County	Dawson	**Upstream River Mile**	94.6
Classification	PCM/I: Partially confined meandering/islands	**Downstream River Mile**	89
General Location	Glendive	**Length**	5.60 mi (9.01 km)

General Comments Reach D6 is located at Glendive and provides a good example of an urbanized reach that is primarily impacted by transportation infrastructure and floodplain dikes in an area prone to severe ice jamming.

Narrative Summary

Reach D6 is located in Dawson County at Glendive. The reach is a 5.6 mile long Partly Confined Meandering reach type, extending from Black Bridge at RM 89.0 to downstream of Glendive at RM 94.6. The partial confinement is imposed by terraces and Hell Creek Formation bluff line. The reach is fairly straight, with minor bendways and several densely vegetated islands. Within Reach D6, the Yellowstone River has been directly affected by both urban/exurban development and the I-94 transportation corridor.

Reach D6 has almost a mile of bank armor including 2,930 feet of rock riprap, 1,200 feet of concrete riprap, and 760 feet of flow deflectors as mapped in 2011. About 8.3 percent of the total bankline is armored. Between 2001 and 2011, about 1,300 feet of rock riprap and 200 feet of flow deflectors were built, whereas 354 feet of concrete riprap were destroyed.

Prior to the 1950s, about three miles of side channel were blocked in the reach by physical features. Since then another three miles have been blocked such that a total of six miles of side channel have been blocked in this urbanized section of the Yellowstone River. The side channel losses occurred under the Interstate and near the mouth of Glendive Creek. In 1950, the side channel under the Interstate was almost three miles long before being blocked off.

Floodplain dikes have isolated historic floodplain area. There are 14,700 feet of floodplain dikes mapped in the reach, most of which was built between 1950 and 1976. There are also 23,736 feet of transportation encroachments. The encroachments associated with the railroad have been in place since 1950; however the length of bridge approaches increased substantially from 1950 to 1976, which is when I-94 was constructed. The large West Glendive Dike (RM 93.5) was constructed in 1957 by the US Army Corps of Engineers to protect the west Glendive area from Yellowstone River flooding.

There are five bridge crossings in Reach D6. The uppermost crossing is referred to as the BNSF “Black Bridge”, which is a 1325 foot-long steel truss bridge at RM 94.5. There is a natural gas pipeline crossing at the bridge. Just downstream at RM 93.6, the “Old Bell Street Bridge’ is a 1,290 foot long bridge that was originally built in 1894, then destroyed by ice in 1899, and rebuilt in 1924. It is currently preserved as a pedestrian bridge. Approximately 0.1 mile downstream, the Towne Street Bridge is a 1,318 foot-long steel girder/floor beam structure that was built in 1958. About 1.3 miles downstream from that structure, I-94 consists of two bridges built in 1968. These bridges are 2,013 and 1,973 feet long, and both are steel girder/floor beam structures. The I-94 bridges restrict about 200 acres of the CMZ.

Some of the most severe ice jamming in Montana occurs in Glendive. A total of 30 ice jam floods have occurred in the Glendive area since 1890 (COE, 2009). Descriptions of these and even older ice jams include loss of life (1894, 1899), bridge failure (1899) and major flooding (1899, 1936, 1969, 1986 and 1994). In 1980, FEMA concluded that the West Glendive Levee did not provide adequate protection from ice jam flooding (COE, 2009). According to the COE (2009), the majority of ice jams form downstream of the I-94 Bridge and its embankment, which acts as a flow obstruction on the left floodplain of the Yellowstone River. This embankment cuts off a side channel of the Yellowstone, "which may have historically provided a relief for floodwaters to flow around the ice jams" (COE, 2009).

Similar to many reaches on the Lower Yellowstone, the river has gotten smaller since 1950. At that time, the bankfull channel area in Reach D6 was 810 acres, and by 2001 it was 640 acres, which is a reduction of 21 percent. This has been accompanied by the encroachment of 134 acres of riparian vegetation into old channel areas. On the floodplain, however, riparian clearing has been notable; since 1950 over 400 acres of riparian vegetation was converted to another land use, which was 32 percent of the entire 1950s riparian footprint.

Floodplain turnover rates in Reach D6 have dropped from 4 acres per year prior to 1976 to 2 acres per year since then. This is also a common trend on the lower river, as the influences of bank armor and reduced flow energy have collectively slowed rates of channel change.

Land use is dominated by agriculture and urban/exurban development; although there is over 1,300 acres of urban, exurban, and transportation-related land uses, there are still over 3,100 acres of agricultural land. Most is non-irrigated, but 502 acres are in flood irrigation and 280 are in pivot. Between 1950 and 2011 approximately two square miles of land was converted to Urban and Exurban uses in the Glendive area. Much of this growth occurred in the now-leveed area on the west side of the river.

About 18 percent of the total 100-year floodplain has become isolated due to human development and most of that isolated floodplain area is behind floodplain dikes. The 5-year floodplain is even more affected; 51 percent of the historic 5-year floodplain is no longer inundated at that frequency.

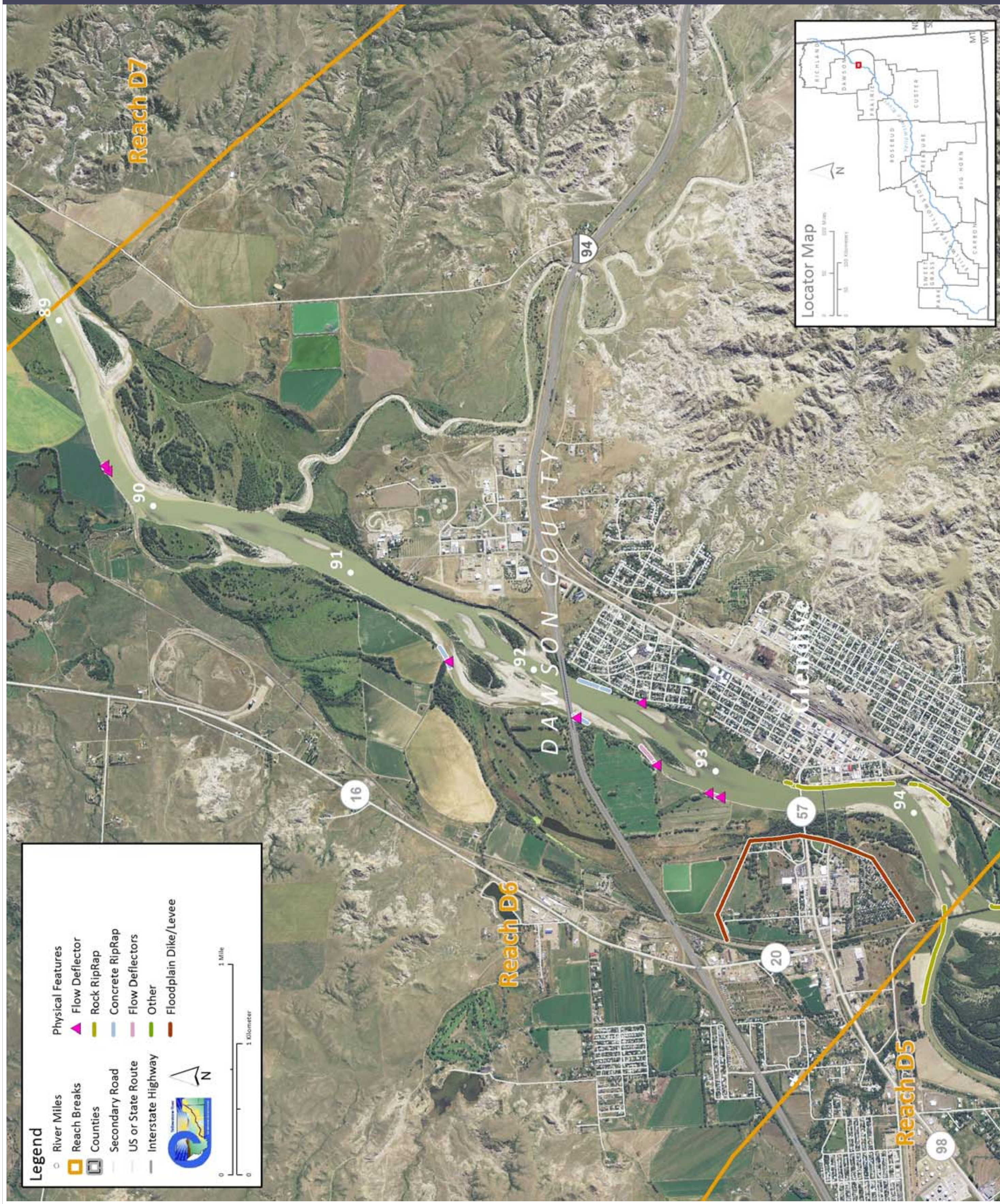
Reach D6 was sampled as part of the fisheries study. A total of 27 fish species were sampled in the reach including three identified by the Montana Natural Heritage Program as a Species of Concern (SOC): the Blue Sucker, Sauger, and Sturgeon chub.

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 from 146,000 cfs pre-development to 125,000 cfs currently, which is a 14 percent reduction. The 2-year flood, which strongly influences overall channel form, has dropped by 22 percent. Summer base flows have dropped by 54 percent with human development, from 6,990 cfs to 3,210 cfs, a 54 percent reduction. In contrast, fall and winter base flows have both increased between 60 percent (winter) and 75 percent (fall). Fall and wither base flows are currently 2,030 and 2,110 cfs, respectively.

CEA-Related observations in Reach D6 include:
•Loss of side channels due to physical features
•Shrinking of channel due to flow consolidation and reduced high flows.
•Extensive transportation encroachment
•Dike construction post-1950 to facilitate urban/exurban development in West Glendive

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach D6 include:
•Bank armor removal at RM 92.8L
•Russian olive removal

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): Sidney

Flood History

Year	Date	Flow on Date	Return Interval
1978	May 23	111,000	10-25 yr
1912	Mar 29	114,000	10-25 yr
1944	Jun 21	120,000	10-25 yr
2011	May 24	124,000	10-25 yr
1918	Jun 20	126,000	25-50 yr
1943	Mar 29	132,000	25-50 yr
1923	Oct 3	134,000	25-50 yr
1952	Mar 31	138,000	25-50 yr
1921	Jun 21	159,000	100-yr

	Downstream Gage	Upstream Gage
Gage No	6329500	6309000
Location	Sidney	Miles City
Period of Record	1911-2015	1929-2015
Distance To (miles)	58.2	89.4

Discharge

	1.01 Yr	2 Yr	5 Yr	10 Yr	50 Yr	100 Yr	500 Yr	7Q10 Summer	95% Sum. Duration
Unregulated		69,400	89,400	103,000	133,000	146,000	177,000	4,790	6,990
Regulated		54,200	74,000	86,800	114,000	125,000	151,000	2,710	3,210
% Change		-21.90%	-17.23%	-15.73%	-14.29%	-14.38%	-14.69%	-43.42%	-54.08%

Flow Duration

Streamflow, in ft3/s, which was equaled or exceeded for indicated percent of time

Season		5%	50%	95%
Spring	Unregulated	67,500	25,200	6,910
	Regulated	52,100	15,000	5,050
	% Change	**-23%**	**-40%**	**-27%**
Summer	Unregulated	47,200	14,900	6,990
	Regulated	35,200	8,930	3,210
	% Change	**-25%**	**-40%**	**-54%**
Fall	Unregulated	9,770	5,960	2,030
	Regulated	11,200	7,450	3,580
	% Change	**15%**	**25%**	**76%**
Winter	Unregulated	14,500	5,330	2,110
	Regulated	15,100	6,500	3,430
	% Change	**4%**	**22%**	**63%**
Annual	Unregulated	49,900	8,920	2,820
	Regulated	37,200	8,020	3,650
	% Change	**-25%**	**-10%**	**29%**

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

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	6329500	2750
1976	USCOE	9-Oct-76	B/W	1:24,000	6329500	9580
1995	USGS DOQQ	12-Jun-96	B/W		6329500	52600
2001	NRCS	August 2-8, 2001	CIR	1:24,000	6329500	4000
2004	Merrick	5/20/04 - 6/3/2004	Color	1:15,840	6329500	5070
2005	NAIP	07/31/2005	color	1-meter pixels	6329500	5280
2005	NAIP	07/14/2005	color	1-meter pixels	6329500	15900
2009	NAIP	8/10/2009	Color	1-meter pixels	6329500	13700
2011	USCOE	October 2012	color	1-ft pixel	6329500	9030
2011	NAIP	7/20/2011	Color	1-meter pixels	6329500	48800
2013	NAIP	07/27/2013	color	1-meter pixels	6329500	
2013	NAIP	07/14/2013	color	1-meter pixels	6329500	

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 descrepancies 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
Stream Stabilization						
	Rock RipRap	1,655	2.8%	2,933	5.0%	1,278
	Flow Deflectors	93	0.2%	330	0.6%	238
	Concrete RipRap	1,533	2.6%	1,188	2.0%	-345
	Between Flow Deflectors	496	0.8%	431	0.7%	-64
	Feature Type Totals	**3,776**	**6.4%**	**4,882**	**8.3%**	**1,106**
Floodplain Control						
	Floodplain Dike/Levee	7,743	13.2%	7,743	13.2%	0
	Feature Type Totals	**7,743**	**13.2%**	**7,743**	**13.2%**	**0**
	Reach Totals	**11,519**	**19.7%**	**12,625**	**21.5%**	**1,106**

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	561	0	0	0	971	0	0	0
Flow Deflectors/Between FDs	430	0	0	0	0	0	0	0
Rock RipRap	0	0	0	1,410	0	0	0	0
Totals	**991**	**0**	**0**	**1,410**	**971**	**0**	**0**	**0**

Bankline/Floodplain Inventory: Time Series

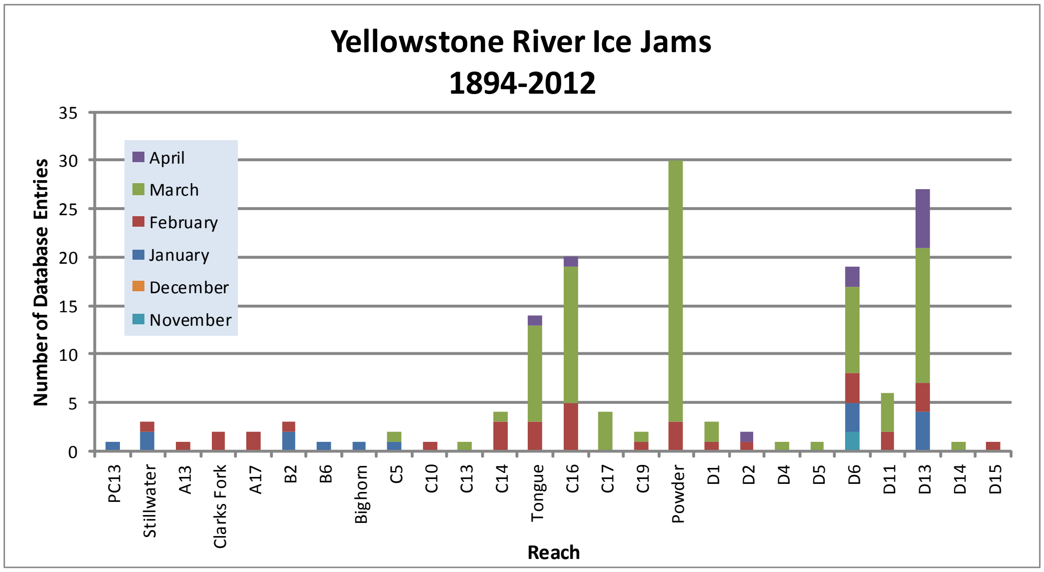
The Human Impacts Timeline assessed physical feature development through time for Yellowstone, Stillwater, and Dawson Counties.

		Sum of Feature Length (ft)					
Feature Class	Feature Type	1950	1976	1995	2001	2004	2005
Other							
	Floodplain Dike/Levee	688	14,720	14,720	14,720	14,720	14,720
	Totals	**688**	**14,720**	**14,720**	**14,720**	**14,720**	**14,720**
Other Off Channel							
	Floodplain Dike/Levee	0	1,505	1,505	1,505	1,505	1,505
	Totals	**0**	**1,505**	**1,505**	**1,505**	**1,505**	**1,505**
Stream Stabilization							
	Rock RipRap	728	3,060	3,060	4,156	4,156	4,156
	Flow Deflector	0	605	605	605	605	605
	Concrete RipRap	0	963	963	963	1,559	1,559
	Totals	**728**	**4,628**	**4,628**	**5,724**	**6,320**	**6,320**
Transportation Encroachment							
	Railroad	8,934	8,934	8,934	8,934	8,934	8,934

Other	0	4,542	4,542	4,542	4,542	4,542
County Road	0	2,447	2,447	2,447	2,447	2,447
Bridge Approach	1,375	7,813	7,813	7,813	7,813	7,813
Totals	**10,309**	**23,736**	**23,736**	**23,736**	**23,736**	**23,736**

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
	NA	94	Death of 3 men
4/1/1904	NA	94	?
3/23/1932	NA	94	?
1/7/1934	NA	94	?
1/1/1936	NA	94	?
4/1/1943	Break-up	94	Severe flooding affecting farmers
3/19/1959	Break-up	94	25K USD
1/1/1969	NA	94	Highway, sewage pump sta., oil well supply flooded
3/15/1972	NA	93	Severe flooding
2/21/1982	NA	94	?
12/29/1992	NA	94	?
3/5/1994	NA	94	Dike nearly overtopped, 60 cattle died,
2/11/1996	Break-up	94	Flooding
2/18/1997	NA	94	?
3/9/1998	Break-up	94	Lowland flooding
3/16/2003	Break-up		
3/16/2003	Break-up		?
3/20/2009	Break-up		Unknown
3/14/2011	Break-up		
12/28/2011			

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
1950	29,804	35,774	2.20
1976	29,529	15,343	1.52
1995	29,484	11,678	1.40
2001	29,301	13,672	1.47
Change 1950 - 2001	**-503**	**-22,102**	**-0.73**

	% Change in Braiding
1950 to 1976:	-30.94%
1976 to 1995:	-8.13%
1995 to 2001:	5.05%
1950 to 2001:	-33.35%

Length of Side Channels Blocked

Pre-1950s (ft)	16,884
Post-1950s (ft)	16,597

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 area 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.)	0	0.0%		
Agriculture (generally relates to field boundaries)	0	0.0%		
Agriculture (isloated by canal or large ditch)	0	0.0%		
Levee/Riprap (protecting agricultural lands)	0	0.0%		
Levee/Riprap (protecting urban, industrial, etc.)	176	9.2%		
Railroad	117	6.1%		
Abandoned Railroad	0	0.0%		
Transportation (Interstate and other roads)	61	3.2%		
Total Not Isolated (Ac)	1565		1126	
Total Floodplain Area (Ac)	1919		1655	
Total Isolated (Ac)	**354**	**18.4%**	**529**	**52.1%**

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 agrigulture 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:	33	0	0	**33**

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 YRCDC 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
225	451	1,819	319	18%	9	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			
	Public Road	17	0.9%
	Non-Irrigated	29	1.6%
	Irrigated	22	1.2%
	Interstate	155	8.5%
RipRap/Flow Deflectors			
	Irrigated	7	0.4%
RipRap			
	Urban Residential	11	0.6%
	Irrigated	27	1.5%
Flow Deflectors			
	Irrigated	58	3.2%
	Totals	**326**	**17.8%**

Land Uses within the CMZ (Acres)

Flood Irrigation	Sprinkler Irrigation	Pivot Irrigation	Urban/ ExUrban	Trans-portation
234.0	0.0	28.5	91.6	31.7

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 1950	Acres 1976	Acres 2001	Acres 2011	% of Reach Area 1950	% of Reach Area 1976	% of Reach Area 2001	% of Reach Area 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	27	72	75	71	0.5%	1.4%	1.4%	1.3%
	Totals	**27**	**72**	**75**	**71**	**0.5%**	**1.4%**	**1.4%**	**1.3%**
Agricultural Land									
	Non-Irrigated	2,897	2,545	2,301	2,285	54.9%	48.2%	43.6%	43.3%
	Irrigated	304	560	792	782	5.8%	10.6%	15.0%	14.8%
	Totals	**3,201**	**3,105**	**3,092**	**3,067**	**60.6%**	**58.8%**	**58.5%**	**58.1%**
Channel									
	Channel	1,380	938	738	756	26.1%	17.8%	14.0%	14.3%
	Totals	**1,380**	**938**	**738**	**756**	**26.1%**	**17.8%**	**14.0%**	**14.3%**
ExUrban									
	ExUrban Other	0	64	143	143	0.0%	1.2%	2.7%	2.7%
	ExUrban Undeveloped	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	ExUrban Industrial	0	60	60	60	0.0%	1.1%	1.1%	1.1%
	ExUrban Commercial	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	ExUrban Residential	0	24	28	28	0.0%	0.4%	0.5%	0.5%
	Totals	**0**	**148**	**231**	**231**	**0.0%**	**2.8%**	**4.4%**	**4.4%**
Transportation									
	Public Road	65	67	67	67	1.2%	1.3%	1.3%	1.3%
	Interstate	0	58	58	58	0.0%	1.1%	1.1%	1.1%
	Railroad	45	45	45	45	0.9%	0.9%	0.9%	0.9%
	Totals	**110**	**170**	**170**	**170**	**2.1%**	**3.2%**	**3.2%**	**3.2%**
Urban									
	Urban Other	150	39	97	97	2.8%	0.7%	1.8%	1.8%
	Urban Residential	198	410	432	435	3.7%	7.8%	8.2%	8.2%
	Urban Commercial	79	116	115	115	1.5%	2.2%	2.2%	2.2%
	Urban Undeveloped	43	51	81	90	0.8%	1.0%	1.5%	1.7%
	Urban Industrial	93	233	251	251	1.8%	4.4%	4.7%	4.7%
	Totals	**563**	**849**	**976**	**988**	**10.7%**	**16.1%**	**18.5%**	**18.7%**

Land Use Timeline - Tiers 3 and 4

Feature Class	Feature Type	Acres 1950	Acres 1976	Acres 2001	Acres 2011	% of Reach Area 1950	% of Reach Area 1976	% of Reach Area 2001	% of Reach Area 2011	Change Between Years (% of Agricultural Land) '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	0	91	279	0.0%	0.0%	2.9%	9.1%	0.0%	2.9%	6.2%	9.1%
	Flood	304	560	701	502	9.5%	18.0%	22.7%	16.4%	8.5%	4.6%	-6.3%	6.9%
	Totals	**304**	**560**	**792**	**782**	**9.5%**	**18.0%**	**25.6%**	**25.5%**	**8.5%**	**7.6%**	**-0.1%**	**16.0%**

Non-Irrigated													
	Multi-Use	2,272	1,881	1,984	2,060	71.0%	60.6%	64.1%	67.2%	-10.4%	3.6%	3.0%	-3.8%
	Hay/Pasture	625	664	317	225	19.5%	21.4%	10.3%	7.3%	1.9%	-11.1%	-2.9%	-12.2%
	Totals	**2,897**	**2,545**	**2,301**	**2,285**	**90.5%**	**82.0%**	**74.4%**	**74.5%**	**-8.5%**	**-7.6%**	**0.1%**	**-16.0%**

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

	Shrub (Acres)			Closed Timber (Acres)			Open Timber (Acres)		
Statistic	1950	1976	2001	1950	1976	2001	1950	1976	2001
Min	0.5	0.3	0.8	0.4	4.5	1.6	2.7	6.1	0.8
Max	313.7	161.4	77.1	138.3	59.0	53.0	142.4	47.9	79.5
Average	27.9	15.5	13.9	24.6	22.8	26.5	29.2	13.3	13.9
Sum	669.5	603.5	403.8	393.2	250.5	345.1	233.5	106.4	139.3

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)	94.7
Channel to Riparian (acres)	229.0
Riparian Encroachment (acres)	**134.4**

Riparian Recruitment

Creation of riparian areas between 1950s and 2001.

1950s Channel Mapped as 2011 Riparian (Ac)	283.9
1950s Floodplain Mapped as 2011 Channel (Ac)	0.9
Total Recruitment (1950s to 2011)(Ac)	**284.8**

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	47.0	88.9	18.6	0.0	**154.5**
Acres/Valley Mile	9.1	17.1	3.6	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 (YRCDC) 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	7.08	0.49%	9.11	0.64	2.11	0.76

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

Low Flow Fisheries Habitat Mapping

Habitat	2001 (Acres) Bankfull	Low Flow	% of Low Flow
Scour Pool	238.7	199.2	27.0%
Rip Rap Margin	18.8	5.5	0.7%
Terrace Pool	153.0	120.1	16.3%
Secondary Channel	52.0	65.6	8.9%
Secondary Channel (Seasonal)	53.4	48.1	6.5%
Channel Crossover	126.1	80.5	10.9%
Point Bar		37.4	5.1%
Side Bar		51.5	7.0%
Mid-channel Bar		14.6	2.0%
Island	97.5	104.8	14.2%
Dry Channel		9.7	1.3%

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 D

A review of the interview data for the segment, Missouri River to Powder River, suggests that people in this area engage in four primary discussions when asked about the Yellowstone River. First, the notion of Eastern Montana is not simply a geographic reference. It is a defining concept that captures the agricultural roots and the cultural values of the people living in the study segment, and the river is an essential element within their notion of Eastern Montana. Second, the river is discussed as a wholesome recreational outlet. However, shifting landownership is noted as an important change in the recreational context. Third, even though agricultural practices are viewed as the mainstay of the local economies, many participants discuss the long-term economic viability of their communities as a concern. Industrial and residential developments along the river's edge are seemingly remote possibilities and are generally discussed with references to flood plain restrictions and the stability of nearby dikes. Finally, discussions of managing the river are limited, but a variety of opinions are offered regarding bank erosion and stabilization techniques.