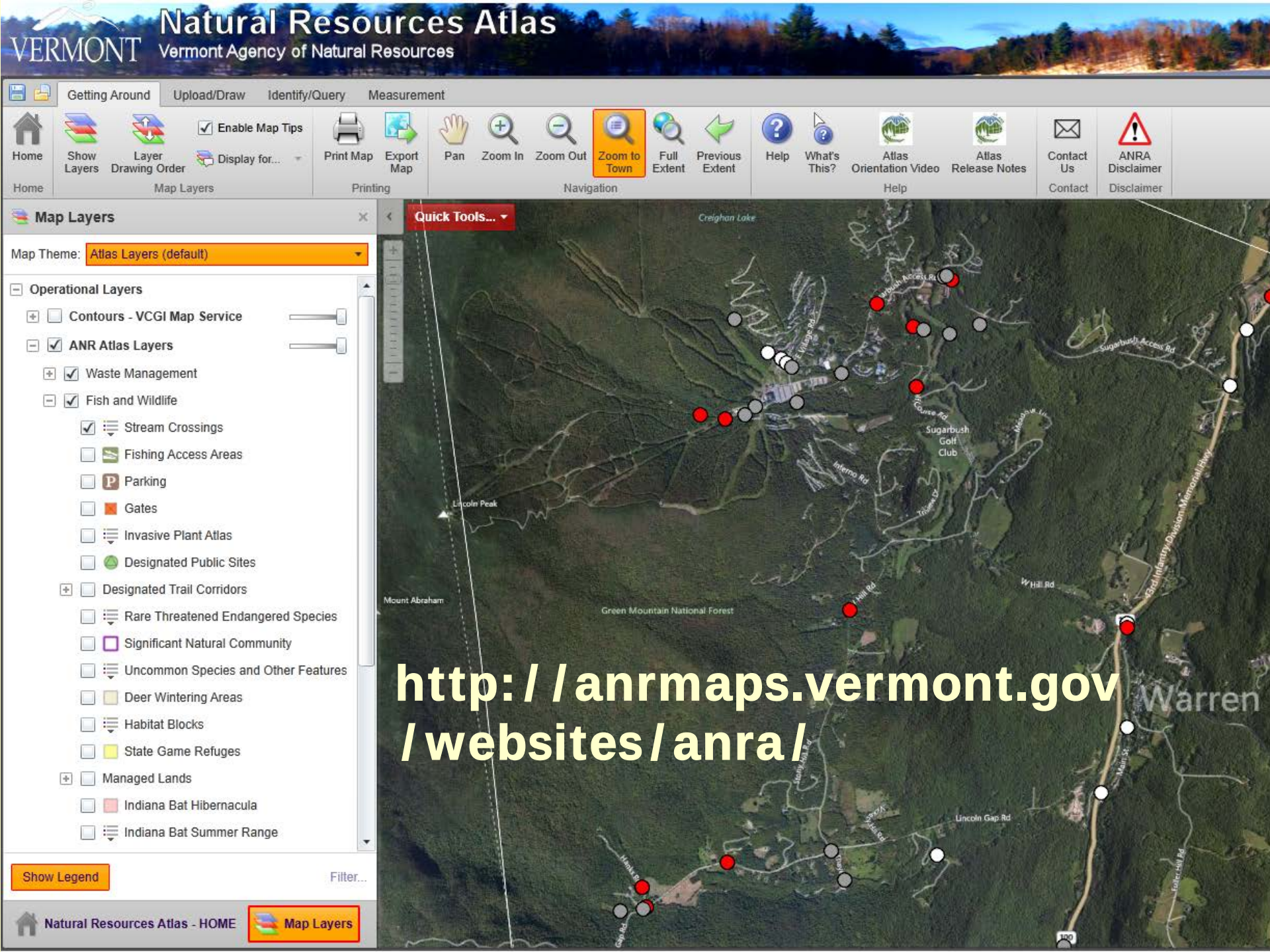
Select All | Select None

- ☐ 0.101 - The SGA-DMS Stream Geomorphic Assessment ID number
- ☐ 0.103 - ID of the drainage basin where the structure is located
- ☐ 0.104 - Name of the drainage basin where the structure is located
- ☐ 0.105 - The name of the dataset the structure belongs to
- ☐ 0.106 - This number is assigned by towns and/or RPCs when local road inventories are completed. The local ID is composed of the town FIPS code and a sequential number. Use those ID's already assigned, or where no local ID's have been assigned, leave this field blank.
- ☐ 0.109 - Structure width divided by channel width as a percent (% bankfull width)
- ☐ 0.110 - Stream Compatibility [Integer from 0 to 25]
- ☐ 0.112 - Concern for structure due to fluvial condition or process
- ☐ 0.113 - Potential failure due to ice or debris jam
- ☐ 0.114 - Openess Ratio
- ☐ 0.115 - Potential failure due to out-flanking
- ☐ 0.116 - Poor location or alignment
- ☐ 0.117 - Aquatic Organism Passage [String of letters, describing a color of Green = fully passable; Gray = partial passage; Orange = passable for adult trout only or Red = impassable for all species]
- ☐ 0.118 - Retrofit Potential; L:Low | M:Medium | H: High (left to right strong, moderate, weak swimmers)
- ☐ 0.119 - Available upstream length of 3rd order streams and larger

Filter rows by Basin

Select All | Select None

- ☐ Black, Barton, Clyde
- ☐ Deerfield
- ☐ Exeter River
- ☐ Hoosic, Walloomsac, Batten Kill
- ☐ Lamoille
- ☐ Lower Connecticut
- ☐ Missisquoi
- ☐ Northern Champlain
- ☐ Ottauquechee, Black
- ☐ Otter, Little Otter, Lewis
- ☐ Passumpsic
- ☐ Piscataqua River
- ☐ Poultney, Mettawee
- ☐ Southern Champlain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Fish and Wildlife
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Fishing Access Areas
Parking
Gates
Invasive Plant Atlas
Designated Public Sites
Designated Trail Corridors
Rare Threatened Endangered Species
Significant Natural Community
Uncommon Species and Other Features
Deer Wintering Areas
Habitat Blocks
State Game Refuges
Managed Lands
Indiana Bat Hibernacula
Indiana Bat Summer Range
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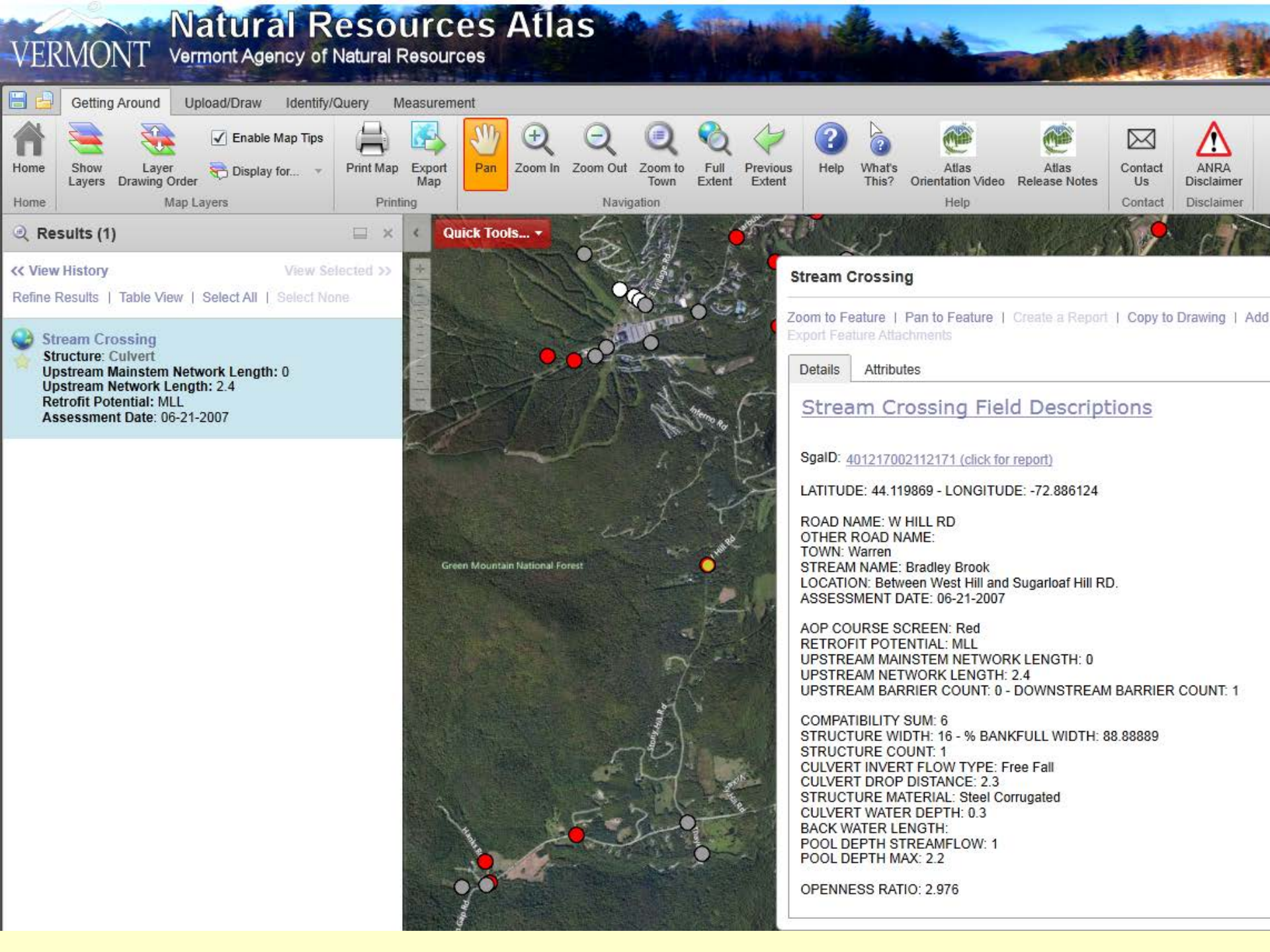
Sugarbush Golf Club
Lincoln Peak
Mount Abraham
Green Mountain National Forest
Lincoln Gap Rd
Warren
http://anrmaps.vermont.gov/websites/anra/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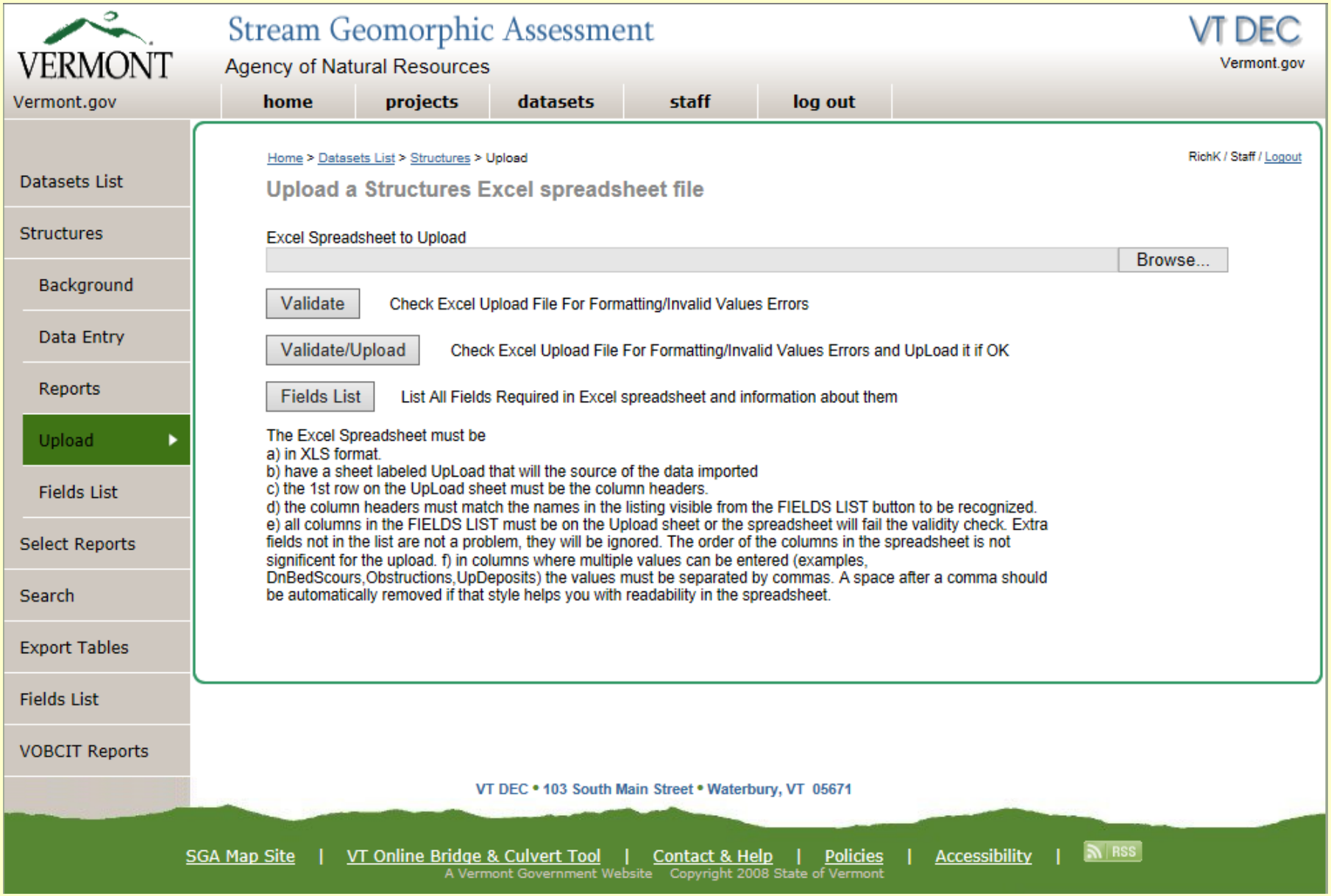
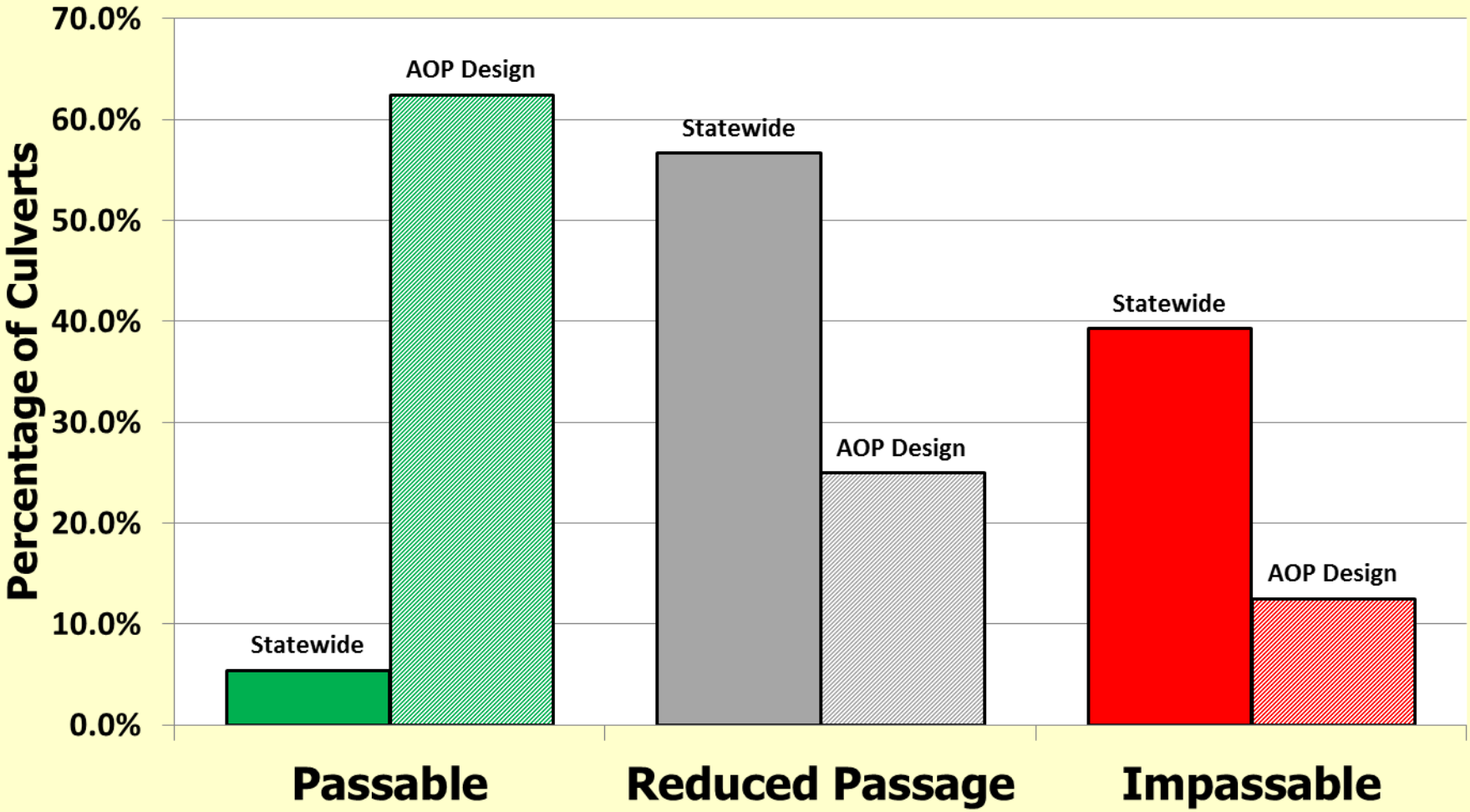
Results (1)
<< View History
View Selected >>
Refine Results | Table View | Select All | Select None
Stream Crossing
Structure: Culvert
Upstream Mainstem Network Length: 0
Upstream Network Length: 2.4
Retrofit Potential: MLL
Assessment Date: 06-21-2007
Quick Tools...
Green Mountain National Forest
Stream Crossing
Zoom to Feature | Pan to Feature | Create a Report | Copy to Drawing | Add
Export Feature Attachments
Details
Attributes
Stream Crossing Field Descriptions
SgaID: 401217002112171 (click for report)
LATITUDE: 44.119869 - LONGITUDE: -72.886124
ROAD NAME: W HILL RD
OTHER ROAD NAME:
TOWN: Warren
STREAM NAME: Bradley Brook
LOCATION: Between West Hill and Sugarloaf Hill RD.
ASSESSMENT DATE: 06-21-2007
AOP COURSE SCREEN: Red
RETROFIT POTENTIAL: MLL
UPSTREAM MAINSTEM NETWORK LENGTH: 0
UPSTREAM NETWORK LENGTH: 2.4
UPSTREAM BARRIER COUNT: 0 - DOWNSTREAM BARRIER COUNT: 1
COMPATIBILITY SUM: 6
STRUCTURE WIDTH: 16 - % BANKFULL WIDTH: 88.88889
STRUCTURE COUNT: 1
CULVERT INVERT FLOW TYPE: Free Fall
CULVERT DROP DISTANCE: 2.3
STRUCTURE MATERIAL: Steel Corrugated
CULVERT WATER DEPTH: 0.3
BACK WATER LENGTH:
POOL DEPTH STREAMFLOW: 1
POOL DEPTH MAX: 2.2
OPENNESS RATIO: 2.976

DMS Upload Tool



AOP Designed Structures Passage Comparison

Statewide (N = 3376): AOP Design (N=32)



The MISSION of the Vermont Fish & Wildlife Department is the conservation of fish, wildlife and plants and their habitats for the people of Vermont.
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