County	Stillwater	**Upstream River Mile**	413.7
Classification	PCA: Partially confined anabranching	**Downstream River Mile**	405.9
General Location	Below Columbus	**Length**	7.80 mi (12.55 km)
General Comments	Valley bottom crossover		

Narrative Summary

Reach A14 is located in Stillwater County, just downstream of Columbus. The reach is a Partially Confined Anabranching (PCA) reach type, reflecting some valley while influence coupled with relatively extensive forested islands. The reach is 7.8 miles long, extending from RM 405.9 to RM 413.7. The partial geologic confinement within Reach A14 is created by interbedded sandstone and shale of the Cretaceous-age Judith River Formation that intermittently forms the active channel margin on either its right or left bank. The Parkman Sandstone, a massive cliff-forming unit within the Judith River Formation, forms cliffs against the channel that are commonly over 150 feet high.

Similar to other reaches in Region A, the overall footprint of the river channel has increased in size since 1950. In 1950, the channel footprint was 637 acres but by 2001 it had expanded to 728 acres. This was accompanied by a net loss of about 32 acres of riparian area to channel during that same timeframe.

Approximately 16 percent of the bankline in Reach A14 is armored, and the armor is almost entirely rock riprap, with a very short section of flow deflectors. The armor is located almost entirely on the northern corridor margin, where transportation infrastructure (mainly railroad) follows the edge of the valley.

Over three miles of side channels have been blocked in Reach A14, with about half of the blockages occurring prior to 1950 and half after. The losses occurred on two distinct channels, one at RM 410 on the south side of the corridor and one at RM 407 on the north side.

Land use in Reach A14 is almost entirely agricultural, with almost 260 acres mapped as agricultural infrastructure. This in part reflects corrals that are part of an animal handling facility on the north side of the river at RM 409. There are 1,300 acres under flood irrigation in the reach, and 144 acres in pivot. A total of 227 acres of developed land are in the Channel Migration Zone, most of that is in flood irrigation (215 acres). Less than 2 percent of the CMZ is isolated by physical features, all of which is behind the armored rail line on the north side of the river.

There is one major diversion in Reach A14; Cove Ditch diverts water from the north bank at RM 410.

Reach A14 was sampled as part of the avian study. The average species richness in Reach A14 was 7.9, which indicates the average number of species observed during site visits to the reach in cottonwood habitats. The average species richness for all sites evaluated is 8. Riparian mapping in Reach A14 shows a reduction of about 100 acres of closed timber in the reach since 1950. Since 1950, Reach A14 has lost most of its forest that would be considered at low risk of cowbird infestation due to its separation from agricultural infrastructure. In 1950, about 10.5 acres of forest per valley mile were identified as low risk and by 2001 that forest area had been reduced to 0.5 acres per valley mile.

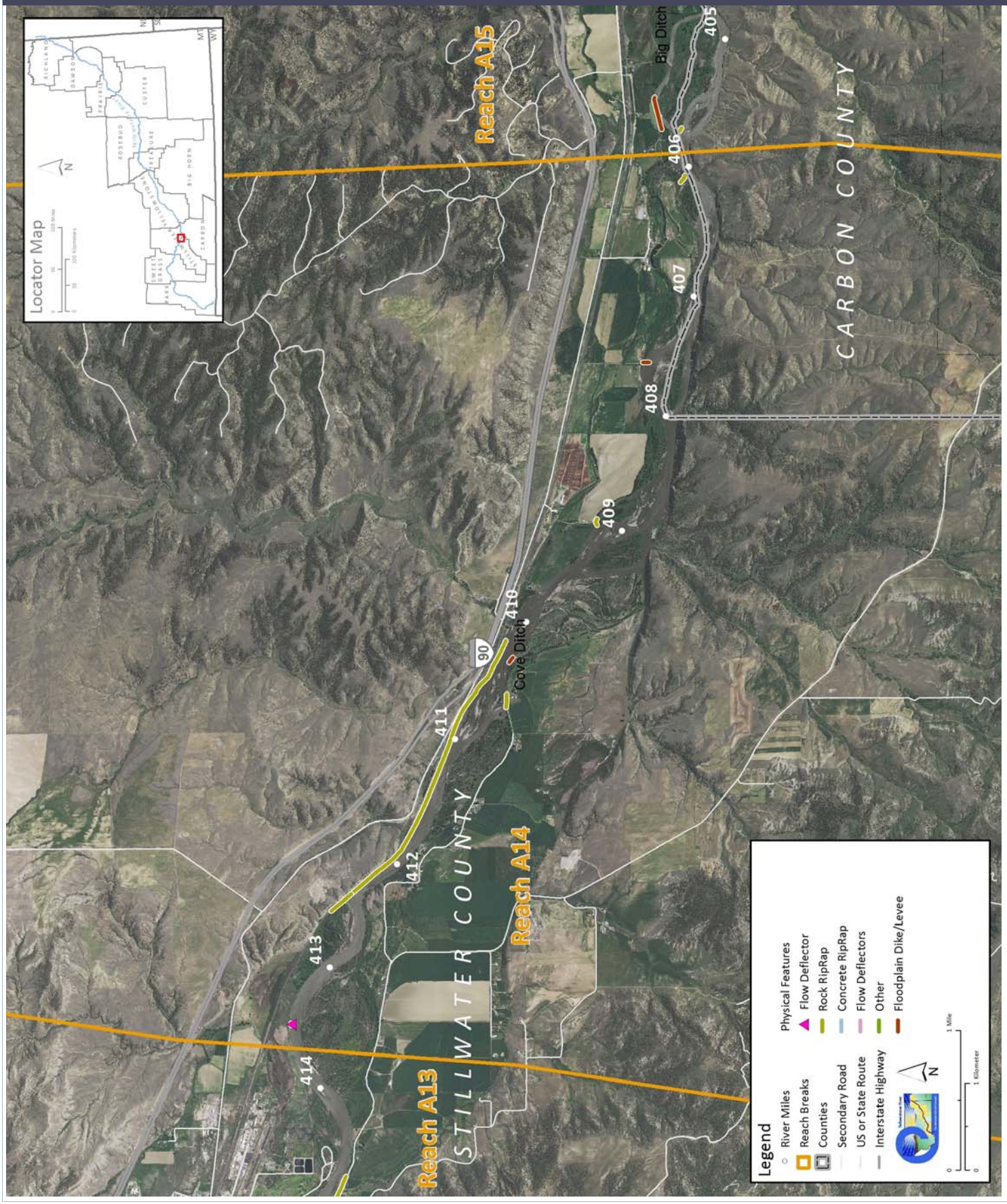
Reach A14 has approximately 2.5 acres of mapped Russian olive, which is concentrated along ditches and low riparian/wetland areas north of the river. There are also over 250 acres of mapped wetland in the each, most of which is emergent marshes and wet meadows. About 27 acres of emergent wetland have been isolated from the river corridor by the rail line at RM 413.5.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been moderate in this reach. The mean annual flood is estimated to have dropped from 16,200 cfs to 15,100 cfs, a drop of about 7 percent. The biggest influence has been on low flows: severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 2,280 cfs to 1,770 cfs with human development, a reduction of 22 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 1,760 cfs under unregulated conditions to 1,680 cfs under regulated conditions at the Livingston gage, a reduction of 4.6 percent.

CEA-Related observations in Reach A14 include:
•Isolation of large wetland area by rail line
•Over 3 miles of side channel blockages
•Large corrals that are part of an animal handling facility within 1,000 feet of the riverbank

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach A14 include:
•Side channel restoration at RM 410 and RM 407
•Russian olive removal (2.5 acres)
•Nutrient management at corrals that are part of an animal handling facility at RM 409
•Irrigation diversion structure management at Cove Ditch Diversion
•Wetland management/restoration at large complex isolated from river by rail line at RM 413.5

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): Livingston

Flood History

Year	Date	Flow on Date	Return Interval
1971	Jun 23	29,200	10-25 yr
1902	Jun 11	30,100	10-25 yr
1943	Jun 20	30,600	10-25 yr
1974	Jun 17	36,300	50-100 yr
1996	Jun 10	37,100	50-100 yr
1997	Jun 6	38,000	50-100 yr
2011	Jun 30	40,600	>100-yr

	Downstream Gage	Upstream Gage
Gage No	6214500	6192500
Location	Billings	Livingston
Period of Record	1929-2015	1929-2015
Distance To (miles)	41.5	92.9

Discharge

	1.01 Yr	2 Yr	5 Yr	10 Yr	50 Yr	100 Yr	500 Yr	7Q10 Summer	95% Sum. Duration
Unregulated	16,200	31,000	38,600	43,300	52,700	56,600	65,200	2,280	1,760
Regulated	15,100	29,800	37,500	42,300	51,900	55,900	64,800	1,770	1,680
% Change	-6.79%	-3.87%	-2.85%	-2.31%	-1.52%	-1.24%	-0.61%	-22.37%	-4.55%

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	22-May-51	B/W	1:28,400	6192500	10600
1976	USCOE	28-Sep-76	B/W	1:24,000	6192500	2560
1995	USGS DOQQ	8/28/97 - 8/26/96 - 7/27/96	B/W		6192500	6960
2001	NRCS	August 2-8, 2001	CIR	1:24,000	6192500	2000
2004	Merrick	14-May-04	Color	1:15,840	6192500	4520
2005	NAIP	07/15/2005	color	1-meter pixels	6192500	5000
2005	NAIP	07/12/2005	color	1-meter pixels	6192500	5960
2009	NAIP	7/22/2009	Color	1-meter pixels	6192500	6990
2009	NAIP	7/7/2009	Color	1-meter pixels	6192500	11300
2009	NAIP	6/29/2009	Color	1-meter pixels	6192500	13900
2011	USCOE	October 2012	color	1-ft pixel	6192500	2530
2011	NAIP	7/24/2011	Color	1-meter pixels	6192500	13100
2013	NAIP	06/15/2013	color	1-meter pixels	6192500	

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	11,650	14.2%	13,458	16.4%	1,807
	Flow Deflectors	64	0.1%	64	0.1%	0
	Feature Type Totals	**11,714**	**14.3%**	**13,521**	**16.5%**	**1,807**
Other In Channel						
	Bedrock Control	676	0.8%	676	0.8%	0
	Feature Type Totals	**676**	**0.8%**	**676**	**0.8%**	**0**
Floodplain Control						
	Transportation Encroachment	1,605	2.0%	1,605	2.0%	0
	Floodplain Dike/Levee	230	0.3%	225	0.3%	-5
	Feature Type Totals	**1,835**	**2.2%**	**1,831**	**2.2%**	**-5**
	Reach Totals	**14,225**	**17.3%**	**16,028**	**19.5%**	**1,803**

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	62	0	0	0	0	0	0	0
Rock RipRap	249	0	0	0	0	11,398	0	0
Totals	**312**	**0**	**0**	**0**	**0**	**11,398**	**0**	**0**

Bankline/Floodplain Inventory: Time Series

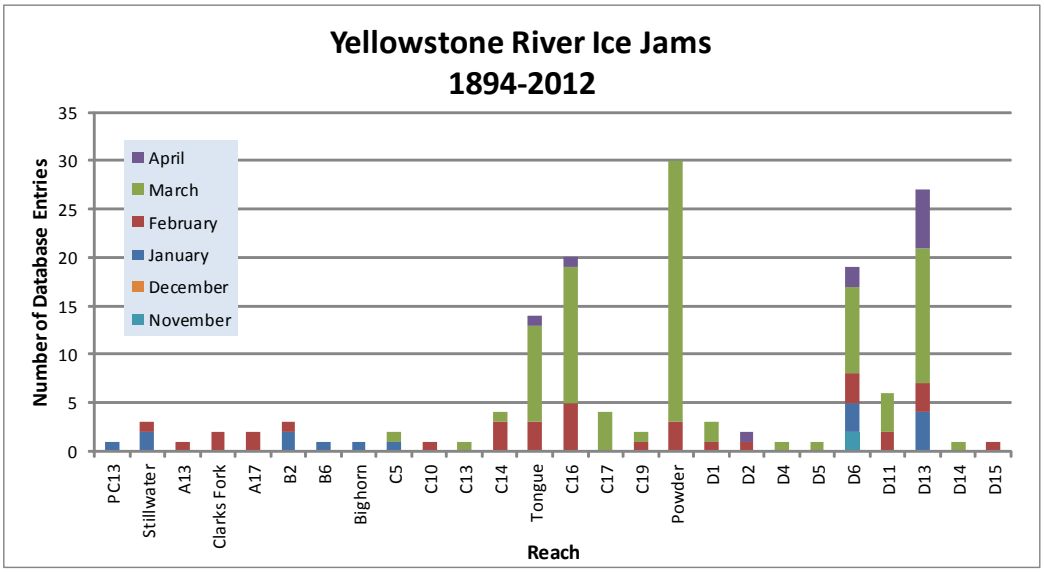
The Human Impacts Timeline assessed physical feature development through time for Yellowstone, Stillwater, and Dawson Counties.

		Sum of Feature Length (ft)					
Feature Class	Feature Type	1950	1976	1995	2001	2004	2005
Irrigation							
	In Channel Diversion	0	207	207	207	207	207
	Floodplain Dike/Levee	6,820	6,820	6,820	6,820	6,820	6,820
	Totals	**6,820**	**7,027**	**7,027**	**7,027**	**7,027**	**7,027**
Other Off Channel							
	Floodplain Dike/Levee	0	258	258	471	471	471
	Floodplain Dike/Levee	2,576	2,576	2,576	2,866	2,866	2,866
	Totals	**2,576**	**2,834**	**2,834**	**3,337**	**3,337**	**3,337**
Stream Stabilization							
	Rock RipRap	13,555	13,555	14,157	14,157	14,157	14,157
	Flow Deflector	0	185	185	185	400	400

Totals	**13,555**	**13,740**	**14,341**	**14,341**	**14,557**	**14,557**
Transportation Encroachment						
Railroad	10,381	10,381	10,381	10,381	10,381	10,381
Other	10,900	10,900	10,900	10,900	10,900	10,900
County Road	1,729	1,729	1,729	1,729	1,729	1,729
Totals	**23,010**	**23,010**	**23,010**	**23,010**	**23,010**	**23,010**

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	42,099	56,155	2.33	1950 to 1976:	-3.61%
1976	40,060	50,059	2.25	1976 to 1995:	-15.02%
1995	41,418	37,765	1.91	1995 to 2001:	1.51%
2001	41,087	38,652	1.94	1950 to 2001:	-16.84%
Change 1950 - 2001	**-1,012**	**-17,502**	**-0.39**		

Length of Side Channels Blocked

Pre-1950s (ft)	9,672
Post-1950s (ft)	9,176

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.)	0	0.0%		
Railroad	0	0.0%		
Abandoned Railroad	0	0.0%		
Transportation (Interstate and other roads)	0	0.0%		
Total Not Isolated (Ac)	838		997	
Total Floodplain Area (Ac)	838		1037	
Total Isolated (Ac)	**0**	**0.0%**	**41**	**13.1%**

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:	12	0	0	**12**

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
293	587	1,671	27	2%	181	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	26	1.4%
	Totals	**26**	**1.4%**

Land Uses within the CMZ (Acres)

Flood Irrigation	Sprinkler Irrigation	Pivot Irrigation	Urban/ ExUrban	Trans-portation
215.4	0.0	0.0	0.0	11.4

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	74	112	249	259	1.3%	1.9%	4.3%	4.4%
	Totals	**74**	**112**	**249**	**259**	**1.3%**	**1.9%**	**4.3%**	**4.4%**
Agricultural Land									
	Non-Irrigated	3,052	2,969	3,002	2,980	52.2%	50.7%	51.3%	50.9%
	Irrigated	1,664	1,644	1,467	1,464	28.4%	28.1%	25.1%	25.0%
	Totals	**4,716**	**4,613**	**4,470**	**4,444**	**80.6%**	**78.8%**	**76.4%**	**75.9%**
Channel									
	Channel	973	929	934	962	16.6%	15.9%	16.0%	16.4%
	Totals	**973**	**929**	**934**	**962**	**16.6%**	**15.9%**	**16.0%**	**16.4%**
ExUrban									
	ExUrban Other	0	12	12	0	0.0%	0.2%	0.2%	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**	**12**	**12**	**0**	**0.0%**	**0.2%**	**0.2%**	**0.0%**
Transportation									
	Public Road	53	55	55	55	0.9%	0.9%	0.9%	0.9%
	Interstate	0	96	96	96	0.0%	1.6%	1.6%	1.6%
	Railroad	37	37	37	37	0.6%	0.6%	0.6%	0.6%
	Totals	**90**	**188**	**189**	**189**	**1.5%**	**3.2%**	**3.2%**	**3.2%**
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	0	144	0.0%	0.0%	0.0%	3.2%	0.0%	0.0%	3.2%	3.2%
	Flood	1,664	1,644	1,467	1,320	35.3%	35.6%	32.8%	29.7%	0.4%	-2.8%	-3.1%	-5.6%
	Totals	**1,664**	**1,644**	**1,467**	**1,464**	**35.3%**	**35.6%**	**32.8%**	**32.9%**	**0.4%**	**-2.8%**	**0.1%**	**-2.3%**

Non-Irrigated

Multi-Use	2,649	2,532	2,599	2,532	56.2%	54.9%	58.1%	57.0%	-1.3%	3.3%	-1.2%	0.8%
Hay/Pasture	403	436	403	448	8.6%	9.5%	9.0%	10.1%	0.9%	-0.4%	1.1%	1.5%
Totals	**3,052**	**2,969**	**3,002**	**2,980**	**64.7%**	**64.4%**	**67.2%**	**67.1%**	**-0.4%**	**2.8%**	**-0.1%**	**2.3%**

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	1.2	0.2	1.3	1.3	0.5	0.9	0.4	1.6	0.7
Max	4.8	10.0	20.9	146.2	107.9	137.3	33.2	114.5	35.7
Average	3.0	2.4	4.9	22.1	15.6	20.3	11.8	25.9	15.9
Sum	6.0	24.3	44.2	729.0	563.0	629.8	106.2	181.0	111.0

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)	182.5
Channel to Riparian (acres)	150.7
Riparian Encroachment (acres)	**-31.8**

Riparian Recruitment

Creation of riparian areas between 1950s and 2001.

1950s Channel Mapped as 2011 Riparian (Ac)	0.0
1950s Floodplain Mapped as 2011 Channel (Ac)	2.5
Total Recruitment (1950s to 2011)(Ac)	**2.5**

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	14.4	211.3	57.6	0.0	**283.3**
Acres/Valley Mile	2.0	29.3	8.0	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	2.55	0.12%	1.00	0.00	0.25	0.10

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.

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 A

In the study segment, Laurel to Springdale, three themes emerge as dominant across the four interest groups. One theme focuses on the changing riverbank profile as more and more residential homes are built on the river's edge. The second theme focuses on the river as a powerful and dynamic physical entity. The third is about the changing social profiles of their communities and how those changes influence user practices.

Yellowstone River Reach Narratives — Reach A15

County	Stillwater	**Upstream River Mile**	405.9
Classification	PCB: Partially confined braided	**Downstream River Mile**	400
General Location	Follows Stillwater/Carbon County line	**Length**	5.90 mi (9.50 km)
General Comments	Follows Stillwater/Carbon County line		

Narrative Summary

Reach A15 is located in Stillwater County between Columbus and Park City. The reach is a Partially Confined Braided (PCB) reach type, reflecting some valley wall influence coupled with relatively extensive open gravel bars and low flow channels. The reach is 5.9 miles long. The partial geologic confinement within Reach A15 is created by interbedded sandstone and shale of the Cretaceous-age Judith River Formation that intermittently forms the active channel margin on its right bank. The Parkman Sandstone, a massive cliff-forming unit within the Judith River Formation, forms cliffs against the channel that are commonly over 150 feet high.

Approximately 8 percent of the bankline in Reach A15 is armored, and the armor is almost entirely rock riprap, with a very short section of concrete armor. The armor is entirely located on the north bank of the river, across from the bluffs to the south.

Although no side channels have been mapped as blocked in the reach, the total anabranching channel length has dropped from 6.2 miles in 1950 to 4.2 miles in 2001.

Land use in Reach A15 is almost entirely agricultural, with over 200 acres mapped as agricultural infrastructure. This includes a large corral complex that is part of an animal handling facility on the north side of the river at RM 404. The corrals are behind a canal, but within a few hundred feet of the riverbank. There are 528 acres under flood irrigation in the reach, and 81 acres in pivot. A total of 119 acres of developed land are in the Channel Migration Zone, and all of that land is in flood irrigation. About 9 percent of the CMZ is isolated by physical features, all of which is behind armored canals associated with the Big Ditch Diversion, which diverts water from the north bank at RM 405.3. The Big Ditch Diversion structure fully spans a side channel of the river that is about 275 feet wide.

Riparian mapping in Reach A15 shows a reduction of about 60 acres of closed timber in the reach since 1950. Riparian recruitment rates have been relatively high; between 1950 and 2001 there were 200 acres of areas that recruited new riparian vegetation, and most of that was in old 1950s channels that were abandoned and became colonized. These abandoned channels also have high concentrations of Russian olive. Since 1950, Reach A15 has lost almost all of its forest that would be considered at low risk of cowbird infestation due to its separation from agricultural infrastructure. In 1950, about 20 acres of forest per valley mile were identified as low risk and by 2001 that forest area had been reduced to 1.

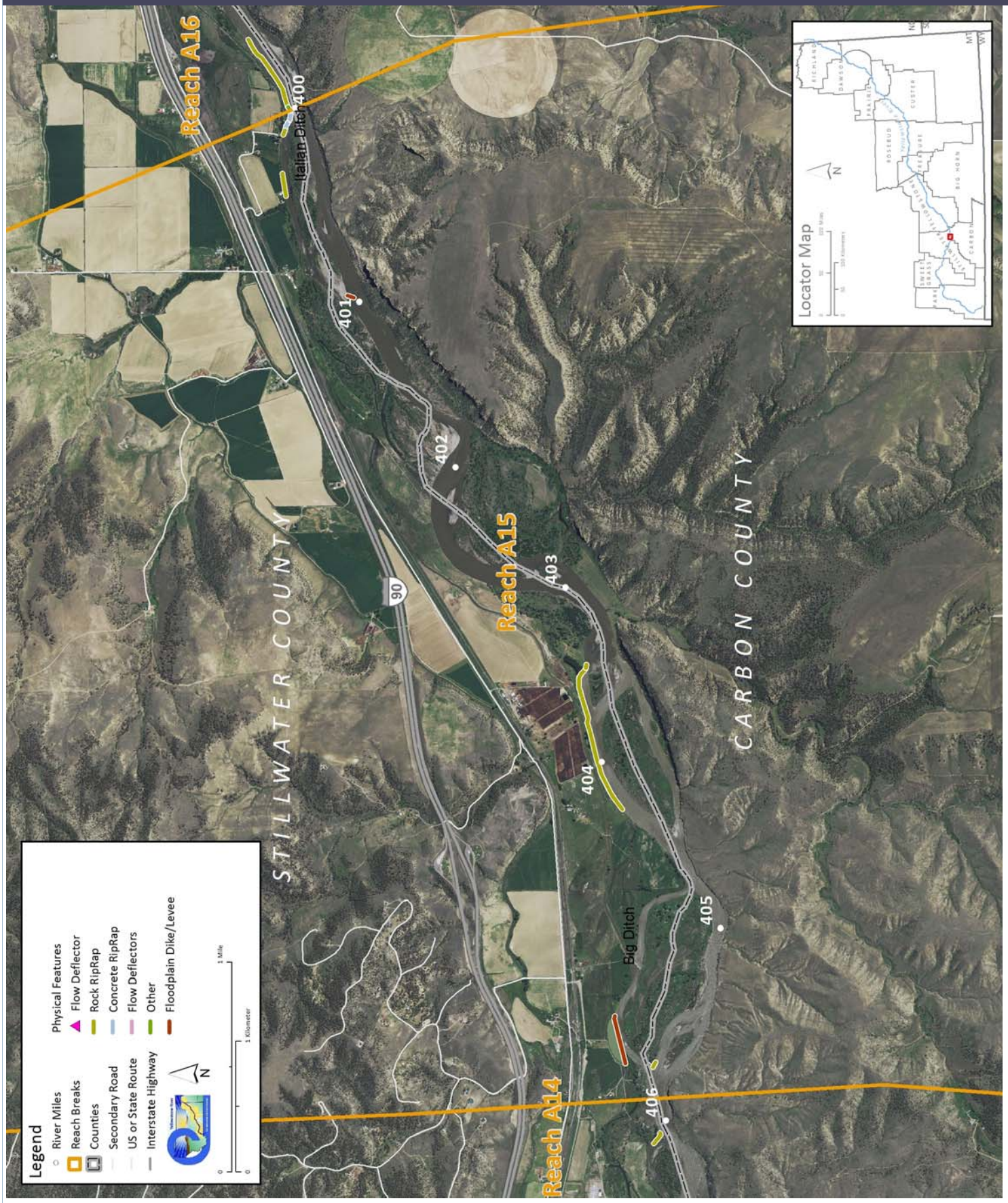
There are also over 150 acres of mapped wetland in the each, most of which is emergent marshes and wet meadows. Large expanses of emergent wetlands have developed in side channels that have been passively lost since 1950 (“passively” meaning not blocked but abandoned).

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been moderate in this reach. The mean annual flood is estimated to have dropped from 16,200 cfs to 15,100 cfs, a drop of about 7 percent. The biggest influence has been on low flows: severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 2,286 cfs to 1,770 cfs with human development, a reduction of 23 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 1,760 cfs under unregulated conditions to 1,680 cfs under regulated conditions at the Livingston gage, a reduction of 4.6 percent.

CEA-Related observations in Reach A15 include:
•Passive loss of 2 miles of side channel
•Russian olive colonization in abandoned side channels
•Emergent wetland development in abandoned side channels
•Large corrals that are part of an animal handling facility within 300 feet of the riverbank

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach A15 include:
•Side channel restoration to reactivate 2 miles of passively lost channels
•Russian olive removal (1.2 acres)
•Nutrient management at corrals that are part of an animal handling facility at RM 404
•Consideration of watercraft passage at Big Ditch Diversion Structure
•Consideration of fish passage limitations at Big Ditch Diversion Structure
•Wetland management/restoration due to extent of mapped wetland (150 acres)

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): Livingston

Flood History

Year	Date	Flow on Date	Return Interval
1971	Jun 23	29,200	10-25 yr
1902	Jun 11	30,100	10-25 yr
1943	Jun 20	30,600	10-25 yr
1974	Jun 17	36,300	50-100 yr
1996	Jun 10	37,100	50-100 yr
1997	Jun 6	38,000	50-100 yr
2011	Jun 30	40,600	>100-yr

	Downstream Gage	Upstream Gage
Gage No	6214500	6192500
Location	Billings	Livingston
Period of Record	1929-2015	1929-2015
Distance To (miles)	35.6	100.7

Discharge

	1.01 Yr	2 Yr	5 Yr	10 Yr	50 Yr	100 Yr	500 Yr	7Q10 Summer	95% Sum. Duration
Unregulated	16,200	31,000	38,600	43,300	52,700	56,600	65,200	2,286	1,760
Regulated	15,100	29,800	37,500	42,300	51,900	55,900	64,800	1,770	1,680
% Change	-6.79%	-3.87%	-2.85%	-2.31%	-1.52%	-1.24%	-0.61%	-22.59%	-4.55%

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	17-May-51	B/W	1:28,400	6192500	7430
1976	USCOE	28-Sep-76	B/W	1:24,000	6192500	2560
1995	USGS DOQQ	27-Jul-96	B/W		6192500	6960
2001	NRCS	August 2-8, 2001	CIR	1:24,000	6192500	2000
2004	Merrick	14-May-04	Color	1:15,840	6192500	4520
2005	NAIP	07/12/2005	color	1-meter pixels	6192500	5960
2009	NAIP	7/7/2009	Color	1-meter pixels	6192500	11300
2009	NAIP	6/29/2009	Color	1-meter pixels	6192500	13900
2011	USCOE	October 2012	color	1-ft pixel	6192500	2530
2011	NAIP	7/24/2011	Color	1-meter pixels	6192500	13100
2013	NAIP	06/15/2013	color	1-meter pixels	6192500	

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	4,633	7.5%	4,667	7.5%	35
	Concrete RipRap	483	0.8%	483	0.8%	0
	Feature Type Totals	**5,116**	**8.2%**	**5,151**	**8.3%**	**35**
Other In Channel						
	Bedrock Control	219	0.4%	219	0.4%	0
	Feature Type Totals	**219**	**0.4%**	**219**	**0.4%**	**0**
Floodplain Control						
	Floodplain Dike/Levee	1,552	2.5%	1,384	2.2%	-168
	Feature Type Totals	**1,552**	**2.5%**	**1,384**	**2.2%**	**-168**
	Reach Totals	**6,887**	**11.1%**	**6,754**	**10.9%**	**-134**

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	492	0	0	0	0	0
Rock RipRap	564	0	3,090	0	0	0	0	0
Totals	**564**	**0**	**3,582**	**0**	**0**	**0**	**0**	**0**

Bankline/Floodplain Inventory: Time Series

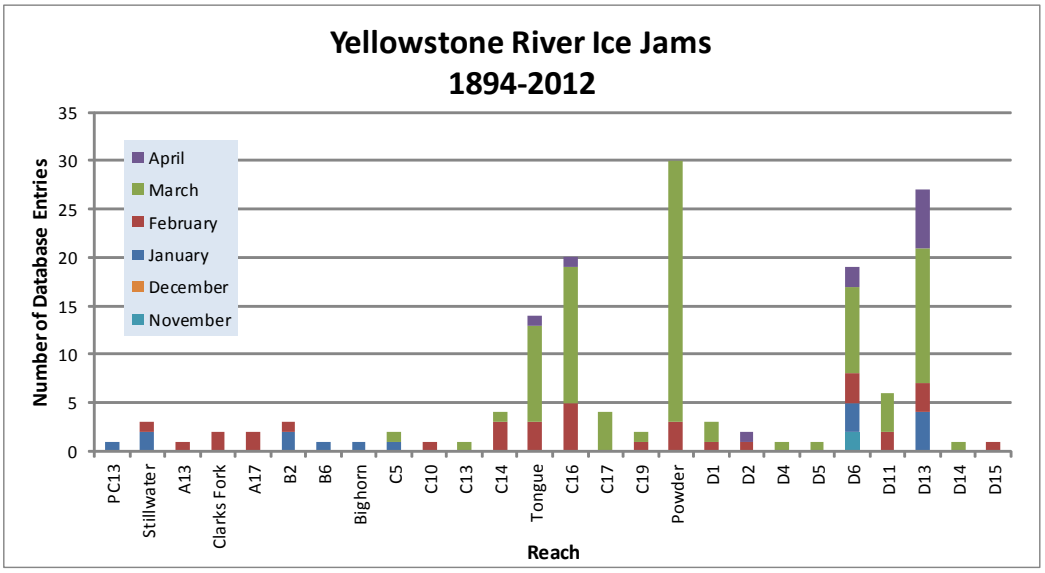
The Human Impacts Timeline assessed physical feature development through time for Yellowstone, Stillwater, and Dawson Counties.

		Sum of Feature Length (ft)					
Feature Class	Feature Type	1950	1976	1995	2001	2004	2005
Irrigation							
	In Channel Diversion	473	473	473	642	642	642
	Floodplain Dike/Levee	5,561	6,313	6,313	6,313	6,313	6,313
	Totals	**6,035**	**6,786**	**6,786**	**6,955**	**6,955**	**6,955**
Other Off Channel							
	Floodplain Dike/Levee	1,287	1,833	1,833	1,833	1,833	1,833
	Floodplain Dike/Levee	0	3,926	3,926	3,926	3,926	3,926
	Totals	**1,287**	**5,759**	**5,759**	**5,759**	**5,759**	**5,759**
Stream Stabilization							
	Rock RipRap	2,363	5,630	6,605	6,605	7,003	7,003
	Concrete RipRap	449	449	449	449	449	449
	Totals	**2,812**	**6,079**	**7,054**	**7,054**	**7,452**	**7,452**

Transportation Encroachment						
Railroad	1,031	1,031	1,031	1,031	1,031	1,031
Totals	**1,031**	**1,031**	**1,031**	**1,031**	**1,031**	**1,031**

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	29,740	32,759	2.10	1950 to 1976:	-18.33%
1976	30,410	21,783	1.72	1976 to 1995:	9.98%
1995	30,548	27,113	1.89	1995 to 2001:	-9.20%
2001	31,077	22,185	1.71	1950 to 2001:	-18.45%
Change 1950 - 2001	**1,337**	**-10,573**	**-0.39**		

Length of Side Channels Blocked

Pre-1950s (ft)	1,617
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)	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)	507		595	
Total Floodplain Area (Ac)	507		622	
Total Isolated (Ac)	**0**	**0.0%**	**27**	**24.5%**

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:	1	0	0	**1**

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
343	686	1,371	122	9%	97	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			
	Other Infrastructure	7	0.5%
	Irrigated	11	0.7%
	Canal	75	5.1%
Dike/Levee			
	Irrigated	30	2.0%
	Totals	**122**	**8.3%**

Land Uses within the CMZ (Acres)

Flood Irrigation	Sprinkler Irrigation	Pivot Irrigation	Urban/ ExUrban	Trans-portation
118.7	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	62	57	57	57	1.7%	1.6%	1.6%	1.6%
	Agricultural Roads	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Other Infrastructure	35	132	154	156	1.0%	3.6%	4.2%	4.3%
	Totals	**97**	**189**	**211**	**213**	**2.6%**	**5.1%**	**5.8%**	**5.8%**
Agricultural Land									
	Non-Irrigated	1,814	1,891	1,917	1,925	49.4%	51.5%	52.2%	52.5%
	Irrigated	925	696	639	608	25.2%	19.0%	17.4%	16.6%
	Totals	**2,739**	**2,587**	**2,556**	**2,534**	**74.6%**	**70.5%**	**69.6%**	**69.0%**
Channel									
	Channel	776	752	757	777	21.1%	20.5%	20.6%	21.2%
	Totals	**776**	**752**	**757**	**777**	**21.1%**	**20.5%**	**20.6%**	**21.2%**
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	2	2	0.0%	0.0%	0.1%	0.1%
	Totals	**0**	**0**	**2**	**2**	**0.0%**	**0.0%**	**0.1%**	**0.1%**
Transportation									
	Public Road	29	35	37	37	0.8%	1.0%	1.0%	1.0%
	Interstate	0	78	78	78	0.0%	2.1%	2.1%	2.1%
	Railroad	30	30	30	30	0.8%	0.8%	0.8%	0.8%
	Totals	**59**	**143**	**145**	**145**	**1.6%**	**3.9%**	**3.9%**	**3.9%**
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	1	81	0.0%	0.0%	0.0%	3.2%	0.0%	0.0%	3.1%	3.2%
	Flood	925	696	638	528	33.8%	26.9%	25.0%	20.8%	-6.9%	-2.0%	-4.1%	-12.9%
	Totals	**925**	**696**	**639**	**608**	**33.8%**	**26.9%**	**25.0%**	**24.0%**	**-6.9%**	**-1.9%**	**-1.0%**	**-9.8%**

Non-Irrigated

Multi-Use	1,664	1,744	1,809	1,788	60.7%	67.4%	70.8%	70.6%	6.7%	3.3%	-0.2%	9.8%
Hay/Pasture	150	146	108	137	5.5%	5.7%	4.2%	5.4%	0.2%	-1.4%	1.2%	-0.1%
Totals	**1,814**	**1,891**	**1,917**	**1,925**	**66.2%**	**73.1%**	**75.0%**	**76.0%**	**6.9%**	**1.9%**	**1.0%**	**9.8%**

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	0.0	0.3	0.4	1.0	1.3	1.6	2.1	13.1	9.8
Max	80.3	32.2	65.3	105.0	137.7	170.7	12.2	50.0	73.0
Average	10.0	5.5	11.1	23.2	29.9	53.5	7.0	25.1	36.1
Sum	110.2	49.2	88.8	487.8	358.9	427.9	21.1	100.5	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)	115.8
Channel to Riparian (acres)	120.5
Riparian Encroachment (acres)	**4.7**

Riparian Recruitment

Creation of riparian areas between 1950s and 2001.

1950s Channel Mapped as 2011 Riparian (Ac)	123.2
1950s Floodplain Mapped as 2011 Channel (Ac)	76.0
Total Recruitment (1950s to 2011)(Ac)	**199.2**

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	10.4	131.1	27.4	0.0	**168.9**
Acres/Valley Mile	2.0	25.4	5.3	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	1.24	0.09%	0.16	0.04	0.48	0.14

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	107.7	57.2	7.6%
Rip Rap Bottom	25.0	24.6	3.3%
Bluff Pool	99.0	83.6	11.0%
Secondary Channel	78.4	57.8	7.6%
Secondary Channel (Seasonal)	67.2	32.3	4.3%
Channel Crossover	129.6	96.2	12.7%
Point Bar		43.5	5.7%
Side Bar		24.9	3.3%
Mid-channel Bar		23.9	3.2%
Island	249.9	250.7	33.1%
Dry Channel		62.1	8.2%

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 A

In the study segment, Laurel to Springdale, three themes emerge as dominant across the four interest groups. One theme focuses on the changing riverbank profile as more and more residential homes are built on the river's edge. The second theme focuses on the river as a powerful and dynamic physical entity. The third is about the changing social profiles of their communities and how those changes influence user practices.

County	Stillwater	**Upstream River Mile**	400
Classification	PCA: Partially confined anabranching	**Downstream River Mile**	392.4
General Location	Park City	**Length**	7.60 mi (12.23 km)
General Comments	Near Park City, Reach A16 provides an example of a reach that supports numerous irrigation point features that appear to have a minimal effect on the stream corridor		

Narrative Summary

Reach A16 is 7.6 miles long and is located just south of Park City. The reach is a Partially Confined Anabranching reach type, indicating some valley wall influences as well as relatively extensive forested islands. The partial geologic confinement within Reach A16 is created by interbedded sandstone and shale. In addition, both low and high alluvial terraces intermittently form the active river corridor margin.

Approximately 9 percent of the bankline in Reach A16 is armored, and the armor is almost entirely rock riprap, some short sections of concrete armor and flow deflectors. The armor is located almost entirely on the northern corridor margin, against terrace margins. Its use is split evenly between protecting agricultural and exurban residential land uses. On the upstream end of the reach, rock armor protects the Italian Ditch Diversion and Canal, which divert water on the north bank of the river at RM 400. Over four miles of floodplain dikes have been mapped in the reach, most of which follow ditches on the north floodplain.

Although there is no evidence that side channels have been intentionally blocked off in Reach A16, there has still been a net loss of over a mile of side channel since 1950. Similar to most reaches in Region A, the loss of side channels has been accompanied by an overall increase in the total channel footprint; since 1950, the bankfull channel area of Reach A16 has increased by 40 acres.

Land use in Reach A16 is almost entirely agricultural, although there are almost 300 acres of urban/exurban development in the mapping footprint. There are corrals that are part of an animal handling facility within 1,000 feet of an abandoned river swale at RM 395. Over a thousand acres under of ground in Reach A16 are under flood irrigation, and about 11 are in pivot. About 150 acres of developed land are in the Channel Migration Zone, and almost 40 acres of that is in urban/exurban development. About 6 percent of the total CMZ is restricted by bank armor and dikes.

There is one pipeline crossing in Reach A16. It crosses under the river at RM 396.7 and consists of a 24 inch crude oil pipeline that is owned by Kinder Morgan Pipelines. This pipeline was horizontally drilled during its installation.

Reach A16 was sampled as part of the avian study. The average species richness in Reach A16 was 8.5, which indicates the average number of species observed during site visits to the reach in cottonwood habitats. The average species richness for all sites evaluated is 8. An average of one cowbird was observed during the field sampling visits. Reach A16 has lost about one half of its riparian forest considered at low risk of cowbird parasitism since 1950. At that time, there were about 12 acres of forest per valley mile considered to be isolated enough from agricultural infrastructure and urban/exurban development to be considered at low risk. By 2011, about 6.6 acres considered low risk remained.

There are over 250 acres of mapped wetland in the reach, with most of that emergent marshes wand wet meadows. Many of these wetland areas occupy old river swales on the floodplain north of the river, or abandoned channels in the active corridor.

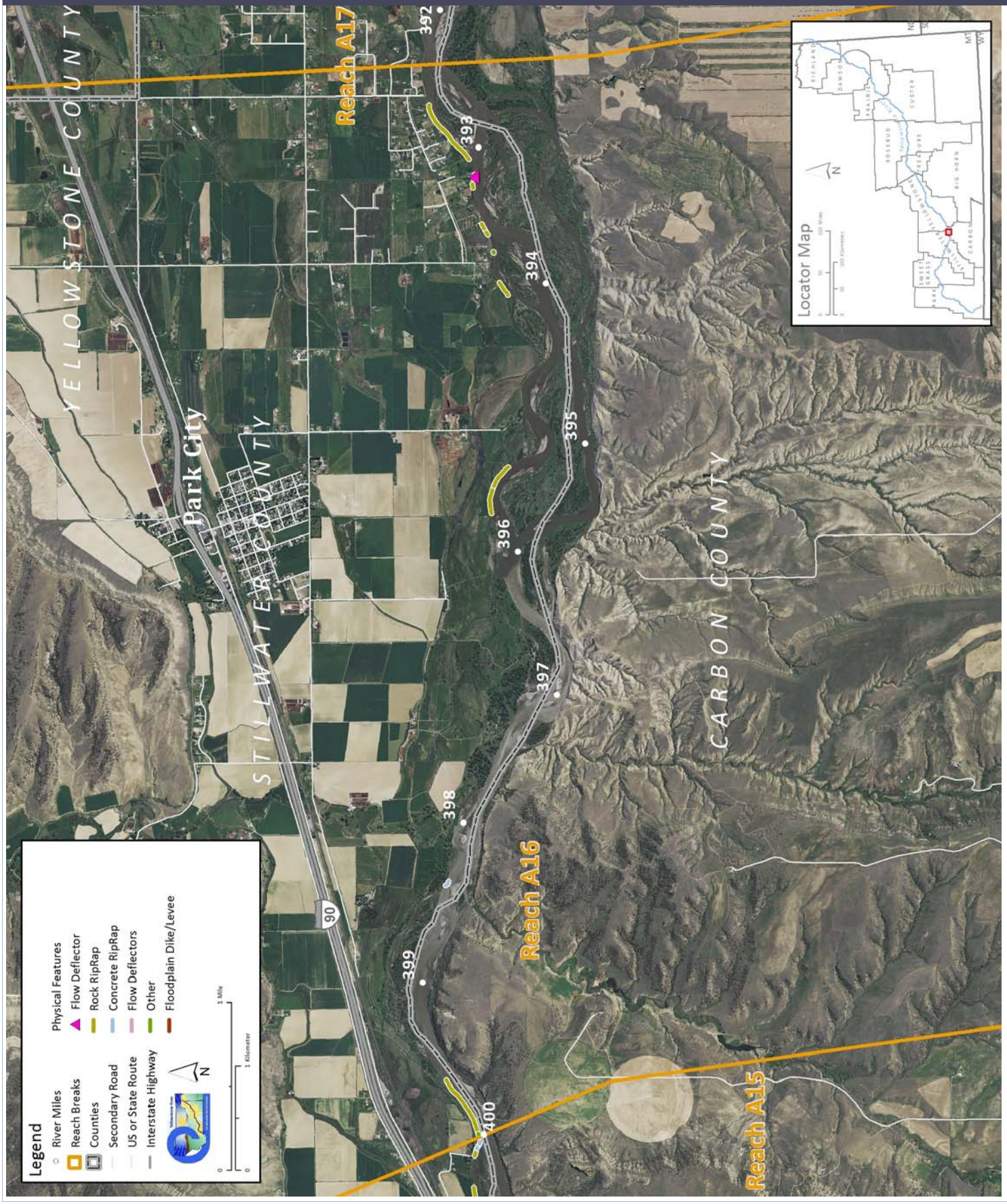
The reach has extensive Russian olive, with almost 30 acres of mapped footprint in the reach.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been moderate in this reach. The mean annual flood is estimated to have dropped from 16,900 cfs to 15,500 cfs, a drop of about 8 percent. The biggest influence has been on low flows: severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 2,310 cfs to 1,780 cfs with human development, a reduction of 23 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 1,760 cfs under unregulated conditions to 1,680 cfs under regulated conditions at the Livingston gage, a reduction of 4.6 percent.

CEA-Related observations in Reach A16 include:
•Passive loss of over a mile of side channel
•Russian olive colonization in abandoned side channels
•Emergent wetland development in abandoned side channels

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach A16 include:
•Diversion structure management at Italian Ditch Diversion RM 400
•Nutrient management at corrals that are part of an animal handling facility at RM 395.
•Russian olive removal (29 acres)
•Wetland management/restoration due to extent of mapped emergent wetland (214 acres emergent, 270 acres total wetland)

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): Livingston

Flood History

Year	Date	Flow on Date	Return Interval
1971	Jun 23	29,200	10-25 yr
1902	Jun 11	30,100	10-25 yr
1943	Jun 20	30,600	10-25 yr
1974	Jun 17	36,300	50-100 yr
1996	Jun 10	37,100	50-100 yr
1997	Jun 6	38,000	50-100 yr
2011	Jun 30	40,600	>100-yr

	Downstream Gage	Upstream Gage
Gage No	6214500	6192500
Location	Billings	Livingston
Period of Record	1929-2015	1929-2015
Distance To (miles)	28.0	106.6

Discharge

	1.01 Yr	2 Yr	5 Yr	10 Yr	50 Yr	100 Yr	500 Yr	7Q10 Summer	95% Sum. Duration
Unregulated	16,900	32,200	40,100	44,900	54,600	58,600	67,500	2,310	1,760
Regulated	15,500	30,600	38,600	43,500	53,500	57,600	66,900	1,780	1,680
% Change	-8.28%	-4.97%	-3.74%	-3.12%	-2.01%	-1.71%	-0.89%	-22.94%	-4.55%

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	5/16/51 - 5/17/1951	B/W	1:28,400	6192500	6000
1976	USCOE	28-Sep-76	B/W	1:24,000	6192500	2560
1995	USGS DOQQ	24-Aug-96	B/W		6192500	3540
2001	NRCS	August 2-8, 2001	CIR	1:24,000	6192500	2000
2004	Merrick	14-May-04	Color	1:15,840	6192500	4520
2005	NAIP	07/12/2005	color	1-meter pixels	6192500	5960
2009	NAIP	7/7/2009	Color	1-meter pixels	6192500	11300
2009	NAIP	6/29/2009	Color	1-meter pixels	6192500	13900
2011	USCOE	October 2012	color	1-ft pixel	6192500	2530
2011	NAIP	7/24/2011	Color	1-meter pixels	6192500	13100
2013	NAIP	06/15/2013	color	1-meter pixels	6192500	

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	4,439	5.5%	6,790	8.4%	2,351
	Flow Deflectors	0	0.0%	90	0.1%	90
	Concrete RipRap	167	0.2%	9	0.0%	-158
	Car Bodies	117	0.1%	117	0.1%	0
	Between Flow Deflectors	0	0.0%	38	0.0%	38
	Feature Type Totals	**4,723**	**5.8%**	**7,043**	**8.7%**	**2,321**
	Reach Totals	**4,723**	**5.8%**	**7,043**	**8.7%**	**2,321**

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
Car Bodies	0	0	79	0	0	0	0	36
Concrete RipRap	0	157	0	0	0	0	0	0
Rock RipRap	0	977	1,988	0	0	0	0	2,450
Totals	**0**	**1,135**	**2,066**	**0**	**0**	**0**	**0**	**2,486**

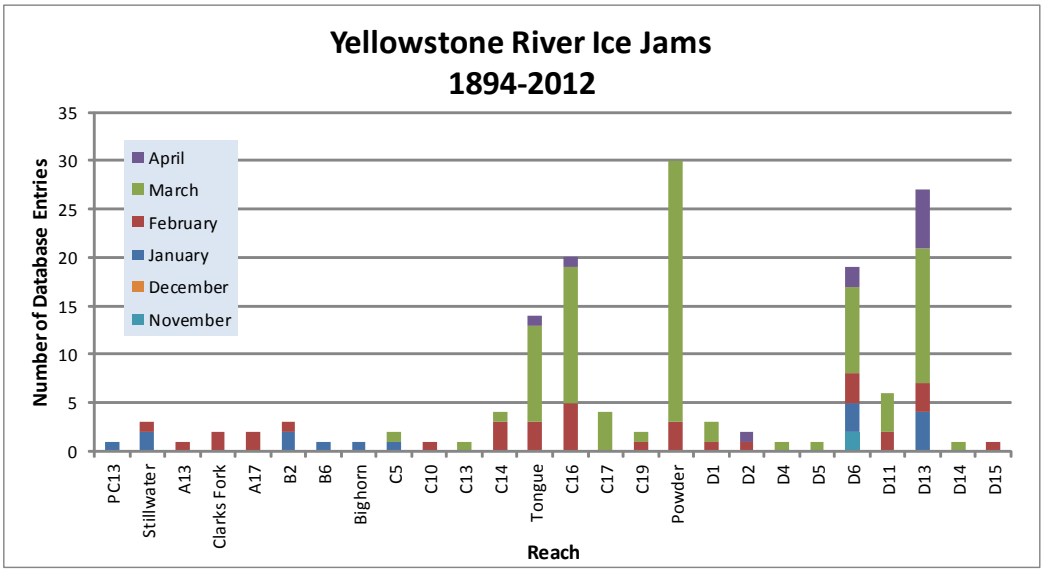
Bankline/Floodplain Inventory: Time Series

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	22,187	22,187	22,187	22,187	22,187	22,187
	Totals	**22,187**	**22,187**	**22,187**	**22,187**	**22,187**	**22,187**
Stream Stabilization							
	Rock RipRap	1,441	1,441	1,976	5,043	5,949	5,949
	Concrete RipRap	0	0	262	262	262	262
	Car Bodies	79	79	112	112	112	112
	Totals	**1,521**	**1,521**	**2,350**	**5,418**	**6,324**	**6,324**
Transportation Encroachment							
	Railroad	4,239	4,239	4,239	4,239	4,239	4,239
	Other	1,669	1,669	1,669	1,669	1,669	1,669
	Totals	**5,908**	**5,908**	**5,908**	**5,908**	**5,908**	**5,908**

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	39,915	59,568	2.49	1950 to 1976:	6.26%
1976	39,509	65,125	2.65	1976 to 1995:	-12.30%
1995	40,855	54,038	2.32	1995 to 2001:	0.11%
2001	40,532	53,715	2.33	1950 to 2001:	-6.71%
Change 1950 - 2001	**618**	**-5,854**	**-0.17**		

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)	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)	815		1108	
Total Floodplain Area (Ac)	815		1151	
Total Isolated (Ac)	**0**	**0.0%**	**42**	**12.5%**

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:	5	0	0	**5**

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
335	671	1,894	61	3%	88	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	44	2.2%
	Exurban Residential	15	0.8%
	Canal	46	2.3%
	Totals	**104**	**5.2%**

Land Uses within the CMZ (Acres)

Flood Irrigation	Sprinkler Irrigation	Pivot Irrigation	Urban/ ExUrban	Trans-portation
110.1	0.0	0.0	38.9	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	25	25	25	25	0.5%	0.5%	0.5%	0.5%
	Agricultural Roads	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Other Infrastructure	46	66	118	108	0.9%	1.2%	2.2%	2.0%
	Totals	**71**	**91**	**142**	**133**	**1.3%**	**1.7%**	**2.6%**	**2.5%**
Agricultural Land									
	Non-Irrigated	2,421	2,331	2,519	2,427	44.9%	43.2%	46.7%	45.0%
	Irrigated	1,588	1,551	1,156	1,106	29.4%	28.7%	21.4%	20.5%
	Totals	**4,009**	**3,883**	**3,674**	**3,533**	**74.3%**	**71.9%**	**68.1%**	**65.4%**
Channel									
	Channel	1,297	1,349	1,252	1,391	24.0%	25.0%	23.2%	25.8%
	Totals	**1,297**	**1,349**	**1,252**	**1,391**	**24.0%**	**25.0%**	**23.2%**	**25.8%**
ExUrban									
	ExUrban Other	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	ExUrban Undeveloped	0	0	80	7	0.0%	0.0%	1.5%	0.1%
	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	2	176	261	0.0%	0.0%	3.3%	4.8%
	Totals	**0**	**2**	**256**	**268**	**0.0%**	**0.0%**	**4.7%**	**5.0%**
Transportation									
	Public Road	11	11	11	11	0.2%	0.2%	0.2%	0.2%
	Interstate	0	52	52	52	0.0%	1.0%	1.0%	1.0%
	Railroad	11	11	11	11	0.2%	0.2%	0.2%	0.2%
	Totals	**21**	**74**	**74**	**74**	**0.4%**	**1.4%**	**1.4%**	**1.4%**
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	11	11	0.0%	0.0%	0.3%	0.3%	0.0%	0.3%	0.0%	0.3%
	Flood	1,588	1,551	1,145	1,095	39.6%	40.0%	31.2%	31.0%	0.3%	-8.8%	-0.2%	-8.6%
	Totals	**1,588**	**1,551**	**1,156**	**1,106**	**39.6%**	**40.0%**	**31.5%**	**31.3%**	**0.3%**	**-8.5%**	**-0.2%**	**-8.3%**

Non-Irrigated

Multi-Use	2,349	1,976	1,894	1,798	58.6%	50.9%	51.5%	50.9%	-7.7%	0.7%	-0.7%	-7.7%
Hay/Pasture	72	356	625	629	1.8%	9.2%	17.0%	17.8%	7.4%	7.8%	0.8%	16.0%
Totals	**2,421**	**2,331**	**2,519**	**2,427**	**60.4%**	**60.0%**	**68.5%**	**68.7%**	**-0.3%**	**8.5%**	**0.2%**	**8.3%**

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	0.7	0.2	0.7	1.4	0.3	0.9	1.8	1.4	1.8
Max	128.0	83.6	72.3	90.3	244.8	245.1	198.1	92.8	38.6
Average	15.2	8.7	10.7	23.2	17.0	29.2	22.4	15.0	26.7
Sum	273.5	182.0	171.6	440.6	610.9	672.2	291.8	149.8	133.4

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)	225.6
Channel to Riparian (acres)	220.7
Riparian Encroachment (acres)	**-5.0**

Riparian Recruitment

Creation of riparian areas between 1950s and 2001.

1950s Channel Mapped as 2011 Riparian (Ac)	222.2
1950s Floodplain Mapped as 2011 Channel (Ac)	121.8
Total Recruitment (1950s to 2011)(Ac)	**344.0**

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	10.7	214.0	43.3	0.0	**268.0**
Acres/Valley Mile	1.6	32.0	6.5	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	28.74	1.83%	19.92	0.17	10.47	9.07

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	223.2	102.4	8.2%
Rip Rap Bottom	34.8	16.6	1.3%
Bluff Pool	63.2	47.7	3.8%
Terrace Pool	18.5	9.8	0.8%
Secondary Channel	62.0	74.5	6.0%
Secondary Channel (Seasonal)	179.2	100.8	8.0%
Channel Crossover	200.6	121.5	9.7%
Point Bar		60.4	4.8%
Side Bar		51.2	4.1%
Mid-channel Bar		64.5	5.2%
Island	470.6	473.6	37.8%
Dry Channel		129.2	10.3%

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.

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 A

In the study segment, Laurel to Springdale, three themes emerge as dominant across the four interest groups. One theme focuses on the changing riverbank profile as more and more residential homes are built on the river's edge. The second theme focuses on the river as a powerful and dynamic physical entity. The third is about the changing social profiles of their communities and how those changes influence user practices.

County	Yellowstone	**Upstream River Mile**	392.4
Classification	UA: Unconfined anabranching	**Downstream River Mile**	386
General Location	To Laurel	**Length**	6.40 mi (10.30 km)
General Comments	To Laurel; WAI Reach A		

Narrative Summary

Reach A17 is 7.6 miles long and is located just above Laurel. The reach is classified as Unconfined Anabranching (UA), which is characteristically one of the most dynamic reach types on the river. The river is flowing in the alluvial valley with minimal influences of the valley wall and through numerous forested islands. There are sites in Reach A17 where the river has migrated almost 1,000 feet since 1950.

Approximately 13 percent of the bankline in Reach A17 is armored by rock riprap, concrete riprap and flow deflectors. Between 2001 and 2011 the total length of rock riprap increased by about a half of a mile. At RM 387, a ~750 foot long stretch of flow deflectors on the left bank have been flanked, and by fall 2011 the river had migrated about 120 feet behind the flanked armor. The deflectors are still visible in the channel. In some places such as at RM 389.8, bank armor on both sides of the river narrows the corridor to about one channel width, or 1,000 feet.

Over a mile of side channels in Reach A17 were blocked prior to 1950. Two major channels were blocked on the north side of the river, one at the Buffalo Mirage Fishing Access Site at RM 391.5, and the other at Rm 389.5. These channels, as well as other secondary channels that were passively loss, host fairly dense concentrations of Russian olive. Similar to most reaches in Region A, the loss of side channels has been accompanied by an increase in the total river footprint, indicating that flow concentration into the main river channel has caused it to enlarge. Between 1950 and 2001, the size of the channel increased from 560 acres to 645 acres.

Land use in Reach A17 is primarily agricultural, although there are almost 600 acres of urban/exurban development in the reach as the river approaches the City of Laurel. Since 1950, there has been a reduction in flood irrigated acres of about 550 acres, and an increase in pivot irrigation from 0 acres in 1950 to 284 acres in 2011. A total of 383 acres of developed ground are in the mapped Channel Migration Zone; and about 11 percent of the CMZ has been isolated by physical features protecting those land uses.

At RM 388.5, a headgate diverts water into an old side channel that has been converted to a canal on the north side of the river. About ½ mile downstream, the canal is riprapped where it was recently threatened by rapid northward river migration. At this location, the river has migrated over 800 feet northward since 1950. The main channel of the river now flows along the riprapped canal embankment for about 750 feet.

There are corrals that are part of an animal handling facility within 600 feet of the north riverbank at RM 392.

Side channel loss and channel migration in Reach A17 has resulted in relatively high rates of riparian recruitment. Since 1950, there has been 330 acres of land that experience recruitment of new riparian vegetation. Most of that recruitment was in abandoned channels (200 acres) and about 27 acres of recruitment was direct result of channel migration.

Two ice jams have been recorded in Reach A17, in 1996 and 1997. Both occurred during the month of February, and were reported to have occurred at the Laurel Bridge.

There are over 200 acres of mapped wetland in the reach, with most of that emergent marshes and wet meadows. Many of these wetland areas occupy river swales on the floodplain north of the river, or abandoned channels in the active corridor.

Almost 22 acres of Russian olive has been mapped in the floodplain.

Reach A17 was sampled as part of the avian study. The average species richness in Reach A17 was 7.7, which indicates the average number of species observed during site visits to the reach in cottonwood habitats. The average species richness for all sites evaluated is 8. An average of 0.9 Cowbirds (a bird that parasitizes other bird's nests) were observed in cottonwood habitats during the field sampling visits. Reach A17 has lost about two thirds of its riparian forest considered at low risk of cowbird parasitism since 1950. At that time, there were about 28 acres of forest per valley mile considered to be isolated enough from agricultural infrastructure and urban/exurban development to be considered at low risk. By 2011, about 10 acres per valley mile considered low risk remained.

A total of three Potential Species of Concern (PSOCs) were observed in Reach A17 during the avian study, including the Black and White Warbler, Chimney Swift, and Ovenbird. One Species of Concern (SOC), the Bobolink, was also observed in Reach A17.

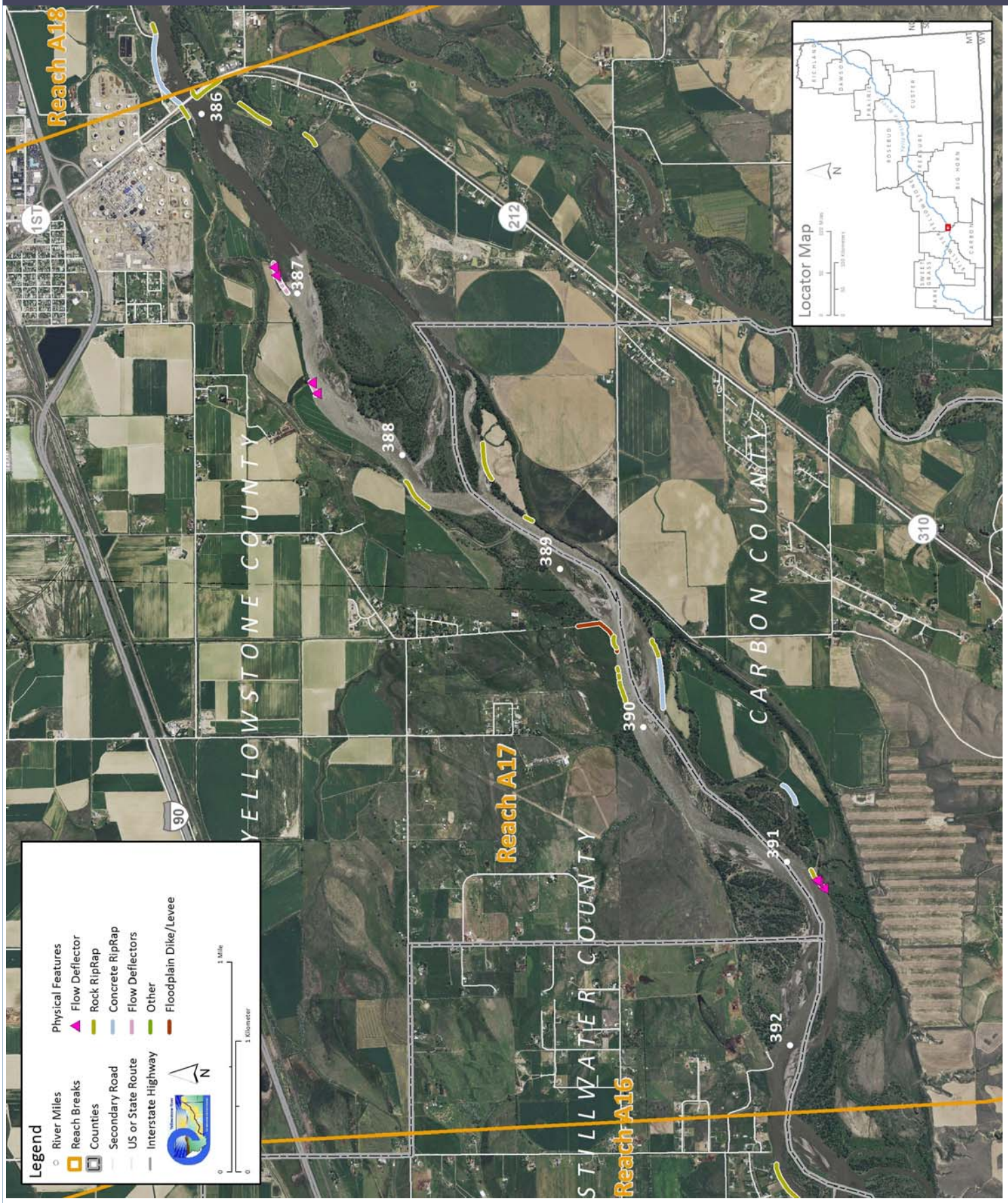
A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been moderate in this reach. The mean annual flood is estimated to have dropped from 16,900 cfs to 15,500 cfs, a drop of about 8 percent. The biggest influence has been on low flows: severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 2,320 cfs to 1,780 cfs with human development, a reduction of 23 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 1,760 cfs under unregulated conditions to 1,680 cfs under regulated conditions at the Livingston gage, a reduction of 4.6 percent.

CEA-Related observations in Reach A17 include:
•Flanking of flow deflectors and accelerated erosion behind flanked structures

•Physical blockage of over a mile of side channel
•Russian olive colonization in abandoned side channels
•Emergent wetland development in abandoned side channels
•Ice jamming potentially associated with the Laurel Bridge

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach A17 include:
•Bank armor removal (flanked flow deflectors), RM 387
•Side channel restoration at RM 391.5 and RM 389.5
•Nutrient management associated with corrals that are part of an animal handling facility at RM 392.
•Russian olive removal (22 acres)
•Wetland management/restoration due to extent of mapped wetland (200 acres)
•Irrigation diversion structure management at headgate on side channel at RM 388.5

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): Livingston

Flood History

Year	Date	Flow on Date	Return Interval
1971	Jun 23	29,200	10-25 yr
1902	Jun 11	30,100	10-25 yr
1943	Jun 20	30,600	10-25 yr
1974	Jun 17	36,300	50-100 yr
1996	Jun 10	37,100	50-100 yr
1997	Jun 6	38,000	50-100 yr
2011	Jun 30	40,600	>100-yr

	Downstream Gage	Upstream Gage
Gage No	6214500	6192500
Location	Billings	Livingston
Period of Record	1929-2015	1929-2015
Distance To (miles)	21.6	114.2

Discharge

	1.01 Yr	2 Yr	5 Yr	10 Yr	50 Yr	100 Yr	500 Yr	7Q10 Summer	95% Sum. Duration
Unregulated	16,900	32,200	40,100	44,900	54,600	58,600	67,500	2,320	1,760
Regulated	15,500	30,600	38,600	43,500	53,500	57,600	66,900	1,780	1,680
% Change	-8.28%	-4.97%	-3.74%	-3.12%	-2.01%	-1.71%	-0.89%	-23.28%	-4.55%

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	5/14/51 - 6/9/51	B/W	1:28,400	6192500	6000
1976	USCOE	28-Sep-76	B/W	1:24,000	6192500	2560
1995	USGS DOQQ	23-Aug-96	B/W		6192500	3730
2001	NRCS	August 2-8, 2001	CIR	1:24,000	6192500	2000
2004	Merrick	14-May-04	Color	1:15,840	6192500	4520
2005	NAIP	07/12/2005	color	1-meter pixels	6192500	5960
2005	NAIP	07/08/2005	color	1-meter pixels	6192500	6410
2009	NAIP	7/7/2009	Color	1-meter pixels	6192500	11300
2011	USCOE	October 2012	color	1-ft pixel	6192500	2530
2011	NAIP	7/24/2011	Color	1-meter pixels	6192500	13100
2013	NAIP	06/15/2013	color	1-meter pixels	6192500	

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	3,601	5.3%	6,185	9.1%	2,584
	Flow Deflectors	236	0.3%	230	0.3%	-6
	Concrete RipRap	2,205	3.2%	2,205	3.2%	0
	Between Flow Deflectors	612	0.9%	441	0.6%	-171
	Feature Type Totals	**6,653**	**9.7%**	**9,061**	**13.3%**	**2,408**
Floodplain Control						
	Floodplain Dike/Levee	1,434	2.1%	1,434	2.1%	0
	Feature Type Totals	**1,434**	**2.1%**	**1,434**	**2.1%**	**0**
	Reach Totals	**8,087**	**11.8%**	**10,495**	**15.4%**	**2,408**

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	1,227	0	659	0	0	0	0	0
Flow Deflectors/Between FDs	846	0	0	0	0	0	0	0
Rock RipRap	1,132	0	1,250	1,207	0	0	0	0
Totals	**3,205**	**0**	**1,909**	**1,207**	**0**	**0**	**0**	**0**

Bankline/Floodplain Inventory: Time Series

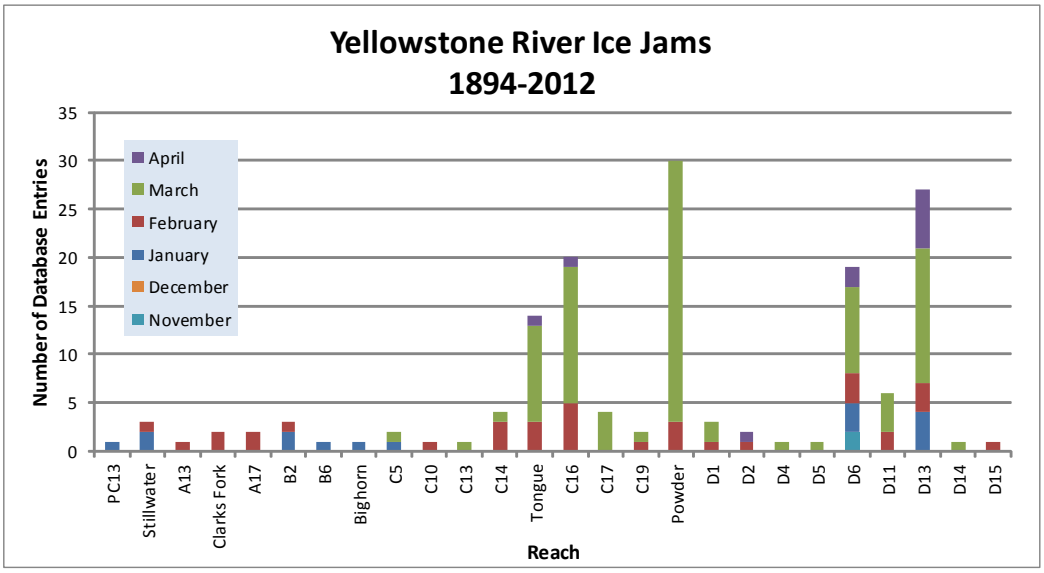
The Human Impacts Timeline assessed physical feature development through time for Yellowstone, Stillwater, and Dawson Counties.

		Sum of Feature Length (ft)					
Feature Class	Feature Type	1950	1976	1995	2001	2004	2005
Irrigation							
	Floodplain Dike/Levee	32,154	32,838	32,838	33,205	33,965	33,965
	Totals	**32,154**	**32,838**	**32,838**	**33,205**	**33,965**	**33,965**
Other							
	Floodplain Dike/Levee	0	2,677	2,677	2,677	2,677	2,677
	Totals	**0**	**2,677**	**2,677**	**2,677**	**2,677**	**2,677**
Other Off Channel							
	Other	2,200	2,200	2,200	2,200	2,200	2,200
	Floodplain Dike/Levee	0	0	0	412	412	412
	Floodplain Dike/Levee	361	576	576	576	576	576
	Totals	**2,562**	**2,776**	**2,776**	**3,189**	**3,189**	**3,189**
Stream Stabilization							
	Rock RipRap	272	3,692	3,886	4,200	4,200	4,200

Flow Deflector	0	0	0	812	812	812
Concrete RipRap	366	988	988	3,055	3,645	3,645
Totals	**638**	**4,681**	**4,875**	**8,066**	**8,656**	**8,656**
Transportation Encroachment						
Floodplain Dike/Levee	5,461	5,461	5,461	5,461	5,461	5,461
Bridge Approach	3,994	3,994	3,994	3,994	3,994	3,994
Totals	**9,455**	**9,455**	**9,455**	**9,455**	**9,455**	**9,455**

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
2/6/1996	NA	386	Flooding
2/21/1997	Freeze-up	386	?

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	34,729	37,999	2.09	1950 to 1976:	1.44%
1976	34,084	38,322	2.12	1976 to 1995:	-12.94%
1995	34,298	29,134	1.85	1995 to 2001:	3.76%
2001	34,137	31,373	1.92	1950 to 2001:	-8.36%
Change 1950 - 2001	**-592**	**-6,626**	**-0.18**		

Length of Side Channels Blocked

Pre-1950s (ft)	7,639
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)	0	0.0%		
Agriculture (isloated by canal or large ditch)	0	0.0%		
Levee/Riprap (protecting agricultural lands)	10	0.8%		
Levee/Riprap (protecting urban, industrial, etc.)	0	0.0%		
Railroad	0	0.0%		
Abandoned Railroad	0	0.0%		
Transportation (Interstate and other roads)	80	5.9%		
Total Not Isolated (Ac)	1253		1092	
Total Floodplain Area (Ac)	1343		1139	
Total Isolated (Ac)	**90**	**6.7%**	**46**	**9.4%**

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:	49	0	0	**49**

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
457	914	2,173	192	9%	78	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			
	Public Road	16	0.7%
	Non-Irrigated	45	2.0%
	Irrigated	114	5.0%
	Canal	23	1.0%
Flow Deflectors			
	Irrigated	25	1.1%
Dike/Levee			
	Irrigated	23	1.0%
	Totals	**246**	**10.9%**

Land Uses within the CMZ (Acres)

Flood Irrigation	Sprinkler Irrigation	Pivot Irrigation	Urban/ ExUrban	Trans-portation
358.9	0.0	0.0	18.7	5.7

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	15	15	15	15	0.3%	0.3%	0.3%	0.3%
	Agricultural Roads	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Other Infrastructure	54	75	97	103	0.9%	1.3%	1.7%	1.8%
	Totals	**69**	**90**	**112**	**118**	**1.2%**	**1.6%**	**1.9%**	**2.1%**
Agricultural Land									
	Non-Irrigated	2,603	2,243	2,491	2,442	45.2%	39.0%	43.3%	42.4%
	Irrigated	1,927	2,113	1,736	1,668	33.5%	36.7%	30.2%	29.0%
	Totals	**4,530**	**4,356**	**4,227**	**4,110**	**78.7%**	**75.6%**	**73.4%**	**71.4%**
Channel									
	Channel	954	984	934	983	16.6%	17.1%	16.2%	17.1%
	Totals	**954**	**984**	**934**	**983**	**16.6%**	**17.1%**	**16.2%**	**17.1%**
ExUrban									
	ExUrban Other	2	2	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	6	25	62	76	0.1%	0.4%	1.1%	1.3%
	ExUrban Commercial	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	ExUrban Residential	51	52	168	216	0.9%	0.9%	2.9%	3.8%
	Totals	**59**	**80**	**230**	**292**	**1.0%**	**1.4%**	**4.0%**	**5.1%**
Transportation									
	Public Road	41	41	41	41	0.7%	0.7%	0.7%	0.7%
	Interstate	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Railroad	10	10	10	10	0.2%	0.2%	0.2%	0.2%
	Totals	**50**	**50**	**50**	**50**	**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	21	21	21	0.0%	0.4%	0.4%	0.4%
	Urban Commercial	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Urban Undeveloped	22	0	0	0	0.4%	0.0%	0.0%	0.0%
	Urban Industrial	74	177	182	182	1.3%	3.1%	3.2%	3.2%
	Totals	**95**	**199**	**204**	**204**	**1.7%**	**3.5%**	**3.5%**	**3.5%**

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	203	284	284	0.0%	4.7%	6.7%	6.9%	4.7%	2.1%	0.2%	6.9%
	Flood	1,927	1,910	1,452	1,384	42.5%	43.8%	34.4%	33.7%	1.3%	-9.5%	-0.7%	-8.9%
	Totals	**1,927**	**2,113**	**1,736**	**1,668**	**42.5%**	**48.5%**	**41.1%**	**40.6%**	**6.0%**	**-7.4%**	**-0.5%**	**-2.0%**

Non-Irrigated

Multi-Use	1,484	1,093	1,201	1,182	32.8%	25.1%	28.4%	28.8%	-7.7%	3.3%	0.4%	-4.0%
Hay/Pasture	1,119	1,150	1,290	1,260	24.7%	26.4%	30.5%	30.7%	1.7%	4.1%	0.1%	6.0%
Totals	**2,603**	**2,243**	**2,491**	**2,442**	**57.5%**	**51.5%**	**58.9%**	**59.4%**	**-6.0%**	**7.4%**	**0.5%**	**2.0%**

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	0.2	0.5	0.0	0.3	0.0	1.0	2.4	1.3	0.4
Max	22.7	88.6	21.9	213.6	142.1	156.2	89.4	52.3	129.8
Average	5.5	16.6	5.6	36.2	22.2	32.2	19.9	21.3	22.1
Sum	83.1	182.6	78.5	723.3	777.5	677.1	258.8	191.6	331.4

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)	255.8
Channel to Riparian (acres)	236.0
Riparian Encroachment (acres)	**-19.8**

Riparian Recruitment

Creation of riparian areas between 1950s and 2001.

1950s Channel Mapped as 2011 Riparian (Ac)	227.5
1950s Floodplain Mapped as 2011 Channel (Ac)	100.2
Total Recruitment (1950s to 2011)(Ac)	**327.7**

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	9.4	203.4	13.4	0.0	**226.2**
Acres/Valley Mile	1.6	35.6	2.3	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	21.84	6.68%	182.62	1.10	3.47	1.43

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	295.5	157.8	16.9%
Rip Rap Bottom	17.4	10.7	1.1%
Terrace Pool	16.4		
Secondary Channel	19.3	54.9	5.9%
Secondary Channel (Seasonal)	143.8	82.1	8.8%
Channel Crossover	147.2	72.5	7.8%
Point Bar		23.6	2.5%
Side Bar		54.9	5.9%
Mid-channel Bar		86.8	9.3%
Island	294.8	292.8	31.3%
Dry Channel		98.2	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.

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 A

In the study segment, Laurel to Springdale, three themes emerge as dominant across the four interest groups. One theme focuses on the changing riverbank profile as more and more residential homes are built on the river's edge. The second theme focuses on the river as a powerful and dynamic physical entity. The third is about the changing social profiles of their communities and how those changes influence user practices.