

County	Treasure	Upstream River Mile	298.1
Classification	UA: Unconfined anabranching	Downstream River Mile	292.3
General Location	From Bighorn confluence	Length	5.80 mi (9.33 km)

Narrative Summary

Reach C1 is located just downstream of the Bighorn River confluence. The Reach is 5.8 miles long and is an Unconfined Anabranching reach type, (UA), indicating the presence of forested islands with minimal valley wall influence on the river. These reach types tend to be the most dynamic of all reach types, with typically high rates of bank migration. At RM 296.5 for example, the river has migrated over 250 feet to the southeast between 2001 and 2011, indicating an average migration rate of over 25 feet per year.

There are about 2,300 feet of rock riprap in the reach, which collectively armors about 4 percent of the total bankline. About 1,000 feet of armor is protecting the rail line and another 500 feet is protecting agricultural ground. The remainder is protecting the Rancher's Ditch Diversion Structure at RM 295.5.

The Rancher's Ditch diversion dam is located approximately 2.5 miles downstream of the Bighorn River confluence. The dam was constructed in the early part of the 20th century and feeds a canal that flows on the north side of the river. There is a large, vegetated island in the Yellowstone River at the point of diversion, and diversion dams block channels on both sides of the island. The 2011 imagery shows that the south channel is becoming progressively abandoned, so that most flow goes over the main diversion structure on the north channel.

Since 1950, there have been over 7,000 feet of side channel blocked by floodplain dikes in the reach. These channels are on the lower end of the reach on the left (northwest) bank at RM 293. Even though side channels have been blocked, there has been a net gain of side channel length in the reach; since 1950, the total anabranching channel length has increased by 3,800 feet.

Since 1950, Reach C1 has experienced over 300 acres of new riparian recruitment, with most of that colonization occurring in old 1950s channel area. In balancing the amount of riparian area eroded out to the colonization acreage, there has still been a net gain of 118 acres of riparian area associated with channel movement. This reflects erosion of non-wooded lands and colonization of resulting open bar surfaces by woody vegetation, as well as the fact that the channel has gotten smaller since 1950; the bankfull area dropped by almost 50 acres (6 percent) between 1950 and 2001.

Whereas 8 percent of the 100-year floodplain has become isolated due to human development, about 47 percent (633 acres) of the 5-year floodplain is no longer inundated at that frequency. About 80 acres of historic 100-year floodplain area has become isolated by the railroad, and another 42 acres due to flow alterations. The loss of 5-year floodplain shows the strong imprint of flow alterations below the mouth of the Bighorn River and of development of those areas that are less frequently inundated; about 216 acres of currently flood irrigated floodplain areas are in the historic 5-year floodplain footprint.

Land use is dominated by agriculture, with 1,212 acres of pivot irrigation development since 1950. About 15 of those acres of pivot are within the Channel Migration Zone (CMZ). Approximately 7 percent of the Channel Migration Zone (CMZ) has been restricted, with about half of the restrictions due to riprap along the railroad, and the other half due to floodplain dikes protecting irrigated lands.

There are several corrals associated with an animal handling facility at RM 296.8R. The river is migrating in the direction of these corrals and is currently about 600 feet from the facility.

Reach C1 supports over 40 acres per valley mile of mapped wetland, which is a relatively high wetland density for the river. There are also over 100 acres of Russian olive mapped in the reach, occupying 2.6 percent of the total floodplain area.

Reach C1 has seen a substantial loss in forested area that is at low risk of cowbird parasitism since 1950. At that time, there were 48 acres per valley mile of such forest, and that number decreased to 20 acres per valley mile by 2001.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been major in this reach. The mean annual flood is estimated to have dropped from 60,800 cfs to 47,100 cfs, a drop of about 23 percent. The 2-year flood, which strongly influences overall channel form, has dropped by 20 percent. Low flows have also been impacted; severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 4,600 cfs to 2,950 cfs with human development, a reduction of 36 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,150 cfs under unregulated conditions to 3,320 cfs under regulated conditions at Reach C10 downstream where the analysis begins, a reduction of 46 percent.

CEA-Related observations in Reach C1 include:

- Blocking of over a mile of side channel by floodplain dikes

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach C1 include:

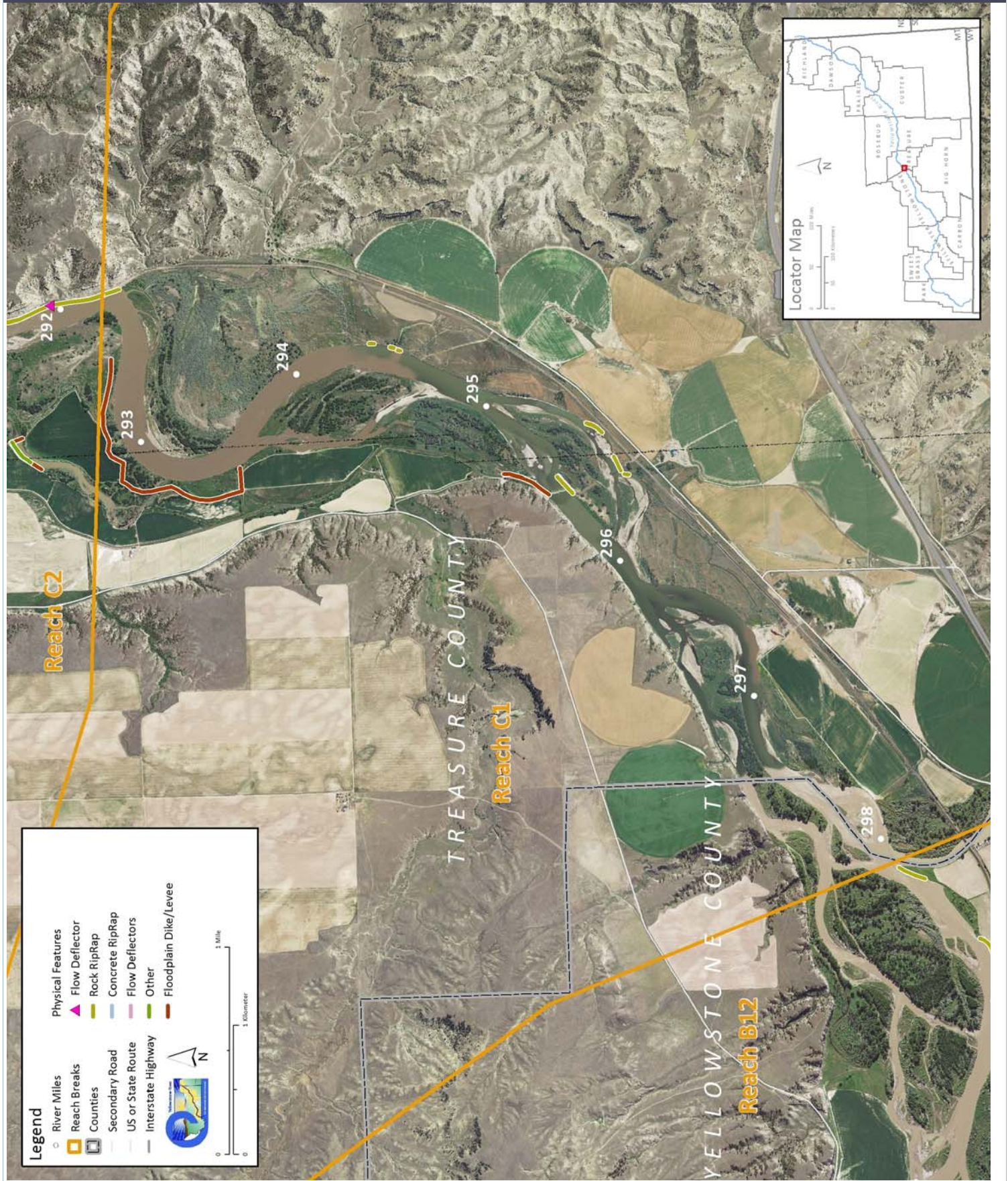
- Fish Passage at Ranchers Ditch Diversion: Structures block two channels at the diversion.
- Watercraft Passage at Ranchers Ditch Diversion
- Irrigation Infrastructure Management at Ranchers Ditch Diversion
- Side channel reactivation at RM 293
- Nutrient management at corrals associated with animal handling facility at RM 296.8R

- Russian olive removal

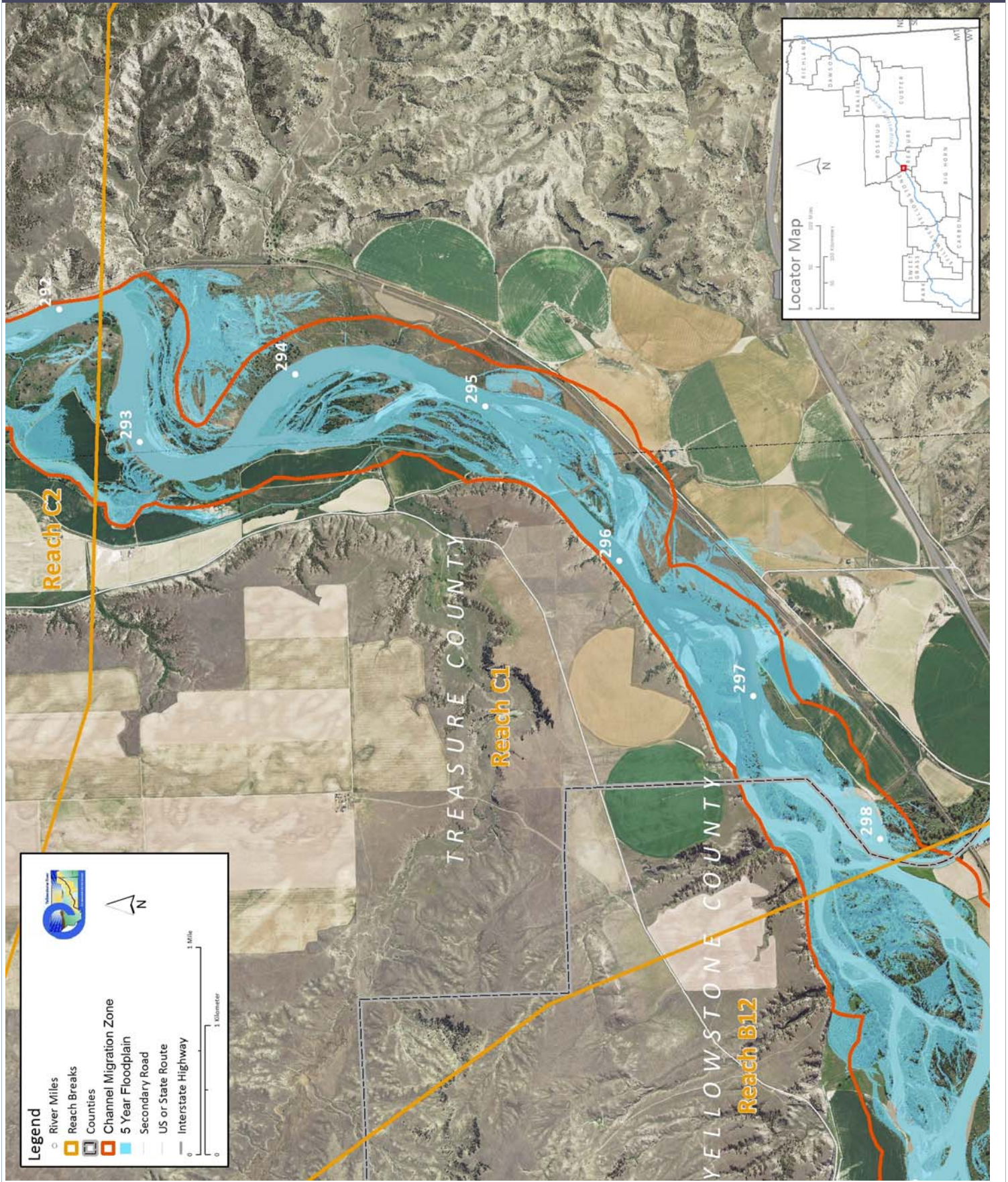
The following table summarizes some key CEA results that have been used to describe overall condition and types of human influences affecting the river. The values are specific to this single reach. Blanks indicate that a particular value was not available for this area. This information is consolidated from a large dataset that is presented in more detail in the full reach narrative report.

Discharge	Undev.	Developed	% Change	"Undeveloped" flows represent conditions prior to significant human development, whereas "developed" flows reflect the current condition of both consumptive and non-consumptive water use.		
2 Year (cfs)	60,800	47,100	-22.5%			
100 Year (cfs)	119,000	99,900	-16.1%			
Bankfull Channel Area (Ac)	1950	1976	1995	2001	1950-2001	Bankfull channel area is the total footprint of the river inundated at approx. the 2-year flood.
	775.2	765.3	696.4	728.8	-46.4	
Physical Features	2011 Length (ft)	% of Bankline	2001-2011 Change	There are additional types of bank armor such as car bodies and steel retaining walls, but they are relatively minor.		
Rock RipRap	2,306	3.7%	406			
Concrete Riprap	0	0.0%	0			
Flow Deflectors	0	0.0%	0			
Total	2,306	3.7%	406			
Length of Side Channels Blocked (ft)	Pre-1950s	Post-1950s	Numerous side channels have been blocked by small dikes.			
	0	7,171				
Floodplain Turnover	1950 - 1976	1976 - 2001	1950-2001 In-channel riparian encroachment (negative number indicates retreat)		The rate of floodplain turnover reflects how many acres of land are eroded by the river. Turnover is associated with the creation of riparian habitat.	
Total Acres	131.9	116.5	118.18 acres			
Acres/Year	5.1	4.7				
Acres/Year/Valley Mile	1.1	1.0				
Open Bar Area	Point Bars	Bank Attached	Mid-Channel	Total	The type and extent of open sand and gravel bars reflect in-stream habitat conditions that can be important to fish, amphibians, and ground-nesting birds such as least terns.	
Change in Area '50 - '01 (Ac)	27.4	54.2	1.9	83.5		
Floodplain Isolation	Acres	% of FP	Floodplain isolation refers to area that historically was flooded, but has become isolated do to flow alterations or physical features such as levees.			
5 Year	633.4	46%				
100 Year	152.2	8%				
Restricted Migration Area	Acres	% of CMZ	Channel Migration Zone restrictions refer to the area and percent of the CMZ that has been isolated by features such as bank armor, dikes, levees, and transportation embankments.			
	113.0	6%				
Land Use	1950	2011	Flood (Ac)	1950	2011	Changes in land use reflect the development of the river corridor through time. The irrigated agricultural are is a sub-set of the mapped agricultural land.
Agricultural Land (Ac)	4,744.8	4,661.6	Sprinkler (Ac)	0.0	0.0	
Ag. Infrastructure (Ac)	50.9	40.2	Pivot (Ac)	0.0	1,212.0	
Exurban (Ac)	0.0	4.8				
Urban (Ac)	0.0	0.0				
Transportation (Ac)	85.4	154.3				
1950s Riparian Vegetation Converted to a Developed Land Use (ac)	To Irrigated	To Other Use	Total Rip. Converted	% of 1950s Rip.	Changes in the extents of riparian vegetation are influenced by land use changes within the corridor.	
	31.9	5.7	37.5	5.0%		
National Wetlands Inventory	Acres	Acres per Valley Mi	Total Wetland Acres	Wetlands units summarized from National Wetlands Inventory Mapping include Riverine (typically open water sloughs), Emergent (marshes and wet meadows) and Shrub-Scrub (open bar areas with colonizing woody vegetation).		
Riverine	2.4	0.5	197.1			
Emergent	121.5	25.8				
Scrub/Shrub	73.2	15.5				
Russian Olive (2001) (Appx. 100-yr Floodplain)	Acres	%	Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.			
	104.5	2.6%				
Riparian Forest at low risk of Cowbird Parasitism (Ac/Valley Mile)	1950	1976	2001	Change 1950-2011	Cowbirds are associated with agricultural and residential development, displacing native bird species by parasitizing their nests.	
	48.3	20.7	19.9	-28.4		

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



County	Treasure	Upstream River Mile	292.3
Classification	PCB: Partially confined braided	Downstream River Mile	286.8
General Location	To Myers Bridge	Length	5.50 mi (8.85 km)

Narrative Summary

Reach C2 is located just upstream of Myers Bridge. The Reach is 5.5 miles long and is a Partially Confined Braided (PCB) reach type indicating some valley wall influence on a channel with fairly extensive low flow channels and open gravel bars. The reach follows the southern bluff line along the entire reach, which is almost entirely armored to protect the railroad.

There are over five miles of bank armor in the reach, most of which is rock riprap protecting the rail line. A total of 46 percent of the bank is armored. Since 2001, 1,200 feet of flow deflectors have been built on the right bank just above Myers Bridge.

About two miles of side channel have recently been blocked in Reach C2. In the upper end of the reach, two large side channels were blocked by a several thousand foot long floodplain dike sometime after 1976, and the old island in between these side channels is now cleared and farmed. The heads of these channels are at RM 293, and removal of the plugs at their heads could potentially reactivate over a mile of side channel connectivity. A second channel on the north side of the river at RM 289 appears relatively old, but has access roads crossing it that appear to block seasonal access. Similar to upstream, the isolation of this ~9,000 foot-long side channel has prompted clearing and farming of the old island area that is currently accessible. In total, about 18 percent (162 acres) of the mapped 1950s riparian vegetation in the reach has been cleared and converted to irrigation.

Land use is dominated by agriculture, with 137 acres of pivot irrigation development since 1950. There are several corrals associated with an animal handling facility at RM 289.5L. The corrals are on the edge of a blocked historic side channel that drains to the river. Dikes, levees, and irrigation-related riprap have collectively isolated just over 10 percent of the Channel Migration Zone in Reach C2.

Over 600 acres of 100-year floodplain has been isolated by human development, and all of that isolation is due to agricultural development on the north side of the river. The isolation reflects 23 percent of the total 100-year floodplain. The 5-year floodplain is even more affected; 59 percent of the historic 5-year floodplain is no longer inundated at that frequency. The loss of 5-year floodplain shows the strong imprint of flow alterations below the mouth of the Bighorn River and consequent development of those areas that are less frequently inundated; about 550 acres of currently flood irrigated areas are in the historic 5-year floodplain footprint.

Since 1950, Reach C2 has experienced about 190 acres of new riparian recruitment, with most of that colonization occurring in old 1950s channel area. There has been a net gain of 40 acres of riparian area in the reach associated with channel movement. This reflects encroachment of vegetation into the channel that has experienced a 20 percent reduction in channel forming (2-year) flow. There are about 46 acres of Russian olive in the reach.

Reach C2 was sampled as part of the fisheries study. A total of 32 fish species were sampled in the reach and one of those species was Sauger, which has been identified by the Montana Natural Heritage Program as a Species of Concern (SOC).

Reach C2 has seen a substantial loss in forested area that is at low risk of cowbird parasitism since 1950. At that time, there were 37 acres per valley mile of such forest, and that number decreased to 6 acres per valley mile by 2001.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been major in this reach. The mean annual flood is estimated to have dropped from 60,900 cfs to 47,100 cfs, a drop of about 23 percent. The 2-year flood, which strongly influences overall channel form, has dropped by 20 percent. Low flows have also been impacted; severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 4,610 cfs to 2,950 cfs with human development, a reduction of 36 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,150 cfs under unregulated conditions to 3,320 cfs under regulated conditions at Reach C10 downstream where the analysis begins, a reduction of 46 percent.

CEA-Related observations in Reach C2 include:

- Blocking of over a mile of side channel by floodplain dikes
- Riparian clearing and irrigation development in isolated 5-year floodplain
- Loss of area at low risk of cowbird parasitism with riparian clearing

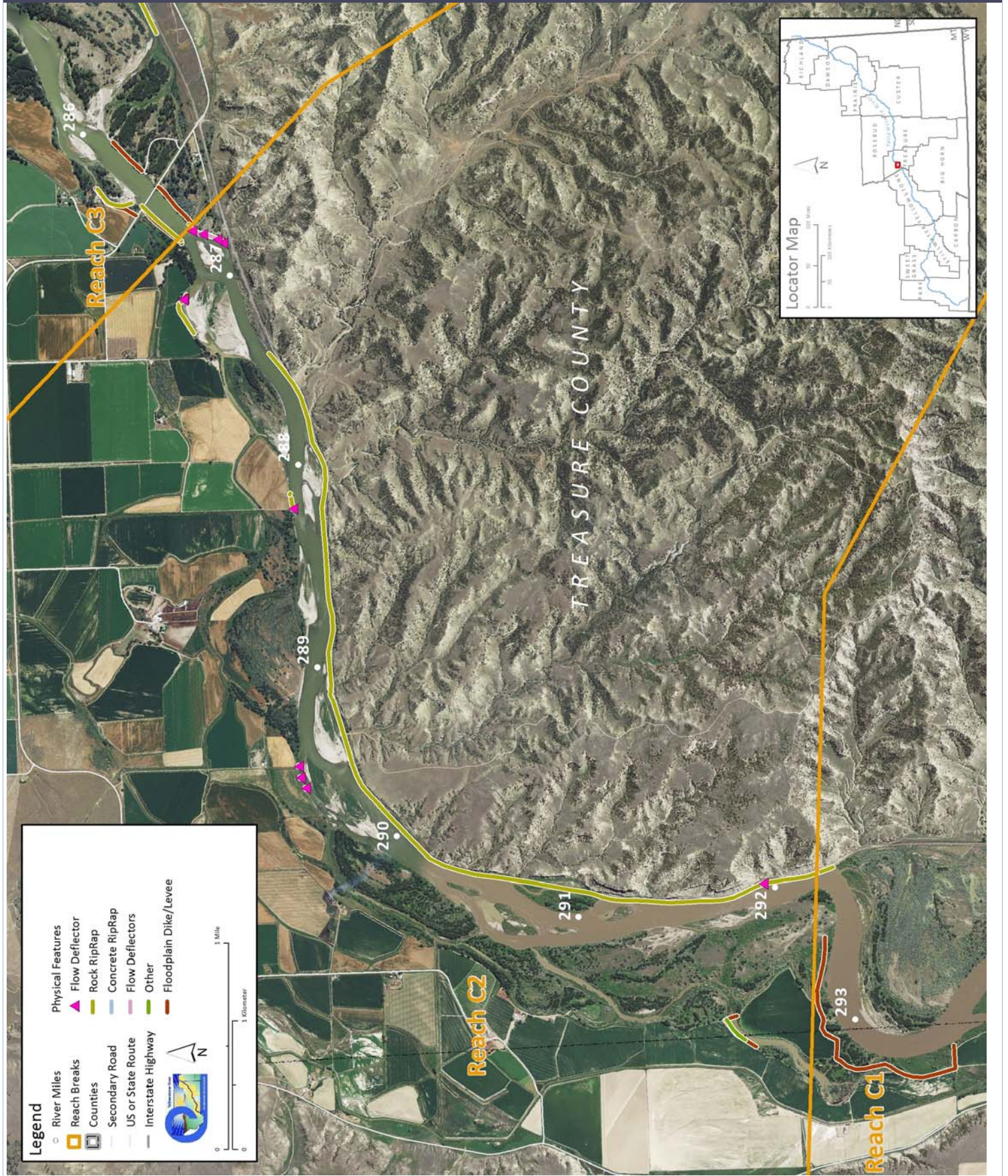
Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach C2 include:

- Side channel reactivation at RM 293
- Side channel reactivation at RM 289
- Nutrient management at corrals associated with an animal handling facility at RM 288.8L
- Russian olive removal

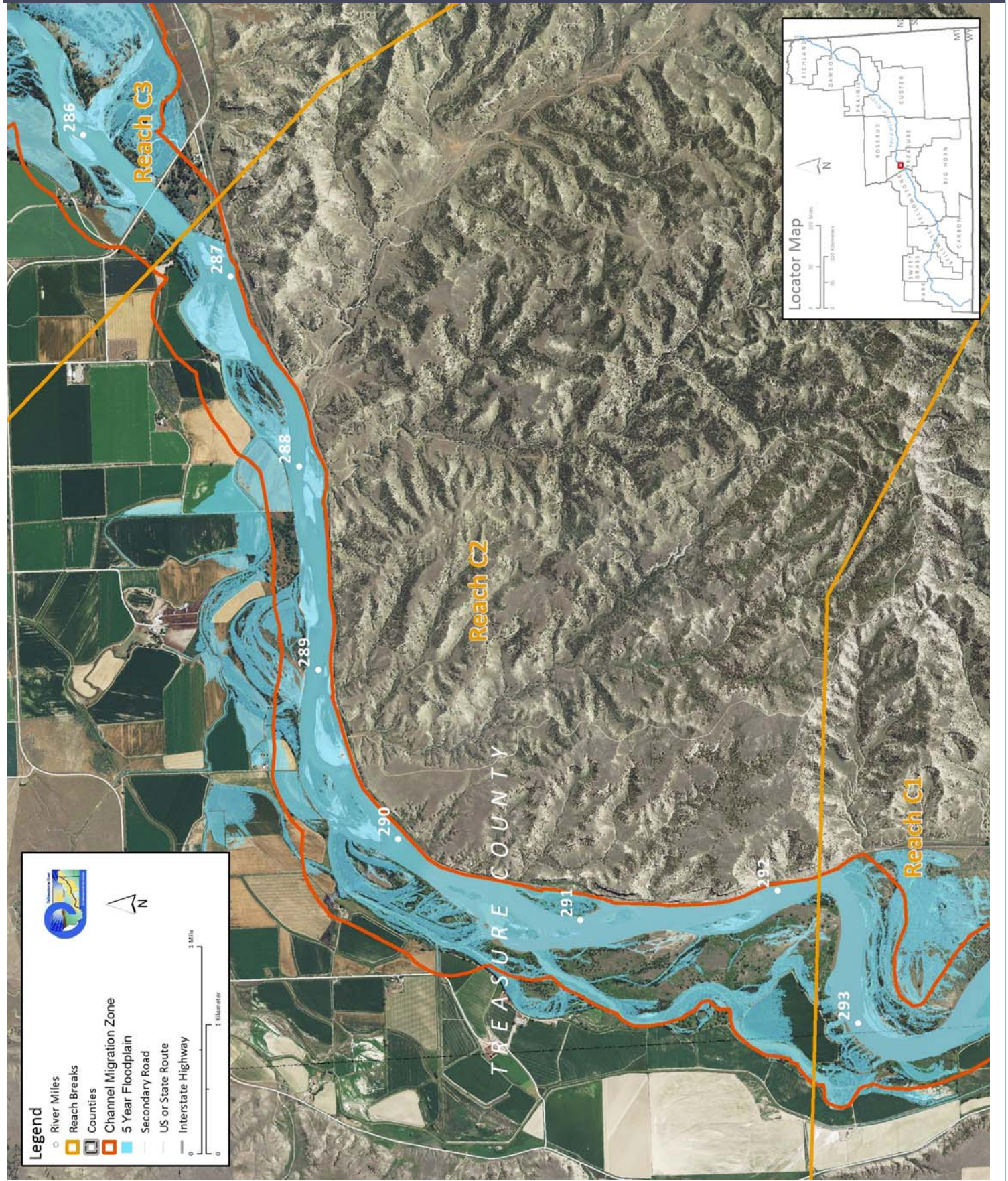
The following table summarizes some key CEA results that have been used to describe overall condition and types of human influences affecting the river. The values are specific to this single reach. Blanks indicate that a particular value was not available for this area. This information is consolidated from a large dataset that is presented in more detail in the full reach narrative report.

Discharge	Undev.	Developed	% Change	"Undeveloped" flows represent conditions prior to significant human development, whereas "developed" flows reflect the current condition of both consumptive and non-consumptive water use.		
2 Year (cfs)	60,900	47,100	-22.7%			
100 Year (cfs)	119,000	100,000	-16.0%			
Bankfull Channel Area (Ac)	1950	1976	1995	2001	1950-2001	Bankfull channel area is the total footprint of the river inundated at approx. the 2-year flood.
	596.8	631.0	578.5	590.0	-6.8	
Physical Features	2011 Length (ft)	% of Bankline	2001-2011 Change	There are additional types of bank armor such as car bodies and steel retaining walls, but they are relatively minor.		
Rock RipRap	25,536	43.9%	10			
Concrete Riprap	0	0.0%	0			
Flow Deflectors	1,256	2.2%	1,256			
Total	26,792	46.0%	1,266			
Length of Side Channels Blocked (ft)	Pre-1950s	Post-1950s	Numerous side channels have been blocked by small dikes.			
	1,014	10,614				
Floodplain Turnover	1950 - 1976	1976 - 2001	1950-2001 In-channel riparian encroachment (negative number indicates retreat)		The rate of floodplain turnover reflects how many acres of land are eroded by the river. Turnover is associated with the creation of riparian habitat.	
Total Acres	112.9	81.5	38.77 acres			
Acres/Year	4.3	3.3				
Acres/Year/Valley Mile	0.8	0.6				
Open Bar Area	Point Bars	Bank Attached	Mid-Channel	Total	The type and extent of open sand and gravel bars reflect in-stream habitat conditions that can be important to fish, amphibians, and ground-nesting birds such as least terns.	
Change in Area '50 - '01 (Ac)	-22.4	9.7	68.5	55.8		
Floodplain Isolation	Acres	% of FP	Floodplain isolation refers to area that historically was flooded, but has become isolated do to flow alterations or physical features such as levees.			
5 Year	959.1	59%				
100 Year	624.5	18%				
Restricted Migration Area	Acres	% of CMZ	Channel Migration Zone restrictions refer to the area and percent of the CMZ that has been isolated by features such as bank armor, dikes, levees, and transportation embankments.			
	167.6	10%				
Land Use	1950	2011	1950	2011	Changes in land use reflect the development of the river corridor through time. The irrigated agricultural are is a sub-set of the mapped agricultural land.	
Agricultural Land (Ac)	5,141.4	5,310.8	Flood (Ac)	2,464.8	2,393.8	
Ag. Infrastructure (Ac)	68.7	189.6	Sprinkler (Ac)	0.0	79.1	
Exurban (Ac)	0.0	4.8	Pivot (Ac)	0.0	137.6	
Urban (Ac)	0.0	0.0				
Transportation (Ac)	56.9	53.6				
1950s Riparian Vegetation Converted to a Developed Land Use (ac)	To Irrigated	To Other Use	Total Rip. Converted	% of 1950s Rip.	Changes in the extents of riparian vegetation are influenced by land use changes within the corridor.	
	161.7	0.0	161.7	18.0%		
National Wetlands Inventory	Acres	Acres per Valley Mi	Total Wetland Acres	Wetlands units summarized from National Wetlands Inventory Mapping include Riverine (typically open water sloughs), Emergent (marshes and wet meadows) and Shrub-Scrub (open bar areas with colonizing woody vegetation).		
Riverine	2.3	0.4	104.1			
Emergent	68.1	12.7				
Scrub/Shrub	33.6	6.3				
Russian Olive (2001) (Appx. 100-yr Floodplain)	Acres	%	Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.			
	45.8	0.9%				
Riparian Forest at low risk of Cowbird Parasitism (Ac/Valley Mile)	1950	1976	2001	Change 1950-2011	Cowbirds are associated with agricultural and residential development, displacing native bird species by parasitizing their nests.	
	36.8	6.5	6.0	-30.8		

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



County	Treasure	Upstream River Mile	286.8
Classification	UA: Unconfined anabranching	Downstream River Mile	282
General Location	To Yellowstone Diversion	Length	4.80 mi (7.72 km)

Narrative Summary

Reach C3 is located in Treasure County, between Myers Bridge and the Yellowstone Ditch Diversion, at the head of the Mission Valley. The reach is a 4.4 mile long Unconfined Anabranching reach type, extending from RM 282.0 to RM 286.4. In this area the alluvial valley bottom is approximately 2.5 miles wide, and this broad valley configuration is due to the presence of relatively erodible Cretaceous-age Bearpaw Shale in the valley walls and valley floor on the west limb of the Porcupine Dome. The Bearpaw Shale consists of dark gray shale that is approximately 800 feet thick. The unit is commonly exposed in the valley walls where the Yellowstone valley bottom is anomalously wide, such as in the Mission and Hammond Valleys, indicating that it is erodible in comparison to the resistant sandstones that typically form the valley margin. Upstream of Myers Bridge, the river has undercut its right bank where Bearpaw Shale underlies Hell Creek sandstone. The rail line follows the river's edge on the sandstone, and land sliding on the shale horizon has resulted in extensive bank armoring to protect the rail line (Womack, 2001).

This reach was used by Koch (1977) to exemplify an especially dynamic river segment where the channel crosses the valley from one valley wall to another. Koch (1977) and Womack (2001) noted that in these areas, the Yellowstone River exhibits a particularly rich and diverse riparian zone.

There are over two miles of bank armor in the reach, all of which is rock riprap. A total of 25 percent of the bank is armored. In addition, approximately 31,000 linear feet of transportation encroachments and floodplain dikes were mapped in the reach. These floodplain features include floodplain dikes at Myers Bridge and the Yellowstone Ditch Diversion, and a long segment of railroad grade that is on a high terrace margin adjacent to an anabranching channel thread. Several of the floodplain dikes are protected by riprap. Land use is dominated by agriculture, with 33 acres of pivot irrigation development since 1950. Physical features such as bank armor, dikes, and levees have isolated 19 percent of the Channel Migration Zone in Reach C3.

The Yellowstone Ditch Diversion Dam is located at the lower end of Reach C3 at River Mile 282. The structure was built in 1909.

Even though Reach C3 has extensive armoring and diking throughout the reach, it has maintained substantial side channel connectivity.

Over 300 acres of 100-year floodplain has been isolated by human development, and all of that isolation is due to agricultural development on the north side of the river. The isolation reflects 12 percent of the total 100-year floodplain. The 5-year floodplain is even more affected; 65 percent of the historic 5-year floodplain is no longer inundated at that frequency. The loss of 5-year floodplain shows the strong imprint of flow alterations below the mouth of the Bighorn River and consequent development of those areas that are less frequently inundated; about 700 acres of currently irrigated areas are in the historic 5-year floodplain footprint.

Reach C3 shows a net encroachment of 192 acres of woody vegetation into the active channel corridor, suggesting that hydrologic alterations may have driven some channel narrowing since 1950. This is also supported by the loss of 121 acres of bankfull area between 1950 and 2001. This reflects encroachment of vegetation into the channel that has experienced a 20 percent reduction in channel forming (2-year) flow. There are about 21 acres of Russian olive in the reach. The reach supports about 30 acres of wetland per valley mile, which is a relatively dense wetland concentration for the corridor.

Reach C3 was sampled as part of the fisheries study. A total of 32 fish species were sampled in the reach and one of those species was Sauger, which has been identified by the Montana Natural Heritage Program as a Species of Concern (SOC).

Reach C3 was sampled as part of the avian study. A total of 39 bird species were identified in the reach. The average species richness in Reach C3 was 8.1, which indicates the average number of species observed during site visits to the reach in cottonwood habitats. The average species richness for sites evaluated is 8. Three bird species identified by the Montana Natural Heritage Program as Potential Species of Concern (PSOC) were also found, the Chimney Swift, the Ovenbird and the Plumbeous Vireo. One species identified as a Species of Concern (SOC) was documented, the Read-headed Woodpecker. In contrast to most other reaches, Reach C3 has seen an increase in the forested area that is at low risk of cowbird parasitism since 1950. At that time, there were 65 acres per valley mile of such forest, and that number increased to 82 acres per valley mile by 2001.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been major in this reach. The 2-year flood, which strongly influences overall channel form, has dropped by 23 percent. Low flows have also been impacted; severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 4,610 cfs to 2,950 cfs with human development, a reduction of 36 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,150 cfs under unregulated conditions to 3,320 cfs under regulated conditions at Reach C10 downstream where the analysis begins, a reduction of 46 percent.

CEA-Related observations in Reach C3 include:

- Influence of flow alterations on floodplain inundation and riparian extent
- Increase in area at low risk of cowbird parasitism with riparian encroachment

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach C3 include:

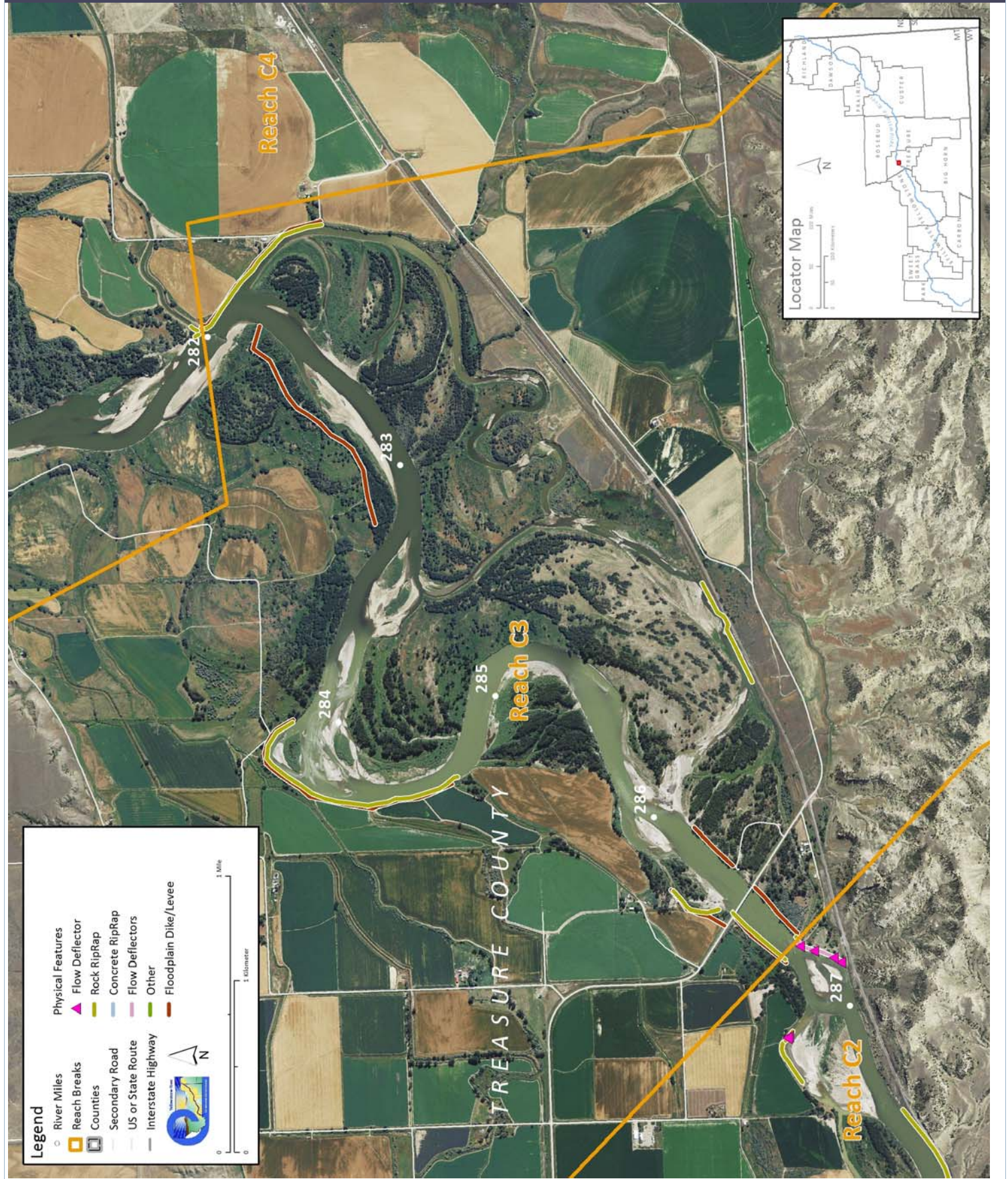
- Fish passage at Yellowstone Ditch Diversion RM 282
- Watercraft passage at Yellowstone Ditch Diversion at RM 282

- Irrigation diversion infrastructure management at Yellowstone Ditch Diversion at RM 282
- Russian olive removal

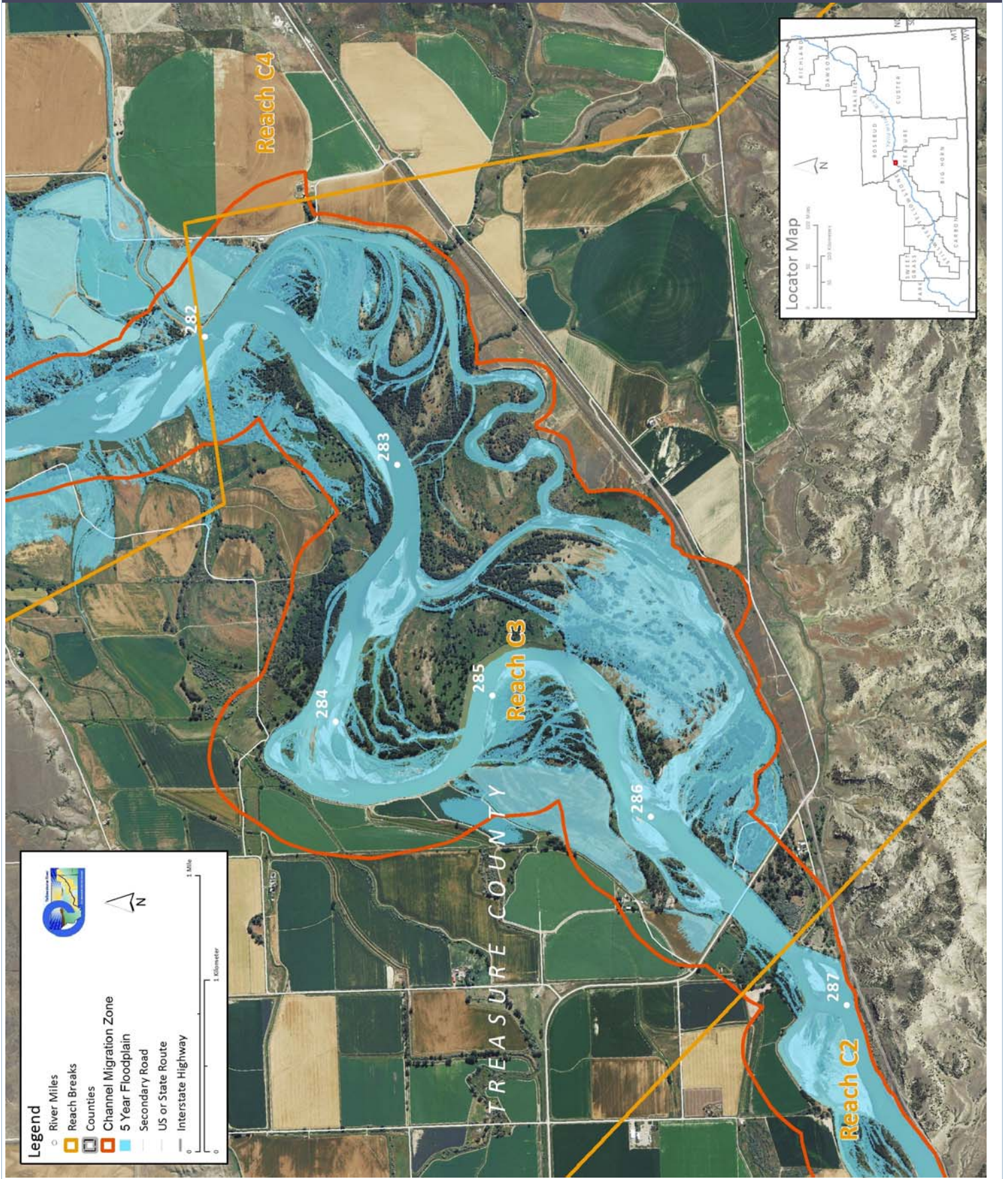
The following table summarizes some key CEA results that have been used to describe overall condition and types of human influences affecting the river. The values are specific to this single reach. Blanks indicate that a particular value was not available for this area. This information is consolidated from a large dataset that is presented in more detail in the full reach narrative report.

Discharge	Undev.	Developed	% Change	"Undeveloped" flows represent conditions prior to significant human development, whereas "developed" flows reflect the current condition of both consumptive and non-consumptive water use.		
2 Year (cfs)	60,900	47,100	-22.7%			
100 Year (cfs)	119,000	100,000	-16.0%			
Bankfull Channel Area (Ac)	1950	1976	1995	2001	1950-2001	Bankfull channel area is the total footprint of the river inundated at approx. the 2-year flood.
	723.7	682.3	598.0	603.1	-120.6	
Physical Features	2011 Length (ft)	% of Bankline	2001-2011 Change	There are additional types of bank armor such as car bodies and steel retaining walls, but they are relatively minor.		
Rock RipRap	12,618	25.4%	62			
Concrete Riprap	0	0.0%	0			
Flow Deflectors	0	0.0%	0			
Total	12,618	25.4%	62			
Length of Side Channels Blocked (ft)	Pre-1950s	Post-1950s	Numerous side channels have been blocked by small dikes.			
	0	0				
Floodplain Turnover	1950 - 1976	1976 - 2001	1950-2001 In-channel riparian encroachment (negative number indicates retreat)		The rate of floodplain turnover reflects how many acres of land are eroded by the river. Turnover is associated with the creation of riparian habitat.	
Total Acres	178.8	94.8	192.11 acres			
Acres/Year	6.9	3.8				
Acres/Year/Valley Mile	2.2	1.2				
Open Bar Area	Point Bars	Bank Attached	Mid-Channel	Total	The type and extent of open sand and gravel bars reflect in-stream habitat conditions that can be important to fish, amphibians, and ground-nesting birds such as least terns.	
Change in Area '50 - '01 (Ac)	-70.2	56.5	-4.4	-18		
Floodplain Isolation	Acres	% of FP	Floodplain isolation refers to area that historically was flooded, but has become isolated do to flow alterations or physical features such as levees.			
5 Year	1,197.5	65%				
100 Year	313.7	12%				
Restricted Migration Area	Acres	% of CMZ	Channel Migration Zone restrictions refer to the area and percent of the CMZ that has been isolated by features such as bank armor, dikes, levees, and transportation embankments.			
	476.5	19%				
Land Use	1950	2011	1950	2011	Changes in land use reflect the development of the river corridor through time. The irrigated agricultural are is a sub-set of the mapped agricultural land.	
Agricultural Land (Ac)	3,275.6	3,177.4	Flood (Ac)	1,881.6	1,777.6	
Ag. Infrastructure (Ac)	41.3	108.4	Sprinkler (Ac)	0.0	0.0	
Exurban (Ac)	0.0	7.8	Pivot (Ac)	0.0	33.2	
Urban (Ac)	0.0	0.0				
Transportation (Ac)	38.9	47.7				
1950s Riparian Vegetation Converted to a Developed Land Use (ac)	To Irrigated	To Other Use	Total Rip. Converted	% of 1950s Rip.	Changes in the extents of riparian vegetation are influenced by land use changes within the corridor.	
	75.3	2.4	77.7	8.0%		
National Wetlands Inventory	Acres	Acres per Valley Mi	Total Wetland Acres	Wetlands units summarized from National Wetlands Inventory Mapping include Riverine (typically open water sloughs), Emergent (marshes and wet meadows) and Shrub-Scrub (open bar areas with colonizing woody vegetation).		
Riverine	6.4	2.0	120.2			
Emergent	90.6	28.7				
Scrub/Shrub	23.2	7.4				
Russian Olive (2001) (Appx. 100-yr Floodplain)	Acres	%	Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.			
	21.2	0.6%				
Riparian Forest at low risk of Cowbird Parasitism (Ac/Valley Mile)	1950	1976	2001	Change 1950-2011	Cowbirds are associated with agricultural and residential development, displacing native bird species by parasitizing their nests.	
	64.9	69.7	81.8	16.9		

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



County	Treasure	Upstream River Mile	282
Classification	PCB: Partially confined braided	Downstream River Mile	278.2
General Location	Below Yellowstone Diversion	Length	3.80 mi (6.12 km)

Narrative Summary

Reach C4 is located in Treasure County, below Yellowstone Diversion Dam. Amelia Island Fishing Access Site is located in the middle of the reach. The reach is a 3.8 mile long Partially Confined Braided reach type, indicating some influence of the valley wall along with fairly common mid-channel bars. Within this reach the river trends toward and along the north valley wall near Hysham.

There are almost 5,000 feet of bank armor in the reach, all of which is rock riprap protecting flood irrigated fields at RM 279. Channel migration at the upstream end of this armor will pose risk of flanking as the bankline continues to erode to the south. A total of 13 percent of the bank is armored. Land use is dominated by agriculture, with 371 acres of pivot irrigation development since 1950. Physical features such as bank armor, dikes, and levees have isolated 9 percent of the Channel Migration Zone in Reach C4. All of the armor is protecting agricultural land. There are 22 acres of land in the CMZ under pivot irrigation.

Reach C4 has lost 8,200 feet of side channel length since 1950; however none of those lost channels were mapped as intentionally blocked.

Reach C4 shows a reduction in floodplain turnover rates from 3.4 acres/valley mile/year from 1950-1976 to 1.8 acres/valley mile/year from 1976-2001. There has also been a net loss of 15.5 acres of mid-channel bars since 1950, and a 10 acre increase in bank-attached bars, indicating a loss in overall low flow channel complexity. About 120 acres of riparian area has been cleared for irrigation, which is 18 percent of the total mapped 1950 riparian zone. There are 34 acres of Russian olive in the reach.

Over 300 acres of 100-year floodplain has been isolated by human development, and all of that isolation is due to agricultural development on the south side of the river. The isolation reflects 20 percent of the total 100-year floodplain. The 5-year floodplain is even more affected; 35 percent of the historic 5-year floodplain is no longer inundated at that frequency. The isolation of the historic 5-year floodplain, which is due primarily to flow alterations, has been associated with increased development in these areas; currently there are about 160 acres of flood irrigated land and 40 acres of pivot within the historic 5-year floodplain.

Reach C4 was sampled as part of the avian study. A total of 39 bird species were identified in the reach. Two bird species identified by the Montana Natural Heritage Program as Potential Species of Concern (PSOC) were also found, the Chimney Swift, and the Ovenbird. In contrast to most other reaches, Reach C4 has seen an increase in the forested area that is at low risk of cowbird parasitism since 1950. At that time, there were 43 acres per valley mile of such forest, and that number increased to 138 acres per valley mile by 2001.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been major in this reach. The 2-year flood, which strongly influences overall channel form, has dropped by 23 percent. Low flows have also been impacted; severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 4,620 cfs to 2,960 cfs with human development, a reduction of 36 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,150 cfs under unregulated conditions to 3,320 cfs under regulated conditions at Reach C10 downstream where the analysis begins, a reduction of 46 percent.

CEA-Related observations in Reach C4 include:

- Influence of flow alterations on floodplain inundation and riparian extent
- Increase in area at low risk of cowbird parasitism with riparian encroachment

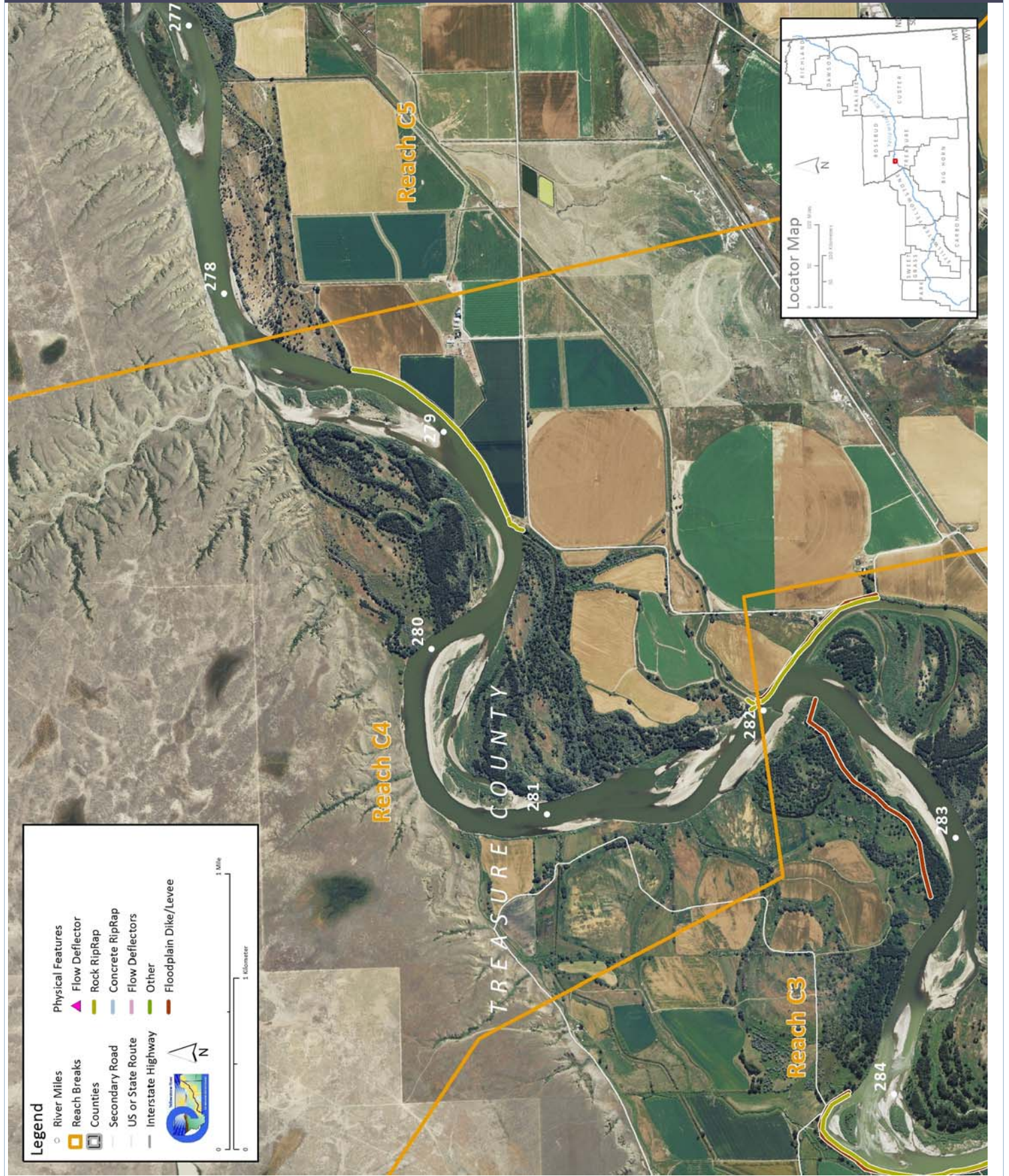
Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach C4 include:

- Russian olive removal

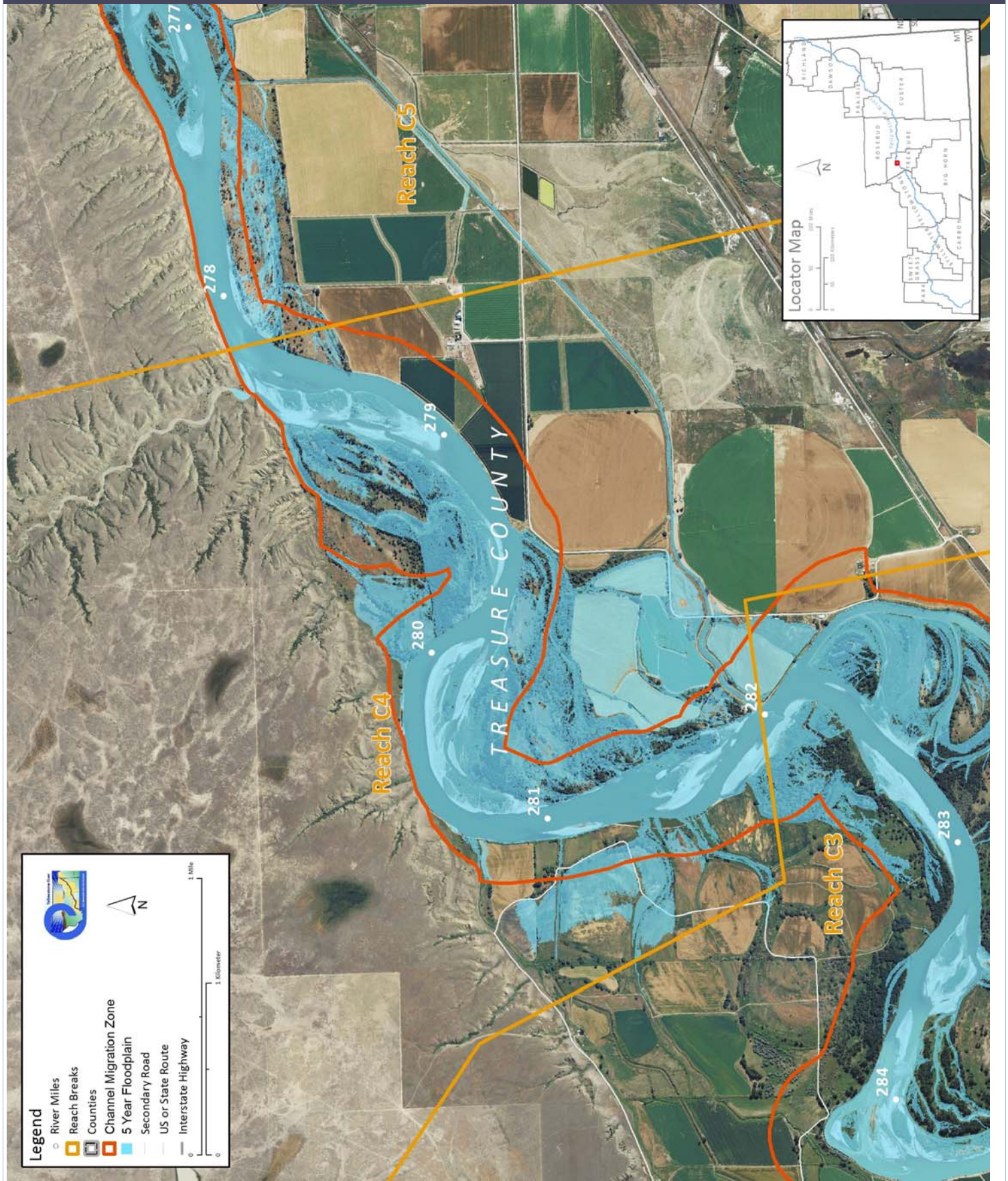
The following table summarizes some key CEA results that have been used to describe overall condition and types of human influences affecting the river. The values are specific to this single reach. Blanks indicate that a particular value was not available for this area. This information is consolidated from a large dataset that is presented in more detail in the full reach narrative report.

Discharge	Undev.	Developed	% Change	"Undeveloped" flows represent conditions prior to significant human development, whereas "developed" flows reflect the current condition of both consumptive and non-consumptive water use.		
2 Year (cfs)	60,900	47,100	-22.7%			
100 Year (cfs)	120,000	100,000	-16.7%			
Bankfull Channel Area (Ac)	1950	1976	1995	2001	1950-2001	Bankfull channel area is the total footprint of the river inundated at approx. the 2-year flood.
	341.3	398.9	397.1	391.2	49.9	
Physical Features	2011 Length (ft)	% of Bankline	2001-2011 Change	There are additional types of bank armor such as car bodies and steel retaining walls, but they are relatively minor.		
Rock RipRap	4,971	12.5%	595			
Concrete Riprap	0	0.0%	0			
Flow Deflectors	0	0.0%	0			
Total	4,971	12.5%	595			
Length of Side Channels Blocked (ft)	Pre-1950s	Post-1950s	Numerous side channels have been blocked by small dikes.			
	0	0				
Floodplain Turnover	1950 - 1976	1976 - 2001	1950-2001 In-channel riparian encroachment (negative number indicates retreat)		The rate of floodplain turnover reflects how many acres of land are eroded by the river. Turnover is associated with the creation of riparian habitat.	
Total Acres	88.4	46.0	12.38 acres			
Acres/Year	3.4	1.8				
Acres/Year/Valley Mile	1.4	0.8				
Open Bar Area	Point Bars	Bank Attached	Mid-Channel	Total	The type and extent of open sand and gravel bars reflect in-stream habitat conditions that can be important to fish, amphibians, and ground-nesting birds such as least terns.	
Change in Area '50 - '01 (Ac)	0	10.1	-15.5	-5.4		
Floodplain Isolation	Acres	% of FP	Floodplain isolation refers to area that historically was flooded, but has become isolated do to flow alterations or physical features such as levees.			
5 Year	363.6	35%				
100 Year	324.1	20%				
Restricted Migration Area	Acres	% of CMZ	Channel Migration Zone restrictions refer to the area and percent of the CMZ that has been isolated by features such as bank armor, dikes, levees, and transportation embankments.			
	114.4	9%				
Land Use	1950	2011	1950	2011	Changes in land use reflect the development of the river corridor through time. The irrigated agricultural are is a sub-set of the mapped agricultural land.	
Agricultural Land (Ac)	2,756.2	2,680.3	Flood (Ac)	1,279.5	807.6	
Ag. Infrastructure (Ac)	66.2	36.7	Sprinkler (Ac)	0.0	0.0	
Exurban (Ac)	0.0	0.0	Pivot (Ac)	0.0	370.8	
Urban (Ac)	0.0	0.0				
Transportation (Ac)	30.9	30.9				
1950s Riparian Vegetation Converted to a Developed Land Use (ac)	To Irrigated	To Other Use	Total Rip. Converted	% of 1950s Rip.	Changes in the extents of riparian vegetation are influenced by land use changes within the corridor.	
	116.0	3.3	119.3	18.0%		
National Wetlands Inventory	Acres	Acres per Valley Mi	Total Wetland Acres	Wetlands units summarized from National Wetlands Inventory Mapping include Riverine (typically open water sloughs), Emergent (marshes and wet meadows) and Shrub-Scrub (open bar areas with colonizing woody vegetation).		
Riverine	1.8	0.8	57.5			
Emergent	30.7	12.9				
Scrub/Shrub	25.1	10.6				
Russian Olive (2001) (Appx. 100-yr Floodplain)	Acres	%	Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.			
	33.9	1.6%				
Riparian Forest at low risk of Cowbird Parasitism (Ac/Valley Mile)	1950	1976	2001	Change 1950-2011	Cowbirds are associated with agricultural and residential development, displacing native bird species by parasitizing their nests.	
	43.3	53.7	138.1	94.8		

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



County	Treasure	Upstream River Mile	278.2
Classification	PCS: Partially confined straight	Downstream River Mile	275
General Location	Hysham	Length	3.20 mi (5.15 km)

Narrative Summary

Reach C5 is located north of Hysham. The reach is a 3.2 mile long Partially Confined Straight reach type, as the river flows straight eastward along the northern bluff line.

There is no mapped bank armor in the reach.

One side channel in the upper part of the reach has had land use encroachment and appears to have potentially been blocked prior to 1950. It is a small seasonal channel, however, and thus may have decayed naturally.

Land use is dominated by agriculture, with 181 acres of pivot irrigation development since 1950. There are about 260 acres of flood irrigated land within the CMZ, but due to the lack of bank armor, none of the CMZ has become restricted.

Two ice jams have been recorded in Reach C5. The first was in January 1997, and the second was a break-up event in mid-March of 2003.

Reach C5 shows a net loss of 15 acres of gravel bars 1950. Most of that loss has been associated with mid-channel bars. About 23 acres of riparian area has been cleared for irrigation, which is 6 percent of the total mapped 1950 riparian zone. There are 22 acres of Russian olive in the reach.

About 19 percent of the total 100-year floodplain has become isolated due to human development. The 5-year floodplain is even more affected; 68 percent of the historic 5-year floodplain is no longer inundated at that frequency. The isolation of the historic 5-year floodplain, due primarily to flow alterations, has been associated with increased development in these areas; currently there are about 380 acres of flood irrigated land within the historic 5-year floodplain. The vast majority of isolated 5-year floodplain area is within flood irrigated fields south of the river. The isolation is due to flow alterations.

Reach C5 was sampled as part of the avian study. A total of 35 bird species were identified in the reach. One bird species identified by the Montana Natural Heritage Program as Potential Species of Concern (PSOC) was found, the Ovenbird. Reach C5 has seen a decrease in the forested area that is at low risk of cowbird parasitism since 1950. At that time, there were 41 acres per valley mile of such forest, and that number decreased to 26 acres per valley mile by 2001.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been major in this reach. The 2-year flood, which strongly influences overall channel form, has dropped by 23 percent. Low flows have also been impacted; severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 4,630 cfs to 2,960 cfs with human development, a reduction of 36 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,150 cfs under unregulated conditions to 3,320 cfs under regulated conditions at Reach C10 downstream where the analysis begins, a reduction of 46 percent.

CEA-Related observations in Reach C5 include:

- Influence of flow alterations on floodplain inundation

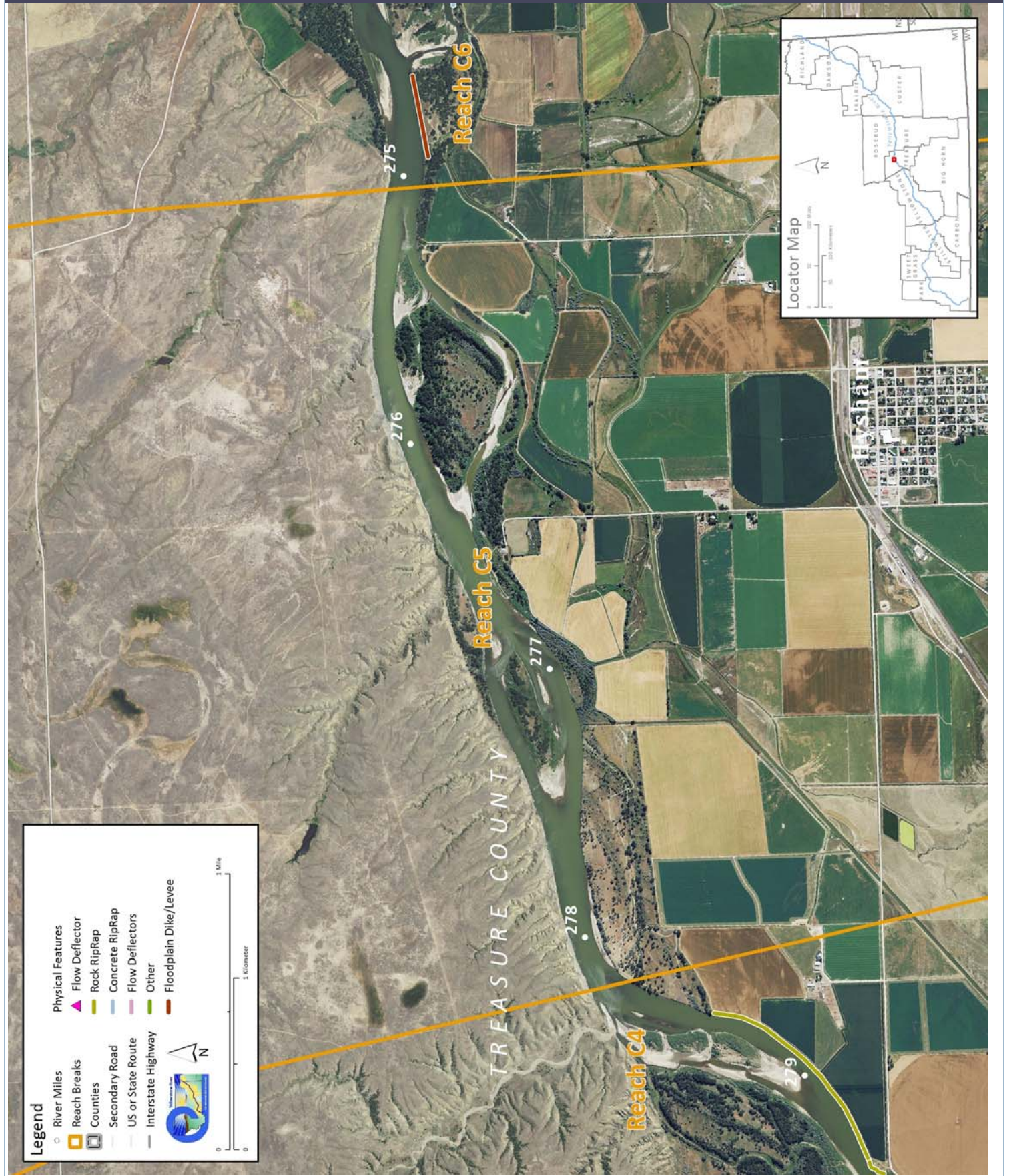
Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach C5 include:

- Russian olive removal

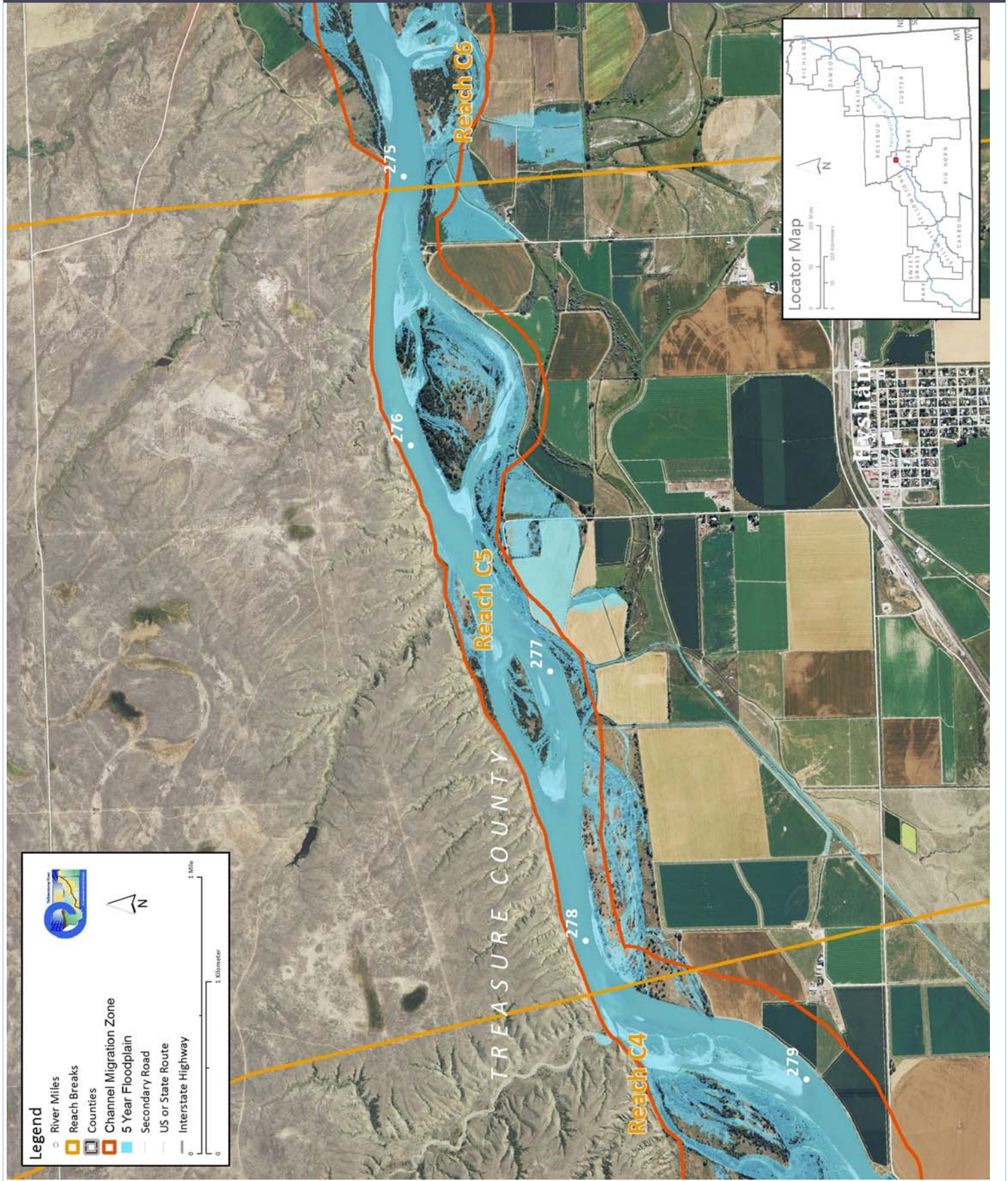
The following table summarizes some key CEA results that have been used to describe overall condition and types of human influences affecting the river. The values are specific to this single reach. Blanks indicate that a particular value was not available for this area. This information is consolidated from a large dataset that is presented in more detail in the full reach narrative report.

Discharge	Undev.	Developed	% Change	"Undeveloped" flows represent conditions prior to significant human development, whereas "developed" flows reflect the current condition of both consumptive and non-consumptive water use.		
2 Year (cfs)	60,900	47,100	-22.7%			
100 Year (cfs)	120,000	100,000	-16.7%			
Bankfull Channel Area (Ac)	1950	1976	1995	2001	1950-2001	Bankfull channel area is the total footprint of the river inundated at approx. the 2-year flood.
	317.0	321.7	312.7	318.9	1.8	
Physical Features	2011 Length (ft)	% of Bankline	2001-2011 Change	There are additional types of bank armor such as car bodies and steel retaining walls, but they are relatively minor.		
Rock RipRap	0	0.0%	0			
Concrete Riprap	0	0.0%	0			
Flow Deflectors	0	0.0%	0			
Total	0	0.0%	0			
Length of Side Channels Blocked (ft)	Pre-1950s	Post-1950s	Numerous side channels have been blocked by small dikes.			
	8,829	0				
Floodplain Turnover	1950 - 1976	1976 - 2001	1950-2001 In-channel riparian encroachment (negative number indicates retreat)		The rate of floodplain turnover reflects how many acres of land are eroded by the river. Turnover is associated with the creation of riparian habitat.	
Total Acres	33.5	24.0	14.76 acres			
Acres/Year	1.3	1.0				
Acres/Year/Valley Mile	0.4	0.3				
Open Bar Area	Point Bars	Bank Attached	Mid-Channel	Total	The type and extent of open sand and gravel bars reflect in-stream habitat conditions that can be important to fish, amphibians, and ground-nesting birds such as least terns.	
Change in Area '50 - '01 (Ac)	-5.7	3.3	-12.1	-14.5		
Floodplain Isolation	Acres	% of FP	Floodplain isolation refers to area that historically was flooded, but has become isolated do to flow alterations or physical features such as levees.			
5 Year	635.6	68%				
100 Year	321.5	19%				
Restricted Migration Area	Acres	% of CMZ	Channel Migration Zone restrictions refer to the area and percent of the CMZ that has been isolated by features such as bank armor, dikes, levees, and transportation embankments.			
Land Use	1950	2011	1950	2011	Changes in land use reflect the development of the river corridor through time. The irrigated agricultural are is a sub-set of the mapped agricultural land.	
Agricultural Land (Ac)	3,273.5	3,245.1	Flood (Ac)	1,866.0	1,492.2	
Ag. Infrastructure (Ac)	66.1	69.8	Sprinkler (Ac)	0.0	0.0	
Exurban (Ac)	0.0	14.6	Pivot (Ac)	0.0	181.2	
Urban (Ac)	29.6	29.5				
Transportation (Ac)	32.6	32.6				
1950s Riparian Vegetation Converted to a Developed Land Use (ac)	To Irrigated	To Other Use	Total Rip. Converted	% of 1950s Rip.	Changes in the extents of riparian vegetation are influenced by land use changes within the corridor.	
	22.8	0.0	22.8	6.0%		
National Wetlands Inventory	Acres	Acres per Valley Mi	Total Wetland Acres	Wetlands units summarized from National Wetlands Inventory Mapping include Riverine (typically open water sloughs), Emergent (marshes and wet meadows) and Shrub-Scrub (open bar areas with colonizing woody vegetation).		
Riverine	13.6	4.5	64.0			
Emergent	43.6	14.4				
Scrub/Shrub	6.9	2.3				
Russian Olive (2001) (Appx. 100-yr Floodplain)	Acres	%	Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.			
	22.4	0.8%				
Riparian Forest at low risk of Cowbird Parasitism (Ac/Valley Mile)	1950	1976	2001	Change 1950-2011	Cowbirds are associated with agricultural and residential development, displacing native bird species by parasitizing their nests.	
	41.2	21.1	26.4	-14.8		

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



County	Treasure	Upstream River Mile	275
Classification	UA: Unconfined anabranching	Downstream River Mile	269.4
General Location	Mission Valley	Length	5.60 mi (9.01 km)

Narrative Summary

Reach C6 is located in the Mission Valley north of Hysham. The reach is a 5.6 mile long Unconfined Anabranching reach type, indicating minimal valley wall influence and extensive side channels and forested islands. In this area the alluvial valley bottom is approximately 2.5 miles wide, and this broad valley has formed in the relatively erodible Cretaceous-age Bearpaw Shale.

There are just over 3,000 feet of bank armor in the reach, which covers 5.1 percent of the total bankline. About 600 feet of a floodplain dike at RM 273.2R appears to have been eroded out since 2001.

Almost 11,000 feet of side channels have been blocked by physical features in the reach since 1950. One floodplain dike that blocked a side channel at RM 227.8L in 2001 was eroded out and has since been rebuilt. Additional side channel length has been lost passively, overall, there has been about a three mile reduction in side channel length in this reach since 1950.

About 20 percent of the total 100-year floodplain has become isolated due to human development. The 5-year floodplain is even more affected; 70 percent of the historic 5-year floodplain is no longer inundated at that frequency. The isolation of the historic 5-year floodplain, due primarily to flow alterations, has been associated with increased development in these areas; currently there are about 650 acres of flood irrigated land and 200 acres of pivot land within the historic 5-year floodplain. The vast majority of isolated 5-year floodplain area is within irrigated fields south of the river, and the isolation appears to be due to both flow alterations and agricultural dikes.

Land use is dominated by agriculture, with 188 acres of pivot irrigation development since 1950. There are about 260 acres of flood irrigated land within the CMZ, but due to the lack of bank armor, none of the CMZ has become restricted.

Riparian mapping data show a net gain of 158 acres of woody vegetation into the active channel corridor since 1950. This has occurred both on migrating point bars that have become vegetated, as well as within abandoned side channels. Since 1950, the total area of open timber increased by approximately 250 acres. There are 40 acres of Russian olive in the reach.

Reach C6 was sampled as part of the fisheries study. A total of 26 fish species were sampled in the reach.

Reach C6 was sampled as part of the avian study. A total of 32 bird species were identified in the reach. Two bird species identified by the Montana Natural Heritage Program as Potential Species of Concern (PSOC) were found, the Ovenbird, and the Chimney Swift. In contrast to most reaches, Reach C6 has seen an increase in the forested area that is at low risk of cowbird parasitism since 1950. At that time, there were 55 acres per valley mile of such forest, and that number increased to 106 acres per valley mile by 2001.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been major in this reach. The 2-year flood, which strongly influences overall channel form, has dropped by 23 percent. Low flows have also been impacted; severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 4,630 cfs to 2,960 cfs with human development, a reduction of 36 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,150 cfs under unregulated conditions to 3,320 cfs under regulated conditions at Reach C10 downstream where the analysis begins, a reduction of 46 percent.

CEA-Related observations in Reach C6 include:

- Active and passive loss of thousands of feet of side channel
- Reconstruction of side-channel blockage following its failure post-2001.

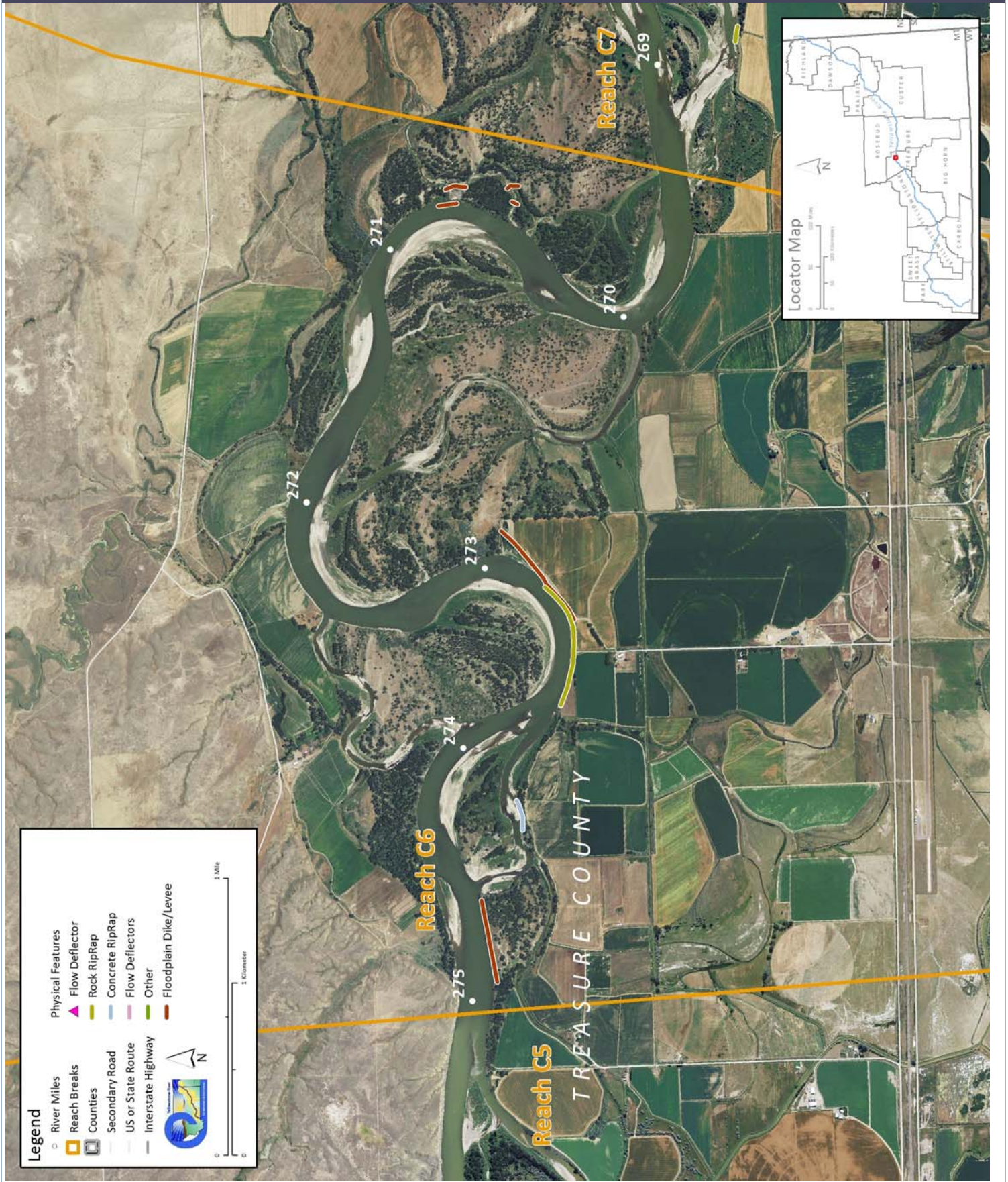
Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach C6 include:

- Side channel reactivation at RM 275R and RM 271L
- Russian olive removal

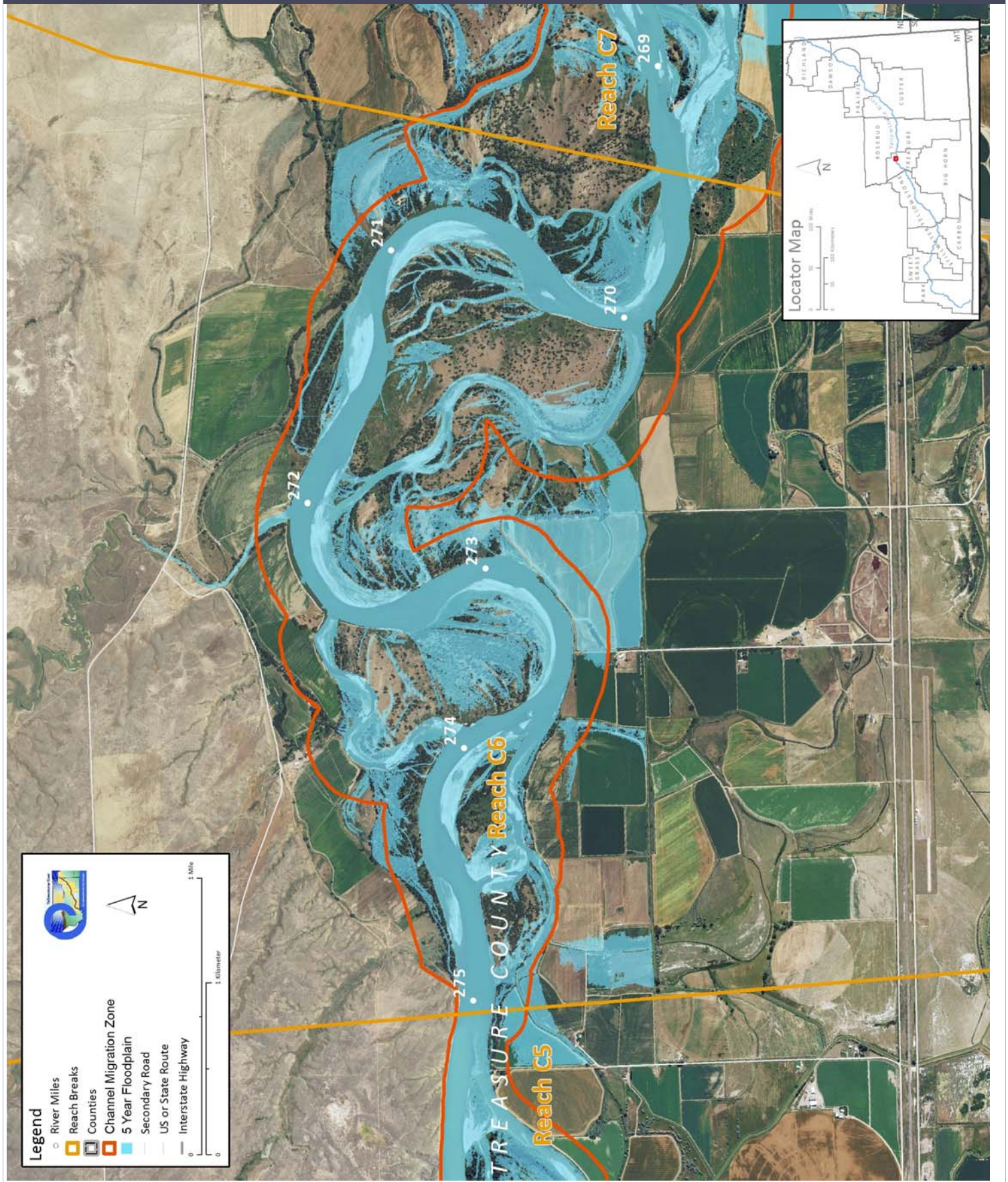
The following table summarizes some key CEA results that have been used to describe overall condition and types of human influences affecting the river. The values are specific to this single reach. Blanks indicate that a particular value was not available for this area. This information is consolidated from a large dataset that is presented in more detail in the full reach narrative report.

Discharge	Undev.	Developed	% Change	"Undeveloped" flows represent conditions prior to significant human development, whereas "developed" flows reflect the current condition of both consumptive and non-consumptive water use.		
2 Year (cfs)	61,000	47,000	-23.0%			
100 Year (cfs)	120,000	100,000	-16.7%			
Bankfull Channel Area (Ac)	1950	1976	1995	2001	1950-2001	Bankfull channel area is the total footprint of the river inundated at approx. the 2-year flood.
	654.7	611.0	545.8	548.9	-105.8	
Physical Features	2011 Length (ft)	% of Bankline	2001-2011 Change	There are additional types of bank armor such as car bodies and steel retaining walls, but they are relatively minor.		
Rock RipRap	2,478	4.1%	0			
Concrete Riprap	574	1.0%	0			
Flow Deflectors	0	0.0%	0			
Total	3,052	5.1%	0			
Length of Side Channels Blocked (ft)	Pre-1950s	Post-1950s	Numerous side channels have been blocked by small dikes.			
	0	10,910				
Floodplain Turnover	1950 - 1976	1976 - 2001	1950-2001 In-channel riparian encroachment (negative number indicates retreat)		The rate of floodplain turnover reflects how many acres of land are eroded by the river. Turnover is associated with the creation of riparian habitat.	
Total Acres	123.2	92.5	158.33 acres			
Acres/Year	4.7	3.7				
Acres/Year/Valley Mile	1.4	1.1				
Open Bar Area	Point Bars	Bank Attached	Mid-Channel	Total	The type and extent of open sand and gravel bars reflect in-stream habitat conditions that can be important to fish, amphibians, and ground-nesting birds such as least terns.	
Change in Area '50 - '01 (Ac)	-9.2	7.6	0.3	-1.4		
Floodplain Isolation	Acres	% of FP	Floodplain isolation refers to area that historically was flooded, but has become isolated do to flow alterations or physical features such as levees.			
5 Year	1,663.9	70%				
100 Year	731.8	20%				
Restricted Migration Area	Acres	% of CMZ	Channel Migration Zone restrictions refer to the area and percent of the CMZ that has been isolated by features such as bank armor, dikes, levees, and transportation embankments.			
	176.0	8%				
Land Use	1950	2011	1950	2011	Changes in land use reflect the development of the river corridor through time. The irrigated agricultural are is a sub-set of the mapped agricultural land.	
Agricultural Land (Ac)	3,400.5	3,584.1	Flood (Ac)	1,754.0	1,365.9	
Ag. Infrastructure (Ac)	34.4	48.3	Sprinkler (Ac)	0.0	0.0	
Exurban (Ac)	0.0	0.0	Pivot (Ac)	0.0	187.6	
Urban (Ac)	0.0	0.0				
Transportation (Ac)	16.0	16.6				
1950s Riparian Vegetation Converted to a Developed Land Use (ac)	To Irrigated	To Other Use	Total Rip. Converted	% of 1950s Rip.	Changes in the extents of riparian vegetation are influenced by land use changes within the corridor.	
	5.9	0.0	5.9	1.0%		
National Wetlands Inventory	Acres	Acres per Valley Mi	Total Wetland Acres	Wetlands units summarized from National Wetlands Inventory Mapping include Riverine (typically open water sloughs), Emergent (marshes and wet meadows) and Shrub-Scrub (open bar areas with colonizing woody vegetation).		
Riverine	19.0	5.5	130.5			
Emergent	89.1	25.8				
Scrub/Shrub	22.5	6.5				
Russian Olive (2001) (Appx. 100-yr Floodplain)	Acres	%	Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.			
	40.0	0.9%				
Riparian Forest at low risk of Cowbird Parasitism (Ac/Valley Mile)	1950	1976	2001	Change 1950-2011	Cowbirds are associated with agricultural and residential development, displacing native bird species by parasitizing their nests.	
	54.8	86.2	106.1	51.3		

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



County	Treasure	Upstream River Mile	269.4
Classification	UA: Unconfined anabranching	Downstream River Mile	260.3
General Location	Mission Valley	Length	9.10 mi (14.65 km)

Narrative Summary

Reach C7 is 9.1 miles long and is located in the Mission Valley downstream of Hysham. It is an Unconfined Anabranching reach type, which indicates little in the way of valley wall influence coupled with extensive side channels and forested islands. The Mission Valley owes its width to the presence of the Bearpaw Shale in the valley wall. Because this Cretaceous-age shale is relatively erodible and prone to mass failure, over time the river has been able to erode the valley wall more easily than in other reaches, creating the large distinct valleys present today. Because the Mission and Hammond Valleys are so wide, the river developed a complex series of channels and an expansive riparian forest. These reaches are especially rich in terms of aquatic and riparian habitat extent, diversity, and geomorphic complexity.

Just over 2,000 feet of rock riprap lines the banks in Reach C7, protecting 2.3 percent of the bankline.

Prior to 1950 about 4,200 feet of side channel had been blocked in Reach C7, and since then, floodplain dikes have blocked another three miles of side channel. Blocked side channels are located at RM 270.8L, RM 263.5R, and RM 261R. Even with all of the blockages, Reach C7 still has on the order of 17 miles of functional side channel length.

Reach C7 appears to be experiencing an active major avulsion just north of Sanders, where an anabranching channel has been developing into a primary channel over the last decade. As rerouting of the river would shorten the main thread by approximately 1.5 miles, an avulsion is very likely to occur in this area over the next several years. The rate at which the anabranching side channel fully captures the main thread will depend on flood events, as floods will accelerate the avulsion process. This avulsion would take pressure off of the main channel to the south, which is currently threatening the rail line at RM 264.8R and RM 266.2R.

About 9 percent of the total 100-year floodplain has become isolated due to human development in Reach C7. The 5-year floodplain is even more affected; 41 percent of the historic 5-year floodplain is no longer inundated at that frequency. The isolation of the historic 5-year floodplain, due primarily to flow alterations, has been associated with increased development in these areas; currently there are about 95 acres of flood irrigated land and 56 acres of pivot land within the historic 5-year floodplain. Much of the isolated 5-year floodplain area is within the active stream corridor and riparian zone however, exemplifying the potential impacts of flow alterations on frequent floodplain inundation.

Land use is dominated by agriculture, with 277 acres of pivot irrigation development since 1950. There are about 350 acres of flood irrigated land and 31 acres of pivot within the CMZ, but only 4 percent of the CMZ is restricted by physical features.

Riparian mapping data show a net gain of 780 acres of woody vegetation into the active channel corridor since 1950. This has occurred both on migrating point bars that have become vegetated, as well as within abandoned side channels. Reach C7 has about 90 acres of wetland per valley mile, which makes it one of the most concentrated wetland areas in the corridor. There are also 164 acres of Russian olive in the reach.

Reach C7 was sampled as part of the fisheries study. A total of 27 fish species were sampled in the reach, including Sauger, which are recognized by the Montana Natural Heritage Program as a Species of Concern (SOC).

Reach C7 was sampled as part of the avian study. A total of 69 bird species were identified in the reach. Four bird species identified by the Montana Natural Heritage Program as Potential Species of Concern (PSOC) were found, the Black and White Warbler, the Plumbeous Vireo, the Ovenbird, and the Chimney Swift. Two Species of Concern (SOC) were identified, the Black Billed Cuckoo and the Bobolink. Brown Headed Cowbirds were also present. Reach C7 has seen an increase in the forested area that is at low risk of cowbird parasitism since 1950. At that time, there were 86 acres per valley mile of such forest, and that number increased to 102 acres per valley mile by 2001.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been major in this reach. The 2-year flood, which strongly influences overall channel form, has dropped by 23 percent. Low flows have also been impacted; severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 4,680 cfs to 2,990 cfs with human development, a reduction of 36 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,150 cfs under unregulated conditions to 3,320 cfs under regulated conditions at Reach C10 downstream where the analysis begins, a reduction of 46 percent.

CEA-Related observations in Reach C7 include:

- Active and passive loss of thousands of feet of side channel

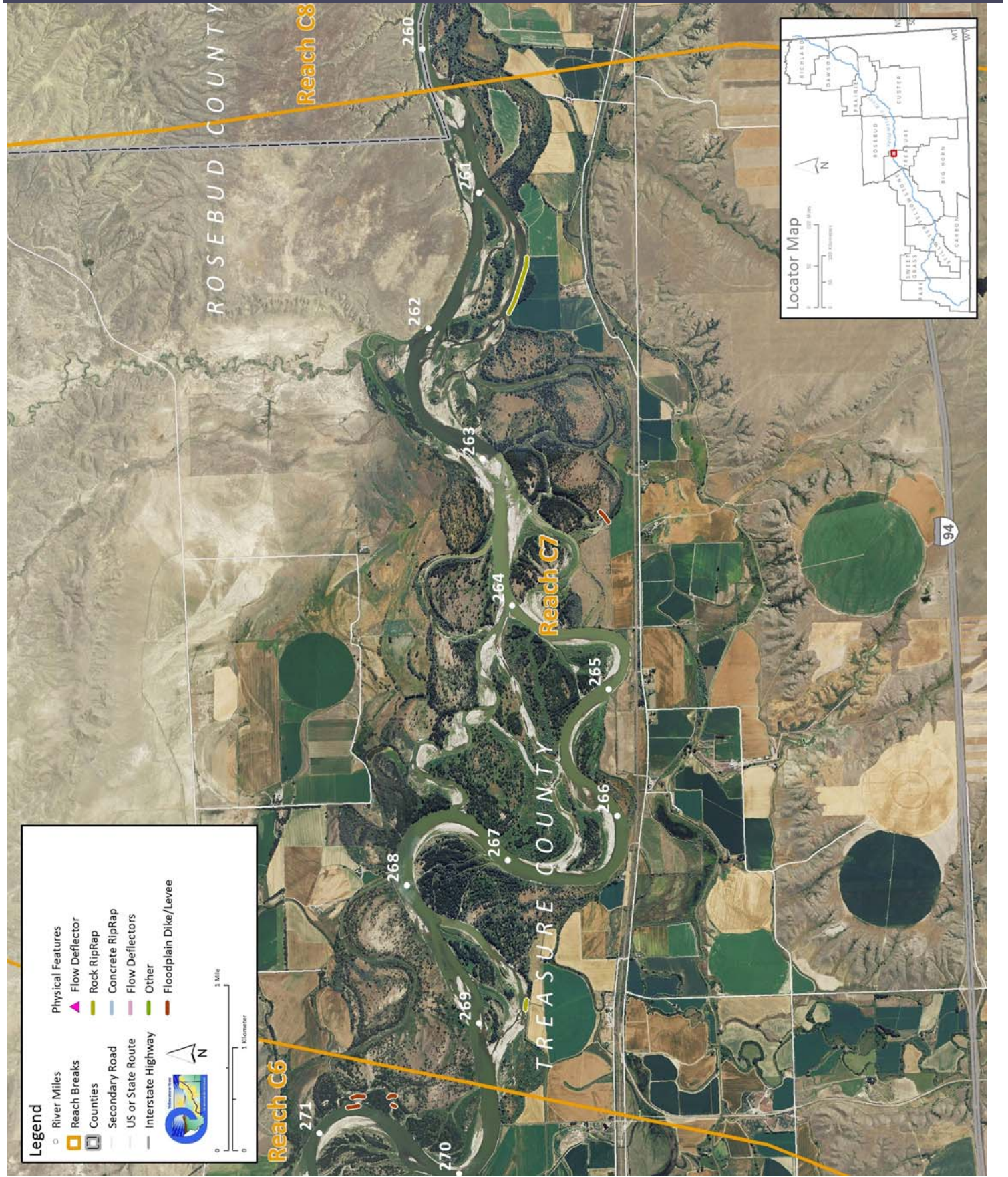
Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach C7 include:

- Side channel reactivation at RM 270.8L, RM 263.5R, and RM 261R
- Russian olive removal

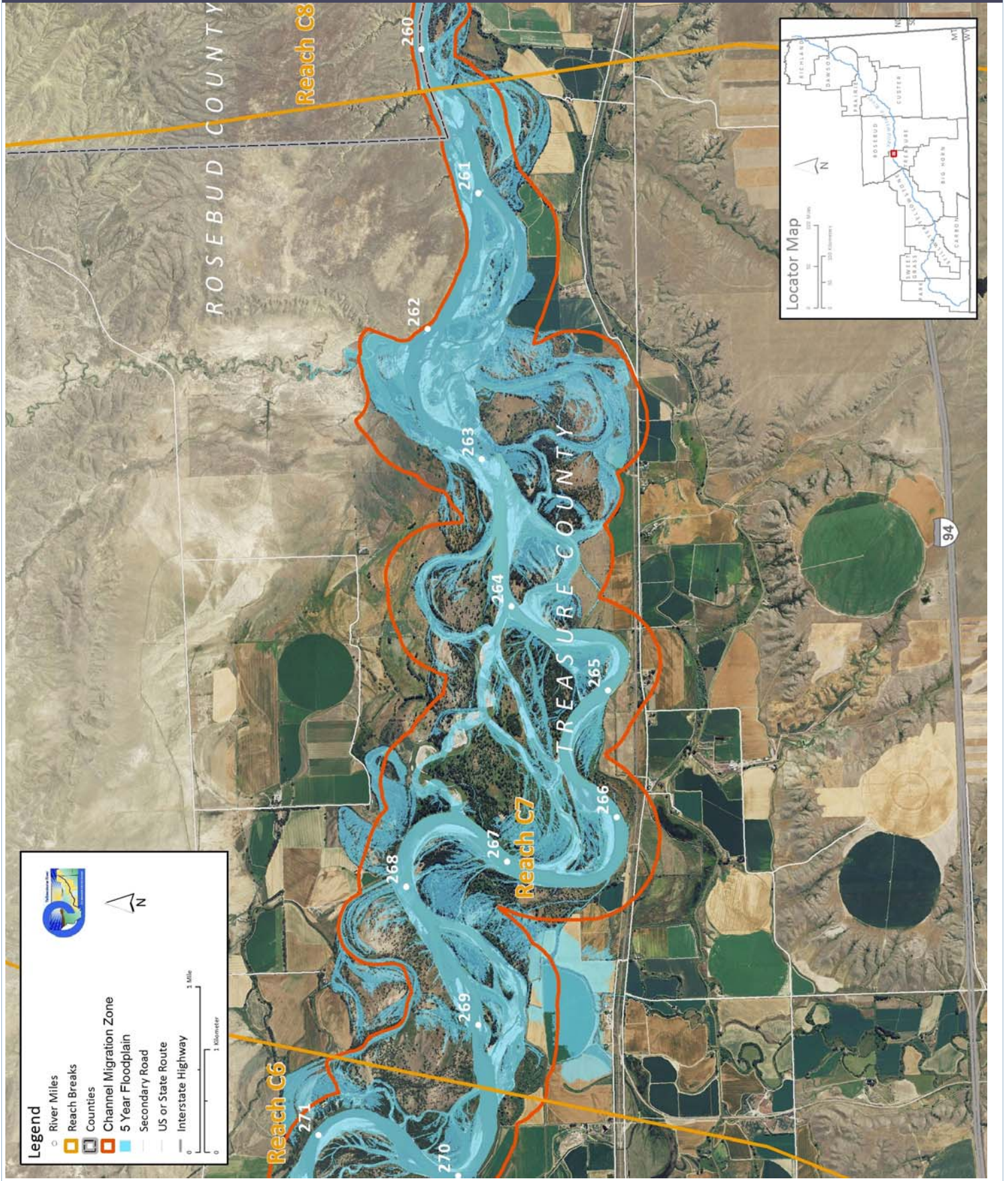
The following table summarizes some key CEA results that have been used to describe overall condition and types of human influences affecting the river. The values are specific to this single reach. Blanks indicate that a particular value was not available for this area. This information is consolidated from a large dataset that is presented in more detail in the full reach narrative report.

Discharge	Undev.	Developed	% Change	"Undeveloped" flows represent conditions prior to significant human development, whereas "developed" flows reflect the current condition of both consumptive and non-consumptive water use.		
2 Year (cfs)	61,100	47,000	-23.1%			
100 Year (cfs)	120,000	100,000	-16.7%			
Bankfull Channel Area (Ac)	1950	1976	1995	2001	1950-2001	Bankfull channel area is the total footprint of the river inundated at approx. the 2-year flood.
	1,264.9	1,329.6	1,230.4	1,217.0	-47.9	
Physical Features	2011 Length (ft)	% of Bankline	2001-2011 Change	There are additional types of bank armor such as car bodies and steel retaining walls, but they are relatively minor.		
Rock RipRap	2,173	2.3%	0			
Concrete Riprap	0	0.0%	0			
Flow Deflectors	0	0.0%	0			
Total	2,173	2.3%	0			
Length of Side Channels Blocked (ft)	Pre-1950s	Post-1950s	Numerous side channels have been blocked by small dikes.			
	4,230	15,593				
Floodplain Turnover	1950 - 1976	1976 - 2001	1950-2001 In-channel riparian encroachment (negative number indicates retreat)		The rate of floodplain turnover reflects how many acres of land are eroded by the river. Turnover is associated with the creation of riparian habitat.	
Total Acres	447.8	278.9	169.5 acres			
Acres/Year	17.2	11.2				
Acres/Year/Valley Mile	2.8	1.8				
Open Bar Area	Point Bars	Bank Attached	Mid-Channel	Total	The type and extent of open sand and gravel bars reflect in-stream habitat conditions that can be important to fish, amphibians, and ground-nesting birds such as least terns.	
Change in Area '50 - '01 (Ac)	-116	58.7	-33.6	-91		
Floodplain Isolation	Acres	% of FP	Floodplain isolation refers to area that historically was flooded, but has become isolated do to flow alterations or physical features such as levees.			
5 Year	1,107.4	41%				
100 Year	378.0	9%				
Restricted Migration Area	Acres	% of CMZ	Channel Migration Zone restrictions refer to the area and percent of the CMZ that has been isolated by features such as bank armor, dikes, levees, and transportation embankments.			
	172.8	4%				
Land Use	1950	2011	1950	2011	Changes in land use reflect the development of the river corridor through time. The irrigated agricultural are is a sub-set of the mapped agricultural land.	
Agricultural Land (Ac)	6,777.9	6,695.6	Flood (Ac)	3,276.6	1,951.2	
Ag. Infrastructure (Ac)	77.0	128.1	Sprinkler (Ac)	0.0	0.0	
Exurban (Ac)	0.0	7.5	Pivot (Ac)	0.0	276.3	
Urban (Ac)	0.0	0.0				
Transportation (Ac)	101.9	104.3				
1950s Riparian Vegetation Converted to a Developed Land Use (ac)	To Irrigated	To Other Use	Total Rip. Converted	% of 1950s Rip.	Changes in the extents of riparian vegetation are influenced by land use changes within the corridor.	
	29.7	0.4	30.1	1.0%		
National Wetlands Inventory	Acres	Acres per Valley Mi	Total Wetland Acres	Wetlands units summarized from National Wetlands Inventory Mapping include Riverine (typically open water sloughs), Emergent (marshes and wet meadows) and Shrub-Scrub (open bar areas with colonizing woody vegetation).		
Riverine	15.7	2.5	552.3			
Emergent	406.2	65.4				
Scrub/Shrub	130.4	21.0				
Russian Olive (2001) (Appx. 100-yr Floodplain)	Acres	%	Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.			
	164.4	2.1%				
Riparian Forest at low risk of Cowbird Parasitism (Ac/Valley Mile)	1950	1976	2001	Change 1950-2011	Cowbirds are associated with agricultural and residential development, displacing native bird species by parasitizing their nests.	
	86.2	76.9	100.3	14.0		

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



County	Treasure	Upstream River Mile	260.3
Classification	PCS: Partially confined straight	Downstream River Mile	253.8
General Location	Rosebud/Treasure County Line	Length	6.50 mi (10.46 km)

Narrative Summary

Reach C8 is 9.1 miles long and is located on the Rosebud/Treasure County line. It is a Partially Confined Straight reach type, as the river flows straight eastward along the northern bluff line.

There is approximately 4,100 feet of rock riprap in the reach, 800 feet of which was built since 2001. About 6 percent of the total bankline is armored.

Prior to 1950 about 2,300 feet of side channel had been blocked in Reach C8, and since then, floodplain dikes have blocked another 8,500 feet of side channel. Blocked side channels are located at RM 260R and RM 257R. Side channels have also been passively lost; since 1950, there has been a total loss of 2.6 miles of side channel in Reach C8. About four miles of active side channel remain.

About 35 percent of the total 100-year floodplain has become isolated due to human development. Most of the isolation is due to flow alterations. The 5-year floodplain is even more affected; 55 percent of the historic 5-year floodplain is no longer inundated at that frequency. The isolation of the historic 5-year floodplain, due primarily to flow alterations, has been associated with increased development in these areas; currently there are about 240 acres of flood irrigated land within the historic 5-year floodplain. Most of the isolated 5-year floodplain area is occupied by flood irrigated fields south of the river.

Land use is dominated by agriculture, with 342 acres of pivot irrigation development since 1950. There are about 178 acres of flood irrigated land and 12 acres of pivot within the CMZ, and 10 percent of the CMZ is restricted by physical features.

Riparian recruitment analyses show that between 1950 and 2001, there was 193 total acres of riparian colonization in the reach. Taking into account losses due to erosion, there was still a net gain of 94 acres of woody vegetation into the active channel corridor since 1950. This has occurred both on migrating point bars that have become vegetated, as well as within abandoned side channels. The extent of closed timber has increased from 293 acres in 1950 to 604 acres in 2001. There are 43 acres of Russian olive in the reach.

Reach C8 was sampled as part of the fisheries study. A total of 30 fish species were sampled in the reach, including Sauger, which are recognized by the Montana Natural Heritage Program as a Species of Concern (SOC).

Reach C8 was sampled as part of the avian study. A total of 37 bird species were identified in the reach. Two bird species identified by the Montana Natural Heritage Program as Potential Species of Concern (PSOC) were found, the Ovenbird and the Chimney Swift. Reach C8 has seen an increase in the forested area that is at low risk of cowbird parasitism since 1950. At that time, there were 51 acres per valley mile of such forest, and that number increased to 61 acres per valley mile by 2001.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been major in this reach. The 2-year flood, which strongly influences overall channel form, has dropped by 23 percent. Low flows have also been impacted; severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 4,680 cfs to 2,990 cfs with human development, a reduction of 36 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,150 cfs under unregulated conditions to 3,320 cfs under regulated conditions at Reach C10 downstream where the analysis begins, a reduction of 46 percent.

CEA-Related observations in Reach C8 include:

- Active and passive loss of thousands of feet of side channel

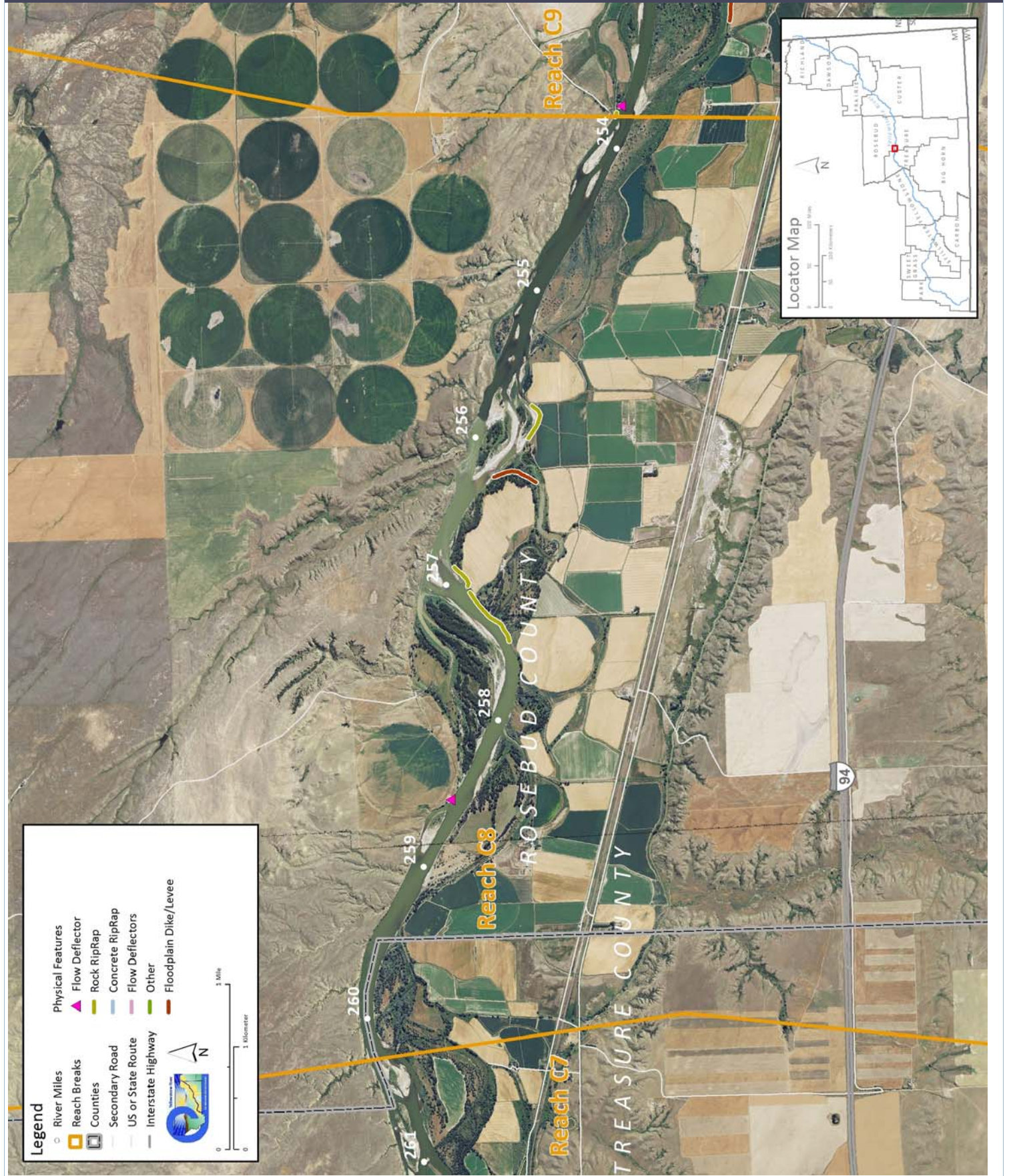
Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach C8 include:

- Side channel reactivation at RM 260R and RM 257R
- Russian olive removal

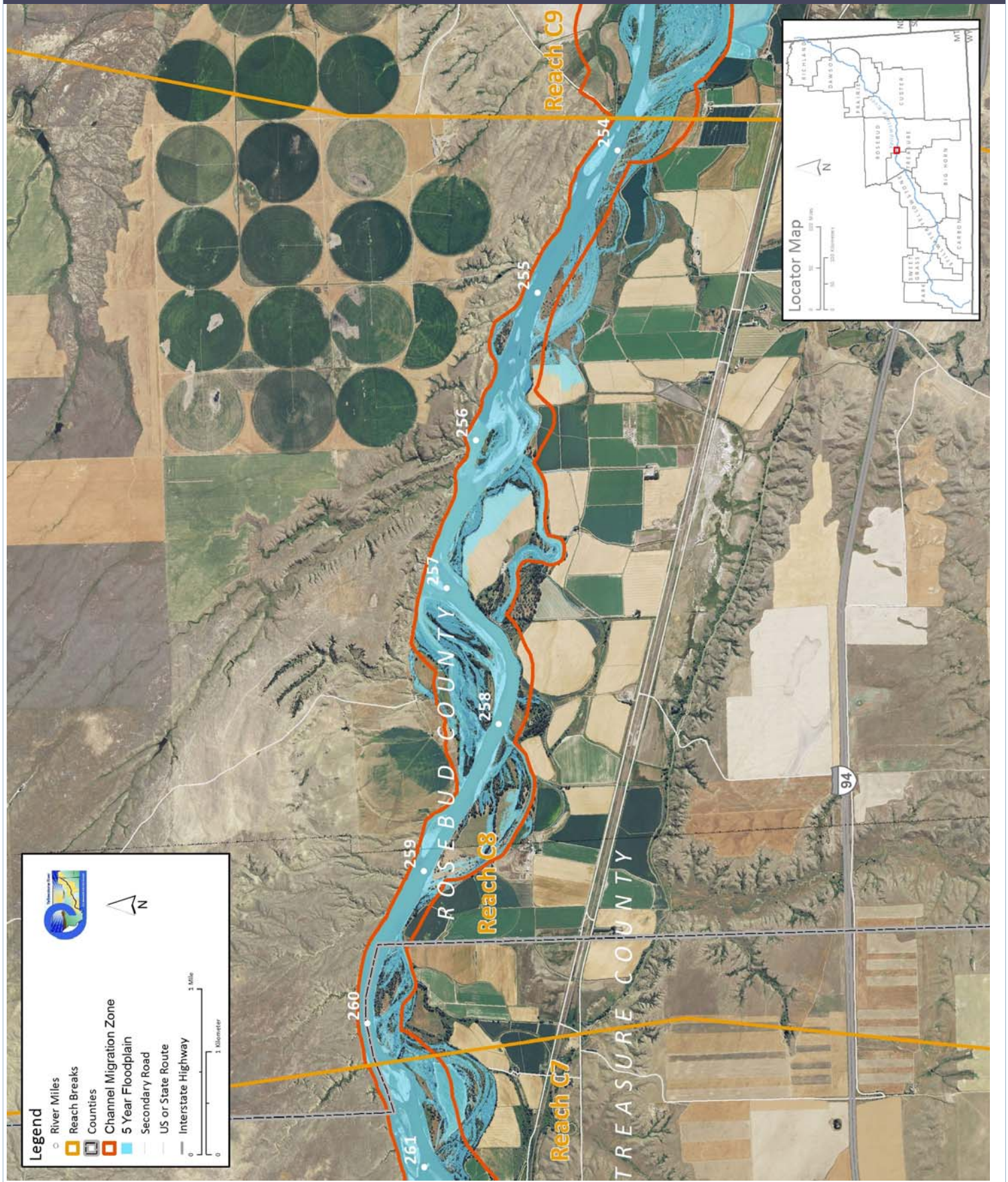
The following table summarizes some key CEA results that have been used to describe overall condition and types of human influences affecting the river. The values are specific to this single reach. Blanks indicate that a particular value was not available for this area. This information is consolidated from a large dataset that is presented in more detail in the full reach narrative report.

Discharge	Undev.	Developed	% Change	"Undeveloped" flows represent conditions prior to significant human development, whereas "developed" flows reflect the current condition of both consumptive and non-consumptive water use.		
2 Year (cfs)	61,100	47,000	-23.1%			
100 Year (cfs)	120,000	100,000	-16.7%			
Bankfull Channel Area (Ac)	1950	1976	1995	2001	1950-2001	Bankfull channel area is the total footprint of the river inundated at approx. the 2-year flood.
	679.9	688.1	620.0	621.9	-58.0	
Physical Features	2011 Length (ft)	% of Bankline	2001-2011 Change	There are additional types of bank armor such as car bodies and steel retaining walls, but they are relatively minor.		
Rock RipRap	4,093	6.0%	807			
Concrete Riprap	0	0.0%	0			
Flow Deflectors	52	0.1%	52			
Total	4,145	6.1%	859			
Length of Side Channels Blocked (ft)	Pre-1950s	Post-1950s	Numerous side channels have been blocked by small dikes.			
	2,323	8,494				
Floodplain Turnover	1950 - 1976	1976 - 2001	1950-2001 In-channel riparian encroachment (negative number indicates retreat)		The rate of floodplain turnover reflects how many acres of land are eroded by the river. Turnover is associated with the creation of riparian habitat.	
Total Acres	140.4	52.4	93.58 acres			
Acres/Year	5.4	2.1				
Acres/Year/Valley Mile	0.9	0.3				
Open Bar Area	Point Bars	Bank Attached	Mid-Channel	Total	The type and extent of open sand and gravel bars reflect in-stream habitat conditions that can be important to fish, amphibians, and ground-nesting birds such as least terns.	
Change in Area '50 - '01 (Ac)	36.5	28	26.7	91.2		
Floodplain Isolation	Acres	% of FP	Floodplain isolation refers to area that historically was flooded, but has become isolated do to flow alterations or physical features such as levees.			
5 Year	670.6	55%				
100 Year	897.7	35%				
Restricted Migration Area	Acres	% of CMZ	Channel Migration Zone restrictions refer to the area and percent of the CMZ that has been isolated by features such as bank armor, dikes, levees, and transportation embankments.			
	166.5	10%				
Land Use	1950	2011	1950	2011	Changes in land use reflect the development of the river corridor through time. The irrigated agricultural are is a sub-set of the mapped agricultural land.	
Agricultural Land (Ac)	6,145.6	6,109.7	Flood (Ac)	2,808.1	2,783.3	
Ag. Infrastructure (Ac)	39.5	104.7	Sprinkler (Ac)	0.0	0.0	
Exurban (Ac)	0.0	0.0	Pivot (Ac)	0.0	341.9	
Urban (Ac)	0.0	0.0				
Transportation (Ac)	98.0	97.9				
1950s Riparian Vegetation Converted to a Developed Land Use (ac)	To Irrigated	To Other Use	Total Rip. Converted	% of 1950s Rip.	Changes in the extents of riparian vegetation are influenced by land use changes within the corridor.	
	75.4	0.0	75.4	9.0%		
National Wetlands Inventory	Acres	Acres per Valley Mi	Total Wetland Acres	Wetlands units summarized from National Wetlands Inventory Mapping include Riverine (typically open water sloughs), Emergent (marshes and wet meadows) and Shrub-Scrub (open bar areas with colonizing woody vegetation).		
Riverine	3.8	0.6	125.6			
Emergent	112.2	18.7				
Scrub/Shrub	9.6	1.6				
Russian Olive (2001) (Appx. 100-yr Floodplain)	Acres	%	Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.			
	43.4	0.9%				
Riparian Forest at low risk of Cowbird Parasitism (Ac/Valley Mile)	1950	1976	2001	Change 1950-2011	Cowbirds are associated with agricultural and residential development, displacing native bird species by parasitizing their nests.	
	50.7	36.3	60.9	10.3		

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



County	Rosebud	Upstream River Mile	253.8
Classification	UA: Unconfined anabranching	Downstream River Mile	243.1
General Location	Hammond Valley	Length	10.70 mi (17.22 km)

Narrative Summary

Reach C9 is 10.7 miles long and is located in the Hammond Valley upstream of Forsyth. The Hammond Valley is an unusually wide segment of the Yellowstone River corridor, similar to the Mission Valley near Hysham. These two valleys owe their shape to the presence of the Bearpaw Shale in the valley wall, which is relatively erodible and prone to mass failure. Because the Mission and Hammond Valleys are so wide, the river has developed a complex series of channels and an expansive riparian forest. These reaches are especially rich in terms of aquatic and riparian habitat extent, diversity, and geomorphic complexity. Reach C9 is an Unconfined Anabranching (UA) reach type, which is typically the most complex and dynamic reach type on the river.

Flow alterations in Reach C9 have been driven primarily by changes in flows on the Bighorn River and water use for irrigation. The 2-year discharge, which is an important flow statistic because it approximately defines the channel capacity, has dropped by 14,400 cfs, or 23.5 percent, due to flow alterations on the river. That reduction in flow has been accompanied by a reduction in the bankfull channel area, or channel size, by 209 acres since 1950.

There are over 10,000 feet of rock riprap in Reach C9, as well as 1,100 feet of flow deflectors. This reach experienced severe bank erosion during the 2011 flood when some banks migrated several hundred feet. In response to that erosion, several thousand feet of bank armor were constructed after 2001, mostly on the south side of the river. This riprap represents both new projects and extensions on older projects. Some flow deflectors in the reach were flanked during the flood and now sit in the middle of the river. Other impacts in Reach C9 include almost four miles of side channel that have been blocked by dikes. This loss is due to the blockage of one very long side channel on the north side of the corridor that was clearly active in 1950, but by 1976 was plugged on its upper end.

The combination of bank armoring and reduced energy due to flow alterations has resulted in a reduced floodplain turnover rate in Reach C9 from 22.2 acres per year to 12.9 acres per year. The area of open bar habitat mapped under low flow conditions dropped by almost 100 acres since 1950, reflecting riparian expansion into the channel, reduced sediment recruitment from banks, and reduced sediment loading from the Bighorn River.

Over 40 percent of the land area that was historically inundated by a 5-year flood now remains dry during that frequency event. Most of these isolated areas currently typically flood irrigated fields, some of which were riparian forest in the 1950s. The vast majority of irrigated land in Reach C9 is under flood irrigation (3,900 acres) while 515 acres are under pivot. In the upstream end of the reach, pivots on either side of the river extend into the Channel Migration Zone. About 6 percent of the total CMZ has been restricted by physical features.

There are several animal handling facilities in Reach C9 that are adjacent to the main river channel or smaller side channels, tributaries, or swales. These are located at RM 252L (side channel), RM 248L (tributary), and RM 245R (main channel).

Reach C9 was sampled as part of the avian study. A total of 73 bird species were identified in the reach. Five bird species identified by the Montana Natural Heritage Program as Potential Species of Concern (PSOC) were found, the Black and White Warbler, Dickcissel, Plumbeous Vireo, Ovenbird, and Chimney Swift. Three Species of Concern (SOC) were identified, the Black-billed Cuckoo, Bobolink, and Red-headed Woodpecker. With the expansion of agriculture in the reach, the extent of forest at low risk of cowbird parasitism dropped from 108 acres per valley mile in 1950 to 64 acres per valley mile in 2001.

Reach C9 has 74 acres of mapped Russian olive, which appears to be concentrated on the banks of isolated side channels and sloughs, but also distributed through cottonwood forest in the downstream portion of the reach.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been major in this reach. The 2-year flood, which strongly influences overall channel form, has dropped by 24 percent. Low flows have also been impacted; severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 4,720 cfs to 3,020 cfs with human development, a reduction of 36 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,150 cfs under unregulated conditions to 3,320 cfs under regulated conditions at Reach C10 downstream where the analysis begins, a reduction of 46 percent.

CEA-related observations in Reach C9 include:

- Reduced floodplain and riparian turnover rates due to flow alterations and bank armoring
- Lost side channel extent due to side channel plugs
- Expansion of Russian olive into abandoned side channels and riparian forest
- 5-year floodplain isolation due to agricultural dikes and flow alterations
- Encroachment of pivot irrigation into Channel Migration Zone
- Increased risk of cowbird parasitism with agricultural expansion

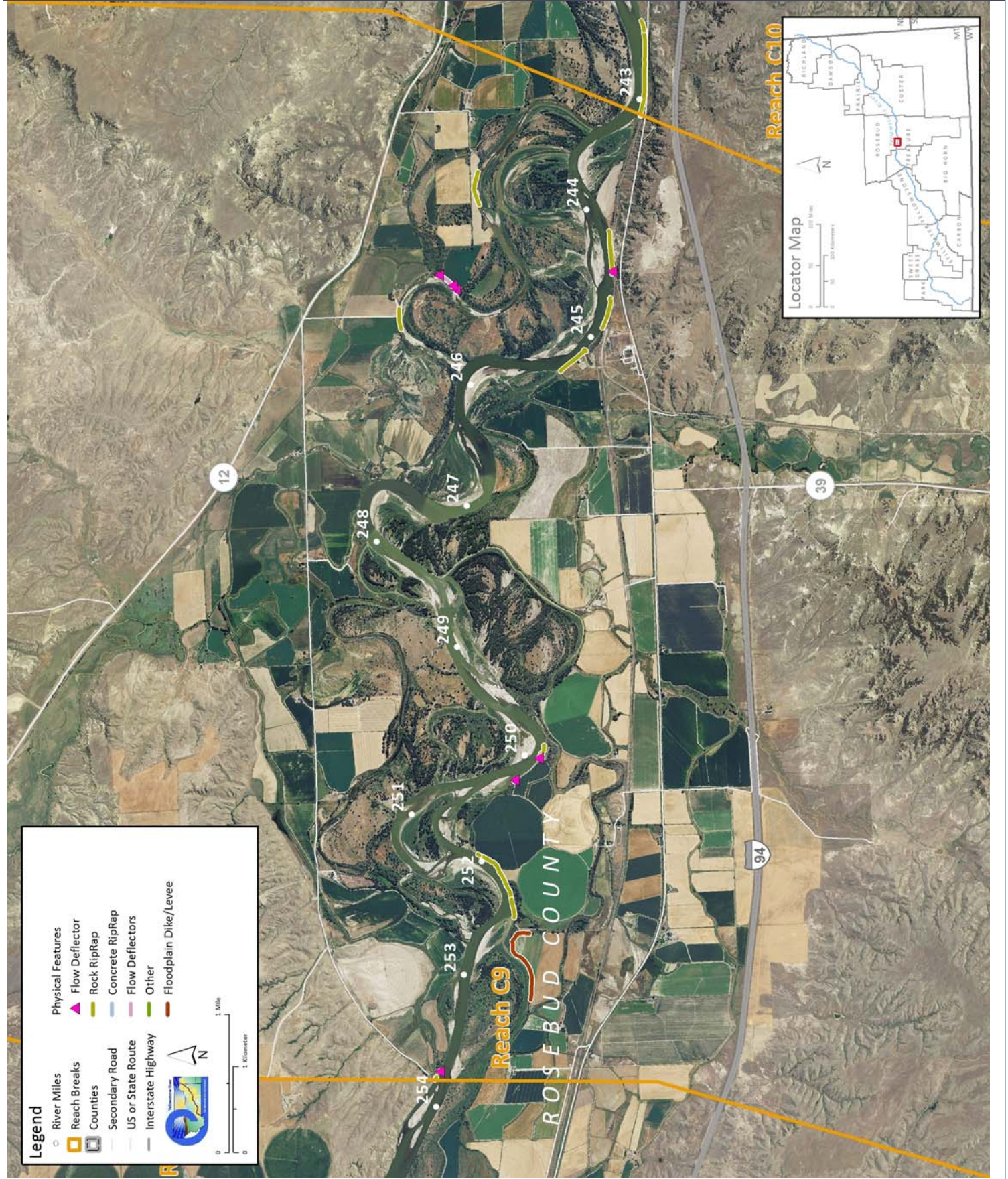
Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach C9 include:

- Side channel reactivation at RM 252L
- Nutrient management associated with animal handling facilities at RM 252L, RM 248L, and RM 245R.
- Russian olive removal

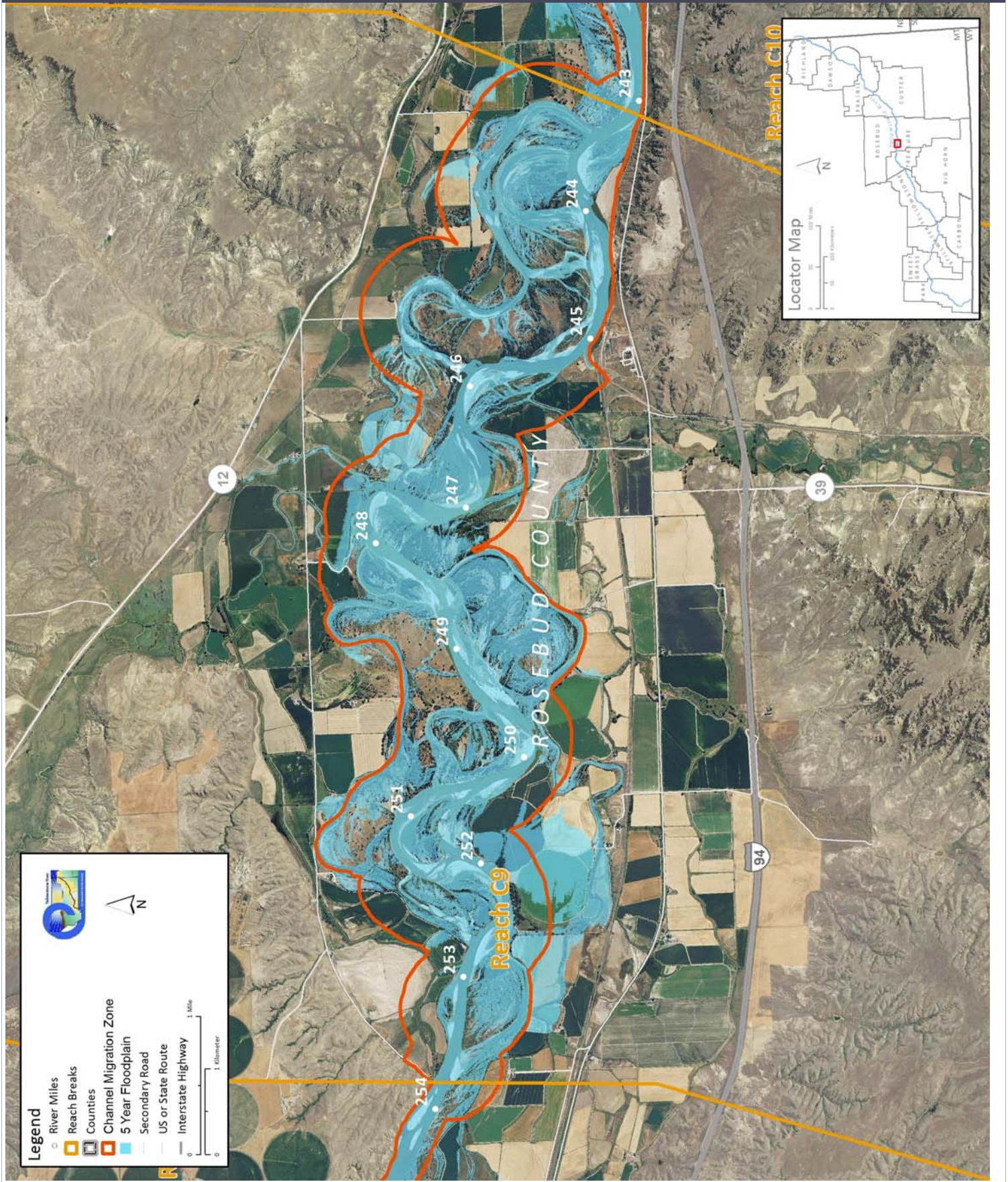
The following table summarizes some key CEA results that have been used to describe overall condition and types of human influences affecting the river. The values are specific to this single reach. Blanks indicate that a particular value was not available for this area. This information is consolidated from a large dataset that is presented in more detail in the full reach narrative report.

Discharge	Undev.	Developed	% Change	"Undeveloped" flows represent conditions prior to significant human development, whereas "developed" flows reflect the current condition of both consumptive and non-consumptive water use.		
2 Year (cfs)	61,300	46,900	-23.5%			
100 Year (cfs)	121,000	101,000	-16.5%			
Bankfull Channel Area (Ac)	1950	1976	1995	2001	1950-2001	Bankfull channel area is the total footprint of the river inundated at approx. the 2-year flood.
	1,562.4	1,537.8	1,336.0	1,353.3	-209.1	
Physical Features	2011 Length (ft)	% of Bankline	2001-2011 Change	There are additional types of bank armor such as car bodies and steel retaining walls, but they are relatively minor.		
Rock RipRap	10,283	9.1%	4,427			
Concrete Riprap	0	0.0%	0			
Flow Deflectors	1,113	1.0%	160			
Total	11,396	10.1%	4,587			
Length of Side Channels Blocked (ft)	Pre-1950s	Post-1950s	Numerous side channels have been blocked by small dikes.			
	0	19,348				
Floodplain Turnover	1950 - 1976	1976 - 2001	1950-2001 In-channel riparian encroachment (negative number indicates retreat)		The rate of floodplain turnover reflects how many acres of land are eroded by the river. Turnover is associated with the creation of riparian habitat.	
Total Acres	576.1	323.2	384.59 acres			
Acres/Year	22.2	12.9				
Acres/Year/Valley Mile	2.9	1.7				
Open Bar Area	Point Bars	Bank Attached	Mid-Channel	Total	The type and extent of open sand and gravel bars reflect in-stream habitat conditions that can be important to fish, amphibians, and ground-nesting birds such as least terns.	
Change in Area '50 - '01 (Ac)	-71.6	17	-44.2	-98.8		
Floodplain Isolation	Acres	% of FP	Floodplain isolation refers to area that historically was flooded, but has become isolated do to flow alterations or physical features such as levees.			
5 Year	2,045.9	43%				
100 Year	300.4	5%				
Restricted Migration Area	Acres	% of CMZ	Channel Migration Zone restrictions refer to the area and percent of the CMZ that has been isolated by features such as bank armor, dikes, levees, and transportation embankments.			
	333.2	6%				
Land Use	1950	2011	1950	2011	Changes in land use reflect the development of the river corridor through time. The irrigated agricultural are is a sub-set of the mapped agricultural land.	
Agricultural Land (Ac)	8,021.5	8,458.6	Flood (Ac)	3,895.4	3,498.6	
Ag. Infrastructure (Ac)	88.2	312.0	Sprinkler (Ac)	0.0	0.0	
Exurban (Ac)	0.9	27.5	Pivot (Ac)	0.0	515.0	
Urban (Ac)	0.0	0.0				
Transportation (Ac)	115.4	104.6				
1950s Riparian Vegetation Converted to a Developed Land Use (ac)	To Irrigated	To Other Use	Total Rip. Converted	% of 1950s Rip.	Changes in the extents of riparian vegetation are influenced by land use changes within the corridor.	
	253.9	0.0	253.9	8.0%		
National Wetlands Inventory	Acres	Acres per Valley Mi	Total Wetland Acres	Wetlands units summarized from National Wetlands Inventory Mapping include Riverine (typically open water sloughs), Emergent (marshes and wet meadows) and Shrub-Scrub (open bar areas with colonizing woody vegetation).		
Riverine	29.2	3.8	582.1			
Emergent	308.5	40.0				
Scrub/Shrub	244.4	31.7				
Russian Olive (2001) (Appx. 100-yr Floodplain)	Acres	%	Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.			
	74.0	0.7%				
Riparian Forest at low risk of Cowbird Parasitism (Ac/Valley Mile)	1950	1976	2001	Change 1950-2011	Cowbirds are associated with agricultural and residential development, displacing native bird species by parasitizing their nests.	
	108.0	65.4	64.1	-44.0		

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



County	Rosebud	Upstream River Mile	243.1
Classification	PCM: Partially confined meandering	Downstream River Mile	236.3
General Location	Forsyth	Length	6.80 mi (10.94 km)

Narrative Summary

Reach C10 is 6.8 miles long and is located at Forsyth. It is a Partially Confined Meandering reach type, as the river flows within a primary meandering thread that is partially confined by the northern bluff line at the Forsyth Bridge.

There is approximately three miles of rock riprap in the reach, 500 feet of which was built since 2001. About a mile of armor is protecting the active rail line on the south side of the river, and another 3,700 feet are protecting the city of Forsyth. Just below Cartersville Dam, a ~330 foot-long stretch of bank armor was flanked sometime between 2001 and 2011. The river has since migrated to the south about 50 feet past the abandoned armor. As of 2011 there were 1,600 feet of flow deflectors mapped in the reach. About 22 percent of the total bankline is armored by either rock riprap or flow deflectors. There is also about a mile of floodplain dikes/levees in the reach, which are located on the south bank at Forsyth.

Cartersville Dam is located at RM 238.5 in the town of Forsyth. This diversion dam was constructed in the early 1930's and consists of a rock rubble riprap core that is capped by concrete. The structure is 800 feet long, spanning the width of the Yellowstone River. The river flows within a single thread at the structure, flowing along the northern bluff line of the Yellowstone River valley. Because of its impacts on the Yellowstone River fishery, efforts have begun to develop suitable alternatives and bypass designs to promote fish passage at Cartersville.

About 20 percent of the total 100-year floodplain has become isolated due to human development. The isolation is due to a combination of floodplain dikes that protect the city of Forsyth and the active railroad. The 5-year floodplain is even more affected; 50 percent of the historic 5-year floodplain is no longer inundated at that frequency. Most of the isolated 5-year floodplain area is occupied by flood irrigated fields north of the river, and by urban development in Forsyth. At RM 238 the river is migrating northward, and has reached the toe of the abandoned Milwaukee Rail Line embankment. Migration through this grade will increase floodplain access on the north side of the river downstream of Cartersville Dam. As this is an urban reach, strategic floodplain reconnection in this area could be beneficial.

One ice jam was reported in Reach C10 in February of 1996. No damages were reported.

Land use is dominated by agriculture (~4,700 acres), with 280 acres of pivot irrigation development since 1950. There are about 850 acres of urban/exurban development in the reach. About 4 percent of the CMZ is restricted by physical features, and most of that area is in town.

There are 250 acres of Russian olive in the reach, most of which is dispersed in riparian areas. Russian olive densities are especially high downstream of Cartersville Diversion dam on the south bank of the river near the water treatment plant.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been major in this reach. The 2-year flood, which strongly influences overall channel form, has dropped by 24 percent. Low flows have also been impacted; severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 4,730 cfs to 3,020 cfs with human development, a reduction of 36 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,150 cfs under unregulated conditions to 3,320 cfs under regulated conditions, a reduction of 46 percent.

CEA-Related observations in Reach C10 include:

- Floodplain isolation due to urban/exurban development.
- Extensive Russian olive colonization in urbanized reach

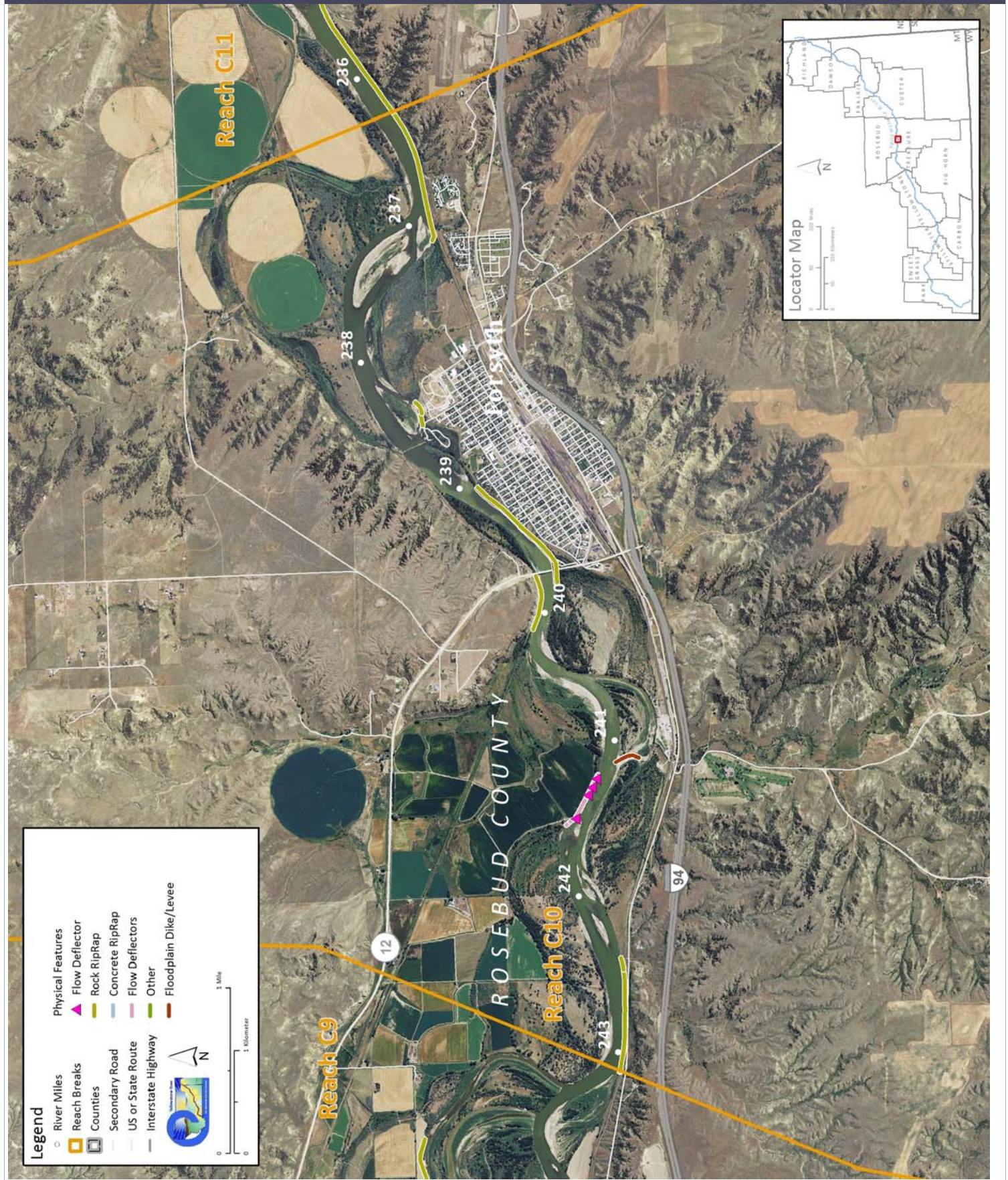
Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach C10 include:

- Floodplain reconnection at RM 238L behind abandoned Milwaukee rail line.
- Diversion structure management at Cartersville Dam
- Watercraft passage at Cartersville Dam
- Fish Passage at Cartersville Dam
- Flanked bank armor removal at RM 238.4R
- Russian olive removal

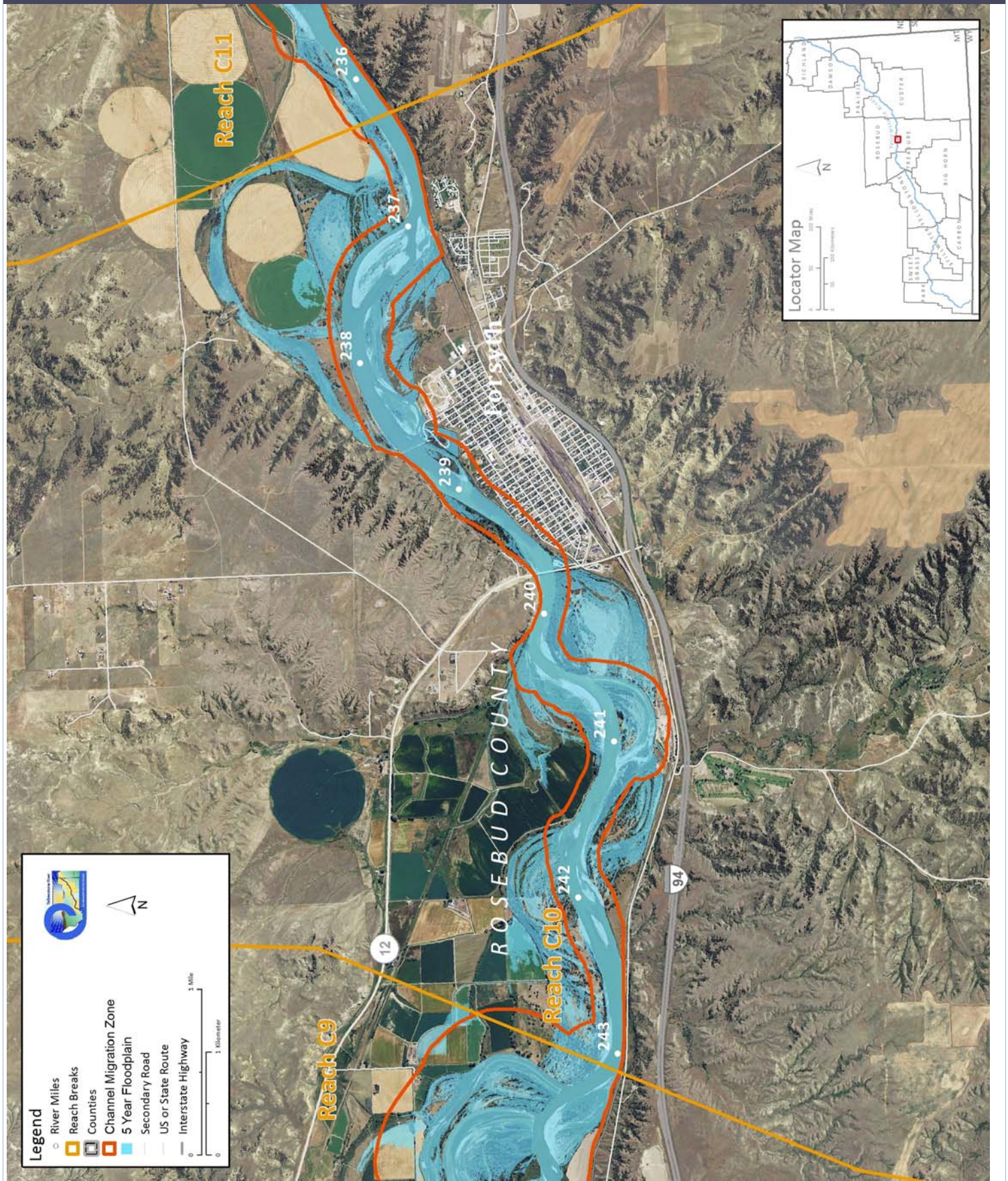
The following table summarizes some key CEA results that have been used to describe overall condition and types of human influences affecting the river. The values are specific to this single reach. Blanks indicate that a particular value was not available for this area. This information is consolidated from a large dataset that is presented in more detail in the full reach narrative report.

Discharge	Undev.	Developed	% Change	"Undeveloped" flows represent conditions prior to significant human development, whereas "developed" flows reflect the current condition of both consumptive and non-consumptive water use.		
2 Year (cfs)	61,300	46,900	-23.5%			
100 Year (cfs)	121,000	101,000	-16.5%			
Bankfull Channel Area (Ac)	1950	1976	1995	2001	1950-2001	Bankfull channel area is the total footprint of the river inundated at approx. the 2-year flood.
	647.9	683.5	628.3	629.8	-18.2	
Physical Features	2011 Length (ft)	% of Bankline	2001-2011 Change	There are additional types of bank armor such as car bodies and steel retaining walls, but they are relatively minor.		
Rock RipRap	14,306	19.8%	493			
Concrete Riprap	0	0.0%	0			
Flow Deflectors	1,648	2.3%	-262			
Total	15,953	22.1%	231			
Length of Side Channels Blocked (ft)	Pre-1950s	Post-1950s	Numerous side channels have been blocked by small dikes.			
	0	0				
Floodplain Turnover	1950 - 1976	1976 - 2001	1950-2001 In-channel riparian encroachment (negative number indicates retreat)	The rate of floodplain turnover reflects how many acres of land are eroded by the river. Turnover is associated with the creation of riparian habitat.		
Total Acres	92.4	61.3				
Acres/Year	3.6	2.5				
Acres/Year/Valley Mile	0.6	0.4	32.02 acres			
Open Bar Area	Point Bars	Bank Attached	Mid-Channel	Total	The type and extent of open sand and gravel bars reflect in-stream habitat conditions that can be important to fish, amphibians, and ground-nesting birds such as least terns.	
Change in Area '50 - '01 (Ac)	-11.2	-7	-11	-29.2		
Floodplain Isolation	Acres	% of FP	Floodplain isolation refers to area that historically was flooded, but has become isolated do to flow alterations or physical features such as levees.			
5 Year	1,118.9	50%				
100 Year	635.9	20%				
Restricted Migration Area	Acres	% of CMZ	Channel Migration Zone restrictions refer to the area and percent of the CMZ that has been isolated by features such as bank armor, dikes, levees, and transportation embankments.			
	72.6	4%				
Land Use	1950	2011	1950	2011	Changes in land use reflect the development of the river corridor through time. The irrigated agricultural are is a sub-set of the mapped agricultural land.	
Agricultural Land (Ac)	5,392.3	4,716.9	Flood (Ac)	904.3	874.1	
Ag. Infrastructure (Ac)	28.7	103.6	Sprinkler (Ac)	0.0	0.0	
Exurban (Ac)	0.0	141.6	Pivot (Ac)	0.0	278.3	
Urban (Ac)	483.8	728.0				
Transportation (Ac)	107.1	247.6				
1950s Riparian Vegetation Converted to a Developed Land Use (ac)	To Irrigated	To Other Use	Total Rip. Converted	% of 1950s Rip.	Changes in the extents of riparian vegetation are influenced by land use changes within the corridor.	
	0.0	20.5	20.5	1.0%		
National Wetlands Inventory	Acres	Acres per Valley Mi	Total Wetland Acres	Wetlands units summarized from National Wetlands Inventory Mapping include Riverine (typically open water sloughs), Emergent (marshes and wet meadows) and Shrub-Scrub (open bar areas with colonizing woody vegetation).		
Riverine	11.6	1.9	131.2			
Emergent	89.6	14.8				
Scrub/Shrub	30.1	5.0				
Russian Olive (2001) (Appx. 100-yr Floodplain)	Acres	%	Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.			
	250.5	5.7%				
Riparian Forest at low risk of Cowbird Parasitism (Ac/Valley Mile)	1950	1976	2001	Change 1950-2011	Cowbirds are associated with agricultural and residential development, displacing native bird species by parasitizing their nests.	
	82.0	15.1	20.2	-61.8		

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



County	Rosebud	Upstream River Mile	236.3
Classification	PCM/I: Partially confined meandering/islands	Downstream River Mile	225
General Location	Forsyth to Cartersville Bridge	Length	11.30 mi (18.19 km)

Narrative Summary

Reach C11 is located in Rosebud County, just downstream from the community of Forsyth. The reach is an 11.3 mile long Partially Confined Meandering channel type, extending from RM 225.0 to RM 236.3. The partial confinement is imposed by bedrock bluffs south of the river. The floodplain area north of the river has become isolated by about 9 miles of abandoned railroad grade. Rosebud Creek enters the Yellowstone River in the lowermost end of the reach from the south, and Little Porcupine Creek and Horse Creek flow in from the north. The Far West fishing access is located on the north bank at the downstream end of the reach. Reach C11 is relatively dynamic with most erosion and bank migration occurring on the downstream limbs of major meanders.

In Reach C11, the river commonly runs along the southern bluff line that is made up of Cretaceous age Lance Formation and Hell Creek Formation. The BNSF line follows this edge of the valley, and as a result much of the bluff line is armored. According to Womack (2001), the Hell Creek Formation in this area consists of resistant cemented sandstone that forms a 12 foot cap over claystone, which is subject to small slumps on the very steep slope below the rail line, thus driving the need for bank armor. Bank migration is also very active in the reach; at RM 229 for example, the river has migrated almost 700 feet southward since 1950 and is now within 100 feet of the rail line.

As of 2011 there were over 4.5 miles of bank armor protecting about 20 percent of the total bankline in Reach C11, and almost all of that armor is rock riprap protection against the active rail line. Since 2001, about 1,500 feet of flow deflectors have been built in the reach as well to protect irrigated fields on the north bank. Physical features mapping indicates the loss of 500 feet of car bodies between 2001 and 2011 at RM 230.1L where the bank has eroded behind the car bodies which are now up to 70 feet out in the river. A ~500 foot-long stretch of rock riprap on the north side of the river at RM 226.6R is currently protecting flood irrigated land, but is becoming flanked on its upstream end.

Reach C11 has seen major losses of side channels due to small floodplain dikes. Since 1950, 4.3 miles of side channel have been blocked. Three major side channels have dikes blocking them; at RM 232R across from the mouth of Porcupine Creek, at RM 230L below the mouth of Horse Creek, and at RM 229R. All of these channels appear to have good potential for reactivation. There are other older dikes that block swales that could also be potentially reactivated (e.g. RM 234R).

Similar to other reaches downstream of the Bighorn River confluence, the river channel has become smaller in Reach C11 since 1950. In 2001, the bankfull footprint was about 130 acres smaller than it was in 1950, and riparian mapping shows over 200 acres of riparian encroachment into old channel areas. Floodplain turnover rates are also lower; from 1950-1975 the average annual rate of floodplain turnover was 9.3 acres per year, and since 1975 it has been 6.4 acres per year.

On the north side of the river, the abandoned Milwaukee rail line isolates extensive historic floodplain area. At the 100 year event, 767 acres of contiguous area is isolated by the old rail line embankment, accounting for 17 percent of the mapped 100-year floodplain area. Just upstream of the mouth of Horse Creek, however, the river has migrated through the embankment. That erosion through the embankment will continue as the river is actively flanking rock riprap at the mouth of Horse Creek. The active BNSF line also isolates pockets of historic floodplain on the south side of the river.

A total of 328 acres of land that would normally be in the river's natural Channel Migration Zone (CMZ) have become restricted by physical features, which represents about 9 percent of the total CMZ area.

Land uses in Reach C11 are predominantly agricultural, with some conversion from flood irrigation to pivot since 1950. As of 2011 there were about 450 acres under pivot irrigation in the reach, and 76 of those acres are within the 5-year floodplain. Pivot irrigation has also encroached into the CMZ; about 65 acres that were developed for pivot are within the CMZ footprint. This area under pivot is at RM 227.5R, where a large pivot field has been developed in the core of a major meander. Irrigation development included riparian clearing; between 1950 and 2011 about 124 acres of riparian area was cleared for irrigation, which is 8 percent of the total 1950s riparian area.

Reach C11 hosts a relatively dense concentration of wetlands; there are almost 40 acres of wetland per valley mile in the reach, most of which is emergent marshes and wet meadows. There are also 183 acres of mapped Russian olive in the reach, which is distributed throughout the riparian zone and locally concentrated in blocked side channels.

Reach C11 was sampled as part of the fisheries study. A total of 27 species were sampled in the reach, including Sauger and Blue Sucker, both of which have been identified as Species of Concern by the Montana Natural Heritage Program.

Reach C11 was also sampled as part of the avian study. A total of 42 bird species were identified in the reach, including three Species of Concern: The Chimney Swift, Ovenbird, and Plumbeous Vireo. Reach C11 has seen a reduction in the extent of riparian forest considered at low risk of cowbird parasitism. In 1950, there were 31.3 acres of such forest per valley mile, and by 2001 that forest extent had dropped to 19.8 acres per valley mile.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been major in this reach. The 2-year flood, which strongly influences overall channel form, has dropped by 24 percent. Low flows have also been impacted; severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 4,820 cfs to 3,060 cfs with human development, a reduction of 37 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,300 cfs

under unregulated conditions to 3,370 cfs under regulated conditions, a reduction of 47 percent.

Fall and winter base flows have increased in Reach C11 by about 60 percent.

CEA-Related observations in Reach C11 include:

- Extensive floodplain isolation by the abandoned Milwaukee rail line on the north bank.
- Extensive blocking of side channels
- A regionally high extent of Russian olive possibly associated with the loss of side channels.
- Extensive armoring with CMZ encroachment
- Flanking of car bodies
- Active flanking of riprap

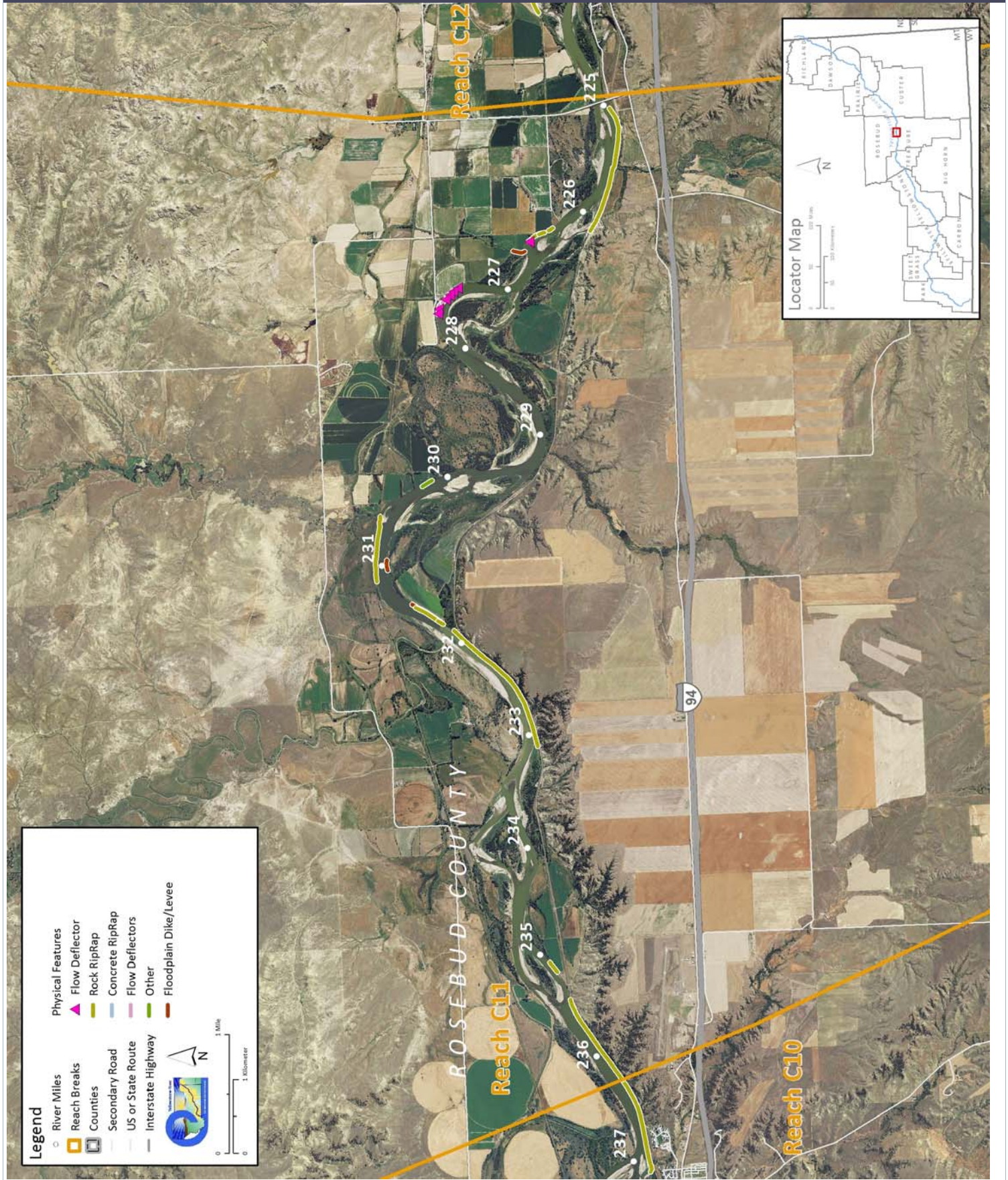
Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach C11 include:

- Removal of car bodies in river at RM 230.1L
- Side channel reactivation at RM 232R, RM 230L, and RM 229 R.
- Floodplain reconnection behind abandoned railroad grade RM 231L
- Russian olive removal

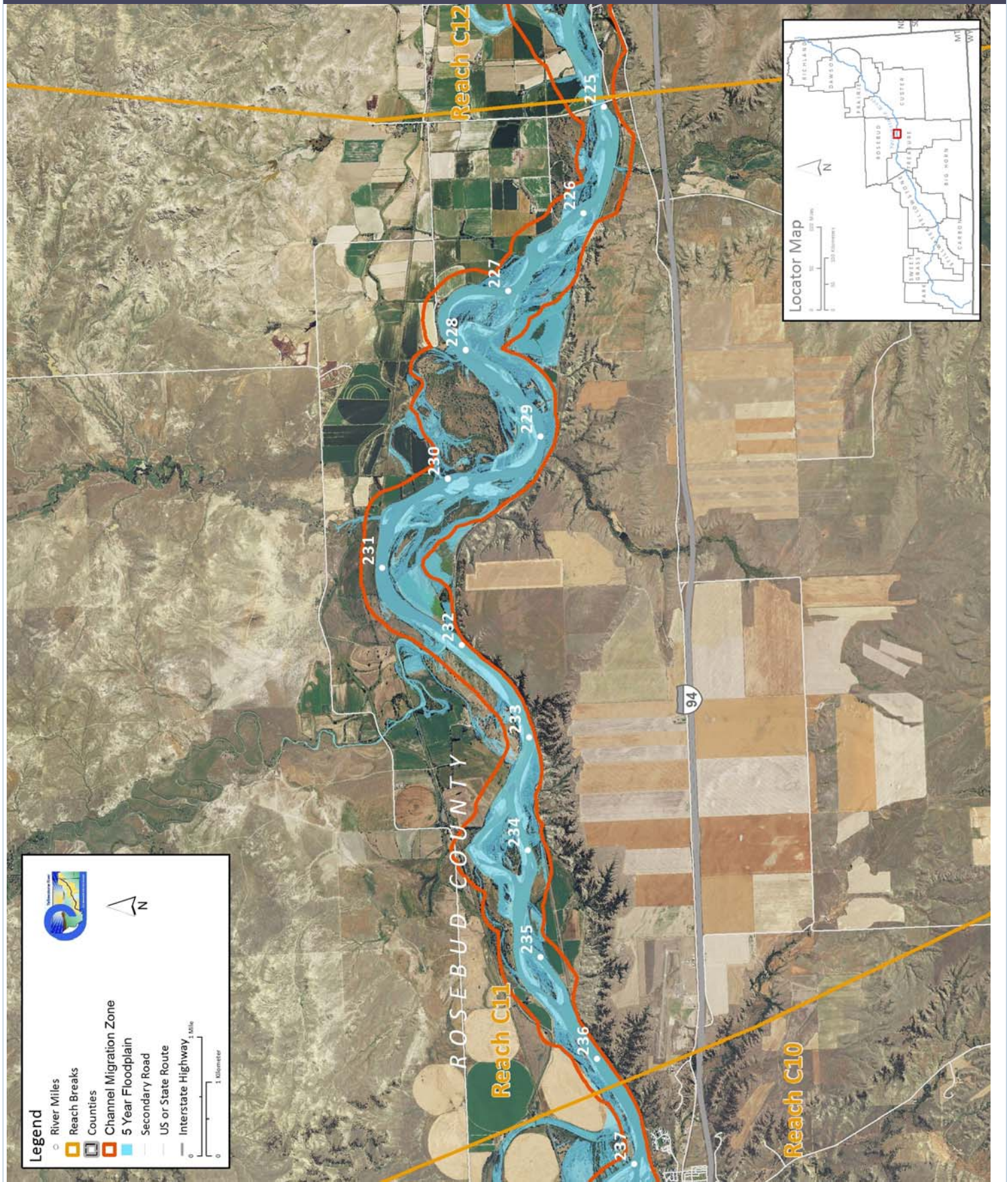
The following table summarizes some key CEA results that have been used to describe overall condition and types of human influences affecting the river. The values are specific to this single reach. Blanks indicate that a particular value was not available for this area. This information is consolidated from a large dataset that is presented in more detail in the full reach narrative report.

Discharge	Undev.	Developed	% Change	"Undeveloped" flows represent conditions prior to significant human development, whereas "developed" flows reflect the current condition of both consumptive and non-consumptive water use.		
2 Year (cfs)	61,800	47,200	-23.6%			
100 Year (cfs)	120,000	99,000	-17.5%			
Bankfull Channel Area (Ac)	1950	1976	1995	2001	1950-2001	Bankfull channel area is the total footprint of the river inundated at approx. the 2-year flood.
	1,314.1	1,280.1	1,149.5	1,190.3	-123.8	
Physical Features	2011 Length (ft)	% of Bankline	2001-2011 Change	There are additional types of bank armor such as car bodies and steel retaining walls, but they are relatively minor.		
Rock RipRap	22,607	18.8%	816			
Concrete Riprap	0	0.0%	0			
Flow Deflectors	1,511	1.3%	1,511			
Total	24,118	20.1%	2,328			
Length of Side Channels Blocked (ft)	Pre-1950s	Post-1950s	Numerous side channels have been blocked by small dikes.			
	0	22,745				
Floodplain Turnover	1950 - 1976	1976 - 2001	1950-2001 In-channel riparian encroachment (negative number indicates retreat)	The rate of floodplain turnover reflects how many acres of land are eroded by the river. Turnover is associated with the creation of riparian habitat.		
Total Acres	241.5	159.1				
Acres/Year	9.3	6.4				
Acres/Year/Valley Mile	1.1	0.7	211.61 acres			
Open Bar Area	Point Bars	Bank Attached	Mid-Channel	Total	The type and extent of open sand and gravel bars reflect in-stream habitat conditions that can be important to fish, amphibians, and ground-nesting birds such as least terns.	
Change in Area '50 - '01 (Ac)	-50.3	41.6	44.5	35.9		
Floodplain Isolation	Acres	% of FP	Floodplain isolation refers to area that historically was flooded, but has become isolated do to flow alterations or physical features such as levees.			
5 Year	1,289.7	51%				
100 Year	1,123.9	25%				
Restricted Migration Area	Acres	% of CMZ	Channel Migration Zone restrictions refer to the area and percent of the CMZ that has been isolated by features such as bank armor, dikes, levees, and transportation embankments.			
	328.1	9%				
Land Use	1950	2011	1950	2011	Changes in land use reflect the development of the river corridor through time. The irrigated agricultural are is a sub-set of the mapped agricultural land.	
Agricultural Land (Ac)	8,045.7	8,737.7	Flood (Ac)	3,056.3	2,655.9	
Ag. Infrastructure (Ac)	67.8	86.7	Sprinkler (Ac)	0.0	0.0	
Exurban (Ac)	0.0	0.0	Pivot (Ac)	0.0	451.4	
Urban (Ac)	2.0	2.0				
Transportation (Ac)	148.6	123.6				
1950s Riparian Vegetation Converted to a Developed Land Use (ac)	To Irrigated	To Other Use	Total Rip. Converted	% of 1950s Rip.	Changes in the extents of riparian vegetation are influenced by land use changes within the corridor.	
	123.5	1.7	125.1	8.0%		
National Wetlands Inventory	Acres	Acres per Valley Mi	Total Wetland Acres	Wetlands units summarized from National Wetlands Inventory Mapping include Riverine (typically open water sloughs), Emergent (marshes and wet meadows) and Shrub-Scrub (open bar areas with colonizing woody vegetation).		
Riverine	51.2	5.8	356.8			
Emergent	230.5	26.1				
Scrub/Shrub	75.1	8.5				
Russian Olive (2001) (Appx. 100-yr Floodplain)	Acres	%	Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.			
	182.6	2.3%				
Riparian Forest at low risk of Cowbird Parasitism (Ac/Valley Mile)	1950	1976	2001	Change 1950-2011	Cowbirds are associated with agricultural and residential development, displacing native bird species by parasitizing their nests.	
	31.3	22.5	19.8	-11.5		

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



County	Rosebud	Upstream River Mile	225
Classification	PCM/I: Partially confined meandering/islands	Downstream River Mile	214.8
General Location	Rosebud	Length	10.20 mi (16.42 km)

Narrative Summary

Reach C12 is 10.2 miles long and extends from the Rosebud Bridge at RM 225 downstream to RM 215. The reach classified as Partially Confined Meandering with Islands (PCM/I), indicating some influence of the valley wall, a main meandering channel thread, and numerous meander cutoffs that have generated large islands. The reach is relatively dynamic; at RM 221.5 for example the river has migrated over 900 feet to the northwest since 1950. At RM 217.2R, the river migrated over 300 feet between 2001 and 2011. Most of the rapid migration is on the outer edges (apices) and downstream limbs of large meanders.

As of 2011 there were 4,700 feet of bank armor protecting about 4 percent of the total bankline in Reach C12, and almost all of that armor is rock riprap. About one half of the armor was built between 2001 and 2011. One short section (200 feet) of flow deflectors was also built between 2001 and 2011. The bank armor is protecting agricultural land and the active rail line. Almost 2,000 feet of the mapped bank armor is north of the town of Rosebud on a channel that has been largely abandoned. This channel abandonment has focused flows in the south channel, which currently flows against the town of Rosebud which has minimal erosion protection.

Prior to 1950, about ½ miles of side channel in Reach C12 were blocked. One short channel is just upstream of the town of Rosebud, and a much longer channel is on the south side of the river at RM 219R.

Similar to other reaches downstream of the Bighorn River confluence, the river channel has become smaller in Reach C12 since 1950. In 1950, the bankfull footprint was about 56 acres larger than it was in 2001, and riparian mapping shows over 211 acres of riparian encroachment into old channel areas. Some of that encroachment has been onto mid-channel bars; there was a net loss of 36 acres of open bars since 1950. Floodplain turnover rates are also lower; from 1950-1975 the average annual rate of floodplain turnover was 8.9 acres per year, and since 1975 it has been 5.8 acres per year.

Over a thousand acres of the 100-year floodplain has become isolated from the river, most of which is north of the abandoned rail line. Several pockets of historic 100-year floodplain have also been isolated on the south side of the river between the rail line and bluff area. In total, 29 percent of the entire historic 100-year floodplain has become isolated. Isolation of the 5-year floodplain has been even more substantial; 1,340 acres or 47 percent of the 5-year floodplain has become isolated at that event. Much of this isolated 5-year floodplain is on flood irrigated fields north of the river.

A total of 216 acres of land that would normally be in the river's natural Channel Migration Zone (CMZ) have become restricted by physical features, which represents about 6 percent of the total CMZ area. At Rosebud, 59 acres of urban/exurban land has been mapped within the CMZ.

Land uses in Reach C12 are predominantly agricultural, with some conversion from flood irrigation to pivot since 1950. As of 2011 there were about 430 acres under pivot irrigation in the reach, and 197 of those acres are within the 5-year floodplain. Pivot irrigation has also encroached into the CMZ; about 200 acres that were developed for pivot are within the CMZ footprint. Irrigation development largely occurred prior to 1950, but additional development since then has included riparian clearing; between 1950 and 2011 about 45 acres of riparian area was cleared for irrigation, which is 5 percent of the total 1950s riparian area.

One animal handling facility was mapped at RM 222L that extends to the river bank.

There are 206 acres of mapped Russian olive in the reach, which is distributed throughout the riparian zone.

Reach C12 was sampled as part of the fisheries study. A total of 37 species were sampled in the reach, including Sauger and Blue Sucker, both of which have been identified as Species of Concern by the Montana Natural Heritage Program.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been major in this reach. The 100-year flood has dropped by 17 percent and the 2-year flood, which strongly influences overall channel form, has dropped by 24 percent. Low flows have also been impacted; severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 4,830 cfs to 3,060 cfs with human development, a reduction of 37 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,310 cfs under unregulated conditions to 3,380 cfs under regulated conditions, a reduction of 46 percent.

Fall and winter base flows have increased in Reach C12 by about 60 percent.

CEA-Related observations in Reach C12 include:

- Extensive floodplain isolation by the abandoned Milwaukee rail line on the north bank.
- Blocking of side channels

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach C12 include:

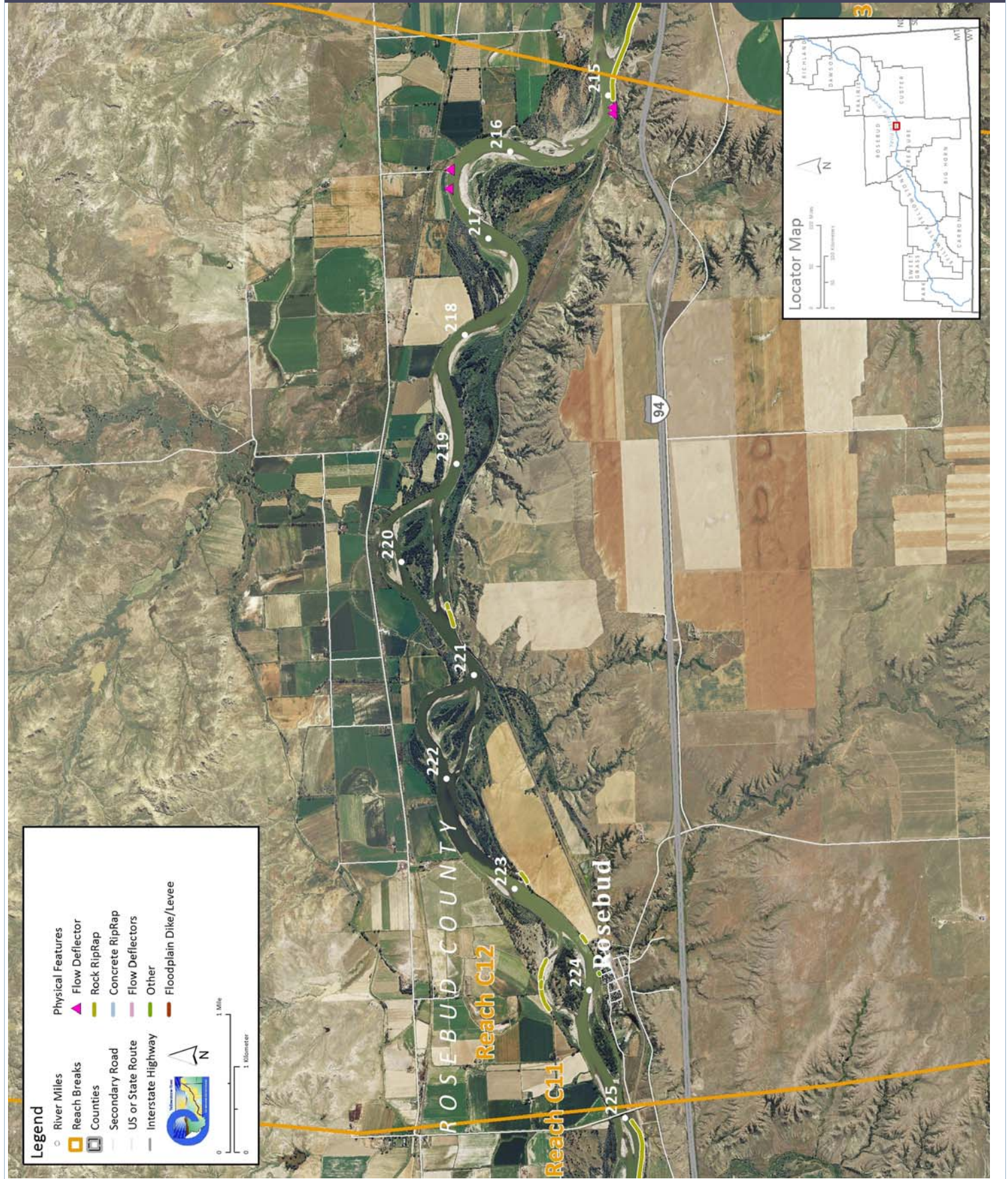
- Side channel reactivation at RM 219 R.
- Floodplain reconnection behind abandoned railroad grade RM 220L
- Nutrient management at Animal Handling Facility at RM 222L

- Russian olive removal

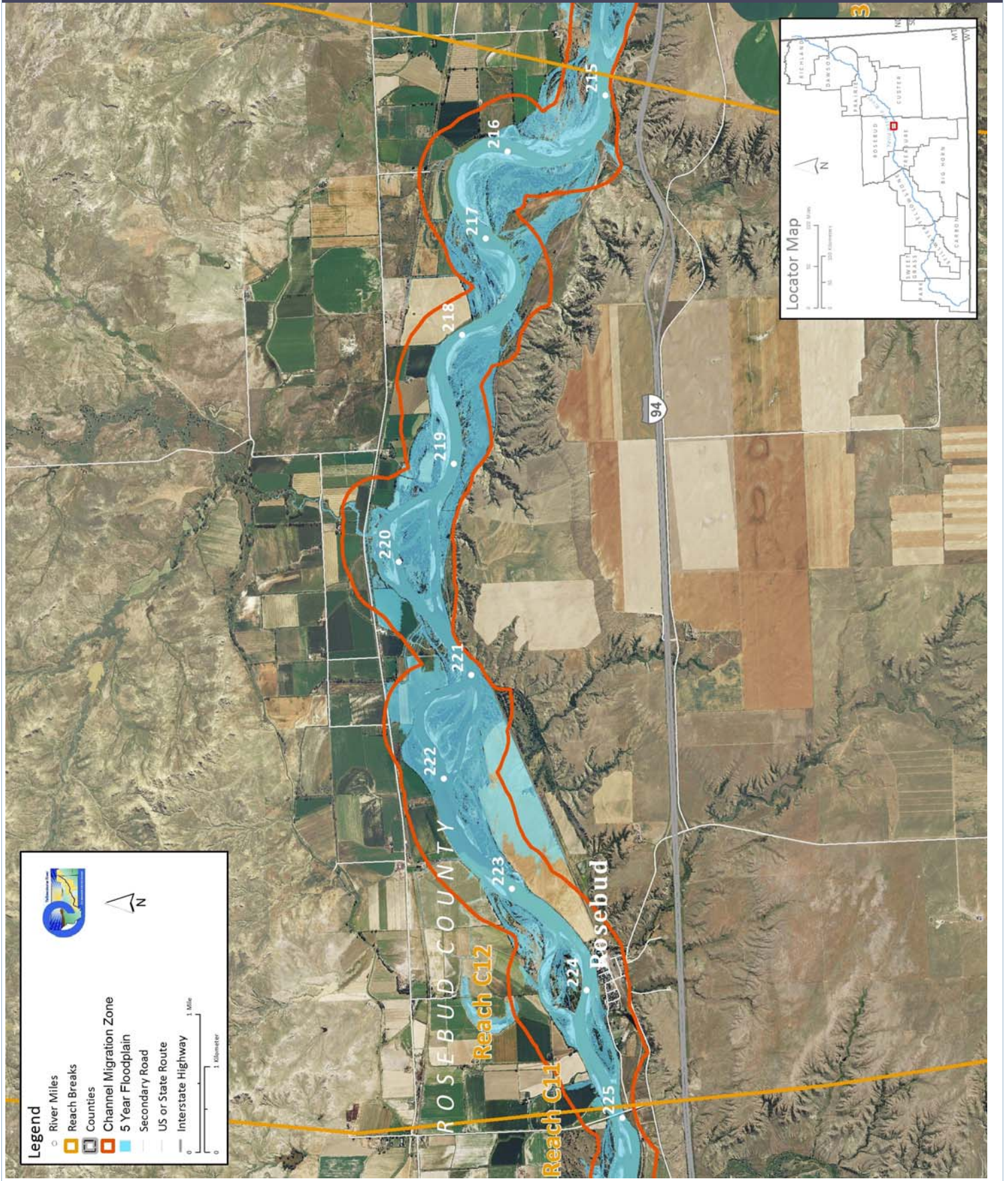
The following table summarizes some key CEA results that have been used to describe overall condition and types of human influences affecting the river. The values are specific to this single reach. Blanks indicate that a particular value was not available for this area. This information is consolidated from a large dataset that is presented in more detail in the full reach narrative report.

Discharge	Undev.	Developed	% Change	"Undeveloped" flows represent conditions prior to significant human development, whereas "developed" flows reflect the current condition of both consumptive and non-consumptive water use.		
2 Year (cfs)	61,900	47,300	-23.6%			
100 Year (cfs)	120,000	98,900	-17.6%			
Bankfull Channel Area (Ac)	1950	1976	1995	2001	1950-2001	Bankfull channel area is the total footprint of the river inundated at approx. the 2-year flood.
	1,087.9	1,069.8	1,020.0	1,033.1	-54.8	
Physical Features	2011 Length (ft)	% of Bankline	2001-2011 Change	There are additional types of bank armor such as car bodies and steel retaining walls, but they are relatively minor.		
Rock RipRap	4,510	4.2%	1,833			
Concrete Riprap	0	0.0%	0			
Flow Deflectors	192	0.2%	192			
Total	4,702	4.4%	2,025			
Length of Side Channels Blocked (ft)	Pre-1950s	Post-1950s	Numerous side channels have been blocked by small dikes.			
	9,079	0				
Floodplain Turnover	1950 - 1976	1976 - 2001	1950-2001 In-channel riparian encroachment (negative number indicates retreat)	The rate of floodplain turnover reflects how many acres of land are eroded by the river. Turnover is associated with the creation of riparian habitat.		
Total Acres	230.2	145.9	211.32 acres			
Acres/Year	8.9	5.8				
Acres/Year/Valley Mile	1.1	0.7				
Open Bar Area	Point Bars	Bank Attached	Mid-Channel	Total	The type and extent of open sand and gravel bars reflect in-stream habitat conditions that can be important to fish, amphibians, and ground-nesting birds such as least terns.	
Change in Area '50 - '01 (Ac)	-40	49.8	-45.7	-36		
Floodplain Isolation	Acres	% of FP	Floodplain isolation refers to area that historically was flooded, but has become isolated do to flow alterations or physical features such as levees.			
5 Year	1,339.7	47%				
100 Year	1,237.1	29%				
Restricted Migration Area	Acres	% of CMZ	Channel Migration Zone restrictions refer to the area and percent of the CMZ that has been isolated by features such as bank armor, dikes, levees, and transportation embankments.			
	216.0	6%				
Land Use	1950	2011	1950	2011	Changes in land use reflect the development of the river corridor through time. The irrigated agricultural are is a sub-set of the mapped agricultural land.	
Agricultural Land (Ac)	7,038.5	7,052.1	Flood (Ac)	3,834.0	2,866.5	
Ag. Infrastructure (Ac)	76.1	128.5	Sprinkler (Ac)	0.0	0.0	
Exurban (Ac)	0.0	1.6	Pivot (Ac)	0.0	429.5	
Urban (Ac)	61.1	59.5				
Transportation (Ac)	162.9	136.7				
1950s Riparian Vegetation Converted to a Developed Land Use (ac)	To Irrigated	To Other Use	Total Rip. Converted	% of 1950s Rip.	Changes in the extents of riparian vegetation are influenced by land use changes within the corridor.	
	45.4	2.5	47.9	5.0%		
National Wetlands Inventory	Acres	Acres per Valley Mi	Total Wetland Acres	Wetlands units summarized from National Wetlands Inventory Mapping include Riverine (typically open water sloughs), Emergent (marshes and wet meadows) and Shrub-Scrub (open bar areas with colonizing woody vegetation).		
Riverine	23.3	2.9	230.4			
Emergent	122.7	15.3				
Scrub/Shrub	84.4	10.6				
Russian Olive (2001) (Appx. 100-yr Floodplain)	Acres	%	Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.			
	205.6	2.8%				
Riparian Forest at low risk of Cowbird Parasitism (Ac/Valley Mile)	1950	1976	2001	Change 1950-2011	Cowbirds are associated with agricultural and residential development, displacing native bird species by parasitizing their nests.	
	18.8	14.2	31.0	12.2		

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



County	Rosebud	Upstream River Mile	214.8
Classification	PCM/I: Partially confined meandering/islands	Downstream River Mile	208.1
General Location	Hathaway	Length	6.70 mi (10.78 km)

Narrative Summary

Reach C13 is 6.7 miles long and extends from RM 215 to RM 208 in Rosebud County. The reach classified as Partially Confined Meandering with Islands (PCM/I), indicating some influence of the valley wall, a main meandering channel thread, and numerous meander cutoffs that have generated large islands. Within this reach the river crosses the valley bottom from the southern bluff line in the upper portion of the reach to the northern bluff line downstream. The length of river between bluff lines is about three miles. Reach C13 locally exhibits very rapid meander migration; at RM 211 for example, the river has migrated 960 feet to the northwest over the last 50 years. At this location the river is now within 65 feet of the abandoned Milwaukee rail line which forms a defacto flood control levee on the north side of the river.

As of 2011 there were about three miles of riprap and flow deflectors protecting 26 percent of the total bankline in Reach C13, including 13,400 feet of rock riprap, 750 feet of concrete riprap, and 4,600 feet of flow deflectors. Most of the rock riprap is protecting the rail line on the south bluff line and the abandoned rail line on the north bluff line. Another 1,350 feet of bankline is protected by old car bodies at RM 201R. All of the flow deflectors, concrete riprap, and car bodies are protecting irrigated fields. Between 2001 and 2011, about 4,000 feet of flow deflectors that were mapped at RM 212.3R were evidently destroyed. It is difficult to tell from the imagery alone whether all of these flow deflectors were flanked, however at RM 212.0, flow deflectors are sitting in the river about 60 feet off of the bank.

Since 1950, a side channel that is about 4,600 feet long was blocked at RM 211.5R. This channel cuts through the core of a large meander, and appears to be naturally reactivating as the bendway translates down the river valley.

Similar to other reaches downstream of the Bighorn River confluence, the river channel has become smaller in Reach C13 since 1950. In 1950, the bankfull footprint was about 76 acres larger than it was in 2001, and riparian mapping shows about 120 acres of riparian encroachment into old channel areas. Floodplain turnover rates are also slightly lower; from 1950-1975 the average annual rate of floodplain turnover was 5.0 acres per year, and since 1975 it has been 4.1 acres per year.

Over 600 acres of the 100-year floodplain has become isolated from the river due to flow alterations, agricultural development, and the abandoned railroad grade. In total, 20 percent of the entire historic 100-year floodplain has become isolated. Isolation of the 5-year floodplain has been even more substantial; 921 acres or 45 percent of the 5-year floodplain has become isolated at that frequency event. Much of this isolated 5-year floodplain is on flood irrigated fields both north and south of the river.

One ice jam was reported in the reach as a break-up event that occurred on March 15, 2011. No damages were reported.

A total of 221 acres of land that would normally be in the river's natural Channel Migration Zone (CMZ) have become restricted by physical features, which represents about 11 percent of the total CMZ area.

Land uses in Reach C13 are predominantly agricultural, with some conversion from flood irrigation to pivot since 1950. As of 2011 there were about 330 acres under pivot irrigation in the reach. Irrigation development largely occurred prior to 1950, but additional development since then has included riparian clearing; between 1950 and 2011 about 133 acres of riparian area was cleared for irrigation, which is 11 percent of the total 1950s riparian area.

There are 216 acres of mapped Russian olive in the reach, which is notably concentrated in abandoned side channels. Reach C13 also has fairly extensive mapped wetlands; there are over 32 mapped wetland acres per valley mile in the reach, most of which is emergent marsh and wet meadows in floodplain swales.

Reach C13 was sampled as part of the fisheries study. A total of 27 species were sampled in the reach, including Sauger and Blue Sucker, both of which have been identified as Species of Concern by the Montana Natural Heritage Program.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been major in this reach. The 100-year flood has dropped by 18 percent and the 2-year flood, which strongly influences overall channel form, has dropped by 24 percent. Low flows have also been impacted; severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 4,840 cfs to 3,070 cfs with human development, a reduction of 37 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,320 cfs under unregulated conditions to 3,380 cfs under regulated conditions, a reduction of 47 percent.

Fall and winter base flows have increased in Reach C13 by about 60 percent.

CEA-Related observations in Reach C13 include:

- Floodplain isolation by the abandoned Milwaukee rail line on the north bank.
- Blocking of side channels
- Post-1950s riparian clearing for irrigation development

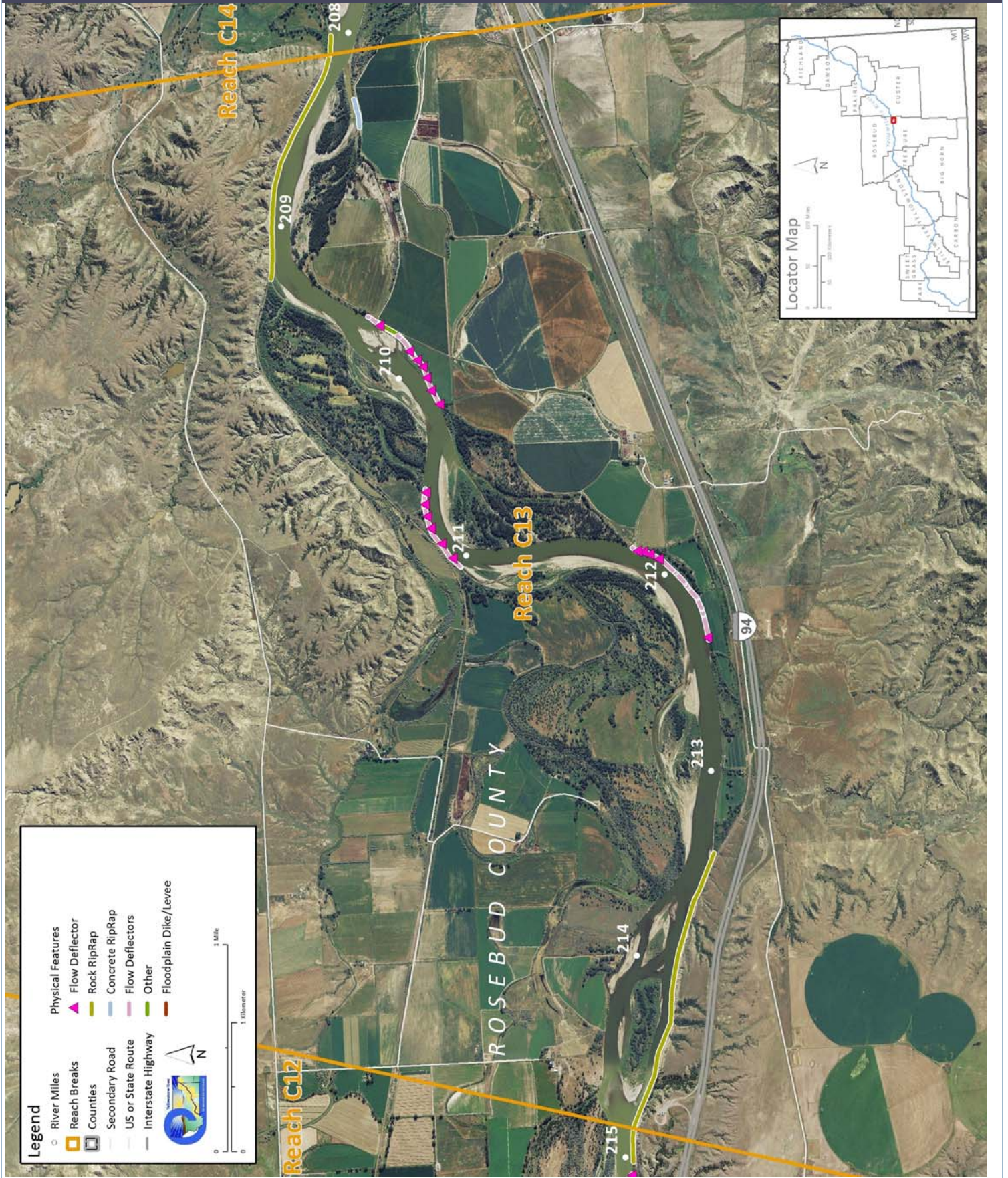
Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach C13 include:

- Removal of flanked barb at RM 212.
- Side channel reactivation at RM 211.6 R.
- CMZ Management due to extent of CMZ restriction (11 percent)

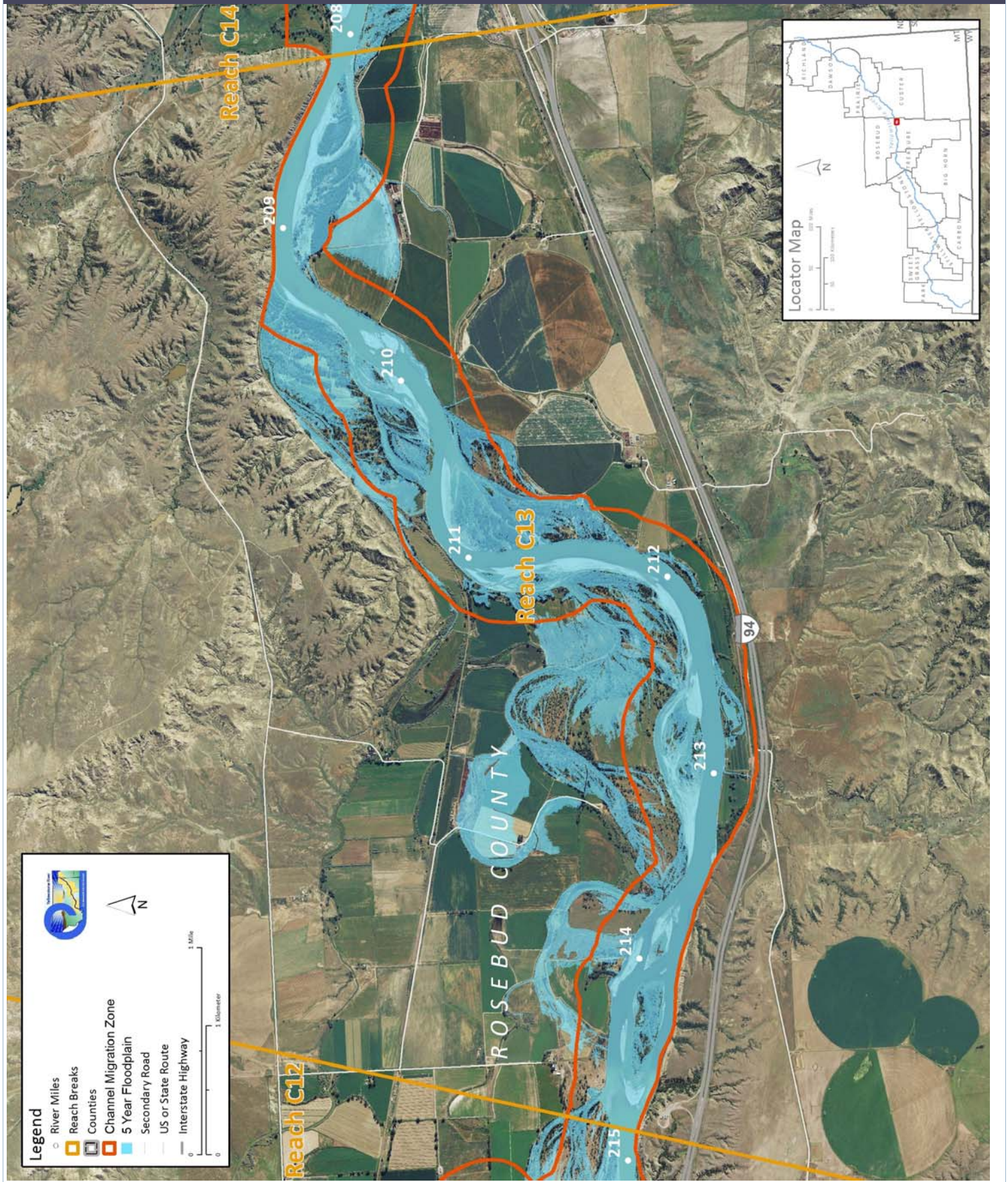
The following table summarizes some key CEA results that have been used to describe overall condition and types of human influences affecting the river. The values are specific to this single reach. Blanks indicate that a particular value was not available for this area. This information is consolidated from a large dataset that is presented in more detail in the full reach narrative report.

Discharge	Undev.	Developed	% Change	"Undeveloped" flows represent conditions prior to significant human development, whereas "developed" flows reflect the current condition of both consumptive and non-consumptive water use.		
2 Year (cfs)	61,900	47,300	-23.6%			
100 Year (cfs)	120,000	98,800	-17.7%			
Bankfull Channel Area (Ac)	1950	1976	1995	2001	1950-2001	Bankfull channel area is the total footprint of the river inundated at approx. the 2-year flood.
	783.2	689.3	711.3	707.5	-75.7	
Physical Features	2011 Length (ft)	% of Bankline	2001-2011 Change	There are additional types of bank armor such as car bodies and steel retaining walls, but they are relatively minor.		
Rock RipRap	13,403	18.8%	0			
Concrete Riprap	744	1.0%	0			
Flow Deflectors	4,567	6.4%	-3,969			
Total	18,714	26.3%	-3,969			
Length of Side Channels Blocked (ft)	Pre-1950s	Post-1950s	Numerous side channels have been blocked by small dikes.			
	0	4,575				
Floodplain Turnover	1950 - 1976	1976 - 2001	1950-2001 In-channel riparian encroachment (negative number indicates retreat)		The rate of floodplain turnover reflects how many acres of land are eroded by the river. Turnover is associated with the creation of riparian habitat.	
Total Acres	129.8	103.2	117.07 acres			
Acres/Year	5.0	4.1				
Acres/Year/Valley Mile	0.8	0.7				
Open Bar Area	Point Bars	Bank Attached	Mid-Channel	Total	The type and extent of open sand and gravel bars reflect in-stream habitat conditions that can be important to fish, amphibians, and ground-nesting birds such as least terns.	
Change in Area '50 - '01 (Ac)	18.4	23.4	-51	-9.1		
Floodplain Isolation	Acres	% of FP	Floodplain isolation refers to area that historically was flooded, but has become isolated do to flow alterations or physical features such as levees.			
5 Year	920.7	45%				
100 Year	640.6	20%				
Restricted Migration Area	Acres	% of CMZ	Channel Migration Zone restrictions refer to the area and percent of the CMZ that has been isolated by features such as bank armor, dikes, levees, and transportation embankments.			
	222.1	11%				
Land Use	1950	2011	1950	2011	Changes in land use reflect the development of the river corridor through time. The irrigated agricultural are is a sub-set of the mapped agricultural land.	
Agricultural Land (Ac)	6,899.7	6,620.2	Flood (Ac)	3,571.5	2,411.6	
Ag. Infrastructure (Ac)	60.1	132.9	Sprinkler (Ac)	0.0	0.1	
Exurban (Ac)	0.0	23.8	Pivot (Ac)	0.0	327.6	
Urban (Ac)	0.0	0.0				
Transportation (Ac)	104.8	242.3				
1950s Riparian Vegetation Converted to a Developed Land Use (ac)	To Irrigated	To Other Use	Total Rip. Converted	% of 1950s Rip.	Changes in the extents of riparian vegetation are influenced by land use changes within the corridor.	
	133.3	0.0	133.3	11.0%		
National Wetlands Inventory	Acres	Acres per Valley Mi	Total Wetland Acres	Wetlands units summarized from National Wetlands Inventory Mapping include Riverine (typically open water sloughs), Emergent (marshes and wet meadows) and Shrub-Scrub (open bar areas with colonizing woody vegetation).		
Riverine	21.1	3.5	209.6			
Emergent	134.3	22.5				
Scrub/Shrub	54.1	9.1				
Russian Olive (2001) (Appx. 100-yr Floodplain)	Acres	%	Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.			
	215.8	3.8%				
Riparian Forest at low risk of Cowbird Parasitism (Ac/Valley Mile)	1950	1976	2001	Change 1950-2011	Cowbirds are associated with agricultural and residential development, displacing native bird species by parasitizing their nests.	
	62.3	30.2	26.6	-35.7		

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



County	Rosebud	Upstream River Mile	208.1
Classification	PCM/I: Partially confined meandering/islands	Downstream River Mile	195.9
General Location	Sheffield	Length	12.20 mi (19.63 km)

Narrative Summary

Reach C14 is 12.2 miles long and is located near Sheffield, which is about 15 miles upstream of Miles City. The reach straddles the Rosebud/Custer County Line. The reach is characterized by a dominant main thread that shows a distinct meandering pattern, with several islands persisting where meander bends have historically cut off. The river intermittently flows along the south valley wall. As a result it is classified as Partially Confined Meandering with Islands (PCM/I). In this section of river the valley bottom is consistently about 1.8 miles wide, and bound by Tertiary-age Fort Union Formation. The active meanderbelt of the Yellowstone River is about 3,000 feet wide.

The large meander features in Reach C14 have experienced significant migration since 1950 and also in recent years; one site at RM 204.5 migrated 977 feet southward between 1950 and 2001, and then over the next ten years continued to migrate another 400 feet so that it is now at the toe of the active rail line. At RM 200.5, the river has migrated 700 feet northward since 2001; eroding out irrigated lands and threatening structures.

As of 2011 there were about four miles of armor protecting 17 percent of the total bankline in Reach C14, including 15,087 feet of rock riprap and 6,300 feet of flow deflectors. Most of the rock riprap is protecting the rail line as it flows along the south bluff of Fort Union Formation, whereas flow deflectors are more commonly used to protect agricultural land. Between 2001 and 2011, about 3,000 feet of flow deflectors were evidently destroyed. Barbs can be seen in the river at RM 205.3R; the bank behind has since been partially armored with rock riprap. Another barb was flanked at RM 204.7L, and the river has migrated over 200 feet behind that structure towards the rail line. Another series of barbs were flanked at RM 203.6L and have since been replaced by rock riprap. Those flanked rock structures are visible on the 2011 air photos almost 200 feet out into the channel. At RM 200.8L, new riprap was built after older armor scoured out in 2011, which was followed by hundreds of feet of northward bank migration during the 2011 flood. Some of the new riprap appears to be trenched behind the bank. About 1,300 feet of rock riprap mapped in 2001 on the left bank at RM 196.9 has been flanked, and is now up to 70 feet out in the river.

Prior to 1950, about 3 miles of side channels were blocked in Reach C14. Chute channels formed through meander tabs have been blocked by small dikes such as at RM 198. Several historic anabranching channels appear to have been blocked prior to 1950 such as at RM 207.8. These areas provide excellent restoration/mitigation opportunities for side channel re-activation.

Similar to other reaches downstream of the Bighorn River confluence, the river channel has become smaller in Reach C14 since 1950. In 1950, the bankfull footprint was about 38 acres larger than it was in 2001, and riparian mapping shows about 208 acres of riparian encroachment into old channel areas. Floodplain turnover rates are also slightly lower; from 1950-1975 the average annual rate of floodplain turnover was 15.6 acres per year, and since 1975 it has been 12.5 acres per year.

Over two thousand acres of the 100-year floodplain has become isolated from the river due to flow alterations, agricultural development, and the abandoned railroad grade. In total, 40 percent of the entire historic 100-year floodplain has become isolated. Most of the isolation is associated with agricultural land development (29 percent of the historic floodplain), with another 10 percent of the isolation due to the abandoned rail grade. Isolation of the 5-year floodplain has been even more substantial; 2,321 acres or 59 percent of the 5-year floodplain has become isolated at that frequency event. Much of this isolated 5-year floodplain is on flood irrigated fields north of the river.

Bank armor on the north side of the river commonly narrows the natural meanderbelt of the river, which has resulted in large extents of the CMZ being restricted to migration. About 740 acres which represents 16 percent of the total CMZ has become restricted by physical features.

Four ice jams have been reported in the reach, including February of 1996, 1997, and 1998, and March of 2003. All of the ice jams in the 1990s were associated with lowland flooding.

One dump site was mapped on the left bank at RM 196.3.

Reach C14 has seen extensive riparian clearing since 1950s. Typically, riparian clearing for agriculture occurred prior to 1950 along the Yellowstone River. In this reach, however, 760 acres of riparian area were cleared since 1950, which represents 30 percent of the total 1950s riparian corridor. In several cases, this includes riparian clearing on large meander tabs. With this clearing, the reach has seen a substantial loss of forest area considered at low risk of cowbird parasitism. In 1950, the reach had 91.8 acres of such forest per valley mile and by 2001 that forest extent had dropped to 51.4 acres per valley mile.

Reach C14 has fairly extensive mapped wetland area; there are over 45 acres of mapped wetlands per valley mile, most of which is emergent marsh and wet meadow. A total of 22 acres of Russian olive were mapped in the reach, which reflects an abrupt reduction in Russian olive extent relative to upstream, where Reaches C10 through C13 have on the order of 200 acres of RO over similar valley distances.

Reach C14 was sampled as part of the fisheries study. A total of 36 species were sampled in the reach, including Sauger which has been identified as Species of Concern by the Montana Natural Heritage Program.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been major in this reach. The 100-year flood has dropped by 18 percent and the 2-year flood, which strongly influences overall channel form, has dropped by 24 percent. Low flows have also been

impacted; severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 4,850 cfs to 3,070 cfs with human development, a reduction of 37 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,330 cfs under unregulated conditions to 3,390 cfs under regulated conditions, a reduction of 47 percent.

Fall and winter base flows have increased in Reach C14 by about 60 percent.

CEA-Related observations in Reach C14 include:

- Passive side channel abandonment due to flow alterations
- Flanking of barb structures on migrating meander bends
- Extensive floodplain isolation by agricultural dikes and abandoned railroad grade
- Pre-1950s blocking of side channels by agricultural dikes
- Armoring of bluff pool habitat against active railroad
- Floodplain isolation by the abandoned Milwaukee rail line on the north bank
- Post-1950s riparian clearing for irrigation development

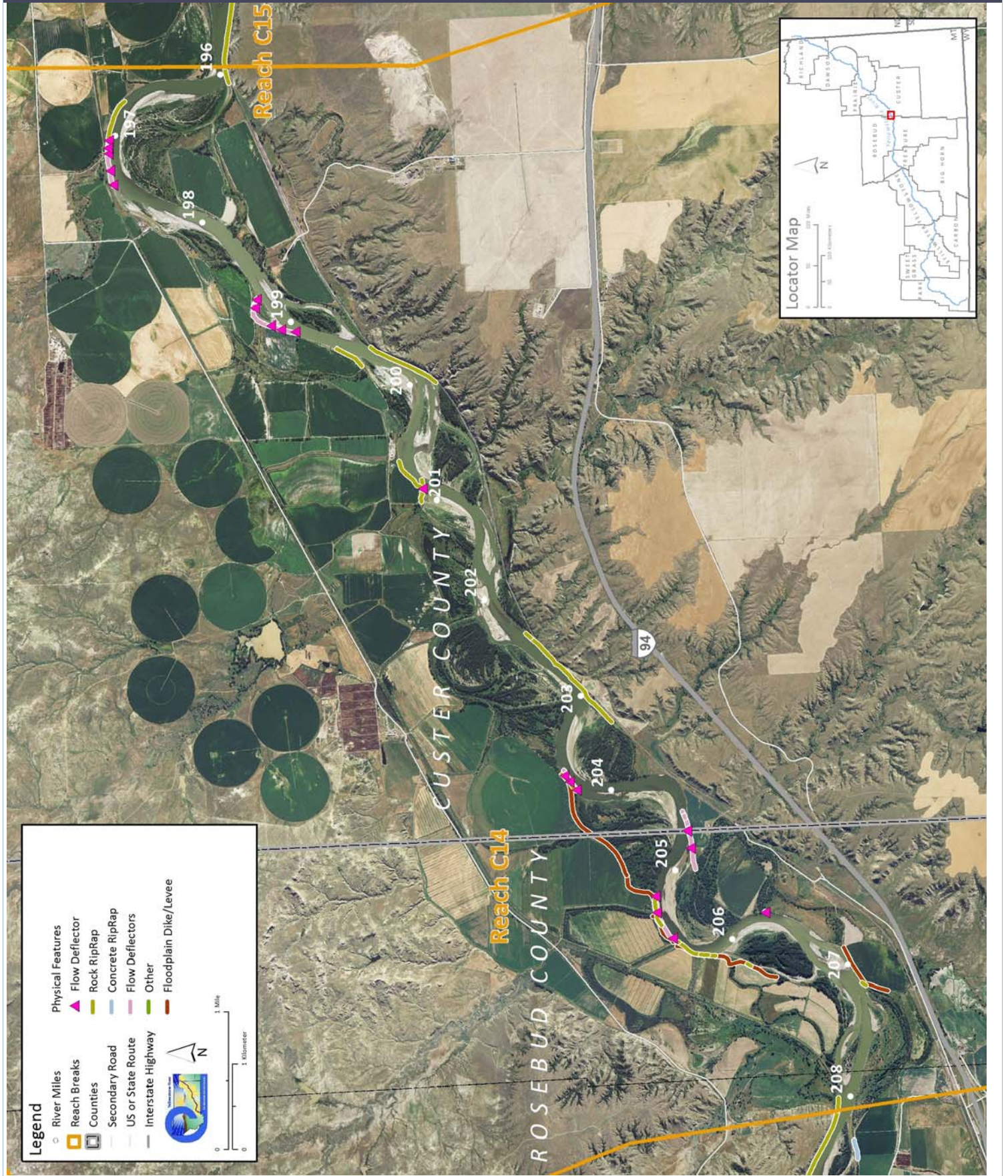
Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach C14 include:

- Removal of flanked barb at RM 205.3
- Side channel reactivation at RM 208L
- CMZ Management due to extent of CMZ restriction (11 percent)
- Dump removal on left bank at RM 196.3L
- Russian olive removal

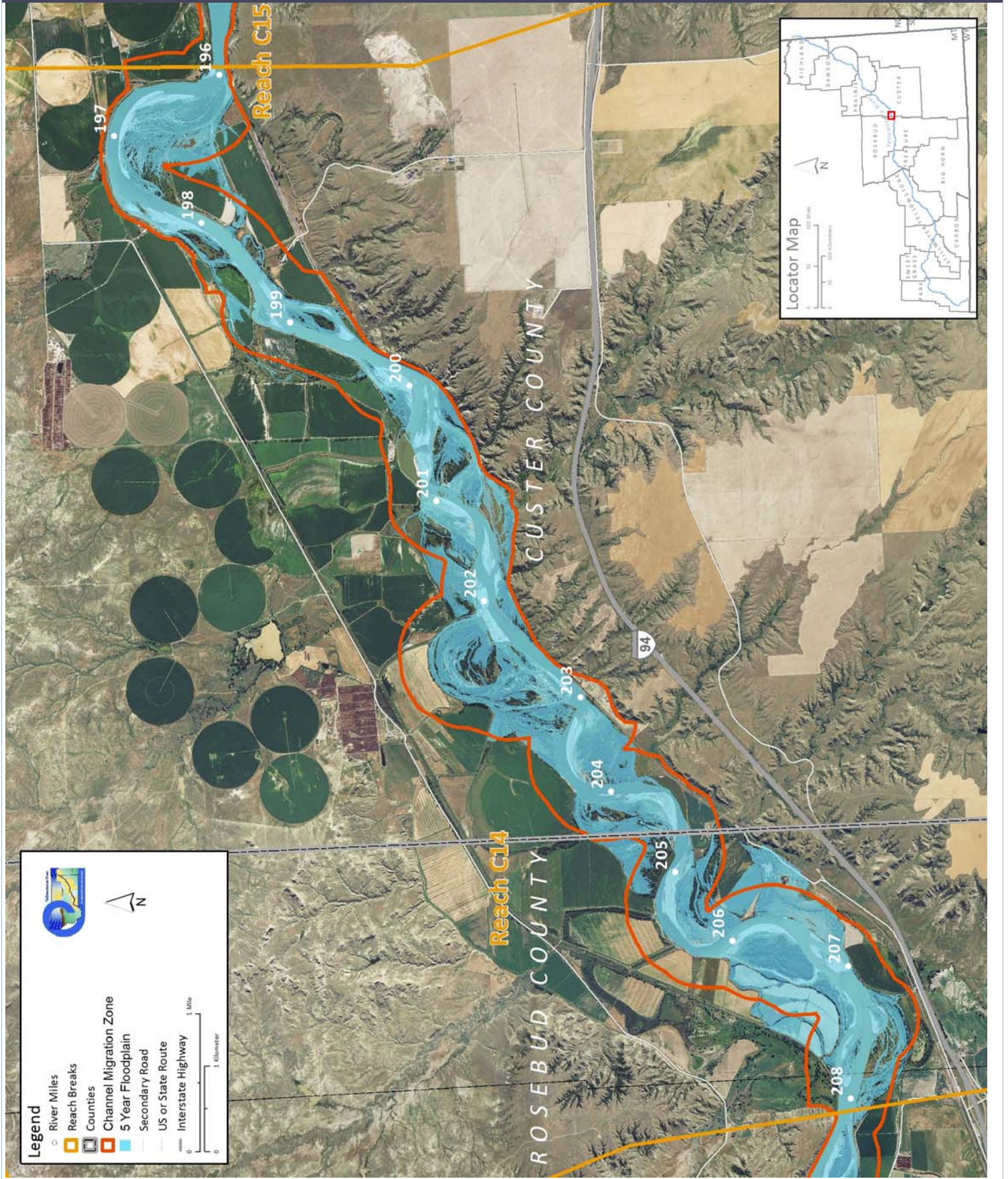
The following table summarizes some key CEA results that have been used to describe overall condition and types of human influences affecting the river. The values are specific to this single reach. Blanks indicate that a particular value was not available for this area. This information is consolidated from a large dataset that is presented in more detail in the full reach narrative report.

Discharge	Undev.	Developed	% Change	"Undeveloped" flows represent conditions prior to significant human development, whereas "developed" flows reflect the current condition of both consumptive and non-consumptive water use.		
2 Year (cfs)	61,900	47,300	-23.6%			
100 Year (cfs)	120,000	98,600	-17.8%			
Bankfull Channel Area (Ac)	1950	1976	1995	2001	1950-2001	Bankfull channel area is the total footprint of the river inundated at approx. the 2-year flood.
	1,355.6	1,388.0	1,289.0	1,318.2	-37.5	
Physical Features	2011 Length (ft)	% of Bankline	2001-2011 Change	There are additional types of bank armor such as car bodies and steel retaining walls, but they are relatively minor.		
Rock RipRap	15,087	11.7%	1,773			
Concrete Riprap	0	0.0%	0			
Flow Deflectors	6,295	4.9%	-2,958			
Total	21,381	16.6%	-1,185			
Length of Side Channels Blocked (ft)	Pre-1950s	Post-1950s	Numerous side channels have been blocked by small dikes.			
	14,986	0				
Floodplain Turnover	1950 - 1976	1976 - 2001	1950-2001 In-channel riparian encroachment (negative number indicates retreat)		The rate of floodplain turnover reflects how many acres of land are eroded by the river. Turnover is associated with the creation of riparian habitat.	
Total Acres	406.4	311.8	207.7 acres			
Acres/Year	15.6	12.5				
Acres/Year/Valley Mile	1.6	1.3				
Open Bar Area	Point Bars	Bank Attached	Mid-Channel	Total	The type and extent of open sand and gravel bars reflect in-stream habitat conditions that can be important to fish, amphibians, and ground-nesting birds such as least terns.	
Change in Area '50 - '01 (Ac)	-68.8	25.9	-32.3	-75.2		
Floodplain Isolation	Acres	% of FP	Floodplain isolation refers to area that historically was flooded, but has become isolated do to flow alterations or physical features such as levees.			
5 Year	2,320.7	59%				
100 Year	2,048.9	40%				
Restricted Migration Area	Acres	% of CMZ	Channel Migration Zone restrictions refer to the area and percent of the CMZ that has been isolated by features such as bank armor, dikes, levees, and transportation embankments.			
	739.2	16%				
Land Use	1950	2011	1950	2011	Changes in land use reflect the development of the river corridor through time. The irrigated agricultural are is a sub-set of the mapped agricultural land.	
Agricultural Land (Ac)	9,424.9	9,016.5	Flood (Ac)	2,516.5	3,398.1	
Ag. Infrastructure (Ac)	76.7	105.6	Sprinkler (Ac)	0.0	0.0	
Exurban (Ac)	0.0	6.4	Pivot (Ac)	0.0	660.0	
Urban (Ac)	0.0	0.0				
Transportation (Ac)	130.9	171.4				
1950s Riparian Vegetation Converted to a Developed Land Use (ac)	To Irrigated	To Other Use	Total Rip. Converted	% of 1950s Rip.	Changes in the extents of riparian vegetation are influenced by land use changes within the corridor.	
	755.3	4.8	760.1	30.0%		
National Wetlands Inventory	Acres	Acres per Valley Mi	Total Wetland Acres	Wetlands units summarized from National Wetlands Inventory Mapping include Riverine (typically open water sloughs), Emergent (marshes and wet meadows) and Shrub-Scrub (open bar areas with colonizing woody vegetation).		
Riverine	48.6	5.0	462.9			
Emergent	292.7	30.0				
Scrub/Shrub	121.6	12.5				
Russian Olive (2001) (Appx. 100-yr Floodplain)	Acres	%	Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.			
	21.6	0.2%				
Riparian Forest at low risk of Cowbird Parasitism (Ac/Valley Mile)	1950	1976	2001	Change 1950-2011	Cowbirds are associated with agricultural and residential development, displacing native bird species by parasitizing their nests.	
	91.8	25.4	51.4	-40.4		

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



County	Custer	Upstream River Mile	195.9
Classification	PCS: Partially confined straight	Downstream River Mile	192.3
General Location	Horton Siding	Length	3.60 mi (5.79 km)

Narrative Summary

Reach C15 is located in Custer County at Horton Siding, about seven miles upstream of Miles City. It is 3.6 miles long and classified as a Partially Confined Straight (PCS) reach type, as the river has low sinuosity and flows along the south valley wall.

As of 2011 there were about 7,600 feet of armor protecting 19 percent of the total bankline in Reach C15, the vast majority of which is rock riprap protecting the rail line as it flows along the south bluff of Fort Union Formation. There are also minor amounts of flow deflectors (80 feet) and car bodies (150 feet) in the reach.

About 17 percent of the historic 100-year floodplain has become isolated. Isolation of the 5-year floodplain has been even more substantial; 298 acres or 61 percent of the 5-year floodplain has become isolated at that frequency event. Floodplain isolation appears to be mostly due to flow alterations, although there are 35 acres if isolated 100-year floodplain behind the abandoned Milwaukee rail line embankment.

Reach C15 has lost approximately 3,000 feet of side channel length since 1950; although there is no indication that side channels were intentionally blocked.

There has been about 1,200 acres of pivot irrigation development in Reach C15 since 1950, and most of that expansion has occurred since 2001. Pivot irrigation is more extensive than flood irrigation in this area, which is somewhat unusual in the Yellowstone River valley. About 10 percent (115 acres) of the land under pivot irrigation is within the Channel Migration Zone (CMZ) of the river, making it especially prone to threats of river erosion.

Reach C15 has seen relatively extensive riparian clearing since 1950s. Typically, riparian clearing for agriculture occurred prior to 1950 along the Yellowstone River. In this reach, however, 48 acres of riparian area were cleared since 1950, which represents 20 percent of the total 1950s riparian corridor. With this clearing, the reach has seen a substantial loss of forest area considered at low risk of cowbird parasitism. In 1950, the reach had 51.3 acres of such forest per valley mile and by 2001 that forest extent had dropped to 37.2 acres per valley mile.

A total of 8 acres of Russian olive have been mapped in Reach C15.

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

Fall and winter base flows have increased in Reach C15 by over 60 percent.

CEA-Related observations in Reach C15 include:

- Passive side channel abandonment due to flow alterations
- Extensive pivot irrigation development since 2001

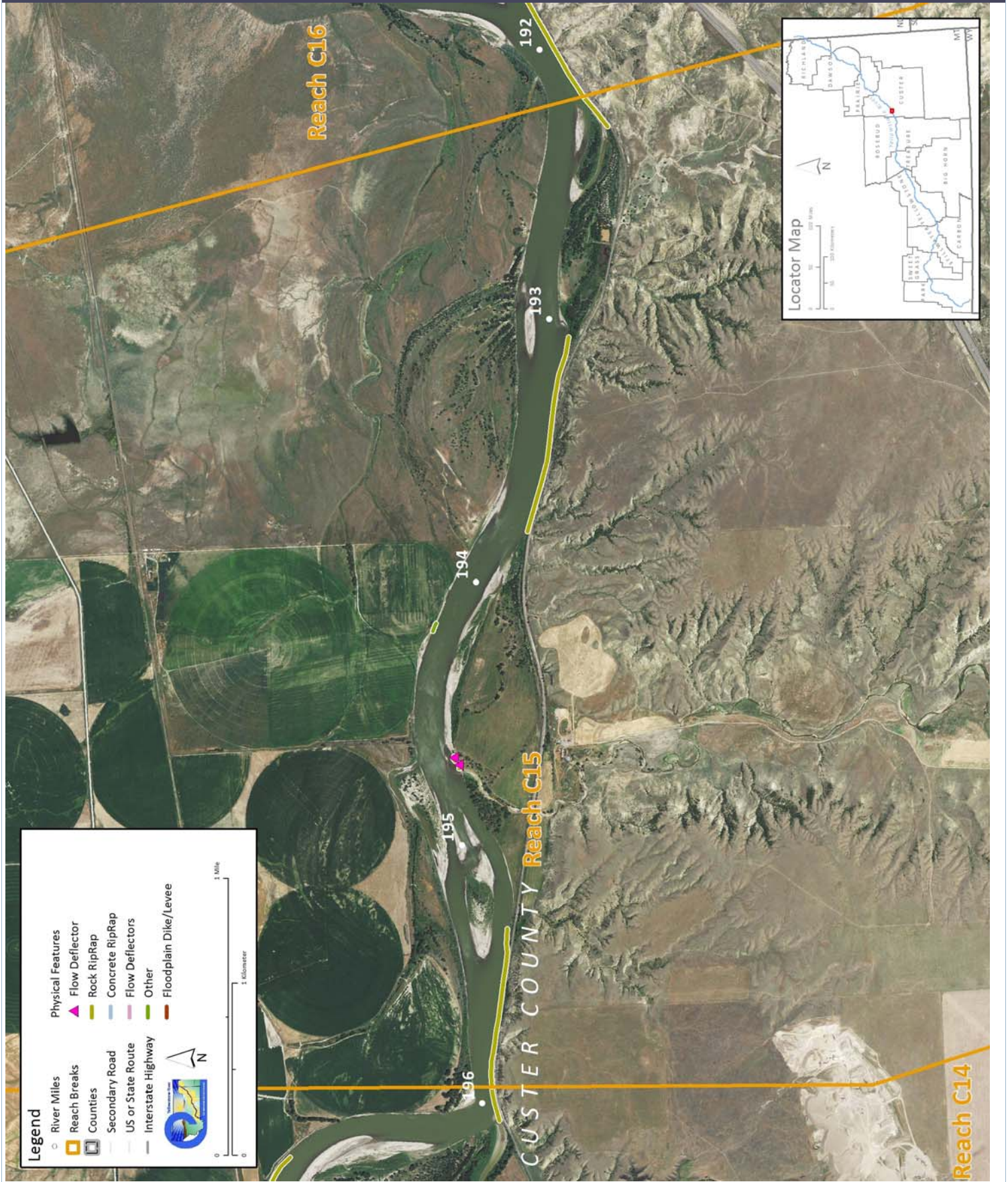
Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach C15 include:

- Russian olive removal

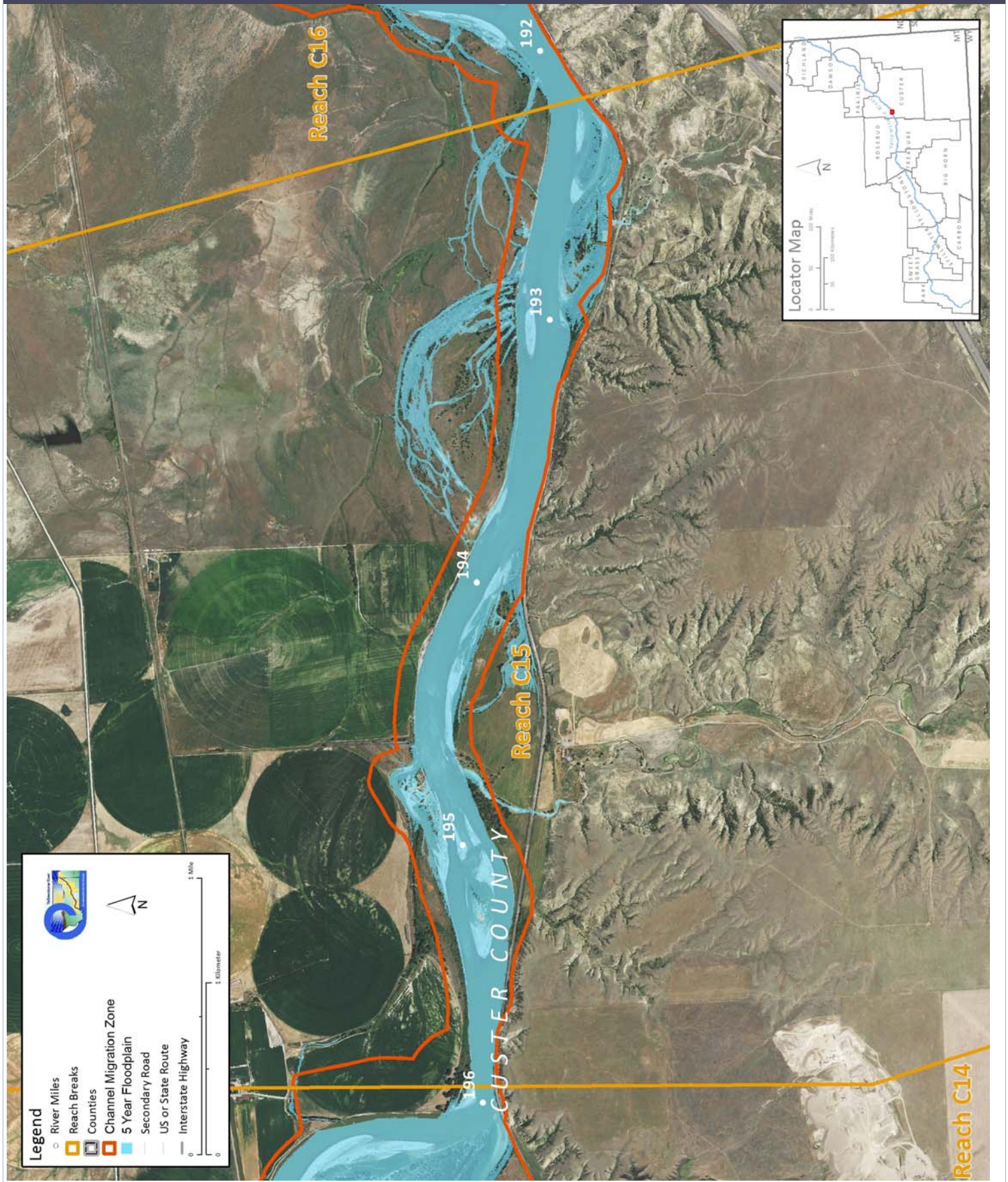
The following table summarizes some key CEA results that have been used to describe overall condition and types of human influences affecting the river. The values are specific to this single reach. Blanks indicate that a particular value was not available for this area. This information is consolidated from a large dataset that is presented in more detail in the full reach narrative report.

Discharge	Undev.	Developed	% Change	"Undeveloped" flows represent conditions prior to significant human development, whereas "developed" flows reflect the current condition of both consumptive and non-consumptive water use.		
2 Year (cfs)	62,000	47,300	-23.7%			
100 Year (cfs)	120,000	98,600	-17.8%			
Bankfull Channel Area (Ac)	1950	1976	1995	2001	1950-2001	Bankfull channel area is the total footprint of the river inundated at approx. the 2-year flood.
	368.5	371.3	359.6	365.6	-2.8	
Physical Features	2011 Length (ft)	% of Bankline	2001-2011 Change	There are additional types of bank armor such as car bodies and steel retaining walls, but they are relatively minor.		
Rock RipRap	7,578	19.2%	-235			
Concrete Riprap	0	0.0%	0			
Flow Deflectors	80	0.2%	80			
Total	7,658	19.4%	-155			
Length of Side Channels Blocked (ft)	Pre-1950s	Post-1950s	Numerous side channels have been blocked by small dikes.			
	0	0				
Floodplain Turnover	1950 - 1976	1976 - 2001	1950-2001 In-channel riparian encroachment (negative number indicates retreat)		The rate of floodplain turnover reflects how many acres of land are eroded by the river. Turnover is associated with the creation of riparian habitat.	
Total Acres	43.6	23.1	12.67 acres			
Acres/Year	1.7	0.9				
Acres/Year/Valley Mile	0.5	0.3				
Open Bar Area	Point Bars	Bank Attached	Mid-Channel	Total	The type and extent of open sand and gravel bars reflect in-stream habitat conditions that can be important to fish, amphibians, and ground-nesting birds such as least terns.	
Change in Area '50 - '01 (Ac)	0	42.5	-7.5	35		
Floodplain Isolation	Acres	% of FP	Floodplain isolation refers to area that historically was flooded, but has become isolated do to flow alterations or physical features such as levees.			
5 Year	298.3	61%				
100 Year	168.3	17%				
Restricted Migration Area	Acres	% of CMZ	Channel Migration Zone restrictions refer to the area and percent of the CMZ that has been isolated by features such as bank armor, dikes, levees, and transportation embankments.			
	15.5	2%				
Land Use	1950	2011	1950	2011	Changes in land use reflect the development of the river corridor through time. The irrigated agricultural are is a sub-set of the mapped agricultural land.	
Agricultural Land (Ac)	3,770.6	3,729.5	Flood (Ac)	323.9	696.2	
Ag. Infrastructure (Ac)	6.4	53.7	Sprinkler (Ac)	0.0	0.0	
Exurban (Ac)	0.0	0.0	Pivot (Ac)	0.0	1,244.4	
Urban (Ac)	0.0	0.0				
Transportation (Ac)	40.0	29.1				
1950s Riparian Vegetation Converted to a Developed Land Use (ac)	To Irrigated	To Other Use	Total Rip. Converted	% of 1950s Rip.	Changes in the extents of riparian vegetation are influenced by land use changes within the corridor.	
	48.0	0.0	48.0	20.0%		
National Wetlands Inventory	Acres	Acres per Valley Mi	Total Wetland Acres	Wetlands units summarized from National Wetlands Inventory Mapping include Riverine (typically open water sloughs), Emergent (marshes and wet meadows) and Shrub-Scrub (open bar areas with colonizing woody vegetation).		
Riverine	7.0	1.9	46.9			
Emergent	25.5	7.1				
Scrub/Shrub	14.4	4.0				
Russian Olive (2001) (Appx. 100-yr Floodplain)	Acres	%	Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.			
	8.0	0.3%				
Riparian Forest at low risk of Cowbird Parasitism (Ac/Valley Mile)	1950	1976	2001	Change 1950-2011	Cowbirds are associated with agricultural and residential development, displacing native bird species by parasitizing their nests.	
	51.3	33.5	37.2	-14.0		

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



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

Narrative Summary

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

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

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

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

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

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

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

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

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

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

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

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

CEA-Related observations in Reach C16 include:

- Pivot irrigation encroachment into CMZ

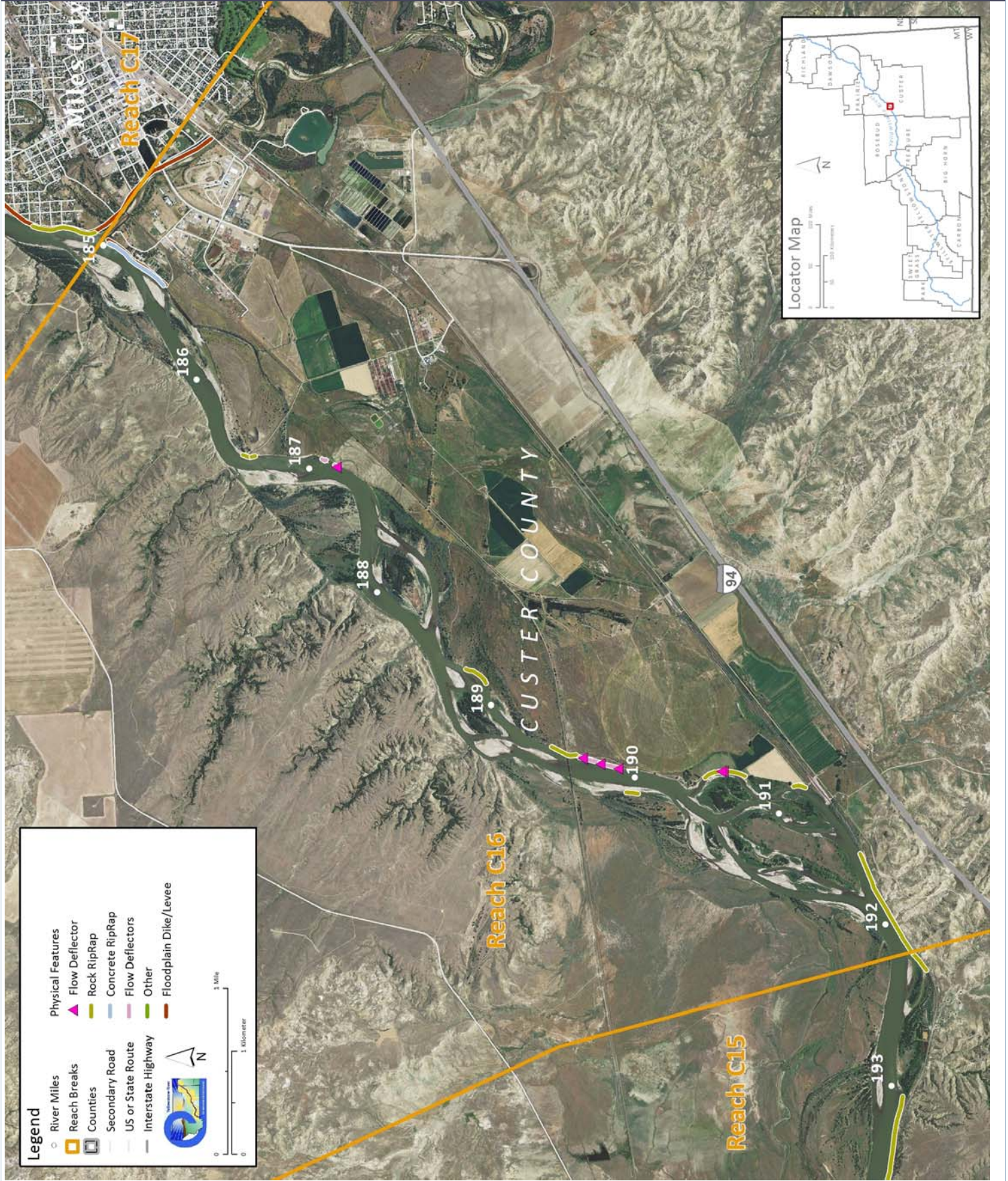
Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach C16 include:

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

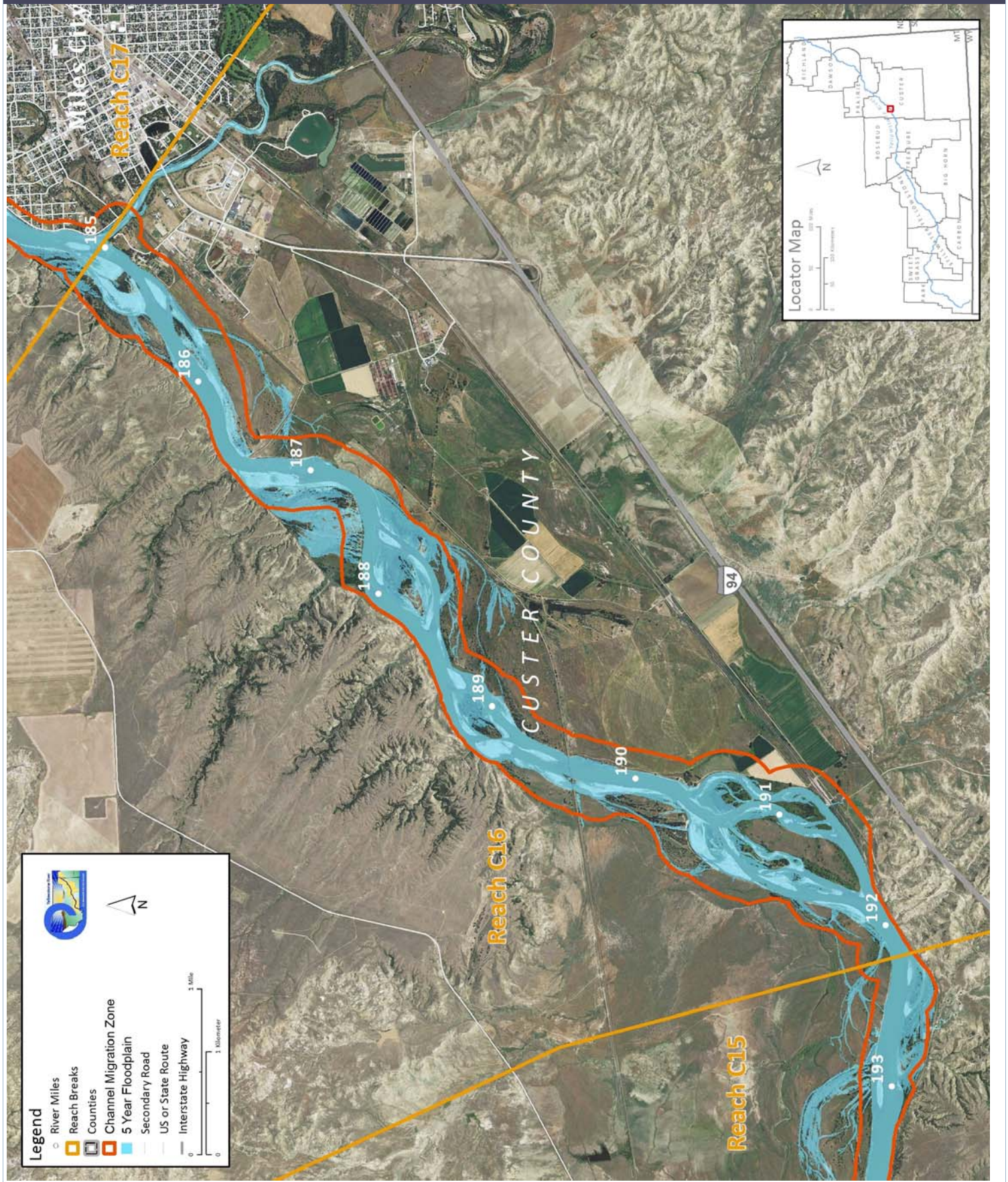
The following table summarizes some key CEA results that have been used to describe overall condition and types of human influences affecting the river. The values are specific to this single reach. Blanks indicate that a particular value was not available for this area. This information is consolidated from a large dataset that is presented in more detail in the full reach narrative report.

Discharge	Undev.	Developed	% Change	"Undeveloped" flows represent conditions prior to significant human development, whereas "developed" flows reflect the current condition of both consumptive and non-consumptive water use.		
2 Year (cfs)	62,000	47,300	-23.7%			
100 Year (cfs)	120,000	98,500	-17.9%			
Bankfull Channel Area (Ac)	1950	1976	1995	2001	1950-2001	Bankfull channel area is the total footprint of the river inundated at approx. the 2-year flood.
	848.9	841.5	827.6	839.3	-9.6	
Physical Features	2011 Length (ft)	% of Bankline	2001-2011 Change	There are additional types of bank armor such as car bodies and steel retaining walls, but they are relatively minor.		
Rock RipRap	7,009	9.2%	221			
Concrete Riprap	2,192	2.9%	0			
Flow Deflectors	1,555	2.0%	-55			
Total	10,756	14.1%	166			
Length of Side Channels Blocked (ft)	Pre-1950s	Post-1950s	Numerous side channels have been blocked by small dikes.			
	0	0				
Floodplain Turnover	1950 - 1976	1976 - 2001	1950-2001 In-channel riparian encroachment (negative number indicates retreat)		The rate of floodplain turnover reflects how many acres of land are eroded by the river. Turnover is associated with the creation of riparian habitat.	
Total Acres	120.7	119.2	54.51 acres			
Acres/Year	4.6	4.8				
Acres/Year/Valley Mile	0.7	0.7				
Open Bar Area	Point Bars	Bank Attached	Mid-Channel	Total	The type and extent of open sand and gravel bars reflect in-stream habitat conditions that can be important to fish, amphibians, and ground-nesting birds such as least terns.	
Change in Area '50 - '01 (Ac)	10.5	46.1	-3	53.6		
Floodplain Isolation	Acres	% of FP	Floodplain isolation refers to area that historically was flooded, but has become isolated do to flow alterations or physical features such as levees.			
5 Year	721.5	62%				
100 Year	308.2	13%				
Restricted Migration Area	Acres	% of CMZ	Channel Migration Zone restrictions refer to the area and percent of the CMZ that has been isolated by features such as bank armor, dikes, levees, and transportation embankments.			
	210.4	9%				
Land Use	1950	2011	1950	2011	Changes in land use reflect the development of the river corridor through time. The irrigated agricultural are is a sub-set of the mapped agricultural land.	
Agricultural Land (Ac)	6,183.9	6,007.7	Flood (Ac)	1,003.6	827.0	
Ag. Infrastructure (Ac)	91.9	159.1	Sprinkler (Ac)	0.0	0.0	
Exurban (Ac)	74.5	3.7	Pivot (Ac)	0.0	303.6	
Urban (Ac)	108.3	366.0				
Transportation (Ac)	117.5	90.6				
1950s Riparian Vegetation Converted to a Developed Land Use (ac)	To Irrigated	To Other Use	Total Rip. Converted	% of 1950s Rip.	Changes in the extents of riparian vegetation are influenced by land use changes within the corridor.	
	1.2	8.3	9.5	1.0%		
National Wetlands Inventory	Acres	Acres per Valley Mi	Total Wetland Acres	Wetlands units summarized from National Wetlands Inventory Mapping include Riverine (typically open water sloughs), Emergent (marshes and wet meadows) and Shrub-Scrub (open bar areas with colonizing woody vegetation).		
Riverine	21.2	3.2	139.1			
Emergent	94.7	14.3				
Scrub/Shrub	23.1	3.5				
Russian Olive (2001) (Appx. 100-yr Floodplain)	Acres	%	Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.			
	170.2	3.7%				
Riparian Forest at low risk of Cowbird Parasitism (Ac/Valley Mile)	1950	1976	2001	Change 1950-2011	Cowbirds are associated with agricultural and residential development, displacing native bird species by parasitizing their nests.	
	54.5	53.7	66.7	12.2		

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



County	Custer	Upstream River Mile	185
Classification	PCS: Partially confined straight	Downstream River Mile	180.5
General Location	Miles City; Tongue River confluence	Length	4.50 mi (7.24 km)

Narrative Summary

Reach C17 is 4.5 miles long and is in Miles City. Through town the Yellowstone River is a Partially Confined Reach type as the river flows on the north edge of town against high bluffs of the Fort Union Formation.

As of 2011 there were just under two miles of armor protecting 21 percent of the total bankline in Reach C17, including 7,300 feet of rock riprap, 2,400 feet of concrete riprap, and less than a hundred feet of flow deflectors. Over 2,700 feet of rock riprap has been constructed in the reach since 2001. Most of the armor is on the right bank through town. The rock riprap is protecting either urban areas (2,540 feet) the railroad (2,040 feet), or agricultural lands (2,400 feet). The concrete riprap is all protecting agricultural land. Reach C17 also has over three miles of mapped floodplain dikes and levees, much of which is the Miles City Levee that is on the right bank of the river through town.

Prior to 1950, about 1,500 feet of side channel was blocked in Reach C17. This channel was actually the lowermost part of the Tongue River, which was re-routed to the Yellowstone and abandoned through what is now Miles City.

Ice jams have been a major issue in Miles City. The ice jam database records 24 ice jams in Reach C17 between 1934 and 2011. Most of the jams occurred in March, with a few in February and one in April in 1950. Damages associated with the jams include damages to the Miles City dike, damaged water gages, flooding, and evacuations.

The levees in Miles City coupled with flow alterations have isolated 683 acres, or 74 percent of the 100-year floodplain in the reach. Isolation of the 5-year floodplain has been similar; 286 acres or 78 percent of the 5-year floodplain has become isolated at that frequency event. Most of the 5-year floodplain isolation is along the historic Tongue River channel that has been cut off from the river.

Bank armor and levees on the south side of the river has narrowed the natural Channel Migration Zone of the river. About 540 acres which represents 40 percent of the total CMZ has become restricted by physical features.

One dump site was mapped on the right bank just below the Highway 59 Bridge at RM 184.

As an urban reach, the riparian corridor had already been largely impacted by 1950. Since then, however, almost 100 acres of additional riparian area has been cleared, representing 23 percent of the entire 1950s riparian footprint. With this clearing, the reach has seen a substantial loss of forest area considered at low risk of cowbird parasitism. In 1950, the reach had 9.1 acres of such forest per valley mile and by 2001 that forest extent had dropped to 0 acres per valley mile.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been major in this reach. The 100-year flood has dropped by 19 percent and the 2-year flood, which strongly influences overall channel form, has dropped by 24 percent. Low flows have also been impacted; severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 5,100 cfs to 3,180 cfs with human development, a reduction of 37 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,730 cfs under unregulated conditions to 3,530 cfs under regulated conditions, a reduction of 48 percent.

Fall and winter base flows have increased in Reach C17 by about 60 percent.

CEA-Related observations in Reach C17 include:

- Side channel blockage with urbanization
- Extensive armoring with urbanization

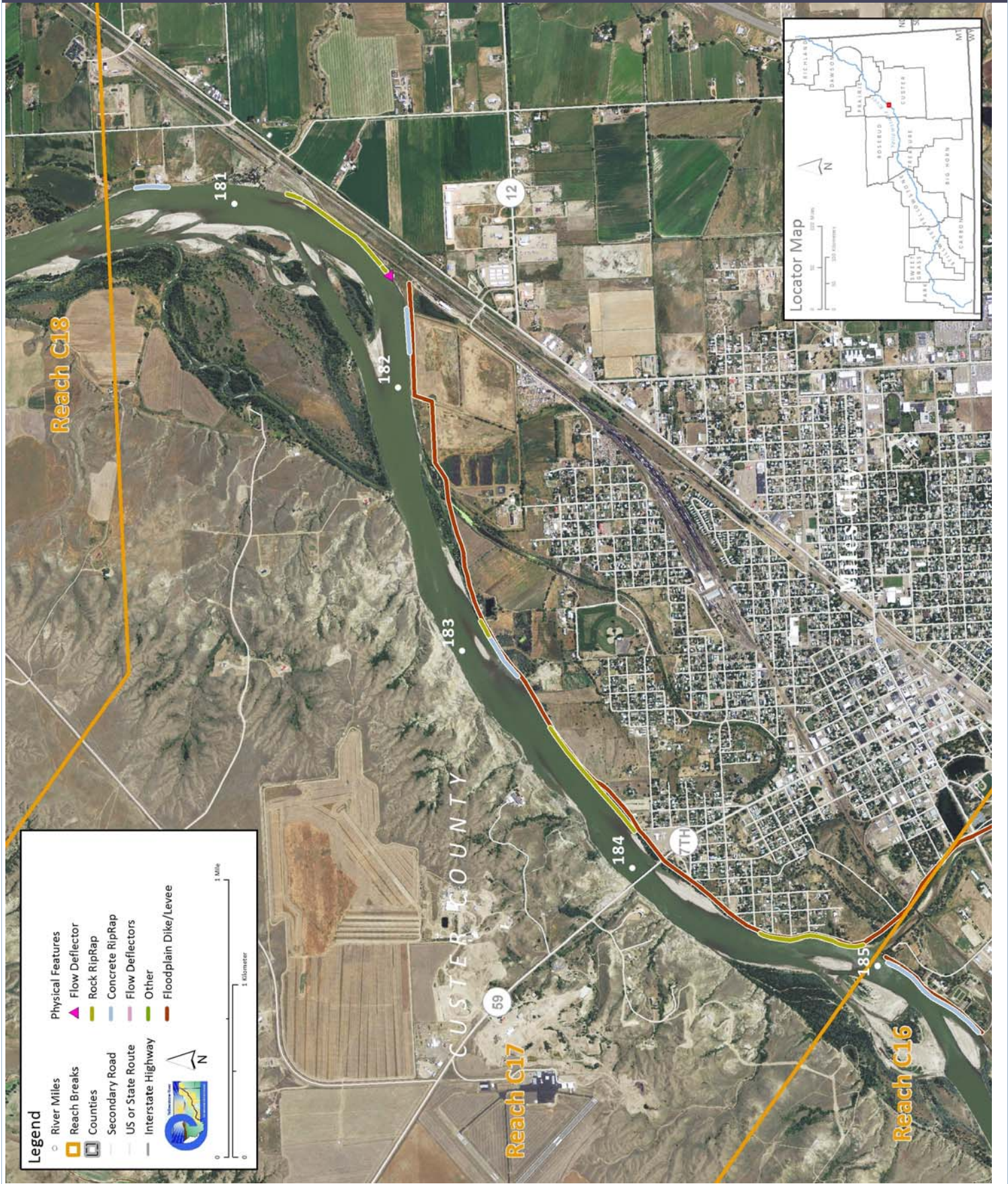
Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach C17 include:

- CMZ Management due to extent of CMZ restriction (41 percent)
- Dump removal on right bank at RM 184R
- Russian olive removal

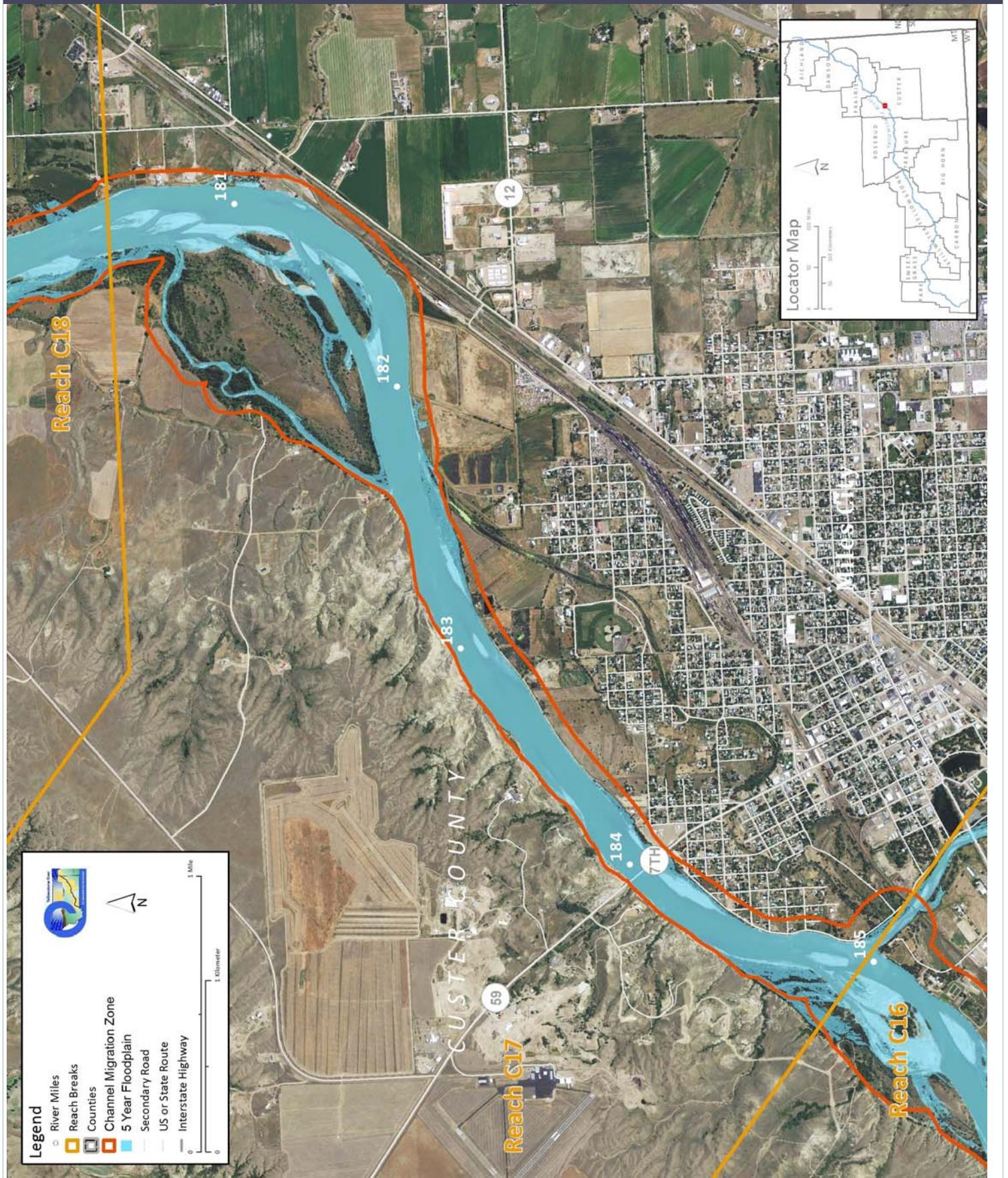
The following table summarizes some key CEA results that have been used to describe overall condition and types of human influences affecting the river. The values are specific to this single reach. Blanks indicate that a particular value was not available for this area. This information is consolidated from a large dataset that is presented in more detail in the full reach narrative report.

Discharge	Undev.	Developed	% Change	"Undeveloped" flows represent conditions prior to significant human development, whereas "developed" flows reflect the current condition of both consumptive and non-consumptive water use.		
2 Year (cfs)	63,400	48,200	-24.0%			
100 Year (cfs)	117,000	94,400	-19.3%			
Bankfull Channel Area (Ac)	1950	1976	1995	2001	1950-2001	Bankfull channel area is the total footprint of the river inundated at approx. the 2-year flood.
	485.6	470.6	452.1	455.9	-29.7	
Physical Features	2011 Length (ft)	% of Bankline	2001-2011 Change	There are additional types of bank armor such as car bodies and steel retaining walls, but they are relatively minor.		
Rock RipRap	7,294	15.5%	2,714			
Concrete Riprap	2,397	5.1%	-3			
Flow Deflectors	92	0.2%	92			
Total	9,784	20.8%	2,803			
Length of Side Channels Blocked (ft)	Pre-1950s	Post-1950s	Numerous side channels have been blocked by small dikes.			
	1,466	0				
Floodplain Turnover	1950 - 1976	1976 - 2001	1950-2001 In-channel riparian encroachment (negative number indicates retreat)	The rate of floodplain turnover reflects how many acres of land are eroded by the river. Turnover is associated with the creation of riparian habitat.		
Total Acres	32.5	34.8				
Acres/Year	1.2	1.4				
Acres/Year/Valley Mile	0.3	0.3	50.08 acres			
Open Bar Area	Point Bars	Bank Attached	Mid-Channel	Total	The type and extent of open sand and gravel bars reflect in-stream habitat conditions that can be important to fish, amphibians, and ground-nesting birds such as least terns.	
Change in Area '50 - '01 (Ac)	2.3	26.2	0	28.6		
Floodplain Isolation	Acres	% of FP	Floodplain isolation refers to area that historically was flooded, but has become isolated do to flow alterations or physical features such as levees.			
5 Year	258.5	78%				
100 Year	682.7	74%				
Restricted Migration Area	Acres	% of CMZ	Channel Migration Zone restrictions refer to the area and percent of the CMZ that has been isolated by features such as bank armor, dikes, levees, and transportation embankments.			
	540.1	40%				
Land Use	1950	2011	1950	2011	Changes in land use reflect the development of the river corridor through time. The irrigated agricultural are is a sub-set of the mapped agricultural land.	
Agricultural Land (Ac)	2,011.1	1,539.5	Flood (Ac)	824.7	609.4	
Ag. Infrastructure (Ac)	31.4	65.2	Sprinkler (Ac)	0.0	0.0	
Exurban (Ac)	30.2	477.1	Pivot (Ac)	0.0	0.0	
Urban (Ac)	1,177.2	1,212.0				
Transportation (Ac)	86.6	61.2				
1950s Riparian Vegetation Converted to a Developed Land Use (ac)	To Irrigated	To Other Use	Total Rip. Converted	% of 1950s Rip.	Changes in the extents of riparian vegetation are influenced by land use changes within the corridor.	
	21.6	75.5	97.1	23.0%		
National Wetlands Inventory	Acres	Acres per Valley Mi	Total Wetland Acres	Wetlands units summarized from National Wetlands Inventory Mapping include Riverine (typically open water sloughs), Emergent (marshes and wet meadows) and Shrub-Scrub (open bar areas with colonizing woody vegetation).		
Riverine	18.5	4.6	67.6			
Emergent	48.4	12.0				
Scrub/Shrub	0.7	0.2				
Russian Olive (2001) (Appx. 100-yr Floodplain)	Acres	%	Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.			
	66.5	2.6%				
Riparian Forest at low risk of Cowbird Parasitism (Ac/Valley Mile)	1950	1976	2001	Change 1950-2011	Cowbirds are associated with agricultural and residential development, displacing native bird species by parasitizing their nests.	
	9.1	2.6	0.0	-9.1		

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



County	Custer	Upstream River Mile	180.5
Classification	PCS: Partially confined straight	Downstream River Mile	177.3
General Location	Downstream of Miles City	Length	3.20 mi (5.15 km)

Narrative Summary

Reach C18 is 3.2 miles long and is located just downstream of Miles City. It is a Partially Confined Straight reach type, as the river flows over steep bedrock shelves that create a series of rapids between Miles City and a few miles above Kinsey Bridge. The river flows along the north bluff line through the whole reach, and has consistently maintained this course since at least 1950.

Reach C18 has no mapped bank armor which is indicative of the natural stability provided to this reach by erosion-resistant bedrock. The 2001 physical features inventory identified 1,742 feet of bedrock outcrop in the reach. A total of three discreet sets of rapids were mapped in the reach, all of which have been described as part of the Buffalo Shoals (RM 180, RM 179.9, and RM 178.2).

Between 1950 and 2001 there was about 26 net acres of riparian encroachment into the channel, and the bankfull channel area decreased by ~30 acres, indicating a diminishing river size over the last half-century. This trend is common below the mouth of the Bighorn River, where flow alterations have reduced peak flows and cause the active river channel to shrink. Consumptive water uses, primarily associated with irrigation, have contributed to the reduced flows.

Prior to 1950, a side channel that was just over 1,000 feet long appears to have been blocked at RM 179. There are currently several blockages across this old channel, including two roads that access a large gravel pit on the right bank of the river. This gravel pit at RM 178.4 is partly within the Channel Migration Zone (CMZ) of the river. Although the channel showed clear expression in the 1950s imagery, it is not very visible in the 2011 imagery, suggesting that restoring this feature may be difficult.

About 20 percent of the total 100-year floodplain has become isolated due to human development, and most of the isolation appears to be due to flow alterations rather than floodplain dikes. The 5-year floodplain is even more affected; 59 percent of the historic 5-year floodplain is no longer inundated at that frequency.

Land use is dominated by flood irrigation with additional gravel pit development (mapped as exurban industrial) and transportation infrastructure. There is one Fishing Access Site at Kinsey Bridge. There are two animal handling facilities north of the river that are within several hundred feet of the streambank; both are downstream of Kinsey Bridge, at RM 166.2 and RM 167.8.

There are 65 acres of Russian olive in the reach, most of which is on the south side of the river away from the bluff line to the north. Over half of the low-flow fish habitat in this reach is bluff pool, potentially making it important for fish with bluff pool habitat preferences.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been major in this reach. The 100-year flood has dropped by 19 percent. The 2-year flood, which strongly influences overall channel form, has dropped by 24 percent. Low flows have also been impacted; severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 5,100 cfs to 3,180 cfs with human development, a reduction of 38 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,730 cfs under unregulated conditions to 3,530 cfs under regulated conditions, a reduction of 48 percent.

CEA-Related observations in Reach C18 include:

- Natural channel stability provided by bedrock
- Minimal bank armoring

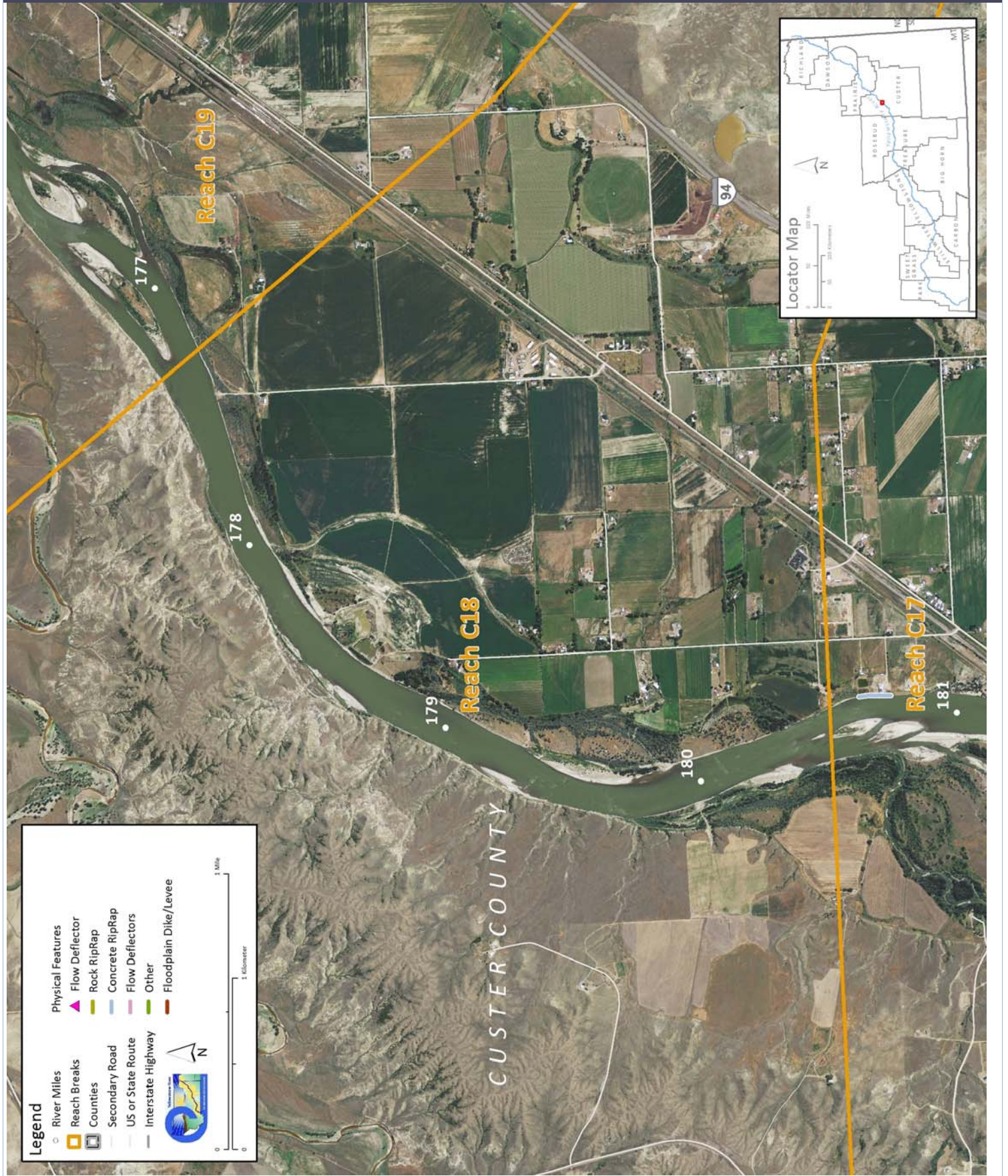
Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach C18 include:

- Russian olive removal

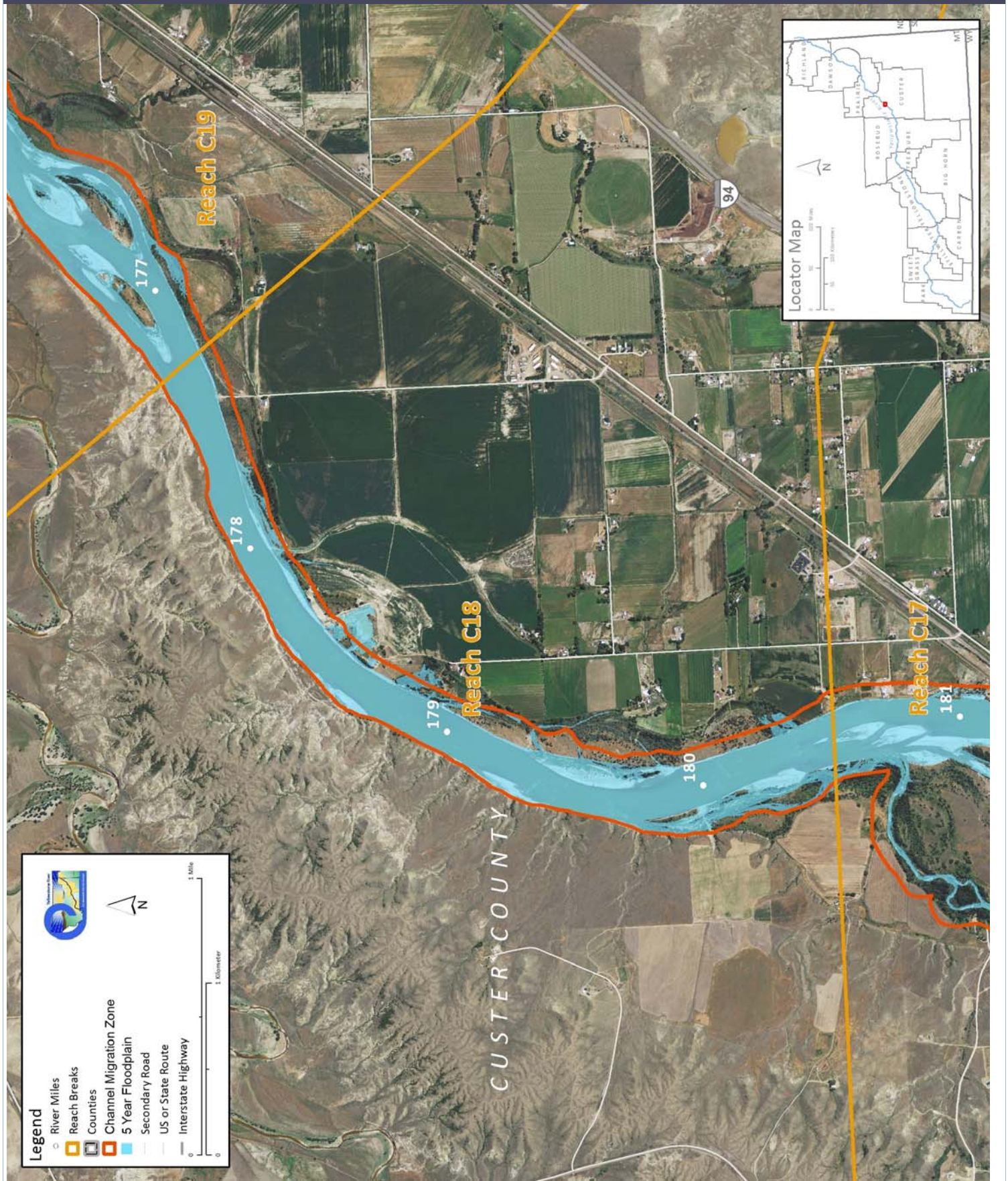
The following table summarizes some key CEA results that have been used to describe overall condition and types of human influences affecting the river. The values are specific to this single reach. Blanks indicate that a particular value was not available for this area. This information is consolidated from a large dataset that is presented in more detail in the full reach narrative report.

Discharge	Undev.	Developed	% Change	"Undeveloped" flows represent conditions prior to significant human development, whereas "developed" flows reflect the current condition of both consumptive and non-consumptive water use.		
2 Year (cfs)	63,400	48,200	-24.0%			
100 Year (cfs)	117,000	94,400	-19.3%			
Bankfull Channel Area (Ac)	1950	1976	1995	2001	1950-2001	Bankfull channel area is the total footprint of the river inundated at approx. the 2-year flood.
	323.6	351.7	346.8	343.9	20.3	
Physical Features	2011 Length (ft)	% of Bankline	2001-2011 Change	There are additional types of bank armor such as car bodies and steel retaining walls, but they are relatively minor.		
Rock RipRap	0	0.0%	0			
Concrete Riprap	0	0.0%	0			
Flow Deflectors	0	0.0%	0			
Total	0	0.0%	0			
Length of Side Channels Blocked (ft)	Pre-1950s	Post-1950s	Numerous side channels have been blocked by small dikes.			
	1,052	0				
Floodplain Turnover	1950 - 1976	1976 - 2001	1950-2001 In-channel riparian encroachment (negative number indicates retreat)		The rate of floodplain turnover reflects how many acres of land are eroded by the river. Turnover is associated with the creation of riparian habitat.	
Total Acres	45.3	21.5	26 acres			
Acres/Year	1.7	0.9				
Acres/Year/Valley Mile	0.6	0.3				
Open Bar Area	Point Bars	Bank Attached	Mid-Channel	Total	The type and extent of open sand and gravel bars reflect in-stream habitat conditions that can be important to fish, amphibians, and ground-nesting birds such as least terns.	
Change in Area '50 - '01 (Ac)	13.9	40.9	-17.3	37.5		
Floodplain Isolation	Acres	% of FP	Floodplain isolation refers to area that historically was flooded, but has become isolated do to flow alterations or physical features such as levees.			
5 Year	67.1	59%				
100 Year	59.4	20%				
Restricted Migration Area	Acres	% of CMZ	Channel Migration Zone restrictions refer to the area and percent of the CMZ that has been isolated by features such as bank armor, dikes, levees, and transportation embankments.			
	1.5	0%				
Land Use	1950	2011	1950	2011	Changes in land use reflect the development of the river corridor through time. The irrigated agricultural are is a sub-set of the mapped agricultural land.	
Agricultural Land (Ac)	2,390.9	2,289.9	Flood (Ac)	1,319.4	1,305.2	
Ag. Infrastructure (Ac)	29.2	85.0	Sprinkler (Ac)	0.0	0.0	
Exurban (Ac)	3.8	41.6	Pivot (Ac)	0.0	0.0	
Urban (Ac)	0.0	0.0				
Transportation (Ac)	21.4	16.4				
1950s Riparian Vegetation Converted to a Developed Land Use (ac)	To Irrigated	To Other Use	Total Rip. Converted	% of 1950s Rip.	Changes in the extents of riparian vegetation are influenced by land use changes within the corridor.	
	31.8	13.0	44.8	17.0%		
National Wetlands Inventory	Acres	Acres per Valley Mi	Total Wetland Acres	Wetlands units summarized from National Wetlands Inventory Mapping include Riverine (typically open water sloughs), Emergent (marshes and wet meadows) and Shrub-Scrub (open bar areas with colonizing woody vegetation).		
Riverine	5.7	1.8	27.5			
Emergent	21.8	7.0				
Scrub/Shrub	0.0	0.0				
Russian Olive (2001) (Appx. 100-yr Floodplain)	Acres	%	Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.			
	65.4	5.1%				
Riparian Forest at low risk of Cowbird Parasitism (Ac/Valley Mile)	1950	1976	2001	Change 1950-2011	Cowbirds are associated with agricultural and residential development, displacing native bird species by parasitizing their nests.	
	2.0	0.0	0.0	-2.0		

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



County	Custer	Upstream River Mile	177.3
Classification	CS: Confined straight	Downstream River Mile	166.2
General Location	Kinsey Bridge	Length	11.10 mi (17.86 km)

Narrative Summary

Reach C19 is 11.1 miles long and is located downstream of Miles City at Kinsey Bridge. It is a Confined Straight reach type, as the river flows over steep bedrock shelves that create a series of rapids between Miles City and a few miles below Kinsey Bridge.

There are approximately 4,000 feet of rock riprap in the reach, about one third of which was built since 2001. All of the armor is protecting the rail line on the south side of the river. By 1950 over three miles of side channels had been blocked off by small floodplain dikes in Reach C19. These old side channels are on both sides of the river just upstream of Kinsey Bridge. Bank migration rates are very low in the reach, and as a result the Channel Migration Zone (CMZ) is unusually narrow.

The Kinsey Main Canal diversion and pump station are located on the left bank at RM 175. The site consists of a rock diversion that extends about 200 feet into the river at an upstream angle to deflect flows into an excavated approach channel and pumping station. Kinsey Bridge is located at RM 172.1 and consists of a Steel multi-beam structure that was built in 1907 for the Milwaukee Railroad, but now supports County Road 62. It is just over 1,000 feet long and has four spans.

The 2001 physical features inventory also identified 7,200 feet of bedrock outcrop in the reach. A total of five discreet sets of rapids were mapped in the reach, including Buffalo Shoals (RM 176 and RM 177), Matthew Rapids (RM 174.5), and two unnamed rapids upstream and downstream of Kinsey Bridge at RM 172.5 and RM 171, respectively.

On the downstream end of the reach, an 8-inch Cenex pipeline that carries petroleum products flows parallel to the river on the landward side of the active BNSF rail line. The pipeline is about 400 feet away from the active riverbank at RM 166.5, but the fact that the rail line sits between the pipeline and the river suggests that its risk of exposure is low.

Between 1950 and 2001 there was about 89 net acres of riparian encroachment into the channel, and the bankfull channel area decreased by ~100 acres, indicating a diminishing river size over the last half-century. This trend is common below the mouth of the Bighorn River, where flow alterations have reduced peak flows and cause the active river channel to shrink. Consumptive water uses, primarily associated with irrigation, have contributed to the reduced flows.

About 13 percent of the total 100-year floodplain has become isolated due to human development, and most of the isolation appears to be due to flow alterations rather than floodplain dikes. The 5-year floodplain is even more affected; 55 percent of the historic 5-year floodplain is no longer inundated at that frequency.

Two ice jams have been reported in Reach C19; one in March of 1994 at RM 168 and the other in February of 1997 at RM 174. No damages were reported.

Land use is dominated by agriculture (~4,700 acres), with 326 acres of pivot irrigation development since 1950. There is one Fishing Access Site at Kinsey Bridge. There are two animal handling facilities north of the river that are within several hundred feet of the streambank; both are downstream of Kinsey Bridge, at RM 166.2 and RM 167.8.

There are 254 acres of Russian olive in the reach, most of which is on the north side of the river away from the bluff line to the south. Russian olive comprises almost 30 percent of all of the mapped shrubs in the reach. There are notably high concentrations of Russian olive in one of the abandoned side channels that is located on the left bank just downstream from the Kinsey Main Canal diversion.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been major in this reach. The 2-year flood, which strongly influences overall channel form, has dropped by 24 percent. Low flows have also been impacted; severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 5,080 cfs to 3,150 cfs with human development, a reduction of 38 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,740 cfs under unregulated conditions to 3,510 cfs under regulated conditions, a reduction of 48 percent.

CEA-Related observations in Reach C19 include:

- Side channel blockages pre-1950
- Russian olive colonization, especially in blocked side channels
- Armoring needs by the railroad on the south bluff line
- Low natural rates of bank movement in reach with extensive bedrock exposure and rapids

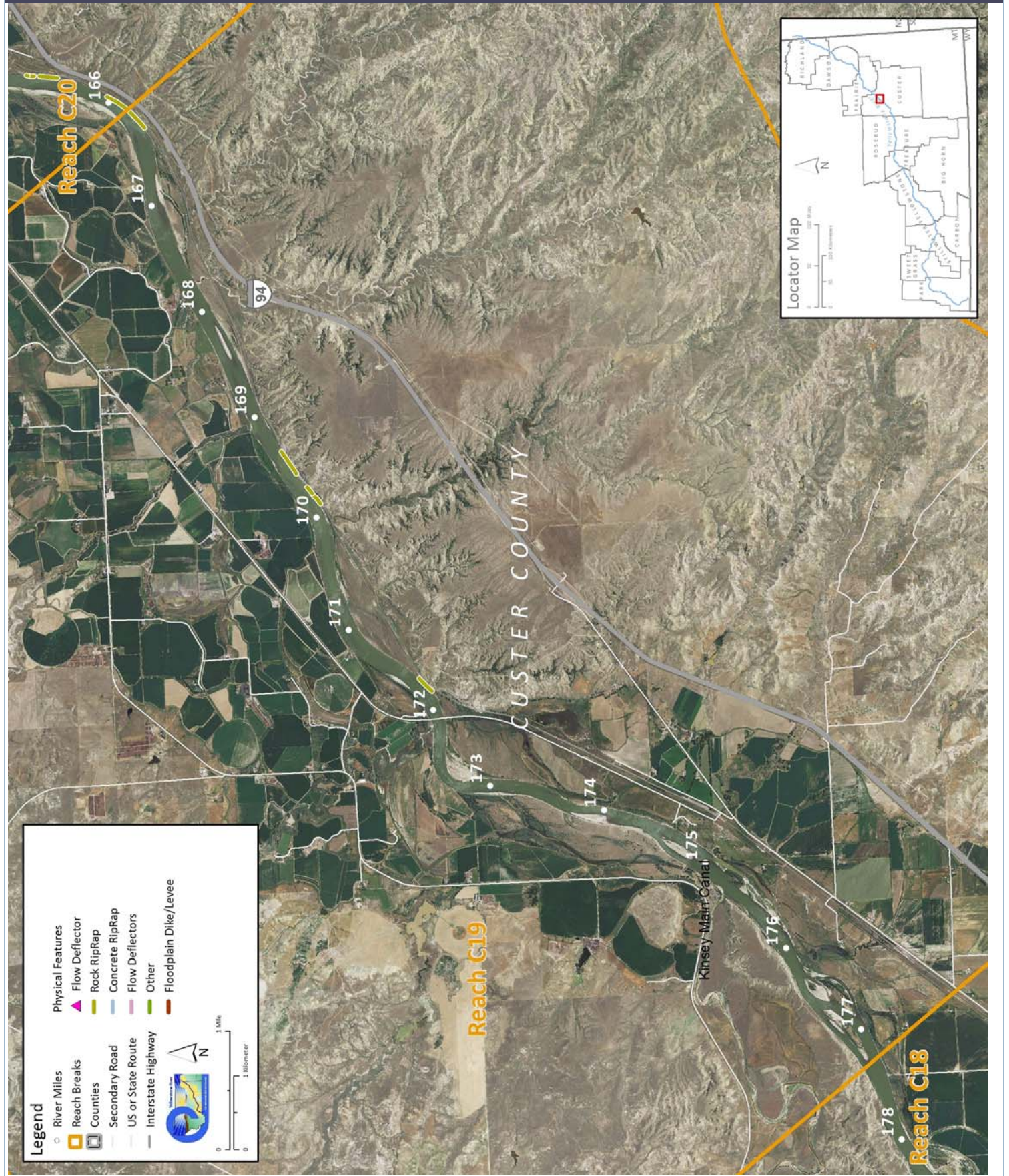
Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach C19 include:

- Side channel reactivation at RM 175L and RM 174R
- Russian olive removal
- Nutrient management at animal handling facilities at RM 166.2L and RM 167.8L

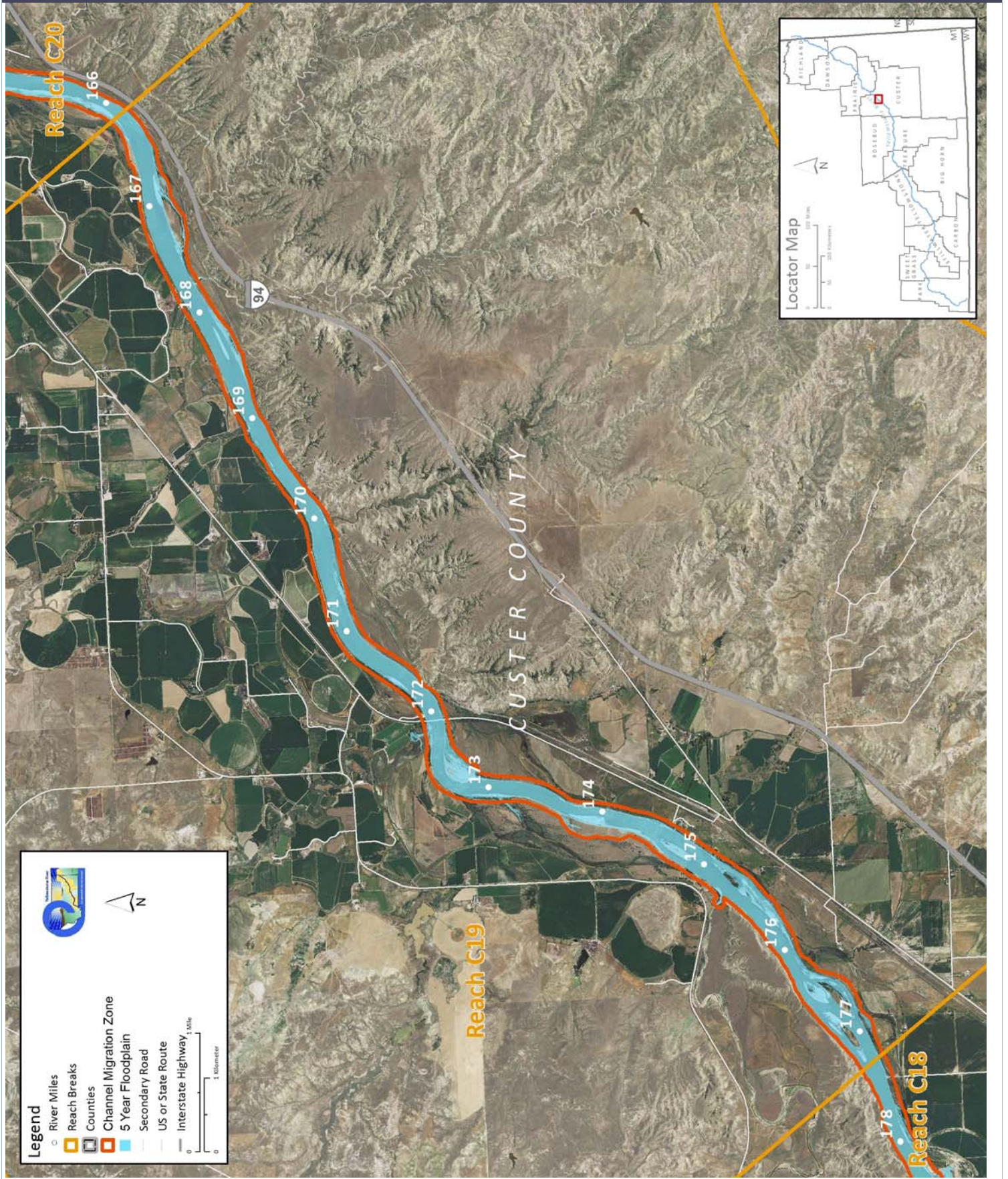
The following table summarizes some key CEA results that have been used to describe overall condition and types of human influences affecting the river. The values are specific to this single reach. Blanks indicate that a particular value was not available for this area. This information is consolidated from a large dataset that is presented in more detail in the full reach narrative report.

Discharge	Undev.	Developed	% Change	"Undeveloped" flows represent conditions prior to significant human development, whereas "developed" flows reflect the current condition of both consumptive and non-consumptive water use.		
2 Year (cfs)	63,700	48,500	-23.9%			
100 Year (cfs)	119,000	96,100	-19.2%			
Bankfull Channel Area (Ac)	1950	1976	1995	2001	1950-2001	Bankfull channel area is the total footprint of the river inundated at approx. the 2-year flood.
	1,259.4	1,190.3	1,150.4	1,157.3	-102.1	
Physical Features	2011 Length (ft)	% of Bankline	2001-2011 Change	There are additional types of bank armor such as car bodies and steel retaining walls, but they are relatively minor.		
Rock RipRap	4,043	3.4%	1,474			
Concrete Riprap	0	0.0%	0			
Flow Deflectors	0	0.0%	0			
Total	4,043	3.4%	1,474			
Length of Side Channels Blocked (ft)	Pre-1950s	Post-1950s	Numerous side channels have been blocked by small dikes.			
	17,355	0				
Floodplain Turnover	1950 - 1976	1976 - 2001	1950-2001 In-channel riparian encroachment (negative number indicates retreat)		The rate of floodplain turnover reflects how many acres of land are eroded by the river. Turnover is associated with the creation of riparian habitat.	
Total Acres	84.9	60.8	88.9 acres			
Acres/Year	3.3	2.4				
Acres/Year/Valley Mile	0.3	0.2				
Open Bar Area	Point Bars	Bank Attached	Mid-Channel	Total	The type and extent of open sand and gravel bars reflect in-stream habitat conditions that can be important to fish, amphibians, and ground-nesting birds such as least terns.	
Change in Area '50 - '01 (Ac)	-4.4	100.2	17.5	113.2		
Floodplain Isolation	Acres	% of FP	Floodplain isolation refers to area that historically was flooded, but has become isolated do to flow alterations or physical features such as levees.			
5 Year	116.2	55%				
100 Year	85.9	13%				
Restricted Migration Area	Acres	% of CMZ	Channel Migration Zone restrictions refer to the area and percent of the CMZ that has been isolated by features such as bank armor, dikes, levees, and transportation embankments.			
	2.6	0%				
Land Use	1950	2011	1950	2011	Changes in land use reflect the development of the river corridor through time. The irrigated agricultural are is a sub-set of the mapped agricultural land.	
Agricultural Land (Ac)	9,752.6	9,591.9	Flood (Ac)	4,385.3	4,125.1	
Ag. Infrastructure (Ac)	178.6	363.1	Sprinkler (Ac)	0.0	0.0	
Exurban (Ac)	0.0	11.8	Pivot (Ac)	0.0	325.8	
Urban (Ac)	0.0	0.0				
Transportation (Ac)	213.2	251.8				
1950s Riparian Vegetation Converted to a Developed Land Use (ac)	To Irrigated	To Other Use	Total Rip. Converted	% of 1950s Rip.	Changes in the extents of riparian vegetation are influenced by land use changes within the corridor.	
	10.4	8.3	18.8	3.0%		
National Wetlands Inventory	Acres	Acres per Valley Mi	Total Wetland Acres	Wetlands units summarized from National Wetlands Inventory Mapping include Riverine (typically open water sloughs), Emergent (marshes and wet meadows) and Shrub-Scrub (open bar areas with colonizing woody vegetation).		
Riverine	16.1	1.5	193.5			
Emergent	165.2	15.4				
Scrub/Shrub	12.2	1.1				
Russian Olive (2001) (Appx. 100-yr Floodplain)	Acres	%	Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.			
	254.1	5.0%				
Riparian Forest at low risk of Cowbird Parasitism (Ac/Valley Mile)	1950	1976	2001	Change 1950-2011	Cowbirds are associated with agricultural and residential development, displacing native bird species by parasitizing their nests.	
	10.1	1.0	0.1	-10.0		

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



County	Custer	Upstream River Mile	166.2
Classification	CS: Confined straight	Downstream River Mile	158.7
General Location	Shirley	Length	7.50 mi (12.07 km)

Narrative Summary

Reach C20 is 7.5 miles long and is located in lowermost Custer County at Shirley. The Bonfield Fishing Access Site is located at RM 161 on the left bank. It is a Confined Straight reach type, as the river flows through the confining geology of the Fort Union Formation sandstones. Small tributaries that enter Reach C20 include Hay Creek (RM 165), Harris Creek (RM 164), Cabin and Cottonwood Creeks (RM 162) and Saugus Creek (RM 160.2). Bank migration rates are very low in the reach, and as a result the Channel Migration Zone (CMZ) is unusually narrow.

There is just over a mile of bank armor in the reach that covers about 8 percent of the total bankline. As of 2011 there was 6,059 feet of rock riprap in reach C20, and 1,650 feet of that armor was built between 2001 and 2011. Most of the rock riprap is protecting the abandoned Milwaukee Rail line on the north side of the river where it runs in the edge of the bluff line. The new armor is protecting the Shirley Pump Station at RM 165.3R. There are also 131 feet of flow deflectors across the river from the Bonfield Fishing Access Site.

Between 1950 and 2001 there was about 50 net acres of riparian encroachment into the channel, and the bankfull channel area decreased by ~58 acres, indicating a diminishing river size over the last half-century. This trend is common below the mouth of the Bighorn River, where flow alterations have reduced peak flows and cause the active river channel to shrink. Consumptive water uses, primarily associated with irrigation, have contributed to the reduced flows.

About 13 percent of the total 100-year floodplain has become isolated due to human development, and most of the isolation appears to be due to flow alterations rather than floodplain dikes. The 5-year floodplain is even more affected; 55 percent of the historic 5-year floodplain is no longer inundated at that frequency.

Land use is dominated by agriculture (~6,200 acres), with 327 acres of pivot irrigation development since 1950. Irrigated fields extend to the active streambank through much of the reach.

There are 84 acres of Russian olive in the reach. The Russian olive is concentrated on tributaries and in riparian areas colonizing old river swales, mostly in the upstream portion of the reach.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been major in this reach. The magnitude of 100-year flood has dropped by 19 percent due to flow alterations associated with human development. The 2-year flood, which strongly influences overall channel form, has dropped by 24 percent. Low flows have also been impacted; severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 5,080 cfs to 3,150 cfs with human development, a reduction of 38 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,750 cfs under unregulated conditions to 3,510 cfs under regulated conditions, a reduction of 48 percent.

CEA-Related observations in Reach C20 include:

- Irrigated land encroachment in reach stabilized by bedrock
- Bank armor on abandoned rail line on northern bluff

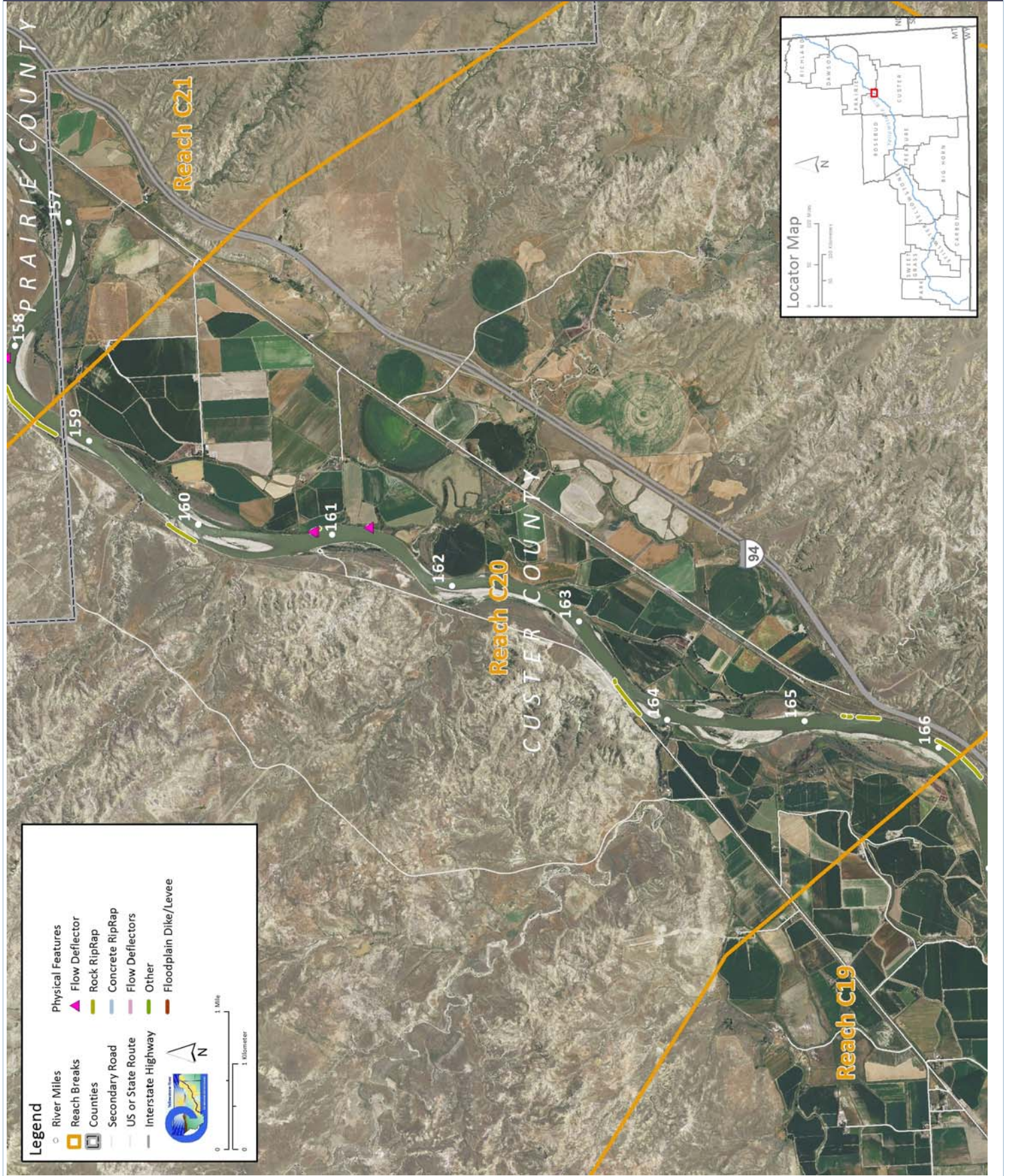
Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach C20 include:

- Russian olive removal

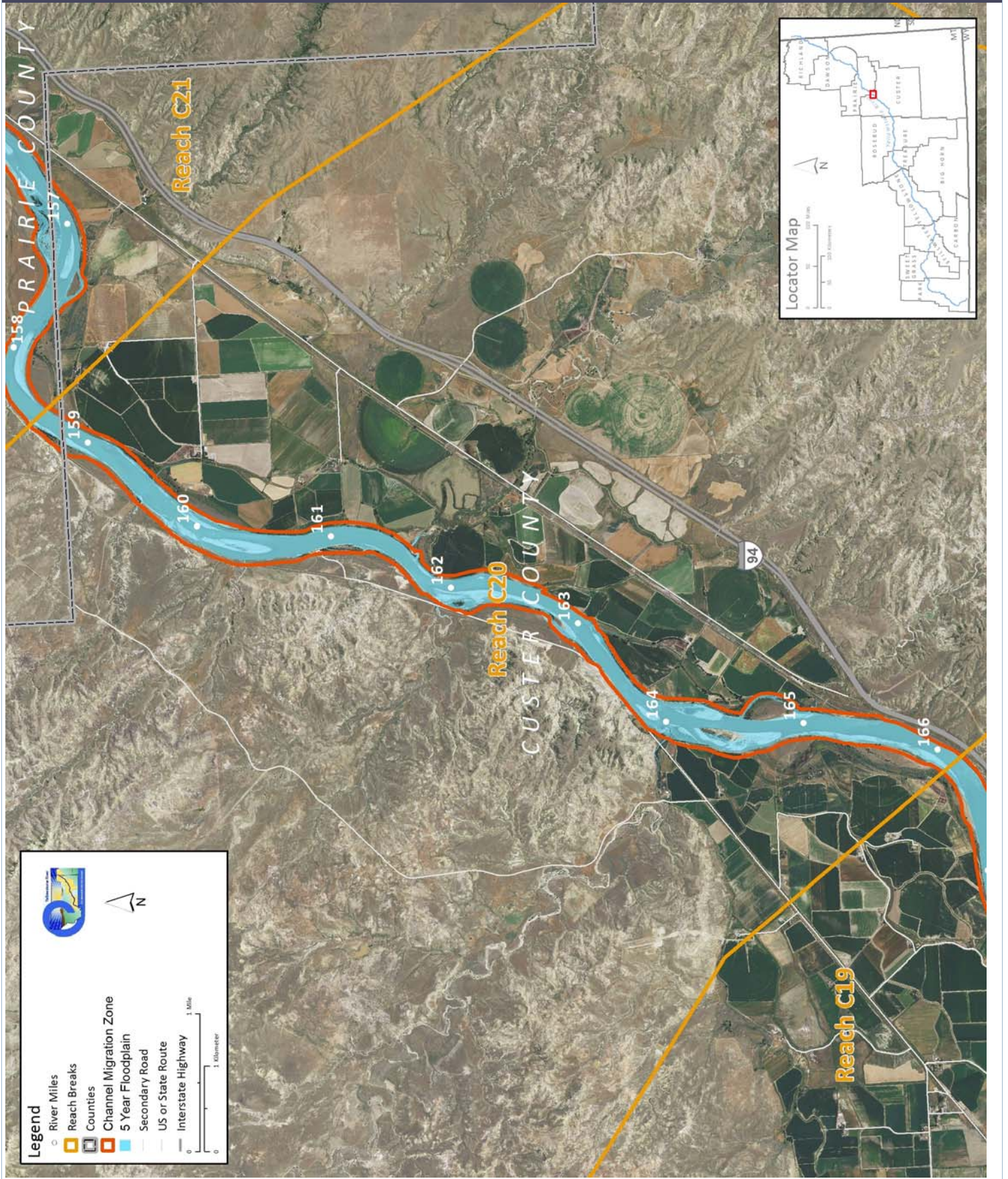
The following table summarizes some key CEA results that have been used to describe overall condition and types of human influences affecting the river. The values are specific to this single reach. Blanks indicate that a particular value was not available for this area. This information is consolidated from a large dataset that is presented in more detail in the full reach narrative report.

Discharge	Undev.	Developed	% Change	"Undeveloped" flows represent conditions prior to significant human development, whereas "developed" flows reflect the current condition of both consumptive and non-consumptive water use.		
2 Year (cfs)	63,800	48,600	-23.8%			
100 Year (cfs)	119,000	96,400	-19.0%			
Bankfull Channel Area (Ac)	1950	1976	1995	2001	1950-2001	Bankfull channel area is the total footprint of the river inundated at approx. the 2-year flood.
	798.7	764.1	746.8	740.8	-57.8	
Physical Features	2011 Length (ft)	% of Bankline	2001-2011 Change	There are additional types of bank armor such as car bodies and steel retaining walls, but they are relatively minor.		
Rock RipRap	6,059	7.6%	1,649			
Concrete Riprap	0	0.0%	0			
Flow Deflectors	131	0.2%	131			
Total	6,190	7.8%	1,781			
Length of Side Channels Blocked (ft)	Pre-1950s	Post-1950s	Numerous side channels have been blocked by small dikes.			
	0	0				
Floodplain Turnover	1950 - 1976	1976 - 2001	1950-2001 In-channel riparian encroachment (negative number indicates retreat)		The rate of floodplain turnover reflects how many acres of land are eroded by the river. Turnover is associated with the creation of riparian habitat.	
Total Acres	53.7	41.2	50.32 acres			
Acres/Year	2.1	1.6				
Acres/Year/Valley Mile	0.3	0.2				
Open Bar Area	Point Bars	Bank Attached	Mid-Channel	Total	The type and extent of open sand and gravel bars reflect in-stream habitat conditions that can be important to fish, amphibians, and ground-nesting birds such as least terns.	
Change in Area '50 - '01 (Ac)	30.1	52.3	-4.3	78.1		
Floodplain Isolation	Acres	% of FP	Floodplain isolation refers to area that historically was flooded, but has become isolated do to flow alterations or physical features such as levees.			
5 Year	95.3	55%				
100 Year	48.3	13%				
Restricted Migration Area	Acres	% of CMZ	Channel Migration Zone restrictions refer to the area and percent of the CMZ that has been isolated by features such as bank armor, dikes, levees, and transportation embankments.			
	1.7	0%				
Land Use	1950	2011	1950	2011	Changes in land use reflect the development of the river corridor through time. The irrigated agricultural are is a sub-set of the mapped agricultural land.	
Agricultural Land (Ac)	6,116.5	5,996.3	Flood (Ac)	2,725.1	2,714.2	
Ag. Infrastructure (Ac)	42.5	158.1	Sprinkler (Ac)	0.0	0.0	
Exurban (Ac)	0.0	1.9	Pivot (Ac)	0.0	327.3	
Urban (Ac)	0.0	0.0				
Transportation (Ac)	113.3	184.3				
1950s Riparian Vegetation Converted to a Developed Land Use (ac)	To Irrigated	To Other Use	Total Rip. Converted	% of 1950s Rip.	Changes in the extents of riparian vegetation are influenced by land use changes within the corridor.	
	5.4	1.5	7.0	3.0%		
National Wetlands Inventory	Acres	Acres per Valley Mi	Total Wetland Acres	Wetlands units summarized from National Wetlands Inventory Mapping include Riverine (typically open water sloughs), Emergent (marshes and wet meadows) and Shrub-Scrub (open bar areas with colonizing woody vegetation).		
Riverine	5.7	0.8	56.5			
Emergent	49.2	6.7				
Scrub/Shrub	1.6	0.2				
Russian Olive (2001) (Appx. 100-yr Floodplain)	Acres	%	Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.			
	83.7	2.0%				
Riparian Forest at low risk of Cowbird Parasitism (Ac/Valley Mile)	1950	1976	2001	Change 1950-2011	Cowbirds are associated with agricultural and residential development, displacing native bird species by parasitizing their nests.	
	2.5	1.9	4.1	1.6		

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



County	Custer	Upstream River Mile	158.7
Classification	CM: Confined meandering	Downstream River Mile	149.2
General Location	To Powder River confluence	Length	9.50 mi (15.29 km)

Narrative Summary

Reach C21 is 9.5 miles long and extends from River Mile (RM) 158.7 downstream to the mouth of the Powder River at RM 149.2. It is a Confined Meandering (CM) reach type, as the river flows down a sinuous course that is highly confined by Fort Union Formation sandstones and younger erosion-resistant terraces.

Reach C21 has just over 4,000 feet of rock riprap and 71 feet of mapped flow deflectors, which collectively armor 4.1 percent of the total stream bank. About one half of the armor is protecting road embankments, and the other half is protecting the railroad.

Bear Rapids forms two distinct shoals as bedrock shelves in the river between RM 153 and RM 154 near the mouth of Camp Creek.

Between 1950 and 2001 there was about 53 net acres of riparian encroachment into the channel, and the bankfull channel area decreased by ~58 acres, indicating a diminishing river size over the last half-century. This trend is common below the mouth of the Bighorn River, where flow alterations have reduced peak flows and cause the active river channel to shrink. Consumptive water uses, primarily associated with irrigation, have contributed to the reduced flows.

Land use is dominated by agriculture with 164 acres of the ~7,000 acre mapping footprint occupied by transportation-related land uses. There is one ~0.6 acre series of corrals near the mouth of Mack Creek at RM 157.2R that are within 200 feet of the river. There are also several acres of corrals within 300 feet of the river on the left bank at RM 154.9L. At RM 153.3R there is another much larger series of corrals that are within 500 feet of Camp Creek.

There are 49 acres of Russian olive in the reach, which appears to dominate riparian areas.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been major in this reach. The 100-year flood has dropped by 19 percent. The 2-year flood, which strongly influences overall channel form, has dropped by 24 percent. Low flows have also been impacted; severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 5,080 cfs to 3,140 cfs with human development, a reduction of 38 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,730 cfs under unregulated conditions to 3,510 cfs under regulated conditions, a reduction of 48 percent.

CEA-Related observations in Reach C21 include:

- Natural channel stability provided by bedrock
- Minimal bank armoring

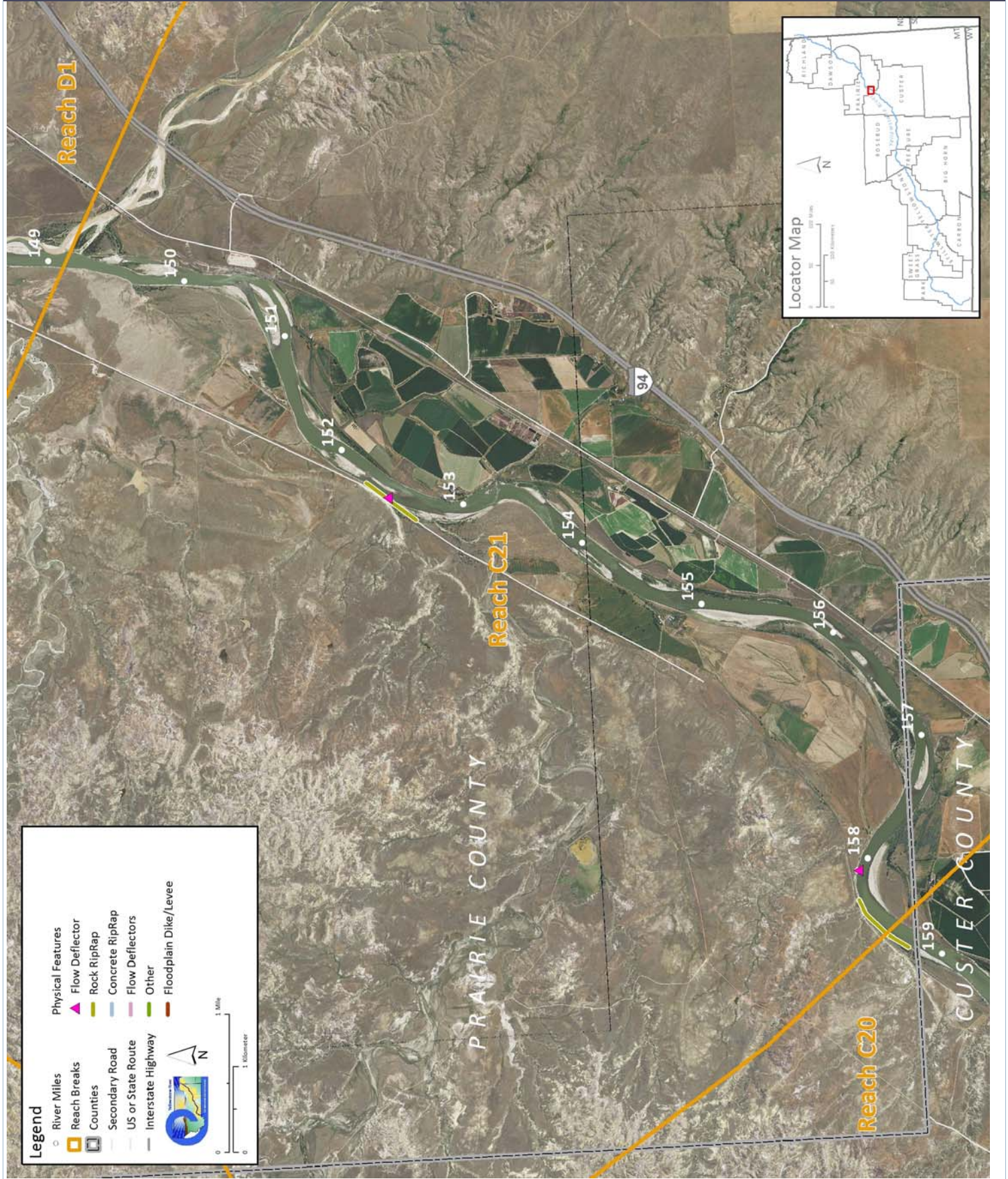
Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach C21 include:

- Russian olive removal
- Nutrient management at corrals at RM 157.2R and RM 153.2R, and 154.9L

The following table summarizes some key CEA results that have been used to describe overall condition and types of human influences affecting the river. The values are specific to this single reach. Blanks indicate that a particular value was not available for this area. This information is consolidated from a large dataset that is presented in more detail in the full reach narrative report.

Discharge	Undev.	Developed	% Change	"Undeveloped" flows represent conditions prior to significant human development, whereas "developed" flows reflect the current condition of both consumptive and non-consumptive water use.		
2 Year (cfs)	63,900	48,600	-23.9%			
100 Year (cfs)	119,000	96,800	-18.7%			
Bankfull Channel Area (Ac)	1950	1976	1995	2001	1950-2001	Bankfull channel area is the total footprint of the river inundated at approx. the 2-year flood.
	973.2	929.6	936.0	914.8	-58.4	
Physical Features	2011 Length (ft)	% of Bankline	2001-2011 Change	There are additional types of bank armor such as car bodies and steel retaining walls, but they are relatively minor.		
Rock RipRap	4,024	4.0%	-41			
Concrete Riprap	0	0.0%	0			
Flow Deflectors	71	0.1%	71			
Total	4,096	4.1%	30			
Length of Side Channels Blocked (ft)	Pre-1950s	Post-1950s	Numerous side channels have been blocked by small dikes.			
	0	0				
Floodplain Turnover	1950 - 1976	1976 - 2001	1950-2001 In-channel riparian encroachment (negative number indicates retreat)		The rate of floodplain turnover reflects how many acres of land are eroded by the river. Turnover is associated with the creation of riparian habitat.	
Total Acres	64.9	62.0	53.32 acres			
Acres/Year	2.5	2.5				
Acres/Year/Valley Mile	0.3	0.3				
Open Bar Area	Point Bars	Bank Attached	Mid-Channel	Total	The type and extent of open sand and gravel bars reflect in-stream habitat conditions that can be important to fish, amphibians, and ground-nesting birds such as least terns.	
Change in Area '50 - '01 (Ac)	29.2	76.2	-1.1	104.4		
Floodplain Isolation	Acres	% of FP	Floodplain isolation refers to area that historically was flooded, but has become isolated do to flow alterations or physical features such as levees.			
5 Year	95.2	35%				
100 Year	12.7	3%				
Restricted Migration Area	Acres	% of CMZ	Channel Migration Zone restrictions refer to the area and percent of the CMZ that has been isolated by features such as bank armor, dikes, levees, and transportation embankments.			
	2.4	0%				
Land Use	1950	2011	1950	2011	Changes in land use reflect the development of the river corridor through time. The irrigated agricultural are is a sub-set of the mapped agricultural land.	
Agricultural Land (Ac)	6,629.3	6,527.2	Flood (Ac)	1,799.1	1,915.9	
Ag. Infrastructure (Ac)	35.4	99.7	Sprinkler (Ac)	0.0	0.0	
Exurban (Ac)	0.0	11.1	Pivot (Ac)	0.0	0.0	
Urban (Ac)	0.0	0.0				
Transportation (Ac)	100.5	163.8				
1950s Riparian Vegetation Converted to a Developed Land Use (ac)	To Irrigated	To Other Use	Total Rip. Converted	% of 1950s Rip.	Changes in the extents of riparian vegetation are influenced by land use changes within the corridor.	
	0.0	1.2	1.2	1.0%		
National Wetlands Inventory	Acres	Acres per Valley Mi	Total Wetland Acres	Wetlands units summarized from National Wetlands Inventory Mapping include Riverine (typically open water sloughs), Emergent (marshes and wet meadows) and Shrub-Scrub (open bar areas with colonizing woody vegetation).		
Riverine	7.7	0.9	79.6			
Emergent	61.4	7.2				
Scrub/Shrub	10.5	1.2				
Russian Olive (2001) (Appx. 100-yr Floodplain)	Acres	%	Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.			
	48.6	0.8%				
Riparian Forest at low risk of Cowbird Parasitism (Ac/Valley Mile)	1950	1976	2001	Change 1950-2011	Cowbirds are associated with agricultural and residential development, displacing native bird species by parasitizing their nests.	
	8.9	3.3	7.5	-1.4		

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP

