MEMORANDUM

TO: Adam Lougee, Addison County Regional Planning Commission
Bryan Davis, Chittenden County Regional Planning Commission

FROM: Roy Schiff, Milone & MacBroom, Inc.

DATE: June 22, 2012

RE: Vermont 116 Culvert AOP Project in Starksboro and Hinesburg, VT
MMI# 3928-03 and 3993-05

Introduction

Vermont Route 116 in Starksboro and Hinesburg is slated for re-paving by the Vermont Agency of Transportation (VTrans) in 2013. Smaller culverts (diameter ~ 48 inches or smaller) that are in structurally poor condition or that cause flooding over the roadway are planned to be replaced in 2012 to allow for settling before resurfacing a year later. This pilot project, led by the Addison and Chittenden County Regional Planning Commissions, injects aquatic organism passage (AOP) assessment and design into the planned culvert replacements on Vermont 116. The primary objective of this project is to identify structures where subtle and inexpensive design changes such as small increases to pipe size or re-setting of the culvert can improve fish passage so that these changes can be readily incorporated into planned culvert replacements. The ultimate goal of this work is to incorporate fish passage improvements into regular paving operations around the state.

Methods and Results

This project consisted of three steps: (1) Assessment and initial prioritization; (2) Hydraulic and AOP calculations, and final prioritization; and (3) Design recommendations.

Assessment and Initial Prioritization

Culvert assessment had been previously performed at some of the structures following the Vermont Bridge and Culvert Assessment (VTANR, 2009). Existing data were reviewed and an assessment plan was made. All existing structures were visited – fifteen in Starksboro and twenty-two in Hinesburg. Photo-documentation was performed (Appendix A). If no data existed culverts were fully assessed. Culverts were re-assessed if field conditions and past assessment data did not agree. Data such as current structural condition and structure slope were recorded for prioritization and calculations. Assessment data were used to generate screening scores for AOP (Schiff et al., 2008b) and geomorphic compatibility (GC) (Schiff et al., 2008a) from the internet-based Vermont Data Management System. Data were used to initially prioritize structures for improvements in AOP, GC, and structural condition.

Tabulated assessment results and maps (Table 1 and Figure 1) were distributed to the project team for review prior to the first of three meetings. Members of the project team had assessed some of the subject culverts or had an interest in their condition and fish passability. The project team included the following members.

- Addison County Regional Planning Commission
- Chittenden County Regional Planning Commission
- Town of Starksboro
- Town of Hinesburg
- Lewis Creek Association
- LaPlatte River Watershed Partnership
- Vermont Agency of Transportation
- Vermont Department of Fish and Wildlife
- Vermont Department of Environmental Conservation
- U.S. Fish and Wildlife Service
- Milone & MacBroom, Inc.

Feedback from the project team was incorporated into the assessment results to refine the initial prioritization. At this stage in the project bridges were removed from further consideration as they were beyond the scope of the project. Sixteen of the smaller structures were found to have no fish habitat and thus AOP was not a consideration at these locations. Many of these culverts were located along roadside ditches or depressions in fields rather than perennial streams. The drainage area to these small structures was typically less than or equal to 0.1 square miles.

Hydraulic and AOP Calculations

Watershed area was delineated in GIS or using the internet-based U.S. Geological Survey StreamtStats tool where peak flow estimation can be performed (Olson, 2002). The 50-year design flow was estimated by numerous regression equations based on guidance in the Vermont Hydraulics Manual (VTrans, 2001). Pipe-sizing hydraulic calculations (FHWA, 1985; VTrans, 2001) were performed for all structures to facilitate current or future replacement. Pipes were sized to maintain an acceptable level of submergence (i.e., $Hw / D = 1.2$) during the design flow.

AOP hydraulic design calculations were performed using FishXing (Furniss et al., 2009) and Vermont AOP guidelines (Bates and Kirn, 2009) to investigate fish passing at the existing structure and the larger structure typically required to adequately contain the design storm. Changes to the pipe slope, inlet and outlet were explored to achieve fish passage. AOP calculations were only performed at those structures where suitable fish habitat existed.

AOP was also explored at larger structures sized to completely span the channel bankfull width to be geomorphically compatible with the stream channel. These larger structures were only recommended at AOP priority locations where improvements beyond the scope of this project may be desired in the future. Hydraulic and AOP calculations were tabulated (Table 2) to illustrate the four possible alternatives – leave the pipe as existing, enlarge the pipe to safely convey the design flow, further enlarge the pipe if necessary to improve AOP, and enlarge the pipe even more if necessary to contain the bankfull channel width. A second project team meeting was held to review the calculation results and initial design recommendations.

Design Recommendations

The final product of the project consists of a table summarizing the design recommendations (Table 3). Structures are grouped by action items for the current VTrans paving project, future AOP improvement recommendations that are beyond the scope of this project, smaller structures where AOP is not an important consideration, and bridges that are outside of the project scope. Eight culverts are slated for replacement with design adjustments to improve AOP before paving (Figure 2). Ten culverts were identified as important AOP improvement projects for the future as they are beyond the scope of small culvert replacements during paving.

Results were presented to the project team for feedback and several groups elected to visit structures to explore design recommendations. U.S. Fish and Wildlife Service visited site 16 in Hinesburg to observe potential brook trout habitat and determined that the site was not an AOP priority due to a nearby natural upstream barrier. Vermont Department of Environmental Conservation visited most sites to explore geomorphic compatibility and generally agreed with the recommendations. One pipe size recommendation was increased to accommodate known debris clogging at a site.

Summary

The total project cost was $25,000 for thirty-seven structures in Starksboro and Hinesburg. The average cost per structure is $675 for assessment, pipe-sizing, and AOP recommendations. The end result of this effort will be implementation of eight AOP improvement culverts during paving of Vermont 116, future design recommendations for ten additional AOP improvement projects as the opportunity arises, and hydraulic pipe sizing at sixteen structures where AOP is not a priority in case the smaller pipes need to be replaced in the future.

The methods and results of this project were presented to the Chittenden County Regional Planning Commission Transportation Advisory Committee, the VTrans Transportation Planning Initiative, and at the National Ecohydraulics Conference in Amherst, Massachusetts. Comments were made during each presentation expressing the desire to use this project as a template for other state and local roads in Vermont and the region to make AOP a regular part of paving projects. The presentations have been distributed to numerous Transportation Agencies in the northeast United States to facilitate this goal.

Bibliography

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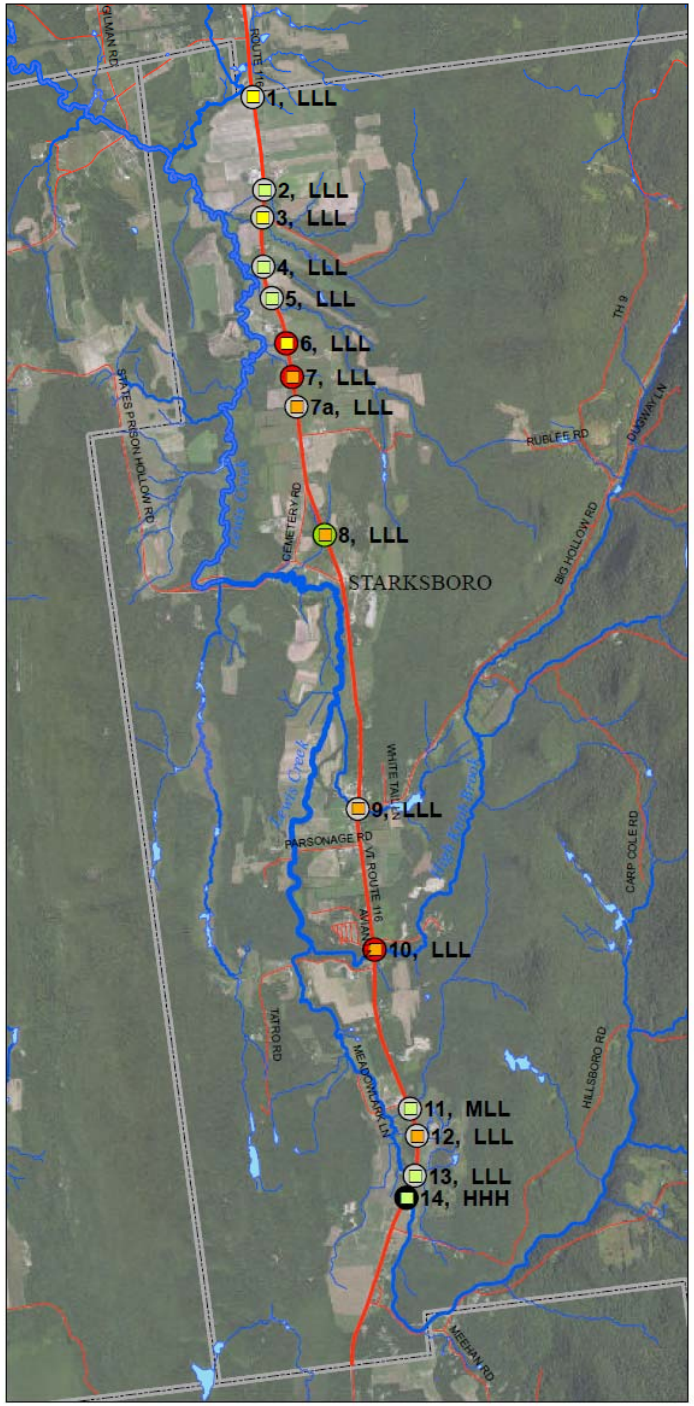
Starksboro



Geomorphic Compatibility

- Fully Compatible
- Mostly Compatible
- Partially Compatible
- Mostly Incompatible
- Fully Incompatible
- Bridge

AOP Coarse Screen

- Full AOP
- Reduced AOP
- No AOP, Except Adult Salmonids
- No AOP
- Bridge
- Lakes and Ponds

River (By Stream Order)

1 2 3 4 5

- Town Boundary
- Railroad
- Route 116
- Roads

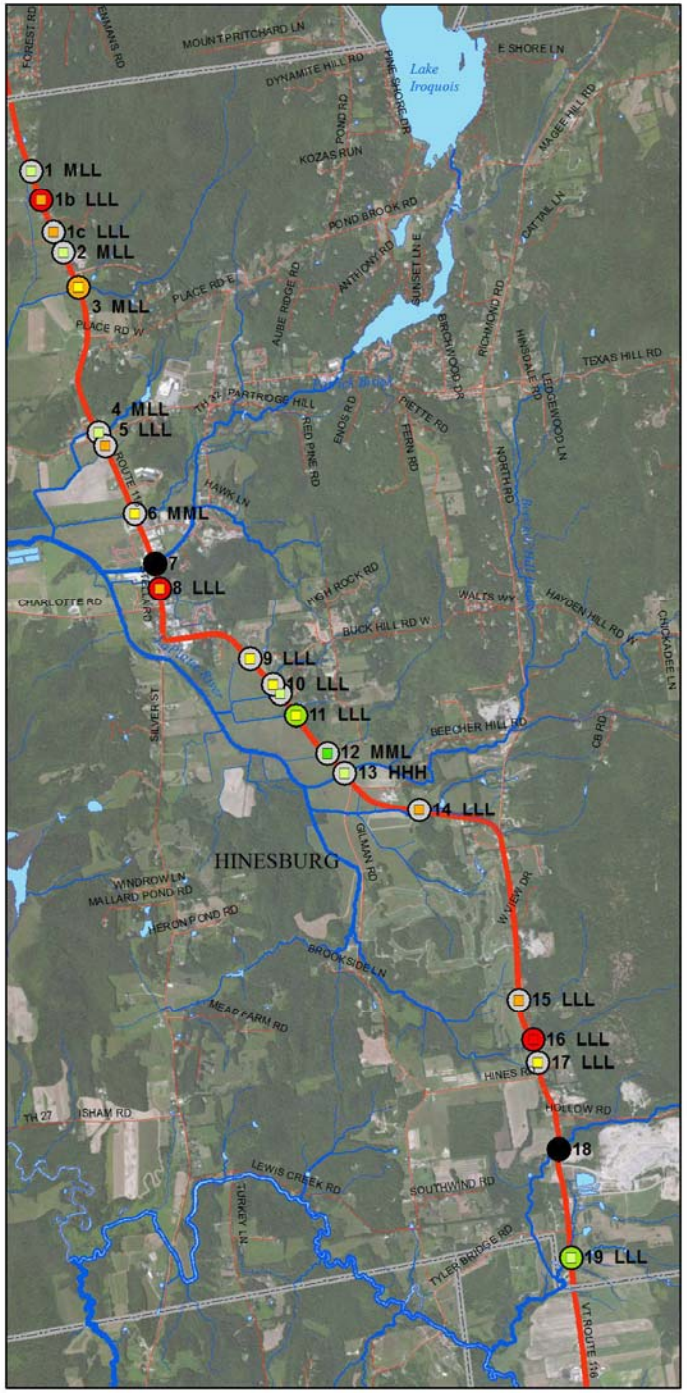
AOP Retrofit Potential Screen
(strong-moderate-weak swimmers/leapers)

H High
M Medium
L Low

0 0.25 0.5 1 Miles

Engineering, Landscape Architecture and Environmental Science
MILONE & MACBROOM®

Hinesburg



Preliminary Assessment Results and Prioritization
VT116 Culvert AOP Assessment Study
Hinesburg, Vermont
(with notes from 3/23/2012 meeting and design flow)

LocalID	SgaID	VTrans Milepost (miles)	Drainage Area (square miles)	Stream Order (Strahler)	Structure Type	Structure Length (ft)	Channel Bankfull Width (ft)*	Structure Width / Channel Width (%)	Culvert Outlet Type	Outlet Drop Height (ft)	Fill over Upstream end of Pipe (feet)	AOP Coarse Screen	Retrofit Potential	GC SCREEN	AOP / Habitat Notes	Structure Condition Notes	AOP Priority #	Structural Priority #	GC Priority #	Constructability	Meeting Notes	50-Year Design Flow (cfs)	Method
1	500116000104072	6.86	0.0	0	24" round RCP	40	*3*	40	At Grade	0	4	GRAY	MLL	LEMON LIME	Limited fish habitat. Road ditch upstream	Good condition.	19	20	18	High		44	BPR Method
1b	500116000204072	6.71	0.2	0	4.3' x 3.2' concrete box	41	*7*	33	Free Fall	2.5	3	RED	LLL	ORANGE	Good habitat potential upstream. Steep cobble stream in wooded corridor.	Moderate condition. Wingwalls and culvert at outlet have spalling, some gaps in wall joints.	7	4	3	Moderate for replacement. Large expensive structure.	Poured in the 1930-40's, rould require federal dollars and an estimated $75-100,000, Vtrans would just repair, discussed additional structure.	52	Average
1c	500116000304072	6.54	0.1	0	24" round CMP	42	*5*	17	Entirely Backwatered	0	6	GRAY	LLL	ORANGE	Limited habitat potential. Two wetland areas upstream with little concentrated flow.	Poor condition. Severely rusted with many holes in lower half.	14	1	7	High		33	BPR Method
2	500116000404072	6.41	0.0	0	30" round CMP	45	*3*	31	Entirely Backwatered	0	5	GRAY	MLL	LEMON LIME	Limited habitat potential. Has defined channel and wooded corridor, but small drainage area.	Appears good, but full of sediment so hard to estimate.	17	14	17	High		21	BPR Method
3	500116000004072	6.24	0.9	2	42" round CMP	50	10	35	Free Fall	0.9	7	ORANGE	MLL	YELLOW	Good habitat potential. Downstream channel needs buffer. Upstream in wooded corridor.	Moderate condition. Some sagging in roof, erosion on embankment.	2	11	6	High		167	Average
4	200116000004072	5.49	0.3	3	4' x 2.5' concrete box	37	10	40	Entirely Backwatered	0	5	GRAY	MLL	LEMON LIME	Good habitat potential. Upstream wooded buffer, gravel channel. Downstream no buffer, mowed through commercial area.	Poor condition. Concrete spalling on roof, at seams, on wingwalls, and header.	10	3	16	Low. Expensive concrete structure. Located at busy intersection.	Hold off on this structure. Intersection work and possible road widening is expected in near future including bike path in summer 2012.	95	Average
5	200116000104072	5.41	0.0	1	18" round RCP	50	*3*	17	Cascade	0	3	GRAY	LLL	ORANGE	Limited fish habitat. Wetland conditions with little concentrated flow.	Poor condition. Concrete eroded, exposing rebar. Headwall crooked and broken. Gaps between sections. Downstream section broken.	18	2	9	High		27	BPR Method
6	300211002804071	5.05	7.4	2	7' x 4' concrete box	30	10	70	Entirely Backwatered	0	3	GRAY	MML	YELLOW	Patrick Brook. Good habitat potential. Wooded buffer, large drainage area.	Moderate Condition. Floor and lower seams scoured and cracked. Otherwise ok condition.	4	6	11	Low. Expensive concrete structure.	Hold off on this structure. Possible road widening associated with work at Commerse Street.	689	Average
7	300211002704071	4.78	7.2	4	16' x 5.5' bridge opening	45	20.6	78	N/A	N/A	N/A	N/A	N/A	N/A	Patrick Canal. Good habitat potential. Adjacent dam may block fish.	Good condition, what is visible above backwater.	22	22	21	N/A		640	Average
8	200116000204072	4.66	0.1	2	36" round CMP	104	*5*	23	Free Fall	2.1	3	RED	LLL	ORANGE	Moderate habitat potenital. Defined channel between and behind homes.	Moderate condition. Leaking joints and some rust. Angle piece on end.	12	10	5	High		124	BPR Method
9	200116000304072	3.92	0.1	1	36" round RCP	60	*5*	21	Partially Backwatered	0	3	GRAY	LLL	YELLOW	Limited habitat potential. Upstream channel is a ditch leading from a wetland with little concentrated flow.	Moderate condition. Riprap falling into ditched channel upstream. Recent HDPE extension on US.	13	5	12	High		124	BPR Method
10	200116000604072	3.73	0.3	2	36" round RCP	65	*7*	25	Entirely Backwatered	0	4	GRAY	LLL	YELLOW	Good habitat potential upstream. Both sides need additional buffers.	Good condition. Downstream end is CMP.	8	17	10	High		92	Average
10b	500116000504072	3.68	0.0	0	18" round RCP	57	*1*	13	Partially Backwatered	0	3	GRAY	LLL	LEMON LIME	No habitat potential. Low spot at base of cliffs.	Good condition. Downstream end is 24" CMP that is deformed.	20	15	19	High		2	BPR Method
11	200116000404072	3.54	0.1	1	18" round RCP	60	*4*	18	Partially Backwatered	0	3	GREEN	LLL	YELLOW	Limited habitat potential. Upstream is a mowed area with little concentrated flow.	Good condition. Downstream end is 24" CMP.	16	18	13	High		31	BPR Method
12	200116000504072	3.29	0.3	1	60" round CMP	65	10	50	Entirely Backwatered	0	3	GRAY	MML	GREEN	Good habitat potential. Upstream needs a buffer, but has a good channel.	Good condition. Some deformation at end.	9	13	20	Moderate for replacement. Large structure.		71	Average
13	300211002504071	3.17	3.2	3	2 x 10' arch pipes	52	*22*	179	At Grade	0	3	GRAY	HHH	LEMON LIME	Beecher Hill Brook. Good habitat potential. Large drainage area upstream.	Good condition. Scour at downstream end.	6	16	8	Low. Large Structures. Would require detour.		489	Average
14	200116000904072	2.73	0.7	3	48" round RCP	75	*11*	25	Cascade	1	3	GRAY	LLL	ORANGE	Good habitat potential. Upstream needs buffer. Other smaller pipe downstream.	Moderate condition. Embankment eroding. Sink hole at road edge at upstream end.	3	9	2	High	Vtrans to reset or replace. Downstream structure at Gilman Road OK. Talk with landowner about downstream farm crossing.	159	Average
15	200116000704072	1.47	0.2	1	36" round RCP	100	*6*	23	Cascade	2.4	16	GRAY	LLL	ORANGE	Moderate habitat potential. Another culvert upstream, then steep cobble forested channel.	Moderate condition. Asphalt liner worn off and some rust.	11	12	4	Low. Deep fill. Does have easy detour on Old Route 116.	Outlet improvements may be possible. Detour exists.	56	BPR Method
16	200116000804072	1.25	0.5	1	35" round CMP	95	*10*	19	Free Fall	1.2	7	RED	LLL	RED	Good upstream habitat. Wooded forest upstream.	Moderate condition. Some rust. Riprap failing. Headwall loose	1	7	1	High	Seek USFWS replacement funds.	118	Average
17	500116000604072	1.14	0.1	0	18" round RCP	50	*4*	8	Entirely Backwatered	0	3	GRAY	LLL	YELLOW	Limited fish habitat. Wetland conditions with little concentrated flow.	Moderate condition. Headwall broken and blocking inlet.	15	8	14	High		59	BPR Method
18	200116001004072	0.69	7.5	3	36' bridge	50	34	106	N/A	N/A	N/A	N/A	N/A	N/A	Hollow Brook. Good upstream habitat.	Moderate condition. Spalling concrete on rails and deck edge. Old footings causing constriction and erosion upstream.	21	21	22	N/A		1061	Average
19	200116001104072	0.15	0.8	3	42" round RCP	40	13	23	Entirely Backwatered	0	4	GREEN	LLL	LEMON LIME	Good upstream habitat. Sinuous channel in shrubby corridor.	Good condition. Hard to observe because full of water.	5	19	15	High		209	Average

NOTES:
RCP = radial concrete pipe. CMP = corrugated metal pipe.
AOP Coarse Screen: Green = Full AOP; Gray = reduced AOP; Red = No AOP.
Retrofit Potential Screen: LLL = low for strong, moderate, and weak swimmers; MLL = medium for strong swimmers, and low for moderate and weak swimmers; MLL = medium for strong and moderate swimmers, and low for weak swimmers; HHH = high for strong, moderate, and weak swimmers
Geomorphic Compatibility Screen: Green = fully compatible; Lemon lime = mostly compatible; Yellow = Partially compatible; Orange = mostly incompatible.
* Bankfull width measured in field and compared to Hydraulic Geometry Curve Estimates. Hydraulic Geometry Curve Estimates used where italicized.

Preliminary Sizing Results
VT116 Culvert AOP Assessment
Hinesburg, Vermont

LocalID	Existing Structure Type	Existing Structure Length (ft)	Channel Bankfull Width (ft)	Conveyance Design Type	Conveyance Design Size (in)	Conveyance Design Fish Passage Percent	Conveyance Design Low Flow AOP Barrier Type	Conveyance Design High Flow AOP Barrier Type	AOP Improvement Notes	Improved Type	Improved Size (in)	Improved Passage Percent	Improved Low Flow AOP Barrier Types	Improved High Flow AOP Barrier Types	AOP Design Type	Changes to Inlet and Outlet Elevations*	Changes to Structure Slope	Alignment	AOP Design Percent Fish Passage	AOP Design Low Flow Barrier Type	AOP High Flow Barrier Type	AOP Priority #
1	24" round RCP	40	3	CPP	36	AOP not applicable. Limited habitat potential.																19
1b	4.3' x 3.2' concrete box	41	7	Box adequately sized for conveyance.	0	0	Depth, Outlet Drop, Pool	Depth, Outlet Drop, Pool, Velocity	Replace with 48" CMP. Embed 0.5'. Lower elevation 4 feet to eliminate drop.	CMP	48	100	None	None	7.3' x 5.3' Pipe Arch	Lower inlet 2.4' to reduce slope and lower outlet by 2.5' to eliminate drop. Modify downstream riffle to increase backwater by 1 foot.	No Change (EX = 1.2%, US = 10%).	Align with US channel by moving US end approximately 50 feet north. Realignment will increase length and skew angle with roadway.	100	None	None	7
1c	24" round CMP	42	5	CPP	36	AOP not applicable. Limited habitat potential.																14
2	30" round CMP	45	3	Pipe adequately sized for conveyance.	0	AOP not applicable. Limited habitat potential.																17
3	42" round CMP	50	10	CMP	66	0	Depth, Outlet Drop	Outlet Drop, Velocity	Increase pipe size from 66" to 72". Embed 1 foot. Lower inlet 1.75', lower outlet 1.5', and decrease slope by 0.5% to eliminate outlet drop	CMP	72	100	None	None	10.7' x 6.9' Pipe Arch	Lower inlet 1.25' to reduce slope and lower outet 1.5' to eliminate drop. Modify farm ford downstream to increase elevation by 0.5' to increase backwater.	Increase slope by 0.5% (PR = 1.5%, EX = 1.0%, US = 1.0%) to eliminate drop.	No Change. Naturally Straight.	100	None	None	2
4	4' x 2.5' concrete box	37	10	CMP	54	100	None	None	Not Needed.	0	0	0	0	0	10.7' x 6.9' Pipe Arch	No Change.	No Change (EX = 0.5%, US = 1.7%).	No Change. Mild Bend.	100	None	None	10
5	18" round RCP	50	3	CPP	30	AOP not applicable. Limited habitat potential.																18
6	7' x 4' concrete box	30	10	Box	14' x 7'	0	Depth	Depth, Velocity	Increase height by 1'. Embed 1'. Lower elevation 1.' and reduce slope by 0.9% to 2.0% to reduce velocity and increase depth of flow.	Box	14' x 7'	100	None	None	14' x 8' Box	Lower inlet by 1.5' to reduce slope. Lower outlet by 1.0' to increase backwater depth.	Decrease slope by 0.9% (PR = 2%, EX = 2.9%, US = 1.7%) to reduce velocities.	No Change. Mild Bend.	100	None	None	4
7	16' x 5.5' bridge opening	45	20.6	Bridges beyond scope of project.	0	Bridge not applicable.																22
8	36" round CMP	104	5	CMP	60	0	Depth, Outlet Drop, Pool	Depth, Outlet Drop, Pool, Velocity	Increase pipe size from 60" to 66". Embed 1'. Lower inlet 2.3', lower outlet 2.6', and increase slope by 0.3% to 1.5% to decrease velocity and increase depth. Increased tailwater elevation 1.5'.	CMP	66	96.6	Depth	None	13' x5' Box	No change to inlet. Lower outlet by 2.1' to eliminate drop.	Increase slope by 2% (PR = 3.2%, EX = 1.2%, US = 4.5%) to eliminate drop.	Realign with DS channel to reduce Severe Skew. US & DS Channelized Straight. Work with Church to restore channel.	0	Depth	Depth	12
9	36" round RCP	60	5	Pipe Arch	6.4' x 4.3'	AOP not applicable. Limited habitat potential.																13
10	36" round RCP	65	7	CMP	54	0	Depth	Depth, Velocity	Embed pipe 1 foot. Lower elevation by 1.0'. Decrease slope by 0.8% to 1.5%.	Conveyance Design	0	100	None	None	7.3' x 5.3' Pipe Arch	Lower inlet 1.35' to decrease slope. Lower outlet 0.5' to increase backwater.	Decrease slope by 1.3% (PR = 1.0%, EX = 2.3%, US = 13.0%) to increase water depth.	Severely Skewed. Sharp Bend. Would require landuse change because channelized against road US and field DS.	100	None	None	8
10b	18" round RCP	57	1	Pipe adequately sized for conveyance.	0	AOP not applicable. Limited habitat potential.																20
11	18" round RCP	60	4	CPP	30	AOP not applicable. Limited habitat potential.																16
12	60" round CMP	65	10	Pipe adequately sized for conveyance.	0	0	Depth	Depth	Embed 1 foot. Lower elevation by 0.5'.	Existing Culvert	0	100	None	None	10.7' x 6.9' Pipe Arch	No Change.	Increase slope by 0.5% (PR = 1%, EX = 0.5%, US = 3.0%) to transition to steeper upstream channel.	No Change. Naturally Straight.	no calc	Depth	Depth	9
13	2 x 10' arch pipes	52	22	Pipes adequately sized for conveyance.	0	0	Depth	Velocity	Beyond Scope - No Improvement	Beyond Scope of Project.	0	0	0	0	22' span bridge	No Change.	No Change (PR = 2.5%, EX = 2.5%, US = 2.5%).	No Change. Channelized Straight.	no calc	Depth	Depth, Velocity	6
14	48" round RCP	75	11	CMP	66	0	Depth, Drop	Drop, Velocity	Increase pipe size from 66" to 72". Embed 1'. Lower inlet elevation by 0.6', lower outlet by 1', increase slope by 0.6% to 3.6% to eliminate drop and decrease length of depth barrier. Downstream culvert needs to be addressed also.	CMP	72	0	Depth	Depth, Velocity	11.4' x 7.3' Pipe Arch	Lower inlet by 0.5' to reduce slope and outlet by 1.0' to eliminate drop.	Increase slope by 0.6% (PR = 3.6%, EX = 3.0%, US = 3.6%) to eliminate drop.	Skewed. Sharp Bend. Channelized along road, difficult to improve alignment.	no calc	Depth	Depth, Velocity	3
15	36" round RCP	100	6	CMP	42	0	Depth, Drop, Pool, Velocity	Drop, Pool, Velocity	Increase pipe size by 1' to 54". Lowered inlet by 2.6' and outlet by 2.4'. Decrease slope from 7% to 5.8%. Increase slope of channel upstream by 2%. Increase tailwater downstream by 1'.	CMP	54	0	Depth, Velocity	Velocity	13.1' x 8.4' Pipe Arch	Lower outlet by 2.6' to reduce slope and outlet by 1.4' to decrease drop. Use grade control downstream to increase backwater by 1 foot.	Decrease slope by 1.2% (PR = 5.8%, EX = 7.0%, US = 2.5%, farther US = 4.5%) and restore and steepen channel us by 2% to help match ds grade.	Sharp Bend. US alignment is not perfect, but culvert length is already too long (100 ft). Skewing culvert is not recommended.	no calc	Depth	Depth, Velocity	11
16	35" round CMP	95	10	CMP	60	0	Drop, Depth, Pool	Drop, Depth, Pool, Velocity	Lower elevation by 1.2' to eliminate drop and decrease length of depth barrier. Increase tailwater elevation by 1.5' to increase water depth.	Conveyance Design	0	0	Depth	Depth, Velocity	10.3' x 6.8' Pipe Arch	Lower inlet by 3.71' and outlet by 2' to eliminate drop. Modify downstream riffle to increase backwater by 1.0'.	Decrease slope by 1.8% (PR = 1.5%, EX = 3.3%, US = 5.0%) to increase water depth.	Sharp Bend. Sediment accumulation has filled channel and changed to a sharp bend alignment. Alignment may correct naturally if sediment conveyance increases.	100	None	None	1
17	18" round RCP	50	4	CMP	36	AOP not applicable. Limited habitat potential.																15
18	36' bridge	50	34	Bridges beyond scope of project.	0	Bridge not applicable.																21
19	42" round RCP	40	13	CMP	72	100	None	None	Not needed.	Conveyance Design	0	0	0	0	13' x 7' Box	No Change.	No Change (PR = 0.8%, EX = 0.8%, US = 1.0%).	No Change. Naturally Straight.	100	None	None	5

AOP Design Recommendations
VT116 Culvert AOP Assessment Study
Hinesburg, Vermont
May 4, 2012

LocalID	VTrans Milepost (miles)	Drainage Area (square miles)	Existing Structure Type	Channel Bankfull Width (ft)	VTrans Plan of Action Due to Condition*	Upgrade for Flow Capacity	Upgrade for AOP Improvement	Upgrade for Full AOP and Geomorphic Compatibility	Design Recommendation	AOP Priority #
1	6.9	0.0	24" RCP	*3*	Clean	36" CPP	*AOP not applicable. Limited habitat potential.*		Clean sediment out of ends.	19
1b	6.7	0.2	4.3' x 3.2' Box	*7*	No Change	No	48" CMP	7.3' x 5.3' Pipe Arch	Replace with 48" CMP. Embed 0.5'. Lower elevation 4 feet to eliminate drop	7
1c	6.5	0.1	24" CMP	*5*	Field Visit	36" CPP	*AOP not applicable. Limited habitat potential.*		*N/A*	14
2	6.4	0.0	30" CMP	*3*	Clean	No	*AOP not applicable. Limited habitat potential.*		Remove sediment from pipe to restore capacity.	17
3	6.2	0.9	42" CMP	10	Field Visit	66" CMP	72" CMP	10.7' x 6.9' Pipe Arch	Lower inlet 1.25' to reduce slope and lower outet 1.5' to eliminate drop. Increase slope by 0.5% to 1.5%. Modify farm ford downstream to increase elevation by 0.5' to increase backwater. Embed 20%	2
4	5.5	0.3	4' x 2.5' Box	10	Field Visit	54" CMP	54" CMP	10.7' x 6.9' Pipe Arch	Install as existing.	10
5	5.4	0.0	18" RCP	*3*	Field Visit	30" CPP	*AOP not applicable. Limited habitat potential.*		*N/A*	18
6	5.1	7.4	7' x 4' Box	10	No Change	14' x 7' Box	14' x 7' Box	14' x 8' Box	Lower inlet by 1.5' to reduce slope. Lower outlet by 1.0' to increase backwater depth. Decrease slope by 0.9% to 2%. Embed 20%.	4
7	4.8	7.2	Bridge	21	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	22
8	4.7	0.1	36" CMP	*5*	No Change	60" CMP	*AOP not applicable. Limited habitat potential.*		Increase pipe size from 60" to 66". Embed 1'. Lower inlet 2.3', lower outlet 2.6', and increase slope by 0.3% to 1.5% to decrease velocity and increase depth. Increased tailwater elevation 1.5'.	12
9	3.9	0.1	36" RCP	*5*	Field Visit	6.4' x 4.3' Pipe Arch	*AOP not applicable. Limited habitat potential.*		Limited fill depth, required pipe arch. 72" pipe satisfied conveyance criteria	13
10	3.7	0.3	36" RCP	*7*	Field Visit	54" CMP	54" CMP	7.3' x 5.3' Pipe Arch	Embed pipe 1 foot. Lower elevation by 1.0'. Decrease slope by 0.8% to 1.5%.	8
10b	3.7	0.0	18" RCP	*1*	No Change	No	*AOP not applicable. Limited habitat potential.*		*N/A*	20
11	3.5	0.1	18" RCP	*4*	No Change	30" CPP	*AOP not applicable. Limited habitat potential.*		*N/A*	16
12	3.3	0.3	60" CMP	10	No Change	No	No	10.7' x 6.9' Pipe Arch	Embed 1 foot. Lower elevation by 0.5'.	9
13	3.2	3.2	Two 10' x 6.5' Pipe Arches	*22*	No Change	No	*Beyond Scope of Project.*	*N/A*	Replace with single span structure at least 100% bankfull width. Likely a bridge structure.	6
14	2.7	0.7	48" RCP	*11*	Field Visit	66" CMP	72" CMP	11.4' x 7.3' Pipe Arch	Increase pipe size from 66" to 72". Embed 1'. Lower inlet elevation by 0.6', lower outlet by 1', increase slope by 0.6% to 3.6% to eliminate drop and decrease length of depth barrier. Downstream culvert needs to be addressed also.	3
15	1.5	0.2	36" RCP	*6*	No Change	42" CMP	*AOP not applicable. Limited habitat potential.*		Increase pipe size by 1' to 54". Lowered inlet by 2.6' and outlet by 2.4'. Decrease slope from 7% to 5.8%. Increase slope of channel upstream by 2%. Increase tailwater downstream by 1'.	11
16	1.3	0.5	35" CMP	*10*	No Change	60" CMP	60" CMP	10.3' x 6.8' Pipe Arch	Lower inlet by 3.71' and outlet by 2' to eliminate drop. Modify downstream riffle to increase backwater by 1.0'. Decrease slope by 1.8% to 1.5%. Embed 20%.	1
17	1.1	0.1	18" RCP	*4*	Repair	36" CMP	*AOP not applicable. Limited habitat potential.*		Fix Headwall.	15
18	0.7	7.5	Bridge	34	*N/A*		*N/A*	*N/A*	*N/A*	21
19	0.2	0.8	42" RCP	13	Field Visit	72" CMP	72" CMP	13' x 7' Box	Install as existing.	5

NOTES:
RCP = radial concrete pipe. CMP = corrugated metal pipe. CPP = corrugated plastic pipe
Bold box indicates recommended structure type and size. See design recommendations for embeddedness, slope, inlet/outlet, and alignme
* Plan of Action based on VTrans initial assessment of MMI field data and recommendation

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