Yellowstone River Reach Narratives — Reach D14

County	Richland	**Upstream River Mile**	27.8
Classification	PCM/I: Partly confined meandering/islands	**Downstream River Mile**	13.5
General Location	To Fariview	**Length**	14.30 mi (23.01 km)
General Comments	Into Mckenzie County, North Dakota: High sinuosity		

Narrative Summary

Reach D14 is located upstream of Fairview. The reach is a 14.3 mile long Partially Confined Meandering with Islands (PCM/I), indicating some valley wall influence, and a meandering main thread with cutoff channels through meander cores forming persistent forested islands.

There is just over a mile of bank armor in the reach, including 3,900 feet of rock riprap and 2,500 feet of flow deflectors. Most of the rock riprap was constructed between 2001 and 2011 (2,300 feet).

Prior to 1950, 3,600 feet of side channel was blocked in the reach at RM 23L.

Similar to many reaches in the Lower Yellowstone Valley, the river channel in Reach D14 has gotten smaller since 1950. The channel contracted by about 309 acres in this reach since 1950, and about 460 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 14.4 acres per year pre-1976 to 6.1 acres per year post-1976. There has also been a major loss of open bar habitat area in the channel; between 1950 and 2001, there was a loss of 510 acres of mid-channel bar area, which can be important habitat to certain species such as least tern.

Land use is predominantly agricultural, with just over a thousand acres of pivot irrigation development since 1950. Development in the reach included conversion of 1,063 acres of 1950s riparian area to other land uses (mostly irrigated agriculture); that represented 36 percent of the entire 1950s riparian footprint. There are 93 acres of pivot irrigated land and 113 acres of urban/exurban development within the Channel Migration Zone (CMZ), making these areas especially susceptible to river erosion. At RM 26L there are three drill pads within the CMZ.

Several dump sites have been mapped on the banks: RM 25R, RM 24.3L, RM 17L, RM 15.8L, and RM 15.8R.

There is one pipeline crossing in Reach D14 at RM 27. It is an 8-inch crude oil pipeline that has been Horizontally Directionally Drilled.

About 41 percent of the historic 5-year floodplain has become isolated, primarily due to flow alterations.

One ice jam was reported in the reach. It was a break-up flood event on March 17, 2011.

There are about 36 acres of mapped Russian olive in the reach.

Reach D14 was sampled as part of the avian study. A total of 30 bird species were identified in the reach. Two bird species identified by the Montana Natural Heritage Program as Potential Species of Concern (PSOC) on the Yellowstone River were found, the Ovenbird and the Plumbeous Vireo. Reach D14 has seen a decrease in the forested area that is at low risk of cowbird parasitism since 1950. At that time, there were 25.6 acres per valley mile of such forest, and that number dropped to 19.6 acres per valley mile by 2001.

CEA-Related observations in Reach D14 include:
•Flow alteration impacts on floodplain access

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach D14 include:
•Solid waste removal at dump sites at RM 25R, RM 24.3L, RM 17L, RM 15.8L, and RM 15.8R.
•Side channel reactivation at RM 23L
•Pipeline crossing Management at RM 27.
•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
Location	#Error	Sidney
Period of Record	#Error	1911-2015
Distance To (miles)	#Error	3.0

Discharge

	1.01 Yr	2 Yr	5 Yr	10 Yr	50 Yr	100 Yr	500 Yr	7Q10 Summer	95% Sum. Duration
Unregulated								NA	NA
Regulated								NA	NA
% Change								NA	NA

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
1949	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	28-Jul-95	B/W		6329500	25000
2001	NRCS	???	CIR	1:24,000	6329500	4000
2005	NAIP	07/14/2005	color	1-meter pixels	6329500	15900
2007	Woolpert	10/15/2007 - 11/2/0007	Color		6329500	
2009	NAIP	7/11/2009	Color	1-meter pixels	6329500	32600
2009	NAIP	7/9/2009	Color	1-meter pixels	6329500	35400
2011	USCOE	October 2012	color	1-ft pixel	6329500	9030
2011	NAIP	7/25/2011	Color	1-meter pixels	6329500	41100
2011	NAIP	7/15/2011	Color	1-meter pixels	6329500	57900
2013	NAIP	07/19/2013	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	1,613	1.1%	3,906	2.6%	2,293
	Flow Deflectors	935	0.6%	1,208	0.8%	273
	Between Flow Deflectors	1,297	0.9%	1,297	0.9%	0
	Feature Type Totals	**3,845**	**2.5%**	**6,411**	**4.2%**	**2,566**
	Reach Totals	**3,845**	**2.5%**	**6,411**	**4.2%**	**2,566**

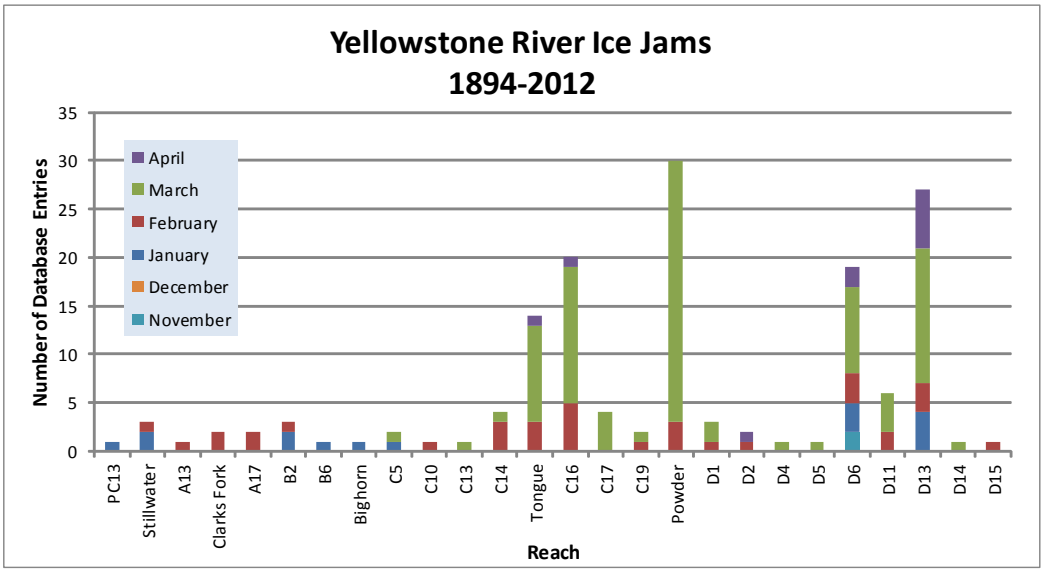
Intent of Bank Protection: 2001

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	1,971	0	0	0	0	0	0	259
Rock RipRap	0	0	446	0	0	0	0	1,168
Totals	**1,971**	**0**	**446**	**0**	**0**	**0**	**0**	**1,427**

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	76,083	3,723	1.05	1950 to 1976:	31.63%
1976	75,267	28,654	1.38	1976 to 1995:	24.21%
1995	75,888	54,254	1.71	1995 to 2001:	-16.71%
2001	75,901	32,508	1.43	1950 to 2001:	36.17%
Change 1950 - 2001	**-182**	**28,786**	**0.38**		

Length of Side Channels Blocked

Pre-1950s (ft)	3,595
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.)	0	0.0%		
Agriculture (generally relates to field boundaries)	1451	17.4%		
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)	6895		3410	
Total Floodplain Area (Ac)	8346		4456	
Total Isolated (Ac)	**1451**	**17.4%**	**1046**	**40.9%**

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:	132	0	33	**164**

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
538	1,077	5,428	118	2%	633	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	14	0.2%
RipRap/Flow Deflectors			
	Irrigated	1	0.0%
RipRap			
	Non-Irrigated	12	0.2%
	Exurban Industrial	69	1.1%
Flow Deflectors			
	Irrigated	65	1.1%
	Totals	**161**	**2.7%**

Land Uses within the CMZ (Acres)

Flood Irrigation	Sprinkler Irrigation	Pivot Irrigation	Urban/ ExUrban	Trans-portation
1586.3	0.0	93.1	113.0	10.9

LAND USE

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

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

Land Use Timeline - Tiers 2 and 3

		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	49	98	143	153	0.5%	0.9%	1.3%	1.4%
	Totals	**49**	**98**	**143**	**153**	**0.5%**	**0.9%**	**1.3%**	**1.4%**
Agricultural Land									
	Non-Irrigated	4,570	3,488	3,179	3,085	42.6%	32.6%	29.7%	28.8%
	Irrigated	3,833	4,692	4,966	4,994	35.8%	43.8%	46.3%	46.6%
	Totals	**8,402**	**8,180**	**8,145**	**8,079**	**78.4%**	**76.3%**	**76.0%**	**75.4%**
Channel									
	Channel	2,199	2,353	2,196	2,249	20.5%	22.0%	20.5%	21.0%
	Totals	**2,199**	**2,353**	**2,196**	**2,249**	**20.5%**	**22.0%**	**20.5%**	**21.0%**
ExUrban									
	ExUrban Other	0	0	23	23	0.0%	0.0%	0.2%	0.2%
	ExUrban Undeveloped	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	ExUrban Industrial	0	15	135	139	0.0%	0.1%	1.3%	1.3%
	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**	**158**	**161**	**0.0%**	**0.1%**	**1.5%**	**1.5%**
Transportation									
	Public Road	62	66	70	70	0.6%	0.6%	0.7%	0.7%
	Interstate	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Railroad	3	3	3	3	0.0%	0.0%	0.0%	0.0%
	Totals	**65**	**69**	**73**	**73**	**0.6%**	**0.6%**	**0.7%**	**0.7%**
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
Irr													
	Sprinkler	0	0	0	0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Pivot	0	0	436	1,003	0.0%	0.0%	5.3%	12.4%	0.0%	5.3%	7.1%	12.4%
	Flood	3,833	4,692	4,530	3,990	45.6%	57.4%	55.6%	49.4%	11.7%	-1.7%	-6.2%	3.8%
	Totals	**3,833**	**4,692**	**4,966**	**4,994**	**45.6%**	**57.4%**	**61.0%**	**61.8%**	**11.7%**	**3.6%**	**0.8%**	**16.2%**

NoIrr

Multi-Use	3,964	3,206	2,956	2,842	47.2%	39.2%	36.3%	35.2%	-8.0%	-2.9%	-1.1%	-12.0%
Hay/Pasture	606	283	223	243	7.2%	3.5%	2.7%	3.0%	-3.8%	-0.7%	0.3%	-4.2%
Totals	**4,570**	**3,488**	**3,179**	**3,085**	**54.4%**	**42.6%**	**39.0%**	**38.2%**	**-11.7%**	**-3.6%**	**-0.8%**	**-16.2%**

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	0.8	0.2	0.8	2.6	0.0	0.7	6.5	3.7	5.5
Max	500.7	159.2	118.8	246.1	421.8	478.2	28.9	8.4	13.3
Average	58.8	28.6	13.9	55.5	70.4	74.5	14.4	6.2	9.6
Sum	2,000.5	885.6	556.3	1,110.9	1,479.0	1,863.1	129.7	18.7	38.4

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)	270.6
Channel to Riparian (acres)	729.7
Riparian Encroachment (acres)	**459.1**

Riparian Recruitment

Creation of riparian areas between 1950s and 2001.

1950s Channel Mapped as 2011 Riparian (Ac)	736.1
1950s Floodplain Mapped as 2011 Channel (Ac)	97.3
Total Recruitment (1950s to 2011)(Ac)	**833.4**

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	8.1	137.1	144.3	0.0	**289.5**
Acres/Valley Mile	0.6	10.9	11.5	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	35.69	0.77%	53.75	0.15	15.92	0.02

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	805.0	536.5	24.0%
Rip Rap Bottom	149.6	127.5	5.7%
Rip Rap Margin	61.0	48.0	2.1%
Bluff Pool	71.9	69.6	3.1%
Terrace Pool	40.0	57.3	2.6%
Secondary Channel	53.2	73.2	3.3%
Secondary Channel (Seasonal)	232.9	175.0	7.8%
Channel Crossover	486.2	301.4	13.5%
Point Bar		65.0	2.9%
Side Bar		113.1	5.1%
Mid-channel Bar		138.6	6.2%
Island	337.6	337.6	15.1%
Dry Channel		191.5	8.6%

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	Mckenzie	**Upstream River Mile**	13.5
Classification	PCM/I: Partially confined meandering/islands	**Downstream River Mile**	7.5
General Location	Downstream of Fairview	**Length**	6.00 mi (9.66 km)

General Comments

Narrative Summary

Reach D15 is located downstream of Fairview. The reach is a 6 mile long Partially Confined Meandering with Islands (PCM/I), indicating some valley wall influence, and a meandering main thread with cutoff channels through meander cores forming persistent forested islands.

No bank armor was mapped in the reach, and no side channels have been blocked.

Similar to many reaches in the Lower Yellowstone Valley, the river channel in Reach D15 has gotten smaller since 1950. The channel contracted by about 190 acres in this reach since 1950, and about 210 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.

Land use is predominantly agricultural, with 71 acres of pivot irrigation development since 1950. A total of 54 percent of the 100 year floodplain has become isolated (1,885 acres), and most of this isolation is from agricultural dikes. Approximately 23 percent of the 5-year floodplain has become isolated (168 acres).

There is a drill pad on the edge of the CMZ at RM 10.8L.

One ice jam was reported in the reach. It was a break-up flood event on February 12, 1996.

Reach D15 was sampled as part of the avian study. A total of 30 bird species were identified in the reach. Two bird species identified by the Montana Natural Heritage Program as Potential Species of Concern (PSOC) on the Yellowstone River were found, the Ovenbird and the Plumbeous Vireo.. Reach D15 has seen a decrease in the forested area that is at low risk of cowbird parasitism since 1950. At that time, there were 25.6 acres per valley mile of such forest, and that number dropped to 19.6 acres per valley mile by 2001.

CEA-Related observations in Reach D15 include:
•Flow alteration impacts on floodplain access

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach D15 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

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
Location	#Error	Sidney
Period of Record	#Error	1911-2015
Distance To (miles)	#Error	17.3

Discharge

	1.01 Yr	2 Yr	5 Yr	10 Yr	50 Yr	100 Yr	500 Yr	7Q10 Summer	95% Sum. Duration
Unregulated								NA	NA
Regulated								NA	NA
% Change								NA	NA

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
1995	USGS DOQQ	1995??	B/W		6329500	
2001	NRCS	August 2-8, 2001	CIR	1:24,000	6329500	4000
2007	Woolpert	10/15/2007 - 11/2/0007	Color		6329500	
2009	NAIP	7/9/2009	Color	1-meter pixels	6329500	35400
2011	USCOE	October 2012	color	1-ft pixel	6329500	9030
2011	NAIP	7/25/2011	Color	1-meter pixels	6329500	41100

PHYSICAL FEATURES

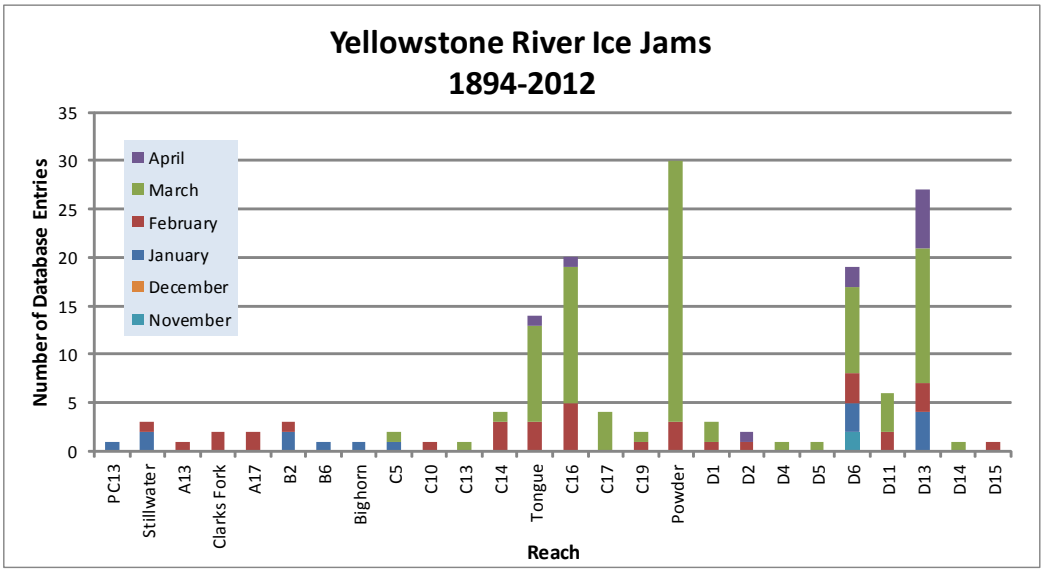
Several efforts to capture the types and extents of physical features in the corridor have been generated by the CEA study. The 2001 Physical Features Inventory was performed through helicopter/video Rapid Aerial Assessment by the NRCS (NRCS, 2001) and did not include Park County. This inventory includes 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.

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
2/12/1996	Break-up	10	?

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	31,574	14,376	1.46	1950 to 1976:	
1976				1976 to 1995:	
1995	31,054	33,170	2.07	1995 to 2001:	-5.23%
2001	31,573	30,311	1.96	1950 to 2001:	34.68%
Change 1950 - 2001	**-1**	**15,935**	**0.50**		

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.)	0	0.0%		
Agriculture (generally relates to field boundaries)	1885	54.4%		
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)	1581		1372	
Total Floodplain Area (Ac)	3466		1540	
Total Isolated (Ac)	**1885**	**54.4%**	**168**	**22.7%**

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:	56	0	0	**56**

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
226	452	1,776	20	1%	0	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	4	0.2%
	Exurban Other	17	1.0%
	Totals	**21**	**1.2%**

Land Uses within the CMZ (Acres)

Flood Irrigation	Sprinkler Irrigation	Pivot Irrigation	Urban/ ExUrban	Trans-portation
240.7	0.0	4.4	10.2	1.1

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%
	Agricultural Roads	0		0	0	0.0%		0.0%	0.0%
	Other Infrastructure	86		188	193	1.0%		2.1%	2.1%
	Totals	**86**		**188**	**193**	**1.0%**		**2.1%**	**2.1%**
Agricultural Land									
	Non-Irrigated	2,260		1,320	1,313	25.1%		14.7%	14.6%
	Irrigated	3,955		6,173	6,173	44.0%		68.6%	68.6%
	Totals	**6,215**		**7,492**	**7,485**	**69.1%**		**83.3%**	**83.2%**
Channel									
	Channel	1,130		1,212	1,214	12.6%		13.5%	13.5%
	Totals	**1,130**		**1,212**	**1,214**	**12.6%**		**13.5%**	**13.5%**
ExUrban									
	ExUrban Other	0		29	29	0.0%		0.3%	0.3%
	ExUrban Undeveloped	0		0	0	0.0%		0.0%	0.0%
	ExUrban Industrial	0		7	7	0.0%		0.1%	0.1%
	ExUrban Commercial	0		0	0	0.0%		0.0%	0.0%
	ExUrban Residential	0		0	0	0.0%		0.0%	0.0%
	Totals	**0**		**36**	**36**	**0.0%**		**0.4%**	**0.4%**
Transportation									
	Public Road	79		71	71	0.9%		0.8%	0.8%
	Interstate	0		0	0	0.0%		0.0%	0.0%
	Railroad	0		0	0	0.0%		0.0%	0.0%
	Totals	**79**		**71**	**71**	**0.9%**		**0.8%**	**0.8%**
Urban									
	Urban Other	0		0	0	0.0%		0.0%	0.0%
	Urban Residential	0		0	0	0.0%		0.0%	0.0%
	Urban Commercial	0		0	0	0.0%		0.0%	0.0%
	Urban Undeveloped	0		0	0	0.0%		0.0%	0.0%
	Urban Industrial	0		0	0	0.0%		0.0%	0.0%
	Totals	**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
Irr													
	Sprinkler	0		0	0	0.0%		0.0%	0.0%		0.0%	0.0%	0.0%
	Pivot	0		20	71	0.0%		0.3%	1.0%		0.3%	0.7%	1.0%
	Flood	3,955		6,153	6,101	63.6%		82.1%	81.5%		18.5%	-0.6%	17.9%
	Totals	**3,955**		**6,173**	**6,173**	**63.6%**		**82.4%**	**82.5%**		**18.8%**	**0.1%**	**18.8%**

NoIrr

Multi-Use	1,804	1,307	1,300	29.0%	17.4%	17.4%	-11.6%	-0.1%	-11.7%
Hay/Pasture	456	13	13	7.3%	0.2%	0.2%	-7.2%	0.0%	-7.2%
Totals	**2,260**	**1,320**	**1,313**	**36.4%**	**17.6%**	**17.5%**	**-18.8%**	**-0.1%**	**-18.8%**

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		1.8	7.7		1.8	13.7		3.6
Max	120.5		39.0	121.8		199.0	35.0		16.2
Average	35.5		12.0	46.0		39.9	22.7		9.9
Sum	568.0		228.1	322.1		678.8	90.8		19.8

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)	93.5
Channel to Riparian (acres)	302.0
Riparian Encroachment (acres)	**208.5**

Riparian Recruitment

Creation of riparian areas between 1950s and 2001.

1950s Channel Mapped as 2011 Riparian (Ac)	304.4
1950s Floodplain Mapped as 2011 Channel (Ac)	77.3
Total Recruitment (1950s to 2011)(Ac)	**381.7**

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	1.6	20.2	68.7	0.0	**90.5**
Acres/Valley Mile	0.3	3.5	11.9	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	0.83	0.10%	5.72	0.00	0.00	0.00

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	197.2	191.0	15.8%
Rip Rap Bottom	133.0	79.1	6.5%
Rip Rap Margin	38.3	34.6	2.9%
Bluff Pool	64.3	43.7	3.6%
Terrace Pool	101.9	36.7	3.0%
Secondary Channel		30.9	2.6%
Secondary Channel (Seasonal)	71.0	68.4	5.6%
Channel Crossover	190.0	133.8	11.0%
Side Bar		124.6	10.3%
Mid-channel Bar		52.1	4.3%
Island	413.3	413.3	34.1%
Dry Channel		3.9	0.3%

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.

County	Mckenzie	**Upstream River Mile**	7.5
Classification	US/I: Unconfined straight/islands	**Downstream River Mile**	0
General Location	To Missouri River	**Length**	7.50 mi (12.07 km)
General Comments	To mouth: low sinuosity; alternate bars; vegetated islands		

Narrative Summary

Reach D16 is the lowermost reach of the Yellowstone River, extending 7.5 miles to the confluence with the Missouri River. It is a unique reach type, referred to as Unconfined Straight (US), and it has numerous forested islands that have developed since the 1950s.

Reach D16 has only a few hundred feet of rock riprap along its 7.5 mile length, and all of that was built since 2001. No side channels have been blocked.

The most striking change in Reach D16 since 1950 is the encroachment of riparian vegetation onto old sand bars. Between 1950 and 2001, the size of the channel has dropped by 550 acres, and there has been 472 acres of riparian encroachment into old channel areas. Much of this encroachment converted open sand bars into forested islands. There has been a loss of over 150 acres of sand bar since 1950. This change has resulted in a conversion of almost 7 miles low flow channels around gravel bars to anabranching side channels around islands.

Land use in the reach is dominated by flood irrigation. The extent of flood irrigated lands increased from 4,600 acres in 1950 to about 8,500 acres in 2011. The floodplain is very flat and broad in this lowermost portion of the Yellowstone River valley, and as a result, floodplain development for agriculture has substantially altered floodplain access. About 29 percent of the 100-year floodplain has become isolated from the river, and a fraction of this (1.6 percent) has been attributed to flow alterations, whereas 27 percent has been associated with agricultural features on the floodplain such as roads and ditches. There are about 480 acres of flood irrigated land within the Channel Migration Zone of Reach D16.

Land use mapping shows several drill pads in the lower portion of the reach that are within several thousand feet of the river. There are four drill pads on a narrow strip of land at the mouth that lies between the Yellowstone and Missouri Rivers.

Reach D16 has a notably high concentration of mapped wetlands. There are about 580 acres of mapped wetland in the reach, which translates to about 80 acres per valley mile. Along the rest of the river, wetland densities rarely exceed 50 acres per valley mile. Reach D16 only has 3.5 acres of mapped Russian olive, which is a relatively low density for reaches below Billings.

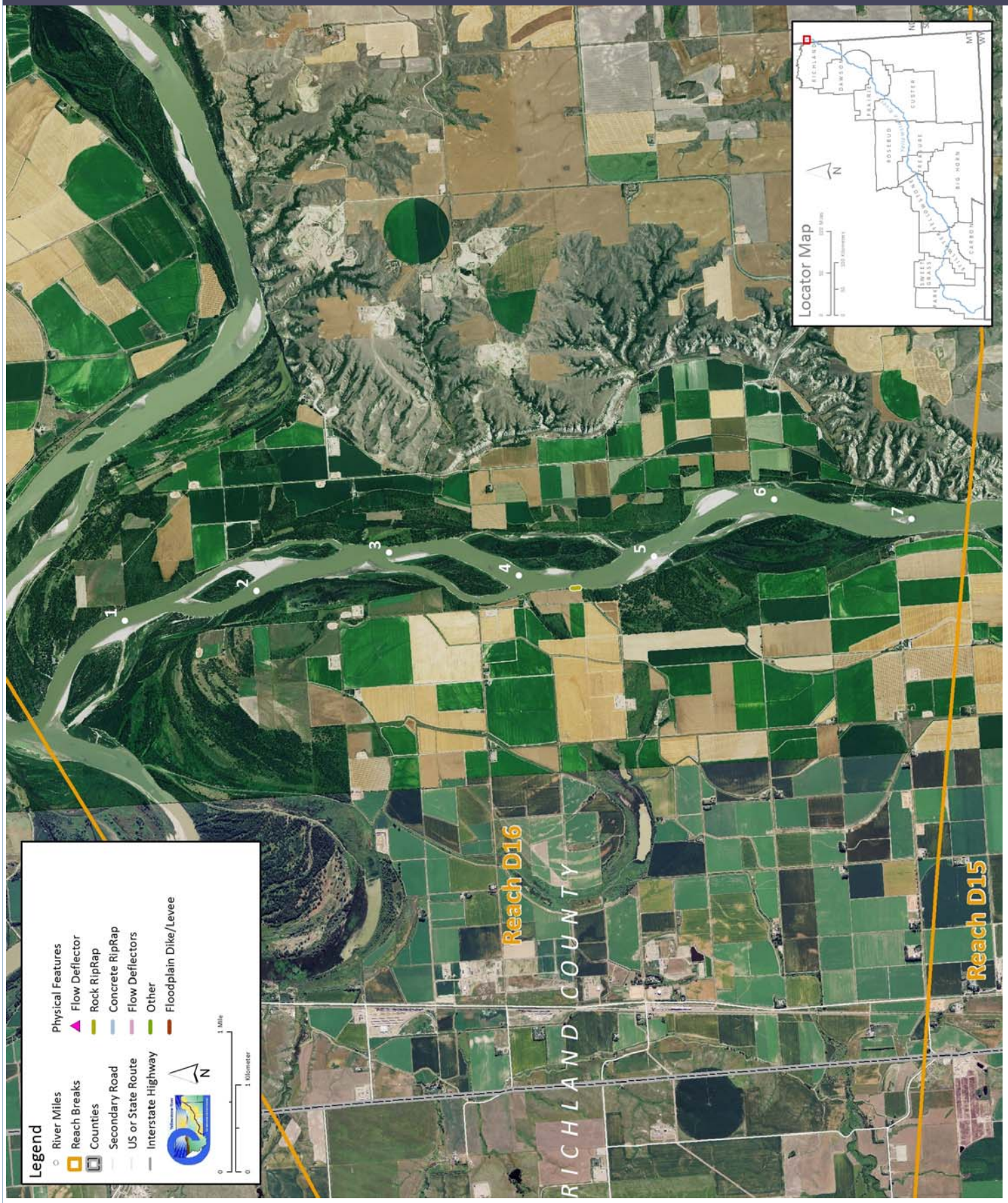
Because of the riparian encroachment, Reach D16 has seen an increase in the area of riparian forest considered at low risk of cowbird parasitism; in 1950 there were about 250 acres of such forest per valley mile, and in 2001 there were 308 acres per valley mile.

The changes in Reach D16 are due in part to major flow alterations in the reach. The 2-year discharge, which is considered to have a large influence on channel size, has been reduced by 22 percent due to human development.

CEA-Related observations in Reach D16 include:
•Extensive riparian encroachment with flow alterations
•Conversion of open sand bars to forested islands

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach D16 include:
•Drill pad considerations
•Riparian protections

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
Location	#Error	Sidney
Period of Record	#Error	1911-2015
Distance To (miles)	#Error	23.3

Discharge

	1.01 Yr	2 Yr	5 Yr	10 Yr	50 Yr	100 Yr	500 Yr	7Q10 Summer	95% Sum. Duration
Unregulated								NA	NA
Regulated								NA	NA
% Change								NA	NA

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	???	???	B/W		6329500	
1995	USGS DOQQ	???	B/W		6329500	
2007	Woolpert	10/15/2007 - 11/2/0007	Color		6329500	
2011	USCOE	October 2012	color	1-ft pixel	6329500	9030
2011	NAIP	7/25/2011	Color	1-meter pixels	6329500	41100

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.

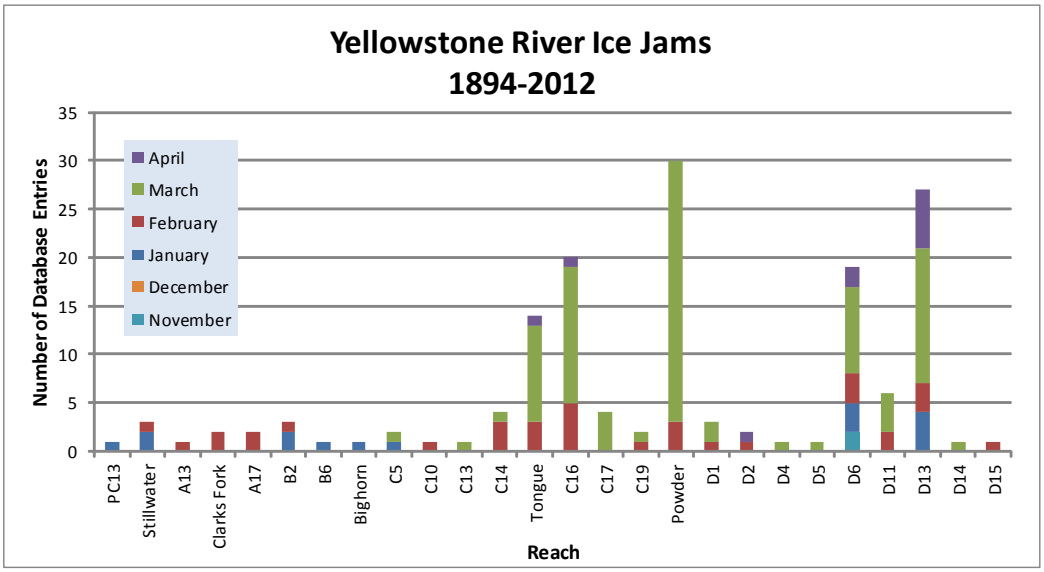
Note: As the goal for each physical features mapping effort were different, with differing mapping extents, there will be descrepancies between total feature lengths (e.g. length of rock riprap) in each data set.

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%	266	0.3%	266
	Feature Type Totals		**0.0%**	**266**	**0.3%**	
	Reach Totals		**0.0%**	**266**	**0.3%**	

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	39,537	8,696	1.22	1950 to 1976:	
1976				1976 to 1995:	
1995	39,507	52,163	2.32	1995 to 2001:	-8.63%
2001	39,089	43,781	2.12	1950 to 2001:	73.78%
Change 1950 - 2001	**-448**	**35,086**	**0.90**		

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.)	22	1.6%		
Agriculture (generally relates to field boundaries)	369	27.7%		
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)	939		1193	
Total Floodplain Area (Ac)	1330		1298	
Total Isolated (Ac)	**390**	**29.4%**	**106**	**31.3%**

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:	8	0	0	**8**

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

Land Uses within the CMZ (Acres)

Flood Irrigation	Sprinkler Irrigation	Pivot Irrigation	Urban/ ExUrban	Trans-portation
481.7	0.0	0.0	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	0		0	0	0.0%		0.0%	0.0%
	Agricultural Roads	0		0	0	0.0%		0.0%	0.0%
	Other Infrastructure	87		229	270	0.5%		1.4%	1.7%
	Totals	**87**		**229**	**270**	**0.5%**		**1.4%**	**1.7%**
Agricultural Land									
	Non-Irrigated	5,841		5,977	5,870	36.3%		37.2%	36.5%
	Irrigated	4,631		8,513	8,492	28.8%		53.0%	52.8%
	Totals	**10,472**		**14,490**	**14,362**	**65.1%**		**90.1%**	**89.3%**
Channel									
	Channel	1,547		1,334	1,361	9.6%		8.3%	8.5%
	Totals	**1,547**		**1,334**	**1,361**	**9.6%**		**8.3%**	**8.5%**
ExUrban									
	ExUrban Other	0		0	0	0.0%		0.0%	0.0%
	ExUrban Undeveloped	0		0	0	0.0%		0.0%	0.0%
	ExUrban Industrial	0		4	64	0.0%		0.0%	0.4%
	ExUrban Commercial	0		0	0	0.0%		0.0%	0.0%
	ExUrban Residential	0		0	0	0.0%		0.0%	0.0%
	Totals	**0**		**4**	**64**	**0.0%**		**0.0%**	**0.4%**
Transportation									
	Public Road	0		18	18	0.0%		0.1%	0.1%
	Interstate	0		0	0	0.0%		0.0%	0.0%
	Railroad	0		0	0	0.0%		0.0%	0.0%
	Totals	**0**		**18**	**18**	**0.0%**		**0.1%**	**0.1%**
Urban									
	Urban Other	0		0	0	0.0%		0.0%	0.0%
	Urban Residential	0		0	0	0.0%		0.0%	0.0%
	Urban Commercial	0		0	0	0.0%		0.0%	0.0%
	Urban Undeveloped	0		0	0	0.0%		0.0%	0.0%
	Urban Industrial	0		0	0	0.0%		0.0%	0.0%
	Totals	**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
Irr													
	Sprinkler	0		0	0	0.0%		0.0%	0.0%		0.0%	0.0%	0.0%
	Pivot	0		0	0	0.0%		0.0%	0.0%		0.0%	0.0%	0.0%
	Flood	4,631		8,513	8,492	44.2%		58.7%	59.1%		14.5%	0.4%	14.9%
	Totals	**4,631**		**8,513**	**8,492**	**44.2%**		**58.7%**	**59.1%**		**14.5%**	**0.4%**	**14.9%**

NoIrr

Multi-Use	5,423	5,308	5,281	51.8%	36.6%	36.8%	-15.2%	0.1%	-15.0%
Hay/Pasture	418	670	589	4.0%	4.6%	4.1%	0.6%	-0.5%	0.1%
Totals	**5,841**	**5,977**	**5,870**	**55.8%**	**41.3%**	**40.9%**	**-14.5%**	**-0.4%**	**-14.9%**

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		1.7	0.6		2.5	3.3		5.3
Max	379.8		185.8	930.0		891.6	31.5		60.8
Average	44.8		26.0	141.0		95.7	13.2		20.1
Sum	1,971.6		988.8	2,537.5		2,965.9	66.1		201.3

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)	296.8
Channel to Riparian (acres)	769.0
Riparian Encroachment (acres)	**472.2**

Riparian Recruitment

Creation of riparian areas between 1950s and 2001.

1950s Channel Mapped as 2011 Riparian (Ac)	757.5
1950s Floodplain Mapped as 2011 Channel (Ac)	117.7
Total Recruitment (1950s to 2011)(Ac)	**875.2**

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	25.3	254.9	278.2	21.7	**580.0**
Acres/Valley Mile	3.6	36.2	39.5	3.1	

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	3.48	0.07%	6.30	0.00	0.00	0.00

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	575.6	457.3	34.3%
Secondary Channel		12.5	0.9%
Secondary Channel (Seasonal)	216.4	152.0	11.4%
Channel Crossover	162.6	117.9	8.8%
Point Bar		10.3	0.8%
Side Bar		78.9	5.9%
Mid-channel Bar		53.1	4.0%
Island	379.1	379.1	28.4%
Dry Channel		72.8	5.5%

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.

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