CLARK CREEK WATERSHED STUDY

TECHNICAL MEMORANDUM 3

JULY 2012

PREPARED FOR

SAUK COUNTY, WISCONSIN
CONSERVATION, PLANNING AND ZONING DEPARTMENT

Montgomery Associates
Resource Solutions, LLC

119 South Main Street • Cottage Grove, WI 53527 ph 608.839.4422 fx 608.839.3322 • www.ma-rs.org

TABLE OF CONTENTS

LIST OF ATTACHMENTS

1 INTRODUCTION

This memorandum summarizes analysis by Montgomery Associates: Resource Solutions, LLC (MARS) of several flood mitigation measures in portions of the headwaters of Clark Creek within Devil's Lake State Park. Recent discussions between DNR and Sauk County representatives have focused on flood mitigation measures that are consistent with DNR's existing management plan for the area. This study evaluated three options in the Quarry Tributary and Southern Tributary subwatersheds of Clark Creek (**Figure 1**):

1. Shallow wetland scrapes adjacent to headwater tributary channels to create additional flood storage.
2. Conversion of agricultural land in DNR's share cropping program to native prairie vegetation to reduce storm runoff.
3. Earthwork to create a hummocky topography in areas to be restored as prairie to provide detention of stormwater runoff from adjacent areas.

The scope of this study was to develop conceptual designs for these options, evaluate their effectiveness at flood mitigation, and develop planning level cost estimates to support decisions by Sauk County about how to proceed.

2 DATA SOURCES AND METHODS

2.1 DATA SOURCES

Watershed Hydrologic Model
Flood discharge of Clark Creek was evaluated using a rainfall-runoff model of the watershed constructed by Montgomery Associates using the U.S. Army Corps of Engineers watershed analysis program HEC-HMS. This model is a modified version of the model developed by the DNR for the Flood Insurance Study (FIS) for Clark Creek.

Clark Creek Hydraulic Model
The impact of reduced flood discharge on the water surface elevation, channel velocity and shear, and flooded valley width was evaluated using the hydraulic model developed in the FEMA FIS for Clark Creek, which uses the U.S. Army Corps of Engineers program HEC-RAS.

Rainfall and Watershed Conditions
This analysis evaluated the 2-year, 10-year, and 100-year events, as well as the June 12, 2008 design storm which was larger than the 100-year event. The analysis of the June 2008 flood is documented in the MARS 2011 Clark Creek Watershed Study report, and it uses the FEMA FIS 100-year rainfall of 5.92 inches and extremely wet watershed soil conditions (Antecedent Moisture Condition 3). This study used the 24-hour rainfall depths included in the DNR hydrologic analysis for the FEMA FIS for the 10-year and 100-year rainfalls. The 2-year rainfall depth was taken from Technical Paper 40, because this event was not included in the FIS study. Rainfall distribution for all events used the curve developed for the FIS based on data from the City of Madison.

Table 1. 24-hour rainfall depths

Storm Event	Rainfall Depth (in)
2-year event	2.9
10-year event	3.98
100-year event	5.92
June 12, 2008 design event	5.92

Topography
Data used to define the elevations of wetland scrapes and adjacent areas for the hydraulic analysis of floodplain storage (described below) include two-foot contours from the Sauk County LIDAR survey and a GPS survey conducted by NRCS in December 2011. Additionally, field measurements of channel cross-sections conducted by MARS were used to supplement the survey data.

Potential Wetland Scrape Locations
The wetland scrape areas shown in **Figure 1** were identified as suitable areas for wetland restorations on a drawing marked up by Sue Josheff and Jeff Schure of the DNR in June 2012, based on mapped information on soil conditions and existing land cover.

2.2 METHODS

Wetland Scrapes for Floodplain Storage

The approach to simulate the effect of wetland scrapes adjacent to the Quarry and Southern Tributaries was to construct HEC-RAS hydraulic models of these two reaches to evaluate storage volume – discharge relationships. These relationships were developed for both existing and proposed conditions to evaluate the flood mitigation benefit of the scrapes. The storage – discharge relationships were input to HEC-HMS model storage nodes to evaluate their impact on downstream flood discharge. This is the same method used by DNR in the Flood Insurance Study to evaluate the storage routing effect of the natural wetland north of Tower Road.

The locations of the scrapes (**Figure 1**) were digitized based on the drawing of suitable locations obtained from DNR. Scrapes were assumed to have a typical depth of 1.5 – 2 feet, consistent with standard restoration practice and not exceeding the likely depth to groundwater (assumed to be the adjacent stream channel invert). The actual depth of scrapes for wetland restoration would likely range from zero to four feet, to produce a variety of habitat conditions.

Hydraulic model cross section locations are shown in **Figure 2**, and cross section plots are included in **Appendix A**. A wide range of discharges from low flow to large flood conditions were simulated. The hydraulic model computed the water surface elevation at each cross section. Storage for the stream reach at each discharge was computed by HEC-RAS, based on the wetted area at each cross section and the distance downstream to the next cross section. Table of discharge and storage volume were exported from HEC-RAS for use in the HEC-HMS model (see **Appendix A**).

The impact of the increased flood storage of the wetland scrapes on downstream discharge was analyzed with the HEC-HMS model. New storage nodes were added to the model in the Quarry and Southern Tributary wetland scrape areas, with storage-discharge relationships defined using the relationships determined with HEC-RAS for existing and proposed conditions. HEC-HMS model schematic layouts are shown in **Appendix B**. Peak flood discharge was evaluated at the HEC-HMS node located 1000 feet upstream of the first STH 113 crossing, near the Maxwell Farm, because this is the beginning of the reach of Clark Creek that has experienced the most consistent flood damages.

Land Conversion to Prairie

State-owned land that is currently farmed but is planned for eventual conversion to prairie is shown on **Figure 1**. The hydrologic impact of this future land use conversion was evaluated by changing the runoff curve numbers in the HEC-HMS watershed model to represent prairie cover. Because the prairie conversion areas are subsets of HEC-HMS model subwatersheds, composite curve numbers were calculated for each subwatershed to represent new prairie areas within the surrounding land cover which will remain the same as existing conditions. Composite curve numbers are summarized in **Table 2**. A curve number of 58 was used to represent prairie for Antecedent Moisture Condition (AMC) II. Curve numbers for Antecedent Moisture Condition III were calculated with the following equation[1]:

[1] Chow, VT, DR Maidment and LW Mays, 1988. Applied Hydrology. McGraw – Hill, New York.

$$CN(III) = \frac{23CN(II)}{10 + 0.13CN(II)}$$

The calculated curve number for prairie for Antecedent Moisture Condition III is 76.

Table 2. Composite curve numbers for subwatersheds with prairie conversion areas

		Existing Conditions		Converted to Prairie	
Subwatershed	Area (Acres)	AMC II	AMC III	AMC II	AMC III
R50W20	553.6	63.9	79.3	63.1	78.8
R130W40	196.5	58.8	75.8	56.2	74.6
R110W70	242.9	62.5	78.8	58.7	76.2
R110W70-2	242.9	55.4	74.0	55.0	73.8
61	70.7	71.7	84.9	59.4	76.9
63	225.1	60.2	77.3	55.9	74.4
R100W50	226.6	58.9	76.4	57.7	75.6

Prairie Detention

This option would entail earthwork to create a hummocky pattern of shallow depressions and ridges in parts of the agricultural fields that will be restored to prairie. This would create a natural variation in topography and moisture conditions, while the depressions would provide detention of stormwater runoff from the adjacent landscape. The area considered in this analysis is south of Tower Road, near the western edge of the large agricultural field (**Figure 1**). The total area shown for this feature is 5 acres. We assumed that half of this area (2.5 acres) would be depressions that could store runoff with an average ponding depth of 1 foot, providing 2.5 acre-feet of storage.

The HEC-HMS model was modified to simulate this feature by adding a storage node downstream of subwatershed 61, representing the agricultural field south of Tower Road. For analysis purposes, the numerous depressions were combined into a single basin with an area of 2.5 acres and a depth of 1 foot. Additional model runs with two and four times this storage volume were completed to evaluate the benefit of expanding the area of hummocky topography creation.

Downstream Impact of Reduced Flood Discharge

The impact of the flood peak discharge reduction on conditions downstream along Clark Creek was analyzed with the HEC-RAS hydraulic model of Clark Creek developed for the FEMA Flood Insurance Study. Three model cross sections were evaluated: near the Maxwell Farm (RS 5162), along STH 113 below the 2nd culvert (RS 3731), and immediately upstream of CTH W (RS 2758), as shown on **Figure 3**. At each location, the water surface elevation, channel velocity and shear stress, and width of inundation were evaluated for a range of peak discharges.

3 FLOOD MITIGATION PERFORMANCE

Scenarios analyzed (**Table 3**) include the following:

1. Conditions existing at the time of the June 2008 flood.
2. Addition of wetland scrapes on the Quarry and Southern Tributaries, as shown on **Figure 1**.
3. Conversion of state-owned agricultural lands to prairie, in addition to the wetland scrapes in Scenario 2.
4. Creation of 2.5 ac-ft of prairie depression storage in the location shown on the attached figure, in addition to the prairie conversion and wetland scrapes of Scenario 3.
5. Same as Scenario 4, but double the prairie depression storage area (deeper depressions and/or larger extent).
6. Same as Scenario 4, but four times the prairie depression storage area (deeper depressions and/or larger extent).

Both the wetland scrapes and prairie conversion provide significant peak flood discharge reduction. The addition of prairie depression storage to these other two measures creates less benefit, and increasing the storage area beyond that shown in the attached figure does not further reduce flood discharge. This indicates that (provided that the wetland scrapes are also constructed) the prairie storage shown in **Figure 1** is adequate to detain runoff from its tributary area, and making the storage area bigger results in an over-sized detention system.

The downstream benefits of reduced flood discharge would be realized as lower water surface elevations, reduced flow velocity and erosive power, and a narrower portion of the floodplain that would be inundated. The hydraulic model from the FIS was used to evaluate the effects of reduced discharge at three downstream cross sections (**Figure 3)**. Results in **Table 4** are presented both in terms of the percentage of the June 12, 2008 peak discharge and the total discharge in cubic feet per second, to allow comparison with the different scenarios in **Table 3**.

Table 3. Peak flood discharge (cfs) 1000 ft upstream of the uppermost STH 113 culvert and % reduction from existing conditions discharge

Scenario	June 2008 event	100 yr event	10 yr event	2 yr event
1) Existing Conditions	1002 cfs	484 cfs	163 cfs	52 cfs
2) Wetland scrapes on Southern Tributary and Quarry Tributary	959 cfs 4%	435 cfs 10%	128 cfs 21%	39 cfs 26%
3) Wetland scrapes + conversion of share cropped land to prairie	910 cfs 9%	377 cfs 22%	103 cfs 37%	31 cfs 41%
4) Wetland scrapes + conversion of share cropped land to prairie + prairie depression storage south of Tower Rd. (2.5 ac-ft)	911 cfs 9%	380 cfs 21%	98 cfs 40%	30 cfs 43%

Scenario	June 2008 event	100 yr event	10 yr event	2 yr event
5) Wetland scrapes + conversion of share cropped land to prairie + prairie depression storage south of Tower Rd. (5.0 ac-ft)	886 cfs 12%	361 cfs 25%	98 cfs 40%	30 cfs 43%
6) Wetland scrapes + conversion of share cropped land to prairie + prairie depression storage south of Tower Rd. (10.0 ac-ft)	859 cfs 14%	361 cfs 25%	98 cfs 40%	30 cfs 43%

Table 4. Change in flood elevation, channel velocity and width of flooded area at three locations in lower Clark Creek for different peak flood discharge reductions

	Reduction from June 12, 2008 flow	Flow (cfs)	WS Elev (ft)	Channel Vel (ft/s)	Flooded Width (ft)	Channel Shear (lbs/ft^2)
RS 5162	0%	1022	924.1	12.4	82.1	7.7
	5%	971	924.0	12.0	79.1	7.3
	10%	920	924.0	11.6	76.2	6.8
	20%	818	923.8	11.1	63.1	6.3
	30%	715	924.0	9.2	74.1	4.3
	50%	511	923.4	8.2	47.0	3.6
	70%	307	922.6	7.5	36.5	3.2
	90%	102	921.3	6.4	18.9	2.6
RS 3731	0%	1242	883.7	11.0	77.1	6.6
	5%	1179.9	883.6	10.9	75.8	6.5
	10%	1117.8	883.6	10.8	75.2	6.4
	20%	993.6	883.5	10.4	73.9	6.0
	30%	869.4	883.4	10.0	72.6	5.6
	50%	621	883.1	8.5	69.3	4.2
	70%	307	882.54	7.32	41.99	3.28
	90%	102	881.19	5.9	16.7	2.37
RS 2758	0%	1242	855.4	7.7	186.4	2.8
	5%	1179.9	855.3	7.6	173.4	2.7
	10%	1117.8	855.3	7.4	163.5	2.6
	20%	993.6	855.1	7.0	143.9	2.3
	30%	869.4	854.9	6.6	127.2	2.1
	50%	621	854.4	5.8	97.9	1.7
	70%	307	853.7	4.7	40.3	1.2
	90%	102	852.4	3.4	25.0	0.7

4 PLANNING LEVEL COSTS

Estimated costs for the wetland scrapes, agricultural land to prairie conversion, and prairie detention creation are summarized in **Table 5**, with details in **Appendix C**. These estimates are based on the conceptual level designs discussed in this report, using unit rates provided by Sauk County and from the Wisconsin Department of Transportation average unit price list. An opinion of probable cost should be prepared in the future when final designs are developed.

Table 5. Planning level cost estimates

Restoration Measure	Estimated Cost	Estimated Cost with 50% Contingency
Wetland scrapes	$278,300	$417,500
Conversion to prairie	$112,000	$168,000
Prairie depression storage creation (Scenario 5: 5 ac-ft of storage)	$33,200	$49,800

These estimates include measures to establish vegetation during the first year of the restoration project. Long-term maintenance, such as mowing and herbicide treatment for invasive species control, will also be necessary, but those costs are not included in these estimates.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

- The wetland scrapes and conversion of share cropped land to native prairie vegetation have similar potential to reduce peak flood discharge. In combination, they could create reductions of approximately 40% for smaller floods such as the 2-year and 10-year events, and 10 - 20% for the 100-year and larger events.
- The creation of topographic depressions to detain runoff within the restored prairie area has smaller potential benefits. It could add a few percent reduction in peak discharge for the 100-year and larger events. It would have little impact on smaller, more frequent floods.
- Conversion of cropland to prairie is the most cost-effective of the three measures evaluated for flood discharge reduction.

5.2 RECOMMENDATIONS

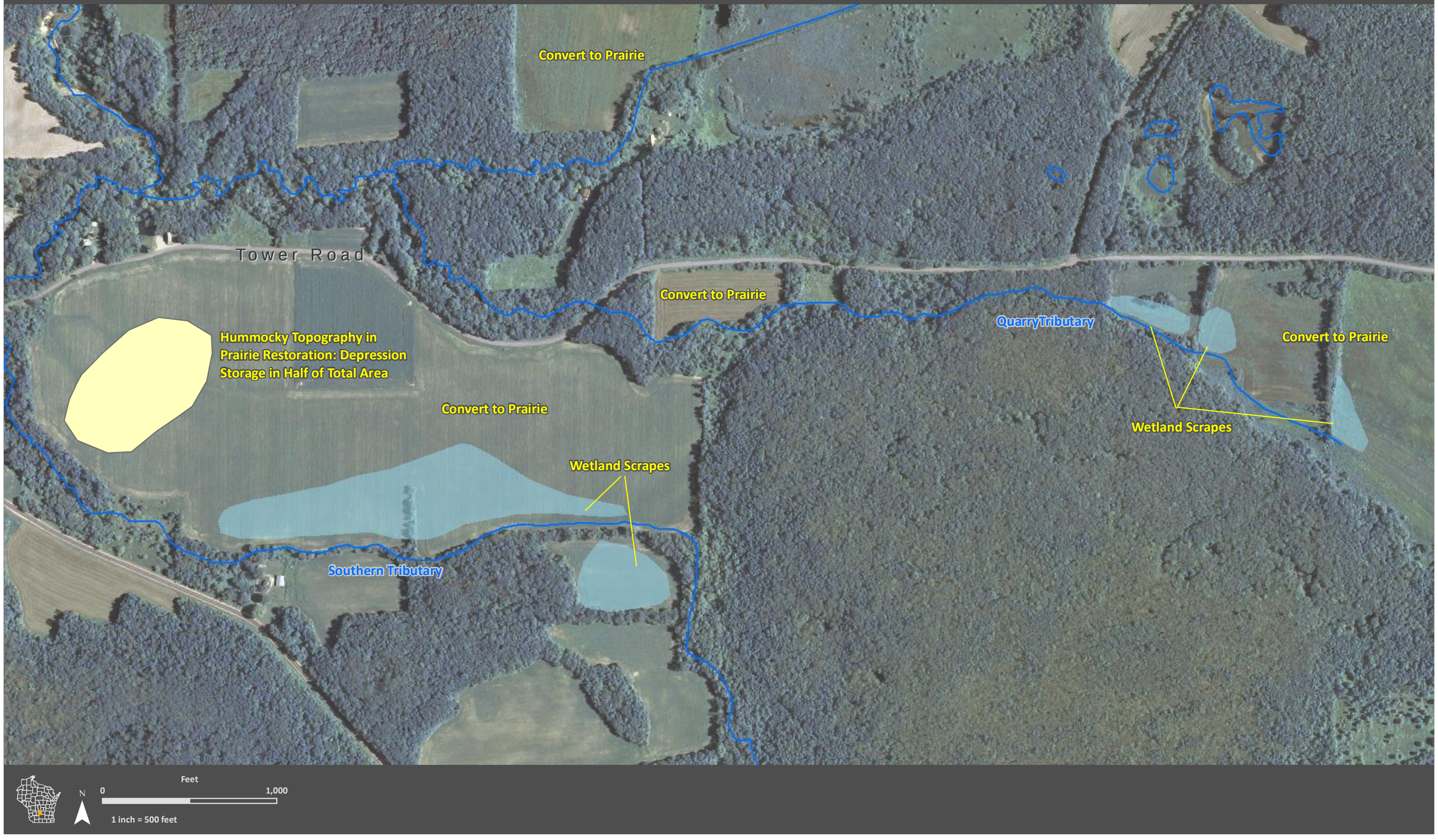
1. We recommend further consideration of the wetland scrape creation and the conversion of agricultural land to native prairie vegetation.
2. Earthwork to create additional runoff storage in prairie restoration areas may not be cost effective to warrant further consideration.

FIGURES

Clark Creek Watershed Study
Sauk County, WI

Figure 1
Flood Mitigation Measure Locations

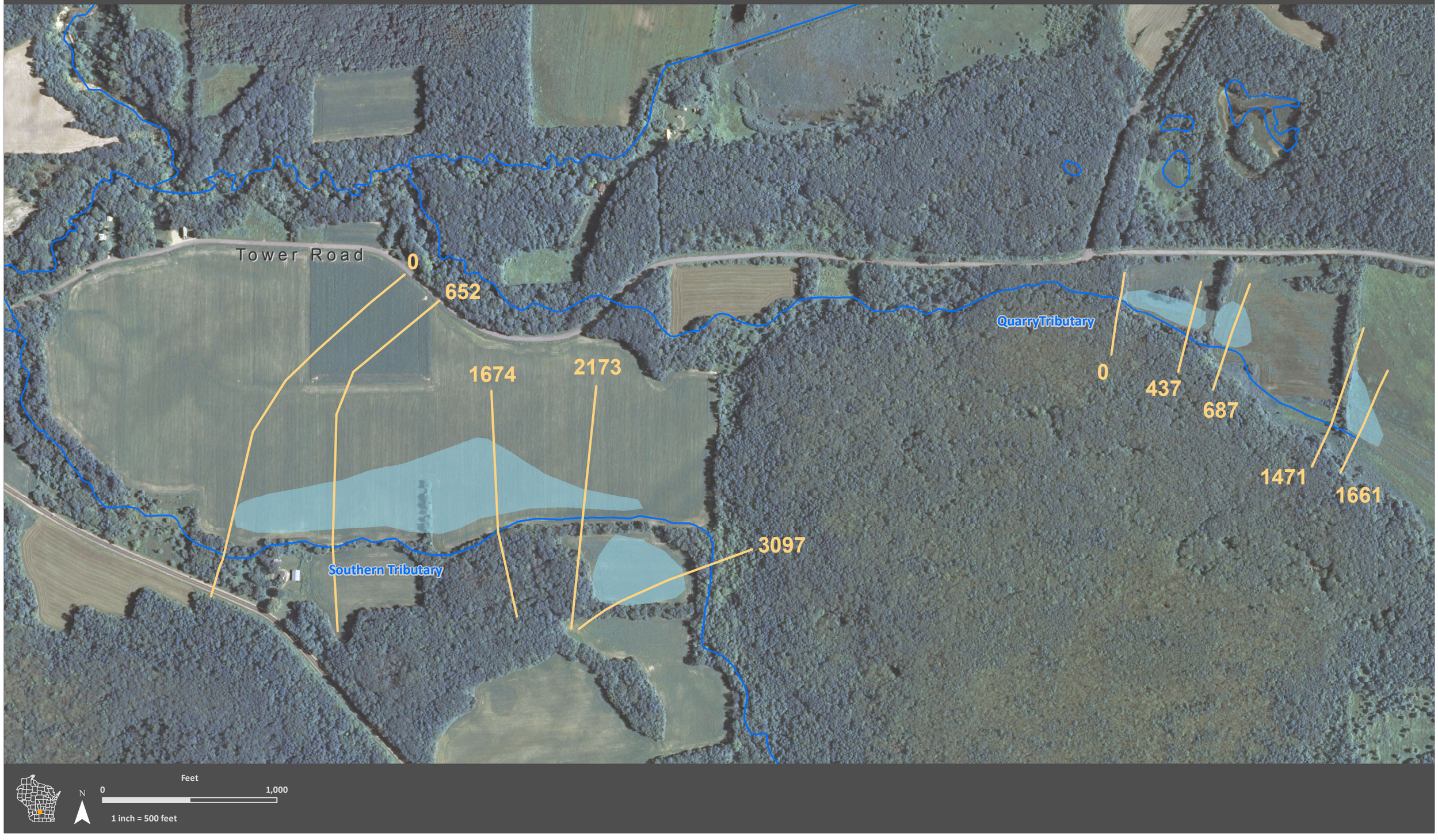
Montgomery Associates: Resource Solutions, LLC
119 South Main Street, Cottage Grove, WI 53527
(608) 839-4422 | www.ma-rs.org | 06/27/2012



Clark Creek Watershed Study
Sauk County, WI

Figure 2
Wetland Scrape Hydraulic Model Cross Section Locations

Montgomery Associates: Resource Solutions, LLC
119 South Main Street, Cottage Grove, WI 53527
(608) 839-4422 | www.ma-rs.org | 06/27/2012



Feet
0
1,000
1 inch = 500 feet
N

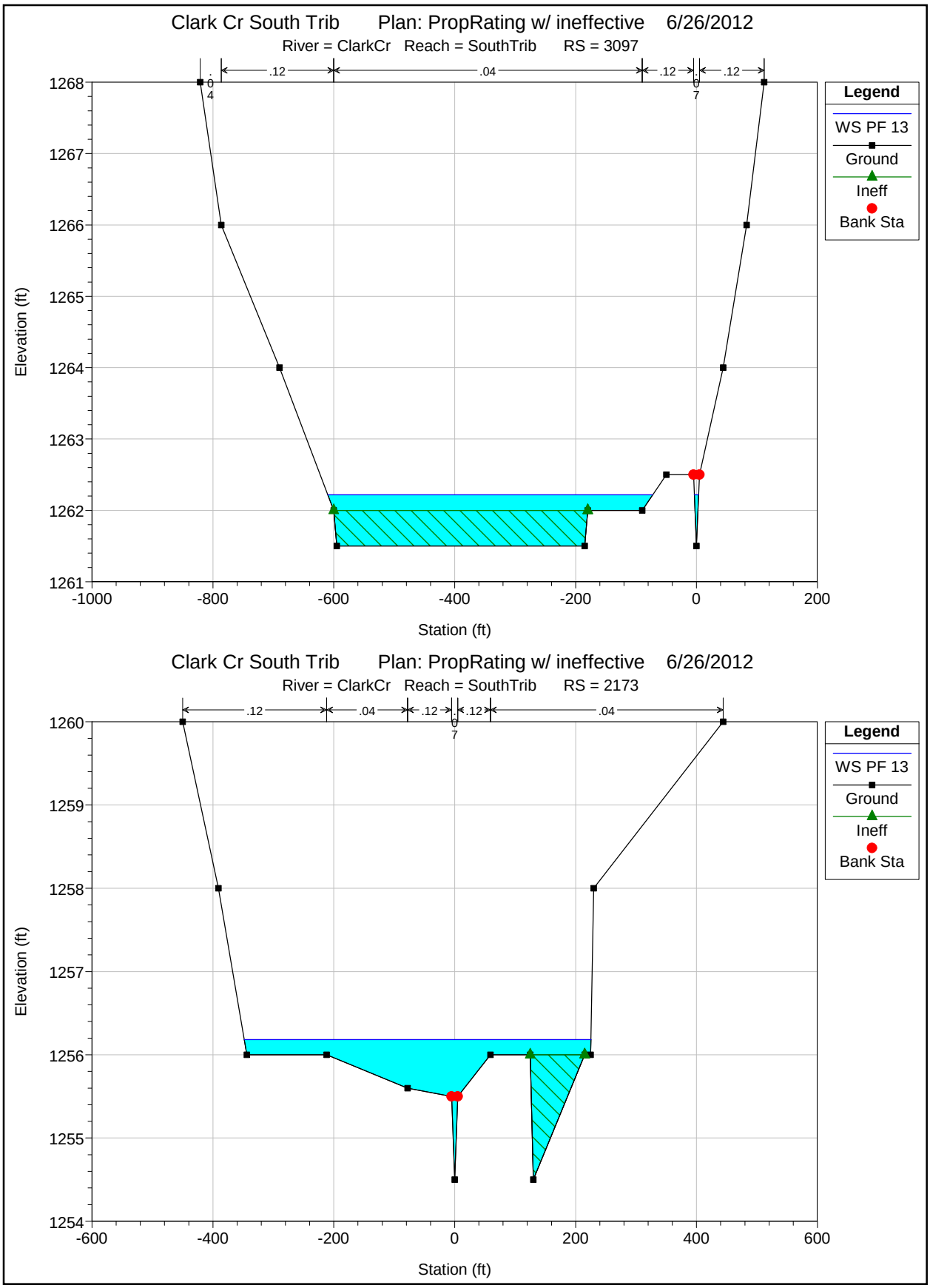
Sauk County
Clark Creek Watershed Study

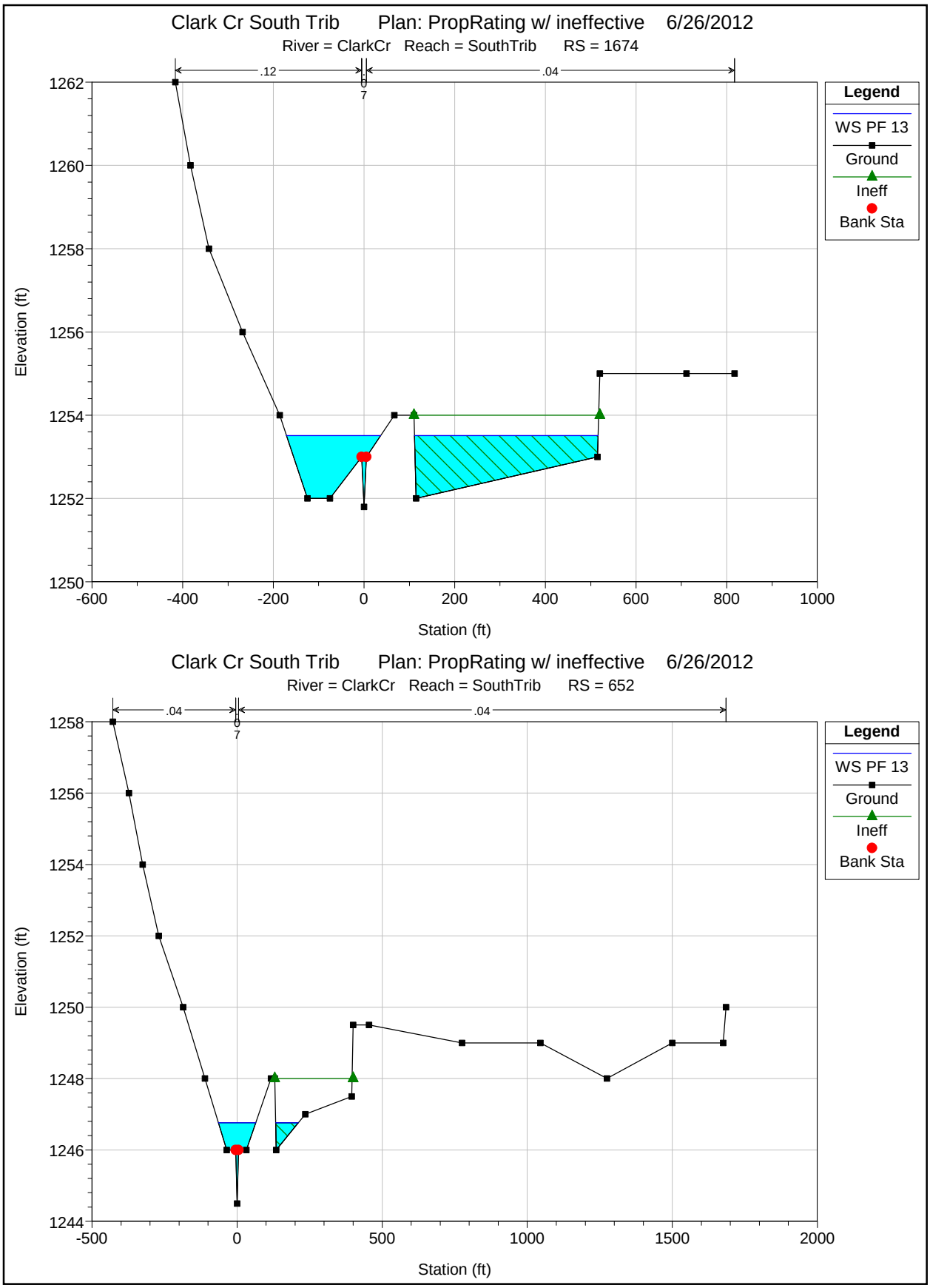
Montgomery Associates:
Resource Solutions, LLC
119 South Main St., Suite A
Cottage Grove, WI 53527

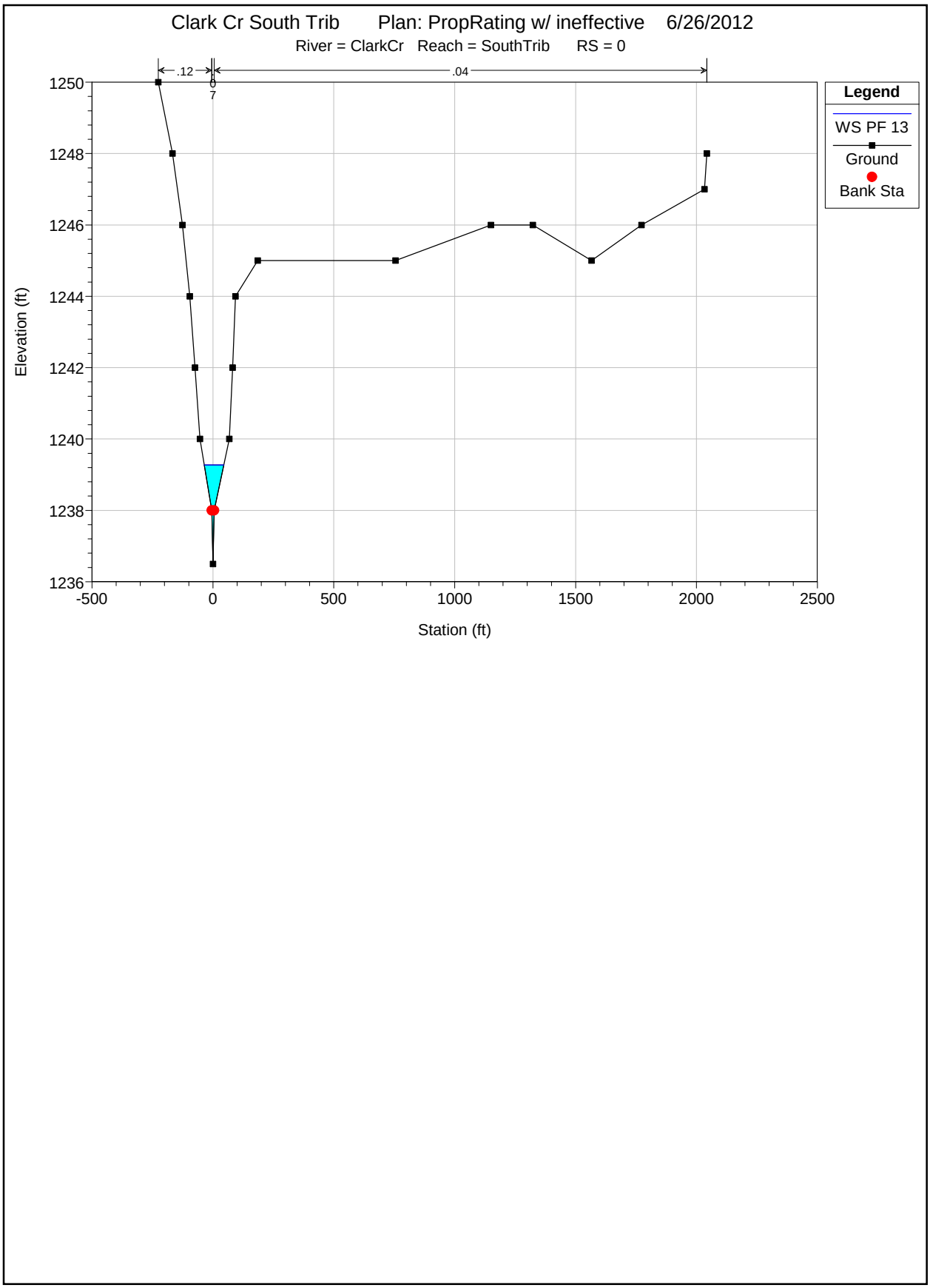
Figure 3
Selected Hydraulic Model Cross Section Locations Downstream on Clark Creek

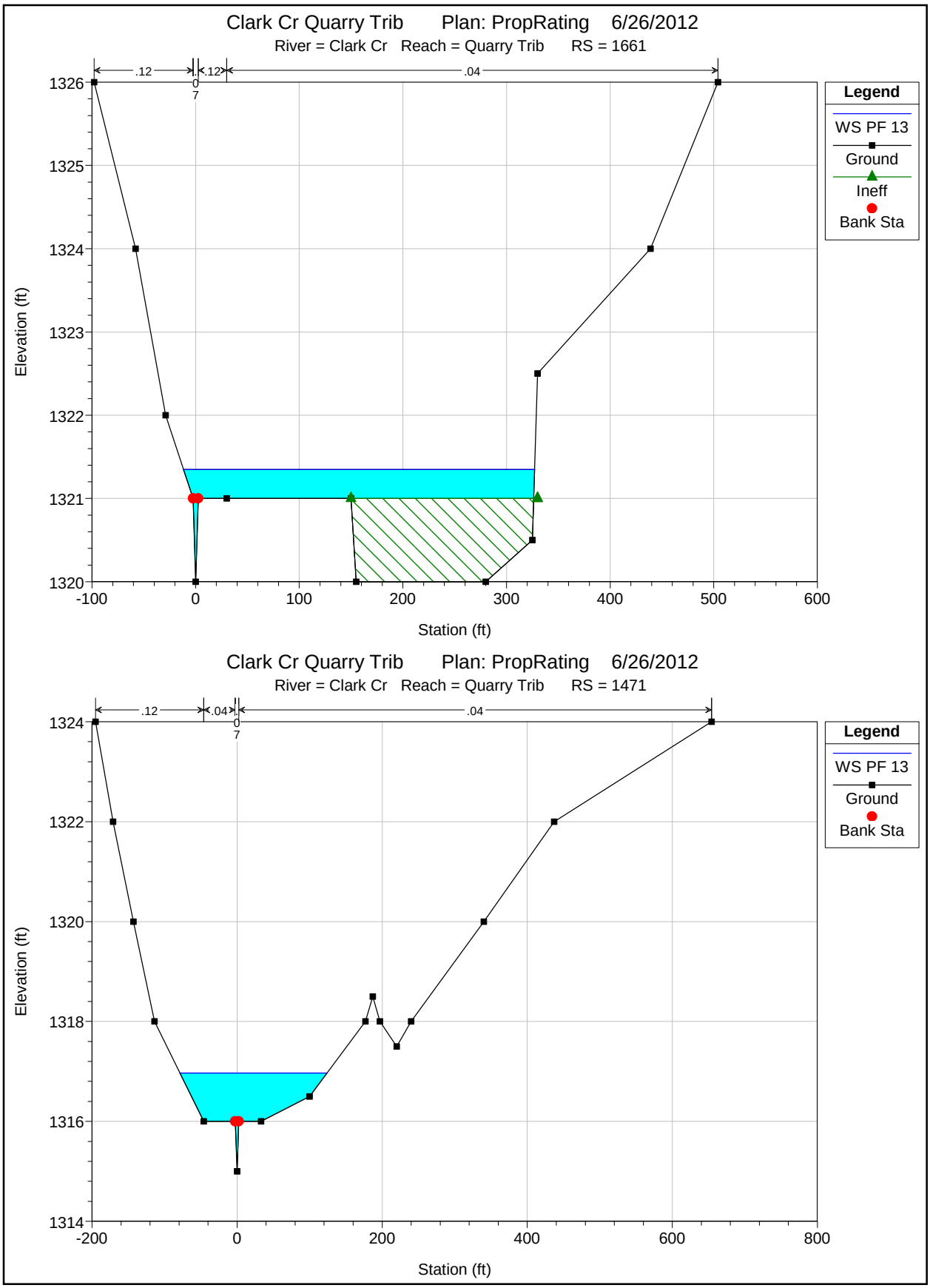
Date: June 2012
Developed by SJG

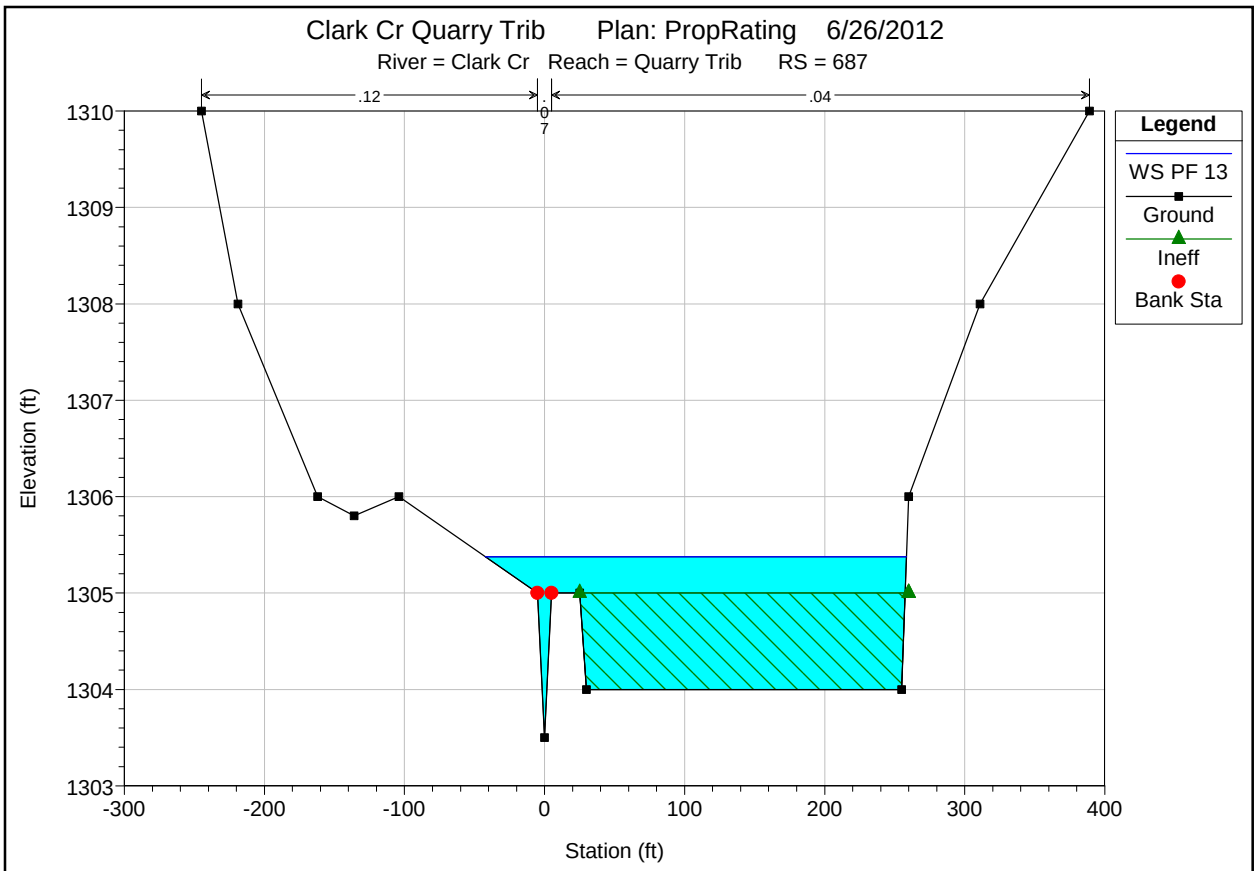
APPENDIX A – WETLAND SCRAPE HYDRAULIC MODEL CROSS SECTION DETAILS

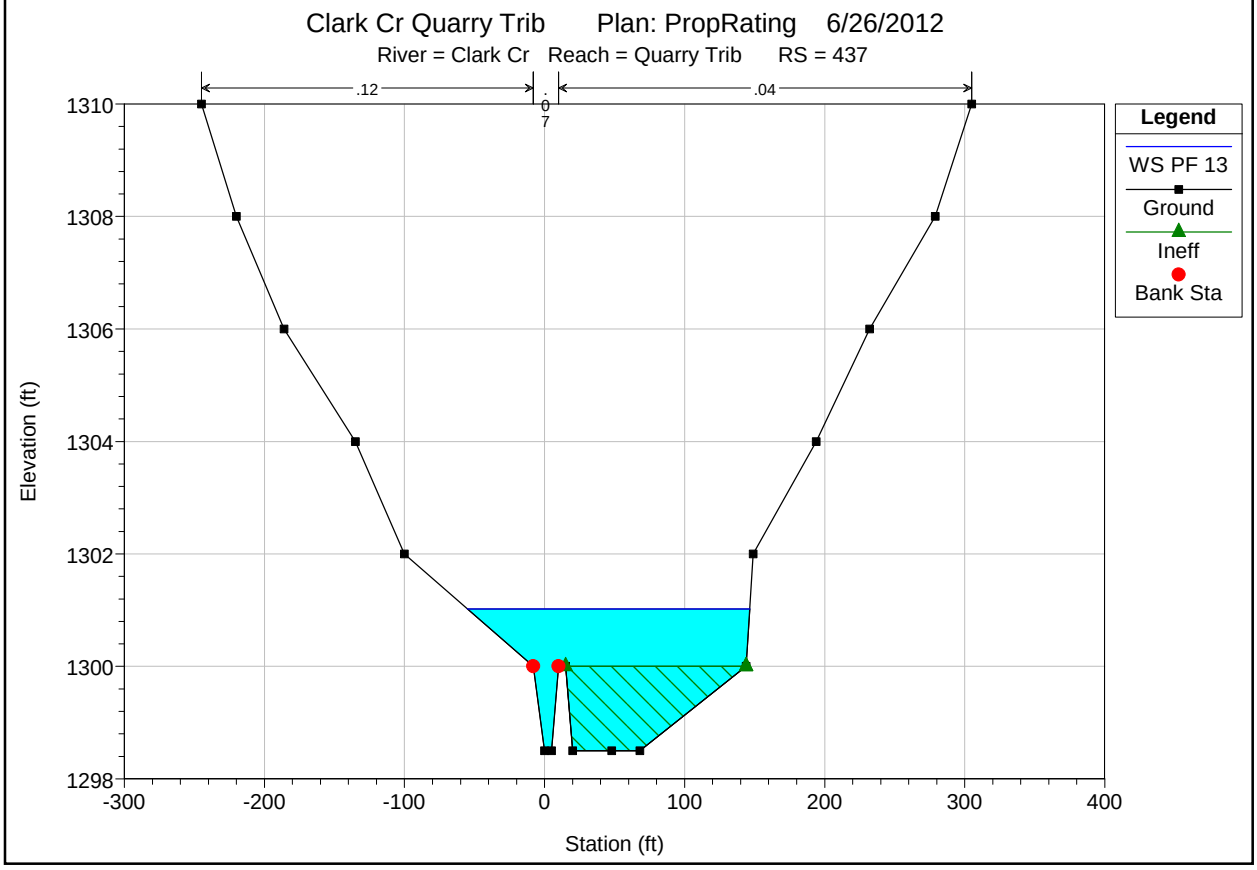

Clark Cr South Trib Plan: PropRating w/ ineffective 6/26/2012
River = ClarkCr Reach = SouthTrib RS = 3097
.12
.04
.12
.12
.04
.07
Legend
WS PF 13
Ground
Ineff
Bank Sta
Elevation (ft)
1268
1267
1266
1265
1264
1263
1262
1261
-1000
-800
-600
-400
-200
0
200
Station (ft)
Clark Cr South Trib Plan: PropRating w/ ineffective 6/26/2012
River = ClarkCr Reach = SouthTrib RS = 2173
.12
.04
.12
.12
.04
.07
Legend
WS PF 13
Ground
Ineff
Bank Sta
Elevation (ft)
1260
1259
1258
1257
1256
1255
1254
-600
-400
-200
0
200
400
600
Station (ft)

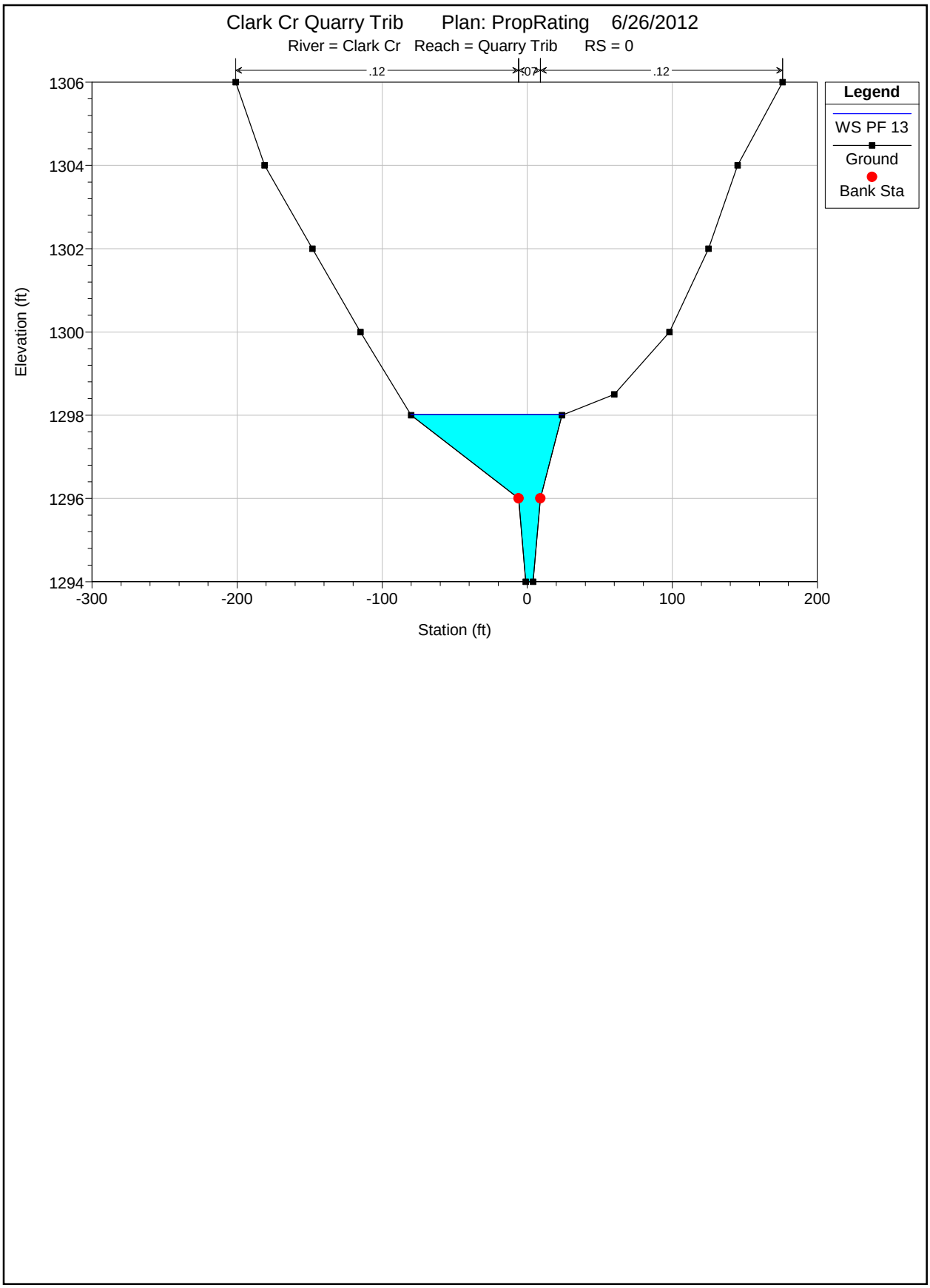

Clark Cr South Trib Plan: PropRating w/ ineffective 6/26/2012
River = ClarkCr Reach = SouthTrib RS = 1674
.12
.04
0
7
Legend
WS PF 13
Ground
Ineff
Bank Sta
Elevation (ft)
1262
1260
1258
1256
1254
1252
1250
-600
-400
-200
0
200
400
600
800
1000
Station (ft)
Clark Cr South Trib Plan: PropRating w/ ineffective 6/26/2012
River = ClarkCr Reach = SouthTrib RS = 652
.04
.04
0
7
Legend
WS PF 13
Ground
Ineff
Bank Sta
Elevation (ft)
1258
1256
1254
1252
1250
1248
1246
1244
-500
0
500
1000
1500
2000
Station (ft)


Clark Cr South Trib Plan: PropRating w/ ineffective 6/26/2012
River = ClarkCr Reach = SouthTrib RS = 0
.12
.04
0
7
Legend
WS PF 13
Ground
Bank Sta
Elevation (ft)
1250
1248
1246
1244
1242
1240
1238
1236
-500
0
500
1000
1500
2000
2500
Station (ft)


Clark Cr Quarry Trib Plan: PropRating 6/26/2012
River = Clark Cr Reach = Quarry Trib RS = 1661
.12
.12
.04
0
7
Legend
WS PF 13
Ground
Ineff
Bank Sta
Elevation (ft)
1326
1325
1324
1323
1322
1321
1320
-100
0
100
200
300
400
500
600
Station (ft)
Clark Cr Quarry Trib Plan: PropRating 6/26/2012
River = Clark Cr Reach = Quarry Trib RS = 1471
.12
.04
.04
0
7
Legend
WS PF 13
Ground
Bank Sta
Elevation (ft)
1324
1322
1320
1318
1316
1314
-200
0
200
400
600
800
Station (ft)


Clark Cr Quarry Trib Plan: PropRating 6/26/2012
River = Clark Cr Reach = Quarry Trib RS = 687
.12
.07
.04
Legend
WS PF 13
Ground
Ineff
Bank Sta
Elevation (ft)
1310
1309
1308
1307
1306
1305
1304
1303
-300
-200
-100
0
100
200
300
400
Station (ft)


Clark Cr Quarry Trib Plan: PropRating 6/26/2012
River = Clark Cr Reach = Quarry Trib RS = 437
.12
.07
.04
Legend
WS PF 13
Ground
Ineff
Bank Sta
Elevation (ft)
1310
1308
1306
1304
1302
1300
1298
-300
-200
-100
0
100
200
300
400
Station (ft)


Clark Cr Quarry Trib Plan: PropRating 6/26/2012
River = Clark Cr Reach = Quarry Trib RS = 0
.12
.07
.12
Legend
WS PF 13
Ground
Bank Sta
Elevation (ft)
1306
1304
1302
1300
1298
1296
1294
-300
-200
-100
0
100
200
Station (ft)

FLOODPLAIN STORAGE FROM HEC-RAS MODEL

Model: Clark Creek South Trib
Plan: Exist Rating

Reach	River Sta	Profile	**Q Total (cfs)**	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	**Volume (acre-ft)**
SouthTrib	3097	PF 1	**1**	1261.5	1261.8	1261.8	1261.88	0.135938	2.19	0.46	3.02	0.99	**0.1**
SouthTrib	3097	PF 2	**5**	1261.5	1262.03	1262.03	1262.03	0.006597	0.7	15.83	518.81	0.24	**0.51**
SouthTrib	3097	PF 3	**10**	1261.5	1262.03	1262.03	1262.04	0.025173	1.37	16.08	518.87	0.47	**0.69**
SouthTrib	3097	PF 4	**15**	1261.5	1262.06	1262.03	1262.06	0.007043	0.75	31.34	522.83	0.25	**1.2**
SouthTrib	3097	PF 5	**20**	1261.5	1262.07		1262.07	0.007765	0.8	36.32	524.11	0.26	**1.52**
SouthTrib	3097	PF 6	**30**	1261.5	1262.08		1262.09	0.008747	0.86	44.91	526.32	0.28	**2.06**
SouthTrib	3097	PF 7	**50**	1261.5	1262.11		1262.12	0.010405	0.97	58.19	529.72	0.31	**2.97**
SouthTrib	3097	PF 8	**75**	1261.5	1262.13		1262.15	0.012137	1.07	71.1	533	0.34	**3.97**
SouthTrib	3097	PF 9	**100**	1261.5	1262.16		1262.18	0.013243	1.15	82.52	535.88	0.35	**4.84**
SouthTrib	3097	PF 10	**125**	1261.5	1262.17		1262.2	0.014617	1.22	91.76	538.2	0.37	**5.65**
SouthTrib	3097	PF 11	**150**	1261.5	1262.19		1262.22	0.015861	1.29	100.05	540.28	0.39	**6.41**
SouthTrib	3097	PF 12	**175**	1261.5	1262.2		1262.24	0.016964	1.36	107.72	542.19	0.4	**7.12**
SouthTrib	3097	PF 13	**200**	1261.5	1262.21		1262.26	0.017996	1.42	114.81	543.95	0.42	**7.8**

FLOODPLAIN STORAGE FROM HEC-RAS MODEL

Model: Clark Creek South Trib
Plan: Prop Rating

Reach	River Sta	Profile	**Q Total (cfs)**	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	**Volume (acre-ft)**
SouthTrib	3097	PF 1	**1**	1261.5	1261.8	1261.8	1261.88	0.135938	2.19	0.46	419.06	0.99	**0.99**
SouthTrib	3097	PF 2	**5**	1261.5	1262.03	1262.03	1262.03	0.006598	0.7	15.83	518.81	0.24	**2.24**
SouthTrib	3097	PF 3	**10**	1261.5	1262.03	1262.03	1262.04	0.025176	1.37	16.08	518.87	0.47	**2.67**
SouthTrib	3097	PF 4	**15**	1261.5	1262.06	1262.03	1262.06	0.007044	0.75	31.34	522.83	0.25	**3.75**
SouthTrib	3097	PF 5	**20**	1261.5	1262.07		1262.07	0.007766	0.8	36.32	524.11	0.26	**4.37**
SouthTrib	3097	PF 6	**30**	1261.5	1262.08		1262.09	0.008748	0.86	44.91	526.32	0.28	**5.51**
SouthTrib	3097	PF 7	**50**	1261.5	1262.11		1262.12	0.010406	0.97	58.19	529.72	0.31	**7.54**
SouthTrib	3097	PF 8	**75**	1261.5	1262.13		1262.15	0.011958	1.07	71.42	533.08	0.33	**9.82**
SouthTrib	3097	PF 9	**100**	1261.5	1262.16		1262.18	0.013143	1.14	82.71	535.93	0.35	**11.76**
SouthTrib	3097	PF 10	**125**	1261.5	1262.17		1262.2	0.014084	1.2	92.81	538.47	0.37	**13.49**
SouthTrib	3097	PF 11	**150**	1261.5	1262.19		1262.22	0.01507	1.27	101.64	540.68	0.38	**15.06**
SouthTrib	3097	PF 12	**175**	1261.5	1262.21		1262.25	0.015984	1.32	109.7	542.69	0.39	**16.51**
SouthTrib	3097	PF 13	**200**	1261.5	1262.22		1262.26	0.017111	1.38	116.6	544.4	0.41	**17.87**

FLOODPLAIN STORAGE FROM HEC-RAS MODEL

Model: Clark Creek Quarry Trib
Plan: Exist Rating

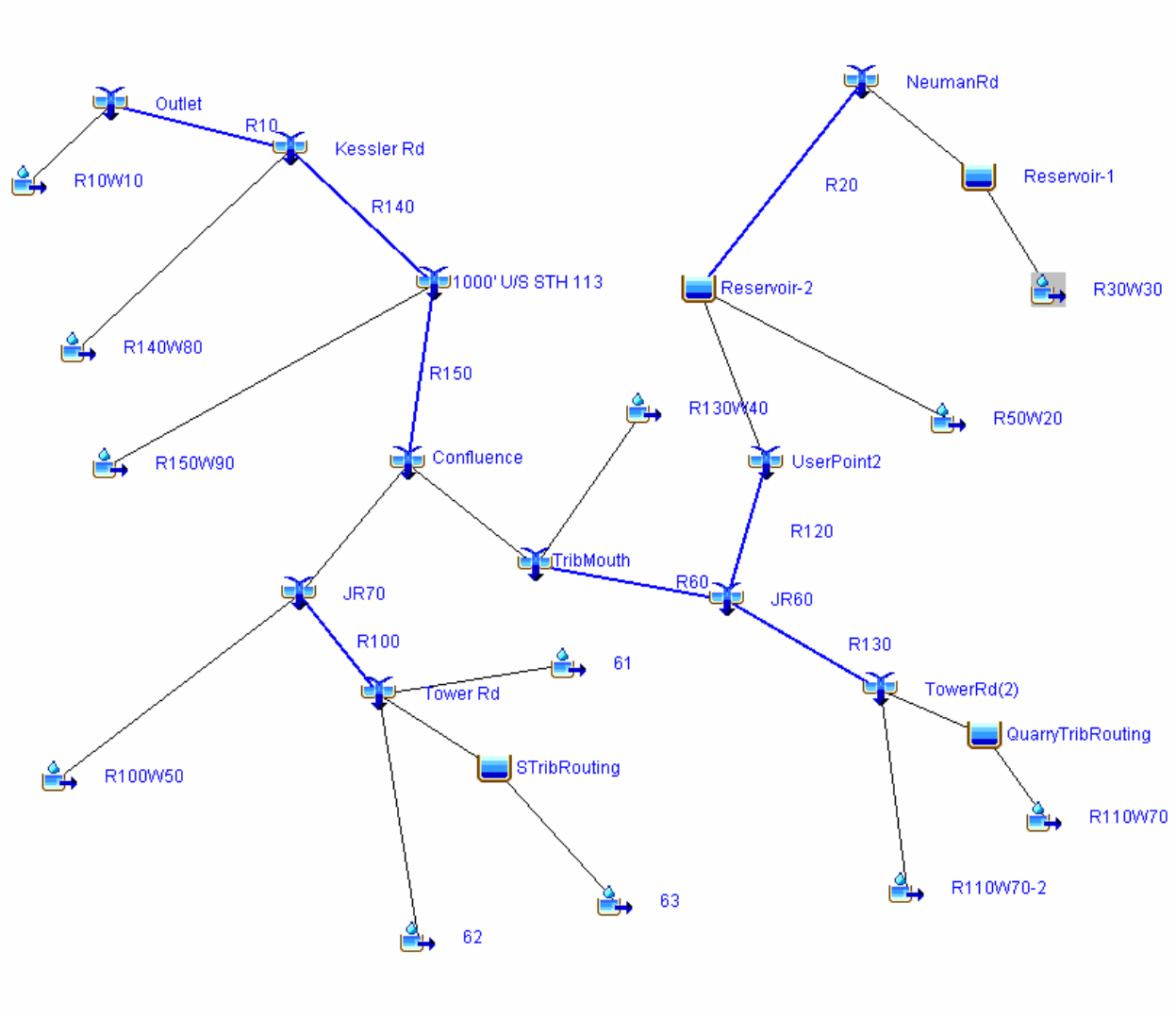
Reach	River Sta	Profile	**Q Total (cfs)**	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	**Volume (acre-ft)**
Quarry Trib	1661	PF 1	**1**	1320	1320.4	1320.4	1320.5	0.133904	2.52	0.4	1.99	1	**0.04**
Quarry Trib	1661	PF 2	**5**	1320	1320.75	1320.75	1320.95	0.112863	3.54	1.41	3.76	1.02	**0.16**
Quarry Trib	1661	PF 3	**10**	1320	1321.1	1321.1	1321.18	0.033198	2.6	6.83	58.73	0.59	**0.27**
Quarry Trib	1661	PF 4	**20**	1320	1321.19	1321.19	1321.26	0.034219	2.9	13.27	83.74	0.62	**0.45**
Quarry Trib	1661	PF 5	**40**	1320	1321.27	1321.27	1321.36	0.042119	3.48	21.26	106.92	0.7	**0.82**
Quarry Trib	1661	PF 6	**70**	1320	1321.35	1321.35	1321.46	0.047254	3.94	30.92	129.5	0.75	**1.33**
Quarry Trib	1661	PF 7	**100**	1320	1321.41	1321.41	1321.54	0.051536	4.3	38.82	145.4	0.8	**1.78**
Quarry Trib	1661	PF 8	**150**	1320	1321.49	1321.49	1321.64	0.051075	4.54	52.11	168.79	0.8	**2.47**
Quarry Trib	1661	PF 9	**200**	1320	1321.57	1321.57	1321.73	0.048779	4.65	65.05	188.81	0.79	**3.1**
Quarry Trib	1661	PF 10	**250**	1320	1321.61	1321.61	1321.81	0.054128	5.03	73.5	200.79	0.84	**3.7**
Quarry Trib	1661	PF 11	**300**	1320	1321.68	1321.68	1321.88	0.047064	4.89	87.97	219.83	0.79	**4.27**
Quarry Trib	1661	PF 12	**350**	1320	1321.73	1321.73	1321.94	0.045622	4.95	99.29	233.63	0.79	**4.84**
Quarry Trib	1661	PF 13	**400**	1320	1321.77	1321.77	1322	0.044208	4.99	110.46	246.49	0.78	**5.35**

FLOODPLAIN STORAGE FROM HEC-RAS MODEL

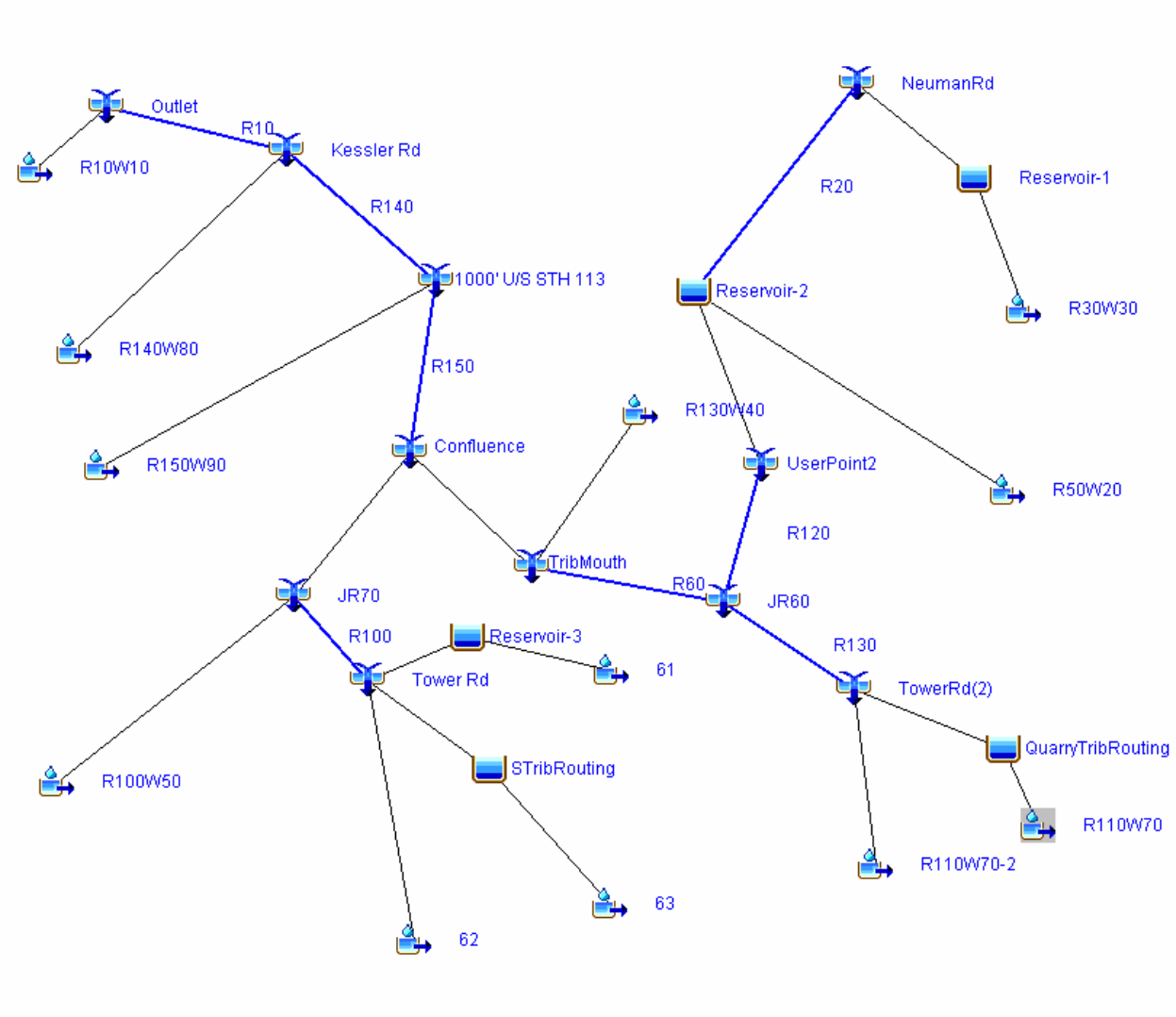
Model: Clark Creek Quarry Trib
Plan: Proposed Rating

Reach	River Sta	Profile	**Q Total (cfs)**	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	**Volume (acre-ft)**
Quarry Trib	1661	PF 1	**1**	1320	1320.4	1320.4	1320.5	0.133904	2.52	0.4	164.83	1	**0.26**
Quarry Trib	1661	PF 2	**5**	1320	1320.75	1320.75	1320.95	0.112863	3.54	1.41	178.15	1.02	**1.13**
Quarry Trib	1661	PF 3	**10**	1320	1321.04	1321.04	1321.06	0.013529	1.56	15.2	329.87	0.37	**2.07**
Quarry Trib	1661	PF 4	**20**	1320	1321.06	1321.06	1321.08	0.018222	1.86	22.86	330.54	0.44	**3.25**
Quarry Trib	1661	PF 5	**40**	1320	1321.08	1321.08	1321.12	0.033911	2.59	29.61	331.13	0.6	**4.9**
Quarry Trib	1661	PF 6	**70**	1320	1321.12	1321.12	1321.17	0.038078	2.85	40.86	332.12	0.64	**5.42**
Quarry Trib	1661	PF 7	**100**	1320	1321.15	1321.15	1321.21	0.036002	2.87	51.94	333.08	0.63	**5.88**
Quarry Trib	1661	PF 8	**150**	1320	1321.18	1321.18	1321.27	0.048984	3.44	60.65	333.84	0.74	**6.5**
Quarry Trib	1661	PF 9	**200**	1320	1321.22	1321.22	1321.33	0.045394	3.44	74.04	335	0.72	**7.12**
Quarry Trib	1661	PF 10	**250**	1320	1321.24	1321.24	1321.39	0.052842	3.79	81	335.6	0.78	**7.64**
Quarry Trib	1661	PF 11	**300**	1320	1321.28	1321.28	1321.44	0.042263	3.53	96.89	336.97	0.7	**8.2**
Quarry Trib	1661	PF 12	**350**	1320	1321.32	1321.32	1321.48	0.040198	3.54	108.05	337.93	0.69	**8.69**
Quarry Trib	1661	PF 13	**400**	1320	1321.35	1321.35	1321.53	0.03832	3.55	118.92	338.86	0.68	**9.21**

APPENDIX B – WATERSHED HYDROLOGIC MODEL LAYOUTS



Layout of HEC-HMS model of wetland scrapes and prairie restoration.



Layout of HEC-HMS model of wetland scrapes, prairie restoration, and prairie detention ("Reservoir 3" downstream of Subwatershed 61).

APPENDIX C – PLANNING LEVEL COST ESTIMATES

Clark Creek Watershed Study
Sauk County, WI

Planning-Level Cost Estimates

Southern & Quarry Tributary Wetland Scrapes

NO.	ITEM DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT PRICE	TOTAL
1	**Site Preparation**				
1a	Mobilization / Demobilization	1	LS	$ 1,000.00	$ 1,000.00
1b	Clearing and grubbing	0.5	AC	$ 6,000.00	$ 3,000.00
	Subtotal for Site Preparation				**$ 4,000.00**
2	**Erosion Control**				
2c	Silt Fence allowance	750	LF	$ 2.00	$ 1,500.00
	Subtotal for Erosion Control				**$ 1,500.00**
3	**Berm Construction**				
3a	Strip, stockpile, place and compact topsoil	18000	CY	$ 3.00	$ 54,000.00
3b	Earthwork	53000	CY	$ 3.00	$ 159,000.00
	Subtotal for Berm Construction				**$ 213,000.00**
4	**Restoration**				
4a	Cover crop seeding	22	AC	$ 487.50	$ 10,800.00
4b	Native wetland spp. seeding	22	AC	$ 1,500.00	$ 33,000.00
4c	Mulch	106000	SY	$ 0.13	$ 13,800.00
	Subtotal for Restoration				**$ 57,600.00**
5	**Maintenance (year 1)**				
5a	Invasive control spraying	22	AC	$ 100.00	$ 2,200.00
	Subtotal for Restoration				**$ 2,200.00**
Cost - No Contingency					**$ 278,300**
Estimating Contingency (50%)					**$ 139,200**
Engineering and Permitting					**$ -**
Total Estimated Cost - With Contingency					**$ 417,500**

Clark Creek Watershed Study
Sauk County, WI

Planning-Level Cost Estimates

Conversion of share cropped land to prairie

NO.	ITEM DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT PRICE	TOTAL
1	**Site Preparation**				
1a	Invasive control spraying	160	AC	$ 100.00	$ 16,000.00
					$ -
	Subtotal for Site Preparation				**$ 16,000.00**
2	**Restoration**				
2a	Seed	160	AC	$ 500.00	$ 80,000.00
2b	Seed application	160	AC	$ 100.00	$ 16,000.00
	Subtotal for Restoration				**$ 96,000.00**
3	**Maintenance (year 1)**				
3a	Mowing (2x)	320	AC	$ 100.00	$ 32,000.00
3b	Invasive control spraying	160	AC	$ 100.00	$ 16,000.00
	Subtotal for Restoration				**$ 48,000.00**
Cost - No Contingency					**$ 112,000**
Estimating Contingency (50%)					**$ 56,000**
Engineering and Permitting					
Total Estimated Cost - With Contingency					**$ 168,000**

Clark Creek Watershed Study
Sauk County, WI

Planning-Level Cost Estimates

Earthwork for Prairie Detention

5 ac-ft of storage within 10 ac area

NO.	ITEM DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT PRICE	TOTAL
1	**Site Preparation**				
1a	Mobilization / Demobilization	1	LS	$ 1,000.00	$ 1,000.00
1b	Clearing and grubbing	0	AC	$ 6,000.00	$ -
	Subtotal for Site Preparation				**$ 1,000.00**
2	**Erosion Control**				
2a	Silt fence	1000	LF	$ 2.00	$ 2,000.00
	Subtotal for Erosion Control				**$ 2,000.00**
3	**Earthwork**				
3b	Earthwork	8067	CY	$ 3.00	$ 24,200.00
	Subtotal for Berm Construction				**$ 24,200.00**
4	**Restoration**				
4a	Seed	10	AC	$ 500.00	$ 5,000.00
4b	Seed application	10	AC	$ 100.00	$ 1,000.00
	Subtotal for Restoration				**$ 6,000.00**
Cost - No Contingency					**$ 33,200**
Estimating Contingency (50%)					**$ 16,600**
Engineering and Permitting					**$ -**
Total Estimated Cost - With Contingency					**$ 49,800**