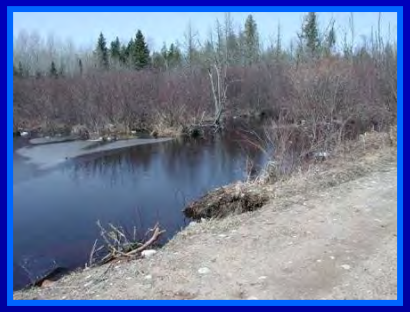
Stream Restoration at Road Crossings in Northern Wisconsin








Dale Higgins, USDA Forest Service

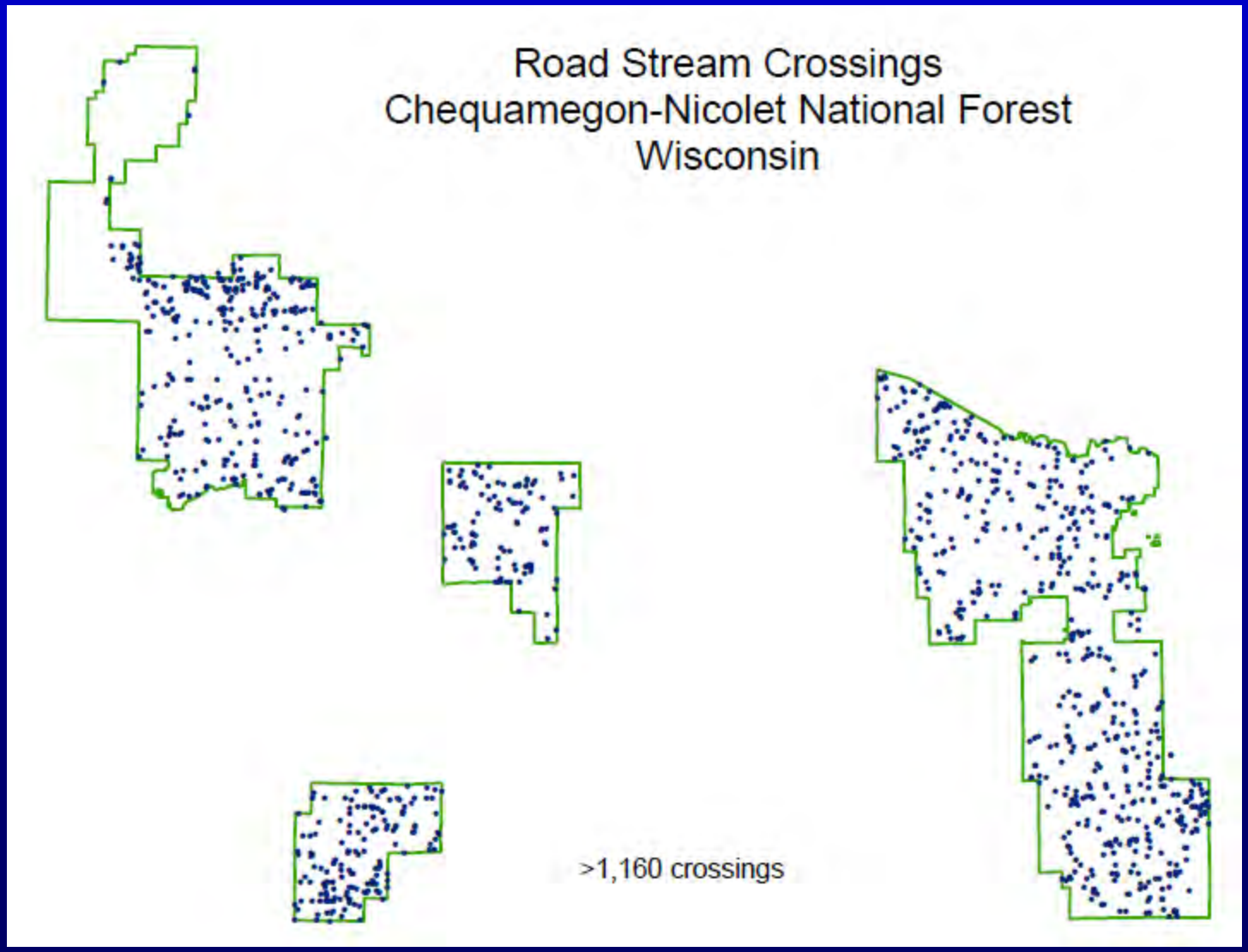
Key Points

Stream Restoration at Road Crossings in N WI

- Large # of road and trail stream crossings on the landscape
- Many crossings adversely impact streams
- Proper replacement of crossings can restore streams

of Crossings: Chequamegon-Nicolet NF

Stream Restoration at Road Crossings in N WI



Number of Crossings: WI

Stream Restoration at Road Crossings in N WI

Road Type	Est # of Crossings
Interstate Hwy	1.3% - 817
US Hwy	3.2% - 1,982
State Hwy	8.6% - 5,381
County Hwy	20.6% - 12,776
Secondary Roads	66.2% - 41,055
Total	**61,971**

WDNR GIS Analysis by Miller, 2008

Stream Crossing Impacts

Stream Restoration at Road Crossings in N WI

- Restrict aquatic organism passage

- Degrade water quality (sediment, water temperature)

- Alter channel morphology (aggradation and scour)

Restoration at Stream Crossings

Stream Restoration at Road Crossings in N WI

- Site assessment especially stream profile survey
- Stream simulation: high and low gradient
- In-stream restoration (where needed)

Low Gradient (<0.5%): BFW-TWC

Stream Restoration at Road Crossings in N WI

- Bankfull width (BFW) - tailwater control (TWC).
- Tailwater provides sufficient depth and velocity to allow AOP
- Sized to match BFW and pass the 100-yr flood (Q_{100}) with a headwater to depth ratio (HW/D) <1 (i.e., below top of culvert)
- Invert elevations are based on analysis of the stream profile
- Invert elevation restores or maintains channel morphology and the natural transport of sediment and organic matter
- Generally no material is placed in the culvert, with exceptions

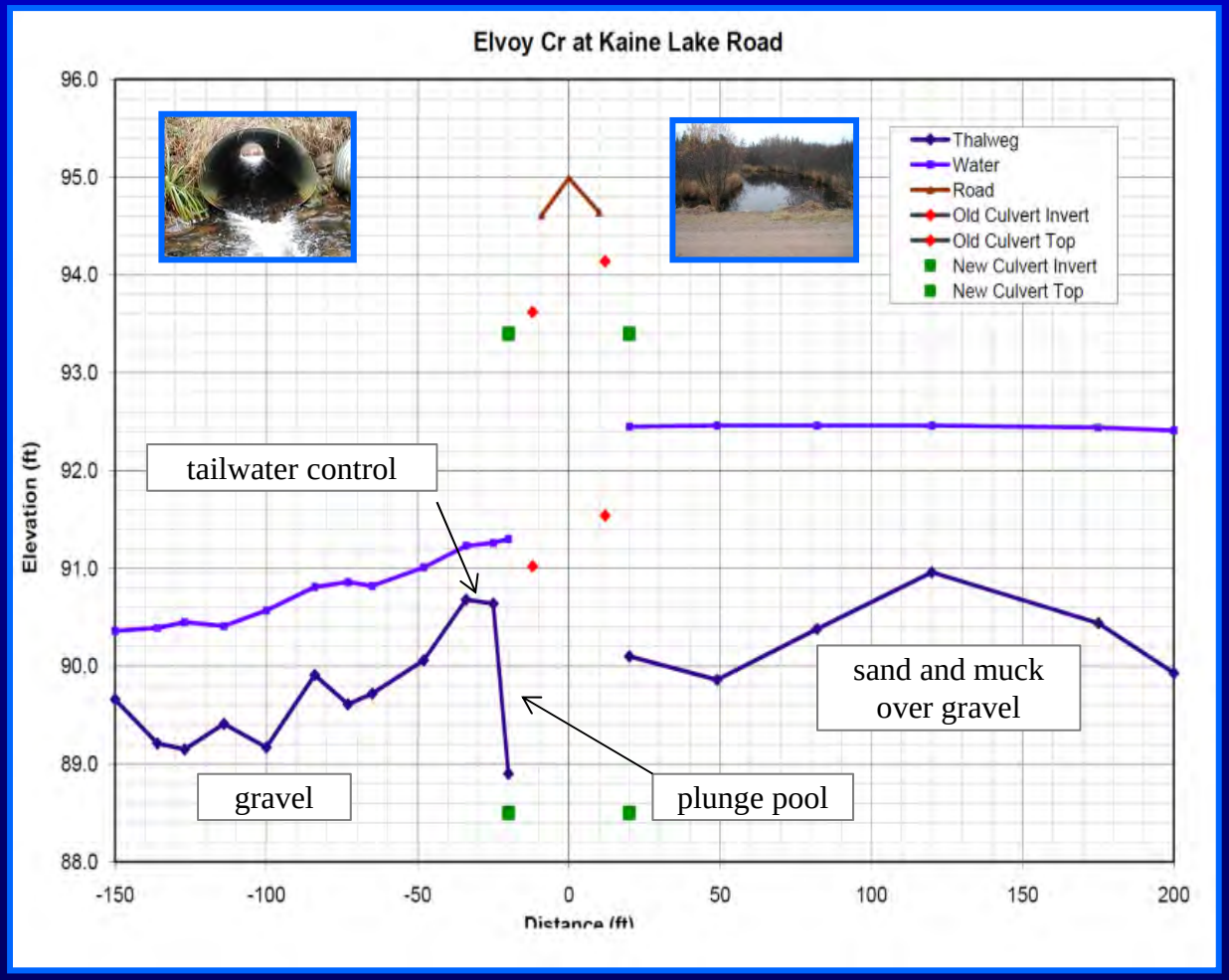
Low Gradient: Inlet Set High

Stream Restoration at Road Crossings in N WI

- Many low gradient streams have slopes of just 0.1-0.2%
- Culverts set just 1.0 ft high can cause water to pond several hundred feet upstream
- Channel aggrades with sand and muck

Low Gradient: Inlet Set High
Upstream Ponding and Aggradation
Stream Restoration at Road Crossings in N WI

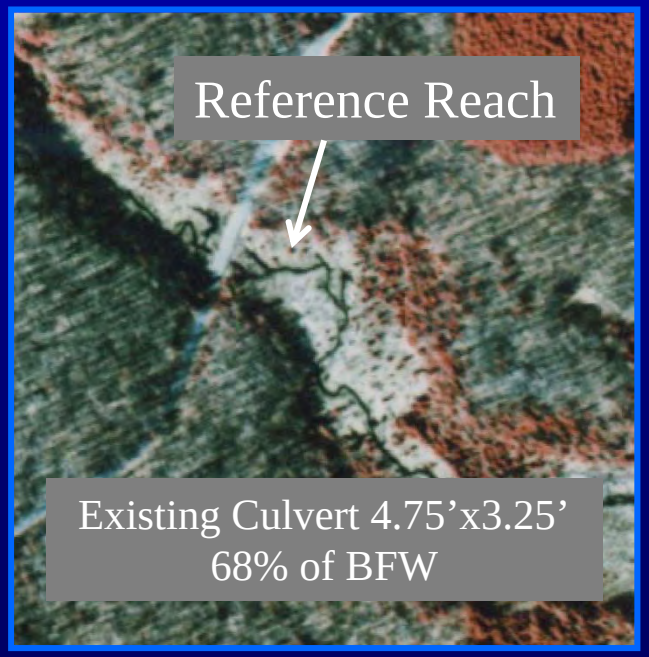
- Culvert replacement can expose gravel buried upstream
- Consider the affect of the tailwater control on upstream aggradation
- Tailwater control may degrade over time or may need to be lowered

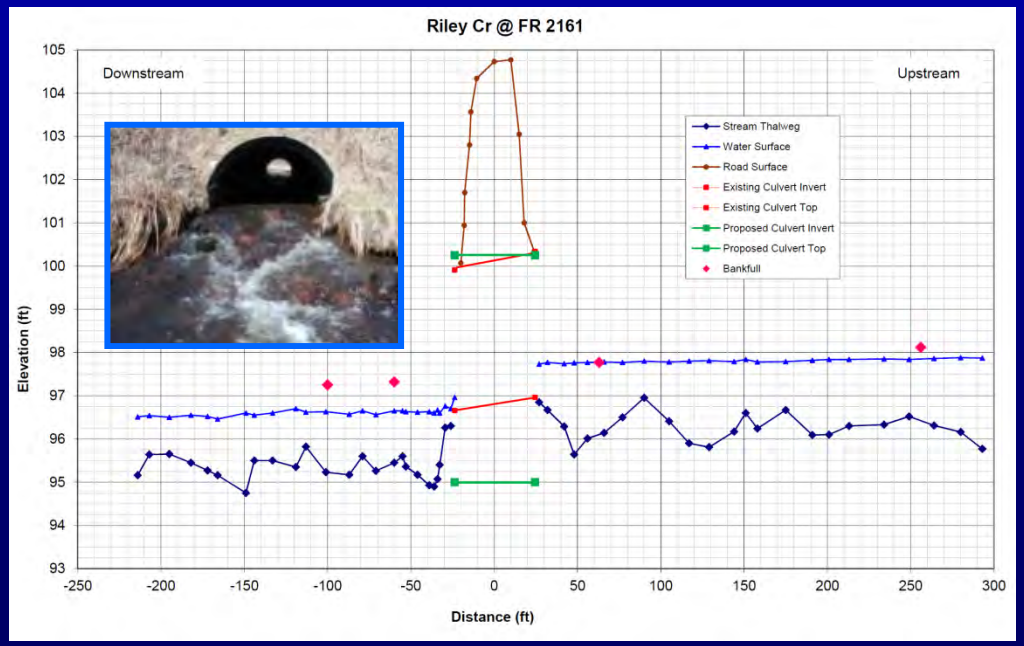


Low Gradient Example: Riley Cr at Forest Road 2161

Stream Restoration at Road Crossings in N WI

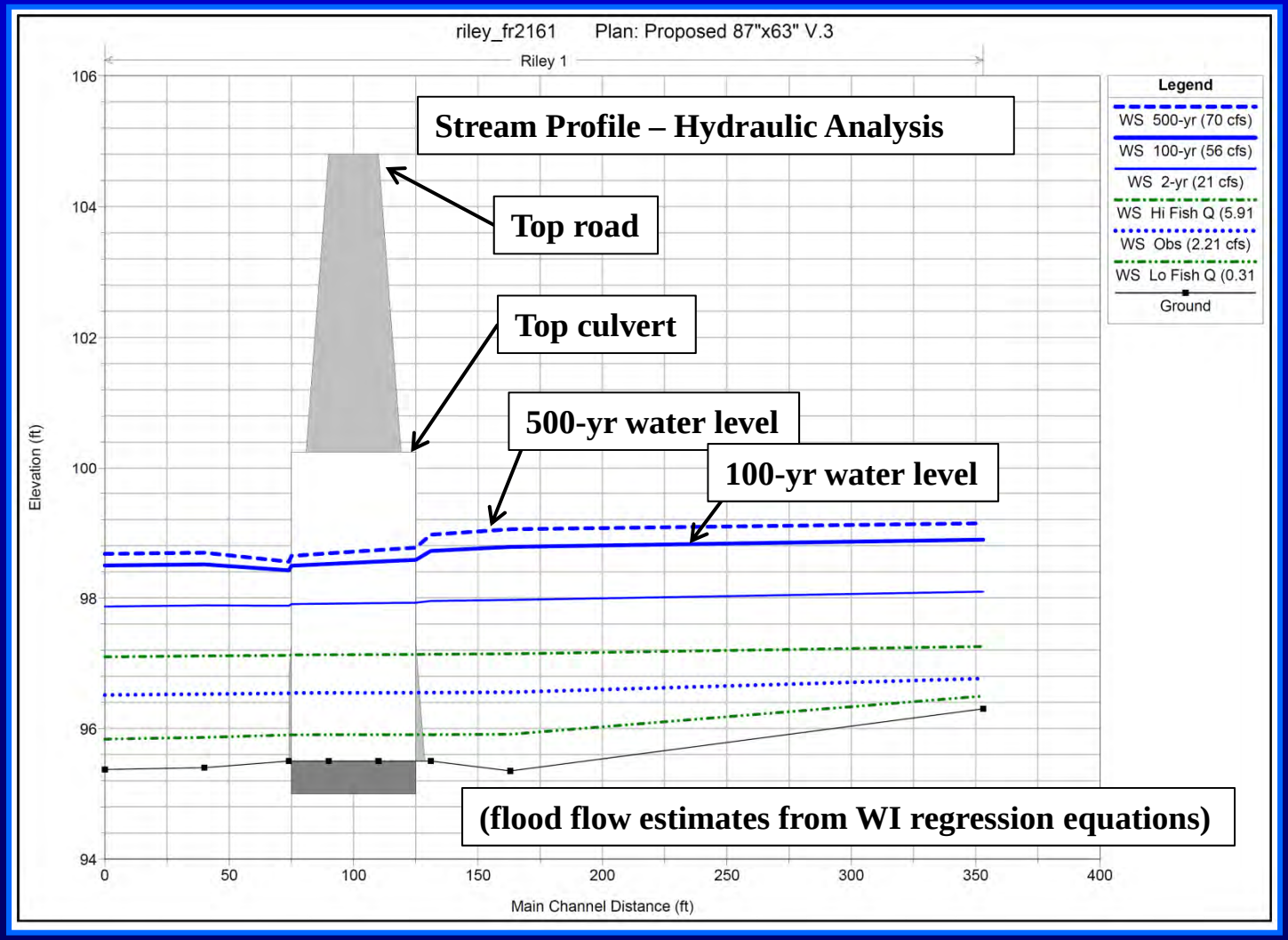
- **Bankfull Width (BFW)**
  - **Min = 7.0 feet**
  - **Mean = 9.2 feet**
  - **Range = 7.0-11.5 feet, n=6**
  - **Drainage Area = 2.25 sq mi**
  - **BFW (E-Reg Eq) = 8.2 ft**





Low Gradient: BFW Culvert Passes Q_{100} With HW/D<1

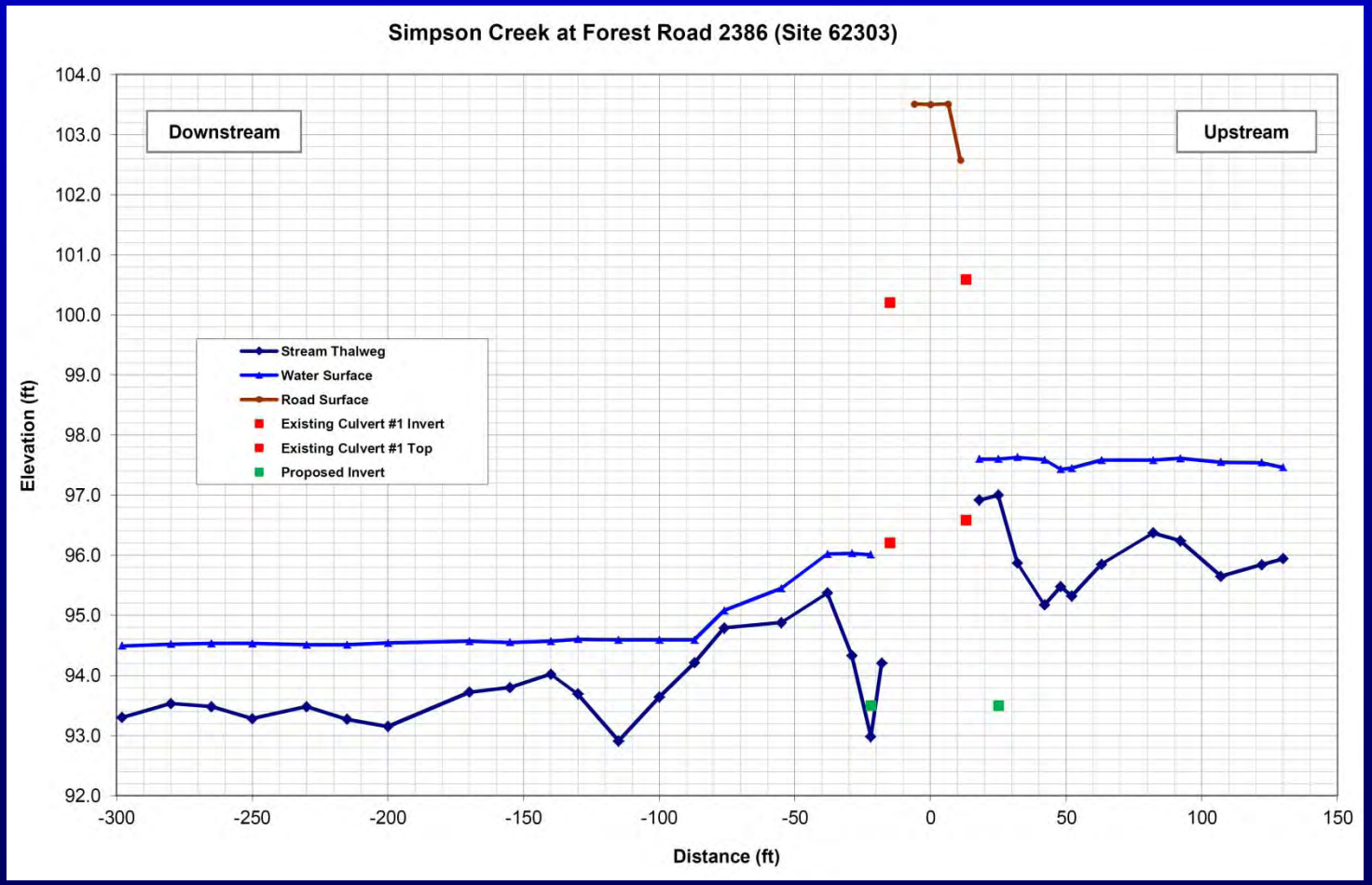
Stream Restoration at Road Crossings in N WI



In N WI watersheds with low flood flows, BFW culverts typically pass the 100-yr discharge with a minor head increase and headwater below the top of culvert.

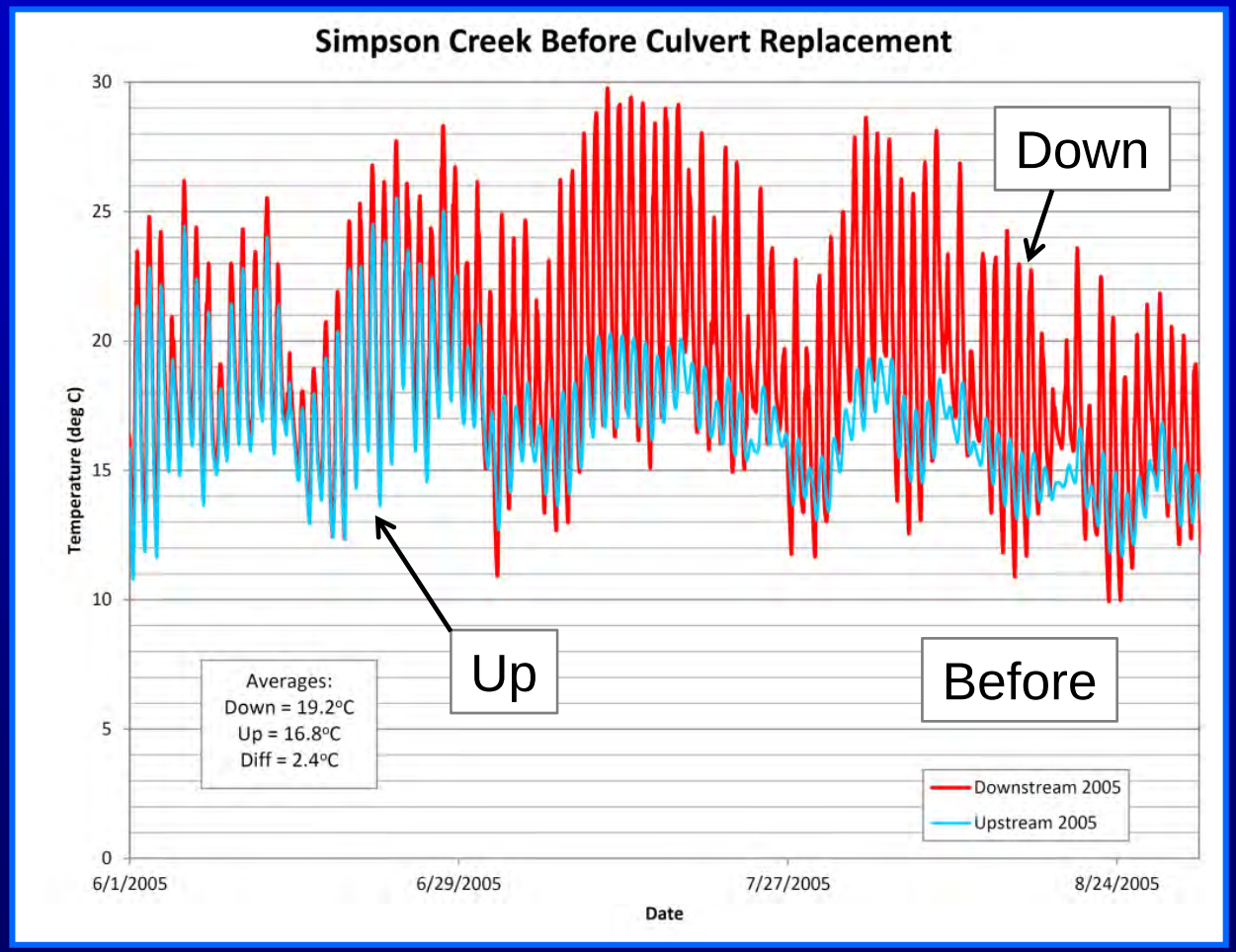
Low Gradient: Undersized Culvert Set Too High Water Temp & other Impacts

Stream Restoration at Road Crossings in N WI



Low Gradient: Undersized Culvert Set Too High Water Temp & other Impacts

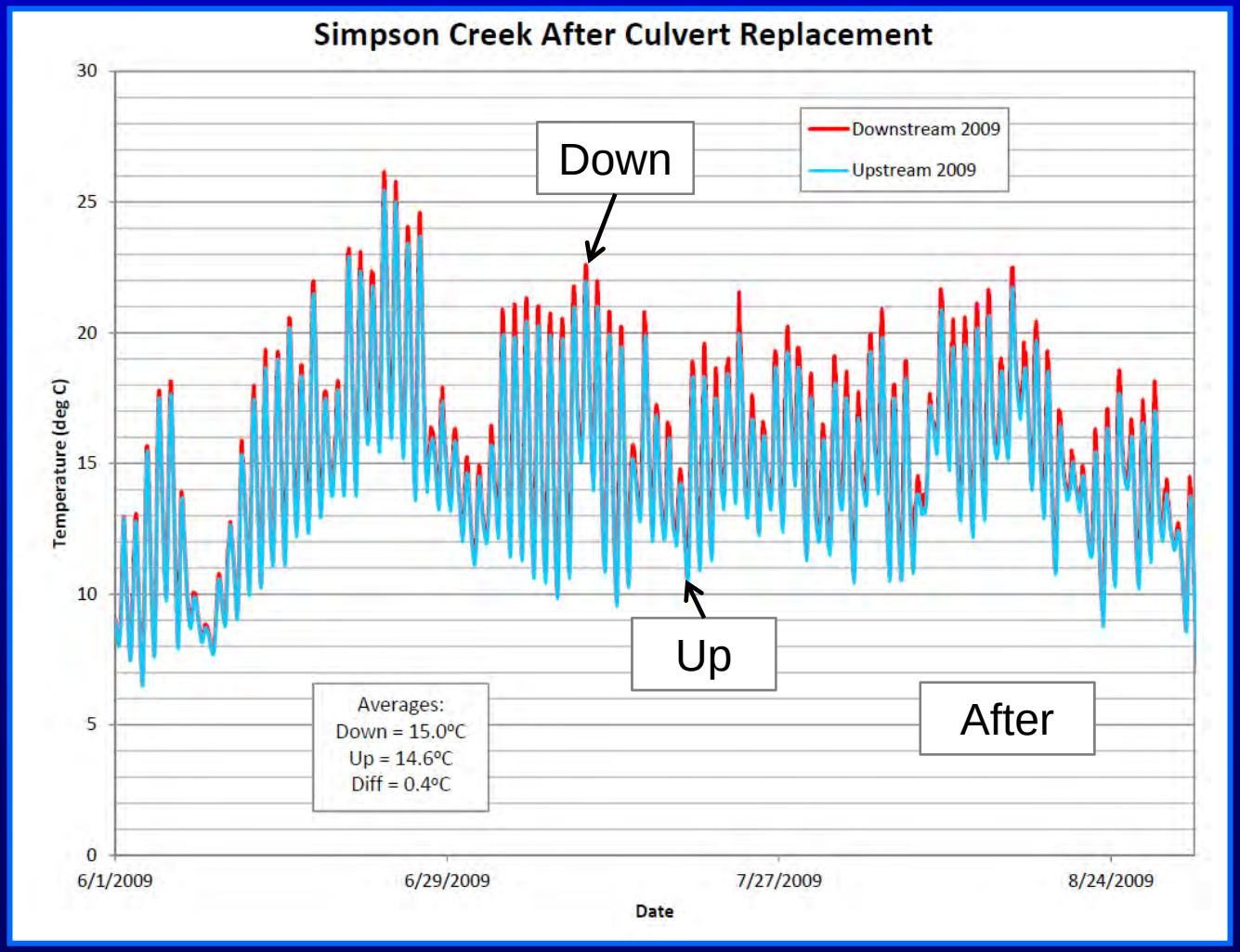
Stream Restoration at Road Crossings



Low Gradient: Undersized Culvert Set Too High

Water Temp & other Impacts

Stream Restoration at Road Crossings



Low Gradient: Structure Considerations

Stream Restoration at Road Crossings in N WI

- May be needed in sand bed streams with low flows
- Without structure to create banks or a thalweg, sand spreads out to create a flat, uniform bed
- Shallow water may impede passage of some sp.

Example of an open-bottom arch from a Michigan.

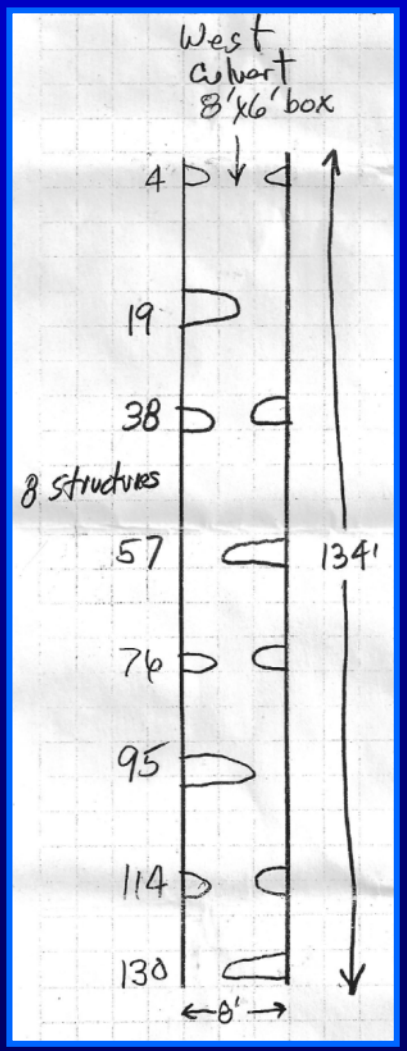
Low Gradient: BFW-TWC

Rock bars for thalweg development: NB Oconto Trib at Hwy 64

Stream Restoration at Road Crossings in N WI

- Culvert width = 8.0 ft
- BFW = 8 ft (ave)
- Culvert width/BFW = 100%
- Culvert length = 135 ft
- CL/BFW = 16.9

- 1 wavelength = 8'x10=80 ft
- 5 bars/wavelength
- Bar spacing=80/5=16 ft
- Total bars=135'/16=8 bars
- Bar spacing adjusted slightly to fit culvert



Low Gradient: BFW-TWC

Rock bars for thalweg development: NB Oconto Trib at Hwy 64

Stream Restoration at Road Crossings in N WI

High Gradient (>1%): Stream Simulation

Stream Restoration at Road Crossings in N WI

- For streams too steep to provide TW control and mobile gravel-cobble beds
- Stream channel constructed through structure
- Provides passage of aquatic organisms, bedload and wood
- Design based on a reference reach
- Structure wider than BFW to allow for stream banks
- Height of structure allows for adjustable bed and passes Q_{100} with HW/D<0.8

Stream Simulation Example: Duck Cr at Hwy 139

Stream Restoration at Road Crossings in N WI

Reference Reach: Duck Cr at Hwy 139

Stream Restoration at Road Crossings in N WI

Mean Bankfull Width = 7.2 ft

Range of BFWs = 5.7-9.9 ft

Key pieces 18-24 inches

Gradient = 3.4%

D50 = 105 mm (small cobble)

Range from sand to boulders

Designing for Aquatic Organism Passage at Road-Stream Crossings

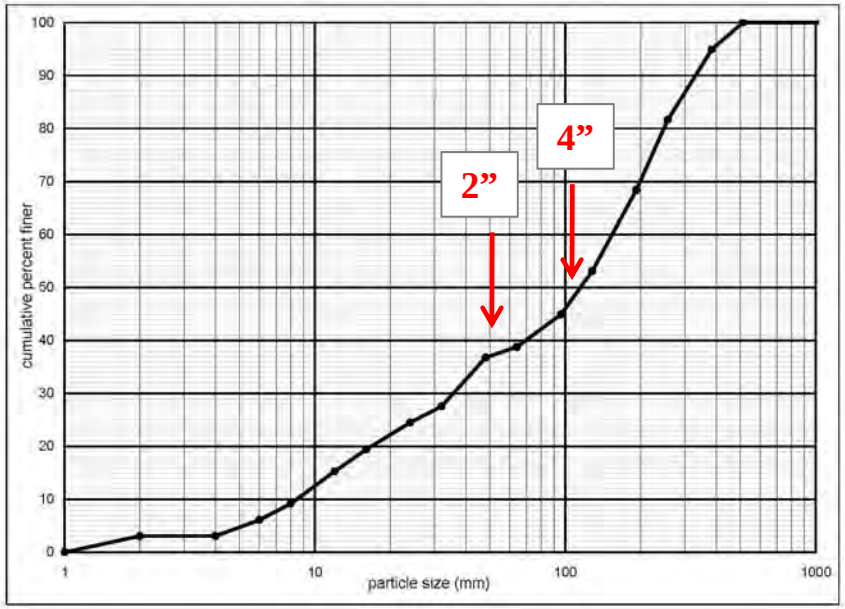
Duck Cr @ Hwy 139 Pebble Count Data, Reference Reach, 118 ft Downstream from Upper Crossing

particle size interval name	size interval (mm)	count or frequency	percent frequency	cumulative percent finer
v large boulders	2048 to 4096	0	0.00	100.00
large boulders	1024 to 2048	0	0.00	100.00
medium boulders	512 to 1024	0	0.00	100.00
small boulders	384 to 512	5	5.10	94.90
	256 to 384	13	13.27	81.63
large cobbles	192 to 256	13	13.27	68.37
	128 to 192	15	15.31	53.06
small cobbles	96 to 128	8	8.16	44.90
	64 to 96	6	6.12	38.78
very coarse gravel	48 to 64	2	2.04	36.73
	32 to 48	9	9.18	27.55
coarse gravel	24 to 32	3	3.06	24.49
	16 to 24	5	5.10	19.39
medium gravel	12 to 16	4	4.08	15.31
	8 to 12	6	6.12	9.18
fine gravel	6 to 8	3	3.06	6.12
	4 to 6	3	3.06	3.06
very fine gravel	2 to 4	0	0.00	3.06
sand, silt, or clay	< 2	3	3.06	0.00
	Total count	98	100.00	

Project Name:	Duck Cr @ Hwy 139
Sample ID:	Reference Reach
Sample Date:	11/16/2007
Sampler Name:	Higgins and Mineau
Sample Locaton:	118 ft Below Upper Xing
Sample Method:	transect method, perpendicular to flow, bankfull.

percentile	particle size (mm)
d95	400
d84	270
d50	120
d16	13
d5	5

% boulders	18.37
% cobbles	42.86
% gravels	35.71
% sands,silts,clays	3.06



Channel Materials: Duck Cr at Hwy 139

Stream Restoration at Road Crossings in N WI

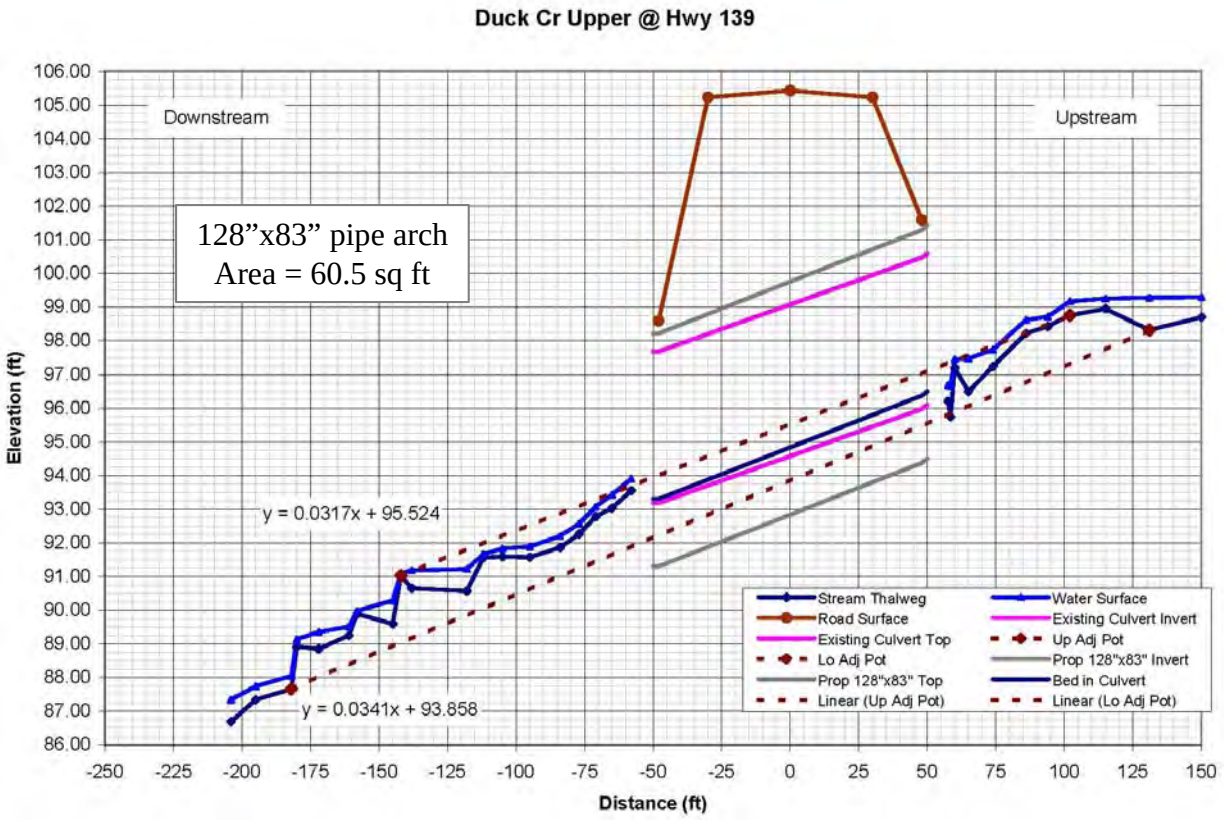
Streambed Mix for Duck Cr Culverts at Highway 139

Size (inches)	% Passing	% by Volume	Size Range	Volume Needed (cu yds)		
				Lower Xing	Upper Xing	Both
20	100	15	12-20"	15	11	25
12	87	15	8-12"	15	11	25
8	70	25	4-8"	25	18	42
4	45	10	2-4"	10	7	17
2	37	15	3/4-2"	15	11	25
<3/4	22	20	sand-3/4"	20	14	34
Total		100		100	70	170

Note: volume assumes 0.7 cu yd/ft of culvert length
Note: also need 410 rocks 18-24", 320 for banks and 90 for bands

Design Profile: Duck Cr at Hwy 139

Stream Restoration at Road Crossings in N WI




Bobcat
MT55
SCHAEFER

Stream Simulation Reference

Stream Restoration at Road Crossings in N WI

Stream Simulation: An Ecological Approach to Providing Passage for Aquatic Organisms at Road-Stream Crossings

USDA Forest Service National Technology and Development Program, 7700—Transportation Management, 0877 1801—SDTDC, May 2008

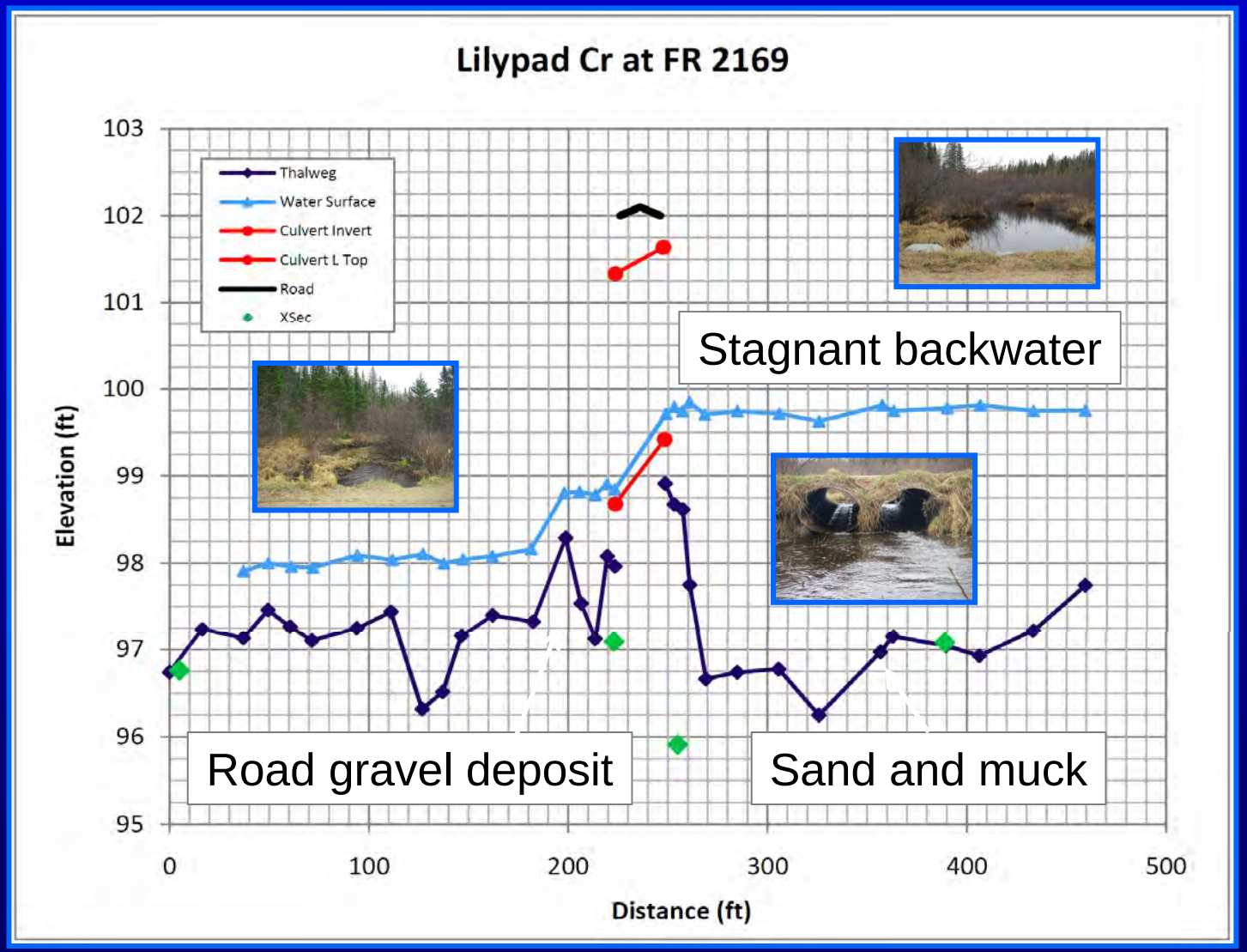
In-Stream Restoration at Crossings

Stream Restoration at Road Crossings in N WI

- High tailwater control, braiding
- Aggradation from failures
- Cutoff meander

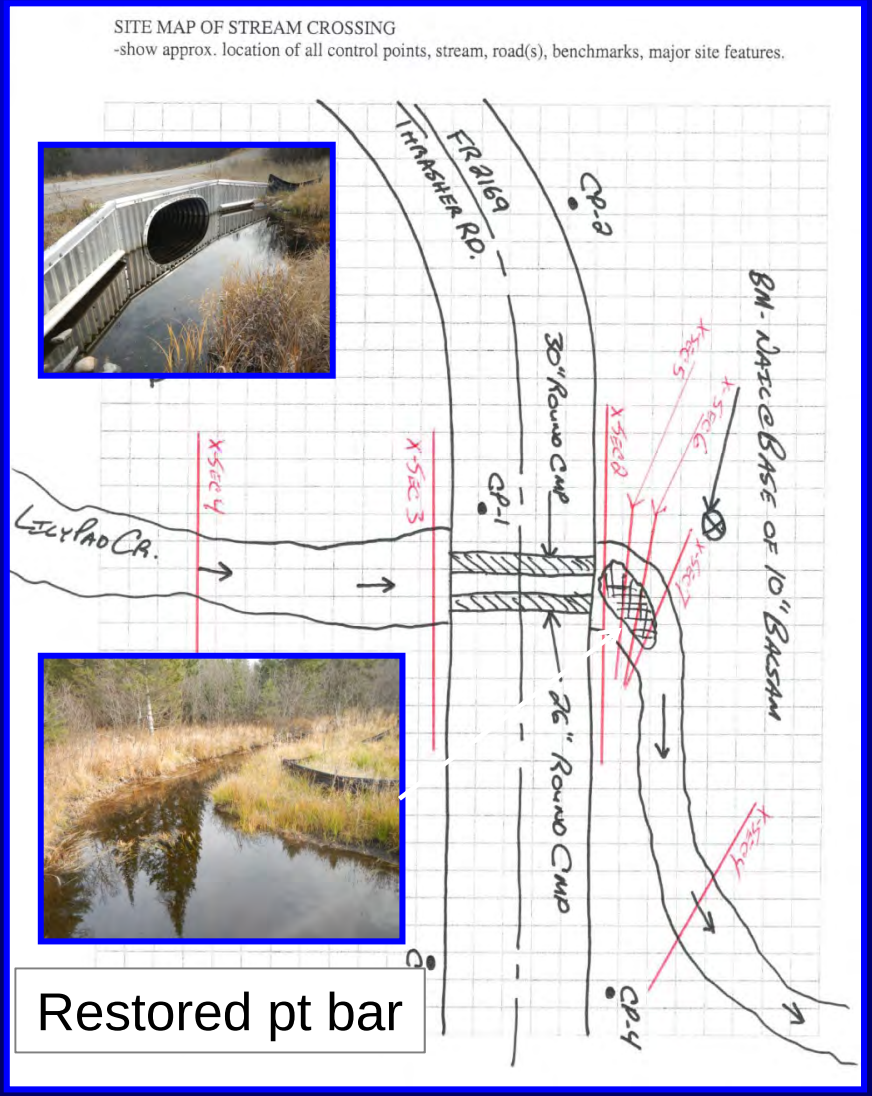
High TW Control and Braiding

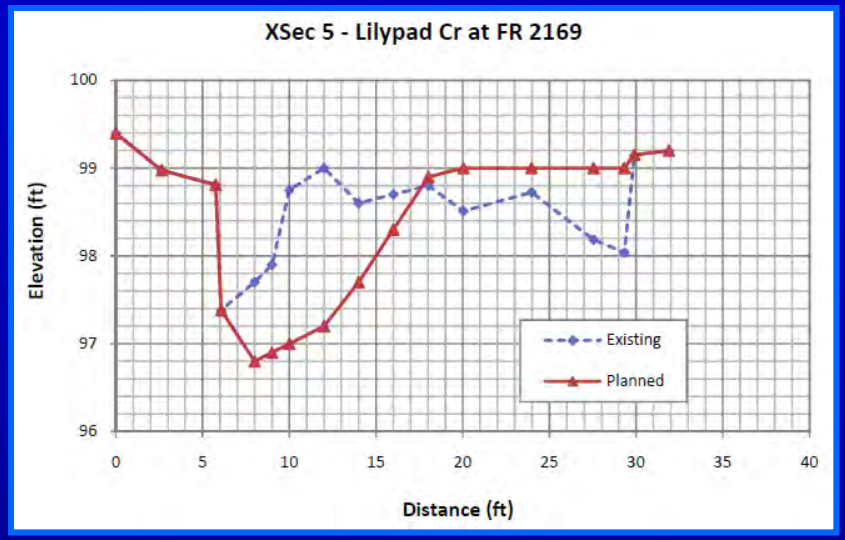
Stream Restoration at Road Crossings in N WI

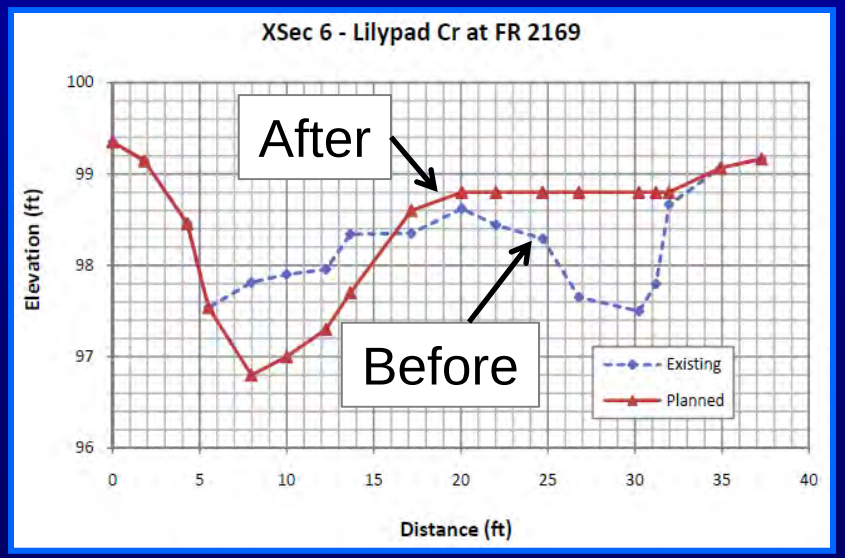


High TW Control and Braiding

Stream Restoration at Road Crossings in N WI

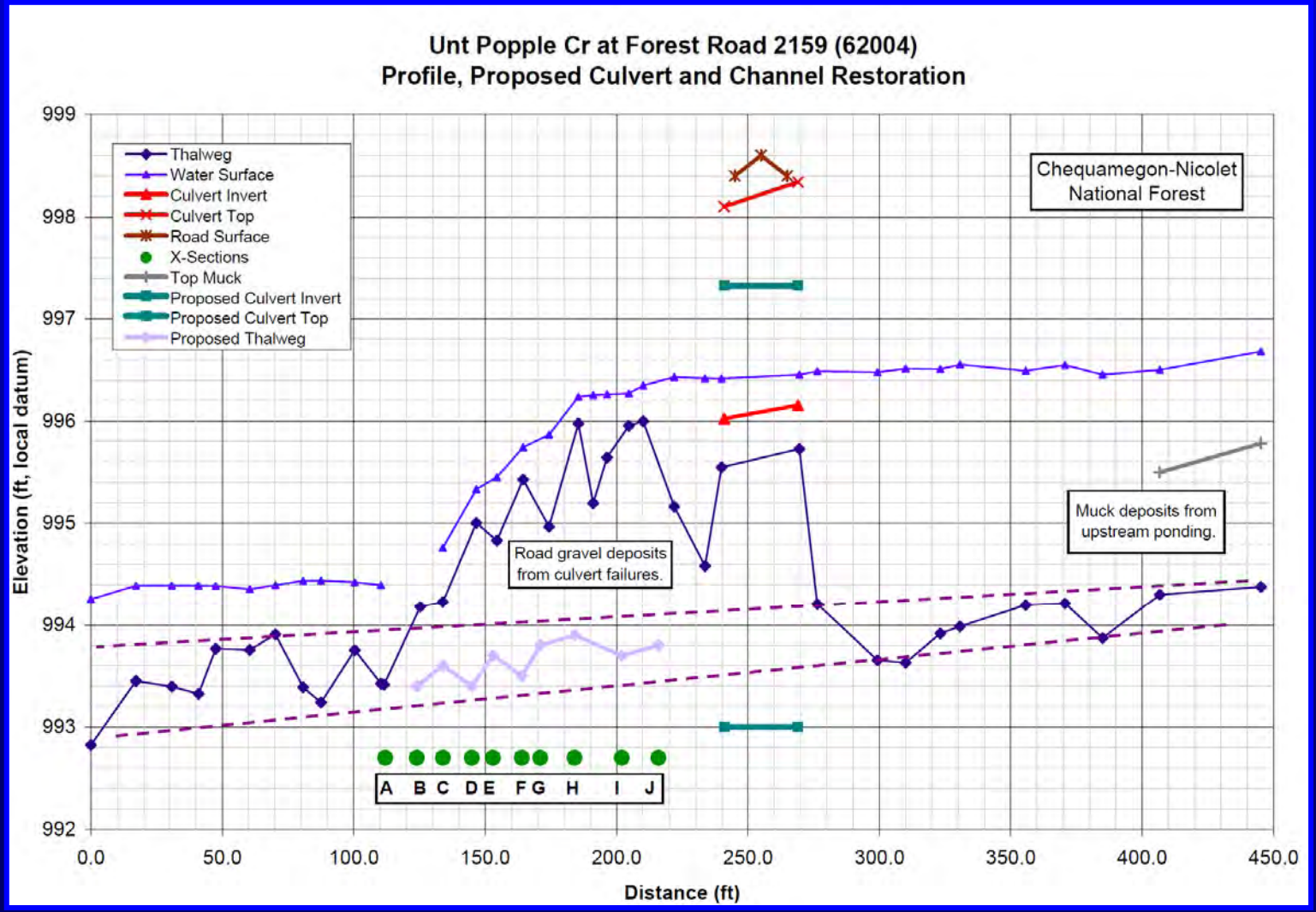






Aggradation from Frequent Failures

Stream Restoration at Road Crossings in N WI



Aggradation from Frequent Failures

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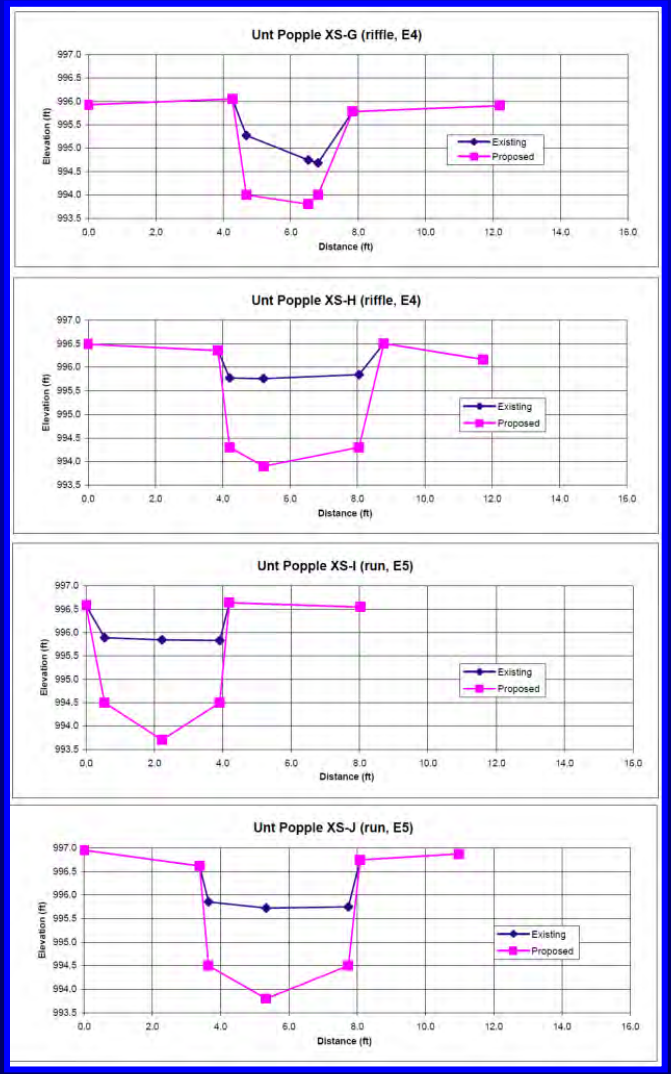

Downstream road sediment removal to restore stream profile and dimensions.

Restore Cutoff Meander: Armstrong Cr

Stream Restoration at Road Crossings in N WI