Yellowstone River Reach Narratives — Reach D3

County	Prairie	**Upstream River Mile**	126.5
Classification	PCS: Partially confined straight	**Downstream River Mile**	118.1
General Location	Downstream of Fallon Bridge	**Length**	8.40 mi (13.52 km)
General Comments	Hugs right bank wall; into Dawson County		

Narrative Summary

Reach D3 straddles the Prairie/Dawson County line, extending from the Fallon Bridge to about two miles into Dawson County. The reach is 8.4 miles long and has been classified as a Partially Confined Straight (PCS) reach type, indicating minimal meandering and some influence of the valley wall on river form and process. Sandstones of the Fort Union Formation typically form the south bank, and younger erosion-resistant terraces confine the channel to the north. Because of the geologic confinement, channel migration rates are low and the riparian corridor is notably thin or absent. The Channel Migration Zone (CMZ) is extremely narrow because there has been only minor bank migration in this reach since 1950. All of the migration measured in the reach was at RM 123, where the river abruptly hits the south valley wall and apparently backwaters as it has developed a series of islands that drive local bank movement. From 1950 to 2011, the right bank migrated almost 900 feet at this single location. These islands provide areas for riparian colonization and habitat for bird species such as least terns.

Approximately 1,500 feet of bank armor have been mapped in the reach; about 2/3 of that armor protects the Interstate Bridge, with the remainder (600 feet) protecting irrigated land. Two pipelines cross the river about 1,000 feet downstream from the Interstate Bridge. One is an 8-inch petroleum product line that has been abandoned and purged, and the other is a product line that was directionally drilled in 1999. About 4,000 feet downstream from the Fallon Bridge, three large bridge piers from an old trestle remain in the middle of the river.

The Glendive Pump Station #1 is located about two miles downstream of the Fallon Bridge at RM 124.5L and is part of the Glendive Unit of the Buffalo Rapids Project. Construction of the unit began November 12, 1937, with ground breaking for excavation of the main canal. The following April 1938, excavation began on the lateral system. The first operation of the pumping station occurred on September 26, 1939, before the Unit was completed; diverted water was allowed to flow about ten miles down the main canal. Ice damage in 2012 required in extensive repairs to the pumping station. The unit serves 16,500 acres of irrigated land.

Land use in Reach D3 is predominantly agricultural, with about 600 acres of pivot irrigation development since 1950. All of the pivots are on the north side of the river, and several of them extend to the river bank and into the CMZ. In total, 57 acres of land under pivot irrigation are within the CMZ, making them especially prone to the threat of bank erosion. Although there has been extensive pivot development, most irrigated land had remained in flood irrigation in 2011 (1,500 acres).

Dump sites were mapped on the banks or in adjacent riparian areas at RM 125.6R, RM 124.2L, and RM 122L.

The most recently available map of the proposed Keystone Pipeline route shows that the line would cross the Yellowstone River at the lower end of Reach D3, at approximately RM 118.2 (www.keystone.steamingmules.com). The river is at Milepost 198 on the proposed pipeline route.

About 108 acres or 49 percent of the historic 5-year floodplain has become isolated in Reach D3, primarily due to flow alterations.

There are 11 acres of mapped Russian olive in the reach.

Bluff pools and terrace pools make up 22 percent of the low flow fish habitat mapped in the reach, indicating that this reach may provide important areas for fish species that prefer this habitat type.

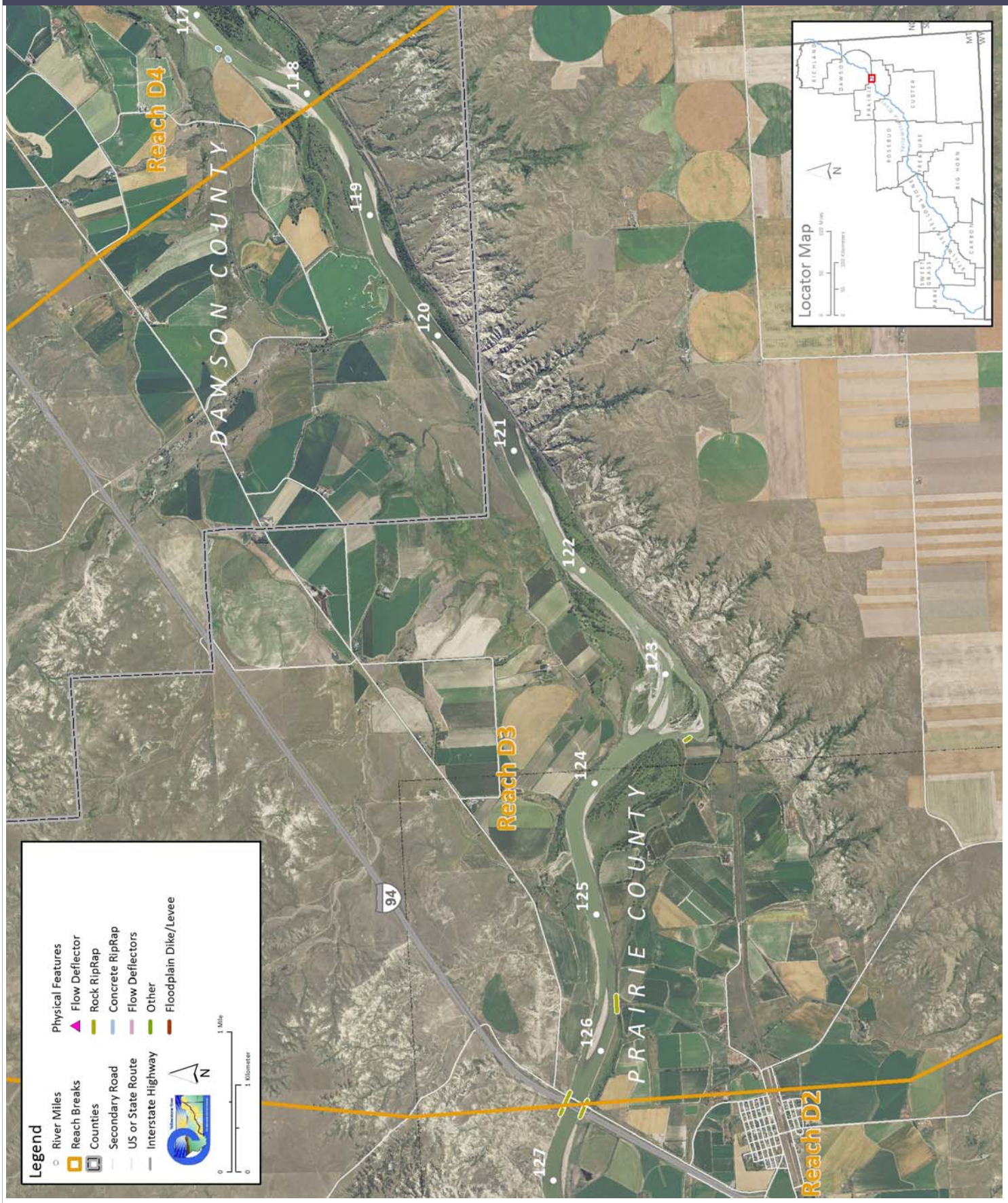
A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been major in this reach. The magnitude of the 100-year flood is now 20,000 cfs or 14 percent lower than it was pre-development. The 2-year flood, which strongly influences overall channel form, has dropped by 22 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 4,820 cfs to 2,750 cfs with human development, a reduction of 43 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,970 cfs under unregulated conditions to 3,240 cfs under regulated conditions, a reduction of 55 percent.

Seasonal low flows have increased by 62 percent in the winter and 75 percent in the fall.

CEA-Related observations in Reach D3 include:
•Isolation of historic 5-year floodplain area due to flow alterations

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach D3 include:
•Solid waste (dump site) removal at RM 125.6R, RM 124.2L, and RM 122L
•Pipeline crossing practices at RM 126.2
•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)	87.3	57.5

Discharge

	1.01 Yr	2 Yr	5 Yr	10 Yr	50 Yr	100 Yr	500 Yr	7Q10 Summer	95% Sum. Duration
Unregulated		68,900	88,500	102,000	131,000	143,000	174,000	4,820	6,970
Regulated		53,700	73,000	85,400	112,000	123,000	147,000	2,750	3,240
% Change		-22.06%	-17.51%	-16.27%	-14.50%	-13.99%	-15.52%	-42.95%	-53.52%

Flow Duration

Streamflow, in ft3/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%
Spring	Unregulated	67,000	25,000	6,870
	Regulated	51,700	14,900	5,010
	% Change	**-23%**	**-40%**	**-27%**
Summer	Unregulated	46,900	14,800	6,970
	Regulated	35,000	8,900	3,240
	% Change	**-25%**	**-40%**	**-54%**
Fall	Unregulated	9,740	5,940	2,060
	Regulated	11,200	7,420	3,600
	% Change	**15%**	**25%**	**75%**
Winter	Unregulated	14,300	5,320	2,110
	Regulated	14,900	6,480	3,420
	% Change	**4%**	**22%**	**62%**
Annual	Unregulated	49,600	8,860	2,820
	Regulated	37,000	7,990	3,660
	% Change	**-25%**	**-10%**	**30%**

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	7/9/96 - 8/26/96	B/W		6329500	35000
2001	NRCS	August 2-8, 2001	CIR	1:24,000	6329500	4000
2005	NAIP	08/05/2005	color	1-meter pixels	6329500	4170
2007	Woolpert	10/15/2007 - 11/2/0007	Color		6329500	
2009	NAIP	8/10/2009	Color	1-meter pixels	6329500	13700
2009	NAIP	8/1/2009	Color	1-meter pixels	6329500	12600
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	07/24/2013	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	1,283	1.5%	1,493	1.7%	210
	Feature Type Totals	**1,283**	**1.5%**	**1,493**	**1.7%**	**210**
	Reach Totals	**1,283**	**1.5%**	**1,493**	**1.7%**	**210**

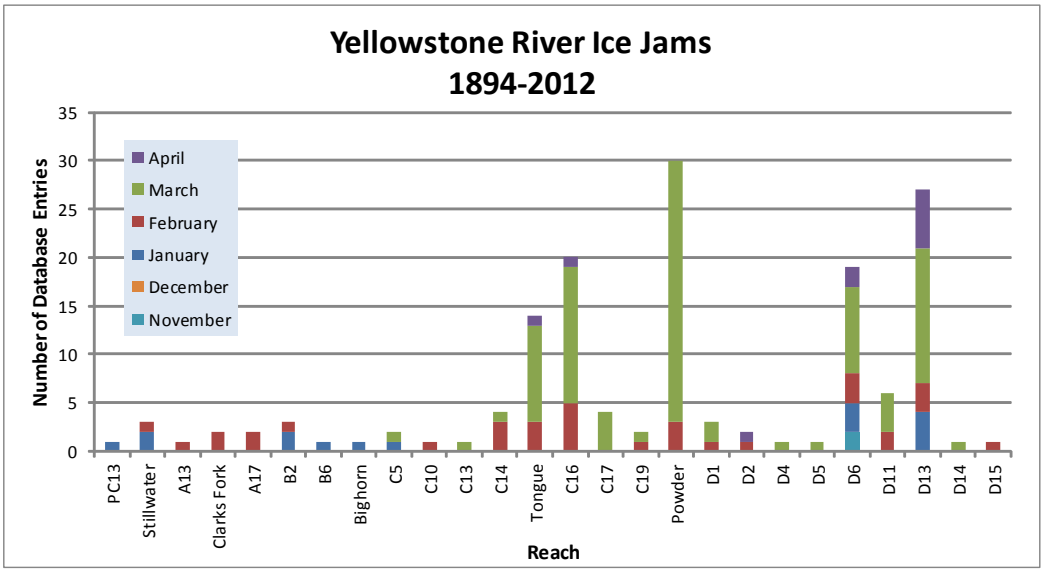
Intent of Bank Protection: 2001

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
Rock RipRap	597	0	0	0	902	0	0	0
Totals	**597**	**0**	**0**	**0**	**902**	**0**	**0**	**0**

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.



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	45,233	13,093	1.29	1950 to 1976:	7.04%
1976	43,598	16,577	1.38	1976 to 1995:	2.31%
1995	43,654	17,992	1.41	1995 to 2001:	1.71%
2001	44,080	19,230	1.44	1950 to 2001:	11.38%
Change 1950 - 2001	**-1,153**	**6,136**	**0.15**		

Length of Side Channels Blocked

Pre-1950s (ft)	0
Post-1950s (ft)	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 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.)	101	12.7%		
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.)	0	0.0%		
Railroad	0	0.0%		
Abandoned Railroad	0	0.0%		
Transportation (Interstate and other roads)	0	0.0%		
Total Not Isolated (Ac)	695		988	
Total Floodplain Area (Ac)	796		1096	
Total Isolated (Ac)	**101**	**12.7%**	**108**	**48.7%**

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:	0	0	3	**3**

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
188	376	1,717	18	1%	137	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
RipRap			
	Irrigated	9	0.5%
	Interstate	8	0.4%
	Totals	**18**	**1.0%**

Land Uses within the CMZ (Acres)

Flood Irrigation	Sprinkler Irrigation	Pivot Irrigation	Urban/ ExUrban	Trans-portation
59.9	0.0	57.4	0.0	4.4

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

		Acres				% of Reach Area			
Feature Class	Feature Type	1950	1976	2001	2011	1950	1976	2001	2011
Agricultural Infrastructure									
	Canal	12	11	12	12	0.2%	0.2%	0.2%	0.2%
	Agricultural Roads	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Other Infrastructure	9	64	63	57	0.1%	0.9%	0.9%	0.8%
	Totals	**21**	**75**	**75**	**69**	**0.3%**	**1.1%**	**1.1%**	**1.0%**
Agricultural Land									
	Non-Irrigated	4,387	3,890	4,076	3,596	63.5%	56.3%	59.0%	52.1%
	Irrigated	1,421	1,835	1,621	2,102	20.6%	26.6%	23.5%	30.4%
	Totals	**5,808**	**5,725**	**5,697**	**5,698**	**84.1%**	**82.9%**	**82.5%**	**82.5%**
Channel									
	Channel	1,009	1,038	1,054	1,058	14.6%	15.0%	15.3%	15.3%
	Totals	**1,009**	**1,038**	**1,054**	**1,058**	**14.6%**	**15.0%**	**15.3%**	**15.3%**
ExUrban									
	ExUrban Other	0	0	0	0	0.0%	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	0	0	0	0.0%	0.0%	0.0%	0.0%
	Totals	**0**	**0**	**0**	**0**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
Transportation									
	Public Road	24	24	24	24	0.3%	0.3%	0.3%	0.3%
	Interstate	0	0	13	13	0.0%	0.0%	0.2%	0.2%
	Railroad	41	41	41	41	0.6%	0.6%	0.6%	0.6%
	Totals	**65**	**65**	**78**	**78**	**0.9%**	**0.9%**	**1.1%**	**1.1%**
Urban									
	Urban Other	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Urban Residential	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Urban Commercial	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Urban Undeveloped	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Urban Industrial	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Totals	**0**	**0**	**0**	**0**	**0.0%**	**0.0%**	**0.0%**	**0.0%**

Land Use Timeline - Tiers 3 and 4

		Acres				% of Reach Area				Change Between Years (% of Agricultural Land)			
Feature Class	Feature Type	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	0	43	598	0.0%	0.0%	0.8%	10.5%	0.0%	0.8%	9.7%	10.5%
	Flood	1,421	1,835	1,578	1,504	24.5%	32.1%	27.7%	26.4%	7.6%	-4.4%	-1.3%	1.9%
	Totals	**1,421**	**1,835**	**1,621**	**2,102**	**24.5%**	**32.1%**	**28.4%**	**36.9%**	**7.6%**	**-3.6%**	**8.4%**	**12.4%**

Non-Irrigated

Multi-Use	4,133	3,809	4,004	3,493	71.2%	66.5%	70.3%	61.3%	-4.6%	3.8%	-9.0%	-9.9%
Hay/Pasture	254	81	72	104	4.4%	1.4%	1.3%	1.8%	-3.0%	-0.1%	0.6%	-2.6%
Totals	**4,387**	**3,890**	**4,076**	**3,596**	**75.5%**	**67.9%**	**71.6%**	**63.1%**	**-7.6%**	**3.6%**	**-8.4%**	**-12.4%**

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	0.8	0.2	1.3	0.3	4.1	1.1	1.2	4.2	0.0
Max	145.5	131.6	99.4	40.2	38.1	156.2	68.0	53.8	52.8
Average	15.7	27.1	20.9	19.8	14.2	28.0	21.9	21.0	18.0
Sum	345.1	542.2	418.0	98.9	142.5	196.1	175.3	105.2	108.2

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)	42.3
Channel to Riparian (acres)	56.1
Riparian Encroachment (acres)	**13.8**

Riparian Recruitment

Creation of riparian areas between 1950s and 2001.

1950s Channel Mapped as 2011 Riparian (Ac)	84.6
1950s Floodplain Mapped as 2011 Channel (Ac)	39.3
Total Recruitment (1950s to 2011)(Ac)	**123.9**

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	12.1	80.1	7.1	0.0	**99.3**
Acres/Valley Mile	1.5	10.2	0.9	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	10.70	0.86%	24.13	0.01	0.88	0.12

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.

Low Flow Fisheries Habitat Mapping

	2001 (Acres)		
Habitat	Bankfull	Low Flow	% of Low Flow
Scour Pool	290.7	173.4	16.5%
Bluff Pool	85.2	47.0	4.5%
Terrace Pool	223.7	190.1	18.0%
Secondary Channel	56.2	69.2	6.6%
Secondary Channel (Seasonal)	53.3	42.6	4.0%
Channel Crossover	183.5	154.4	14.6%
Point Bar		23.9	2.3%
Side Bar		51.5	4.9%
Mid-channel Bar		31.5	3.0%
Island	179.0	179.0	17.0%
Dry Channel		91.4	8.7%

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.

Yellowstone River Reach Narratives — Reach D4

County	Dawson	**Upstream River Mile**	118.1
Classification	PCM/I: Partially confined meandering/islands	**Downstream River Mile**	107.1
General Location	Hoyt	**Length**	11.00 mi (17.70 km)

General Comments

Narrative Summary

Reach D4 is located in western Dawson County. The reach is 11 miles long and has a meandering planform with forested islands that formed where meanders have cut off.

Approximately 1,500 feet of bank armor have been mapped in the reach, including 920 feet of rock riprap and 590 feet of concrete riprap. This armor collectively covers about 1.3 percent of the bankline.

Prior to 1950, a side channel on the south floodplain at RM 110.8R was blocked by a small dike. This channel remnant is about a mile and a half long and currently has blockages at its middle and lower end.

Similar to many reaches in the Lower Yellowstone Valley, the river channel in Reach D4 has gotten smaller since 1950. The channel contracted by about 115 acres in this reach since 1950, and about 84 acres of riparian vegetation has encroached into old channel areas. This pattern has been consistent in the lower river, and relates primarily to a reduction in flows due to human development. Although there has been net encroachment of riparian vegetation, most of this cover is either shrub or open timber. The extent of closed timber dropped from 371 acres in 1950 to 191 acres in 2001.

Land use is predominantly agricultural, with about 180 acres of pivot irrigation development since 1950. About 20 acres of land in pivot irrigation has encroached into the Channel Migration Zone (CMZ), making it especially susceptible to damage by river erosion. Although there has been extensive pivot development, most irrigated land had remained in flood irrigation in 2011 (2,300 acres). Approximately 125 acres of flood irrigated land is within the CMZ.

One solid waste dump site was mapped on the right bank at RM 117.8L. Animal handling facilities (corral complexes) were mapped within a few thousand feet of the river at RM 112.2R, RM 114L, and RM 116L.

About 195 acres or 46 percent of the historic 5-year floodplain has become isolated, primarily due to flow alterations.

There are 16 acres of mapped Russian olive in the reach. Most of the Russian olive is in tributary drainages that flow into the Yellowstone River from the north.

Due to a reduction in the extent of closed timber with time, the extent of riparian forest considered at low risk of cowbird parasitism in Reach D4 has been reduced since 1950. At that time, there were 36.5 acres per mile of forest considered less prone to cowbirds, but by 2001 that had dropped to 14.7 acres per mile of such forest.

One ice jam was recorded in Reach D4. On March 4, 1994, a breakup jam forced local evacuations due to flooding.

Bluff pools and terrace pools make up 22 percent of the low flow fish habitat mapped in the reach, indicating that this reach may provide important areas for fish species that prefer this habitat type.

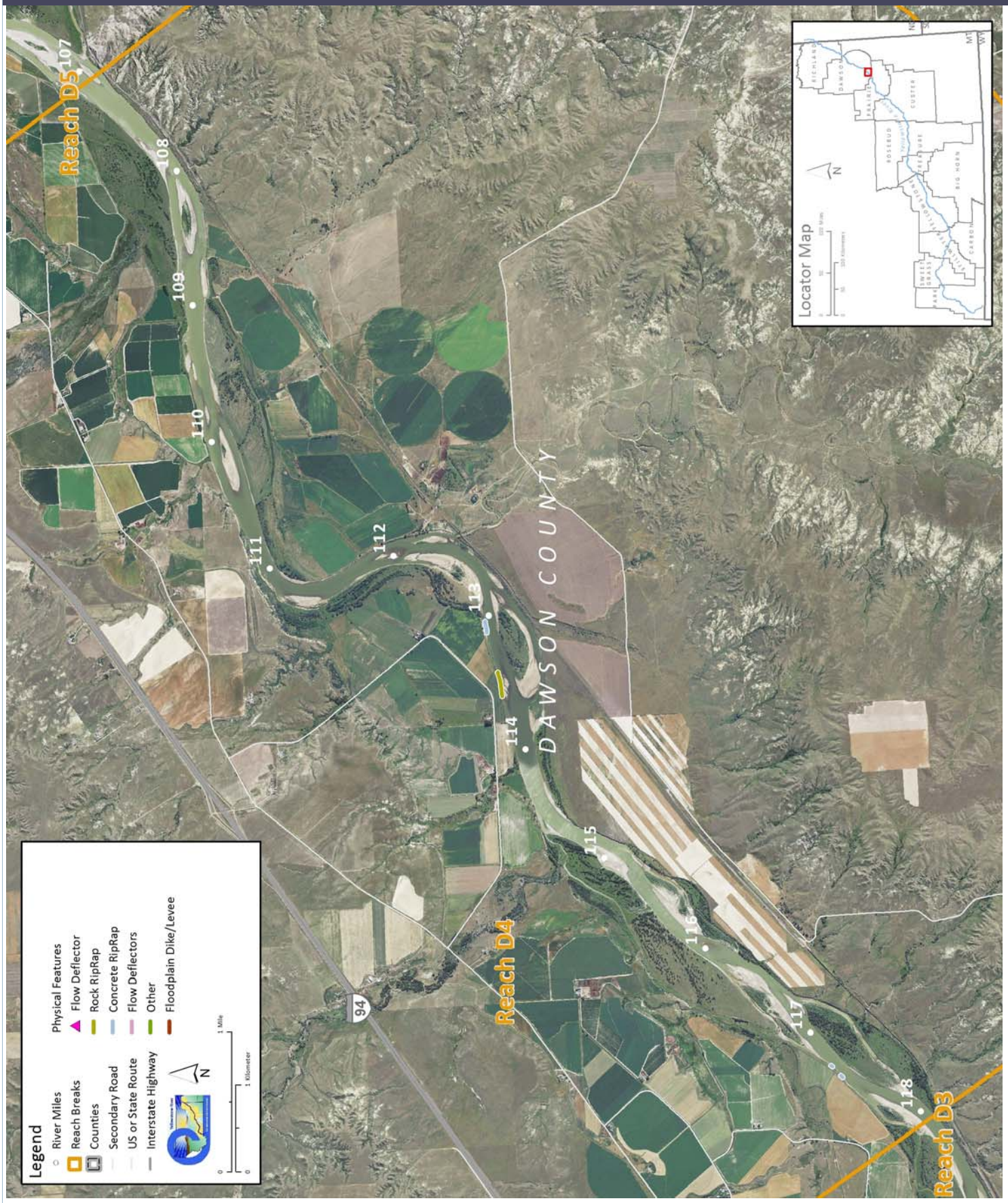
A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been major in this reach. The magnitude of the 100-year flood is now 121,000 cfs, or 14 percent lower than it was pre-development. The 2-year flood, which strongly influences overall channel form, has dropped by 22 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 4,800 cfs to 2,730 cfs with human development, a reduction of 43 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,980 cfs under unregulated conditions to 3,220 cfs under regulated conditions, a reduction of 54 percent.

Seasonal low flows have increased by 63 percent in the winter and 76 percent in the fall.

CEA-Related observations in Reach D4 include:
•Increased risk of cowbird parasitism with loss of closed timber

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach D4 include:
•Side channel reactivation at RM 110.3R
•Solid waste (dump site) removal at RM 117.8L
•Russian olive removal
•Nutrient management at corral complexes at RM 112.2R, RM 114L, and RM 116L

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

	Downstream Gage	Upstream Gage
Gage No	6329500	6309000
Location	Sidney	Miles City
Period of Record	1911-2015	1929-2015
Distance To (miles)	76.3	65.9

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

Discharge

	1.01 Yr	2 Yr	5 Yr	10 Yr	50 Yr	100 Yr	500 Yr	7Q10 Summer	95% Sum. Duration
Unregulated		69,100	88,900	102,000	132,000	145,000	175,000	4,800	6,980
Regulated		53,900	73,500	86,100	113,000	124,000	149,000	2,730	3,220
% Change		-22.00%	-17.32%	-15.59%	-14.39%	-14.48%	-14.86%	-43.13%	-53.87%

Flow Duration

Streamflow, in ft3/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%
Spring	Unregulated	67,300	25,100	6,890
	Regulated	51,900	15,000	5,030
	% Change	**-23%**	**-40%**	**-27%**
Summer	Unregulated	47,100	14,900	6,980
	Regulated	35,100	8,910	3,220
	% Change	**-25%**	**-40%**	**-54%**
Fall	Unregulated	9,750	5,950	2,040
	Regulated	11,200	7,430	3,590
	% Change	**15%**	**25%**	**76%**
Winter	Unregulated	14,400	5,320	2,110
	Regulated	15,000	6,490	3,430
	% Change	**4%**	**22%**	**63%**
Annual	Unregulated	49,800	8,890	2,820
	Regulated	37,100	8,000	3,650
	% Change	**-26%**	**-10%**	**29%**

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	6/12/96 - 8/8/96 - 7/9/96	B/W		6329500	
2001	NRCS	August 2-8, 2001	CIR	1:24,000	6329500	4000
2004	Merrick	20-May-04	Color	1:15,840	6329500	5070
2005	NAIP	08/05/2005	color	1-meter pixels	6329500	4170
2005	NAIP	07/31/2005	color	1-meter pixels	6329500	5280
2009	NAIP	8/1/2009	Color	1-meter pixels	6329500	12600
2011	USCOE	October 2012	color	1-ft pixel	6329500	9030
2011	NAIP	7/20/2011	Color	1-meter pixels	6329500	48800
2013	NAIP	07/24/2013	color	1-meter pixels	6329500	
2013	NAIP	07/27/2013	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	0	0.0%	921	0.8%	921
	Concrete RipRap	0	0.0%	587	0.5%	587
	Feature Type Totals		**0.0%**	**1,509**	**1.3%**	
Other In Channel						
	Bedrock Outcrop	1,961	1.7%	1,961	1.7%	0
	Feature Type Totals	**1,961**	**1.7%**	**1,961**	**1.7%**	**0**
	Reach Totals	**1,961**	**1.7%**	**3,469**	**3.0%**	**1,509**

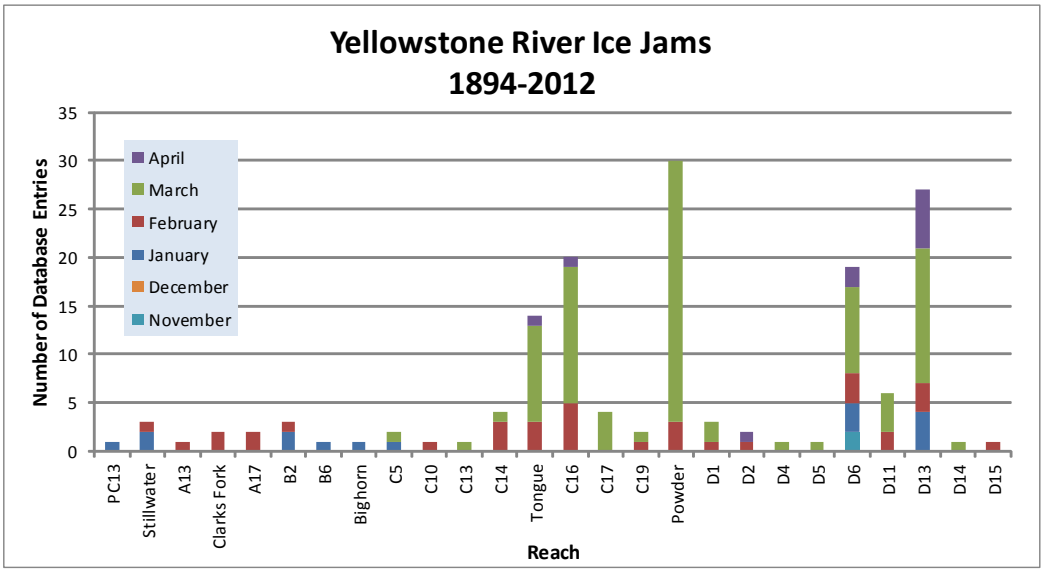
Bankline/Floodplain Inventory: Time Series

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
Irrigation							
	Floodplain Dike/Levee	0	1,978	1,978	1,978	1,978	1,978
	Totals	**0**	**1,978**	**1,978**	**1,978**	**1,978**	**1,978**
Other Off Channel							
	Floodplain Dike/Levee	0	481	481	481	481	481
	Totals	**0**	**481**	**481**	**481**	**481**	**481**
Transportation Encroachment							
	Railroad	18,032	18,032	18,032	18,032	18,032	18,032
	Totals	**18,032**	**18,032**	**18,032**	**18,032**	**18,032**	**18,032**

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
3/4/1994	Break-up	115	Evacuations

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	59,835	38,509	1.64	1950 to 1976:	-2.57%
1976	58,168	34,978	1.60	1976 to 1995:	-5.47%
1995	58,151	29,871	1.51	1995 to 2001:	-6.86%
2001	57,997	23,767	1.41	1950 to 2001:	-14.22%
Change 1950 - 2001	**-1,838**	**-14,742**	**-0.23**		

Length of Side Channels Blocked

Pre-1950s (ft)	8,549
Post-1950s (ft)	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 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.)	98	7.7%		
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.)	0	0.0%		
Railroad	0	0.0%		
Abandoned Railroad	0	0.0%		
Transportation (Interstate and other roads)	0	0.0%		
Total Not Isolated (Ac)	1171		1463	
Total Floodplain Area (Ac)	1269		1658	
Total Isolated (Ac)	**98**	**7.7%**	**195**	**46.0%**

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:	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 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
194	388	2,581	38	1%	194	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
RipRap			
	Irrigated	18	0.6%
Dike/Levee			
	Railroad	38	1.3%
	Totals	**55**	**2.0%**

Land Uses within the CMZ (Acres)

Flood Irrigation	Sprinkler Irrigation	Pivot Irrigation	Urban/ ExUrban	Trans-portation
125.3	0.0	19.8	0.0	7.4

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

		Acres				% of Reach Area			
Feature Class	Feature Type	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	75	70	140	143	0.8%	0.7%	1.5%	1.5%
	Totals	**75**	**70**	**140**	**143**	**0.8%**	**0.7%**	**1.5%**	**1.5%**
Agricultural Land									
	Non-Irrigated	6,022	5,263	5,482	5,350	63.0%	55.1%	57.4%	56.0%
	Irrigated	1,601	2,384	2,446	2,545	16.8%	24.9%	25.6%	26.6%
	Totals	**7,623**	**7,646**	**7,929**	**7,895**	**79.8%**	**80.0%**	**83.0%**	**82.6%**
Channel									
	Channel	1,770	1,752	1,400	1,431	18.5%	18.3%	14.7%	15.0%
	Totals	**1,770**	**1,752**	**1,400**	**1,431**	**18.5%**	**18.3%**	**14.7%**	**15.0%**
ExUrban									
	ExUrban Other	0	0	0	0	0.0%	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	0	0	0	0.0%	0.0%	0.0%	0.0%
	Totals	**0**	**0**	**0**	**0**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
Transportation									
	Public Road	35	35	35	35	0.4%	0.4%	0.4%	0.4%
	Interstate	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Railroad	52	52	52	52	0.5%	0.5%	0.5%	0.5%
	Totals	**88**	**87**	**87**	**87**	**0.9%**	**0.9%**	**0.9%**	**0.9%**
Urban									
	Urban Other	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Urban Residential	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Urban Commercial	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Urban Undeveloped	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Urban Industrial	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Totals	**0**	**0**	**0**	**0**	**0.0%**	**0.0%**	**0.0%**	**0.0%**

Land Use Timeline - Tiers 3 and 4

		Acres				% of Reach Area				Change Between Years (% of Agricultural Land)			
Feature Class	Feature Type	1950	1976	2001	2011	1950	1976	2001	2011	'50-76	'76-01	'01-11	'50-11
Irrigated													
	Sprinkler	0	0	0	44	0.0%	0.0%	0.0%	0.6%	0.0%	0.0%	0.6%	0.6%
	Pivot	0	120	94	180	0.0%	1.6%	1.2%	2.3%	1.6%	-0.4%	1.1%	2.3%
	Flood	1,601	2,264	2,352	2,321	21.0%	29.6%	29.7%	29.4%	8.6%	0.1%	-0.3%	8.4%
	Totals	**1,601**	**2,384**	**2,446**	**2,545**	**21.0%**	**31.2%**	**30.9%**	**32.2%**	**10.2%**	**-0.3%**	**1.4%**	**11.2%**

Non-Irrigated

Multi-Use	3,481	4,225	4,539	4,430	45.7%	55.3%	57.2%	56.1%	9.6%	2.0%	-1.1%	10.4%
Hay/Pasture	2,541	1,038	943	920	33.3%	13.6%	11.9%	11.7%	-19.8%	-1.7%	-0.2%	-21.7%
Totals	**6,022**	**5,263**	**5,482**	**5,350**	**79.0%**	**68.8%**	**69.1%**	**67.8%**	**-10.2%**	**0.3%**	**-1.4%**	**-11.2%**

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	0.3	0.2	0.2	1.8	2.2	2.9	2.7	7.0	2.9
Max	100.4	130.6	147.3	57.4	108.1	39.9	54.8	53.5	86.9
Average	16.4	17.2	22.4	28.6	25.5	17.4	18.9	24.2	20.2
Sum	556.0	688.0	671.9	371.5	331.2	191.2	151.5	145.4	222.0

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)	108.5
Channel to Riparian (acres)	193.1
Riparian Encroachment (acres)	**84.5**

Riparian Recruitment

Creation of riparian areas between 1950s and 2001.

1950s Channel Mapped as 2011 Riparian (Ac)	258.6
1950s Floodplain Mapped as 2011 Channel (Ac)	34.4
Total Recruitment (1950s to 2011)(Ac)	**293.0**

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	8.0	103.2	24.3	0.0	**135.5**
Acres/Valley Mile	0.8	10.1	2.4	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	16.30	1.65%	80.00	0.00	3.42	1.01

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.

Low Flow Fisheries Habitat Mapping

	2001 (Acres)		
Habitat	Bankfull	Low Flow	% of Low Flow
Scour Pool	256.5	189.9	13.6%
Bluff Pool	153.4	132.1	9.4%
Terrace Pool	208.3	183.9	13.1%
Secondary Channel	82.3	60.1	4.3%
Secondary Channel (Seasonal)	114.7	125.4	9.0%
Channel Crossover	401.3	246.6	17.6%
Point Bar		39.1	2.8%
Side Bar		83.7	6.0%
Mid-channel Bar		60.8	4.3%
Island	165.8	166.9	11.9%
Dry Channel		111.6	8.0%

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.

Yellowstone River Reach Narratives — Reach D5

County	Dawson	**Upstream River Mile**	107.1
Classification	PCA: Partially confined anabranching	**Downstream River Mile**	94.6
General Location	To Glendive	**Length**	12.50 mi (20.12 km)
General Comments	Long secondary channels; to Glendive		

Narrative Summary

Reach D5 is located just south of Glendive. The reach is a 12.5 mile long Partially Confined Anabranching reach type, indicating the presence of forested islands with some valley wall influence on the river. The downstream end of the reach is at Black Bridge. Within Reach D5, the river flows across the Cedar Creek Anticline, which is a~115 mile long structure that extends from Glendive to Buffalo South Dakota. Oil was discovered on the anticline in 1951, and since then over a half a billion barrels of oil have been produced from 2,700 wells. As the river flows right through the anticline, the Pierre Shale becomes exposed in the right bluff line and the channel becomes more dynamic than upstream reaches. Active drill pads are located on both sides of the river; several of them are within the 100-year floodplain, and two are mapped within the CMZ.

Reach D5 has just over a mile of bank armor and most of that armor is rock riprap. There are also 1,050 feet of concrete armor and a few flow deflectors. About 640 feet of riprap was built between 2001 and 2011. The majority of the bank armor is protecting either streambank just upstream of Black Bridge. Black Bridge forms a major constriction in the river corridor and bank migration upstream of the bridge has been extensive. The bridge is oriented about 45 degrees off of the axis of the river corridor which further disrupts channel processes upstream. Just upstream of the bridge the river migrated over 1,700 feet eastward between 1950 and 2001, which is over 30 feet per year on average.

Since 1950, a side channel that is over 9,000 feet of side channel has been blocked by a dike at RM 105R. The dike crossing the head of this old channel is about 720 feet long. There are still several side channels in the reach that are perennial (flow year-round) and over a mile long.

Floodplain turnover rates have dropped in Reach D5 since 1976; prior to that time, floodplain turnover rates were about 18.5 acres per year, and since then rates have averaged 14.2 acres per year. The reduction in rates has been coupled by an increase in the extent of woody riparian vegetation of almost 300 acres.

Land use is dominated by agriculture, with 219 acres of pivot irrigation development since 1950. Some of the irrigation development took place in historic riparian areas; a total of 161 acres of riparian lands were converted for agricultural and other land uses since 1950. Development near Glendive has created about 310 acres of urban/exurban land uses in the reach. About 190 acres or 3 percent of the total CMZ has become restricted by physical features. Residential development near Glendive has encroached into the CMZ; in 2011, there were over 75 acres of urban/exurban land uses mapped within the CMZ.

Six dump sites were mapped in the reach in 2001. These sites are at RM 104L, RM 104.2L, RM 101L, RM 98L, RM 97.5L, and RM 97.1L.

One ice jam has been recorded in Reach D5. A breakup event was recorded on March 17, 2011, but no damages were recorded.

There is one pipeline crossing in the reach at RM 100. This crossing is the Poplar Pipeline owned by Bridger Pipeline, a 10 inch crude oil pipeline that ruptured in 2015. The pipeline crossing is located at the downstream end of a large forested island. Bank migration at the site has been relatively slow.

About 8 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 near Black Bridge. The 5-year floodplain is even more affected; 31 percent of the historic 5-year floodplain is no longer inundated at that frequency. There has been over 1,260 acres of woody riparian vegetation recruitment in the reach since 1950, indicating generation of new forest, some of which reflects encroachment due to lower flows and a shrinking river channel. The bankfull area of the channel has dropped by 255 acres since 1950. Some of that riparian expansion has been due to Russian olive colonization; there are just under 50 acres of mapped Russian olive in the Reach D5 floodplain.

Reach D5 was sampled as part of the fisheries study. A total of 33 fish species were sampled in the reach including four identified by the Montana Natural Heritage Program as a Species of Concern (SOC): the Blue Sucker, Pallid sturgeon, Sauger, and Sturgeon chub.

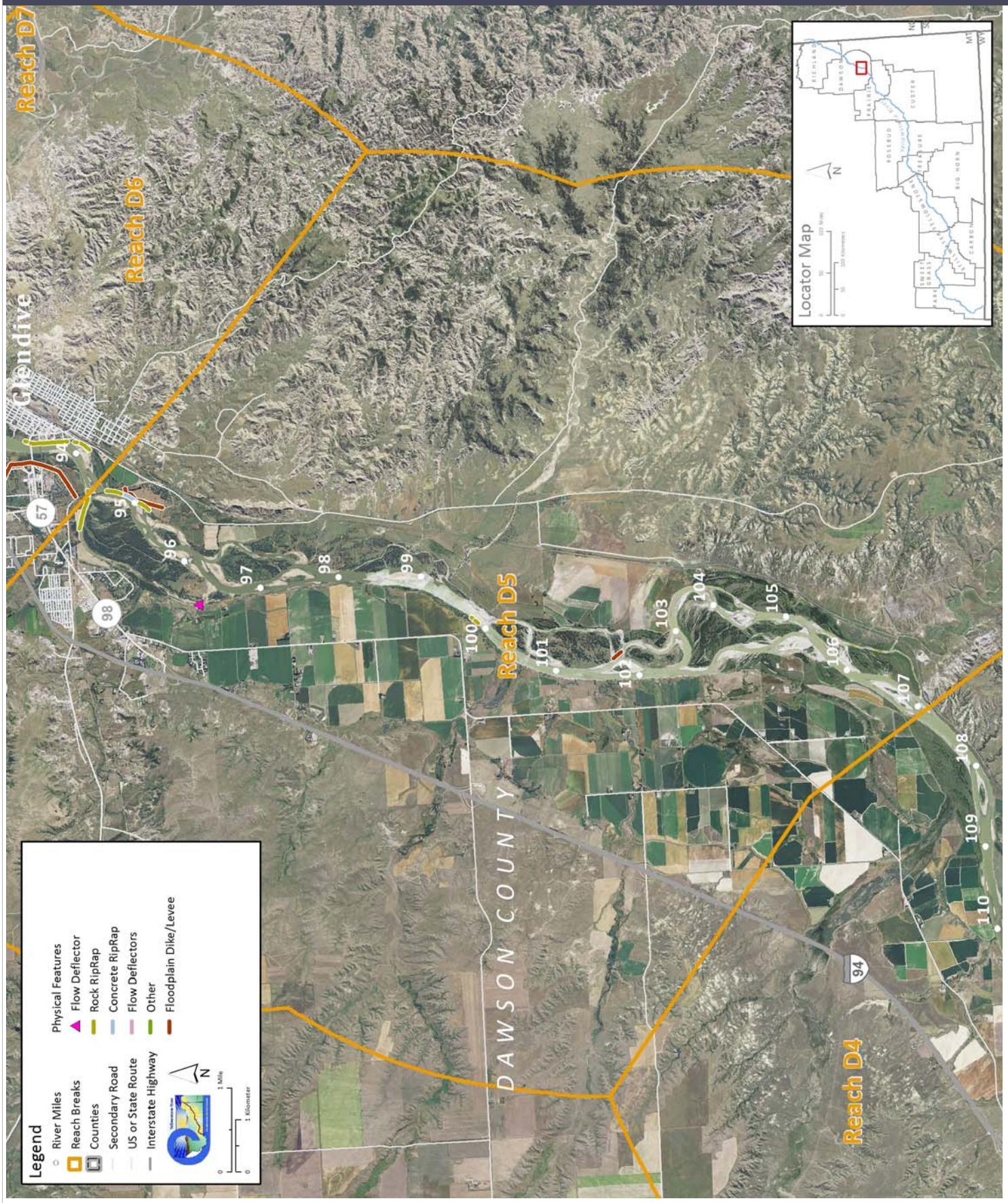
Reach D5 was sampled as part of the avian study. A total of 33 bird species were identified in the reach. One bird species identified by the Montana Natural Heritage Program as Potential Species of Concern (PSOC) was found, the Plumbeous Vireo. The Red-headed Woodpecker was also observed, which has been identified as a Species of Concern (SOC). Reach D5 has seen a decrease in the forested area that is at low risk of cowbird parasitism since 1950. At that time, there were 86 acres per valley mile of such forest, and that number decreased to 38 acres per valley mile by 2001.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been major in this reach. The 2-year flood, which strongly influences overall channel form, has dropped by 22 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 4,800 cfs to 2,720 cfs with human development, a reduction of 436 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,980 cfs under unregulated conditions to 3,220 cfs, a reduction of 54 percent.

CEA-Related observations in Reach D5 include:
•Channel migration issues upstream of major constriction that is poorly aligned to corridor (Black Bridge)

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach D5 include:
•Side channel reactivation at RM 104.5
•Russian olive removal
•Pipeline Crossing Practices at RM 100
•Dump site removal at RM 104L, RM 104.2L, RM 101L, RM 98L, RM 97.5L, and RM 97.1L

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

	Downstream Gage	Upstream Gage
Gage No	6329500	6309000
Location	Sidney	Miles City
Period of Record	1911-2015	1929-2015
Distance To (miles)	63.8	76.9

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

Discharge

	1.01 Yr	2 Yr	5 Yr	10 Yr	50 Yr	100 Yr	500 Yr	7Q10 Summer	95% Sum. Duration
Unregulated		69,200	89,100	102,000	132,000	145,000	176,000	4,800	6,980
Regulated		54,000	73,700	86,400	113,000	124,000	150,000	2,720	3,220
% Change		-21.97%	-17.28%	-15.29%	-14.39%	-14.48%	-14.77%	-43.33%	-53.87%

Flow Duration

Streamflow, in ft3/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%
Spring	Unregulated	67,300	25,100	6,900
	Regulated	52,000	15,000	5,040
	% Change	**-23%**	**-40%**	**-27%**
Summer	Unregulated	47,100	14,900	6,980
	Regulated	35,100	8,920	3,220
	% Change	**-25%**	**-40%**	**-54%**
Fall	Unregulated	9,760	5,950	2,040
	Regulated	11,200	7,440	3,580
	% Change	**15%**	**25%**	**75%**
Winter	Unregulated	14,400	5,330	2,110
	Regulated	15,000	6,490	3,430
	% Change	**4%**	**22%**	**63%**
Annual	Unregulated	49,800	8,900	2,820
	Regulated	37,100	8,010	3,650
	% Change	**-26%**	**-10%**	**29%**

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	
2001	NRCS	August 2-8, 2001	CIR	1:24,000	6329500	4000
2004	Merrick	5/20/2004 - 6/3/04	Color	1:15,840	6329500	5070
2005	NAIP	07/31/2005	color	1-meter pixels	6329500	5280
2009	NAIP	8/10/2009	Color	1-meter pixels	6329500	13700
2009	NAIP	8/1/2009	Color	1-meter pixels	6329500	12600
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	07/24/2013	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	3,771	2.8%	4,409	3.3%	638
	Flow Deflectors	0	0.0%	58	0.0%	58
	Concrete RipRap	1,049	0.8%	1,049	0.8%	0
	Feature Type Totals	**4,820**	**3.6%**	**5,516**	**4.1%**	**696**
Floodplain Control						
	Transportation Encroachment	2,815	2.1%	2,815	2.1%	0
	Floodplain Dike/Levee	3,546	2.7%	2,914	2.2%	-632
	Feature Type Totals	**6,361**	**4.8%**	**5,729**	**4.3%**	**-632**
	Reach Totals	**11,181**	**8.4%**	**11,244**	**8.4%**	**63**

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	1,050	0	0
Rock RipRap	2,801	558	328	0	0	328	0	0
Totals	**2,801**	**558**	**328**	**0**	**0**	**1,378**	**0**	**0**

Bankline/Floodplain Inventory: Time Series

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

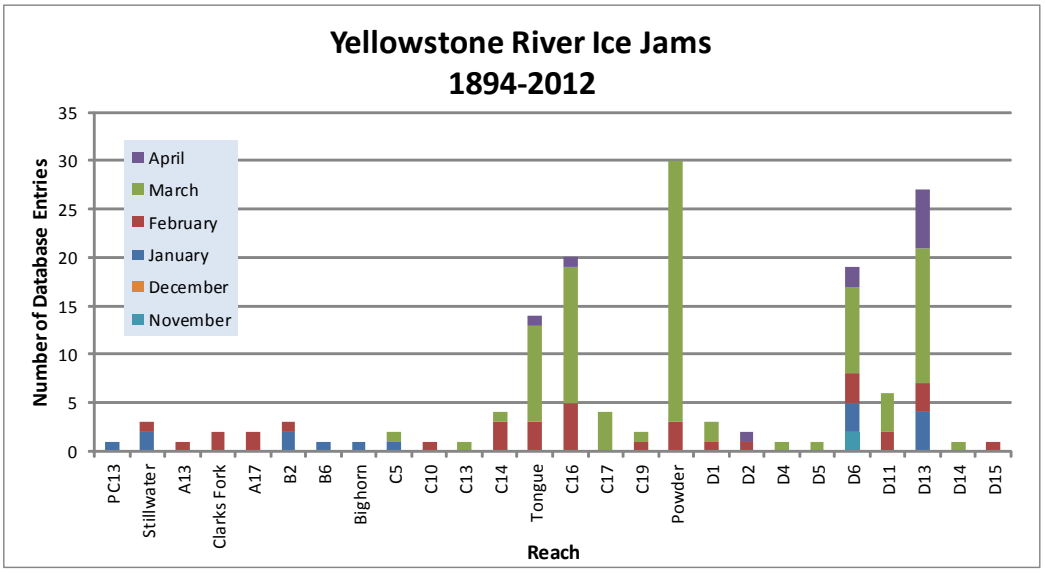
		Sum of Feature Length (ft)					
Feature Class	Feature Type	1950	1976	1995	2001	2004	2005
Irrigation							
	Floodplain Dike/Levee	6,008	6,008	6,008	6,008	6,008	6,008
	Totals	**6,008**	**6,008**	**6,008**	**6,008**	**6,008**	**6,008**
Other							
	Floodplain Dike/Levee	0	1,233	2,007	2,007	2,007	2,007
	Totals	**0**	**1,233**	**2,007**	**2,007**	**2,007**	**2,007**
Other Off Channel							
	Floodplain Dike/Levee	1,760	6,350	9,893	9,893	10,262	10,262
	Totals	**1,760**	**6,350**	**9,893**	**9,893**	**10,262**	**10,262**
Stream Stabilization							
	Rock RipRap	0	3,844	3,844	3,844	3,844	3,844
	Concrete RipRap	0	0	0	1,036	1,036	1,036
	Totals	**0**	**3,844**	**3,844**	**4,879**	**4,879**	**4,879**

Transportation Encroachment

Railroad	13,917	13,917	13,917	13,917	13,917	13,917
Other	2,394	3,975	6,409	6,409	6,409	6,409
County Road	13,899	13,899	13,899	13,899	13,899	13,899
Bridge Approach	1,707	1,707	1,707	1,707	1,707	1,707
Totals	**31,917**	**33,499**	**35,933**	**35,933**	**35,933**	**35,933**

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
3/17/2011	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	65,846	96,726	2.47	1950 to 1976:	1.76%
1976	66,784	101,011	2.51	1976 to 1995:	16.27%
1995	59,770	114,837	2.92	1995 to 2001:	-13.84%
2001	66,626	101,078	2.52	1950 to 2001:	1.95%
Change 1950 - 2001	**780**	**4,352**	**0.05**		

Length of Side Channels Blocked

Pre-1950s (ft)	
Post-1950s (ft)	9,066

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.)	60	1.9%		
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.)	0	0.0%		
Railroad	101	3.1%		
Abandoned Railroad	0	0.0%		
Transportation (Interstate and other roads)	88	2.7%		
Total Not Isolated (Ac)	2974		3035	
Total Floodplain Area (Ac)	3222		3571	
Total Isolated (Ac)	**248**	**7.7%**	**536**	**30.8%**

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:	14	0	0	**14**

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
481	962	5,721	190	3%	24	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	0.6%
RipRap			
	Irrigated	98	1.7%
Dike/Levee			
	Railroad	56	1.0%
	Totals	**190**	**3.3%**

Land Uses within the CMZ (Acres)

Flood Irrigation	Sprinkler Irrigation	Pivot Irrigation	Urban/ ExUrban	Trans-portation
466.3	0.0	2.2	75.2	10.7

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

		Acres				% of Reach Area			
Feature Class	Feature Type	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	25	56	100	114	0.2%	0.5%	0.9%	1.1%
	Totals	**25**	**56**	**100**	**114**	**0.2%**	**0.5%**	**0.9%**	**1.1%**
Agricultural Land									
	Non-Irrigated	6,204	5,054	4,598	4,469	58.4%	47.6%	43.3%	42.1%
	Irrigated	865	1,664	1,927	1,910	8.1%	15.7%	18.1%	18.0%
	Totals	**7,069**	**6,718**	**6,526**	**6,379**	**66.6%**	**63.3%**	**61.4%**	**60.1%**
Channel									
	Channel	3,422	3,471	3,523	3,612	32.2%	32.7%	33.2%	34.0%
	Totals	**3,422**	**3,471**	**3,523**	**3,612**	**32.2%**	**32.7%**	**33.2%**	**34.0%**
ExUrban									
	ExUrban Other	0	0	11	0	0.0%	0.0%	0.1%	0.0%
	ExUrban Undeveloped	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	ExUrban Industrial	0	15	23	24	0.0%	0.1%	0.2%	0.2%
	ExUrban Commercial	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	ExUrban Residential	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Totals	**0**	**15**	**34**	**24**	**0.0%**	**0.1%**	**0.3%**	**0.2%**
Transportation									
	Public Road	43	40	40	40	0.4%	0.4%	0.4%	0.4%
	Interstate	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Railroad	63	63	62	62	0.6%	0.6%	0.6%	0.6%
	Totals	**106**	**103**	**103**	**102**	**1.0%**	**1.0%**	**1.0%**	**1.0%**
Urban									
	Urban Other	0	9	28	28	0.0%	0.1%	0.3%	0.3%
	Urban Residential	0	174	203	203	0.0%	1.6%	1.9%	1.9%
	Urban Commercial	0	7	13	20	0.0%	0.1%	0.1%	0.2%
	Urban Undeveloped	0	23	25	55	0.0%	0.2%	0.2%	0.5%
	Urban Industrial	0	46	68	85	0.0%	0.4%	0.6%	0.8%
	Totals	**0**	**258**	**337**	**391**	**0.0%**	**2.4%**	**3.2%**	**3.7%**

Land Use Timeline - Tiers 3 and 4

		Acres				% of Reach Area				Change Between Years (% of Agricultural Land)			
Feature Class	Feature Type	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	0	0	218	0.0%	0.0%	0.0%	3.4%	0.0%	0.0%	3.4%	3.4%
	Flood	865	1,664	1,927	1,691	12.2%	24.8%	29.5%	26.5%	12.5%	4.8%	-3.0%	14.3%
	Totals	**865**	**1,664**	**1,927**	**1,910**	**12.2%**	**24.8%**	**29.5%**	**29.9%**	**12.5%**	**4.8%**	**0.4%**	**17.7%**

Non-Irrigated

Multi-Use	5,911	4,695	4,329	4,243	83.6%	69.9%	66.3%	66.5%	-13.7%	-3.5%	0.2%	-17.1%
Hay/Pasture	294	360	269	226	4.2%	5.4%	4.1%	3.5%	1.2%	-1.2%	-0.6%	-0.6%
Totals	**6,204**	**5,054**	**4,598**	**4,469**	**87.8%**	**75.2%**	**70.5%**	**70.1%**	**-12.5%**	**-4.8%**	**-0.4%**	**-17.7%**

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	0.6	0.3	0.2	0.4	3.7	1.1	3.4	0.5	6.5
Max	174.6	163.1	121.9	127.9	121.5	182.7	61.9	175.9	181.9
Average	22.6	18.6	18.9	39.0	31.6	39.5	19.4	40.9	42.6
Sum	1,490.2	1,298.6	1,249.1	819.3	662.6	948.2	330.4	654.9	511.5

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)	505.9
Channel to Riparian (acres)	800.4
Riparian Encroachment (acres)	**294.4**

Riparian Recruitment

Creation of riparian areas between 1950s and 2001.

1950s Channel Mapped as 2011 Riparian (Ac)	850.2
1950s Floodplain Mapped as 2011 Channel (Ac)	410.1
Total Recruitment (1950s to 2011)(Ac)	**1260.3**

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	23.7	152.8	102.2	0.0	**278.7**
Acres/Valley Mile	2.2	14.3	9.5	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 (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	48.95	2.58%	112.24	0.44	24.58	7.97

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

Low Flow Fisheries Habitat Mapping

Habitat	2001 (Acres) Bankfull	Low Flow	% of Low Flow
Scour Pool	430.8	270.5	7.7%
Rip Rap Bottom	27.7	21.7	0.6%
Terrace Pool	317.0	298.3	8.5%
Secondary Channel	280.9	177.4	5.0%
Secondary Channel (Seasonal)	483.7	320.2	9.1%
Channel Crossover	291.0	201.0	5.7%
Point Bar		116.4	3.3%
Side Bar		51.2	1.5%
Mid-channel Bar		187.1	5.3%
Island	1,691.8	1,693.7	48.0%
Dry Channel		189.8	5.4%

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.

Bird Species Observed in Reach/Region

Species of Concern | Potential Species of Concern

Reach	Region		Reach	Region		Reach	Region		Reach	Region	
☑	☑	American Robin	☐	☑	Chipping Sparrow	☐	☑	Killdeer	☐	☑	Song Sparrow
☑	☑	American Crow	☑	☑	Clay-collared Sparrow	☐	☐	Lark Bunting	☐	☑	Spotted Sandpiper
☑	☑	American Goldfinch	☐	☐	Cliff Swallow	☑	☑	Lark Sparrow	☑	☑	Spotted Towhee
☐	☑	American Kestrel	☑	☑	Common Grackle	☑	☑	Lazuli Bunting	☐	☐	Sharp-shinned Hawk
☑	☑	American Redstart	☐	☐	Common Merganser	☑	☑	Least Flycatcher	☐	☐	Swainson's Thrush
☐	☑	Bald Eagle	☐	☑	Common Nighthawk	☐	☑	Mallard	☐	☐	Sandhill Crane
☐	☐	Baltimore Oriole	☐	☐	Common Raven	☐	☐	Mountain Bluebird	☑	☑	Tree Swallow
☐	☐	Barn Swallow	☑	☑	Common Yellowthroat	☑	☑	Mourning Dove	☐	☐	Turkey Vulture
☐	☑	Belted Kingfisher	☐	☑	Cooper's Hawk	☑	☑	Northern Flicker	☐	☐	Upland Sandpiper
☐	☑	Black-billed Cuckoo	☐	☑	Dickcissel	☐	☑	Orchard Oriole	☐	☐	Vesper Sparrow
☐	☑	Black-billed Magpie	☑	☑	Downy Woodpecker	☐	☐	Osprey	☐	☐	Violet-green Swallow
☑	☑	Black-capped Chickadee	☐	☑	Eastern Bluebird	☐	☑	Ovenbird	☑	☑	Warbling Vireo
☐	☑	Black-and-white Warbler	☑	☑	Eastern Kingbird	☑	☑	Plumbeous Vireo	☑	☑	Western Kingbird
☑	☑	Black-headed Grosbeak	☐	☐	Eurasian Collared-dove	☑	☑	Red-headed Woodpecker	☑	☑	Western Meadowlark
☐	☑	Blue Jay	☑	☑	European Starling	☐	☐	Red-naped Sapsucker	☐	☑	Western Wood-pewee
☐	☑	Bobolink	☑	☑	Field Sparrow	☐	☑	Red Crossbill	☐	☑	White-breasted Nuthatch
☐	☑	Brewer's Blackbird	☐	☑	Franklin's Gull	☐	☑	Ring-necked Pheasant	☐	☐	White-throated Swift
☑	☑	Brown-headed Cowbird	☐	☑	Grasshopper Sparrow	☐	☑	Red-tailed hawk	☐	☑	Wild Turkey
☐	☐	Brown Creeper	☐	☑	Gray Catbird	☐	☑	Rock Dove	☐	☑	Wood Duck
☐	☑	Brown Thrasher	☐	☑	Great Blue Heron	☑	☑	Red-winged Blackbird	☐	☑	Yellow-bellied Sapsucker
☑	☑	Bullock's Oriole	☐	☑	Great Horned Owl	☑	☑	Red-eyed Vireo	☐	☑	Yellow-billed Cuckoo
☐	☐	Canada Goose	☐	☑	Hairy Woodpecker	☐	☑	Red-breasted Grosbeak	☑	☑	Yellow-breasted Chat
☑	☑	Cedar Waxwing	☐	☐	House Finch	☐	☐	Say's Phoebe	☐	☐	Yellow-headed Blackbird
☐	☑	Chimney Swift	☑	☑	House Wren	☐	☑	Savannah Sparrow	☑	☑	Yellow Warbler

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.

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.

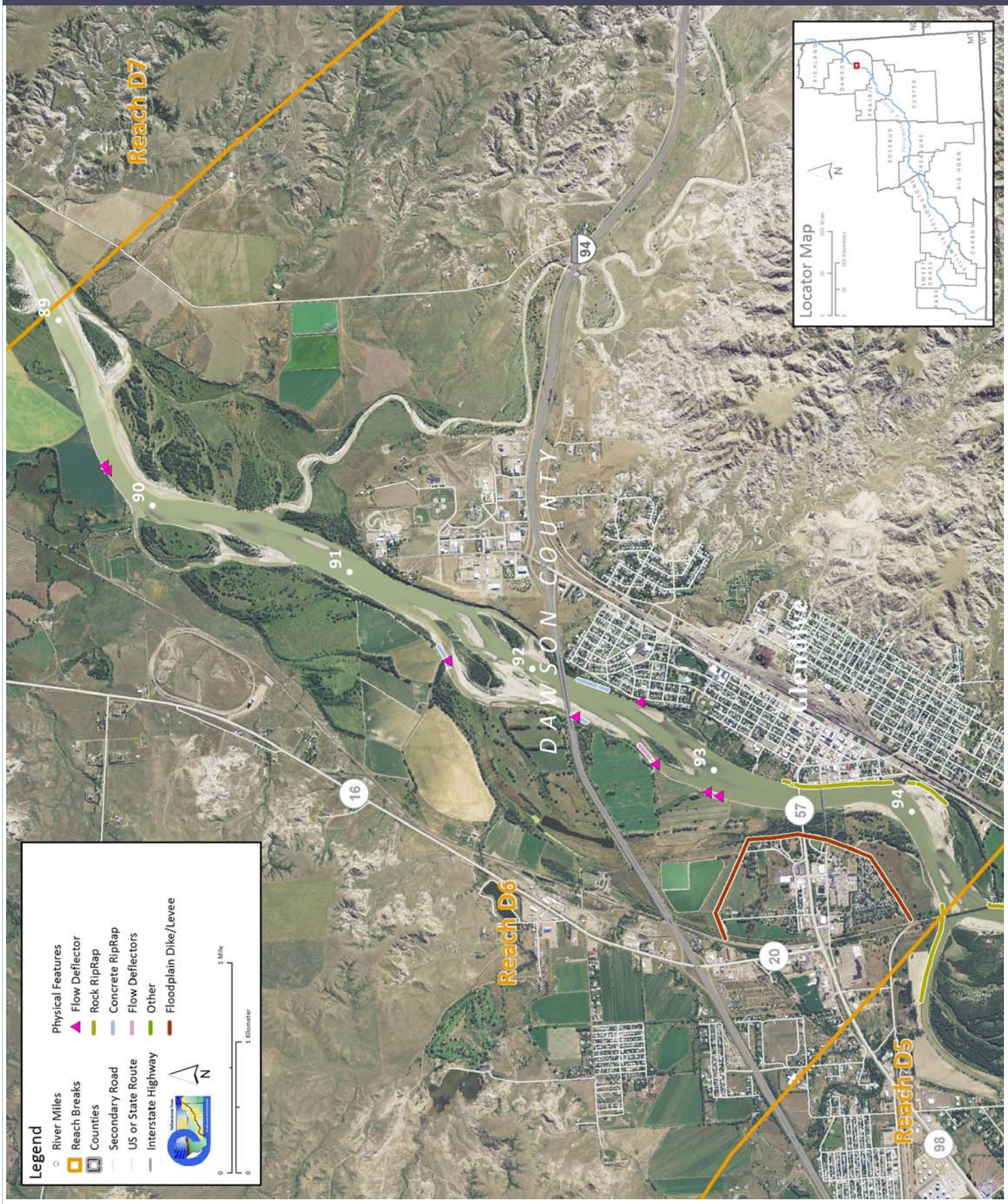
A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been major in this reach. The 100-year flood has dropped from 146,000 cfs pre-development to 125,000 cfs currently, which is a 14 percent reduction. The 2-year flood, which strongly influences overall 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

	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

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

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

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

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%**

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

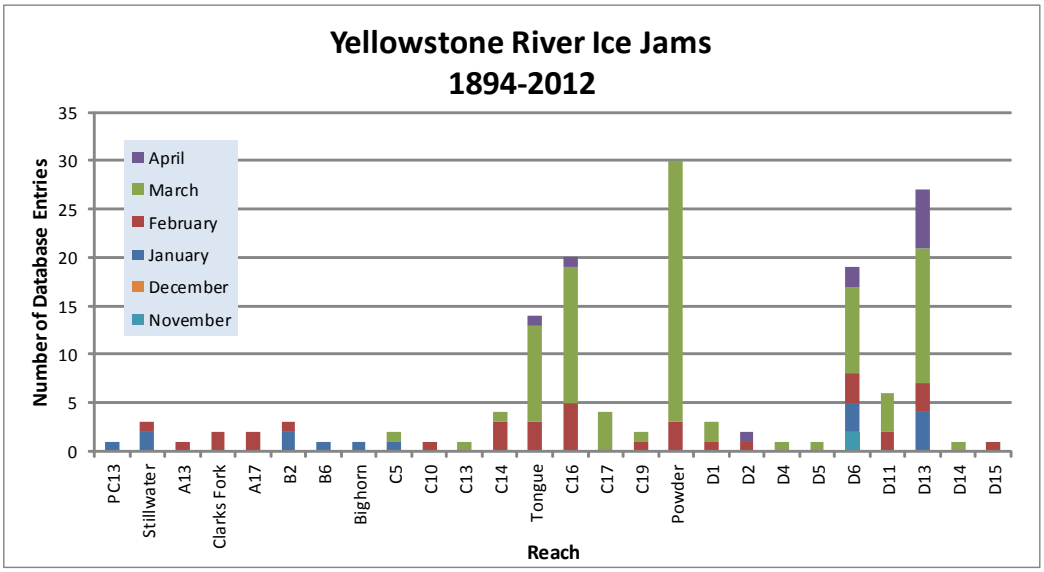
The Human Impacts Timeline assessed physical feature development through time for Yellowstone, Stillwater, and Dawson Counties.

Feature Class	Feature Type	Sum of Feature Length (ft) 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		% Change in Braiding
1950	29,804	35,774	2.20	1950 to 1976:	-30.94%
1976	29,529	15,343	1.52	1976 to 1995:	-8.13%
1995	29,484	11,678	1.40	1995 to 2001:	5.05%
2001	29,301	13,672	1.47	1950 to 2001:	-33.35%
Change 1950 - 2001	**-503**	**-22,102**	**-0.73**		

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

		Acres				% of Reach Area			
Feature Class	Feature Type	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	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

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

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.

Yellowstone River Reach Narratives — Reach D7

County	Dawson	**Upstream River Mile**	89
Classification	PCA: Partially confined anabranching	**Downstream River Mile**	81.4
General Location	Downstream of Glendive	**Length**	7.60 mi (12.23 km)

General Comments

Narrative Summary

Reach D7 is located just downstream of Glendive. It is 7.6 miles long and is a Partially Confined Anabranching (PCA) reach type, including some valley wall influence as well as numerous forested islands. These reach types tend to be relatively dynamic with high rates of channel change through time. The Stipek Fishing Access Site is located in the middle portion of the reach.

No bank armor has been mapped in Reach D7, and no side channels have been blocked by dikes. About two miles of transportation encroachment by the railroad was mapped in Reach D7, all of which was in place by 1950.

Similar to many reaches in the Lower Yellowstone Valley, the river channel in Reach D7 has gotten smaller since 1950. The channel contracted by about 121 acres in this reach since 1950, and about 150 acres of riparian vegetation has encroached into old channel areas. This pattern has been consistent in the lower river, and relates primarily to a reduction in flows due to human development. Floodplain turnover rates have dropped from 8.9 acres per year pre-1976 to5.4 acres per year post-1976.

Even though no side channels have been intentionally blocked, Reach D7 has lost about 3,800 feet of side channel length since 1950. This is likely due to passive loss caused by a reduction in high flows. Lower flows have also resulted in the isolation of 48 percent of the historic 5-year floodplain.

Land use is predominantly agricultural, with about 258 acres of pivot irrigation development since 1950. There are 27 acres of pivot irrigation and 21 acres of exurban land uses in the Channel Migration Zone. Two dump sites have been mapped on the right bank at RM 84R and RM 85.9R.

There are 7.4 acres of mapped Russian olive in the reach.

Reach D7 was part of the avian study. A total of 43 species were identified in the reach, including the Ovenbird, which has been identified by the Montana Natural Heritage Program as a Potential Special Concern. The Black-billed Cuckoo and Red-headed Woodpecker were also identified, both of which are Species of Concern.

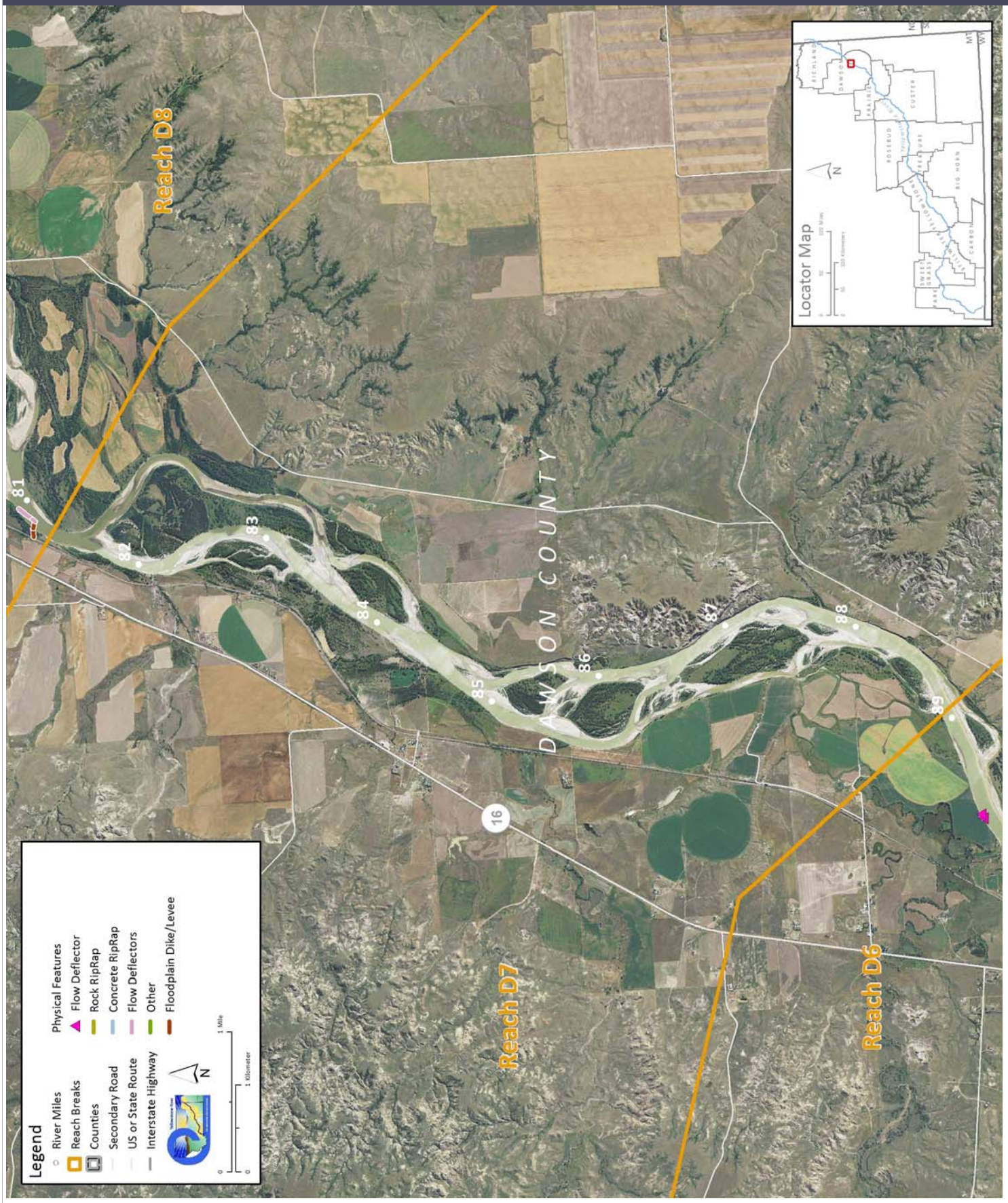
A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been major in this reach. The magnitude of the 100-year flood is now 127,000 cfs, which 12 percent lower than it was pre-development (145,000 cfs). The 2-year flood, which strongly influences overall channel form, has dropped by 22 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 4,700 cfs to 2,600 cfs with human development, a reduction of 45 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,890 cfs under unregulated conditions to 3,110 cfs under regulated conditions, a reduction of 55 percent.

Seasonal low flows have increased by 78 percent in the winter and 62 percent in the fall. Both fall and winter base flows are currently about 3,500 cfs.

CEA-Related observations in Reach D7 include:
•Passive loss of side channels with flow alterations

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach D7 include:
•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

	Downstream Gage	Upstream Gage
Gage No	6329500	6309000
Location	Sidney	Miles City
Period of Record	1911-2015	1929-2015
Distance To (miles)	50.6	95.0

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

Discharge

	1.01 Yr	2 Yr	5 Yr	10 Yr	50 Yr	100 Yr	500 Yr	7Q10 Summer	95% Sum. Duration
Unregulated		69,500	89,600	103,000	133,000	145,000	176,000	4,700	6,890
Regulated		54,200	74,200	87,200	115,000	127,000	153,000	2,600	3,110
% Change		-22.01%	-17.19%	-15.34%	-13.53%	-12.41%	-13.07%	-44.68%	-54.86%

Flow Duration

Streamflow, in ft3/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%
Spring	Unregulated	67,500	25,100	6,960
	Regulated	52,100	14,900	5,080
	% Change	**-23%**	**-41%**	**-27%**
Summer	Unregulated	47,300	14,900	6,890
	Regulated	35,200	8,820	3,110
	% Change	**-26%**	**-41%**	**-55%**
Fall	Unregulated	9,800	5,940	2,010
	Regulated	11,200	7,430	3,570
	% Change	**14%**	**25%**	**78%**
Winter	Unregulated	14,800	5,380	2,120
	Regulated	15,400	6,550	3,440
	% Change	**4%**	**22%**	**62%**
Annual	Unregulated	49,900	8,900	2,820
	Regulated	37,200	8,020	3,620
	% Change	**-25%**	**-10%**	**28%**

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	5/20/2004 - 6/3/04	Color	1:15,840	6329500	5070
2005	NAIP	07/14/2005	color	1-meter pixels	6329500	15900
2009	NAIP	8/10/2009	Color	1-meter pixels	6329500	13700
2009	NAIP	7/11/2009	Color	1-meter pixels	6329500	32600
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	

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.

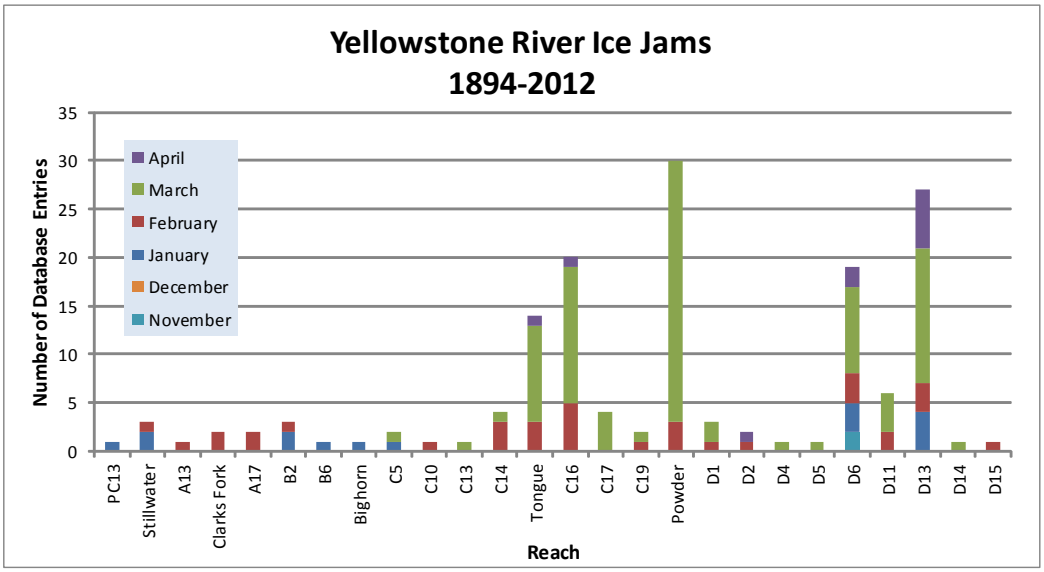
Bankline/Floodplain Inventory: Time Series

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
Transportation Encroachment							
	Railroad	12,529	12,529	12,529	12,529	12,529	12,529
	Totals	**12,529**	**12,529**	**12,529**	**12,529**	**12,529**	**12,529**

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.



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	43,833	59,956	2.37	1950 to 1976:	1.78%
1976	39,713	55,991	2.41	1976 to 1995:	3.49%
1995	40,102	59,914	2.49	1995 to 2001:	-4.10%
2001	40,314	56,108	2.39	1950 to 2001:	1.01%
Change 1950 - 2001	**-3,519**	**-3,848**	**0.02**		

Length of Side Channels Blocked

Pre-1950s (ft)	0
Post-1950s (ft)	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 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.)	44	2.4%		
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.)	0	0.0%		
Railroad	0	0.0%		
Abandoned Railroad	0	0.0%		
Transportation (Interstate and other roads)	0	0.0%		
Total Not Isolated (Ac)	1762		1532	
Total Floodplain Area (Ac)	1806		1928	
Total Isolated (Ac)	**44**	**2.4%**	**395**	**47.9%**

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:	2	0	0	**2**

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
341	682	2,811	6	0%	127	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	6	0.2%
	Totals	**6**	**0.2%**

Land Uses within the CMZ (Acres)

Flood Irrigation	Sprinkler Irrigation	Pivot Irrigation	Urban/ ExUrban	Trans-portation
180.4	2.2	27.3	20.7	9.0

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

		Acres				% of Reach Area			
Feature Class	Feature Type	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	29	64	81	84	0.4%	0.9%	1.2%	1.2%
	Totals	**29**	**64**	**81**	**84**	**0.4%**	**0.9%**	**1.2%**	**1.2%**
Agricultural Land									
	Non-Irrigated	4,756	4,485	3,767	3,629	70.5%	66.5%	55.9%	53.8%
	Irrigated	0	182	876	992	0.0%	2.7%	13.0%	14.7%
	Totals	**4,756**	**4,668**	**4,644**	**4,621**	**70.5%**	**69.2%**	**68.9%**	**68.5%**
Channel									
	Channel	1,869	1,918	1,881	1,899	27.7%	28.4%	27.9%	28.2%
	Totals	**1,869**	**1,918**	**1,881**	**1,899**	**27.7%**	**28.4%**	**27.9%**	**28.2%**
ExUrban									
	ExUrban Other	0	0	24	23	0.0%	0.0%	0.4%	0.3%
	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	3	22	26	0.0%	0.0%	0.3%	0.4%
	Totals	**0**	**3**	**46**	**49**	**0.0%**	**0.0%**	**0.7%**	**0.7%**
Transportation									
	Public Road	57	59	59	59	0.8%	0.9%	0.9%	0.9%
	Interstate	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Railroad	31	31	31	31	0.5%	0.5%	0.5%	0.5%
	Totals	**88**	**90**	**90**	**90**	**1.3%**	**1.3%**	**1.3%**	**1.3%**
Urban									
	Urban Other	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Urban Residential	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Urban Commercial	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Urban Undeveloped	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Urban Industrial	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Totals	**0**	**0**	**0**	**0**	**0.0%**	**0.0%**	**0.0%**	**0.0%**

Land Use Timeline - Tiers 3 and 4

		Acres				% of Reach Area				Change Between Years (% of Agricultural Land)			
Feature Class	Feature Type	1950	1976	2001	2011	1950	1976	2001	2011	'50-76	'76-01	'01-11	'50-11
Irrigated													
	Sprinkler	0	0	26	26	0.0%	0.0%	0.5%	0.6%	0.0%	0.5%	0.0%	0.6%
	Pivot	0	0	0	258	0.0%	0.0%	0.0%	5.6%	0.0%	0.0%	5.6%	5.6%
	Flood	0	182	851	708	0.0%	3.9%	18.3%	15.3%	3.9%	14.4%	-3.0%	15.3%
	Totals	**0**	**182**	**876**	**992**	**0.0%**	**3.9%**	**18.9%**	**21.5%**	**3.9%**	**15.0%**	**2.6%**	**21.5%**

Non-Irrigated

Multi-Use	3,714	2,925	2,899	2,816	78.1%	62.7%	62.4%	61.0%	-15.4%	-0.2%	-1.5%	-17.1%
Hay/Pasture	1,043	1,560	868	812	21.9%	33.4%	18.7%	17.6%	11.5%	-14.7%	-1.1%	-4.3%
Totals	**4,756**	**4,485**	**3,767**	**3,629**	**######**	**96.1%**	**81.1%**	**78.5%**	**-3.9%**	**-15.0%**	**-2.6%**	**-21.5%**

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	0.2	0.5	0.9	0.1	0.7	2.7	2.7	2.0	1.4
Max	107.9	88.8	35.3	153.3	159.7	298.9	53.7	26.1	48.2
Average	13.4	13.5	8.2	44.6	35.5	66.1	15.1	11.3	16.8
Sum	617.6	619.7	318.1	757.7	815.5	1,123.3	136.3	67.6	134.1

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)	209.9
Channel to Riparian (acres)	359.2
Riparian Encroachment (acres)	**149.4**

Riparian Recruitment

Creation of riparian areas between 1950s and 2001.

1950s Channel Mapped as 2011 Riparian (Ac)	366.8
1950s Floodplain Mapped as 2011 Channel (Ac)	53.7
Total Recruitment (1950s to 2011)(Ac)	**420.6**

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	28.9	72.3	47.1	0.0	**148.2**
Acres/Valley Mile	4.2	10.6	6.9	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	7.44	0.21%	1.67	0.00	4.97	1.12

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.

Low Flow Fisheries Habitat Mapping

	2001 (Acres)		
Habitat	Bankfull	Low Flow	% of Low Flow
Scour Pool	349.7	212.3	11.3%
Bluff Pool	138.1	163.2	8.7%
Secondary Channel	186.2	130.8	7.0%
Secondary Channel (Seasonal)	262.8	190.1	10.1%
Channel Crossover	164.3	124.7	6.6%
Point Bar		89.5	4.8%
Side Bar		69.3	3.7%
Mid-channel Bar		60.2	3.2%
Island	778.5	789.4	42.0%
Dry Channel		47.6	2.5%

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.

Bird Species Observed in Reach/Region

Species of Concern | Potential Species of Concern

Reach	Region		Reach	Region		Reach	Region		Reach	Region	
☑	☑	American Robin	☑	☑	Chipping Sparrow	☑	☑	Killdeer	☑	☑	Song Sparrow
☑	☑	American Crow	☐	☑	Clay-collared Sparrow	☐	☐	Lark Bunting	☑	☑	Spotted Sandpiper
☑	☑	American Goldfinch	☐	☐	Cliff Swallow	☑	☑	Lark Sparrow	☑	☑	Spotted Towhee
☑	☑	American Kestrel	☑	☑	Common Grackle	☑	☑	Lazuli Bunting	☐	☐	Sharp-shinned Hawk
☑	☑	American Redstart	☐	☐	Common Merganser	☑	☑	Least Flycatcher	☐	☐	Swainson's Thrush
☑	☑	Bald Eagle	☐	☑	Common Nighthawk	☐	☑	Mallard	☐	☐	Sandhill Crane
☐	☐	Baltimore Oriole	☐	☐	Common Raven	☐	☐	Mountain Bluebird	☑	☑	Tree Swallow
☐	☐	Barn Swallow	☑	☑	Common Yellowthroat	☑	☑	Mourning Dove	☐	☐	Turkey Vulture
☐	☑	Belted Kingfisher	☐	☑	Cooper's Hawk	☑	☑	Northern Flicker	☐	☐	Upland Sandpiper
☑	☑	Black-billed Cuckoo	☐	☑	Dickcissel	☑	☑	Orchard Oriole	☐	☐	Vesper Sparrow
☑	☑	Black-billed Magpie	☑	☑	Downy Woodpecker	☐	☐	Osprey	☐	☐	Violet-green Swallow
☑	☑	Black-capped Chickadee	☐	☑	Eastern Bluebird	☑	☑	Ovenbird	☑	☑	Warbling Vireo
☐	☑	Black-and-white Warbler	☑	☑	Eastern Kingbird	☐	☑	Plumbeous Vireo	☑	☑	Western Kingbird
☑	☑	Black-headed Grosbeak	☐	☐	Eurasian Collared-dove	☑	☑	Red-headed Woodpecker	☑	☑	Western Meadowlark
☐	☑	Blue Jay	☑	☑	European Starling	☐	☐	Red-naped Sapsucker	☑	☑	Western Wood-pewee
☐	☑	Bobolink	☐	☑	Field Sparrow	☐	☑	Red Crossbill	☑	☑	White-breasted Nuthatch
☑	☑	Brewer's Blackbird	☐	☑	Franklin's Gull	☑	☑	Ring-necked Pheasant	☐	☐	White-throated Swift
☑	☑	Brown-headed Cowbird	☐	☑	Grasshopper Sparrow	☐	☑	Red-tailed hawk	☐	☑	Wild Turkey
☐	☐	Brown Creeper	☐	☑	Gray Catbird	☐	☑	Rock Dove	☐	☑	Wood Duck
☐	☑	Brown Thrasher	☐	☑	Great Blue Heron	☐	☑	Red-winged Blackbird	☐	☑	Yellow-bellied Sapsucker
☐	☑	Bullock's Oriole	☐	☑	Great Horned Owl	☑	☑	Red-eyed Vireo	☐	☑	Yellow-billed Cuckoo
☐	☐	Canada Goose	☑	☑	Hairy Woodpecker	☐	☑	Red-breasted Grosbeak	☑	☑	Yellow-breasted Chat
☑	☑	Cedar Waxwing	☐	☐	House Finch	☐	☐	Say's Phoebe	☐	☐	Yellow-headed Blackbird
☐	☑	Chimney Swift	☑	☑	House Wren	☐	☑	Savannah Sparrow	☑	☑	Yellow Warbler

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.

County	Dawson	**Upstream River Mile**	81.4
Classification	PCA: Partially confined anabranching	**Downstream River Mile**	71.1
General Location	Intake	**Length**	10.30 mi (16.58 km)
General Comments	To Intake		

Narrative Summary

Reach D8 is located in Dawson County, and includes Intake Diversion Dam. The reach is a Partly Confined Anabranching reach type, indicating distinct side channels around forested islands, and some valley wall influence on the active channel. Intake Diversion Dam is located on the lower end of the reach at RM 73.

The primary form of bank stabilization in Reach D8 is rock riprap, with 4,576 feet or 1.9 percent of the total bankline mapped as armored in 2011. All of the bank armor in Reach D8 is protecting either Intake Diversion or the railroad grade; the majority (3,178 feet) is against the rail line. In the uppermost part of the reach at RM 81L, over 1,500 feet of flow deflectors were flanked between 2001 and 2011. At RM 77L, the river has flanked two sections of rock riprap protecting the rail line, forming two large scallops in the bank that currently threaten to undermine the toe of the railroad embankment.

The largest diversion dam on the Yellowstone River is Intake Diversion Dam at RM 73. Construction of the dam began in 1905, in response to authorization under the Reclamation Act of 1902 (http://www.fws.gov/yellowstonerivercoordinator/Intake.html). Intake Dam was completed in 1911 and is used to irrigate 50,000 acres of land in eastern Montana and western North Dakota. The original dam crest was 12 feet above the river bed; and the structure stretches 700 feet across the river. With a diversion capacity of 1,200 cfs, it feeds Intake Canal and a ~225 mile network of lateral canals that distribute water to approximately 500 farms. Fish passage issues at this structure are currently being addressed by the Bureau Reclamation, US Army Corps of Engineers, MT Fish Wildlife and Parks, US Fish and Wildlife Service, and Lower Yellowstone Irrigation District.

Reach D8 has lost almost three miles of side channel length since 1950, and none of this loss is attributable to floodplain dikes. Similar to other reaches in the lower Yellowstone River valley, side channel loss has occurred to both intentional blockages, as well as lost connectivity due to flow alterations. Flow alterations have also resulted in lost connectivity to the 5-year floodplain; development in the basin has resulted in the isolation of 58 percent of the historic 5-year floodplain.

There are 110 acres of sprinkler irrigation and 19 acres of exurban land in the Channel Migration Zone in Reach D8, making these areas especially susceptible to threats of river erosion.

There has been a net increase of woody riparian vegetation in Reach D8 of approximately 210 acres since 1950, indicating riparian colonization of open gravel bars and channel margins.

There are about 10 acres of mapped Russian olive in the reach.

Reach D8 was sampled as part of the avian study. A total of 21 species were identified in the reach, including the Red-headed Woodpecker, which is a Species of Concern.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been major in this reach. The magnitude of the 100-year flood is now 128,000 cfs, which 12 percent lower than it was pre-development (145,000 cfs). The 2-year flood, which strongly influences overall channel form, has dropped by 22 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 4,630 cfs to 2,520 cfs with human development, a reduction of 46 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,810 cfs under unregulated conditions to 3,030 cfs under regulated conditions, a reduction of 55 percent.

Seasonal low flows have increased by 78 percent in the winter and 62 percent in the fall. Both fall and winter base flows are currently about 3,500 cfs.

CEA-Related observations in Reach D8 include:
•Passive loss of side channels with flow alterations
•Low avian species richness
•Passive loss of 5-year floodplain area

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach D8 include:
•Flanked bank armor removal at RM 77L and RM 81L
•Fish Passage Practices at Intake Diversion Dam (RM 73)
•Watercraft Passage PRACTICE at Intake Diversion Dam (RM 73)
•Irrigation Structure Management at Intake Diversion Dam (RM 73)
•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

	Downstream Gage	Upstream Gage
Gage No	6329500	6309000
Location	Sidney	Miles City
Period of Record	1911-2015	1929-2015
Distance To (miles)	40.3	102.6

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

Discharge

	1.01 Yr	2 Yr	5 Yr	10 Yr	50 Yr	100 Yr	500 Yr	7Q10 Summer	95% Sum. Duration
Unregulated		69,500	89,700	103,000	132,000	145,000	175,000	4,630	6,810
Regulated		54,200	74,300	87,400	116,000	128,000	155,000	2,520	3,030
% Change		-22.01%	-17.17%	-15.15%	-12.12%	-11.72%	-11.43%	-45.57%	-55.51%

Flow Duration

Streamflow, in ft3/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%
Spring	Unregulated	67,500	25,000	7,000
	Regulated	52,100	14,800	5,100
	% Change	**-23%**	**-41%**	**-27%**
Summer	Unregulated	47,400	14,800	6,810
	Regulated	35,200	8,740	3,030
	% Change	**-26%**	**-41%**	**-56%**
Fall	Unregulated	9,820	5,920	2,000
	Regulated	11,200	7,410	3,560
	% Change	**14%**	**25%**	**78%**
Winter	Unregulated	15,000	5,410	2,120
	Regulated	15,600	6,580	3,450
	% Change	**4%**	**22%**	**63%**
Annual	Unregulated	49,800	8,890	2,820
	Regulated	37,100	8,010	3,590
	% Change	**-26%**	**-10%**	**27%**

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	8/8/96 - 6/12/96	B/W		6329500	52600
2001	NRCS	August 2-8, 2001	CIR	1:24,000	6329500	4000
2004	Merrick	5/20/2004 - 6/3/04	Color	1:15,840	6329500	5070
2005	NAIP	07/14/2005	color	1-meter pixels	6329500	15900
2009	NAIP	7/11/2009	Color	1-meter pixels	6329500	32600
2011	USCOE	October 2012	color	1-ft pixel	6329500	9030
2011	NAIP	7/21/2011	Color	1-meter pixels	6329500	46600
2011	NAIP	7/20/2011	Color	1-meter pixels	6329500	48800
2013	NAIP	07/27/2013	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	4,140	3.9%	4,576	4.3%	435
	Flow Deflectors	122	0.1%	0	0.0%	-122
	Between Flow Deflectors	641	0.6%	0	0.0%	-641
	Feature Type Totals	**4,904**	**4.6%**	**4,576**	**4.3%**	**-328**
Floodplain Control						
	Floodplain Dike/Levee	519	0.5%	319	0.3%	-200
	Feature Type Totals	**519**	**0.5%**	**319**	**0.3%**	**-200**
	Reach Totals	**5,423**	**5.1%**	**4,895**	**4.6%**	**-528**

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
Flow Deflectors/Between FDs	0	764	0	0	0	0	0	0
Rock RipRap	0	0	961	0	0	3,178	0	0
Totals	**0**	**764**	**961**	**0**	**0**	**3,178**	**0**	**0**

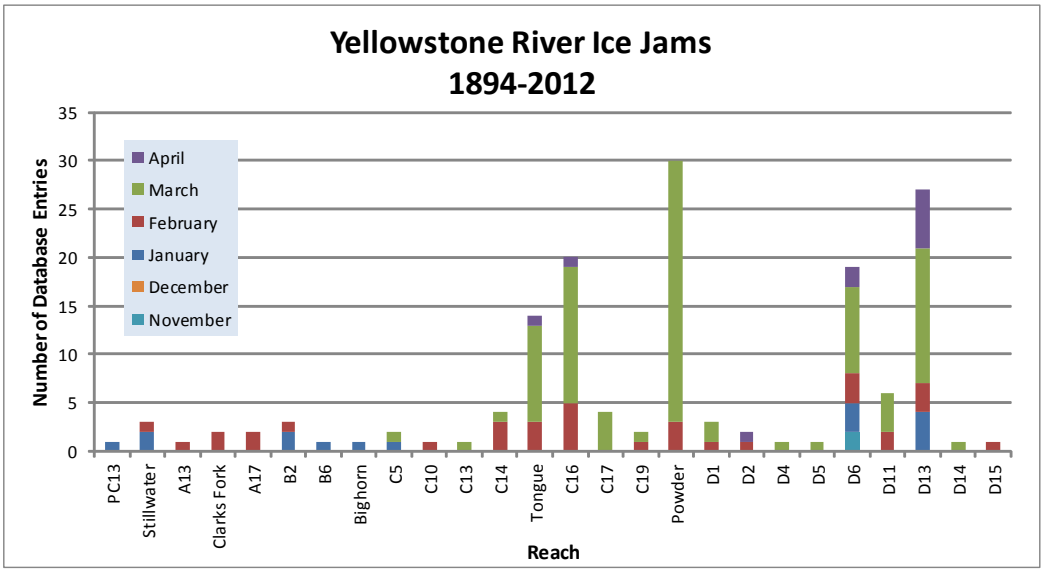
Bankline/Floodplain Inventory: Time Series

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
Irrigation							
	In Channel Diversion	669	669	669	669	669	669
	Floodplain Dike/Levee	5,268	5,268	5,268	5,268	5,268	5,268
	Totals	**5,936**	**5,936**	**5,936**	**5,936**	**5,936**	**5,936**
Other Off Channel							
	Floodplain Dike/Levee	478	478	478	478	478	478
	Totals	**478**	**478**	**478**	**478**	**478**	**478**
Stream Stabilization							
	Rock RipRap	962	2,562	2,562	3,433	3,433	3,433
	Flow Deflector	0	0	0	0	734	734
	Totals	**962**	**2,562**	**2,562**	**3,433**	**4,168**	**4,168**
Transportation Encroachment							
	Railroad	10,300	10,300	10,300	10,300	10,300	10,300
	County Road	4,206	4,206	4,206	4,206	4,206	4,206
	Totals	**14,506**	**14,506**	**14,506**	**14,506**	**14,506**	**14,506**

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.



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	55,112	53,812	1.98	1950 to 1976:	9.19%
1976	54,712	63,359	2.16	1976 to 1995:	5.96%
1995	53,646	69,029	2.29	1995 to 2001:	-1.33%
2001	53,643	67,389	2.26	1950 to 2001:	14.16%
Change 1950 - 2001	**-1,470**	**13,577**	**0.28**		

Length of Side Channels Blocked

Pre-1950s (ft)	0
Post-1950s (ft)	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 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.)	61	1.6%		
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.)	0	0.0%		
Railroad	38	1.0%		
Abandoned Railroad	0	0.0%		
Transportation (Interstate and other roads)	0	0.0%		
Total Not Isolated (Ac)	3746		1729	
Total Floodplain Area (Ac)	3845		2342	
Total Isolated (Ac)	**99**	**2.6%**	**613**	**57.7%**

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:	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 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
274	549	4,130	44	1%	1,067	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
RipRap			
	Railroad	28	0.5%
	Totals	**28**	**0.5%**

Land Uses within the CMZ (Acres)

Flood Irrigation	Sprinkler Irrigation	Pivot Irrigation	Urban/ ExUrban	Trans-portation
213.7	109.0	0.0	19.4	16.4

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

		Acres				% of Reach Area			
Feature Class	Feature Type	1950	1976	2001	2011	1950	1976	2001	2011
Agricultural Infrastructure									
	Canal	29	29	29	29	0.3%	0.3%	0.3%	0.3%
	Agricultural Roads	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Other Infrastructure	11	54	86	88	0.1%	0.6%	1.0%	1.0%
	Totals	**40**	**83**	**115**	**117**	**0.5%**	**1.0%**	**1.3%**	**1.4%**
Agricultural Land									
	Non-Irrigated	5,278	5,010	4,746	4,639	61.4%	58.3%	55.2%	54.0%
	Irrigated	51	331	592	615	0.6%	3.8%	6.9%	7.2%
	Totals	**5,329**	**5,341**	**5,338**	**5,253**	**62.0%**	**62.1%**	**62.1%**	**61.1%**
Channel									
	Channel	3,070	3,024	2,971	3,054	35.7%	35.2%	34.6%	35.5%
	Totals	**3,070**	**3,024**	**2,971**	**3,054**	**35.7%**	**35.2%**	**34.6%**	**35.5%**
ExUrban									
	ExUrban Other	0	0	21	21	0.0%	0.0%	0.2%	0.2%
	ExUrban Undeveloped	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	ExUrban Industrial	17	36	36	36	0.2%	0.4%	0.4%	0.4%
	ExUrban Commercial	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	ExUrban Residential	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Totals	**17**	**36**	**56**	**56**	**0.2%**	**0.4%**	**0.7%**	**0.7%**
Transportation									
	Public Road	95	69	71	71	1.1%	0.8%	0.8%	0.8%
	Interstate	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Railroad	45	44	44	44	0.5%	0.5%	0.5%	0.5%
	Totals	**140**	**113**	**116**	**116**	**1.6%**	**1.3%**	**1.3%**	**1.3%**
Urban									
	Urban Other	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Urban Residential	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Urban Commercial	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Urban Undeveloped	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Urban Industrial	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Totals	**0**	**0**	**0**	**0**	**0.0%**	**0.0%**	**0.0%**	**0.0%**

Land Use Timeline - Tiers 3 and 4

		Acres				% of Reach Area				Change Between Years (% of Agricultural Land)			
Feature Class	Feature Type	1950	1976	2001	2011	1950	1976	2001	2011	'50-76	'76-01	'01-11	'50-11
Irrigated													
	Sprinkler	7	8	157	164	0.1%	0.2%	2.9%	3.1%	0.0%	2.8%	0.2%	3.0%
	Pivot	0	0	157	180	0.0%	0.0%	2.9%	3.4%	0.0%	2.9%	0.5%	3.4%
	Flood	44	322	278	271	0.8%	6.0%	5.2%	5.2%	5.2%	-0.8%	-0.1%	4.3%
	Totals	**51**	**331**	**592**	**615**	**1.0%**	**6.2%**	**11.1%**	**11.7%**	**5.2%**	**4.9%**	**0.6%**	**10.7%**

Non-Irrigated

Multi-Use	4,732	4,285	3,801	3,693	88.8%	80.2%	71.2%	70.3%	-8.6%	-9.0%	-0.9%	-18.5%
Hay/Pasture	546	724	945	946	10.2%	13.6%	17.7%	18.0%	3.3%	4.1%	0.3%	7.8%
Totals	**5,278**	**5,010**	**4,746**	**4,639**	**99.0%**	**93.8%**	**88.9%**	**88.3%**	**-5.2%**	**-4.9%**	**-0.6%**	**-10.7%**

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	0.2	1.2	1.3	3.4	2.8	3.0	2.7	8.5	2.1
Max	186.4	197.8	271.2	110.6	400.1	301.4	100.9	103.7	106.7
Average	31.7	23.8	43.9	41.4	70.6	51.6	26.9	53.9	29.1
Sum	1,491.5	1,240.2	1,184.8	994.8	1,483.3	1,444.0	430.9	269.3	203.4

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)	172.8
Channel to Riparian (acres)	380.3
Riparian Encroachment (acres)	**207.5**

Riparian Recruitment

Creation of riparian areas between 1950s and 2001.

1950s Channel Mapped as 2011 Riparian (Ac)	403.3
1950s Floodplain Mapped as 2011 Channel (Ac)	32.0
Total Recruitment (1950s to 2011)(Ac)	**435.2**

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	13.7	46.2	24.3	0.0	**84.2**
Acres/Valley Mile	2.0	6.6	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 (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	9.70	0.18%	1.32	0.04	5.84	1.92

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.

Low Flow Fisheries Habitat Mapping

Habitat	2001 (Acres) Bankfull	Low Flow	% of Low Flow
Scour Pool	501.8	362.7	12.2%
Rip Rap Bottom	20.9	21.3	0.7%
Rip Rap Margin	64.5	59.0	2.0%
Terrace Pool	51.4	43.2	1.5%
Secondary Channel	106.4	42.3	1.4%
Secondary Channel (Seasonal)	198.9	173.7	5.8%
Channel Crossover	288.7	258.5	8.7%
Point Bar		86.4	2.9%
Side Bar		76.7	2.6%
Mid-channel Bar		40.6	1.4%
Island	1,695.9	1,695.9	57.0%
Dry Channel		71.7	2.4%
Dam Influenced	51.5	43.9	1.5%

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.

Bird Species Observed in Reach/Region

Species of Concern | Potential Species of Concern

Reach	Region		Reach	Region		Reach	Region		Reach	Region	
☑	☑	American Robin	☐	☑	Chipping Sparrow	☐	☑	Killdeer	☐	☑	Song Sparrow
☐	☑	American Crow	☐	☑	Clay-collared Sparrow	☐	☐	Lark Bunting	☐	☑	Spotted Sandpiper
☑	☑	American Goldfinch	☐	☐	Cliff Swallow	☐	☑	Lark Sparrow	☐	☑	Spotted Towhee
☑	☑	American Kestrel	☑	☑	Common Grackle	☑	☑	Lazuli Bunting	☐	☐	Sharp-shinned Hawk
☐	☑	American Redstart	☐	☐	Common Merganser	☑	☑	Least Flycatcher	☐	☐	Swainson's Thrush
☐	☑	Bald Eagle	☐	☑	Common Nighthawk	☐	☑	Mallard	☐	☐	Sandhill Crane
☐	☐	Baltimore Oriole	☐	☐	Common Raven	☐	☐	Mountain Bluebird	☐	☑	Tree Swallow
☐	☐	Barn Swallow	☑	☑	Common Yellowthroat	☑	☑	Mourning Dove	☐	☐	Turkey Vulture
☐	☑	Belted Kingfisher	☐	☑	Cooper's Hawk	☑	☑	Northern Flicker	☐	☐	Upland Sandpiper
☐	☑	Black-billed Cuckoo	☐	☑	Dickcissel	☐	☑	Orchard Oriole	☐	☐	Vesper Sparrow
☐	☑	Black-billed Magpie	☑	☑	Downy Woodpecker	☐	☐	Osprey	☐	☐	Violet-green Swallow
☑	☑	Black-capped Chickadee	☐	☑	Eastern Bluebird	☐	☑	Ovenbird	☑	☑	Warbling Vireo
☐	☑	Black-and-white Warbler	☑	☑	Eastern Kingbird	☐	☑	Plumbeous Vireo	☐	☑	Western Kingbird
☐	☑	Black-headed Grosbeak	☐	☐	Eurasian Collared-dove	☑	☑	Red-headed Woodpecker	☐	☑	Western Meadowlark
☐	☑	Blue Jay	☑	☑	European Starling	☐	☐	Red-naped Sapsucker	☑	☑	Western Wood-pewee
☐	☑	Bobolink	☐	☑	Field Sparrow	☐	☑	Red Crossbill	☐	☑	White-breasted Nuthatch
☑	☑	Brewer's Blackbird	☐	☑	Franklin's Gull	☐	☑	Ring-necked Pheasant	☐	☐	White-throated Swift
☐	☑	Brown-headed Cowbird	☐	☑	Grasshopper Sparrow	☐	☑	Red-tailed hawk	☐	☑	Wild Turkey
☐	☐	Brown Creeper	☐	☑	Gray Catbird	☐	☑	Rock Dove	☐	☑	Wood Duck
☐	☑	Brown Thrasher	☐	☑	Great Blue Heron	☑	☑	Red-winged Blackbird	☐	☑	Yellow-bellied Sapsucker
☐	☑	Bullock's Oriole	☐	☑	Great Horned Owl	☑	☑	Red-eyed Vireo	☐	☑	Yellow-billed Cuckoo
☐	☐	Canada Goose	☐	☑	Hairy Woodpecker	☐	☑	Red-breasted Grosbeak	☐	☑	Yellow-breasted Chat
☑	☑	Cedar Waxwing	☐	☐	House Finch	☐	☐	Say's Phoebe	☐	☐	Yellow-headed Blackbird
☐	☑	Chimney Swift	☑	☑	House Wren	☐	☑	Savannah Sparrow	☐	☑	Yellow Warbler

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.

Yellowstone River Reach Narratives — Reach D9

County	Dawson	**Upstream River Mile**	71.1
Classification	PCM/I: Partially confined meandering/islands	**Downstream River Mile**	67.8
General Location	Downstream of Intake	**Length**	3.30 mi (5.31 km)
General Comments	Downstream of Intake		

Narrative Summary

Reach D9 is located in Dawson County and starts 1 mile below the Intake Diversion Dam. The reach is a 3.3 mile long Partly Confined Meandering with Islands (PCM/I) reach type, indicating a single-threaded channel with vegetated islands and some valley wall influence on the active channel. This reach is currently the most upstream reach that fully supports pallid sturgeon and paddlefish in the watershed.

This reach has almost no bank armor. There are almost three miles of floodplain dikes associated with irrigation, and two miles of transportation encroachment associated with the railroad grade.

By 1950 almost three miles of side channel had been blocked in Reach D9, with another mile blocked since then. At RM 68.8L, discreet dikes block a side channel that remains within the riparian area, suggesting some potential for restoration.

There is one small rapid in the reach at RM 69.8 where it appears that a bedrock shelf is exposed in the riverbed.

Isolation of the 100 year floodplain has resulted from both physical features on the floodplain as well as reduced flows with human development. In Reach D9, 170 acres of the floodplain, which is 15 percent of the historic floodplain area, is no longer inundated at that frequency. Most of this area isolated is out in flood irrigated fields on the west floodplain. The 5-year floodplain, which has become smaller primarily due to flow alterations, has lost 161 acres or 50 percent of its original footprint.

Land use is predominantly agricultural, with about 183 acres of pivot irrigation development since 1950. There are a total of 19 acres of pivot-irrigated ground within the Channel Migration Zone (CMZ), making these fields especially prone to river erosion.

Reach D9 has seen an increase in the amount of forest area considered at low risk of cowbird parasitism. In 1950, there were 42.3 acres per valley mile of such forest, and by 2001, that number had increased to 79.7 acres per valley mile.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been major in this reach. The magnitude of the 100-year flood is now 128,000 cfs, which is 12 percent lower than it was pre-development (145,000 cfs). The 2-year flood, which strongly influences overall channel form, has dropped by 22 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 4,630 cfs to 2,460 cfs with human development, a reduction of 47 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,760 cfs under unregulated conditions to 2,980 cfs under regulated conditions, a reduction of 56 percent.

In the fall and winter, low flows are typically around 3,500 cfs, which is 60-75 percent higher than historic flow conditions.

CEA-Related observations in Reach D9 include:
•Floodplain isolation due to flow alterations and agricultural dikes
•Side channel blockages

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach D9 include:
•Side channel reactivation at RM 68.8L
•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

	Downstream Gage	Upstream Gage
Gage No	6329500	6309000
Location	Sidney	Miles City
Period of Record	1911-2015	1929-2015
Distance To (miles)	37.0	112.9

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

Discharge

	1.01 Yr	2 Yr	5 Yr	10 Yr	50 Yr	100 Yr	500 Yr	7Q10 Summer	95% Sum. Duration
Unregulated		69,600	89,800	103,000	132,000	145,000	175,000	4,630	6,760
Regulated		54,200	74,400	87,600	116,000	128,000	156,000	2,460	2,980
% Change		-22.13%	-17.15%	-14.95%	-12.12%	-11.72%	-10.86%	-46.87%	-55.92%

Flow Duration

Streamflow, in ft3/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%
Spring	Unregulated	67,500	25,000	7,030
	Regulated	52,100	14,800	5,110
	% Change	**-23%**	**-41%**	**-27%**
Summer	Unregulated	47,400	14,800	6,760
	Regulated	35,200	8,680	2,980
	% Change	**-26%**	**-41%**	**-56%**
Fall	Unregulated	9,830	5,900	1,990
	Regulated	11,200	7,400	3,550
	% Change	**14%**	**25%**	**78%**
Winter	Unregulated	15,200	5,440	2,120
	Regulated	15,800	6,610	3,460
	% Change	**4%**	**22%**	**63%**
Annual	Unregulated	49,800	8,880	2,820
	Regulated	37,100	8,010	3,580
	% Change	**-26%**	**-10%**	**27%**

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	8-Aug-96	B/W		6329500	10300
2001	NRCS	August 2-8, 2001	CIR	1:24,000	6329500	4000
2004	Merrick	3-Jun-04	Color	1:15,840	6329500	9950
2005	NAIP	07/14/2005	color	1-meter pixels	6329500	15900
2009	NAIP	7/11/2009	Color	1-meter pixels	6329500	32600
2011	USCOE	October 2012	color	1-ft pixel	6329500	9030
2011	NAIP	7/21/2011	Color	1-meter pixels	6329500	46600
2013	NAIP	07/27/2013	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						
	Flow Deflectors	0	0.0%	45	0.1%	45
	Feature Type Totals		**0.0%**	**45**	**0.1%**	
Other In Channel						
	Bedrock Outcrop	417	1.1%	417	1.1%	0
	Feature Type Totals	**417**	**1.1%**	**417**	**1.1%**	**0**
	Reach Totals	**417**	**1.1%**	**462**	**1.3%**	**45**

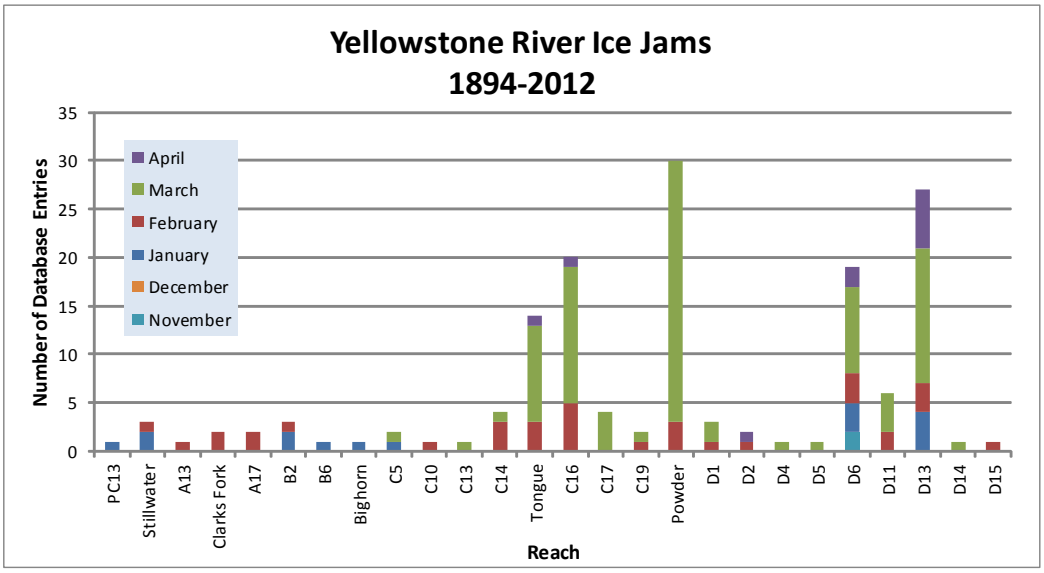
Bankline/Floodplain Inventory: Time Series

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
Irrigation							
	Floodplain Dike/Levee	15,737	15,737	15,737	15,737	15,737	15,737
	Totals	**15,737**	**15,737**	**15,737**	**15,737**	**15,737**	**15,737**
Other Off Channel							
	Floodplain Dike/Levee	0	1,038	1,038	1,038	1,038	1,038
	Totals	**0**	**1,038**	**1,038**	**1,038**	**1,038**	**1,038**
Transportation Encroachment							
	Railroad	11,580	11,580	11,580	11,580	11,580	11,580
	Totals	**11,580**	**11,580**	**11,580**	**11,580**	**11,580**	**11,580**

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.



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	17,273	14,070	1.81	1950 to 1976:	-12.98%
1976	17,792	10,303	1.58	1976 to 1995:	23.66%
1995	18,461	17,589	1.95	1995 to 2001:	2.57%
2001	18,461	18,515	2.00	1950 to 2001:	10.38%
Change 1950 - 2001	**1,188**	**4,445**	**0.19**		

Length of Side Channels Blocked

Pre-1950s (ft)	14,796
Post-1950s (ft)	6,635

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.)	137	12.4%		
Agriculture (generally relates to field boundaries)	0	0.0%		
Agriculture (isloated by canal or large ditch)	33	3.0%		
Levee/Riprap (protecting agricultural lands)	0	0.0%		
Levee/Riprap (protecting urban, industrial, etc.)	0	0.0%		
Railroad	0	0.0%		
Abandoned Railroad	0	0.0%		
Transportation (Interstate and other roads)	0	0.0%		
Total Not Isolated (Ac)	940		578	
Total Floodplain Area (Ac)	1111		739	
Total Isolated (Ac)	**170**	**15.3%**	**161**	**50.4%**

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:	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 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
344	688	1,094	0	0%	310	0	0%

Land Uses within the CMZ (Acres)

Flood Irrigation	Sprinkler Irrigation	Pivot Irrigation	Urban/ ExUrban	Trans-portation
29.0	0.0	19.2	0.0	0.0

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

		Acres				% of Reach Area			
Feature Class	Feature Type	1950	1976	2001	2011	1950	1976	2001	2011
Agricultural Infrastructure									
	Canal	65	65	65	65	1.7%	1.7%	1.7%	1.7%
	Agricultural Roads	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Other Infrastructure	16	16	13	13	0.4%	0.4%	0.3%	0.3%
	Totals	**81**	**81**	**78**	**78**	**2.1%**	**2.1%**	**2.1%**	**2.1%**
Agricultural Land									
	Non-Irrigated	2,248	2,244	2,221	2,211	59.1%	59.0%	58.4%	58.1%
	Irrigated	760	886	891	891	20.0%	23.3%	23.4%	23.4%
	Totals	**3,008**	**3,130**	**3,112**	**3,102**	**79.1%**	**82.3%**	**81.8%**	**81.6%**
Channel									
	Channel	679	557	578	588	17.9%	14.7%	15.2%	15.5%
	Totals	**679**	**557**	**578**	**588**	**17.9%**	**14.7%**	**15.2%**	**15.5%**
ExUrban									
	ExUrban Other	0	0	0	0	0.0%	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	0	0	0	0.0%	0.0%	0.0%	0.0%
	Totals	**0**	**0**	**0**	**0**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
Transportation									
	Public Road	19	19	19	19	0.5%	0.5%	0.5%	0.5%
	Interstate	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Railroad	16	16	16	16	0.4%	0.4%	0.4%	0.4%
	Totals	**35**	**35**	**35**	**35**	**0.9%**	**0.9%**	**0.9%**	**0.9%**
Urban									
	Urban Other	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Urban Residential	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Urban Commercial	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Urban Undeveloped	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Urban Industrial	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Totals	**0**	**0**	**0**	**0**	**0.0%**	**0.0%**	**0.0%**	**0.0%**

Land Use Timeline - Tiers 3 and 4

		Acres				% of Reach Area				Change Between Years (% of Agricultural Land)			
Feature Class	Feature Type	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	0	183	183	0.0%	0.0%	5.9%	5.9%	0.0%	5.9%	0.0%	5.9%
	Flood	760	886	708	708	25.3%	28.3%	22.8%	22.8%	3.0%	-5.5%	0.1%	-2.5%
	Totals	**760**	**886**	**891**	**891**	**25.3%**	**28.3%**	**28.6%**	**28.7%**	**3.0%**	**0.3%**	**0.1%**	**3.4%**

Non-Irrigated

Multi-Use	1,963	2,017	1,992	1,989	65.3%	64.4%	64.0%	64.1%	-0.8%	-0.4%	0.1%	-1.2%
Hay/Pasture	285	228	228	222	9.5%	7.3%	7.3%	7.2%	-2.2%	0.1%	-0.2%	-2.3%
Totals	**2,248**	**2,244**	**2,221**	**2,211**	**74.7%**	**71.7%**	**71.4%**	**71.3%**	**-3.0%**	**-0.3%**	**-0.1%**	**-3.4%**

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	0.9	1.9	1.8	4.6	3.5	2.9	5.3	9.5	5.2
Max	97.0	44.4	29.9	144.7	168.6	521.6	39.3	68.7	5.2
Average	22.9	12.4	10.5	52.2	40.5	52.1	15.5	27.0	5.2
Sum	480.6	286.1	146.3	417.5	526.9	781.5	77.3	108.0	5.2

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)	112.1
Channel to Riparian (acres)	147.4
Riparian Encroachment (acres)	**35.3**

Riparian Recruitment

Creation of riparian areas between 1950s and 2001.

1950s Channel Mapped as 2011 Riparian (Ac)	147.4
1950s Floodplain Mapped as 2011 Channel (Ac)	31.2
Total Recruitment (1950s to 2011)(Ac)	**178.6**

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	1.9	21.8	18.1	0.0	**41.9**
Acres/Valley Mile	0.6	7.2	6.0	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	1.04	0.05%	0.21	0.00	0.44	0.07

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.

Low Flow Fisheries Habitat Mapping

	2001 (Acres)		
Habitat	Bankfull	Low Flow	% of Low Flow
Scour Pool	160.1	82.7	14.3%
Bluff Pool	112.3	76.9	13.3%
Secondary Channel		8.8	1.5%
Secondary Channel (Seasonal)	84.8	57.5	9.9%
Channel Crossover	57.4	61.4	10.6%
Point Bar		47.2	8.2%
Side Bar		21.4	3.7%
Mid-channel Bar		2.6	0.5%
Island	159.7	159.4	27.6%
Dry Channel		60.5	10.5%

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.

Yellowstone River Reach Narratives — Reach D10

County	Dawson	**Upstream River Mile**	67.8
Classification	PCA: Partially confined anabranching	**Downstream River Mile**	56.3
General Location	Lowermost Dawson County, Richland County	**Length**	11.50 mi (18.51 km)
General Comments	Vegatated islands		

Narrative Summary

Reach D10 is located in lowermost Dawson County and extends into upper Richland County. The reach is an 11.5 mile long Partially Confined Anabranching (PCA) reach type, indicating some valley wall influence and numerous forested islands.

In 2011 there were just about 730 feet of rock riprap in the reach armoring 0.6 percent of the total stream bank. Prior to that some armor had been lost; between 2001 and 2011, almost 500 feet of rock riprap and 1,050 feet of concrete riprap were destroyed. Some of the greatest damage was at RM 64.2L, where several hundred feet of flow deflectors were flanked, and now are in the river over 100 feet off of the bank. The remaining bank protection in this area continues to flank. Another is at RM 60, where the flanking of concrete riprap has been followed by over 200 feet of erosion behind the original armor.

Similar to many reaches in the Lower Yellowstone Valley, the river channel in Reach D10 has gotten smaller since 1950. The channel contracted by about 404 acres in this reach since 1950, and about 406 acres of riparian vegetation has encroached into old channel areas. This pattern has been consistent in the lower river, and relates primarily to a reduction in flows due to human development. The encroachment was at the expense of open gravel bars; between 1950 and 2001, the reach lost 151 acres of mid-channel bar habitat. Floodplain turnover rates have dropped as well; prior to 1976 measured floodplain turnover rates in this reach were 13.9 acres per year, and post-1976 rages were 7.0 acres per year.

Reach D10 has a relatively high concentration of mapped wetlands; the NWI mapping shows a total of 278 acres of mapped wetland, much of which is emergent marsh and wet meadow.

Land use is dominated by agriculture, with 230 acres of pivot irrigation development since 1950. Some of the irrigation development took place in historic riparian areas; a total of 457 acres of riparian lands were converted for agricultural and other land uses since 1950. This equates to 15 percent of the entire 1950 riparian footprint. There are 97 acres of land under pivot irrigation within the Channel Migration Zone (CMZ) of the river, making these areas especially prone to river erosion.

About 38 percent of the historic 5-year floodplain has become isolated, primarily due to flow alterations.

Reach D10 was sampled as part of the avian study. A total of 57 species were identified in the reach, indicating relatively high bird species richness on the Yellowstone River. Four species identified are considered Potential Species of Concern (PSOC) by the Montana Natural Heritage Center: The Black and White Warbler, Dickscissel, Ovenbird, and Plumbeous Vireo. The Red-headed Woodpecker was also identified which is a Species of Concern. Similar to Reach D9 upstream, Reach D10 has seen an increase in the amount of forest area considered at low risk of cowbird parasitism. In 1950, there were 92 acres per valley mile of such forest, and by 2001, that number had increased to 112 acres per valley mile.

There are about 12 acres of mapped Russian olive in the reach.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been major in this reach. The 2-year flood, which strongly influences overall channel form, has dropped by 22 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 2,810 cfs with human development, a reduction of 43 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,940 cfs under unregulated conditions to 3,270 cfs under regulated conditions, a reduction of 53 percent.

CEA-Related observations in Reach D10 include:
•Armor flanking and accelerated erosion behind

Recommended Practices (May include Yellowstone River Recommended Practices--YRRPs) for Reach D10 include:
•Removal of flanked armor at RM 60 and RM 64.2L
•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

	Downstream Gage	Upstream Gage
Gage No	6329500	6309000
Location	Sidney	Miles City
Period of Record	1911-2015	1929-2015
Distance To (miles)	25.5	116.2

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

Discharge

	1.01 Yr	2 Yr	5 Yr	10 Yr	50 Yr	100 Yr	500 Yr	7Q10 Summer	95% Sum. Duration
Unregulated		69,700	90,000	103,000	132,000	144,000	173,000	4,450	6,620
Regulated		54,200	74,700	88,100	118,000	130,000	159,000	2,310	2,840
% Change		-22.24%	-17.00%	-14.47%	-10.61%	-9.72%	-8.09%	-48.09%	-57.10%

Flow Duration

Streamflow, in ft3/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%
Spring	Unregulated	67,400	24,900	7,100
	Regulated	52,000	14,600	5,150
	% Change	**-23%**	**-41%**	**-27%**
Summer	Unregulated	47,500	14,700	6,620
	Regulated	35,300	8,540	2,840
	% Change	**-26%**	**-42%**	**-57%**
Fall	Unregulated	9,870	5,870	1,970
	Regulated	11,300	7,370	3,530
	% Change	**14%**	**26%**	**79%**
Winter	Unregulated	15,600	5,500	2,130
	Regulated	16,200	6,670	3,480
	% Change	**4%**	**21%**	**63%**
Annual	Unregulated	49,800	8,860	2,830
	Regulated	37,000	8,000	3,530
	% Change	**-26%**	**-10%**	**25%**

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	MDT	28-Oct-77	B/W	1:12,000	6329500	5800
1995	USGS DOQQ	7/9/96 - 7/15/96 - 8/8/96	B/W		6329500	35000
2001	NRCS	August 2-8, 2001	CIR	1:24,000	6329500	4000
2004	Merrick	3-Jun-04	Color	1:15,840	6329500	9950
2005	NAIP	07/14/2005	color	1-meter pixels	6329500	15900
2009	NAIP	7/11/2009	Color	1-meter pixels	6329500	32600
2011	USCOE	October 2012	color	1-ft pixel	6329500	9030
2011	NAIP	7/21/2011	Color	1-meter pixels	6329500	46600
2013	NAIP	07/19/2013	color	1-meter pixels	6329500	
2013	NAIP	07/27/2013	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	1,175	1.0%	728	0.6%	-447
	Concrete RipRap	1,051	0.9%	0	0.0%	-1,051
	Feature Type Totals	**2,226**	**1.9%**	**728**	**0.6%**	**-1,498**
Other In Channel						
	Bedrock Outcrop	787	0.7%	787	0.7%	0
	Feature Type Totals	**787**	**0.7%**	**787**	**0.7%**	**0**
	Reach Totals	**3,012**	**2.5%**	**1,515**	**1.3%**	**-1,498**

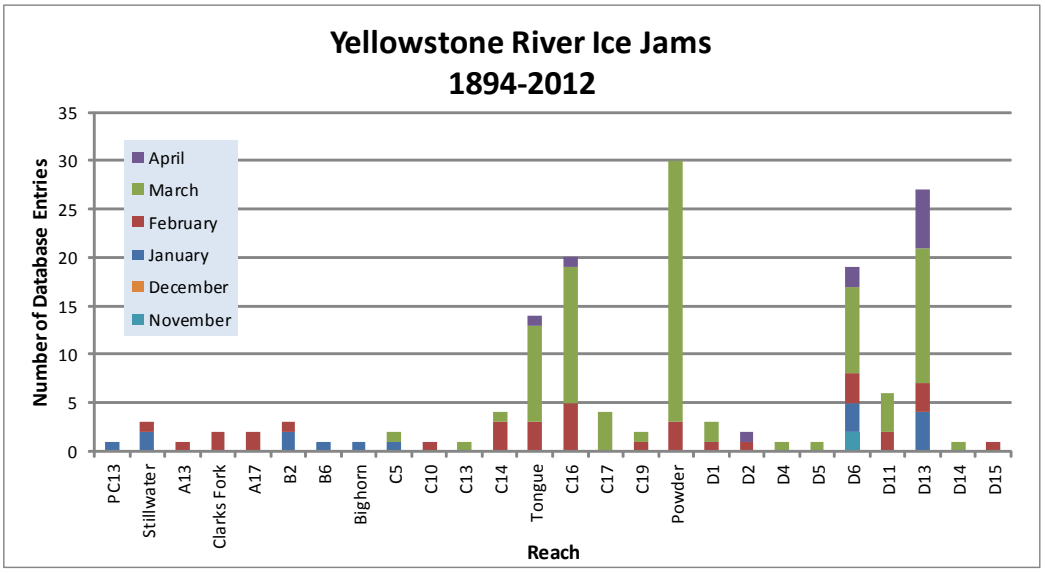
Intent of Bank Protection: 2001

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	1,050	0	0	0	0	0	0	0
Rock RipRap	0	1,174	0	0	0	0	0	0
Totals	**1,050**	**1,174**	**0**	**0**	**0**	**0**	**0**	**0**

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.



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	59,537	92,853	2.56	1950 to 1976:	-4.18%
1976	60,364	87,686	2.45	1976 to 1995:	-3.62%
1995	61,165	83,424	2.36	1995 to 2001:	11.88%
2001	59,913	98,546	2.64	1950 to 2001:	3.33%
Change 1950 - 2001	**376**	**5,693**	**0.09**		

Length of Side Channels Blocked

Pre-1950s (ft)	0
Post-1950s (ft)	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 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.)	94	1.9%		
Agriculture (generally relates to field boundaries)	13	0.3%		
Agriculture (isloated by canal or large ditch)	121	2.5%		
Levee/Riprap (protecting agricultural lands)	0	0.0%		
Levee/Riprap (protecting urban, industrial, etc.)	0	0.0%		
Railroad	423	8.7%		
Abandoned Railroad	0	0.0%		
Transportation (Interstate and other roads)	0	0.0%		
Total Not Isolated (Ac)	4236		2758	
Total Floodplain Area (Ac)	4887		3576	
Total Isolated (Ac)	**651**	**13.3%**	**818**	**38.3%**

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:	121	0	0	**121**

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
526	1,051	4,753	95	2%	233	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	8	0.2%
RipRap			
	Non-Irrigated	44	0.9%
	Totals	**52**	**1.0%**

Land Uses within the CMZ (Acres)

Flood Irrigation	Sprinkler Irrigation	Pivot Irrigation	Urban/ ExUrban	Trans-portation
540.6	0.0	96.5	5.7	1.8

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

		Acres				% of Reach Area			
Feature Class	Feature Type	1950	1976	2001	2011	1950	1976	2001	2011
Agricultural Infrastructure									
	Canal	26	26	26	26	0.3%	0.3%	0.3%	0.3%
	Agricultural Roads	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Other Infrastructure	18	18	29	26	0.2%	0.2%	0.4%	0.3%
	Totals	**44**	**44**	**55**	**53**	**0.5%**	**0.5%**	**0.7%**	**0.6%**
Agricultural Land									
	Non-Irrigated	3,863	4,018	4,158	3,825	47.1%	49.0%	50.7%	46.6%
	Irrigated	723	1,130	1,533	1,505	8.8%	13.8%	18.7%	18.3%
	Totals	**4,586**	**5,148**	**5,692**	**5,330**	**55.9%**	**62.8%**	**69.4%**	**65.0%**
Channel									
	Channel	3,546	2,979	2,424	2,788	43.2%	36.3%	29.6%	34.0%
	Totals	**3,546**	**2,979**	**2,424**	**2,788**	**43.2%**	**36.3%**	**29.6%**	**34.0%**
ExUrban									
	ExUrban Other	0	0	0	0	0.0%	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	5	6	6	0.0%	0.1%	0.1%	0.1%
	Totals	**0**	**5**	**6**	**6**	**0.0%**	**0.1%**	**0.1%**	**0.1%**
Transportation									
	Public Road	5	5	5	5	0.1%	0.1%	0.1%	0.1%
	Interstate	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Railroad	21	21	21	21	0.3%	0.3%	0.3%	0.3%
	Totals	**26**	**26**	**26**	**26**	**0.3%**	**0.3%**	**0.3%**	**0.3%**
Urban									
	Urban Other	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Urban Residential	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Urban Commercial	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Urban Undeveloped	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Urban Industrial	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Totals	**0**	**0**	**0**	**0**	**0.0%**	**0.0%**	**0.0%**	**0.0%**

Land Use Timeline - Tiers 3 and 4

		Acres				% of Reach Area				Change Between Years (% of Agricultural Land)			
Feature Class	Feature Type	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	0	232	229	0.0%	0.0%	4.1%	4.3%	0.0%	4.1%	0.2%	4.3%
	Flood	723	1,130	1,301	1,275	15.8%	21.9%	22.9%	23.9%	6.2%	0.9%	1.1%	8.2%
	Totals	**723**	**1,130**	**1,533**	**1,505**	**15.8%**	**21.9%**	**26.9%**	**28.2%**	**6.2%**	**5.0%**	**1.3%**	**12.5%**

Non-Irrigated

Multi-Use	3,442	3,567	3,909	3,594	75.1%	69.3%	68.7%	67.4%	-5.8%	-0.6%	-1.2%	-7.6%
Hay/Pasture	421	452	250	231	9.2%	8.8%	4.4%	4.3%	-0.4%	-4.4%	-0.1%	-4.8%
Totals	**3,863**	**4,018**	**4,158**	**3,825**	**84.2%**	**78.1%**	**73.1%**	**71.8%**	**-6.2%**	**-5.0%**	**-1.3%**	**-12.5%**

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	0.8	0.3	0.1	0.3	1.3	1.6	0.0	7.0	5.6
Max	148.9	156.3	88.8	213.5	693.9	870.0	80.0	32.7	42.8
Average	27.8	13.6	16.9	48.9	59.9	53.4	20.8	17.3	24.7
Sum	1,251.2	680.8	796.1	1,760.9	1,797.3	2,083.2	228.3	138.1	172.7

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)	343.0
Channel to Riparian (acres)	748.9
Riparian Encroachment (acres)	**405.9**

Riparian Recruitment

Creation of riparian areas between 1950s and 2001.

1950s Channel Mapped as 2011 Riparian (Ac)	758.1
1950s Floodplain Mapped as 2011 Channel (Ac)	164.3
Total Recruitment (1950s to 2011)(Ac)	**922.3**

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	21.6	136.8	120.4	0.0	**278.7**
Acres/Valley Mile	2.3	14.7	12.9	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	11.90	0.22%	5.79	0.02	5.83	2.33

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.

Low Flow Fisheries Habitat Mapping

	2001 (Acres)		
Habitat	Bankfull	Low Flow	% of Low Flow
Scour Pool	307.2	219.2	9.0%
Rip Rap Bottom	115.7	62.0	2.6%
Bluff Pool	188.0	134.9	5.6%
Secondary Channel	103.1	73.2	3.0%
Secondary Channel (Seasonal)	449.9	415.5	17.1%
Channel Crossover	275.2	148.3	6.1%
Point Bar		248.7	10.3%
Side Bar		20.5	0.8%
Mid-channel Bar		21.3	0.9%
Island	985.0	989.2	40.8%
Dry Channel		91.3	3.8%

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.

Bird Species Observed in Reach/Region

Species of Concern | Potential Species of Concern

Reach	Region		Reach	Region		Reach	Region		Reach	Region	
☑	☑	American Robin	☐	☑	Chipping Sparrow	☐	☑	Killdeer	☑	☑	Song Sparrow
☑	☑	American Crow	☑	☑	Clay-collared Sparrow	☐	☐	Lark Bunting	☑	☑	Spotted Sandpiper
☑	☑	American Goldfinch	☐	☐	Cliff Swallow	☑	☑	Lark Sparrow	☑	☑	Spotted Towhee
☑	☑	American Kestrel	☑	☑	Common Grackle	☑	☑	Lazuli Bunting	☐	☐	Sharp-shinned Hawk
☑	☑	American Redstart	☐	☐	Common Merganser	☑	☑	Least Flycatcher	☐	☐	Swainson's Thrush
☑	☑	Bald Eagle	☑	☑	Common Nighthawk	☐	☑	Mallard	☐	☐	Sandhill Crane
☑	☑	Baltimore Oriole	☐	☐	Common Raven	☐	☐	Mountain Bluebird	☑	☑	Tree Swallow
☐	☐	Barn Swallow	☑	☑	Common Yellowthroat	☑	☑	Mourning Dove	☐	☐	Turkey Vulture
☑	☑	Belted Kingfisher	☑	☑	Cooper's Hawk	☑	☑	Northern Flicker	☐	☐	Upland Sandpiper
☐	☑	Black-billed Cuckoo	☑	☑	Dickcissel	☐	☑	Orchard Oriole	☐	☐	Vesper Sparrow
☑	☑	Black-billed Magpie	☑	☑	Downy Woodpecker	☐	☐	Osprey	☐	☐	Violet-green Swallow
☑	☑	Black-capped Chickadee	☑	☑	Eastern Bluebird	☑	☑	Ovenbird	☑	☑	Warbling Vireo
☑	☑	Black-and-white Warbler	☑	☑	Eastern Kingbird	☑	☑	Plumbeous Vireo	☑	☑	Western Kingbird
☑	☑	Black-headed Grosbeak	☐	☐	Eurasian Collared-dove	☑	☑	Red-headed Woodpecker	☑	☑	Western Meadowlark
☑	☑	Blue Jay	☑	☑	European Starling	☐	☐	Red-naped Sapsucker	☑	☑	Western Wood-pewee
☐	☑	Bobolink	☑	☑	Field Sparrow	☐	☑	Red Crossbill	☑	☑	White-breasted Nuthatch
☑	☑	Brewer's Blackbird	☐	☑	Franklin's Gull	☑	☑	Ring-necked Pheasant	☐	☐	White-throated Swift
☑	☑	Brown-headed Cowbird	☑	☑	Grasshopper Sparrow	☑	☑	Red-tailed hawk	☑	☑	Wild Turkey
☐	☐	Brown Creeper	☑	☑	Gray Catbird	☐	☑	Rock Dove	☐	☑	Wood Duck
☑	☑	Brown Thrasher	☐	☑	Great Blue Heron	☑	☑	Red-winged Blackbird	☐	☑	Yellow-bellied Sapsucker
☑	☑	Bullock's Oriole	☐	☑	Great Horned Owl	☑	☑	Red-eyed Vireo	☑	☑	Yellow-billed Cuckoo
☐	☐	Canada Goose	☑	☑	Hairy Woodpecker	☐	☑	Red-breasted Grosbeak	☑	☑	Yellow-breasted Chat
☑	☑	Cedar Waxwing	☐	☐	House Finch	☐	☐	Say's Phoebe	☐	☐	Yellow-headed Blackbird
☐	☑	Chimney Swift	☑	☑	House Wren	☐	☑	Savannah Sparrow	☑	☑	Yellow Warbler

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.