

<b>County</b>	Custer	<b>Upstream River Mile</b>	192.3
<b>Classification</b>	PCM/I: Partially confined meandering/islands	<b>Downstream River Mile</b>	185
<b>General Location</b>	to Miles City	<b>Length</b>	7.30 mi (11.75 km)
<b>General Comments</b>	to Miles City		

## Narrative Summary

Reach C16 is 7.32 miles long and is located just upstream of Miles City. The downstream limit of the reach is the mouth of the Tongue River at RM 185. The reach is characterized by a dominant main thread that shows a distinct meandering pattern, with several islands persisting where meander bends have historically cut off. The river intermittently flows along the valley wall. As a result it is classified as Partially Confined Meandering with Islands (PCM/I).

As of 2011 there were about two miles of armor protecting 14 percent of the total bankline in Reach C16, including 7,000 feet of rock riprap, 2,200 feet of concrete riprap, and 1,550 feet of flow deflectors. All of the concrete armor is protecting urban areas around the water treatment plant in Miles City. The flow deflectors protect non-irrigated agricultural land, and the rock riprap is protecting agricultural land (irrigated and non-irrigated), roads, and the rail line. A ~550 foot-long stretch of armor at RM 190.5R has been flanked since 2001, and erosion behind the armor now threatens a road; the river has locally eroded into the road embankment. There were also several miles of transportation encroachments and floodplain levees mapped in the reach.

About 13 percent (308 acres) of the 100-year floodplain has become isolated from the river in Reach C16, meaning it is no longer inundated at what was historically a 100-year flood event. Isolation can be due to flow changes and/or physical features that block overflows from reaching floodplain areas. Most of the 100-year floodplain isolation (185 acres) is due to the active rail line. Isolation of the 5-year floodplain has been even more substantial, with 62 percent (721 acres) of the historic 5-year floodplain no longer inundated at what was historically a 5-year flood event.

Three ice jams have been reported in the reach, including February of 2011, and March of 2003 and 2012. No damages were recorded in the ice jam database.

At RM 186.6 a steel trestle bridge built for the now abandoned Milwaukee Railroad crosses the river where it is about 1,000 feet wide. There are several very large barbs on the right bank of the river upstream of the bridge that extend about 100 feet off of the bank, and there is riprap directly under the structure.

About 210 acres which represents 9 percent of the total CMZ have become restricted by physical features. Areas that have become restricted to channel migration include the water treatment plant just upstream of the mouth of the Tongue River, behind the railroad grade at RM 191.5, and locally behind stretches of bank armor protecting irrigated and non-irrigated fields.

Mapped land uses in Reach C16 range from agricultural to urban to transportation infrastructure. The total acreage of flood irrigated land in the reach has dropped from 1,000 acres in 1950 to 830 acres in 2001; and during that time about 300 acres were developed for pivot. All of the pivot development occurred prior to 1976. Pivot irrigation has encroached into the active river corridor; approximately 27 acres of pivot-irrigated land is within the natural Channel Migration Zone (CMZ) of the river, making it especially susceptible to threats of river erosion. This pivot is at RM 190R, where a ~300 acre pivot field extends to within 150 feet of the river bank.

Reach C16 shows an increase in forest area considered to be at low risk of cowbird parasitism. In 1950, the reach had 54.5 acres of such forest per valley mile and by 2001 that forest extent had increased to 66.7 acres per valley mile.

A total of 170 acres of Russian olive were mapped in the reach, which is an abrupt increase relative to the two reaches upstream. The Russian olive is distributed throughout the riparian corridor but becomes more prolific in the downstream direction towards Miles City.

Reach C16 was sampled as part of the fisheries study. A total of 32 fish species were sampled in the reach, including Blue Sucker and Sauger, which have been identified as Species of Concern (SOC) by the Montana Natural Heritage Program.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been major in this reach. The 100-year flood has dropped by 18 percent and the 2-year flood, which strongly influences overall channel form, has dropped by 24 percent. Low flows have also been impacted; severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 4,850 cfs to 3,070 cfs with human development, a reduction of 37 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,340 cfs under unregulated conditions to 3,390 cfs under regulated conditions, a reduction of 47 percent.

Fall and winter base flows have increased in Reach C16 by about 60 percent.

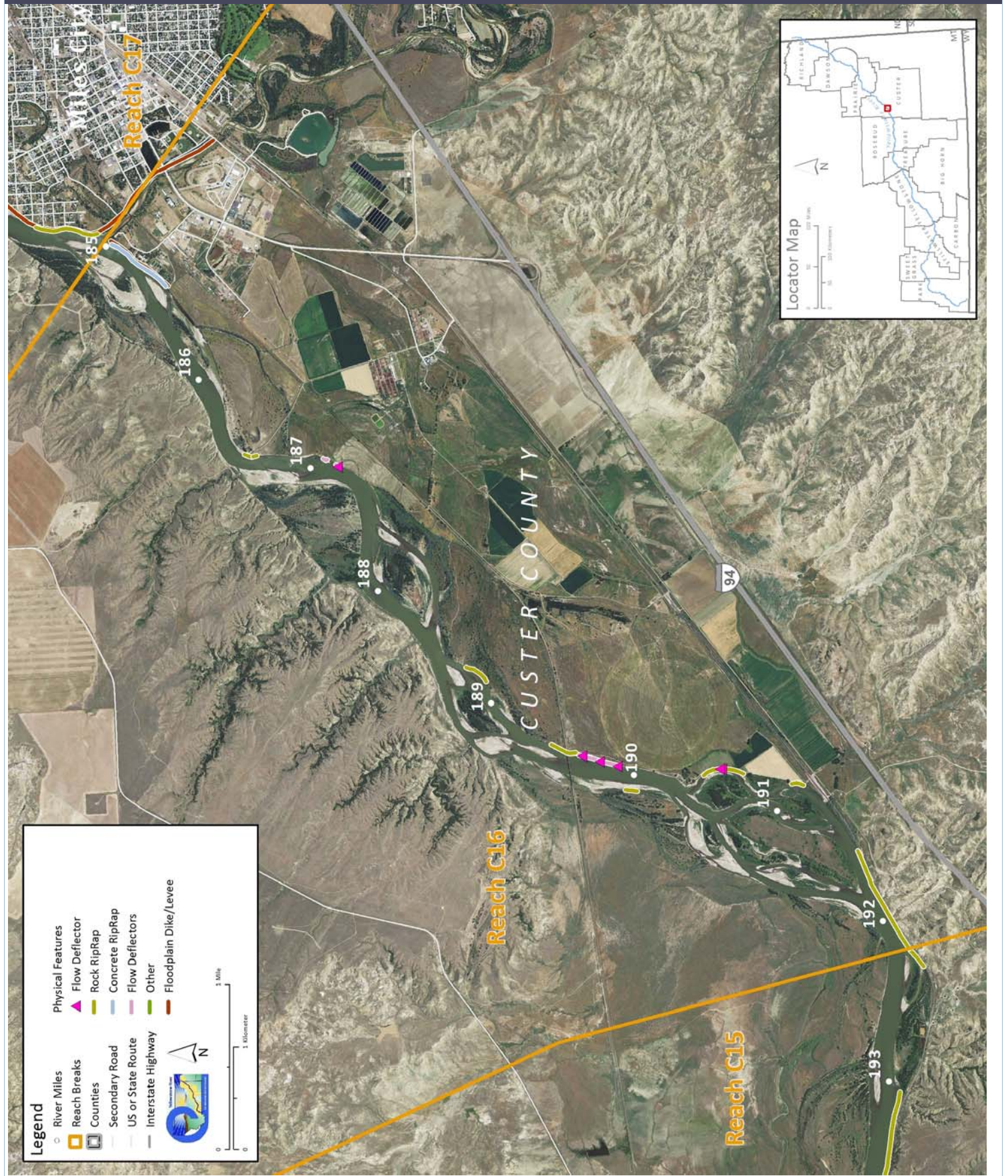
CEA-Related observations in Reach C16 include:

- Pivot irrigation encroachment into CMZ

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach C16 include:

- Russian olive removal
- Removal of flanked rock riprap at RM 190.5R to prevent accelerated erosion behind

## PHYSICAL FEATURES MAP (2011)



## HYDROLOGIC SUMMARY

Hydrologic data available for the Reach Narratives include data from representative gaging stations, modeling from the COE from the Big Horn river upstream, and modeling by the USGS for the Big Horn River to the Missouri River confluence. Gaging stations that best represent the watershed area within any reach are used to describe the flood history within the reach. Hydrology modeling results generated for all reaches provides unregulated and regulated flow values. Seasonal and annual flow duration data generated by the USGS are available for reaches C10 through D13.

### Gage Representation (Gage-Based): Miles City

#### Flood History

Year	Date	Flow on Date	Return Interval	Gage No	Downstream Gage	Upstream Gage
1974	Jun 22	75,400	10-25 yr		6309000	6214500
1997	Jun 15	83,300	10-25 yr		Miles City	Billings
1943	Jun 26	83,700	10-25 yr		1929-2015	1929-2015
2011	May 24	85,400	10-25 yr		Distance To (miles)	1.0
1944	Jun 19	96,300	50-100 yr			172.1
1978	May 22	102,000	50-100 yr			

#### Discharge

	1.01 Yr	2 Yr	5 Yr	10 Yr	50 Yr	100 Yr	500 Yr	7Q10 Summer	95% Sum. Duration
<b>Unregulated</b>		62,000	77,900	88,100	110,000	120,000	142,000	4,850	6,340
<b>Regulated</b>		47,300	61,700	70,900	90,400	98,500	117,000	3,070	3,390
<b>% Change</b>		-23.71%	-20.80%	-19.52%	-17.82%	-17.92%	-17.61%	-36.70%	-46.53%

#### Flow Duration

Streamflow, in ft<sup>3</sup>/s, which was equaled or exceeded for indicated percent of time

Note that these statistics are only available from Reach C10 downstream. See the USGS report for detailed information.

Season		5%	50%	95%
<b>Spring</b>	Unregulated	60,700	22,700	6,100
	Regulated	46,900	13,700	4,430
	<b>% Change</b>	<b>-23%</b>	<b>-40%</b>	<b>-27%</b>
<b>Summer</b>	Unregulated	42,800	13,500	6,340
	Regulated	32,600	8,340	3,390
	<b>% Change</b>	<b>-24%</b>	<b>-38%</b>	<b>-47%</b>
<b>Fall</b>	Unregulated	9,150	5,550	2,300
	Regulated	10,500	6,900	3,640
	<b>% Change</b>	<b>15%</b>	<b>24%</b>	<b>58%</b>
<b>Winter</b>	Unregulated	11,700	4,960	2,020
	Regulated	12,400	6,040	3,260
	<b>% Change</b>	<b>6%</b>	<b>22%</b>	<b>61%</b>
<b>Annual</b>	Unregulated	45,500	7,950	2,800
	Regulated	34,200	7,400	3,630
	<b>% Change</b>	<b>-25%</b>	<b>-7%</b>	<b>30%</b>

## AERIAL PHOTOGRAPHY

A variety of aerial photographic sources provide the basis for much of the Cumulative Effects Assessment analysis. The table below lists the air photos compiled for the reach and the associated discharge at the most representative USGS gaging station.

	Source	Acquisition Date	Type	Scale	Gage	Discharge
1950	USGS-EROS	26-Aug-49	B/W	1:14,800	6309000	3620
1976	USCOE	29-Sep-76	B/W	1:24,000	6309000	9520
1995	USGS DOQQ	7/7/96 - 7/10/98	B/W		6295000	39800
2001	NRCS	August 2-8, 2001	CIR	1:24,000	6295000	3500
2005	NAIP	08/05/2005	color	1-meter pixels	6309000	5620
2005	NAIP	07/08/2005	color	1-meter pixels	6309000	18800
2007	Woolpert	10/15/2007 - 11/2/0007	Color			
2009	NAIP	7/17/2009	Color	1-meter pixels	6309000	23300
2011	USCOE	October 2012	color	1-ft pixel	6309000	8100
2011	NAIP	7/16/2011	Color	1-meter pixels	6309000	57900
2013	NAIP	07/19/2013	color	1-meter pixels	6309000	

## PHYSICAL FEATURES

Several efforts to capture the types and extents of physical features in the corridor have been generated by the CEA study. The 2001 Physical Features Inventory was performed through helicopter/video Rapid Aerial Assessment by the NRCS (NRCS, 2001) and did not include Park County. This inventory includes point and linear features that represent bank armor, irrigation structures, transportation encroachments, and areas of accelerated erosion. Bank armor mapped in the 2001 inventory only reflects features on the active channel margin, and thus excludes off-channel features on historic side channels. Some floodplain restriction features such as dikes and levees in the 2001 Physical Features Inventory may extend well beyond the active channel. In 2013, the 2001 inventory was revised to include Park County. At that time, some attribute inconsistencies in the original data were addressed. This dataset was then updated to reflect conditions in the 2011 NAIP imagery.

For Stillwater, Yellowstone and Dawson Counties, a Physical Features Timeline was generated that includes additional mapping based on aerial photography and assigns approximate dates of feature construction based on observed presence/absence in historic imagery between the 1950s and 2005 (DTM and AGI, 2008). The Physical Features Timeline contains features that were not mapped in the 2001 inventory (e.g. bank armor abandoned in floodplain areas by 2001). As such the total bank armor extent in the 2005 data is commonly greater than that identified in 2001 or 2013.

Note: As the goal for each physical features mapping effort were different, with differing mapping extents, there will be discrepancies between total feature lengths (e.g. length of rock riprap) in each data set.

### 2001 and 2011 Physical Features Bankline Inventories

Feature Class	Feature Type	2001 Length (ft)	% of Bankline	2011 Length (ft)	% of Bankline	2001-2011 Change
<b>Stream Stabilization</b>						
	Rock RipRap	6,789	8.9%	7,009	9.2%	221
	Flow Deflectors	601	0.8%	491	0.6%	-110
	Concrete RipRap	2,192	2.9%	2,192	2.9%	0
	Between Flow Deflectors	1,009	1.3%	1,064	1.4%	55
	<b>Feature Type Totals</b>	<b>10,590</b>	<b>13.9%</b>	<b>10,756</b>	<b>14.1%</b>	<b>166</b>
<b>Floodplain Control</b>						
	Transportation Encroachment	26,981	35.3%	26,981	35.3%	0
	Floodplain Dike/Levee	4,960	6.5%	4,960	6.5%	0
	<b>Feature Type Totals</b>	<b>31,940</b>	<b>41.8%</b>	<b>31,940</b>	<b>41.8%</b>	<b>0</b>
	<b>Reach Totals</b>	<b>42,531</b>	<b>55.7%</b>	<b>42,696</b>	<b>55.9%</b>	<b>166</b>

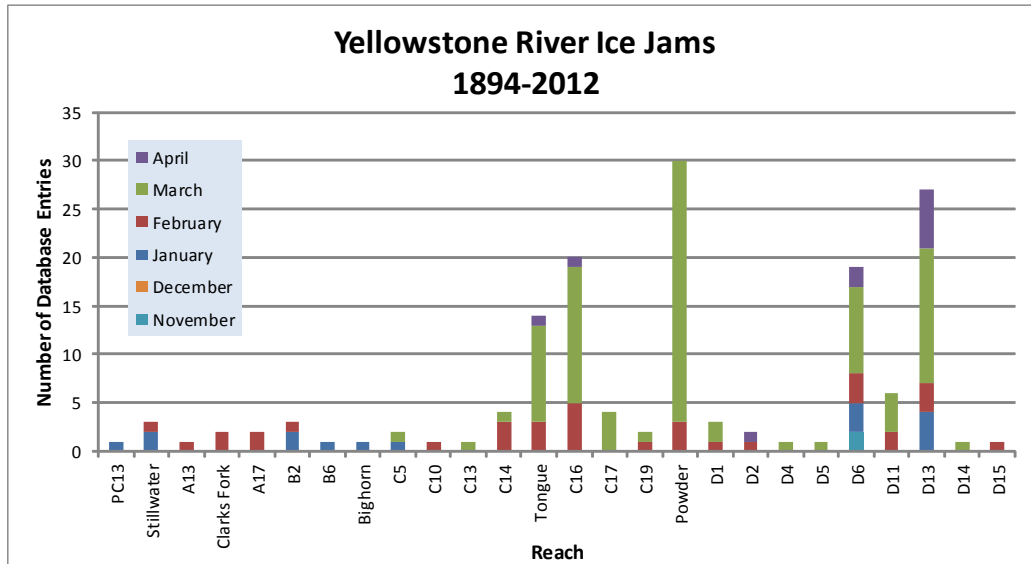
### Intent of Bank Protection: 2001

The 2001 bank protection features were assessed for the 'intent' of what they protect.

Feature Type	Irrigated	Non-Irrig.	Ag. Infrastr.	Road	Interstate	Railroad	Urban	Exurban
Concrete RipRap	0	0	0	0	0	0	2,191	0
Flow Deflectors/Between FDs	0	1,610	0	0	0	0	0	0
Rock RipRap	1,735	380	0	295	0	5,120	0	0
<b>Totals</b>	<b>1,735</b>	<b>1,991</b>	<b>0</b>	<b>295</b>	<b>0</b>	<b>5,120</b>	<b>2,191</b>	<b>0</b>

## ICE JAMS

Ice jam data were obtained from the National Ice Jam Database maintained by the Ice Engineering Group at Army Corps of Engineers Cold Regions Research and Engineering Laboratory (<https://rsgis.crrel.usace.army.mil/icejam/>). From this database, Yellowstone River ice jams are summarized by reach in the Yellowstone River Historic Events Timeline (DTM and AGI, 2008b). The basic information for each ice jam is presented as a list of events. The graph represents the number of database entries for a reach. Note that a single jam event may have multiple entries.



Jam Date	Jam Type	River Mile	Damages
3/14/2003	Break-up		?
2/14/2011	Break-up		
3/7/2012	Break-up		

## GEOMORPHIC

The geomorphology data presented below consist of measured changes in Braiding Parameter since 1950 and blocked side channels. Braiding parameter is a measure of the total length of side channels relative to that of the main channel. The braiding parameter is calculated as the sum of anabranching and primary channel lengths divided by the primary channel length. Secondary channels within the bankfull margins are a function of flow stage and hence were not included in the braiding parameter calculation. If a reach has a braiding parameter of 3, then the total bankfull channel length is three times that of the main channel. The mean braiding parameter measured for all 88 reaches is 1.8.

Blocked side channels that were either plugged with a small dike or cutoff by larger features such as a levee or road prism were identified for the pre and post-1950s eras.

Additional geomorphic parameters are discussed in more detail in the study report and appendices.

### Braiding (Bankfull)

	Primary Chan. Length (ft)	Anab. Ch. Length (ft)	Bankfull Braiding Parameter	% Change in Braiding
1950	38,597	49,582	2.28	1950 to 1976: -4.95%
1976	38,461	45,055	2.17	1976 to 1995: -4.17%
1995	38,125	41,208	2.08	1995 to 2001: 0.92%
2001	38,194	42,010	2.10	1950 to 2001: -8.08%
Change 1950 - 2001	-403	-7,572	-0.18	

Length of Side Channels Blocked	Pre-1950s (ft)	Post-1950s (ft)
	0	0

## HYDRAULICS

Available hydraulic information includes county-based HEC-RAS modeling efforts by the Army Corps of Engineers with the exclusion of Park County. Floodplain modeling was performed for four conditions representing a developed and undeveloped floodplain, and unregulated and regulated flows for the 1.5, 2, 5, 10, 20, 50, 100, 200, and 500-year events. Park County has limited FEMA hydraulic modeling and was not included in the analysis.

The results of HEC-RAS modeling for the 5 and 100-year flood events were assessed to compare the extents of inundated area for the pristine (undeveloped floodplain, unregulated flows) and developed (developed floodplain, regulated flows) conditions. The data sets provided for each flow condition were unioned in the GIS to identify areas where the inundated extent differed. These areas of human-caused floodplain isolation due to either flow alterations or physical features such as levees. For the 100-year flood event, isolated areas greater than 5 acres were attributed with the interpreted reason for isolation (railroad, levee, etc.). The resulting values are presented as acres and percent of the pristine floodplain that has been isolated. The pristine floodplain is defined as the total floodplain footprint minus the area of the mapped 2001 bankfull channel (mapped islands were included in the floodplain area).

### Floodplain Isolation

	100-Year		5-Year	
	Isolated Acres	% of Floodplain	Isolated Acres	% of Floodplain
Non-Structural (hydrology, geomorphic, etc.)	53	2.2%		
Agriculture (generally relates to field boundaries)	42	1.7%		
Agriculture (isolated by canal or large ditch)	0	0.0%		
Levee/Riprap (protecting agricultural lands)	0	0.0%		
Levee/Riprap (protecting urban, industrial, etc.)	14	0.6%		
Railroad	185	7.6%		
Abandoned Railroad	0	0.0%		
Transportation (Interstate and other roads)	13	0.5%		
<b>Total Not Isolated (Ac)</b>	<b>2139</b>		<b>1282</b>	
<b>Total Floodplain Area (Ac)</b>	<b>2447</b>		<b>2003</b>	
<b>Total Isolated (Ac)</b>	<b>308</b>	<b>12.6%</b>	<b>721</b>	<b>62.0%</b>

The 5-year floodplain is a good allegory for the extent of the riparian zone. Thus, irrigated areas within the 5-year floodplain tend to represent riparian zones that have been converted to agriculture and may result in additional bank protection to protect the agricultural production and irrigation infrastructure.

	Flood	Sprinkler	Pivot	Total
Irrigated Acres within the 5 Year Flooplain:	0	0	0	0

## CHANNEL MIGRATION ZONE

A series of Channel Migration Maps were developed for the Yellowstone River from Gardiner to its mouth in McKenzie County, North Dakota (Thatcher, Swindell, and Boyd, 2009). These maps and their accompanying report can be accessed from the YRDC Website. The channel migration zone (CMZ) developed for the Yellowstone River is defined as a composite area made up of the existing channel, the historic channel since 1950 (Historic Migration Zone, or HMZ), and an Erosion Buffer that encompasses areas prone to channel erosion over the next 100 years. Areas within this CMZ that have been isolated by constructed features such as armor or floodplain dikes are attributed as "Restricted Migration Areas" (RMA). Beyond the CMZ boundaries, outlying areas that pose risks of channel avulsion are identified as "Avulsion Potential Zones".

Mean 50-Yr Migration Distance (ft)	Erosion Buffer (ft)	Total CMZ Acreage	Restricted CMZ Acreage	% Restricted Migration Area	Total AHZ Acreage	Restricted AHZ Acreage	% Restricted Avulsion Area
332	663	2,033	195	10%	214	0	0%

### 2011 Restricted Migration Area Summary

Note that these data reflect the observed conditions in the 2011 aerial photography (NAIP for Park and Sweet Grass Counties, COE for the rest of the river).

Reason for Restriction	Land Use Protected	RMA Acres	Percent of CMZ
Road/Railroad	Prism		
	Railroad	35	1.5%
	Public Road	18	0.8%
	Non-Irrigated	8	0.4%
RipRap			
	Urban Industrial	50	2.2%
	Railroad	7	0.3%
	Non-Irrigated	15	0.7%
	Irrigated	49	2.2%
Flow Deflectors			
	Non-Irrigated	30	1.3%
	<b>Totals</b>	<b>210</b>	<b>9.3%</b>

### Land Uses within the CMZ (Acres)

Flood Irrigation	Sprinkler Irrigation	Pivot Irrigation	Urban/ExUrban	Transportation
38.5	0.0	27.0	21.1	4.9



## LAND USE

Land uses were mapped from aerial photography Gardiner to the confluence of the Missouri River in North Dakota for four time periods: 1950s, 1976, 2001, and 2011. Mapping was performed at approximately 1:6,000 to ensure consistent mapping across all data sets. Typically, if a feature could not be easily mapped at the target mapping scale, it was not separated out from the adjacent land use.

A four-tiered system was used to allow analysis at a variety of levels. Tier 1 breaks land use into Agricultural and Non-Agricultural uses. Tier two subdivided uses into productive Agricultural Land and Infrastructure for the Agricultural land, and Urban, Exurban and Transportation categories for the Non-Agricultural land. Tier three further breaks down land uses into more refined categories such as Irrigated or Non-Irrigated and Residential, Commercial, or Industrial. Finally, Tier 4 focuses primarily on the productive agricultural lands, identifying the type of irrigation (Pivot, Sprinkler or Flood).

### Land Use Timeline - Tiers 2 and 3

Feature Class	Feature Type	Acres				% of Reach Area			
		1950	1976	2001	2011	1950	1976	2001	2011
Agricultural Infrastructure									
	Canal	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Agricultural Roads	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Other Infrastructure	92	158	159	159	1.2%	2.0%	2.1%	2.1%
	<b>Totals</b>	<b>92</b>	<b>158</b>	<b>159</b>	<b>159</b>	<b>1.2%</b>	<b>2.0%</b>	<b>2.1%</b>	<b>2.1%</b>
Agricultural Land									
	Non-Irrigated	5,180	4,894	4,895	4,877	66.8%	63.1%	63.1%	62.9%
	Irrigated	1,004	1,199	1,131	1,131	12.9%	15.5%	14.6%	14.6%
	<b>Totals</b>	<b>6,184</b>	<b>6,093</b>	<b>6,026</b>	<b>6,008</b>	<b>79.8%</b>	<b>78.6%</b>	<b>77.7%</b>	<b>77.5%</b>
Channel									
	Channel	1,176	1,111	1,107	1,125	15.2%	14.3%	14.3%	14.5%
	<b>Totals</b>	<b>1,176</b>	<b>1,111</b>	<b>1,107</b>	<b>1,125</b>	<b>15.2%</b>	<b>14.3%</b>	<b>14.3%</b>	<b>14.5%</b>
ExUrban									
	ExUrban Other	74	0	0	0	1.0%	0.0%	0.0%	0.0%
	ExUrban Undeveloped	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	ExUrban Industrial	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	ExUrban Commercial	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	ExUrban Residential	0	4	4	4	0.0%	0.0%	0.0%	0.0%
	<b>Totals</b>	<b>74</b>	<b>4</b>	<b>4</b>	<b>4</b>	<b>1.0%</b>	<b>0.0%</b>	<b>0.0%</b>	<b>0.0%</b>
Transportation									
	Public Road	54	16	10	10	0.7%	0.2%	0.1%	0.1%
	Interstate	0	48	48	48	0.0%	0.6%	0.6%	0.6%
	Railroad	63	63	32	32	0.8%	0.8%	0.4%	0.4%
	<b>Totals</b>	<b>118</b>	<b>128</b>	<b>91</b>	<b>91</b>	<b>1.5%</b>	<b>1.6%</b>	<b>1.2%</b>	<b>1.2%</b>
Urban									
	Urban Other	102	173	200	200	1.3%	2.2%	2.6%	2.6%
	Urban Residential	0	0	37	37	0.0%	0.0%	0.5%	0.5%
	Urban Commercial	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Urban Undeveloped	0	8	39	39	0.0%	0.1%	0.5%	0.5%
	Urban Industrial	6	78	90	90	0.1%	1.0%	1.2%	1.2%
	<b>Totals</b>	<b>108</b>	<b>259</b>	<b>366</b>	<b>366</b>	<b>1.4%</b>	<b>3.3%</b>	<b>4.7%</b>	<b>4.7%</b>

### Land Use Timeline - Tiers 3 and 4

Feature Class	Feature Type	Acres				% of Reach Area				Change Between Years (% of Agricultural Land)			
		1950	1976	2001	2011	1950	1976	2001	2011	'50-76	'76-01	'01-11	'50-11
Irrigated													
	Sprinkler	0	0	0	0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Pivot	0	304	304	304	0.0%	5.0%	5.0%	5.1%	5.0%	0.1%	0.0%	5.1%
	Flood	1,004	895	827	827	16.2%	14.7%	13.7%	13.8%	-1.5%	-1.0%	0.0%	-2.5%
	<b>Totals</b>	<b>1,004</b>	<b>1,199</b>	<b>1,131</b>	<b>1,131</b>	<b>16.2%</b>	<b>19.7%</b>	<b>18.8%</b>	<b>18.8%</b>	<b>3.4%</b>	<b>-0.9%</b>	<b>0.1%</b>	<b>2.6%</b>

Non-Irrigated

Multi-Use	3,531	4,643	4,806	4,751	57.1%	76.2%	79.8%	79.1%	19.1%	3.5%	-0.7%	22.0%
Hay/Pasture	1,649	250	89	126	26.7%	4.1%	1.5%	2.1%	-22.6%	-2.6%	0.6%	-24.6%
<b>Totals</b>	<b>5,180</b>	<b>4,894</b>	<b>4,895</b>	<b>4,877</b>	<b>83.8%</b>	<b>80.3%</b>	<b>81.2%</b>	<b>81.2%</b>	<b>-3.4%</b>	<b>0.9%</b>	<b>-0.1%</b>	<b>-2.6%</b>

## RIPARIAN

Riparian mapping data are derived from the Yellowstone River Riparian Vegetation Mapping study (DTM/AGI 2008). This study coarsely mapped the riparian vegetation communities using 1950's, 1976-1977, and 2001 aerial imagery in a GIS environment. The polygons are digitized at a scale of approximately 1:7,500, with a minimum mapping unit of approximately 10 acres. The goal of the delineation was to capture areas of similar vegetation structure as they appeared on the aerial imagery, while maintaining a consistent scale.

The "Riparian Turnover" values quantify the total area within the active channel area that converted from either woody vegetation to open bar or water, or from open bar or water to woody vegetation. A comparison of these values allows some consideration of overall riparian encroachment into the river corridor from 1950 to 2001.

### Riparian Mapping

Statistic	Shrub (Acres)			Closed Timber (Acres)			Open Timber (Acres)		
	1950	1976	2001	1950	1976	2001	1950	1976	2001
Min	0.8	0.3	0.9	0.0	0.8	0.7	6.3	1.7	1.0
Max	84.1	74.1	29.0	61.8	68.9	71.3	62.0	81.1	84.9
Average	10.9	8.7	7.4	15.0	14.3	16.0	18.1	18.8	21.3
Sum	347.5	234.2	177.6	346.1	315.4	336.9	217.2	225.6	320.2

### Riparian Turnover

Conversion of riparian areas to channel, or from channel to riparian between the 1950's and 2001 data set.

Riparian to Channel (acres) 119.9

Channel to Riparian (acres) 174.4

**Riparian Encroachment (acres) 54.5**

### Riparian Recruitment

Creation of riparian areas between 1950s and 2001.	1950s Channel Mapped as 2011 Riparian (Ac)	175.1
	1950s Floodplain Mapped as 2011 Channel (Ac)	26.8
	<b>Total Recruitment (1950s to 2011)(Ac)</b>	<b>201.9</b>

## WETLANDS

Wetland areas were mapped to National Wetland Inventory standards by the Montana Natural Heritage Program. Palustrine wetlands within the mapped 100-year inundation boundary were extracted and summarized into four categories: Riverine (Unconsolidated Bottom - UB, Aquatic Bed - AB, and Unconsolidated Shore - US), Emergent - EM, Scrub-Shrub - SS, and Forested - FO.

	Riverine	Emergent	Scrub/Shrub	Forested	Total
Mapped Acres	21.2	94.7	23.1	0.0	<b>139.1</b>
Acres/Valley Mile	3.2	14.3	3.5	0.0	

## RUSSIAN OLIVE

Russian olive is considered an invasive species and its presence in the Yellowstone River corridor is fairly recent. As such, its spread can be used as a general indicator of invasive plants within the corridor. It has the added benefit of being easily identified in multi-spectral aerial photography, making it possible to inventory large areas using remote techniques.

In 2011, Natural Resources Conservation Service (NRCS) in Bozeman, MT conducted an inventory of Russian olive locations in the Yellowstone River watershed. This study utilized the Feature Analyst extension within ArcGIS to interpret multi-spectral 2008 NAIP imagery for the presence of Russian olive. The resulting analysis was converted from raster format to a polygon ESRI shape file for distribution and further analysis within a GIS environment.

This work scope was tasked with integrating the resulting Russian olive inventory into the Yellowstone River Conservation Districts Council (YRDC) Cumulative Effects Assessment (CEA) GIS and associated reach-based database. Additionally, analysis of Russian olive within the corridor was conducted to characterize its distribution in throughout the corridor and its association with other corridor data sets.

	Floodplain Area (Ac)	% of Floodplain	Other Area (Ac)	Inside RMA (Ac)	Inside '50s Channel (Ac)	Inside 50s Island (Ac)
Russian Olive in Reach	170.16	3.72%	41.91	4.03	53.93	17.93

## FISHERIES SUMMARY

Fisheries data available for the Reach Narratives include low-flow and high-flow habitat mapping of 2001 conditions for 406 miles of river, extending from the mouth upstream to a point approximately 8 miles upstream of Park City. Habitat mapping was performed remotely on the 2001 CIR aerial photography utilizing habitat classifications developed by Montana Fish, Wildlife, and Parks (DTM 2009). Historic habitat mapping using the 1950's imagery is limited to Reach B1 (high-flow) and D9 (low and high-flow).

Fisheries field sampling data have been provided by Ann Marie Reinhold (MSU). In this study, the Yellowstone River from Park City to Sidney was divided into five segments. Within each segment, fish were sampled in reaches modified by riprap ("treatment reaches") and relatively unmodified reaches ("control reaches"). Fish sampling was conducted during summer and autumn of 2009, 2010, and 2011. Boat electrofishing, trammel nets, mini-fyke nets and bag seines were used to collect data from river bends.

Fish presence data is only presented for those reaches that were sampled.

The Low Flow Habitat Mapping followed schema developed by Montana Fish Wildlife and Parks to identify key habitat units for certain aquatic species.

## Fish Species Observed in Reach/Region

Species of Concern

Reach	Region	Reach	Region	Reach	Region	Reach	Region
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> Bigmouth buffalo	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> Flathead chub	<input type="checkbox"/>	<input type="checkbox"/> Northern redbelly dace	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> Stonecat
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> Black bullhead	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> Freshwater drum	<input type="checkbox"/>	<input type="checkbox"/> Pallid sturgeon	<input type="checkbox"/>	<input type="checkbox"/> Sturgeon chub
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> Black crappie	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> Goldeye	<input type="checkbox"/>	<input checked="" type="checkbox"/> Pumpkinseed	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> Sucker species
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> <b>Blue sucker</b>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> Green sunfish	<input type="checkbox"/>	<input type="checkbox"/> Rainbow trout	<input type="checkbox"/>	<input type="checkbox"/> Sunfish species
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> Bluegill	<input type="checkbox"/>	<input checked="" type="checkbox"/> Lake chub	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> River carpsucker	<input type="checkbox"/>	<input checked="" type="checkbox"/> Walleye
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> Brook stickleback	<input type="checkbox"/>	<input checked="" type="checkbox"/> Largemouth bass	<input type="checkbox"/>	<input checked="" type="checkbox"/> Rock bass	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> Western silvery minnow
<input type="checkbox"/>	<input checked="" type="checkbox"/> Brown trout	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> Longnose dace	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> Sand shiner	<input type="checkbox"/>	<input type="checkbox"/> White bass
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> Burbot	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> Longnose sucker	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> Sauger	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> White crappie
<input type="checkbox"/>	<input type="checkbox"/> Catfish species	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> Minnow species	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> Shorthead redhorse	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> White sucker
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> Channel catfish	<input type="checkbox"/>	<input type="checkbox"/> Mottled sculpin	<input type="checkbox"/>	<input type="checkbox"/> Shortnose gar	<input type="checkbox"/>	<input checked="" type="checkbox"/> Yellow bullhead
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> Common carp	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> Mountain sucker	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> Shovelnose sturgeon	<input type="checkbox"/>	<input type="checkbox"/> Yellow perch
<input type="checkbox"/>	<input checked="" type="checkbox"/> Creek chub	<input type="checkbox"/>	<input checked="" type="checkbox"/> Mountain whitefish	<input type="checkbox"/>	<input type="checkbox"/> Sicklefin chub		
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> Emerald shiner	<input type="checkbox"/>	<input checked="" type="checkbox"/> Northern pike	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> Smallmouth bass		
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> Fathead minnow	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> Northern plains killifish	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> Smallmouth buffalo		

## Low Flow Fisheries Habitat Mapping

2001 (Acres)

Habitat	Bankfull	Low Flow	% of Low Flow
Scour Pool	234.3	102.3	9.2%
Rip Rap Bottom	58.7	44.9	4.1%
Rip Rap Margin	52.3	47.5	4.3%
Bluff Pool	97.8	86.3	7.8%
Terrace Pool	6.8		
Secondary Channel	88.3	114.0	10.3%
Secondary Channel (Seasonal)	109.6	87.6	7.9%
Channel Crossover	187.8	120.1	10.9%
Point Bar		24.5	2.2%
Side Bar		59.4	5.4%
Mid-channel Bar		59.1	5.3%
Island	269.2	266.2	24.1%
Dry Channel		93.1	8.4%
Confluence Area	1.6	1.6	0.1%

## AVIAN

Birds were sampled in 2006 and 2007 by Danielle Jones of Montana State University. Point count methods were used at 304 randomly chosen sites in 21 braided or anabranching reaches. Each site was visited multiple times within a season, and sites were visited in both years. Birds were sampled in grassland, shrubland, and cottonwood forest habitats. Additional bird data was collected by Amy Cilimburg of Montana Audubon in summer 2012. High priority areas for data collection were identified with the assistance of the YRCDC Technical Advisory Committee. The Audubon methodology recorded data for a wider variety of bird species relative to the MSU study, including raptors and waterfowl.

## CULTURAL INVENTORY SUMMARY

The Yellowstone River Cultural Inventory - 2006 documents the variety and intensity of different perspectives and values held by people who share the Yellowstone River. Between May and November of 2006, a total of 313 individuals participated in the study. They represented agricultural, civic, recreational, or residential interest groups. Also, individuals from the Crow and the Northern Cheyenne tribes were included.

There are three particular goals associated with the investigation. The first goal is to document how the people of the Yellowstone River describe the physical character of the river and how they think the physical processes, such as floods and erosion, should be managed. Within this goal, efforts have been made to document participants' views regarding the many different bank stabilization techniques employed by landowners. The second goal is to document the degree to which the riparian zone associated with the river is recognized and valued by the participants. The third goal is to document concerns regarding the management of the river's resources. Special attention is given to the ways in which residents from diverse geographical settings and diverse interest groups view river management and uses. The results illustrate the commonalities of thought and the complexities of concerns expressed by those who share the resources of the Yellowstone River.

### Summary of Cultural Views in Region C

In the study segment, Powder River to Big Horn River, three conversations emerged across the four interest groups. The first conversation focuses on the "familiar way of life." The conversation exposes a local identity that is tied to agriculture and to traditional forms of recreation, such as hunting and fishing. When asked if the familiar management practices are sufficient in terms of sharing the river's resources, some locals express concerns. The second conversation explicitly acknowledges that the demand for recreational access to the river's resources is in its infancy in terms of representing a problem. The third conversation focuses on controlling the river with rip-rap and dikes.