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**APPENDIX D**  
**BIG SPRING CREEK TMDL TECHNICAL ASSISTANCE AERIAL**  
**PHOTOGRAPHY ASSESSMENT (FINAL)**  
**COTTONWOOD CREEK**

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## 1.0 INTRODUCTION

This report presents the results of a remote assessment of channel and riparian vegetation conditions that was conducted for Cottonwood Creek in central Montana. This assessment of Cottonwood Creek is a portion of the assessment of Big Spring Creek and three of its tributary streams: Cottonwood Creek, Beaver Creek and East Fork of Big Spring Creek. Big Spring Creek is a tributary to the Judith River and is located in Central Montana near Lewistown. Under Section 303(d) of the Clean Water Act, three of the above streams, Big Spring Creek, Cottonwood Creek and Beaver Creek, are listed on the 2002 Montana 303(d) List. Existing data on the East Fork of Big Spring Creek were insufficient for making a beneficial use support determination in 2002, and the stream was scheduled for reassessment. Table 1-1 summarizes 303(d) status of the streams assessed in this report.

**Table 1-1** *303(d) Status of Cottonwood Creek and Selected Tributaries in 2002*

Stream	Beneficial Uses Impacted	Probable Causes	Probable Sources
<b>Big Spring Creek</b>	Aquatic Life Cold Water Fishery	Fish Habitat Degradation Nutrients PCBs Riparian Degradation Sedimentation	Municipal Point Sources Agriculture Grazing Land Disposal Septic Systems Hydromodification Channelization
<b>Cottonwood Creek</b>	Aquatic Life Cold Water Fishery Drinking Water Supply Industrial Recreation	Dewatering Fish Habitat Degradation Flow Alteration Nutrients Organic Enrichment Riparian Degradation Sedimentation	Agriculture Grazing Hydromodification Habitat Modification Removal of Riparian Vegetation
<b>Beaver Creek</b>	Aquatic Life Cold Water Fishery Drinking Water Supply Recreation	Bank erosion Dewatering Fish habitat degradation Flow alteration Nutrients Riparian Degradation Sedimentation	Agriculture Grazing Habitat Modification Removal of Riparian Vegetation
<b>East Fork of Big Spring Creek</b>	Scheduled for Reassessment	Scheduled for Reassessment	Scheduled for Reassessment

According to the Montana Water Quality Act, the State of Montana must monitor the extent to which the state's surface water bodies support legally designated beneficial uses. As part of this monitoring, the state must develop Total Maximum Daily Loads (TMDLs) and associated water quality restoration plans for Montana water bodies in which one or more pollutants impair designated beneficial uses. The Montana Department of Environmental Quality (MDEQ) will be developing a TMDL for Big Spring Creek Planning Area. The results of the remote assessment presented in this report were designed to provide technical assistance to the MDEQ Big Spring Creek TMDL Assessment (MDEQ Task Order No. 202104-03). A copy of MDEQ Task Order No. 202104-03 is provided as Appendix A.

## 2.0 METHODS

Black and white stereo aerial photography, 7.5-minute topographic maps and planimetric maps were used to delineate the target streams into relatively homogeneous reaches. Reach breaks were established using the following criteria: 1) at status boundaries as delineated by the applicable planimetric map, 2) at significant changes in channel slope, valley type, 3) at functional changes in riparian vegetation and 4) at the confluence of major tributary streams. Reach names and breaks were transcribed onto the topographic maps and aerial photos. Table 2-1 provides a summary of the topographic and planimetric maps used for each target stream.

**Table 2-1** *Map Summary*

Stream	Topographic Map(s)	Planimetric Map(s)
Big Spring Creek	Danvers Spring Creek Junction Glengarry Lewistown Pike Creek	BLM Lewistown 1:100,000-scale planimetric map
Cottonwood Creek	Spring Creek Junction Glengarry West Fork Beaver Creek Castle Butte Jump Off Peak	BLM Lewistown 1:100,000-scale planimetric map
Beaver Creek	Glengarry West Fork Beaver Creek Castle Butte	Lewis and Clark National Forest Forest Visitors Map
E. Fork of Big Spring Creek	Heath Half Moon Canyon	BLM Big Snowy 1:100,000-scale planimetric map

Within each reach, aerial photography was used to characterize and assess several parameters (described below in Section 2.1) pertaining to channel and riparian vegetation condition for each target stream. The dates of the aerial photographs varied somewhat between the streams: aerial photo coverage from June 6, 1989 was used to assess Big Spring Creek; aerial photos taken on May 30, 1995 were used to assess the three target tributaries to Big Spring Creek. All aerial photographs were at a scale of 1:6,000. Data were entered into the *Watershed Condition Inventory Remote Data Collection Form* created by Land & Water Consulting and edited and approved by Pete Schade of the MDEQ. Completed data forms are included as Appendix B.

Each target stream was assessed from its mouth to its headwaters, with the exception of East Fork of Big Spring Creek where aerial photo coverage was not available for approximately the lower eight miles of the stream. Because of the lack of photo coverage these eight miles were not included in this assessment.

## 2.1 Assessment Parameters

The following parameters were included in the aerial photo assessment:

### 2.1.1 Reach Information

**Reach Name:** Consists of the first three letters of the target stream name followed by a number (e.g. COT14). Reaches are numbered consecutively from the stream's mouth to its headwaters.

**Reach Length (ft):** The linear length of the specified stream reach. Measured to the nearest foot using a digital planimeter and topographic map.

### 2.1.2 Riparian Vegetation Area

**Buffer Width:** Measured to the nearest 5 feet to a maximum of 50 feet. An average width of the riparian vegetation buffer adjacent to both sides of the stream in the delineated reach.

**Vegetation Type (%):** Ocularly assessed from the aerial photos. Types included (within a 50' buffer): 1) Conifers and Deciduous Trees, 2) Woody Shrubs, 3) Grass/Sedge (groundcover), 4) Bare ground/Disturbed and 5) Impervious/Urban.

**Vegetation Condition:** This parameter was replaced by "Vegetation Impact Category", described below. The replacement was made to more accurately organize and compare the reaches. This parameter appears on the data collection forms, but no data were collected.

**Degraded Riparian Vegetation:** number of feet of stream bank (both sides) with human-impacts to riparian vegetation. Impacts included: 1) areas that had physically observable damaged riparian communities (e.g. trampled), 2) complete lack of riparian vegetation and 3) no woody vegetation observable on banks where such vegetation would be expected based on comparison with upstream/downstream reaches. Impacted riparian vegetation areas were transcribed onto topographic maps and impacted areas were measured to the nearest decimal foot with GIS. The percentage of the reach with degraded riparian vegetation was then calculated by the following formula:

$(\text{feet degraded riparian vegetation}) / (\text{feet of stream bank, both sides}) = \% \text{ of the reach impacted}$

**Vegetation Impact Category:** The reaches were ranked according to the level (% of reach) of impacts and assigned to an impact category according to the following criteria: 1) degraded riparian conditions along 50% or more of the reach indicates a **Highly Impacted** condition; 2) degraded riparian conditions along 25-49% of the reach indicates a **Moderately Impacted** condition; and 3) degraded riparian conditions along 1-24% of the reach indicates a **Lightly Impacted** to riparian vegetation condition. Only reaches with no observable impacts to riparian vegetation (% of reach impacted = 0) were ranked as **Not Impacted**.

### 2.1.3 Channel Condition

**Sinuosity:** Sinuosity = reach channel length / reach valley length (as measured from an aerial photo)

**Valley Gradient or Slope (%):** Gradient = change in elevation in feet / distance of elevation change in feet (measured between contour intervals from the topographic map)

**Rosgen Type (Level 1):** Stream channel classification based on channel slope, sinuosity, valley type, stream pattern and form (Rosgen, 1996).

**Rosgen Type Potential (Level 1):** Potential (future) Rosgen stream classification based on ocular evidence of natural stream geomorphologic transition *or* evidence of a degraded stream condition that with improvement would have a different stream classification

**Channel Degradation:** Evidence of the following channel degradation characteristics on an aerial photo: 1) Rip rap, 2) Channelization, 3) Unstable Banks, 4) Severely Eroding Banks. Unstable banks were characterized as those with ocular evidence of light to moderate erosion, while severely eroding banks were characterized as those with evidence of wider scale bank slumping, mass wasting or bank failure.

Impacted channel areas were transcribed onto topographic maps and impacted areas were measured to the nearest decimal foot with GIS. The percentage of the reach with each of the above channel characteristics was then calculated by the following formula:

(feet of channel characteristic) / (feet of stream bank, both sides) = % of the reach impacted

**Overall Channel Condition:** This parameter was replaced by “Channel Impact Category”, described below. The replacement was made to more accurately organize and compare the reaches. This parameter appears on the data collection forms, but no data were collected.

**Channel Impact Category:** The reaches were ranked according to the cumulative score of *anthropogenic* impacts created by the summation of % of each reach in the four channel degradation parameters (rip rap, channelization, unstable banks, severely eroding banks): reaches with a cumulative score greater than 50 were labeled as **Highly Impacted**; reaches with a score of 25 to 49 were labeled as **Moderately Impacted**; reaches with a score of 1 to 24 were labeled as **Lightly Impacted**; reaches with a score of 0 were labeled as **Not Impacted**. In calculating the channel impact score, the eroding stream banks that appeared to result from naturally erodible bank terraces were removed so that only anthropogenic impacts were included.

**Meander Cutoff Potential:** Subjective rating of Low, Medium or High potential that a stream meander will be cut off in the future due to erosion/deposition.

### 2.1.4 General Characteristics

**Reference Potential:** Whether or not the reach could be considered *reference*, or a reach representing “ideal” or least impacted channel and vegetation characteristics

**Land Use:** Adjacent anthropogenic or natural land use characteristics that may be contributing to water quality impairment and/or bank instability. Land use comments were transcribed onto aerial photos.



### 3.0 IMPACT SUMMARY

#### 3.1 Cottonwood Creek

This section presents a summary and analysis of selected riparian and channel condition variables. Appendix B presents a tabular summary of all of the data collected on Cottonwood Creek.

##### 3.1.1 Riparian Vegetation Impacts

Table 3-1 provides a summary of selected characteristics of riparian vegetation on Cottonwood Creek. The majority of reaches were classified as either Moderately Impacted or Lightly Impacted. Only two reaches (COT 21 and COT 20) were classified as Highly Impacted, indicating that 50% or more of the riparian vegetation was significantly impacted by human activities on these two reaches. Cottonwood Creek reaches that were ranked as Lightly or Not Impacted will be considered “Vegetation Reference Reaches” for the purposes of this assessment (Section 4.0).

**Table 3-1** *Riparian Vegetation Characteristics – Cottonwood Creek*

Reach	Buffer Width (ft)	Total Bank Length (ft)	Vegetation Types (% of reach)					Degraded Riparian Vegetation (% of reach)	Vegetation Impact Category
			Con/Dec	Woody Shrub	Bare ground/disturbed	Grass/Sedge	Impervious/Urban		
COT21	10	6718	10	50	20	20	0	69	Highly Impacted
COT20	20	8710	20	40	10	30	0	61	Highly Impacted
COT23	35	9680	50	0	5	45	0	49	Moderately Impacted
COT18	30	9622	40	30	5	25	0	40	Moderately Impacted
COT27	50	7150	20	50	20	10	0	39	Moderately Impacted
COT6	35	14578	50	40	0	10	0	37	Moderately Impacted
COT17	50	7136	50	30	0	20	0	36	Moderately Impacted
COT9	15	9082	40	20	0	40	0	35	Moderately Impacted
COT15	50	13700	50	25	5	20	0	33	Moderately Impacted
COT7	>50	17076	30	50	0	20	0	30	Moderately Impacted
COT28	40	9028	40	30	0	30	0	30	Moderately Impacted
COT14	50	8956	50	30	10	10	0	29	Moderately Impacted
COT24	50	9602	40	35	10	10	5	27	Moderately Impacted
COT2	15	16972	30	20	0	50	0	26	Moderately Impacted
COT3	20	14240	10	30	0	60	0	25	Moderately Impacted
COT4	30	17006	20	50	0	30	0	25	Moderately Impacted
COT25	35	9890	40	50	0	10	0	23	Lightly Impacted
COT19	>50	15164	15	70	5	10	0	18	Lightly Impacted
COT1	>50	15194	20	60	0	20	0	18	Lightly Impacted
COT16	50	13958	50	30	0	20	0	18	Lightly Impacted
COT13	>50	13306	50	30	0	20	0	16	Lightly Impacted
COT8	>50	11168	30	50	0	20	0	14	Lightly Impacted
COT11	>50	12514	60	20	0	20	0	14	Lightly Impacted
COT22	50	14748	40	40	10	10	0	13	Lightly Impacted
COT10	>50	18926	50	30	0	10	10	5	Lightly Impacted
COT12	>50	17240	70	15	0	15	0	4	Lightly Impacted
COT26	>50	9926	45	35	0	20	0	2	Lightly Impacted
COT5	>50	11896	30	60	0	10	0	0	Not Impacted
COT29	>50	14206	70	15	0	15	0	0	Not Impacted
COT30	>50	14832	100	0	0	0	0	0	Not Impacted

### 3.1.2 Stream Channel Characteristics

Table 3-2 provides a summary of selected stream channel characteristics of Cottonwood Creek. As was the case with the riparian vegetation, most reaches fell into the Moderately Impacted or Lightly Impacted categories. Only one reach, COT1, was rated as Highly Impacted. Cottonwood Creek reaches that were ranked as Lightly or Not Impacted to the stream channel will be considered “Channel Reference Reaches” for the purposes of this assessment (Section 4.0). Note that the Cumulative Channel Impact Score is the sum of the four Channel Degradation Characteristics minus the portion of the eroding banks that were classified as natural erosion from unvegetated terraces.

**Table 3-2** *Stream Channel Characteristics – Cottonwood Creek*

Reach	Total Bank Length (ft)	Channel Degradation (% of reach)				Minus (-) “Natural” Erosion (%)	Total Cumulative Channel Impact Score	Channel Impact Category
		Rip rap	Channelized	Unstable Banks	Severely Eroding Banks			
COT1	15164	0	22	12	5	5	34	Highly Impacted*
COT23	9680	0	0	22	20	0	42	Moderately Impacted
COT20	8710	0	0	32	3	0	35	Moderately Impacted
COT9	9082	0	0	16	18	0	34	Moderately Impacted
COT25	9890	0	0	33	0	0	33	Moderately Impacted
COT24	9602	0	0	15	16	0	31	Moderately Impacted
COT27	7150	0	0	30	0	0	30	Moderately Impacted
COT14	8956	0	0	2	27	0	29	Moderately Impacted
COT6	14578	0	0	9	14	1	22	Lightly Impacted
COT17	7136	0	0	22	0	0	22	Lightly Impacted
COT18	9622	0	0	14	9	3	20	Lightly Impacted
COT19	13958	0	0	15	3	0	18	Lightly Impacted
COT8	11168	4	0	9	6	3	16	Lightly Impacted
COT16	15194	0	0	10	3	0	13	Lightly Impacted
COT2	16972	0	0	12	6	6	12	Lightly Impacted
COT21	6718	0	0	11	0	0	11	Lightly Impacted
COT22	14748	0	0	5	5	0	10	Lightly Impacted
COT13	12514	0	0	6	6	3	9	Lightly Impacted
COT11	13306	0	0	7	6	4	9	Lightly Impacted
COT10	18926	0	0	5	6	5	6	Lightly Impacted
COT15	14240	1	0	4	0	0	5	Lightly Impacted
COT28	13700	0	0	5	0	0	5	Lightly Impacted
COT3	9028	0	0	2	4	1	5	Lightly Impacted
COT4	17006	0	0	2	13	11	4	Lightly Impacted
COT12	17240	0	0	4	0	0	4	Lightly Impacted
COT7	17076	0	0	7	3	3	3	Lightly Impacted
COT26	11896	0	0	0	0	0	0	Not Impacted
COT29	9926	0	0	0	0	0	0	Not Impacted
COT30	14206	0	0	0	0	0	0	Not Impacted
COT5	14832	0	0	0	1	1	0	Not Impacted

\* Downgraded to Highly Impacted due to 22% channelization of the reach

Table 3-3 provides a comparison of Vegetation and Channel Impact ratings, listed from the most highly impacted to the least impacted. In general, vegetation and channel conditions in each reach were within one impact category of one another, with the exception of COT21, where the vegetation was highly impacted but the channel only lightly impacted, and COT1, where the vegetation was lightly impacted but the channel was highly impacted.

**Table 3-3** *Vegetation/Channel Impact Comparison - Cottonwood Creek*

Reach	Vegetation Impact Category	Channel Impact Category	Reach	Vegetation Impact Category	Channel Impact Category	Reach	Vegetation Impact Category	Channel Impact Category
COT20	Highly Impacted	Moderately Impacted	COT4	Moderately Impacted	Lightly Impacted	COT11	Lightly Impacted	Lightly Impacted
COT21	Highly Impacted	Lightly Impacted	COT6	Moderately Impacted	Lightly Impacted	COT12	Lightly Impacted	Lightly Impacted
COT1	Lightly Impacted	Highly Impacted	COT7	Moderately Impacted	Lightly Impacted	COT13	Lightly Impacted	Lightly Impacted
COT9	Moderately Impacted	Moderately Impacted	COT15	Moderately Impacted	Lightly Impacted	COT16	Lightly Impacted	Lightly Impacted
COT14	Moderately Impacted	Moderately Impacted	COT17	Moderately Impacted	Lightly Impacted	COT19	Lightly Impacted	Lightly Impacted
COT23	Moderately Impacted	Moderately Impacted	COT18	Moderately Impacted	Lightly Impacted	COT22	Lightly Impacted	Lightly Impacted
COT24	Moderately Impacted	Moderately Impacted	COT28	Moderately Impacted	Lightly Impacted	COT26	Lightly Impacted	Not Impacted
COT27	Moderately Impacted	Moderately Impacted	COT25	Lightly Impacted	Moderately Impacted	COT29	Not Impacted	Not Impacted
COT2	Moderately Impacted	Lightly Impacted	COT8	Lightly Impacted	Lightly Impacted	COT30	Not Impacted	Not Impacted
COT3	Moderately Impacted	Lightly Impacted	COT10	Lightly Impacted	Lightly Impacted	COT5	Not Impacted	Not Impacted

### 3.1.3 Previous Assessments

The Natural Resource Conservation Service (NRCS) conducted a helicopter survey of several of the Big Spring Creek tributaries in 1995. Observations that could be compared with Land & Water's assessment of Cottonwood Creek are summarized below in Table 3-4.

**Table 3-4** *1995 Helicopter Survey (NRCS) - Cottonwood Creek (feet)*

Source	Channelization	"Entrenched/Eroding Banks/Active Erosion Site"	"Impacted/Absent Veg. Community"
1995 NRCS Survey	2,977	22,805	31,283
Land & Water Assessment	3,457	54,364 (Unstable Banks + Severely Eroding Banks)	81,585 (Degraded Riparian Vegetation)

Includes both natural and anthropogenic sources

In all three data categories presented in Table 3-4, Land & Water found higher levels of impact than were found in the NRCS helicopter survey. The reasons for the different findings are not clear, but probably result from the different methodologies employed in the two assessments. No information regarding the method used by the NRCS or how the agency defined vegetation impacts or eroding banks was located for this report.

## 4.0 DISCUSSION/RECOMMENDATIONS

### 4.1 Relationship of Riparian Vegetation Characteristics with Channel Erosion

Select riparian characteristics were compared to the total percentage of unstable and eroding banks in each reach in order to provide a qualitative estimate of the correlation between riparian vegetation and bank stability (Table 4-1). The combined % of unstable and eroding banks was sorted and divided in quartiles, and the data presented in Table 4-1 are presented separately for each of these quartiles. Few, if any, obvious connections between vegetation condition and bank stability are obvious from this comparison, suggesting a more complicated set of circumstances controls bank stability in Cottonwood Creek.

**Table 4-1 Comparison Between Riparian Vegetation Characteristics and Channel Erosion - Cottonwood Creek**

Reach	Riparian Vegetation Characteristics						Combined Unstable/Eroding Banks (% of reach)
	Buffer Width (ft)	Con/Dec(% of reach)	Woody Shrub (% of reach)	Bare ground/disturbed (%of reach)	Grass/Sedge (% of reach)	Impervious/Urban(%of reach)	
COT23	35	50	0	5	45	0	42
COT20	20	20	40	10	30	0	35
COT9	15	40	20	0	40	0	34
COT25	35	40	50	0	10	0	33
COT24	50	40	35	10	10	5	31
COT27	50	20	50	20	10	0	30
COT14	50	50	30	10	10	0	29
COT6	35	50	40	0	10	0	23
<i>Averages Quartile 4</i>	36	39	33	7	21	1	32
COT17	50	50	30	0	20	0	22
COT18	30	40	30	5	25	0	22
COT2	15	30	20	0	50	0	18
COT19	>50	15	70	5	10	0	18
COT1	>50	20	60	0	20	0	17
COT4	30	20	50	0	30	0	15
COT8	>50	30	50	0	20	0	15
COT13	>50	50	30	0	20	0	13
<i>Averages Quartile 3</i>	43	32	43	1	24	0	18
COT16	50	50	30	0	20	0	13
COT11	>50	60	20	0	20	0	12
COT10	>50	50	30	0	10	10	11
COT21	10	10	50	20	20	0	11
COT7	>50	30	50	0	20	0	10
COT22	50	40	40	10	10	0	10
COT3	20	10	30	0	60	0	6
<i>Averages Quartile 2</i>	35	36	36	4	23	1	10

**Table 4-1 Comparison Between Riparian Vegetation Characteristics and Channel Erosion - Cottonwood Creek (continued)**

Reach	Riparian Vegetation Characteristics						Combined Unstable/Eroding Banks (% of reach)
	Buffer Width (ft)	Con/Dec(% of reach)	Woody Shrub (% of reach)	Bare ground/disturbed (%of reach)	Grass/Sedge (% of reach)	Impervious/Urban(%of reach)	
COT28	40	40	30	0	30	0	5
COT12	>50	70	15	0	15	0	4
COT15	50	50	25	5	20	0	4
COT5	>50	30	60	0	10	0	1
COT26	>50	45	35	0	20	0	0
COT29	>50	70	15	0	15	0	0
COT30	>50	100	0	0	0	0	0
<i>Averages Quartile 1</i>	50	58	26	1	16	0	2

#### 4.2 Characteristics of Reference Reaches

Vegetation and Channel Reference Reaches were identified for Cottonwood Creek to provide a gauge for forming restoration targets. As was discussed in Section 3.1.1 and 3.1.2, reference reaches are those that were classified as Lightly or Not Impacted in the vegetation and channel condition assessments. The reference reaches occur throughout the three regions of Cottonwood Creek (upper, middle, and lower). A summary of the average characteristics of the reference reaches is presented for vegetation and channel conditions in Table 4-2 and 4-3, respectively.

**Table 4-2 Vegetation Reference Reaches - Cottonwood Creek**

Location on Cottonwood Cr.	Reach	Coniferous/Deciduous (%)	Woody Shrub (%)	Degraded Riparian Vegetation (%)
Upper	COT25	40	50	23
Middle	COT19	15	70	18
Lower	COT1	20	60	18
Middle	COT16	50	30	18
Middle	COT13	50	30	16
Lower	COT8	30	50	14
Middle	COT11	60	20	14
Upper	COT22	40	40	13
Lower	COT10	50	30	5
Middle	COT12	70	15	4
Upper	COT26	45	35	2
Lower	COT5	30	60	0
Upper	COT29	70	15	0
Upper	COT30	100	0	0
<i>averages</i>		48	36	10
<b>TARGET</b>		48% tree + 36% shrub = ≥ 84% tree/shrub types		<b>Degraded Riparian Vegetation ≤ 10%</b>

**Table 4-3 Channel Reference Reaches - Cottonwood Creek**

Reach	Location on Cottonwood Cr.	Channelization (%)	Unstable Banks (%)	Severely Eroding Banks (%)
COT6	Lower	0	9	14
COT17	Middle	0	22	0
COT18	Middle	0	14	9
COT19	Middle	0	15	3
COT8	Lower	0	9	6
COT16	Middle	0	10	3
COT2	Lower	0	12	6
COT21	Upper	0	11	0
COT22	Upper	0	5	5
COT13	Middle	0	6	6
COT11	Middle	0	7	6
COT10	Lower	0	5	6
COT15	Middle	0	4	0
COT28	Upper	0	5	0
COT3	Lower	0	2	4
COT4	Lower	0	2	13
COT12	Middle	0	4	0
COT7	Lower	0	7	3
COT26	Upper	0	0	0
COT29	Upper	0	0	0
COT30	Upper	0	0	0
COT5	Lower	0	0	1
	<i>averages</i>	0	7	4
	<b>TARGET</b>	<b>Channelized 0%</b>	<b>7% unstable _4% severely eroding = Eroding Banks ≤ 11%</b>	

### 4.3 Comparison of Reference Reaches with Highly Degraded Reaches

The target conditions derived in Tables 4-2 and 4-3 above were compared to the conditions in the most degraded reaches on Cottonwood Creek. For Cottonwood Creek, the “most degraded” reaches were defined to be those in which 1) the vegetation conditions or the channel condition were rated as Highly Impacted; and/or 2) reaches in which both categories scored as Moderately Impacted (Table 3-3). These represent reaches of Cottonwood Creek that appear to be in the greatest need of restoration and where the largest potential reductions in sediment loading could be achieved. Table 4-4 summarizes the most degraded reaches and describes their land use characteristics. Table 4-5 compares the most degraded reaches to reference conditions.

**Table 4-4 “Most Degraded” Reaches – Cottonwood Creek**

Reach	Location on Big Spring Cr.	Vegetation Impact Category	Channel Impact Category	Land Use Characteristics
COT20	Middle	Highly Impacted	Moderately Impacted	grazing; concentrated stock access points; fiord
COT21	Middle	Highly Impacted	Lightly Impacted	numerous fiords; concentrated stock access points; grazing
COT1	Lower	Lightly Impacted	Highly Impacted	ranch; fiord; floodplain is fenced off
COT9	Lower	Moderately Impacted	Moderately Impacted	grazing; agriculture fields to bank
COT14	Middle	Moderately Impacted	Moderately Impacted	grazing; agriculture fields to bank
COT23	Upper	Moderately Impacted	Moderately Impacted	fiord; grazing; stock access
COT24	Upper	Moderately Impacted	Moderately Impacted	ranch on bank; grazing; road adjacent to bank; 2 fiords; bridge
COT27	Upper	Moderately Impacted	Moderately Impacted	grazing; road adjacent to bank

**Table 4-5 Comparison of most degraded reaches with target conditions – Cottonwood Creek**

	Target Variable	Target Value (%)	COT20	COT21	COT1	COT9	COT14	COT23	COT24	COT27
Vegetation	Tree/shrub Types	$\geq 84$	60	60	80	60	80	50	75	70
	Degraded Riparian Vegetation	$\leq 10$	61	69	18	35	29	49	27	39
Channel	Channelized	0	0	0	22	0	0	0	0	0
	Eroding Banks	$\leq 11$	35	11	17	34	29	42	31	30

### 4.3 Restoration Focus Areas

#### 4.3.1 Previous Restoration Activities

In 1995, the NRCS conducted several restoration projects on privately owned and state land on Cottonwood Creek. Table 4-6 describes the restoration projects that were detailed in the NRCS study. There was no information available regarding the success of these projects or describing whether the riparian management was continued past the 1995 study.

**Table 4-6**      *1995 NRCS Restoration Projects*

Reaches	Owner	Riparian Fencing (ft)	Channel Improved* (ft)	Stream/Riparian Improved* (ft)	Off-site Watering Locations Provided	Comments
COT4/COT6	Dave Leinenger	6,330	None	9,480	Two	Restoration complete
COT13	Floyd Maxwell	None	None	None	One	Planning and design complete (as of 1995)

\*No information was provided as to the improvement technique.

#### 4.3.2 Restoration Priorities

For each of the “most degraded” reaches of Cottonwood Creek described in Section 4.3, this section summarizes the major impacts observed during the air photo assessment. Because of their heavily impacted condition, these reaches represent the areas most likely in need in restoration.

*COT20* – The primary impact was to riparian vegetation; 61% of the riparian vegetation community was impacted. 35% of the channel was unstable or eroding, three times the reference value for Cottonwood Creek. Evidence of grazing and concentrated stock access points was noted. Proper riparian function may be improved by providing off-site watering locations coupled with riparian fencing. The tree/shrub cover was 60%, which was 24% below the average reference reach value.

*COT21* – The channel was less degraded on COT21 than on its adjacent upstream reach COT20 (above). The channel condition met Cottonwood Creek reference conditions. The primary impact was to riparian vegetation; 69% of the riparian vegetation community was impacted. The tree/shrub cover was 60%, which was 24% below the average reference reach value. Evidence of grazing, concentrated stock water access points and numerous vehicle fjords across the stream were noted. Proper riparian function may be improved by providing off-site watering locations coupled with riparian fencing. The tree/shrub cover was 60%, which was 24% below the average reference reach value.

*COT1* – This reach begins at the confluence of Cottonwood Creek and Big Spring Creek. COT1 was primarily affected by a long channelized section (22%). The riparian characteristic values were within 10% of target values. The value of bank erosion was within 10% of the target channel value. Restructuring of the channelized portion of the reach to a more sinuous condition



will aid in reducing stream flow velocities. Maintenance of the current functioning riparian zone is recommended through riparian fencing and off-site watering locations.

*COT9* – 35% of the riparian vegetation was degraded, three times the degraded vegetation reference value for Cottonwood Creek. Similarly, 34% of the channel was unstable or eroding, three times the channel reference value. The vegetation and channel conditions were primarily impacted by evidence of grazing and agricultural fields that came to the bank edge. The tree/shrub cover was 60%, which was 24% below the average reference reach value.

*COT14* – There was 80% tree and shrub cover in the riparian zone. 29% of the riparian community was degraded, nearly 20% over the vegetation reference value. Similarly, 29% of the channel was unstable or eroding, nearly 20% over the channel reference value. The vegetation and channel conditions were primarily impacted by grazing and agricultural fields that came to the bank edge.

*COT23* – 50% of the riparian zone consisted of trees and shrubs. Nearly 50% of the riparian vegetation on the reach was degraded. 42% of the banks on the reach were unstable or eroding. The riparian vegetation and channel were impacted by grazing, concentrated stock access and vehicle crossing.

*COT24* – *COT24* had 25% greater tree/shrub cover and a more healthy riparian and channel condition than its adjacent downstream reach, *COT23* (above). The value of riparian degradation and channel instability/erosion exceeded the reference values by approximately 20%. Riparian function and channel stability were impacted by grazing and a dirt road and ranch on the stream bank.

*COT27* - 39% of the riparian vegetation was degraded, nearly four times the degraded vegetation reference value for Cottonwood Creek. 30% of the channel was unstable or eroding, three times the channel reference value. The vegetation and channel conditions were primarily impacted by grazing and agricultural fields that came to the bank edge. The tree/shrub cover was 60%, which was 24% below the average reference reach value.

## 5.0 CONCLUSIONS

Degraded riparian vegetation appeared to be the most common impact to Beaver Creek and the greatest potential cause of increased sediment input. The primary sources of vegetation impacts were related to land use: agriculture and grazing appeared to have had significant impacts to riparian communities.

On the majority of the reaches, both the vegetation condition and the channel condition were classified as Moderately and Lightly Impacted.

Select riparian characteristics were compared to the total percentage of unstable and eroding banks in each reach in order to provide a quantitative estimate of the correlation between riparian vegetation and bank stability. Few if any connections between vegetation condition and bank

stability were obvious from the comparison, suggesting that a more complicated set of circumstances controls bank stability on Cottonwood Creek, or possibly that a more detailed analysis is required to understand the causes of bank instability on Cottonwood Creek.

Across the entire length of Cottonwood Creek, conditions were generally good, with 25% of the riparian vegetation in a degraded condition and 16% of the banks in either unstable (10%) or severely eroding (6%) condition. Few permanent “hard” alterations to the stream have been made through channelization or riprap, suggesting that restoration potential is very good.

**Table 5-1** *Summary of Degradation Statistics*

Degraded Riparian Vegetation	Riprap	Channelization	Unstable Banks	Severely Eroding Banks
25%	0%	1%	10%	6%

The air photo assessment that was conducted for this report was not at a scale that allows for detailed site-specific restoration recommendations. However, the following general recommendations could guide restoration efforts, particularly in those reaches identified in Section 4.3 as “most degraded” and thus most in need of restoration:

- Providing at least a 50 foot vegetation buffer between Cottonwood Creek and fields/roads;
- Improving proper riparian function by providing off-site watering locations coupled with riparian fencing;
- Enhancing the tree and woody shrub community where there is potential to aid in erosion reduction or maintenance of bank stability;
- Restructuring of the channelized portions of the reach to a more sinuous condition to aid in reducing stream flow velocities; and
- Mechanical bank stabilization where possible.