

County	Prairie	Upstream River Mile	149.2
Classification	CM: Confined meandering	Downstream River Mile	137
General Location	To Terry Bridge	Length	12.20 mi (19.63 km)

Narrative Summary

Reach D1 is located in Prairie County, and extends from just below the mouth of the Powder River to Terry. The reach is a 12.2 mile long Confined Meandering (CM) reach type, indicating that the river flows along a meandering course that is confined by older geologic units. Sandstones of the Fort Union Formation and younger erosion-resistant terraces confine the channel through the reach. Because of the geologic confinement, channel migration rates are low and the riparian corridor is notably thin or absent. There is one Fishing Access Site at the upper end of the reach at the Powder River confluence (Powder River Depot).

There are less than 1000 feet of bank armor in the reach; including about 550 feet of rock riprap and 140 feet of flow deflectors. The flow deflectors were all built between 2001 and 2011. During that timeframe there was a loss of 650 feet of rock riprap where it was protecting an old railroad bridge at RM 144.5. The bridge was built in 1907 for the railroad and now serves County Road 42.

Wolf Rapids is located on the apex of a large meander at RM 146. These rapids are formed from an exposed bedrock shelf that extends across the entire river.

Reach D1 has lost almost a mile of side channel length since 1950, but none of this loss has been associated with intentional blockages. There has been 126 acres of riparian recruitment into abandoned 1950s channels.

Land use is predominantly agricultural, and there has been 310 acres of land developed under pivot irrigation. There are two animal handling facilities just north of Terry that are adjacent to old swales. One dump site was mapped on the right bank of the river at RM 137.5R, about ¾ miles upstream from the Terry Bridge.

About 51 percent of the historic 5-year floodplain has become isolated, primarily due to flow alterations. The abandoned Milwaukee rail line embankment has been breached by river erosion in several locations on the south side of the river.

A total of four ice jams have been reported in the reach. One of these events was in February (1996), and three occurred in March (1993, 2009, and 2011). No damages were reported.

There are about 20 acres of mapped Russian olive in the reach.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been major in this reach. The 2-year flood, which strongly influences overall channel form, has dropped by 22 percent. Low flows have also been impacted; severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 4,850 cfs to 2,810 cfs with human development, a reduction of 42 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,940 cfs under unregulated conditions to 3,270 cfs under regulated conditions, a reduction of 53 percent.

CEA-Related observations in Reach D1 include:

- Breaching of abandoned Milwaukee Railroad line

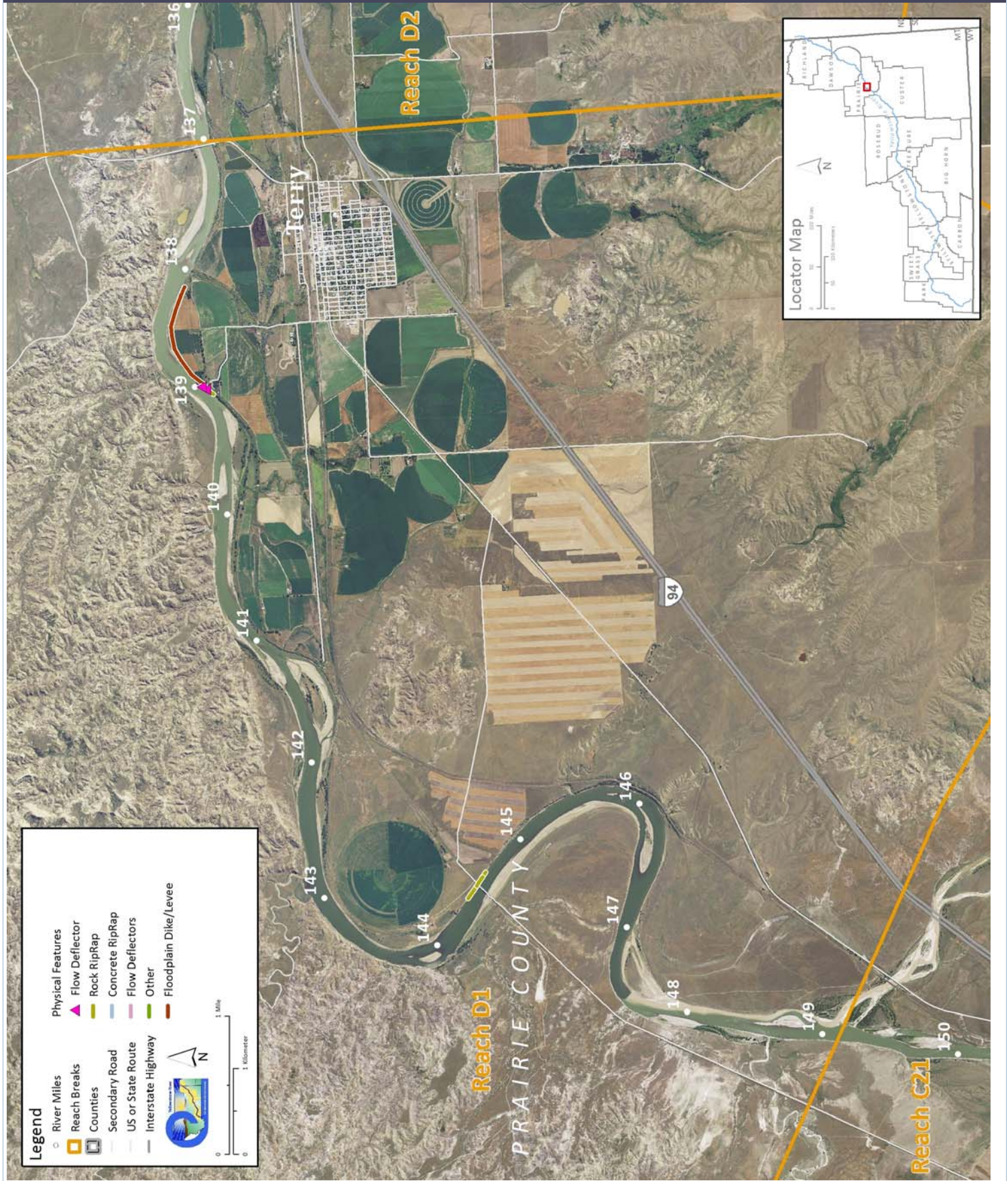
Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach D1 include:

- Dump site Practice at RM 137.5R
- Russian olive removal

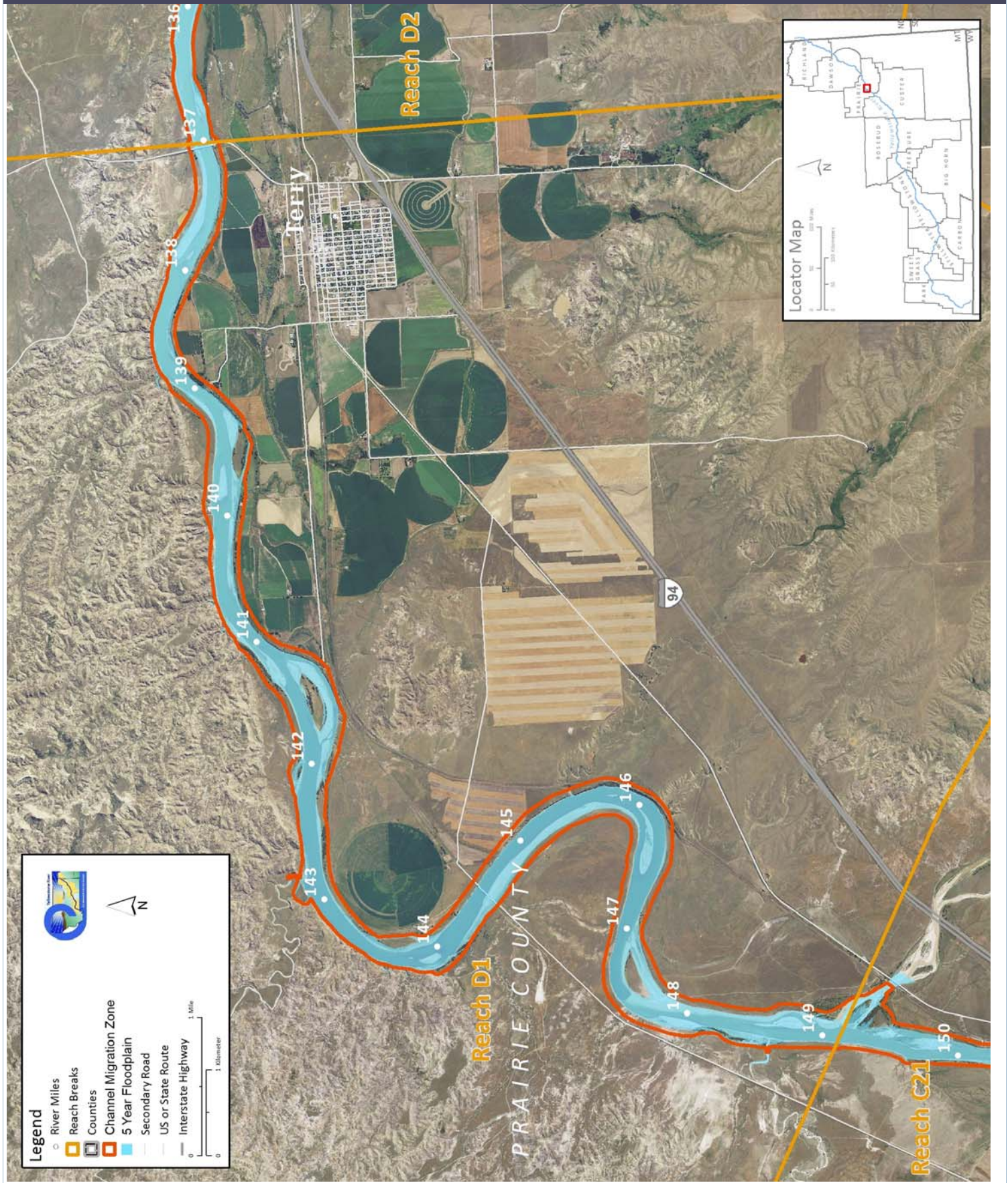
The following table summarizes some key CEA results that have been used to describe overall condition and types of human influences affecting the river. The values are specific to this single reach. Blanks indicate that a particular value was not available for this area. This information is consolidated 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)	68,200	53,000	-22.3%			
100 Year (cfs)	140,000	119,000	-15.0%			
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.
	1,265.9	1,213.5	1,213.1	1,230.9	-34.9	
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	545	0.4%	-651			
Concrete Riprap	0	0.0%	0			
Flow Deflectors	243	0.2%	243			
Total	787	0.6%	-409			
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	88.0	68.1	7.17 acres			
Acres/Year	3.4	2.7				
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)	-50.3	92.6	12.9	55.2		
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	95.5	51%				
100 Year	14.9	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.			
	11.8	1%				
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)	6,528.5	6,539.6	Flood (Ac)	682.4	846.1	
Ag. Infrastructure (Ac)	7.0	56.6	Sprinkler (Ac)	0.0	0.0	
Exurban (Ac)	0.0	16.2	Pivot (Ac)	0.0	310.5	
Urban (Ac)	0.0	0.0				
Transportation (Ac)	103.5	58.7				
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.	
	1.2	0.2	1.4	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	27.0	3.0	45.0			
Emergent	18.0	2.0				
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.			
	19.9	1.4%				
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.	
	5.8	2.9	3.4	-2.4		

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



County	Prairie	Upstream River Mile	137
Classification	CM: Confined meandering	Downstream River Mile	126.5
General Location	To Fallon, I-90 Bridge	Length	10.50 mi (16.90 km)

Narrative Summary

Reach D2 is located in Prairie County, and extends from Terry to Fallon and the I-90 Bridge. The reach is a 10.5 mile long Confined Meandering (CM) reach type, indicating that the river flows along a meandering course that is confined by older geologic units. Sandstones of the Fort Union Formation and younger erosion-resistant terraces confine the channel through the reach. Because of the geologic confinement, channel migration rates are low and the riparian corridor is notably thin or absent. The Channel Migration Zone (CMZ) is extremely narrow because there has been essentially no bank migration in this reach since 1950.

There are just over 1,000 feet of bank armor in the reach; all of which is rock riprap that is protecting the Fallon Bridge.

Land use is predominantly agricultural with more acreage irrigated under pivot than under flood; as of 2011 there were 712 acres in flood and 1,070 acres in pivot in the reach. All of the pivots are on the north side of the river, and several of them extend to the river bank.

One dump site was mapped on the right bank at RM 135.1. There is also an animal handling facility on lower O'Fallon Creek near RM 130.

About 57 percent of the historic 5-year floodplain has become isolated, primarily due to flow alterations. There has been almost 50 acres of riparian encroachment in the reach, likely due to reduced 2-year flows.

Two ice jams have been reported in the reach. In early April of 1943, the breakup of ice jams at Fallon resulted in a 13 foot rise in the river stage at Intake. According to records, many of the farmers "remained in their homes, taking refuge in the attics and second floors of their homes, and some in the haylofts of their barns". More recently in February 1996, lowland flooding resulted from another ice jam breakup.

There are about 20 acres of mapped Russian olive in the reach.

Bluff pools and terrace pools make up 57 percent of the low flow fish habitat mapped in the reach, indicating that this reach may provide important areas for fish species that prefer this habitat type.

O'Fallon Creek enters the Yellowstone River at RM 129. The lowermost 3,100 feet of this creek has been diked off, and the channel now bypasses that remnant and flows directly into the Yellowstone. This abandoned channel supports some emergent wetland and could potentially provide excellent restoration opportunities for wetlands and slackwater areas connected to the Yellowstone River in this highly confined reach.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been major in this reach. The 2-year flood, which strongly influences overall channel form, has dropped by 22 percent. Low flows have also been impacted; severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 4,850 cfs to 2,810 cfs with human development, a reduction of 43 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,940 cfs under unregulated conditions to 3,270 cfs under regulated conditions, a reduction of 53 percent.

CEA-Related observations in Reach D2 include:

- Breaching of abandoned Milwaukee Railroad line
- Diking of lower O'Fallon Creek and isolation of ~3,000 feet of historic tributary channel

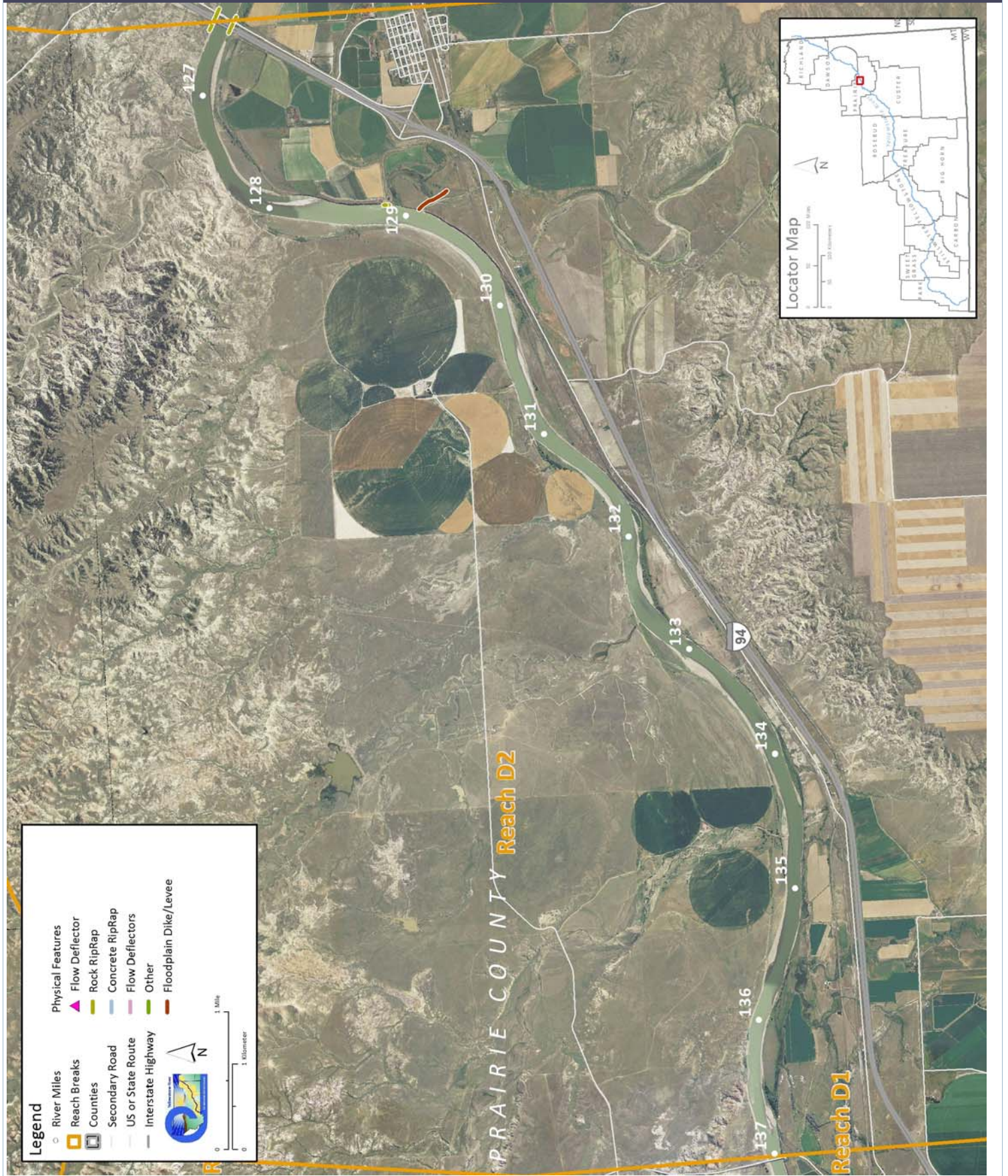
Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach D2 include:

- Dump site YRRP at RM 137.5R
- Nutrient management at animal handling facility on lower O'Fallon Creek RM 130
- Russian olive removal

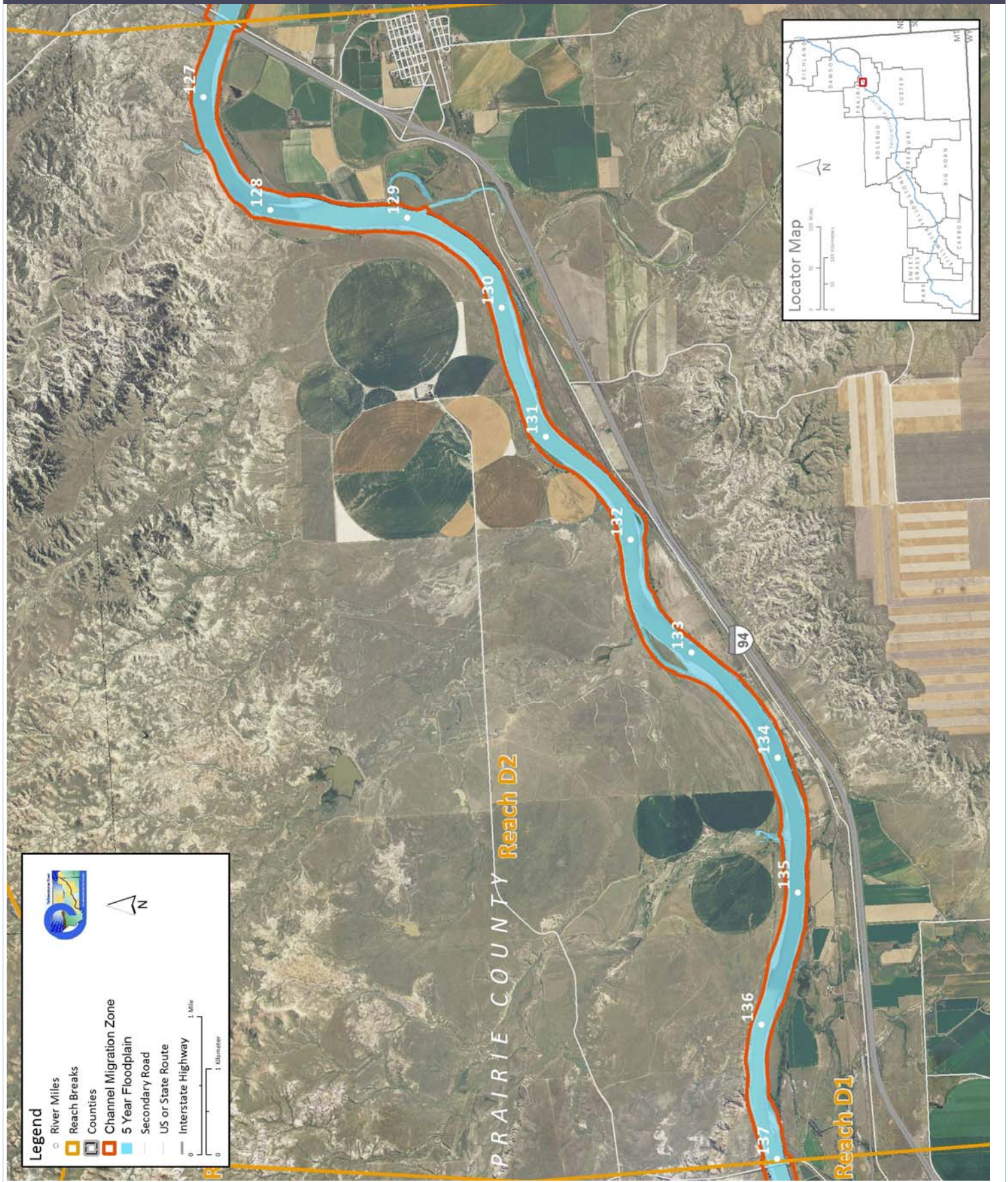
The following table summarizes some key CEA results that have been used to describe overall condition and types of human influences affecting the river. The values are specific to this single reach. Blanks indicate that a particular value was not available for this area. This information is consolidated 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)	68,300	53,100	-22.3%			
100 Year (cfs)	141,000	120,000	-14.9%			
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.
	1,007.7	979.9	984.9	993.8	-13.9	
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	1,055	0.9%	166			
Concrete Riprap	0	0.0%	0			
Flow Deflectors	0	0.0%	0			
Total	1,055	0.9%	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	48.8	32.3	48.3 acres			
Acres/Year	1.9	1.3				
Acres/Year/Valley Mile	0.2	0.1				
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)	-117	51.9	3.4	-61.7		
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	100.7	57%				
100 Year	39.7	7%				
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.			
	5.6	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)	7,045.8	6,783.1	Flood (Ac)	630.5	711.7	
Ag. Infrastructure (Ac)	9.7	60.7	Sprinkler (Ac)	0.0	0.0	
Exurban (Ac)	0.0	3.2	Pivot (Ac)	0.0	1,070.2	
Urban (Ac)	0.0	0.0				
Transportation (Ac)	142.2	348.3				
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.	
	2.4	2.8	5.2	2.0%		
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	11.0	1.1	38.4			
Emergent	22.9	2.3				
Scrub/Shrub	4.5	0.5				
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.			
	10.8	1.0%				
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.	
	7.2	1.6	7.4	0.2		

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



County	Prairie	Upstream River Mile	126.5
Classification	PCS: Partially confined straight	Downstream River Mile	118.1
General Location	Downstream of Fallon Bridge	Length	8.40 mi (13.52 km)

Narrative Summary

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

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

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

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

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

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

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

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

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

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been major in this reach. The magnitude of the 100-year flood is now 20,000 cfs or 14 percent lower than it was pre-development. The 2-year flood, which strongly influences overall channel form, has dropped by 22 percent. Low flows have also been impacted; severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 4,820 cfs to 2,750 cfs with human development, a reduction of 43 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,970 cfs under unregulated conditions to 3,240 cfs under regulated conditions, a reduction of 55 percent.

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

CEA-Related observations in Reach D3 include:

- Isolation of historic 5-year floodplain area due to flow alterations

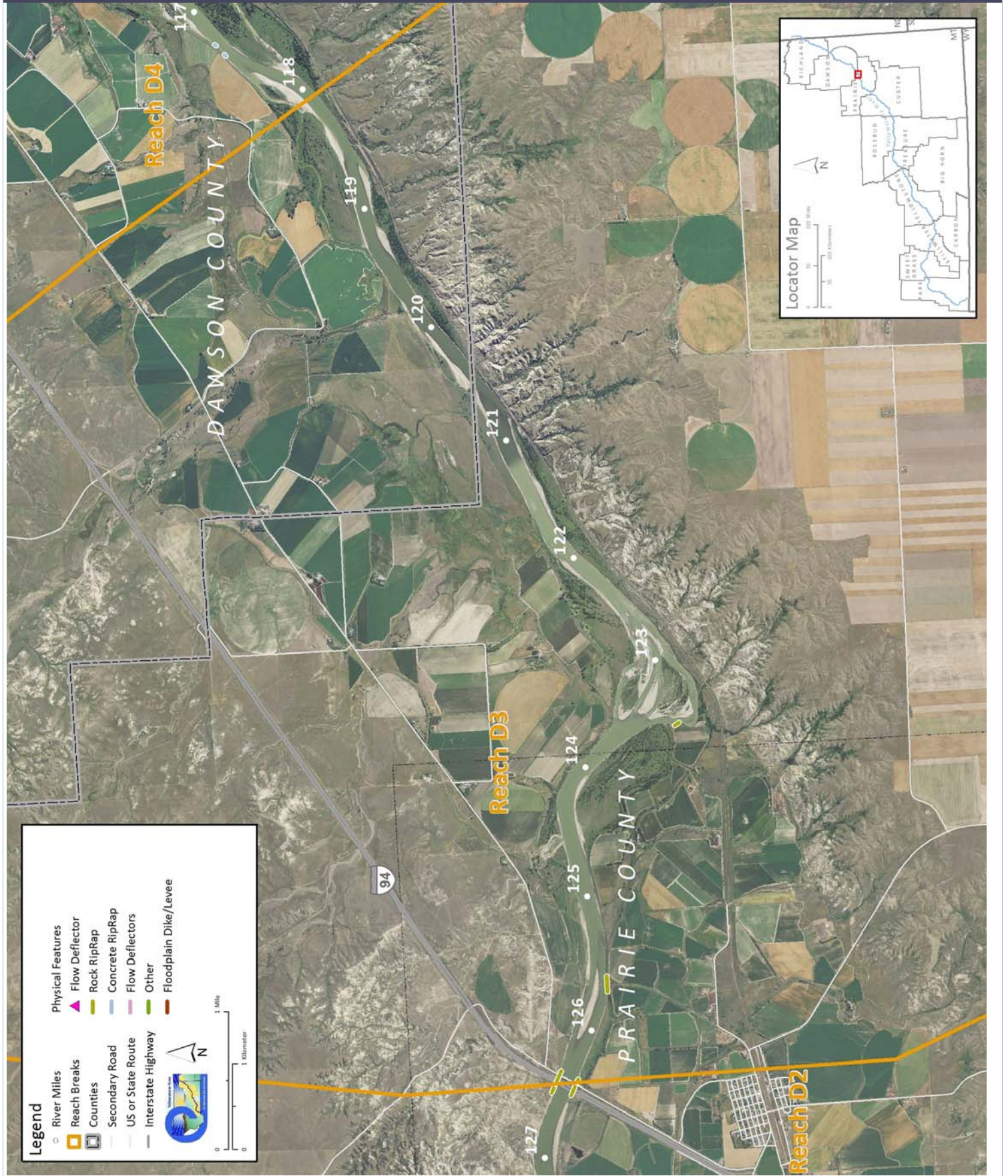
Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach D3 include:

- Solid waste (dump site) removal at RM 125.6R, RM 124.2L, and RM 122L
- Pipeline crossing practices at RM 126.2
- Russian olive removal

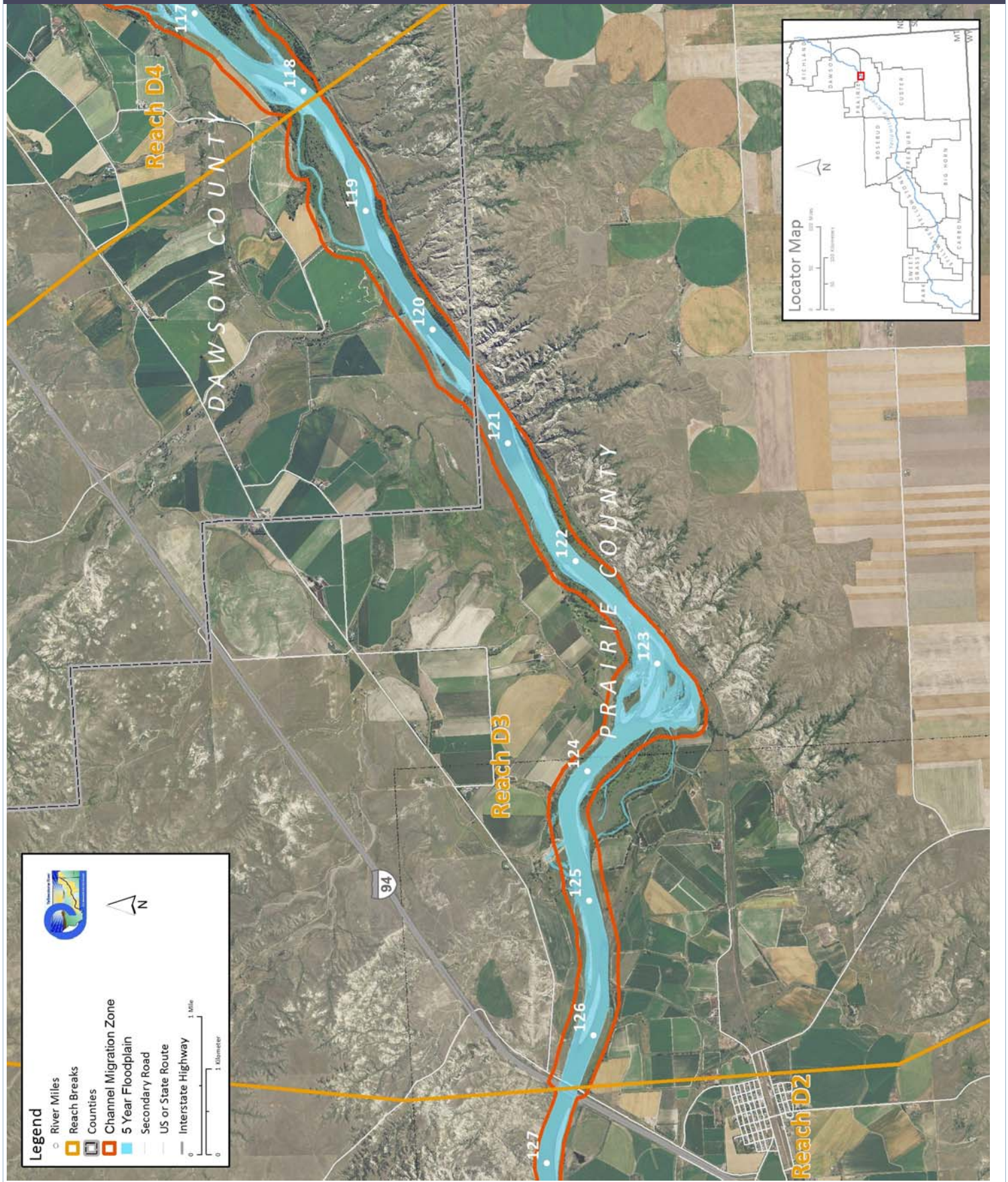
The following table summarizes some key CEA results that have been used to describe overall condition and types of human influences affecting the river. The values are specific to this single reach. Blanks indicate that a particular value was not available for this area. This information is consolidated 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)	68,900	53,700	-22.1%			
100 Year (cfs)	143,000	123,000	-14.0%			
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.
	859.0	873.8	874.4	875.1	16.1	
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	1,492	1.7%	210			
Concrete Riprap	0	0.0%	0			
Flow Deflectors	0	0.0%	0			
Total	1,492	1.7%	210			
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	85.7	56.1	13.81 acres			
Acres/Year	3.3	2.2				
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)	-86.9	37	13.8	-36.1		
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	107.6	49%				
100 Year	100.7	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.			
	17.7	1%				
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)	5,808.1	5,698.2	Flood (Ac)	1,421.0	1,504.2	
Ag. Infrastructure (Ac)	21.5	69.3	Sprinkler (Ac)	0.0	0.0	
Exurban (Ac)	0.0	0.0	Pivot (Ac)	0.0	597.7	
Urban (Ac)	0.0	0.0				
Transportation (Ac)	65.1	78.0				
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.	
	5.3	0.0	5.3	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	12.1	1.5	99.3			
Emergent	80.1	10.2				
Scrub/Shrub	7.1	0.9				
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.			
	10.7	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.	
	30.6	7.8	5.5	-25.1		

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



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

Narrative Summary

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

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

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

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

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

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

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

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

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

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

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

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been major in this reach. The magnitude of the 100-year flood is now 121,000 cfs, or 14 percent lower than it was pre-development. The 2-year flood, which strongly influences overall channel form, has dropped by 22 percent. Low flows have also been impacted; severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 4,800 cfs to 2,730 cfs with human development, a reduction of 43 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,980 cfs under unregulated conditions to 3,220 cfs under regulated conditions, a reduction of 54 percent.

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

CEA-Related observations in Reach D4 include:

- Increased risk of cowbird parasitism with loss of closed timber

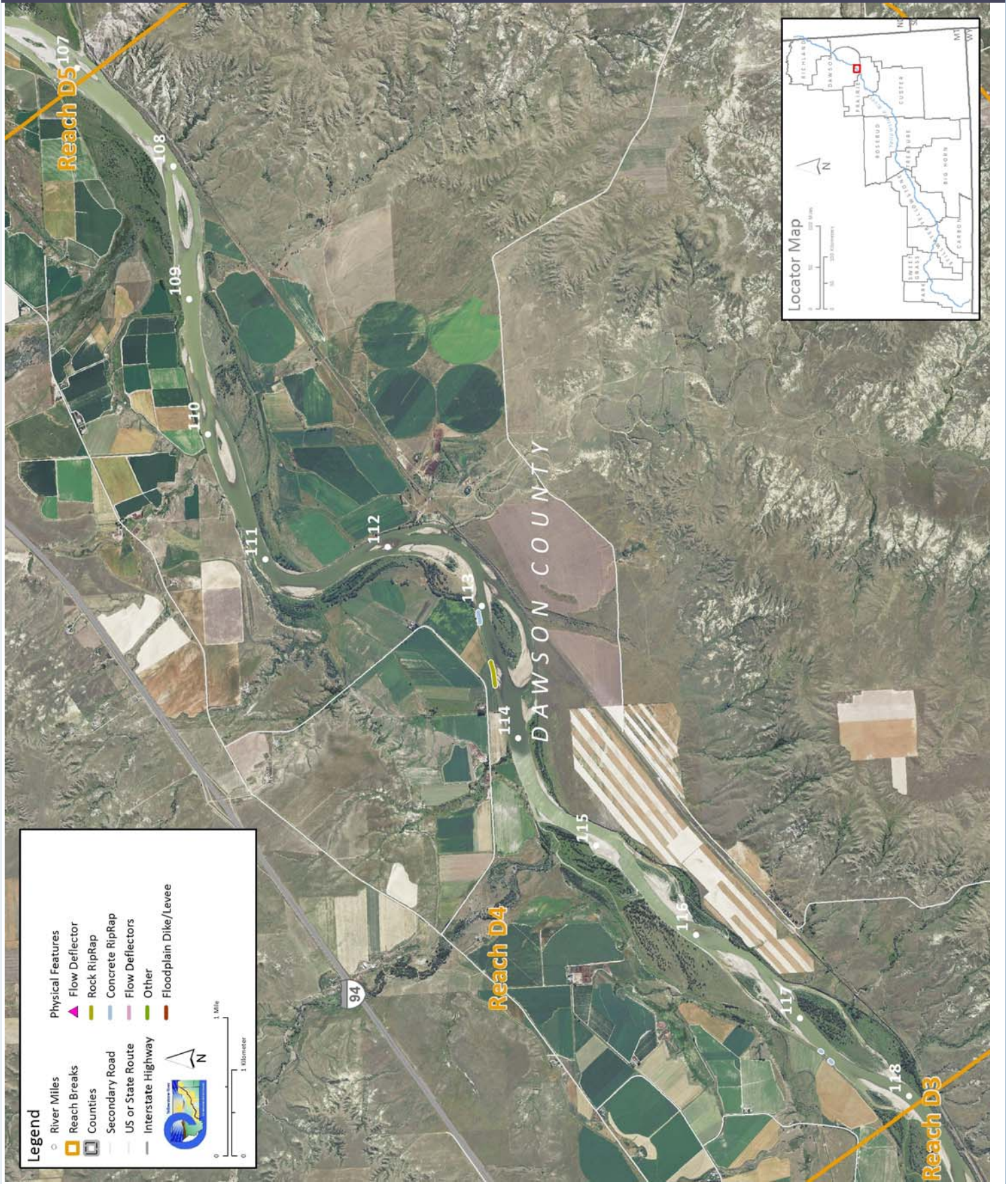
Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach D4 include:

- Side channel reactivation at RM 110.3R
- Solid waste (dump site) removal at RM 117.8L
- Russian olive removal
- Nutrient management at corral complexes at RM 112.2R, RM 114L, and RM 116L

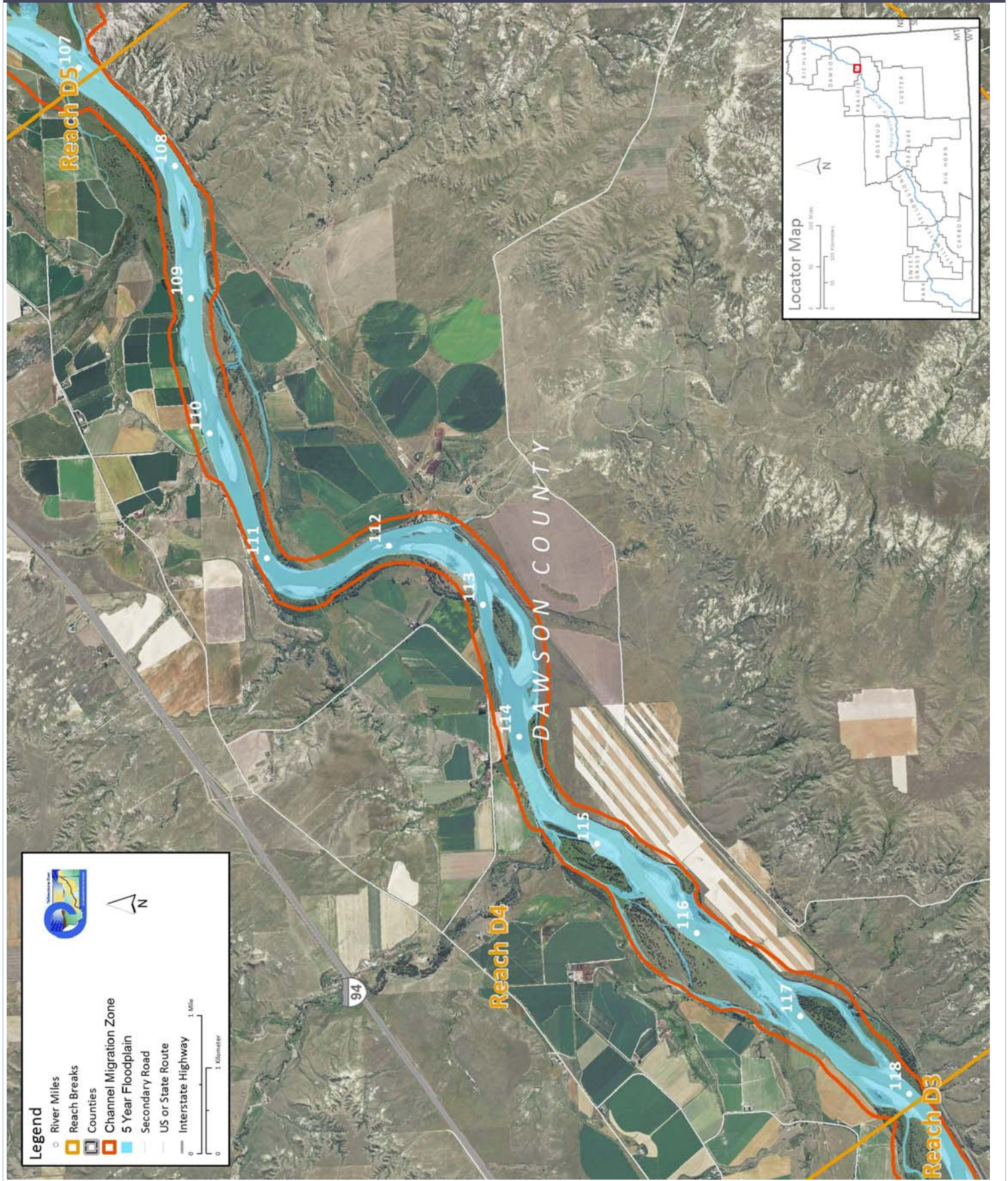
The following table summarizes some key CEA results that have been used to describe overall condition and types of human influences affecting the river. The values are specific to this single reach. Blanks indicate that a particular value was not available for this area. This information is consolidated 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)	69,100	53,900	-22.0%			
100 Year (cfs)	145,000	124,000	-14.5%			
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.
	1,349.9	1,279.9	1,230.5	1,234.4	-115.5	
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	921	0.8%	921			
Concrete Riprap	587	0.5%	587			
Flow Deflectors	0	0.0%	0			
Total	1,509	1.3%	1,509			
Length of Side Channels Blocked (ft)	Pre-1950s	Post-1950s	Numerous side channels have been blocked by small dikes.			
	8,549	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	143.9	90.3	84.53 acres			
Acres/Year	5.5	3.6				
Acres/Year/Valley Mile	0.5	0.4				
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)	-1.2	70.4	-36.2	33.1		
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	194.6	46%				
100 Year	97.9	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.			
	55.2	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)	7,623.1	7,894.5	Flood (Ac)	1,601.4	2,320.7	
Ag. Infrastructure (Ac)	75.0	142.8	Sprinkler (Ac)	0.0	44.1	
Exurban (Ac)	0.0	0.0	Pivot (Ac)	0.0	180.0	
Urban (Ac)	0.0	0.0				
Transportation (Ac)	87.6	86.8				
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.	
	3.1	0.2	3.3	0.0%		
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	8.0	0.8	135.5			
Emergent	103.2	10.1				
Scrub/Shrub	24.3	2.4				
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.			
	16.3	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.	
	36.5	23.4	14.7	-21.8		

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



County	Dawson	Upstream River Mile	107.1
Classification	PCA: Partially confined anabranching	Downstream River Mile	94.6
General Location	To Glendive	Length	12.50 mi (20.12 km)

Narrative Summary

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

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

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

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

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

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

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

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

About 8 percent of the total 100-year floodplain has become isolated due to human development and most of that isolated floodplain area is behind floodplain dikes near Black Bridge. The 5-year floodplain is even more affected; 31 percent of the historic 5-year floodplain is no longer inundated at that frequency. There has been over 1,260 acres of woody riparian vegetation recruitment in the reach since 1950, indicating generation of new forest, some of which reflects encroachment due to lower flows and a shrinking river channel. The bankfull area of the channel has dropped by 255 acres since 1950. Some of that riparian expansion has been due to Russian olive colonization; there are just under 50 acres of mapped Russian olive in the Reach D5 floodplain.

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

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

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been major in this reach. The 2-year flood, which strongly influences overall channel form, has dropped by 22 percent. Low flows have also been impacted; severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 4,800 cfs to 2,720 cfs with human development, a reduction of 436 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,980 cfs under unregulated conditions to 3,220 cfs, a reduction of 54 percent.

CEA-Related observations in Reach D5 include:

- Channel migration issues upstream of major constriction that is poorly aligned to corridor (Black Bridge)

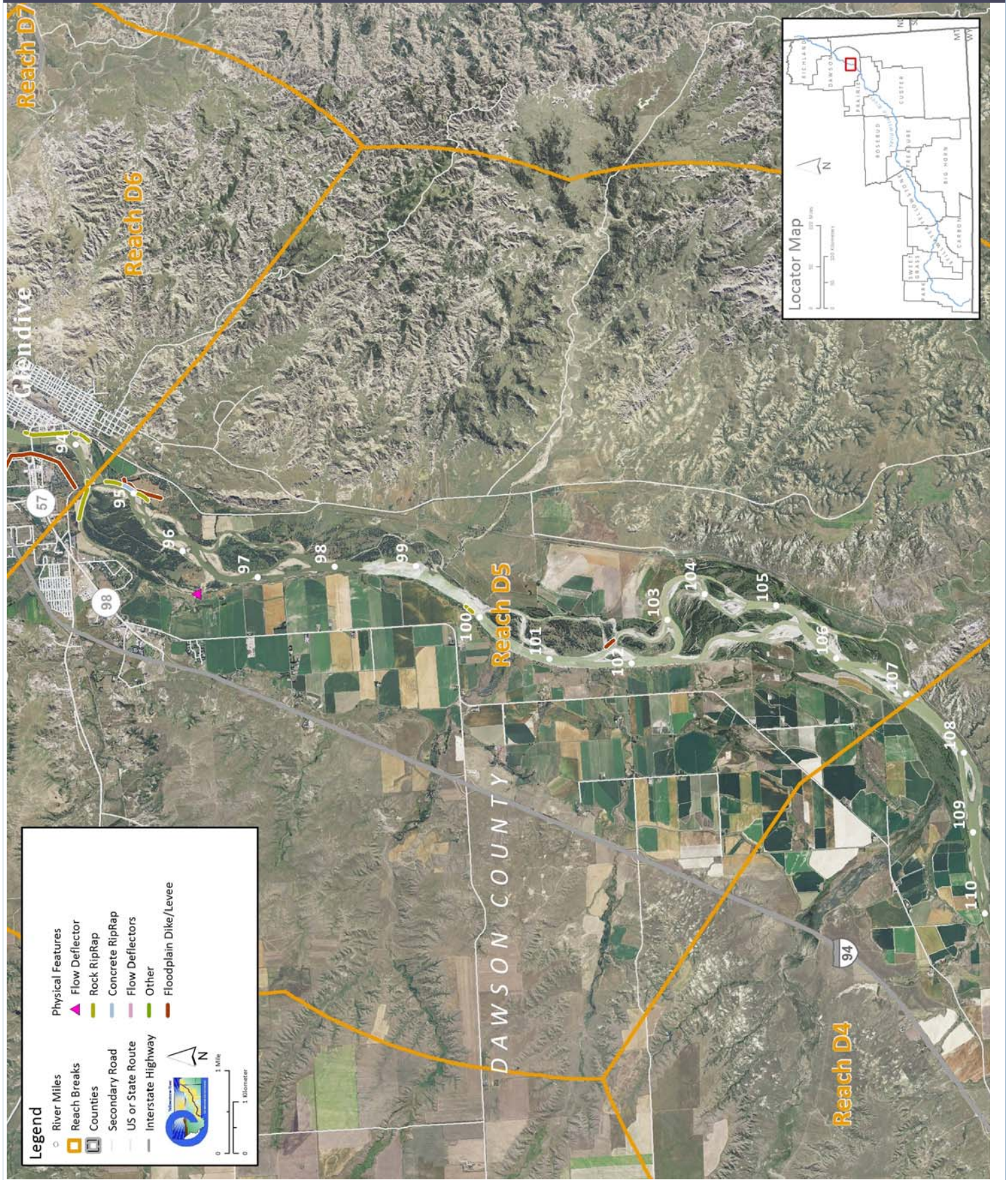
Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach D5 include:

- Side channel reactivation at RM 104.5
- Russian olive removal
- Pipeline Crossing Practices at RM 100
- Dump site removal at RM 104L, RM 104.2L, RM 101L, RM 98L, RM 97.5L, and RM 97.1L

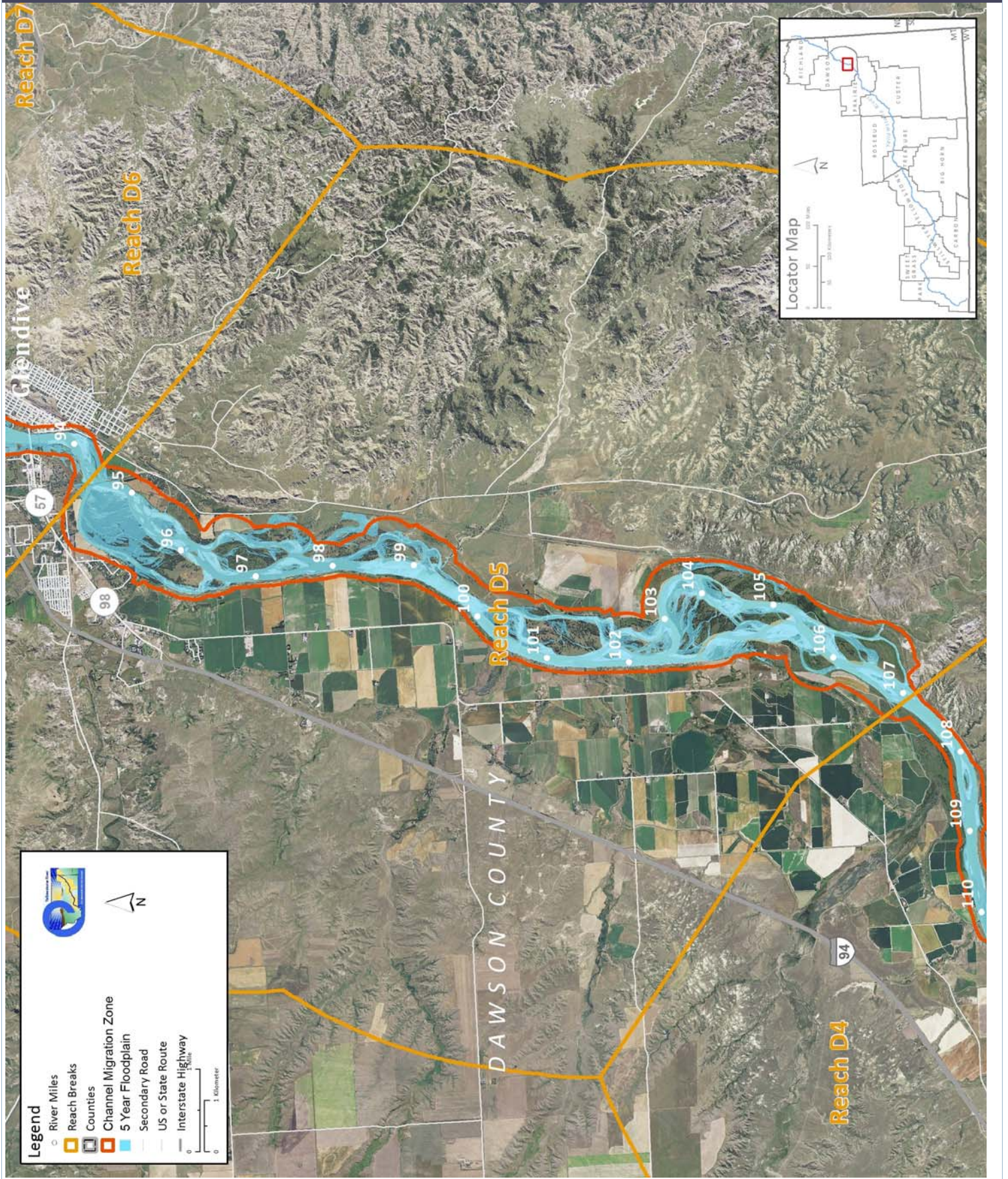
The following table summarizes some key CEA results that have been used to describe overall condition and types of human influences affecting the river. The values are specific to this single reach. Blanks indicate that a particular value was not available for this area. This information is consolidated 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)	69,200	54,000	-22.0%			
100 Year (cfs)	145,000	124,000	-14.5%			
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.
	2,086.3	1,995.7	1,964.9	1,830.9	-255.4	
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	4,408	3.3%	638			
Concrete Riprap	1,049	0.8%	0			
Flow Deflectors	58	0.0%	58			
Total	5,515	4.1%	696			
Length of Side Channels Blocked (ft)	Pre-1950s	Post-1950s	Numerous side channels have been blocked by small dikes.			
		9,066				
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	479.8	355.3	294.44 acres			
Acres/Year	18.5	14.2				
Acres/Year/Valley Mile	1.7	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)	-7.9	28.3	21.8	42.2		
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	536.1	31%				
100 Year	248.3	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.			
	189.6	3%				
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)	7,069.1	6,378.8	Flood (Ac)	864.7	1,691.1	
Ag. Infrastructure (Ac)	25.2	114.2	Sprinkler (Ac)	0.0	0.0	
Exurban (Ac)	0.0	23.7	Pivot (Ac)	0.0	218.5	
Urban (Ac)	0.0	391.2				
Transportation (Ac)	105.6	102.2				
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.	
	114.0	46.8	160.8	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	23.7	2.2	278.7			
Emergent	152.8	14.3				
Scrub/Shrub	102.2	9.5				
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.			
	49.0	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.	
	86.2	57.1	38.3	-47.9		

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



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

Narrative Summary

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

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

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

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

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

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

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

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

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

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

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

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been major in this reach. The 100-year flood has dropped from 146,000 cfs pre-development to 125,000 cfs currently, which is a 14 percent reduction. The 2-year flood, which strongly influences overall channel form, has dropped by 22 percent. Summer base flows have dropped by 54 percent with human development, from 6,990 cfs to 3,210 cfs, a 54 percent reduction. In contrast, fall and winter base flows have both increased between 60 percent (winter) and 75 percent (fall). Fall and winter base flows are currently 2,030 and 2,110 cfs, respectively.

CEA-Related observations in Reach D6 include:

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

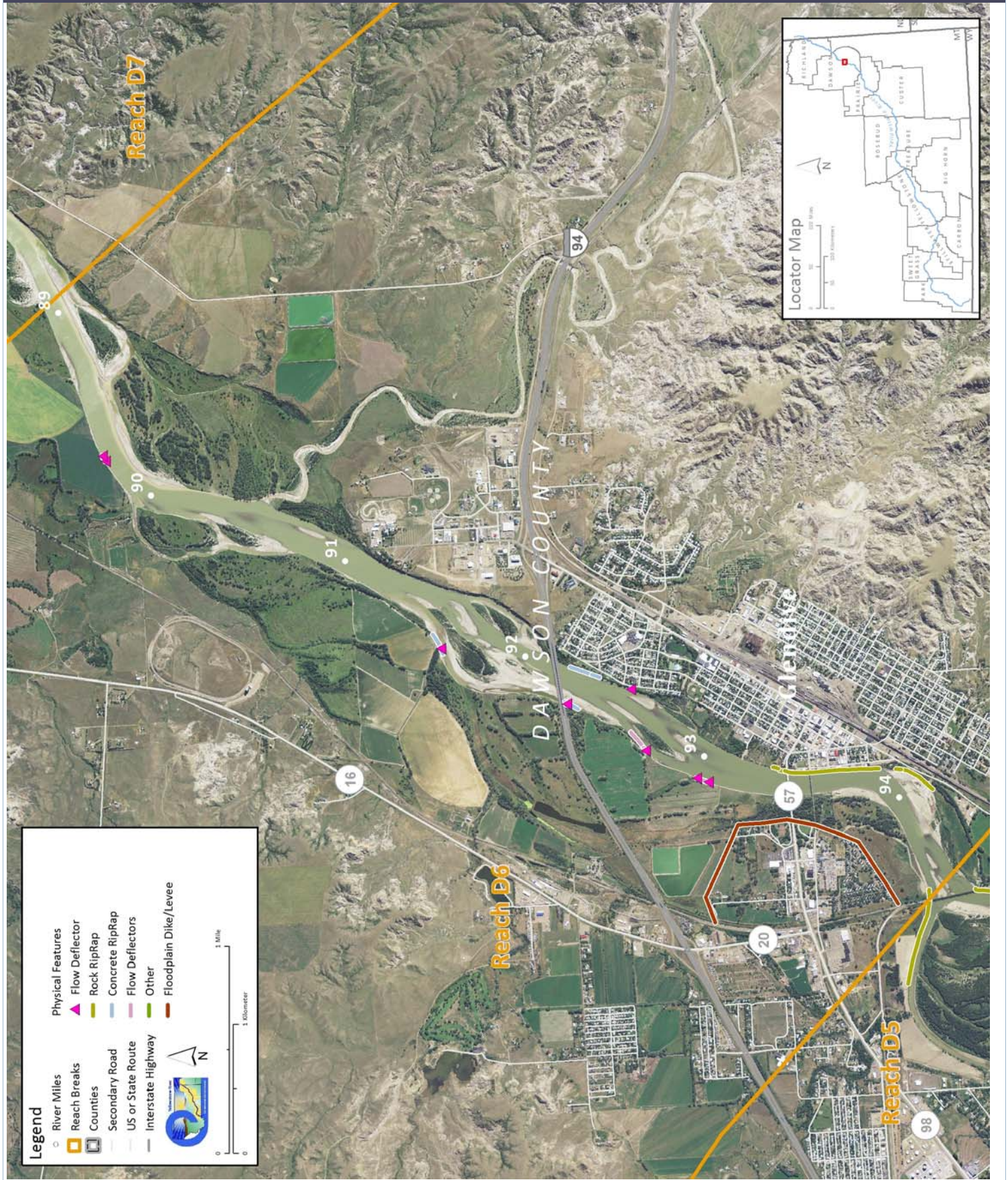
Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach D6 include:

- Bank armor removal at RM 92.8L
- Russian olive removal

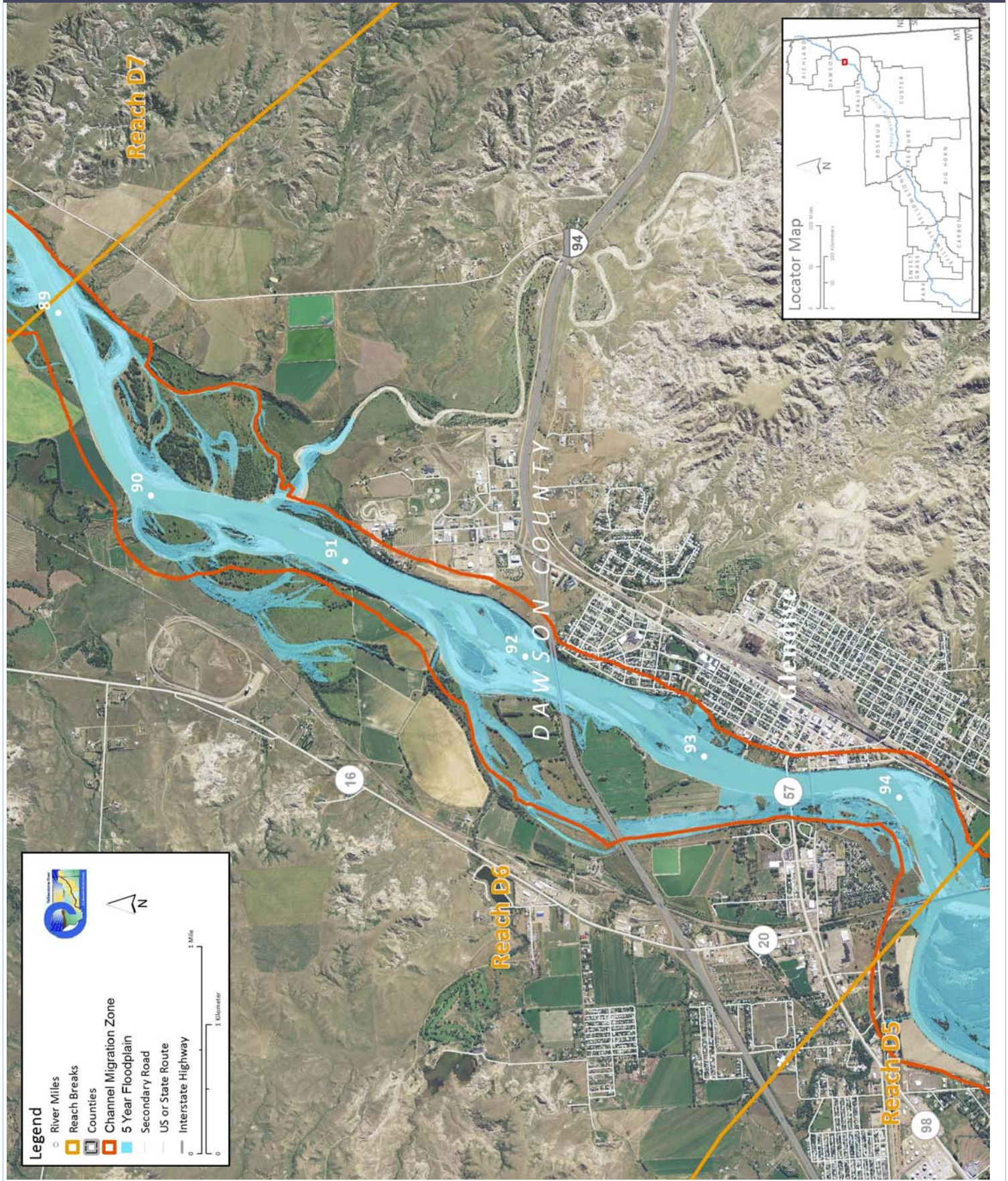
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Discharge	Undev.	Developed	% Change	"Undeveloped" flows represent conditions prior to significant human development, whereas "developed" flows reflect the current condition of both consumptive and non-consumptive water use.		
2 Year (cfs)	69,400	54,200	-21.9%			
100 Year (cfs)	146,000	125,000	-14.4%			
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.
	810.6	695.8	659.4	640.3	-170.4	
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	2,933	5.0%	1,278			
Concrete Riprap	1,188	2.0%	-345			
Flow Deflectors	762	1.3%	173			
Total	4,882	8.3%	1,106			
Length of Side Channels Blocked (ft)	Pre-1950s	Post-1950s	Numerous side channels have been blocked by small dikes.			
	16,884	16,597				
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	103.6	49.8				
Acres/Year	4.0	2.0				
Acres/Year/Valley Mile	0.8	0.4	134.35 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)	37.4	9.5	7.4	54.3		
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	528.6	52%				
100 Year	354.0	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.			
	326.0	18%				
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)	3,201.5	3,067.3	Flood (Ac)	304.1	502.4	
Ag. Infrastructure (Ac)	27.4	70.7	Sprinkler (Ac)	0.0	0.0	
Exurban (Ac)	0.0	231.2	Pivot (Ac)	0.0	279.4	
Urban (Ac)	563.1	987.6				
Transportation (Ac)	110.3	169.6				
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.	
	274.9	134.3	409.2	32.0%		
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	47.0	9.1	154.5			
Emergent	88.9	17.1				
Scrub/Shrub	18.6	3.6				
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.			
	7.1	0.5%				
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.	
	21.8	4.3	24.8	3.0		

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



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

Narrative Summary

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

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

Similar to many reaches in the Lower Yellowstone Valley, the river channel in Reach D7 has gotten smaller since 1950. The channel contracted by about 121 acres in this reach since 1950, and about 150 acres of riparian vegetation has encroached into old channel areas. This pattern has been consistent in the lower river, and relates primarily to a reduction in flows due to human development. Floodplain turnover rates have dropped from 8.9 acres per year pre-1976 to 5.4 acres per year post-1976.

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

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

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

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

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been major in this reach. The magnitude of the 100-year flood is now 127,000 cfs, which is 12 percent lower than it was pre-development (145,000 cfs). The 2-year flood, which strongly influences overall channel form, has dropped by 22 percent. Low flows have also been impacted; severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 4,700 cfs to 2,600 cfs with human development, a reduction of 45 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,890 cfs under unregulated conditions to 3,110 cfs under regulated conditions, a reduction of 55 percent.

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

CEA-Related observations in Reach D7 include:

- Passive loss of side channels with flow alterations

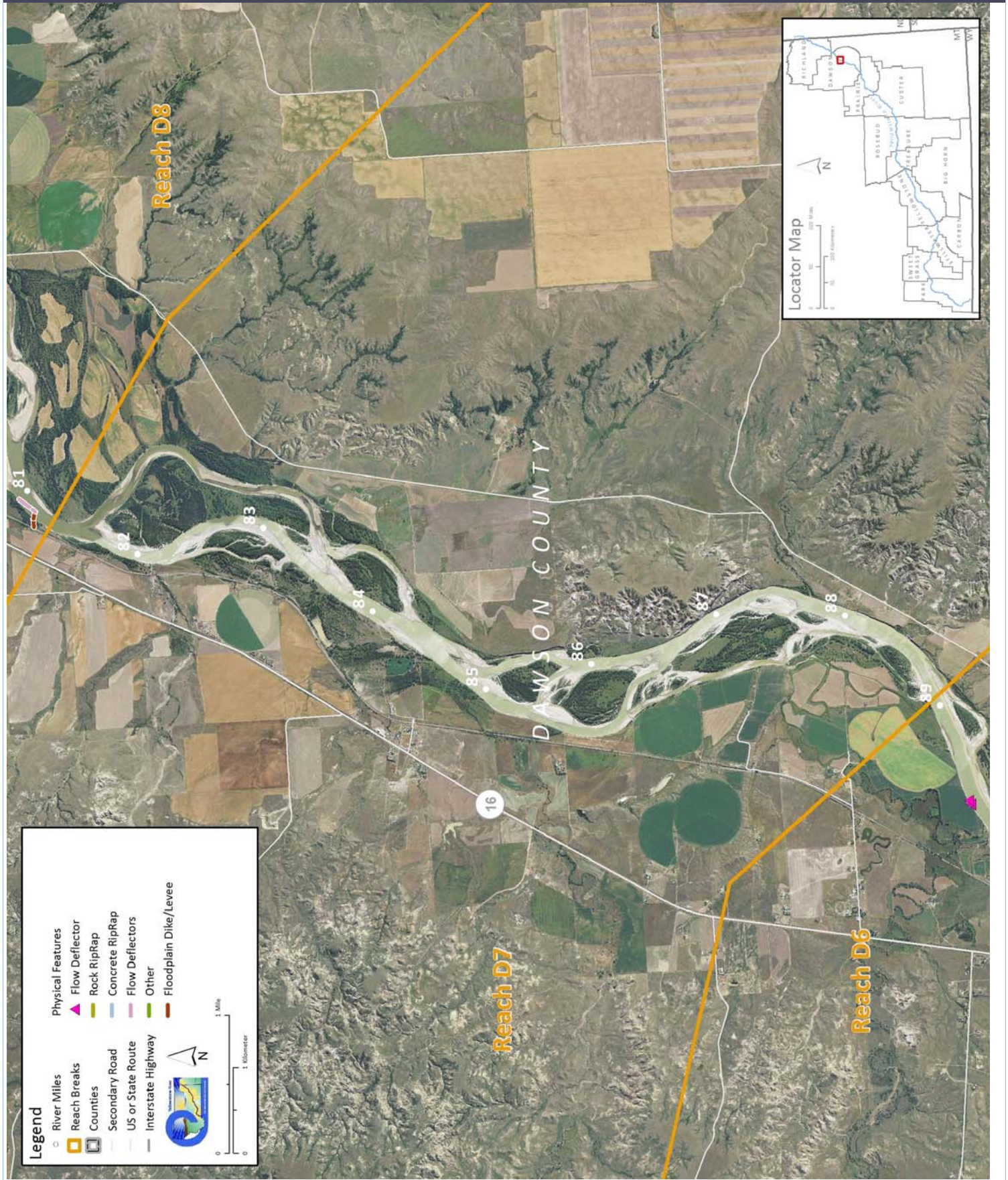
Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach D7 include:

- Russian olive removal

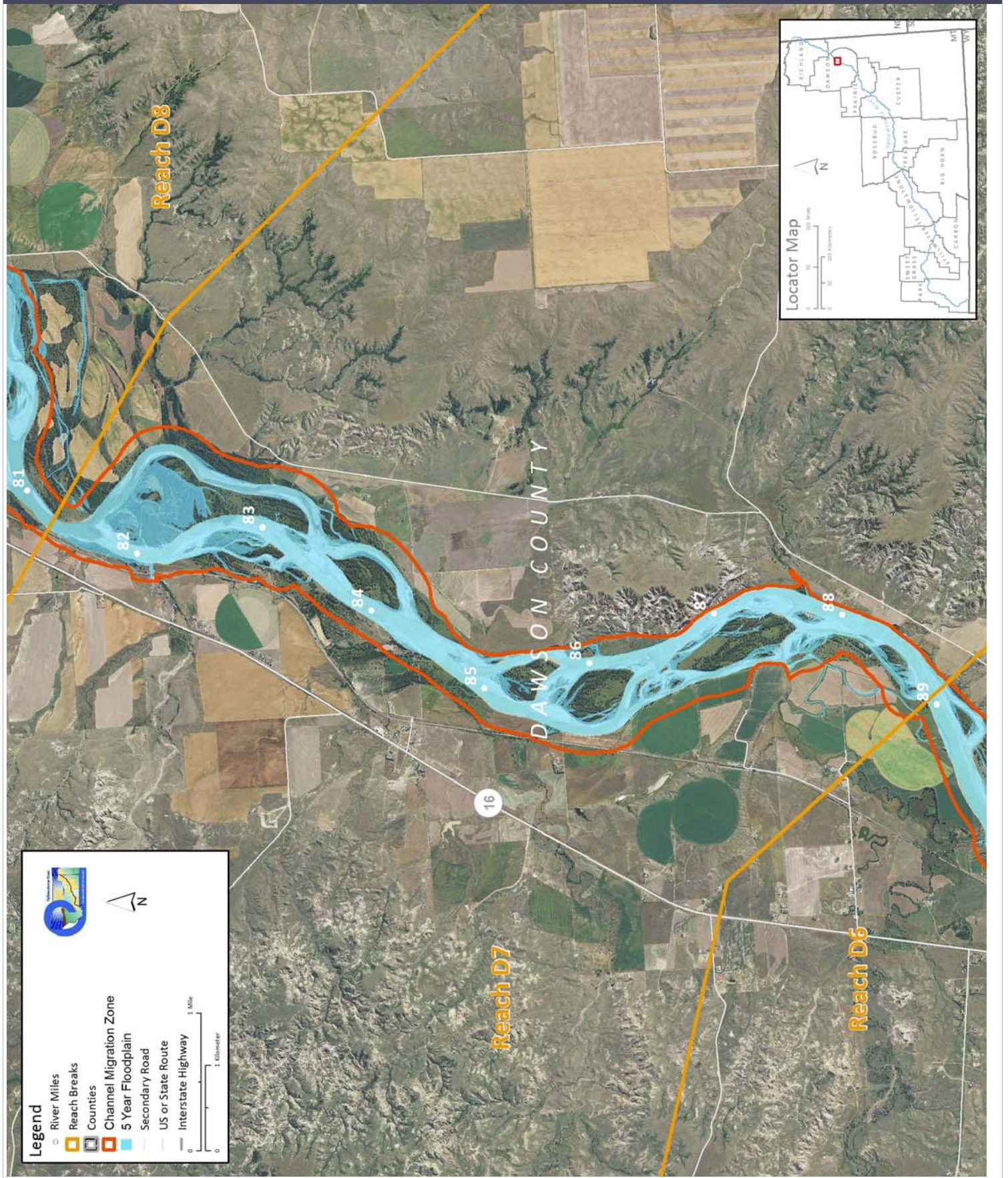
The following table summarizes some key CEA results that have been used to describe overall condition and types of human influences affecting the river. The values are specific to this single reach. Blanks indicate that a particular value was not available for this area. This information is consolidated 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)	69,500	54,200	-22.0%			
100 Year (cfs)	145,000	127,000	-12.4%			
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.
	1,223.9	1,230.6	1,141.1	1,102.9	-121.1	
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	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.			
	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	230.7	133.9	149.38 acres			
Acres/Year	8.9	5.4				
Acres/Year/Valley Mile	1.3	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)	-52.3	40.4	-2.8	-14.6		
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	395.2	48%				
100 Year	43.6	2%				
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.			
	6.0	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)	4,756.4	4,620.5	Flood (Ac)	0.0	708.1	
Ag. Infrastructure (Ac)	29.3	83.7	Sprinkler (Ac)	0.0	25.5	
Exurban (Ac)	0.0	48.9	Pivot (Ac)	0.0	258.3	
Urban (Ac)	0.0	0.0				
Transportation (Ac)	88.2	90.2				
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.	
	57.6	19.8	77.4	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	28.9	4.2	148.2			
Emergent	72.3	10.6				
Scrub/Shrub	47.1	6.9				
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.			
	7.4	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.	
	116.2	85.5	108.4	-7.9		

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



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

Narrative Summary

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

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

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

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

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

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

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

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

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been major in this reach. The magnitude of the 100-year flood is now 128,000 cfs, which is 12 percent lower than it was pre-development (145,000 cfs). The 2-year flood, which strongly influences overall channel form, has dropped by 22 percent. Low flows have also been impacted; severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 4,630 cfs to 2,520 cfs with human development, a reduction of 46 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,810 cfs under unregulated conditions to 3,030 cfs under regulated conditions, a reduction of 55 percent.

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

CEA-Related observations in Reach D8 include:

- Passive loss of side channels with flow alterations
- Low avian species richness
- Passive loss of 5-year floodplain area

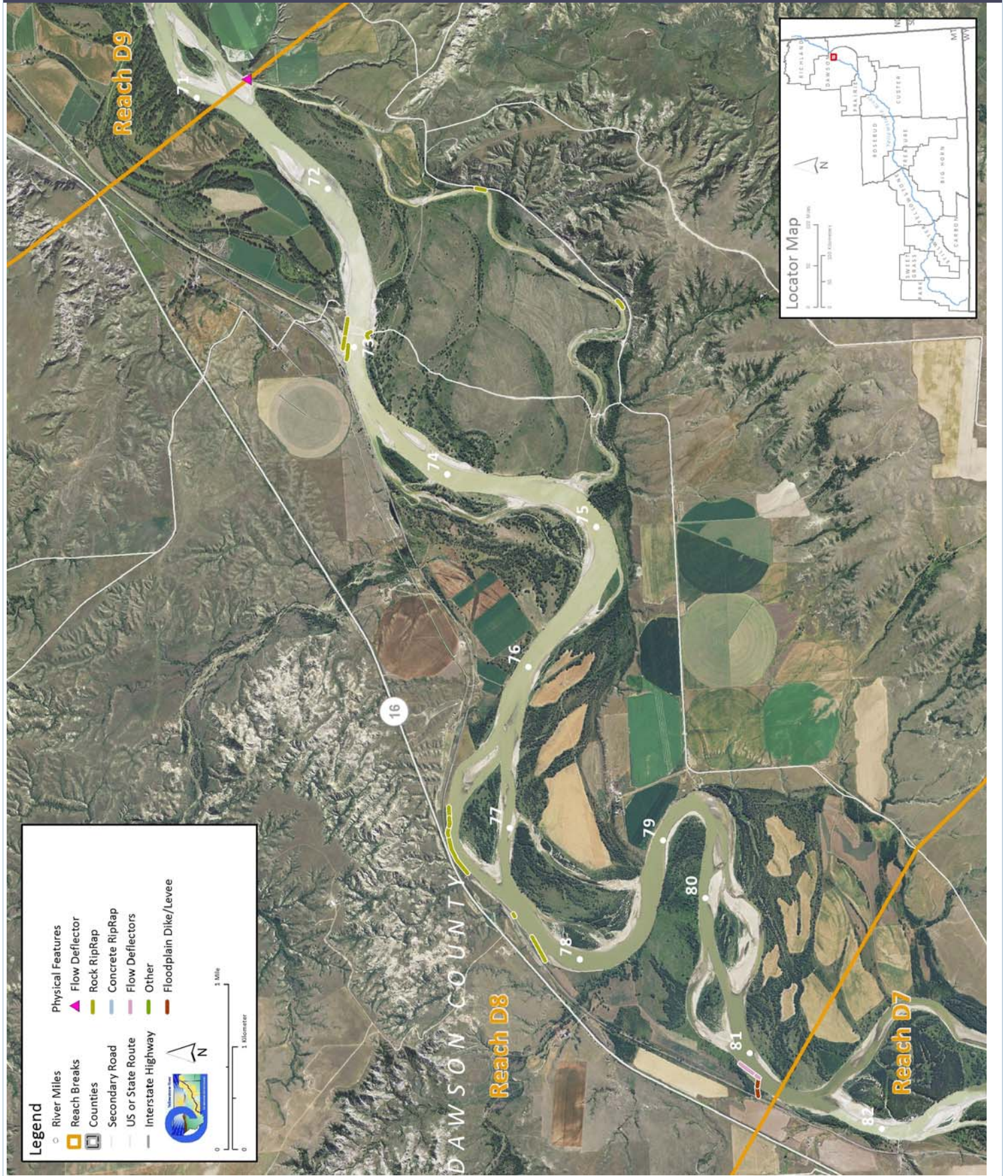
Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach D8 include:

- Flanked bank armor removal at RM 77L and RM 81L
- Fish Passage Practices at Intake Diversion Dam (RM 73)
- Watercraft Passage PRACTICE at Intake Diversion Dam (RM 73)
- Irrigation Structure Management at Intake Diversion Dam (RM 73)
- Russian olive removal

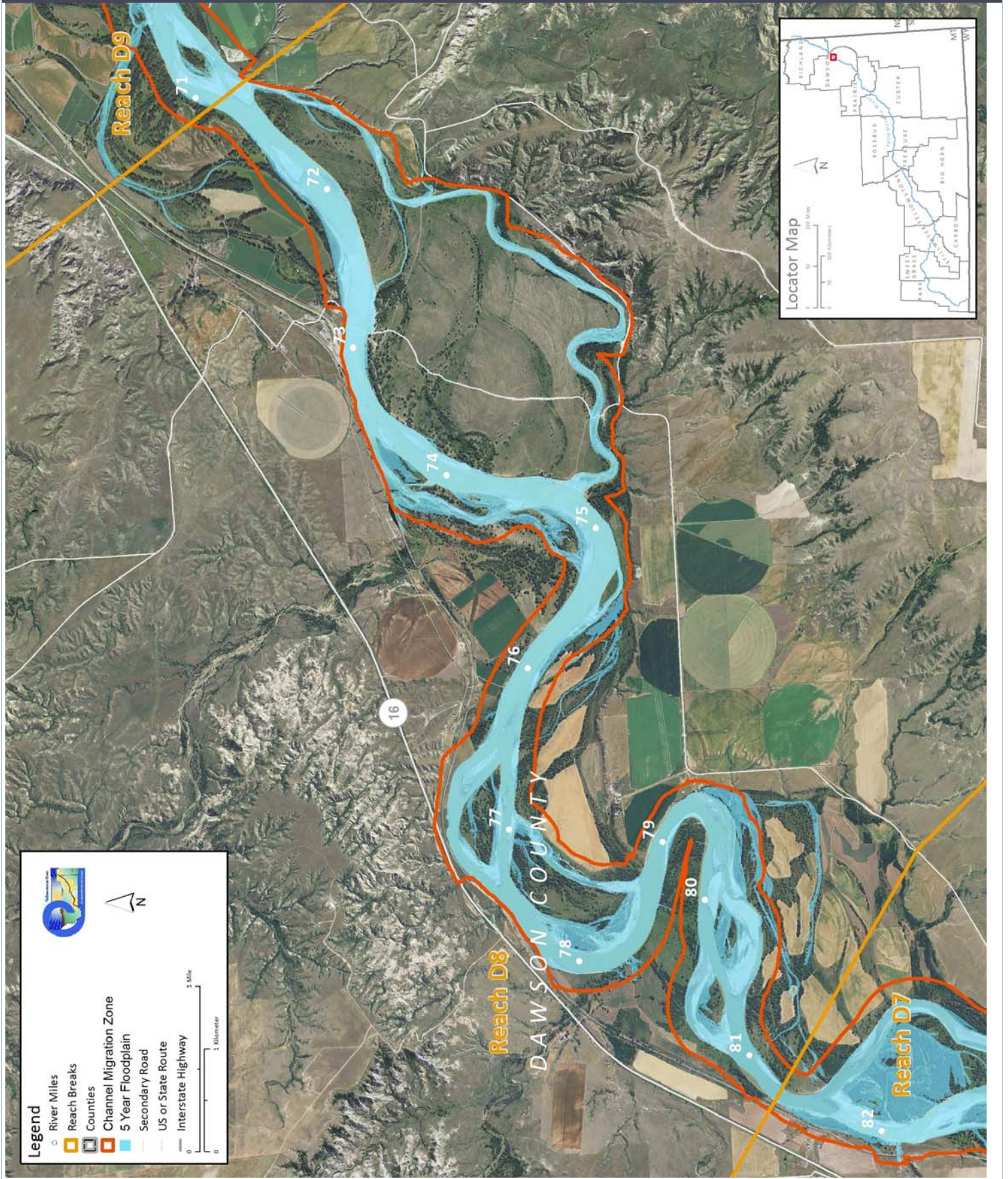
The following table summarizes some key CEA results that have been used to describe overall condition and types of human influences affecting the river. The values are specific to this single reach. Blanks indicate that a particular value was not available for this area. This information is consolidated 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)	69,500	54,200	-22.0%			
100 Year (cfs)	145,000	128,000	-11.7%			
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.
	1,463.9	1,387.3	1,312.1	1,280.0	-183.9	
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	4,576	4.3%	435			
Concrete Riprap	0	0.0%	0			
Flow Deflectors	0	0.0%	-763			
Total	4,576	4.3%	-328			
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	177.2	104.2	207.5 acres			
Acres/Year	6.8	4.2				
Acres/Year/Valley Mile	1.0	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)	-121.4	56.3	17.9	-47.1		
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	612.7	58%				
100 Year	99.2	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.			
	28.2	1%				
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)	5,328.8	5,253.4	Flood (Ac)	44.2	270.7	
Ag. Infrastructure (Ac)	39.9	117.3	Sprinkler (Ac)	7.0	164.3	
Exurban (Ac)	17.3	56.5	Pivot (Ac)	0.0	180.0	
Urban (Ac)	0.0	0.0				
Transportation (Ac)	139.9	115.5				
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.	
	151.6	23.2	174.8	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	13.7	2.0	84.2			
Emergent	46.2	6.6				
Scrub/Shrub	24.3	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.			
	9.7	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.	
	106.2	97.2	85.0	-21.1		

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



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

Narrative Summary

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

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

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

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

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

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

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

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been major in this reach. The magnitude of the 100-year flood is now 128,000 cfs, which is 12 percent lower than it was pre-development (145,000 cfs). The 2-year flood, which strongly influences overall channel form, has dropped by 22 percent. Low flows have also been impacted; severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 4,630 cfs to 2,460 cfs with human development, a reduction of 47 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,760 cfs under unregulated conditions to 2,980 cfs under regulated conditions, a reduction of 56 percent.

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

CEA-Related observations in Reach D9 include:

- Floodplain isolation due to flow alterations and agricultural dikes
- Side channel blockages

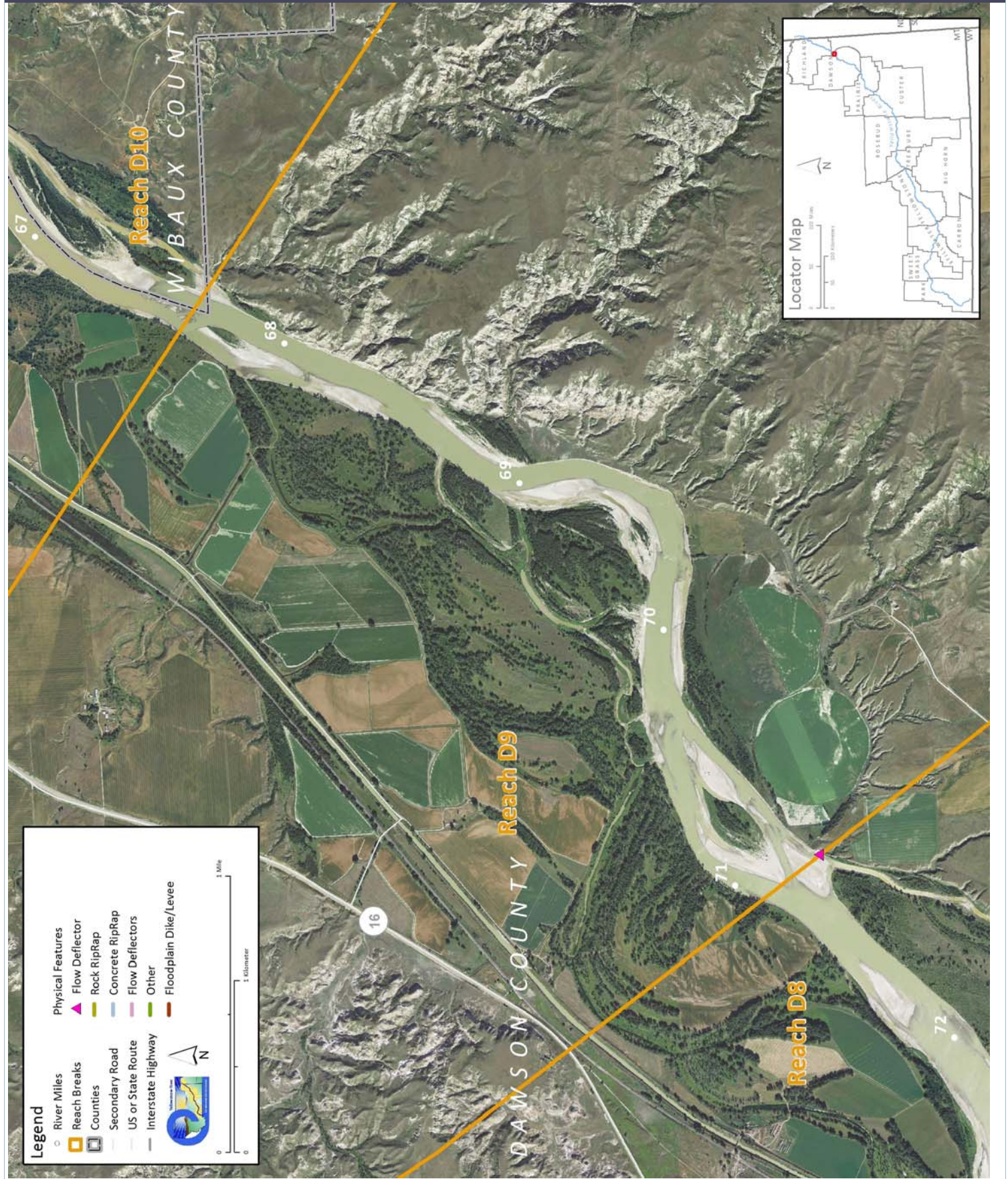
Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach D9 include:

- Side channel reactivation at RM 68.8L
- Russian olive removal

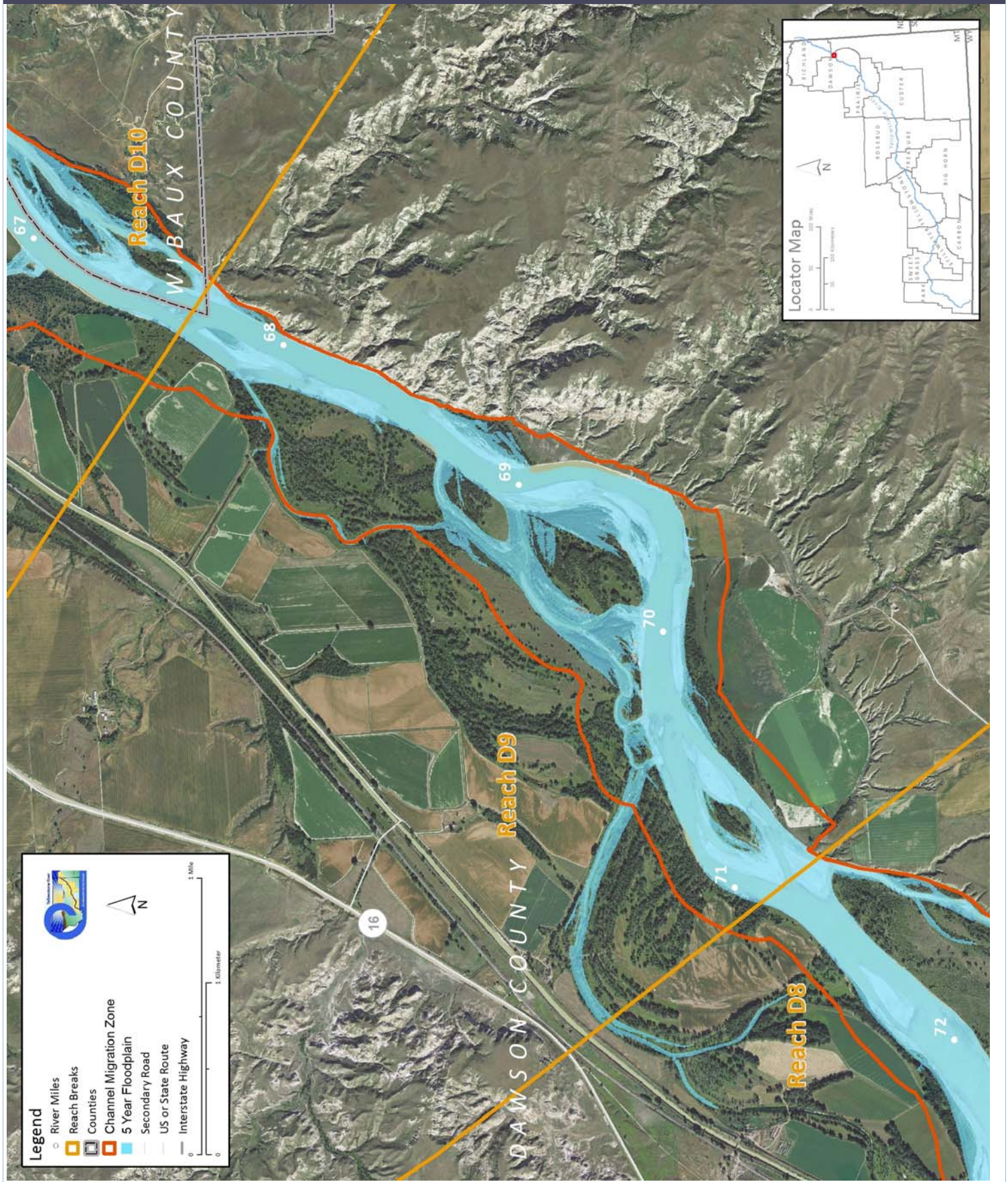
The following table summarizes some key CEA results that have been used to describe overall condition and types of human influences affecting the river. The values are specific to this single reach. Blanks indicate that a particular value was not available for this area. This information is consolidated 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)	69,600	54,200	-22.1%			
100 Year (cfs)	145,000	128,000	-11.7%			
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.
	434.7	456.9	410.8	418.7	-16.0	
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	0	0.0%	0			
Concrete Riprap	0	0.0%	0			
Flow Deflectors	45	0.1%	45			
Total	45	0.1%	45			
Length of Side Channels Blocked (ft)	Pre-1950s	Post-1950s	Numerous side channels have been blocked by small dikes.			
	14,796	6,635				
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	95.2	61.2				
Acres/Year	3.7	2.4				
Acres/Year/Valley Mile	1.2	0.8	35.3 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)	47.2	15	-22.5	39.7		
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	161.4	50%				
100 Year	170.4	15%				
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)	3,008.1	3,102.1	Flood (Ac)	760.3	708.0	
Ag. Infrastructure (Ac)	81.3	78.3	Sprinkler (Ac)	0.0	0.0	
Exurban (Ac)	0.0	0.0	Pivot (Ac)	0.0	183.0	
Urban (Ac)	0.0	0.0				
Transportation (Ac)	35.2	35.2				
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.	
	73.2	0.0	73.2	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	1.9	0.6	41.9			
Emergent	21.8	7.2				
Scrub/Shrub	18.1	6.0				
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.			
	1.0	0.0%				
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.	
	42.3	53.1	79.7	37.4		

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



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

Narrative Summary

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

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

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

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

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

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

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

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

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been major in this reach. The 2-year flood, which strongly influences overall channel form, has dropped by 22 percent. Low flows have also been impacted; severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 4,850 cfs to 2,810 cfs with human development, a reduction of 43 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,940 cfs under unregulated conditions to 3,270 cfs under regulated conditions, a reduction of 53 percent.

CEA-Related observations in Reach D10 include:

- Armor flanking and accelerated erosion behind

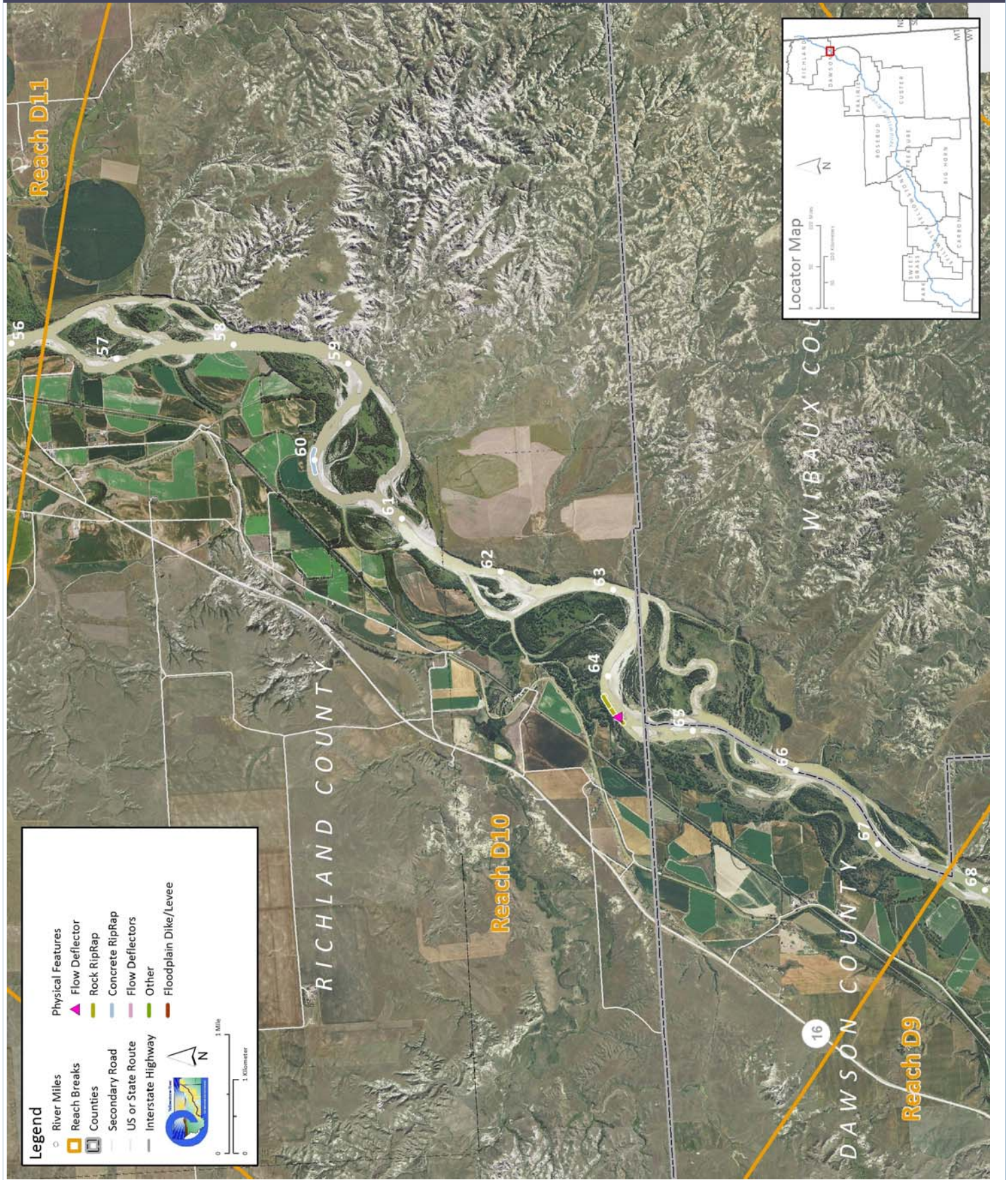
Recommended Practices (May include Yellowstone River Recommended Practices--YRRPs) for Reach D10 include:

- Removal of flanked armor at RM 60 and RM 64.2L
- Russian olive removal

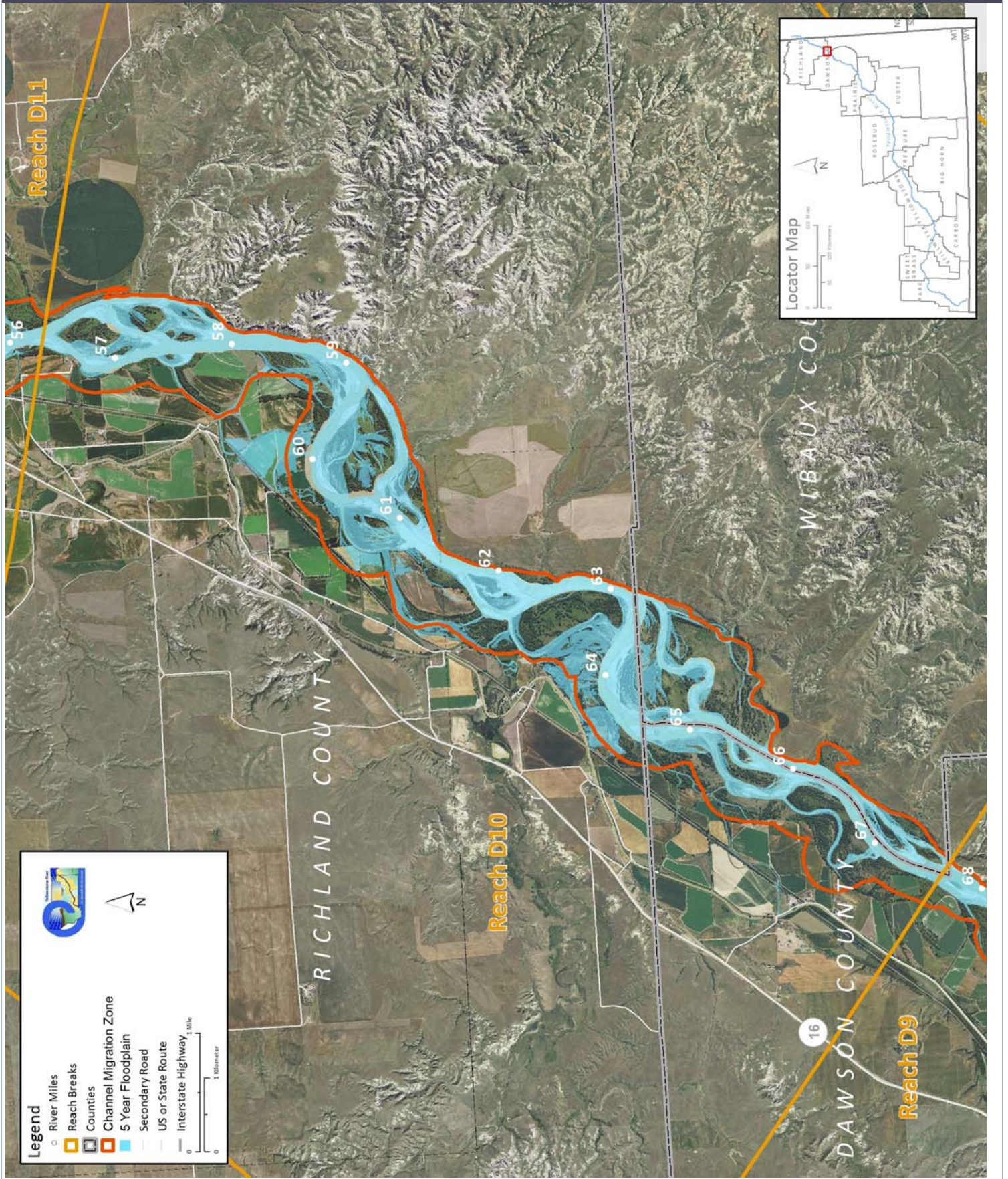
The following table summarizes some key CEA results that have been used to describe overall condition and types of human influences affecting the river. The values are specific to this single reach. Blanks indicate that a particular value was not available for this area. This information is consolidated 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)	69,700	54,200	-22.2%			
100 Year (cfs)	144,000	130,000	-9.7%			
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.
	1,843.3	1,737.0	1,544.0	1,439.2	-404.1	
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	728	0.6%	-447			
Concrete Riprap	0	0.0%	-1,051			
Flow Deflectors	0	0.0%	0			
Total	728	0.6%	-1,498			
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	361.0	174.9				
Acres/Year	13.9	7.0				
Acres/Year/Valley Mile	1.5	0.8	405.87 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)	36.4	1.8	-150.8	-112.6		
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	818.1	38%				
100 Year	650.9	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.			
	52.1	1%				
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)	4,586.0	5,330.0	Flood (Ac)	722.6	1,275.4	
Ag. Infrastructure (Ac)	44.1	52.6	Sprinkler (Ac)	0.0	0.0	
Exurban (Ac)	0.0	5.7	Pivot (Ac)	0.0	229.5	
Urban (Ac)	0.0	0.0				
Transportation (Ac)	25.7	25.7				
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.	
	455.3	2.2	457.5	15.0%		
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	21.6	2.3	278.7			
Emergent	136.8	14.7				
Scrub/Shrub	120.4	12.9				
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.			
	11.9	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.	
	92.0	111.0	111.8	19.8		

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



County	Richland	Upstream River Mile	56.3
Classification	PCA: Partially confined anabranching	Downstream River Mile	49.9
General Location	Savage; Elk Island	Length	6.40 mi (10.30 km)

Narrative Summary

Reach D11 is 10.3 miles long, located near Savage and Elk Island. It is a Partially Confined Anabranching reach type (PCA) indicating distinct side channels around vegetated islands with some valley wall influences. The valley wall is comprised of Tertiary-age Fort Union Formation, and a distinct terrace surface borders the active stream corridor. Fort Union Formation rocks are exposed on a right bank bluff on the downstream end of the reach.

There is no mapped bank armor in Reach D11. Prior to 1950, however, about three miles of side channel had been blocked, mostly around Elk Island.

The most striking change in Reach D11 since 1950 is the encroachment of riparian vegetation onto old sand bars. Between 1950 and 2001, the size of the channel has dropped by 313 acres, and there has been 294 acres of riparian encroachment into old channel areas. Much of this encroachment converted open sand bars into forested islands. There has been a loss of over 100 acres of sand bar since 1950. This change has resulted in a conversion of almost 7 miles low flow channels around gravel bars to anabranching side channels around islands.

Reach D11 has had six ice jams-related floods reported since 1943. They all occurred in February or March, and several of them reported flood damages.

Approximately 36 percent of the historic 5-year floodplain has become isolated, largely due to flow alterations.

Land use in the reach is dominated by flood irrigation.

There are about 32 acres of Russian olive mapped in the reach.

Reach D11 was sampled as part of the avian study. A total of 61 bird species were identified in the reach, indicating high bird species richness. Five bird species identified by the Montana Natural Heritage Program as Potential Species of Concern (PSOC) were found, the Black and white Warbler, Chimney Swift, Dickcissel, Ovenbird, and Plumbeous Vireo. The Red-headed woodpecker was also observed, which has been identified as a Species of Concern (SOC). Reach D11 has seen an increase in the amount of forest area considered at low risk of cowbird parasitism. In 1950, there were 216.4 acres per valley mile of such forest, and by 2001, that number had increased to 247.2 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 22 percent. Low flows have also been impacted; severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 4,370 cfs to 2,220 cfs with human development, a reduction of 50 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,540 cfs under unregulated conditions to 2,750 cfs under regulated conditions, a reduction of 59 percent. Fall and winter low flows are about 3,500 cfs; these discharges are about 60 percent to 80 percent higher than they were prior to development.

CEA-Related observations in Reach D11 include:

- Reduction in 5-year floodplain footprint with flow alterations
- Increased fall and winter low flows with development
- Reduced summer low flows with development
- Reduced channel forming discharge causing channel contraction
- Extensive riparian encroachment with flow alterations
- Conversion of open sand bars to forested islands

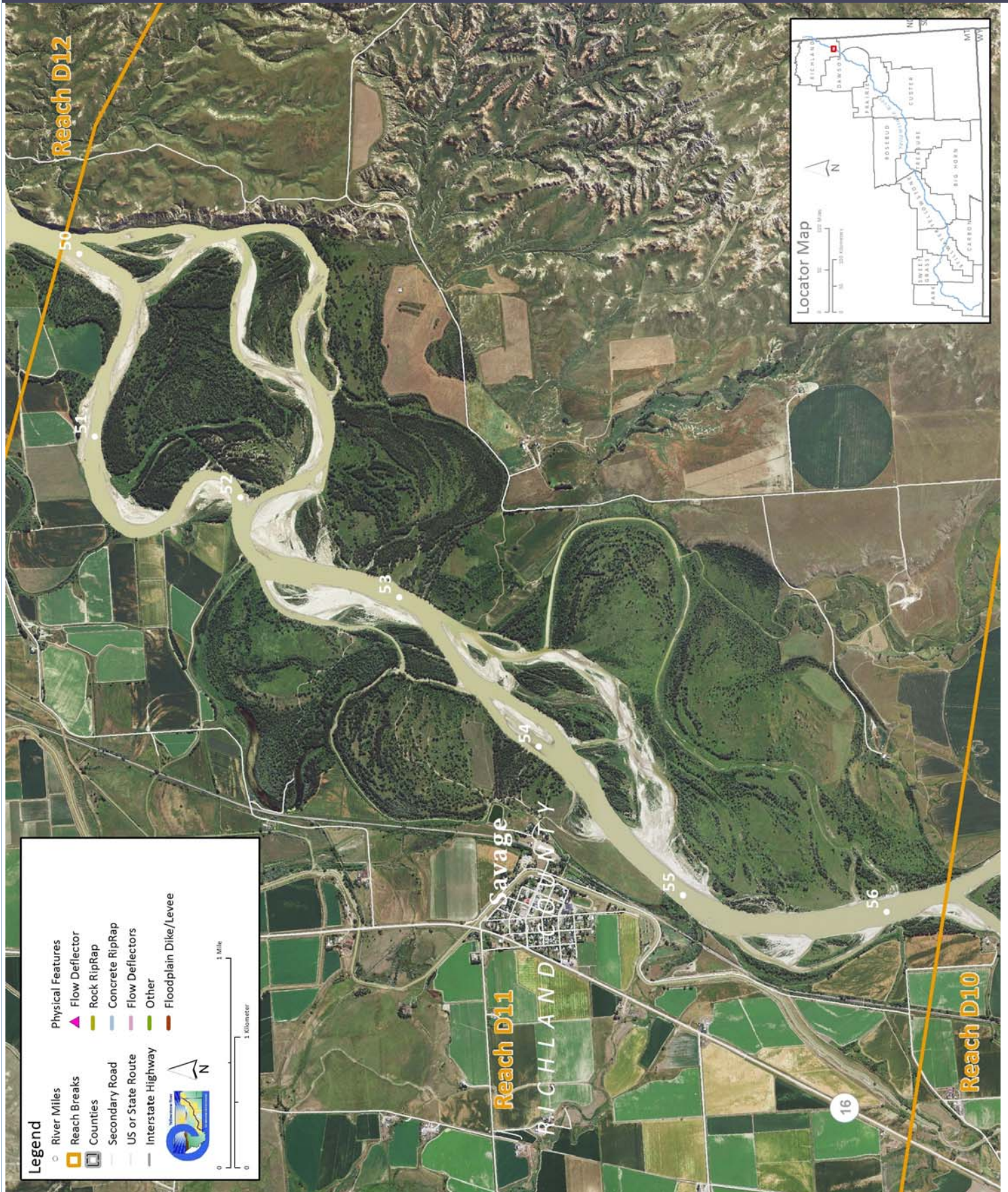
Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach D11 include:

- Side channel reactivation RM 53L
- Russian olive removal

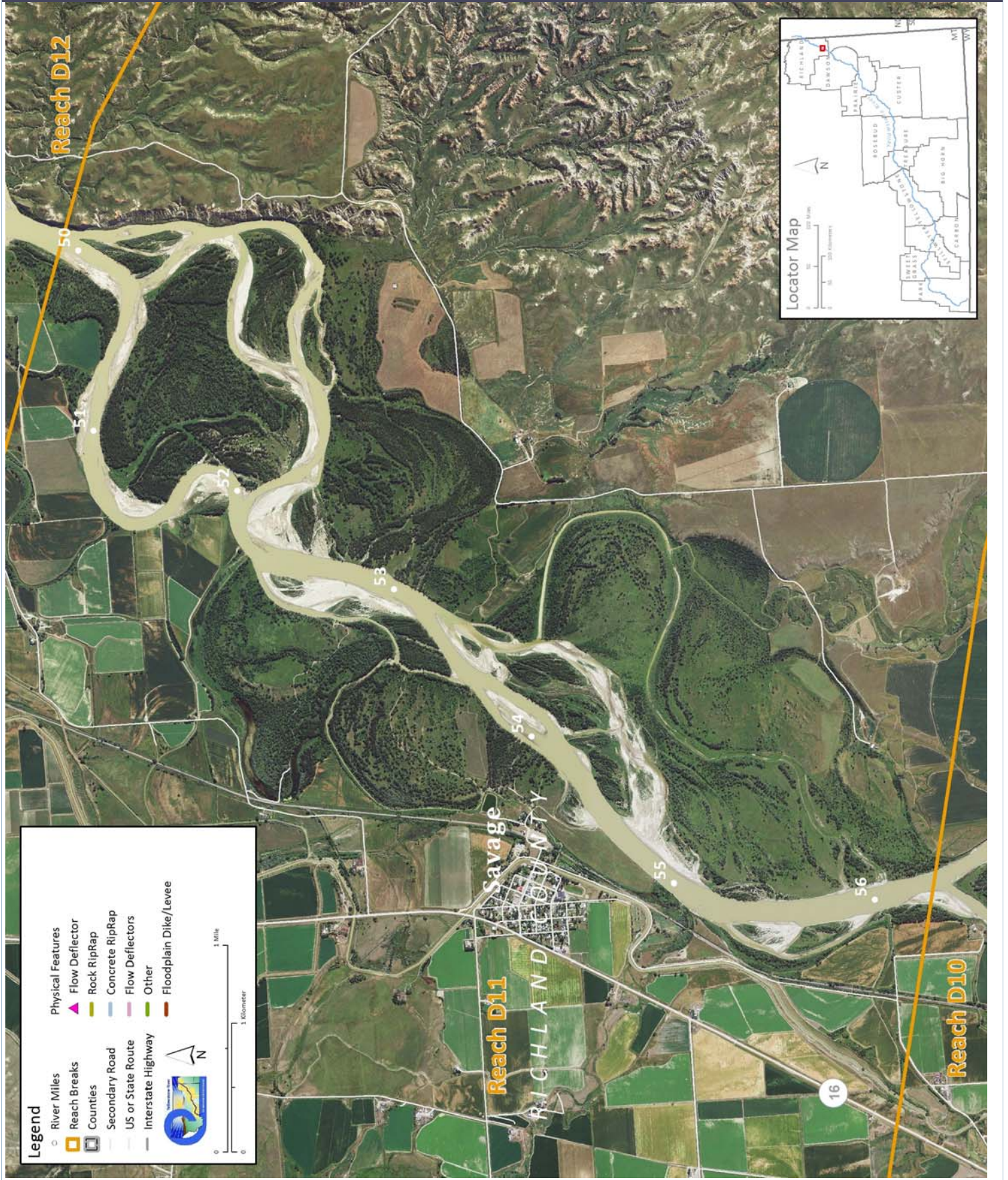
The following table summarizes some key CEA results that have been used to describe overall condition and types of human influences affecting the river. The values are specific to this single reach. Blanks indicate that a particular value was not available for this area. This information is consolidated 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)	69,800	54,200	-22.3%			
100 Year (cfs)	144,000	131,000	-9.0%			
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.
	1,284.2	1,135.9	1,095.2	971.7	-312.5	
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	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.			
	15,601	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	387.4	178.3	294.92 acres			
Acres/Year	14.9	7.1				
Acres/Year/Valley Mile	2.8	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)	-6.2	11.8	-108.9	-103.3		
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	861.6	36%				
100 Year	104.0	2%				
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.			
	62.2	1%				
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)	3,337.6	4,457.3	Flood (Ac)	610.2	658.4	
Ag. Infrastructure (Ac)	39.9	49.7	Sprinkler (Ac)	0.0	0.0	
Exurban (Ac)	1.6	0.5	Pivot (Ac)	0.0	11.2	
Urban (Ac)	13.0	35.0				
Transportation (Ac)	31.4	39.1				
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.	
	46.2	0.2	46.3	2.0%		
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	24.4	4.5	188.2			
Emergent	119.1	22.1				
Scrub/Shrub	44.7	8.3				
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.			
	31.8	1.1%				
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.	
	216.4	252.2	247.2	30.8		

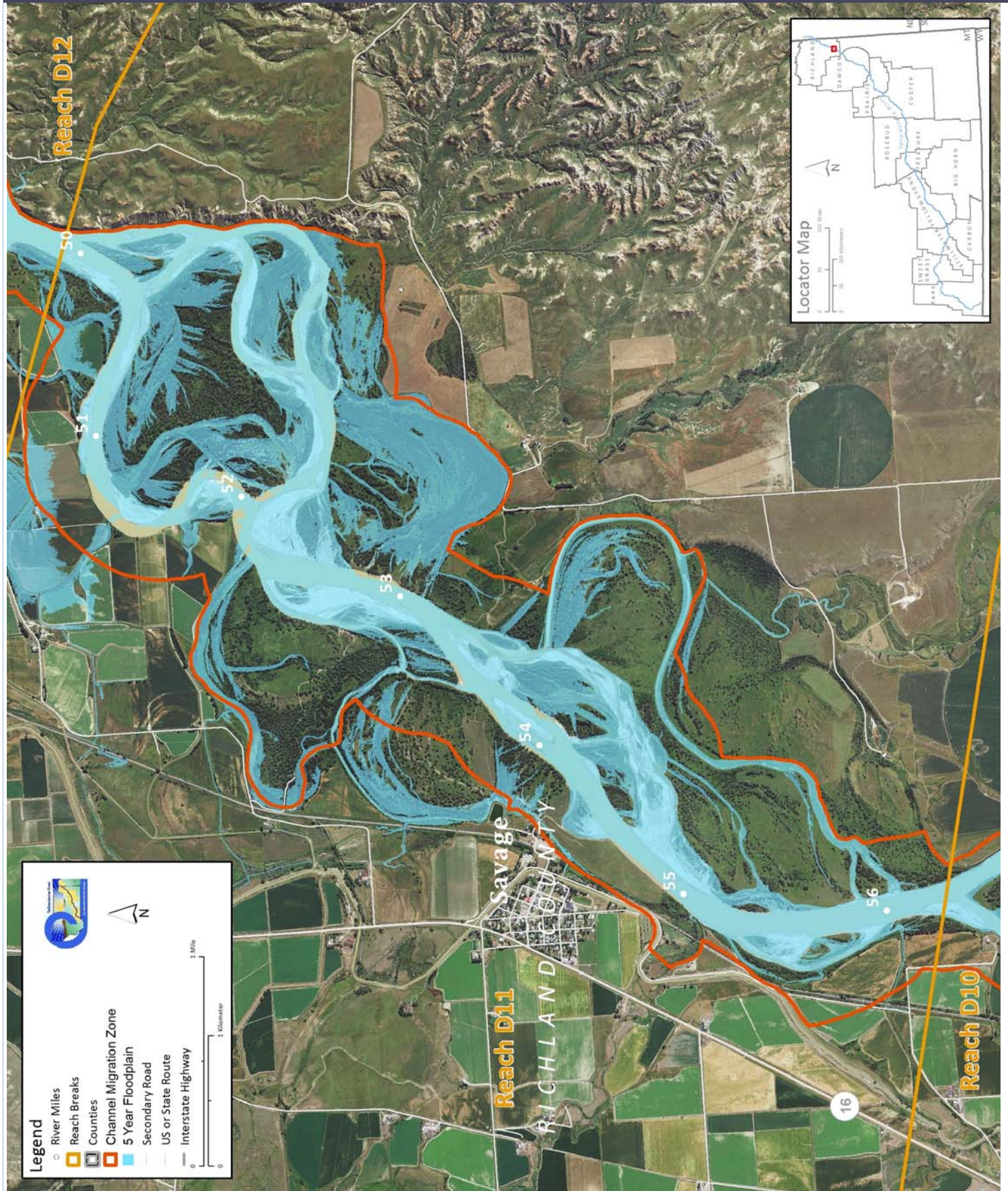
PHYSICAL FEATURES MAP (2011)



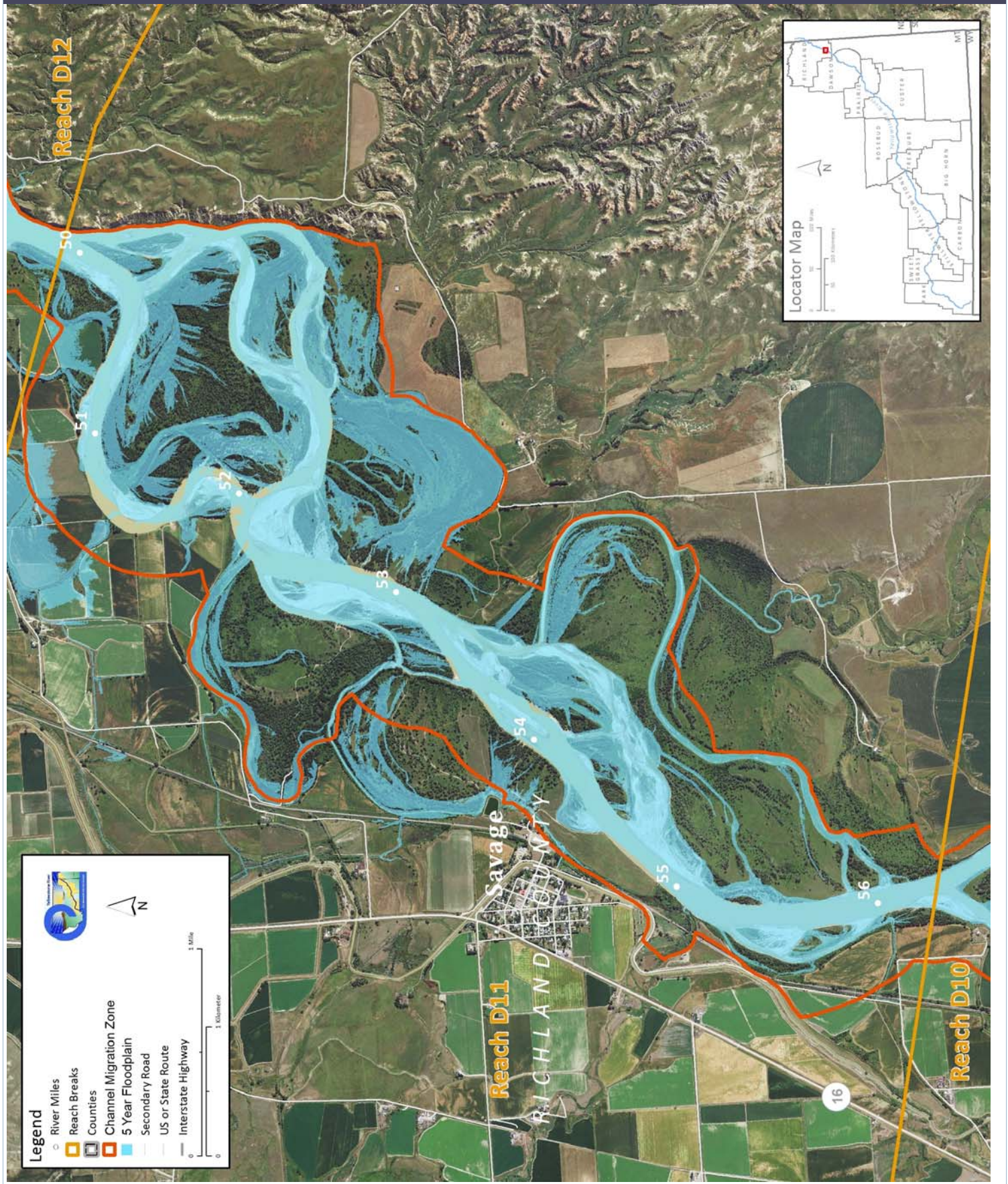
PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



CHANNEL MIGRATION ZONE MAP



County	Richland	Upstream River Mile	49.9
Classification	PCA: Partially confined anabranching	Downstream River Mile	36.3
General Location	Seven Sisters	Length	13.60 mi (21.89 km)

Narrative Summary

Reach D12 is located in Richland County at Seven Sisters. The Seven Sisters Fishing Access Site is located in the lower portion of the reach. The reach is a 13.6 mile long Partially Confined Anabranching reach type, indicating some influence of the valley wall along with extensive forested islands. This reach supports over 20 miles of side channels, and islands that are miles long and over ½ mile wide.

There are almost 7,000 feet of bank armor in the reach, and about one third of that was built since 2001. Most of the armor (3,250 feet) is rock riprap, and there are about 2,000 feet each of concrete riprap and flow deflectors. A total of 5 percent of the bank is armored, which is a relatively low concentration of bank armor for the Yellowstone River. All of the armor is protecting agricultural land, most of it against a flood irrigated field on the left bank in the lower end of the reach at RM 37.

Since 1950, a side channel that is almost three miles long was blocked at RM 45.3L. There have also been some gains in side channel length in the reach, such that the net change in length is a loss of approximately one mile. As of 2001, this reach supported almost 21 miles of anabranching channel.

Land use is dominated by agriculture, with 583 acres of pivot irrigation development since 1950. Physical features such as bank armor, dikes, and levees have isolated 3 percent of the Channel Migration Zone in Reach D12, and as of 2011 there were 224 acres of land in the CMZ under pivot irrigation, and 900 acres under flood.

Reach D12 shows, like most other reaches below the Bighorn River, a shrinking channel with reduced rates of erosion and floodplain turnover. For example, the bankfull channel area in the reach dropped by 480 acres since 1950, and there was almost 600 acres of riparian encroachment into old channel areas. Floodplain turnover rates have dropped from 2.1 acres/valley mile/year from 1950-1976 to 1.3 acres/valley mile/year from 1976-2001. This equates to 330 fewer acres of floodplain turnover since 1976. There has also been a net loss of 159 acres of open bar area as the channel has become smaller and more forested. On the floodplain, riparian acreage has decreased; about 350 acres or 9 percent of the total riparian area was cleared for irrigation since 1950.

There are 75 acres of Russian olive in the reach.

The 100-year floodplain has been isolated in this reach, but compared to other reaches the isolation has been fairly minor. About 300 acres of 100-year floodplain has been isolated by human development, which is 5 percent of the total 100-year floodplain. Although only about 5 percent of the 100-year floodplain has been isolated, the impact of flow alterations on the smaller 5-year floodplain has been much more severe; 42 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 300 acres of flood irrigated land and within the historic 5-year floodplain footprint.

There is an animal feeding facility on the right bank at RM 46.8.

Reach D12 was sampled as part of the fisheries study. A total of 37 fish species were sampled in the reach. Three species collected in the reach have been identified by the Montana Natural Heritage Program as Species of Concern (SOC): Pallid Sturgeon, Sauger, and Sturgeon Chub.

Reach D12 was also sampled as part of the avian study. A total of 59 bird species were identified in the reach. All five bird species identified by the Montana Natural Heritage Program as Potential Species of Concern (PSOC) on the Yellowstone River were also found, the Black and White Warbler, the Chimney Swift, the Dickcissel, the Ovenbird, and the Plumbeous Vireo. Similarly, all three bird species identified as Species of Concern (SOC) were identified: the Black-billed Cuckoo, Bobolink, and Red-headed Woodpecker. In contrast to most other reaches, Reach D12 has seen an increase in the forested area that is at low risk of cowbird parasitism since 1950. At that time, there were 103 acres per valley mile of such forest, and that number increased to 115 acres per valley mile by 2001.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been major in this reach. The 2-year flood, which strongly influences overall channel form, has dropped by 22 percent. Low flows have also been impacted; severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 4,310 cfs to 2,410 cfs with human development, a reduction of 50 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,470 cfs under unregulated conditions to 2,680 cfs under regulated conditions, a reduction of 59 percent.

CEA-Related observations in Reach D12 include:

- Increase in area at low risk of cowbird parasitism with riparian encroachment

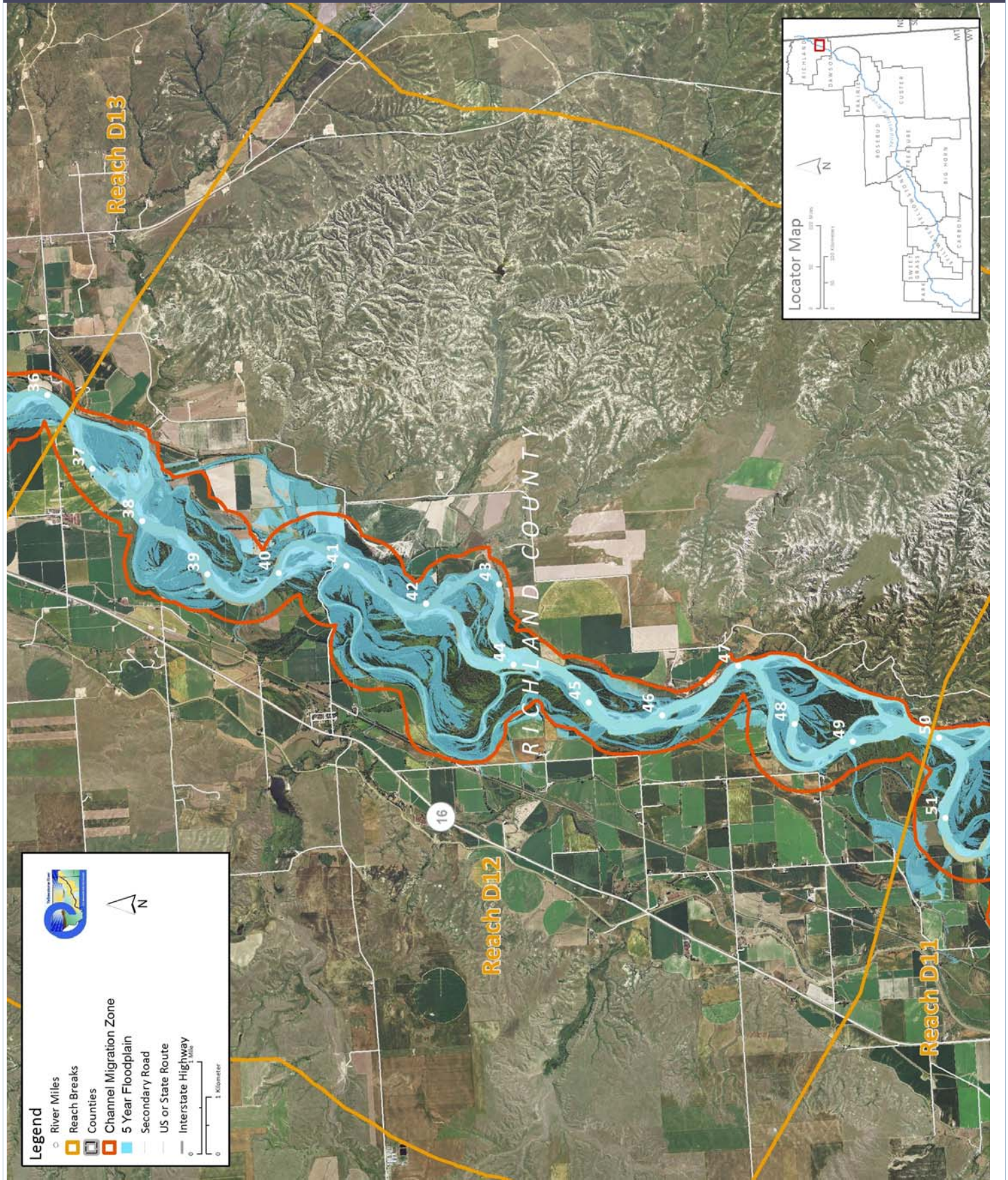
Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach D12 include:

- Nutrient management at animal handling facility at RM 46.8R
- Side channel reactivation at RM 45.3R
- 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)	69,800	54,300	-22.2%			
100 Year (cfs)	144,000	132,000	-8.3%			
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.
	2,239.4	1,957.5	1,919.3	1,754.7	-484.8	
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	3,251	2.3%	2,655			
Concrete Riprap	1,945	1.4%	0			
Flow Deflectors	1,801	1.3%	118			
Total	6,997	4.9%	2,773			
Length of Side Channels Blocked (ft)	Pre-1950s	Post-1950s	Numerous side channels have been blocked by small dikes.			
	0	14,624				
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	596.0	338.4				
Acres/Year	22.9	13.5				
Acres/Year/Valley Mile	2.1	1.3	597.01 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)	-205.7	27.4	19.8	-158.5		
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	2,113.3	42%				
100 Year	344.5	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.			
	197.9	3%				
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)	5,885.9	6,086.8	Flood (Ac)	2,107.6	2,364.7	
Ag. Infrastructure (Ac)	59.8	154.9	Sprinkler (Ac)	0.0	0.0	
Exurban (Ac)	0.0	1.7	Pivot (Ac)	0.0	582.7	
Urban (Ac)	0.0	0.0				
Transportation (Ac)	43.7	58.6				
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.	
	353.9	0.8	354.7	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	28.0	2.6	285.0			
Emergent	117.2	10.9				
Scrub/Shrub	139.8	13.0				
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.			
	74.8	1.4%				
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.	
	103.2	104.8	115.5	12.3		

CHANNEL MIGRATION ZONE MAP



County	Richland	Upstream River Mile	36.3
Classification	PCM/I: Partly confined meandering/islands	Downstream River Mile	27.8
General Location	To Sidney	Length	8.50 mi (13.68 km)

Narrative Summary

Reach D13 is located just upstream of Sidney. It is 8.5 miles long, and is a PCM/I reach type, indicating a primary meandering channel thread with distinct islands largely formed by historic bendway cutoffs. The reach has multiple pipeline crossings, and the Highway 23 Bridge and approach have confined the river and isolated floodplain area. Floodplain development for irrigated agricultural is extensive, and in many cases irrigated fields intersect the channel bank. These locations are commonly armored, and low field dikes affect floodplain access.

In 2011 there was almost 16,000 feet of bank armor in the reach, protecting 16 percent of the total bank line. That includes 2,440 feet of car bodies. The car body revetments are all located off of the main channel at RM 32.2L. About ½ mile of rock riprap was constructed between 2001 and 2011.

Although no side channels have been intentionally blocked in the reach, there has still been a net loss of almost two miles of side channel since 1950, reflecting passive abandonment of side channels with flow alterations.

There are three mapped pipeline crossings in the reach, two at the Sidney Bridge and another about a mile upstream. The two on the bridge are apparently installed on the bridge structure itself. The one upstream at RM 32.1 is described as an LPG pipeline installed in 1997; however no more information was available.

Reach D13 has had 28 reported ice jam events since 1917. Especially severe damages were reported in the ice jam of March 25, 1943.

Human development has resulted in isolation of 18 percent of the historic 100-year floodplain and 26 percent of the 5-year floodplain. This isolation includes the effects of transportation infrastructure embankments (mainly Highway 23), low agricultural dikes on the edges of irrigated fields, and reduced flood magnitudes. There has been fairly extensive land use encroachment into the Channel Migration Zone: as of 2011 there were 250 acres of pivot irrigation and 137 acres of urban/exurban land uses within the CMZ, making these areas especially prone to the threat of river erosion. One drill pad was mapped within 1,500 feet of the river at RM 32. There is also a large animal handling facility that drains to an irrigation return flow point at RM 29.

Reach D13 shows, like most other reaches below the Bighorn River, a shrinking channel with reduced rates of erosion and floodplain turnover. The bankfull channel area in the reach dropped by 220 acres since 1950, and there was a similar amount of mapped riparian encroachment into old channel areas. Floodplain turnover rates have dropped from 14.3 acres per year from 1950-1976 to 6.1 acres per year from 1976-2001. There has also been a net loss of 45 acres of open bar area as the channel has become smaller and more forested. On the floodplain, riparian acreage has decreased; about 424 acres or 27 percent of the total riparian area was cleared for irrigation since 1950.

Like numerous reaches below the Bighorn River confluence, Reach D13 exhibits a shift from a largely braided pattern in 1950 to an anabranching pattern today. The pattern shift reflects the fact that side channels that used to flow around open bars (braided) now flow around wooded islands (anabranching). This shift appears largely due to riparian encroachment onto sand bars since 1950. This encroachment reflects the flow alterations identified in the reach, and may also be due to the altered sediment regime imposed by upstream influences including Yellowtail Dam. Changes in sediment loading have not been quantified in the CEA.

There are 45 acres of Russian olive mapped in the reach.

Reach D13 was sampled as part of the fisheries study. A total of 38 fish species were sampled in the reach, including six Species of Concern: the Blue Sucker, Pallid Sturgeon, Sauger, Shortnose Gar, Sicklefin Chub, and Sturgeon Chub.

Reach D13 was also sampled as part of the avian study. A total of 39 bird species were identified in the reach. The Red-headed Woodpecker was found, which is a Species of Concern (SOC). In contrast to most other reaches, Reach D12 has seen a reduction in the forested area that is at low risk of cowbird parasitism since 1950. At that time, there were 27.6 acres per valley mile of such forest, and that number decreased to 18.1 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 magnitude of the 100-year flood is now 134,000 cfs, which 6 percent lower than it was pre-development (143,000 cfs). The 2-year flood, which strongly influences overall channel form, has dropped by 22 percent. Low flows have also been impacted; severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 4,190 cfs to 2,000 cfs with human development, a reduction of 52 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,340 cfs under unregulated conditions to 2,550 cfs under regulated conditions, a reduction of 60 percent.

Seasonal low flows have increased by 82 percent in the fall and 63 percent in the winter. Both fall and winter base flows are currently about 3,500 cfs.

CEA-Related observations in Reach D13 include:

- Conversion of river pattern from braided to anabranching due to riparian encroachment onto sand bars since 1950.
- Passive side channel abandonment due to hydrologic alterations and potentially downcutting due to CMZ confinement.

- 100-year floodplain isolation due to low agricultural field dikes.
- 100-year floodplain isolation due to transportation infrastructure.
- Channel Migration Zone (CMZ) restrictions that significantly confine the river corridor, potentially causing downcutting. This may be an important Increase in area at low risk of cowbird parasitism with riparian encroachment

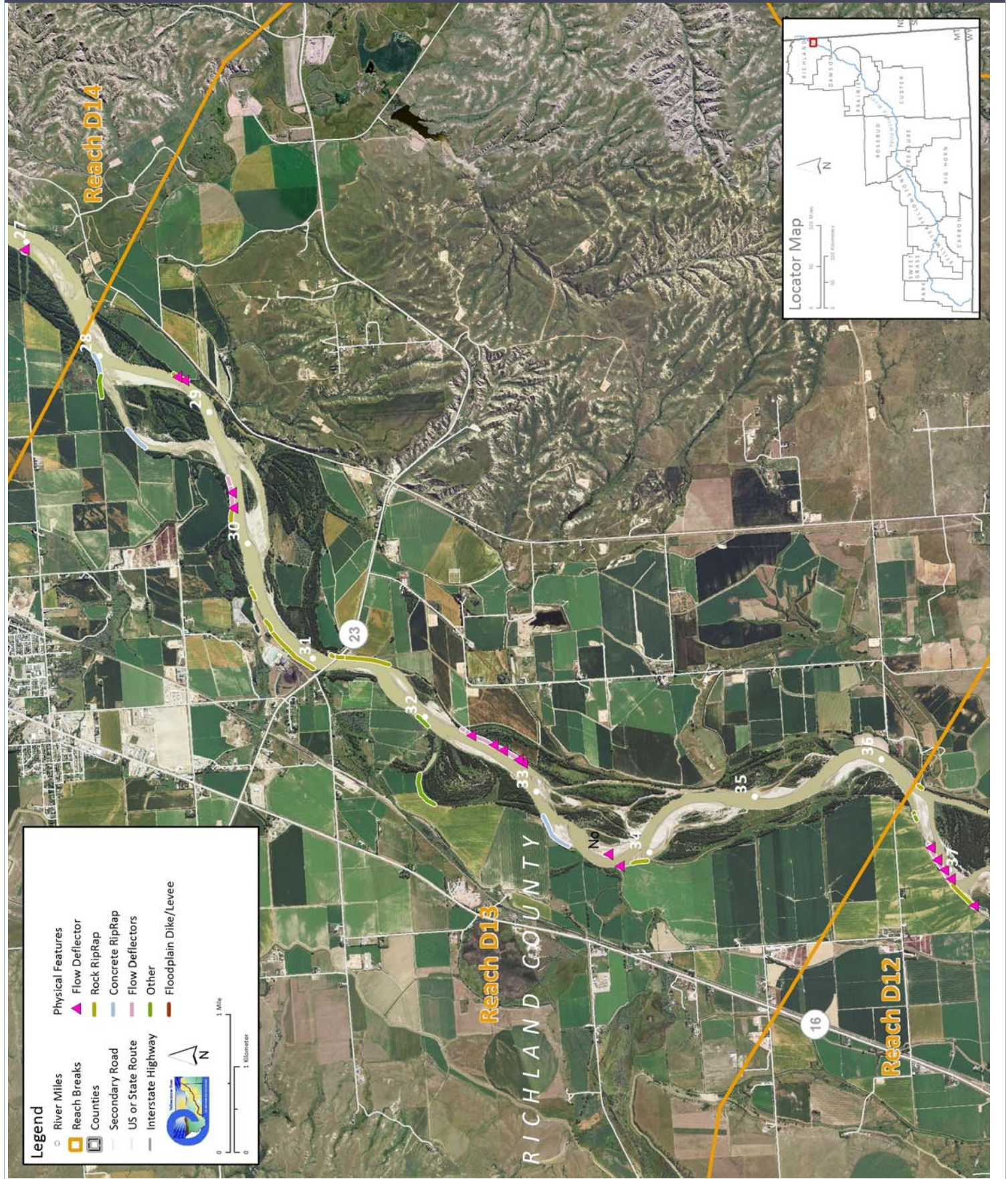
Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach D13 include:

- Nutrient Management at Animal Handling Facility at RM 29L
- Pipeline Crossing PRACTICE RM 32.1
- Old car body removal RM 32.2L
- Russian olive removal

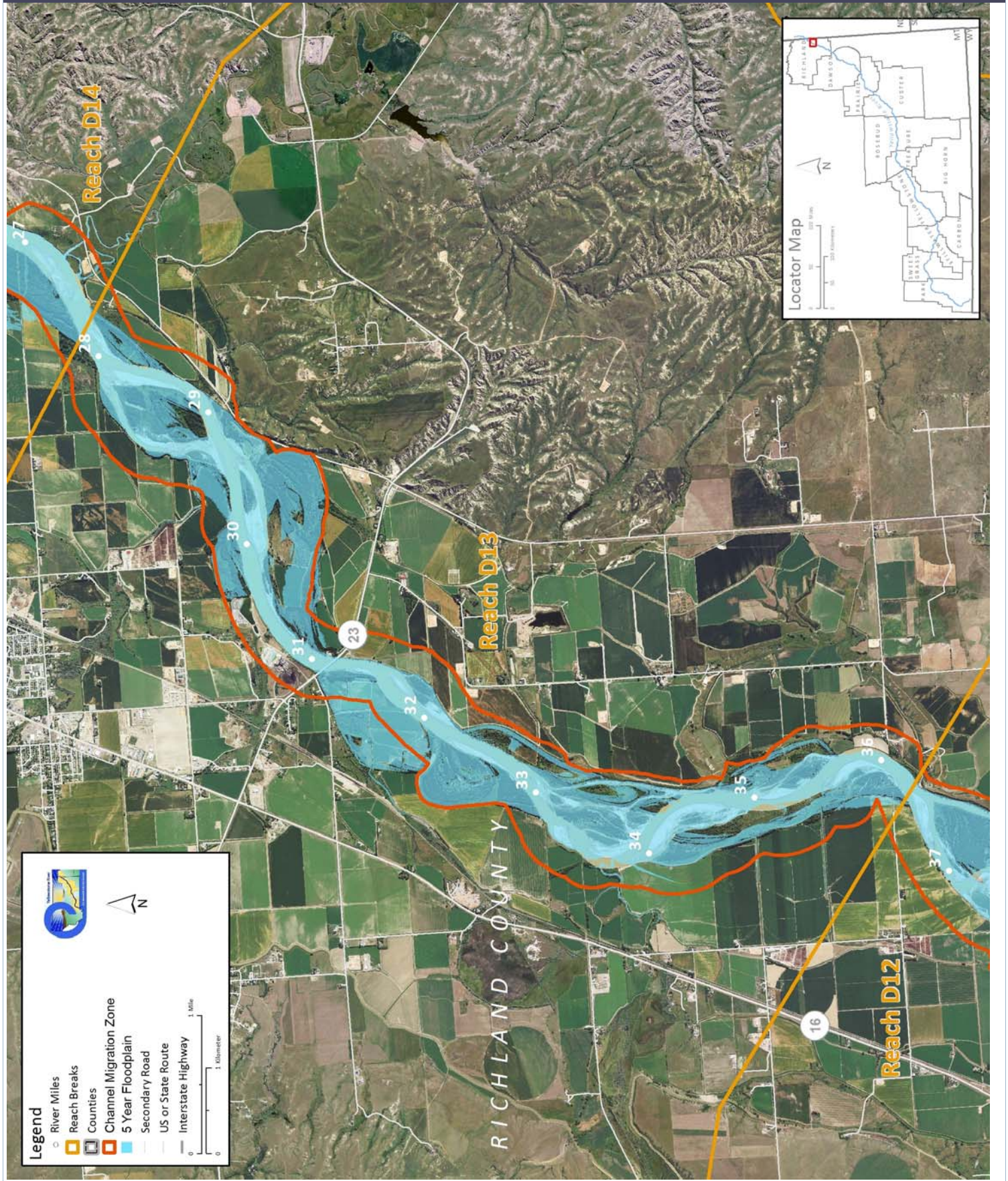
The following table summarizes some key CEA results that have been used to describe overall condition and types of human influences affecting the river. The values are specific to this single reach. Blanks indicate that a particular value was not available for this area. This information is consolidated 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)	69,900	54,300	-22.3%			
100 Year (cfs)	143,000	134,000	-6.3%			
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.
	1,163.3	1,160.8	991.3	942.8	-220.5	
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	6,386	7.1%	2,410			
Concrete Riprap	3,329	3.7%	0			
Flow Deflectors	4,179	4.6%	143			
Total	13,894	15.4%	2,553			
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	371.6	151.8	291.7 acres			
Acres/Year	14.3	6.1				
Acres/Year/Valley Mile	1.9	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)	-58.3	-10.5	23.6	-45.3		
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	466.6	26%				
100 Year	766.0	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.			
	639.4	18%				
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)	5,052.4	4,997.8	Flood (Ac)	3,209.5	2,324.4	
Ag. Infrastructure (Ac)	73.2	210.1	Sprinkler (Ac)	0.0	0.0	
Exurban (Ac)	5.1	216.3	Pivot (Ac)	0.0	893.5	
Urban (Ac)	0.0	0.0				
Transportation (Ac)	53.4	56.8				
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.	
	424.0	19.4	443.4	27.0%		
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	65.0	8.5	252.0			
Emergent	126.5	16.6				
Scrub/Shrub	60.6	7.9				
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.			
	44.7	3.2%				
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.	
	27.6	23.0	18.1	-9.4		

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



County	Richland	Upstream River Mile	27.8
Classification	PCM/I: Partly confined meandering/islands	Downstream River Mile	13.5
General Location	To Fairview	Length	14.30 mi (23.01 km)

Narrative Summary

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

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

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

Similar to many reaches in the Lower Yellowstone Valley, the river channel in Reach D14 has gotten smaller since 1950. The channel contracted by about 309 acres in this reach since 1950, and about 460 acres of riparian vegetation has encroached into old channel areas. This pattern has been consistent in the lower river, and relates primarily to a reduction in flows due to human development. Floodplain turnover rates have dropped from 14.4 acres per year pre-1976 to 6.1 acres per year post-1976. There has also been a major loss of open bar habitat area in the channel; between 1950 and 2001, there was a loss of 510 acres of mid-channel bar area, which can be important habitat to certain species such as least tern.

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

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

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

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

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

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

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

CEA-Related observations in Reach D14 include:

- Flow alteration impacts on floodplain access

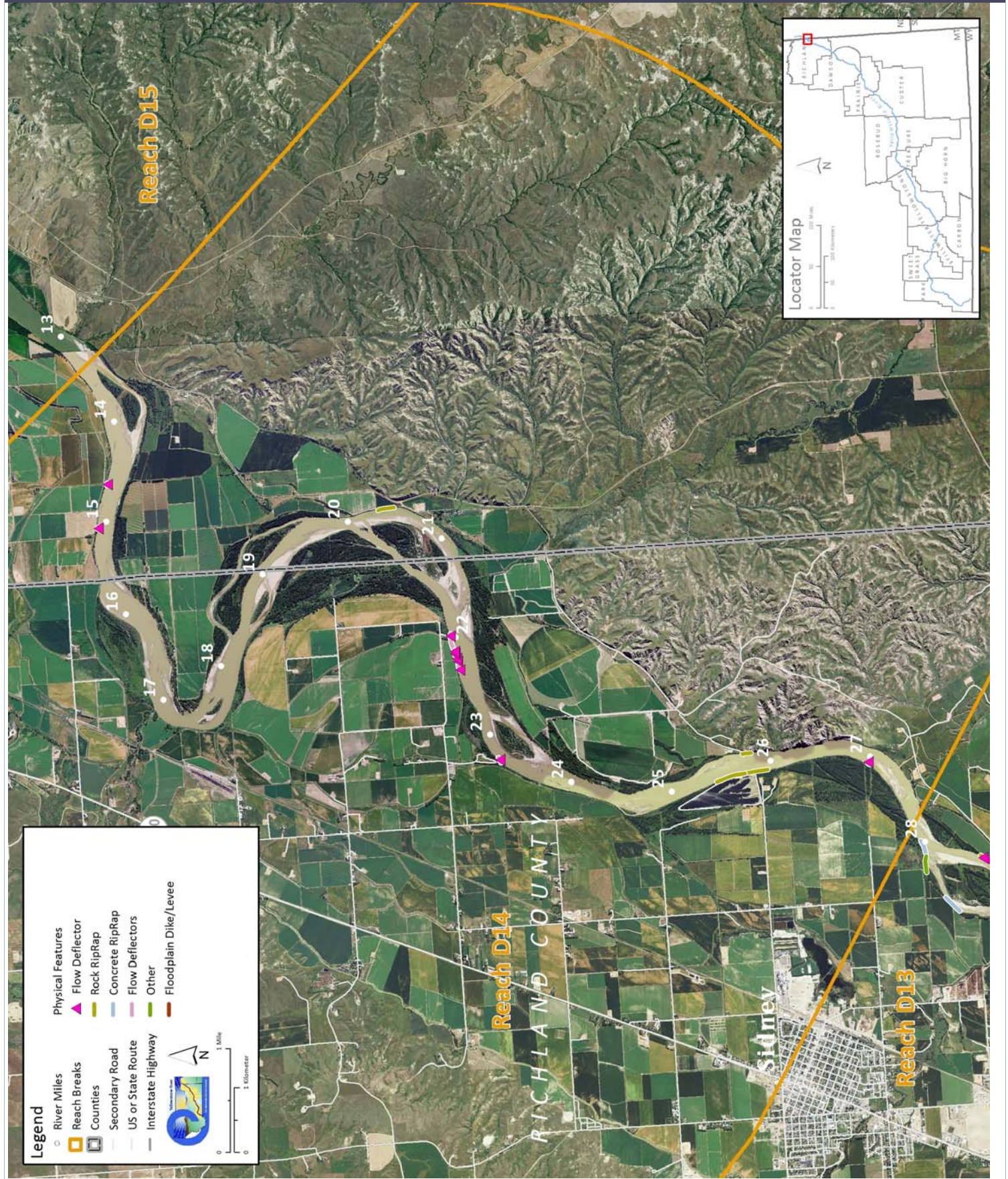
Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach D14 include:

- Solid waste removal at dump sites at RM 25R, RM 24.3L, RM 17L, RM 15.8L, and RM 15.8R.
- Side channel reactivation at RM 23L
- Pipeline crossing Management at RM 27.
- Russian olive removal

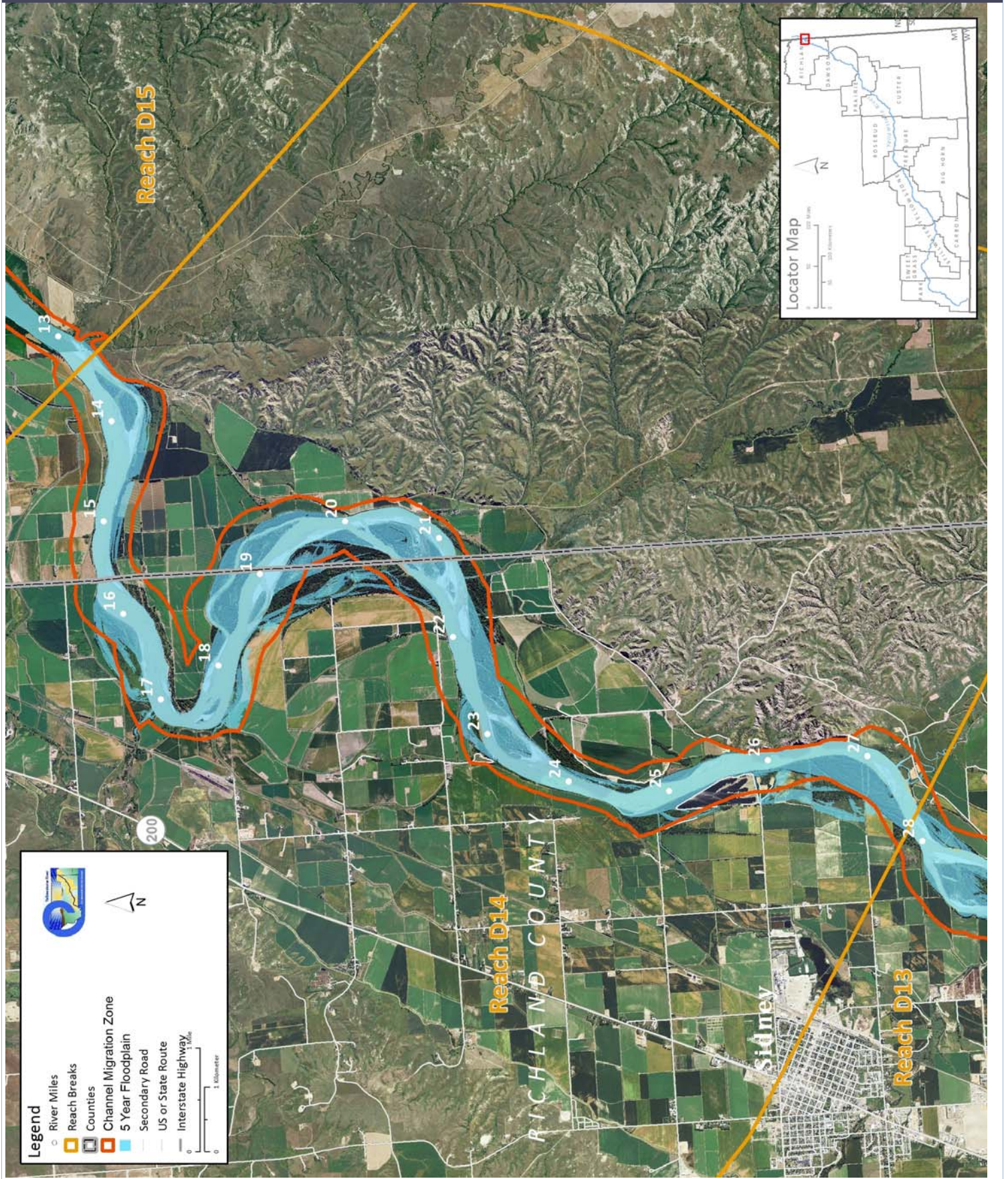
The following table summarizes some key CEA results that have been used to describe overall condition and types of human influences affecting the river. The values are specific to this single reach. Blanks indicate that a particular value was not available for this area. This information is consolidated 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)	69,900	54,300	-22.3%			
100 Year (cfs)	143,000	134,000	-6.3%			
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.
	2,206.2	2,091.0	1,933.5	1,896.8	-309.4	
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	3,906	2.6%	2,293			
Concrete Riprap	0	0.0%	0			
Flow Deflectors	2,505	1.7%	273			
Total	6,411	4.2%	2,566			
Length of Side Channels Blocked (ft)	Pre-1950s	Post-1950s	Numerous side channels have been blocked by small dikes.			
	3,595	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	375.2	152.5	459.11 acres			
Acres/Year	14.4	6.1				
Acres/Year/Valley Mile	1.1	0.5				
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)	9.8	94.4	-510.3	-406.1		
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	1,046.3	41%				
100 Year	1,450.6	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.			
	160.9	3%				
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)	8,402.4	8,078.6	Flood (Ac)	3,832.7	3,990.2	
Ag. Infrastructure (Ac)	49.0	153.3	Sprinkler (Ac)	0.0	0.0	
Exurban (Ac)	0.0	161.4	Pivot (Ac)	0.0	1,003.3	
Urban (Ac)	0.0	0.0				
Transportation (Ac)	65.0	73.2				
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.	
	940.2	123.1	1,063.3	36.0%		
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	8.1	0.6	289.5			
Emergent	137.1	10.9				
Scrub/Shrub	144.3	11.5				
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.			
	35.7	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.	
	25.6	38.1	19.6	-5.9		

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



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

Narrative Summary

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

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

Similar to many reaches in the Lower Yellowstone Valley, the river channel in Reach D15 has gotten smaller since 1950. The channel contracted by about 190 acres in this reach since 1950, and about 210 acres of riparian vegetation has encroached into old channel areas. This pattern has been consistent in the lower river, and relates primarily to a reduction in flows due to human development.

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

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

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

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

CEA-Related observations in Reach D15 include:

- Flow alteration impacts on floodplain access

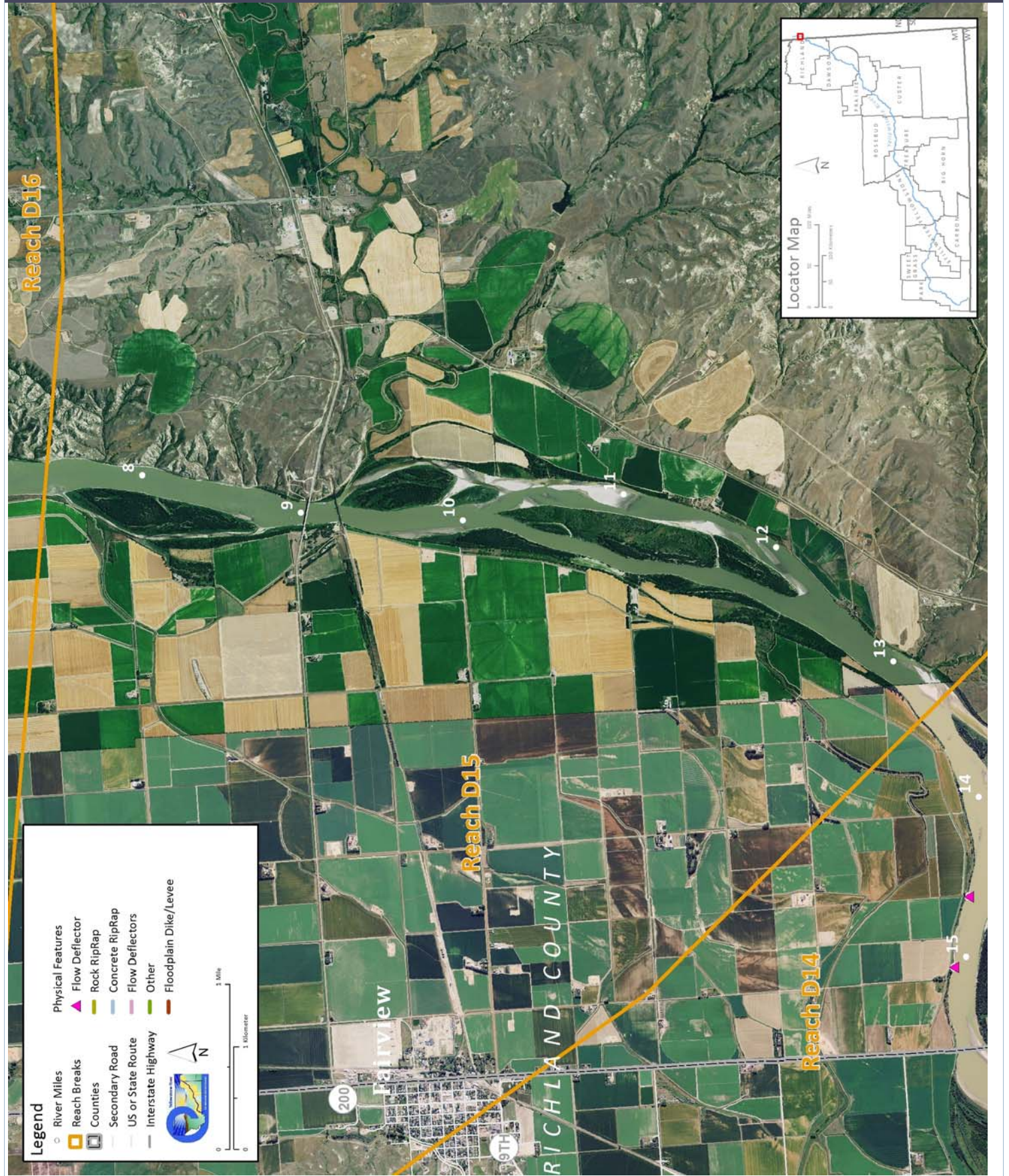
Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach D15 include:

- Russian olive removal

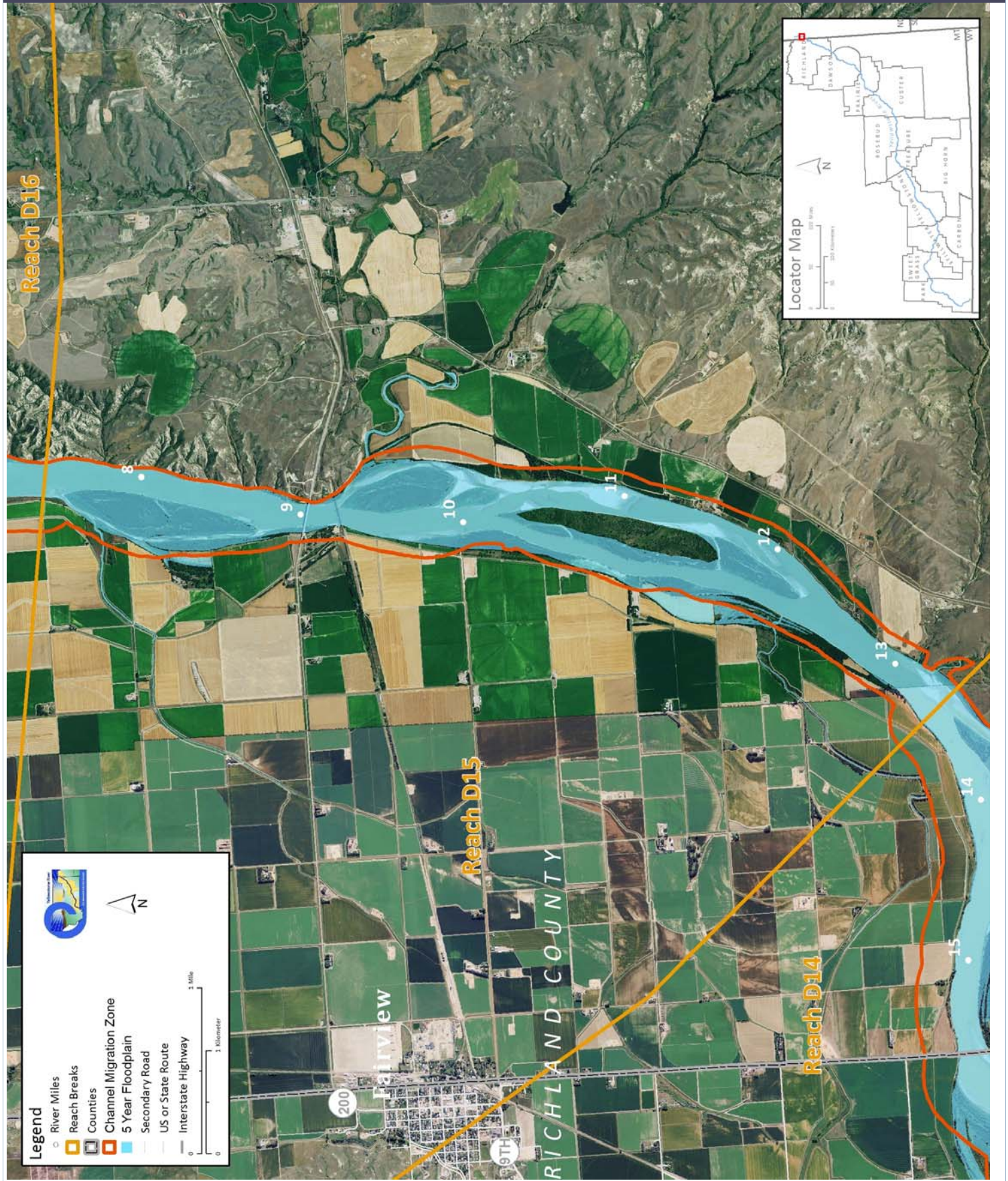
The following table summarizes some key CEA results that have been used to describe overall condition and types of human influences affecting the river. The values are specific to this single reach. Blanks indicate that a particular value was not available for this area. This information is consolidated 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)	69,900	54,300	-22.3%			
100 Year (cfs)	143,000	134,000	-6.3%			
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.
	988.3		887.9	798.9	-189.3	
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.			
	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 Acres/Year Acres/Year/Valley Mile			208.49 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)	0	89.7	-57.5	32.2		
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	168.1	23%				
100 Year	1,884.7	54%				
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.			
	21.1	1%				
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)	6,215.4	7,485.3	Flood (Ac)	3,955.0	6,101.5	
Ag. Infrastructure (Ac)	86.2	192.8	Sprinkler (Ac)	0.0	0.0	
Exurban (Ac)	0.0	35.8	Pivot (Ac)	0.0	71.3	
Urban (Ac)	0.0	0.0				
Transportation (Ac)	79.3	70.6				
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.	
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	1.6	0.3	90.5			
Emergent	20.2	3.5				
Scrub/Shrub	68.7	11.9				
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.			
	0.8	0.1%				
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.	
	10.1		23.0	12.9		

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



County	Mckenzie	Upstream River Mile	7.5
Classification	US/I: Unconfined straight/islands	Downstream River Mile	0
General Location	To Missouri River	Length	7.50 mi (12.07 km)

Narrative Summary

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

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

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

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

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

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

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

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

CEA-Related observations in Reach D16 include:

- Extensive riparian encroachment with flow alterations
- Conversion of open sand bars to forested islands

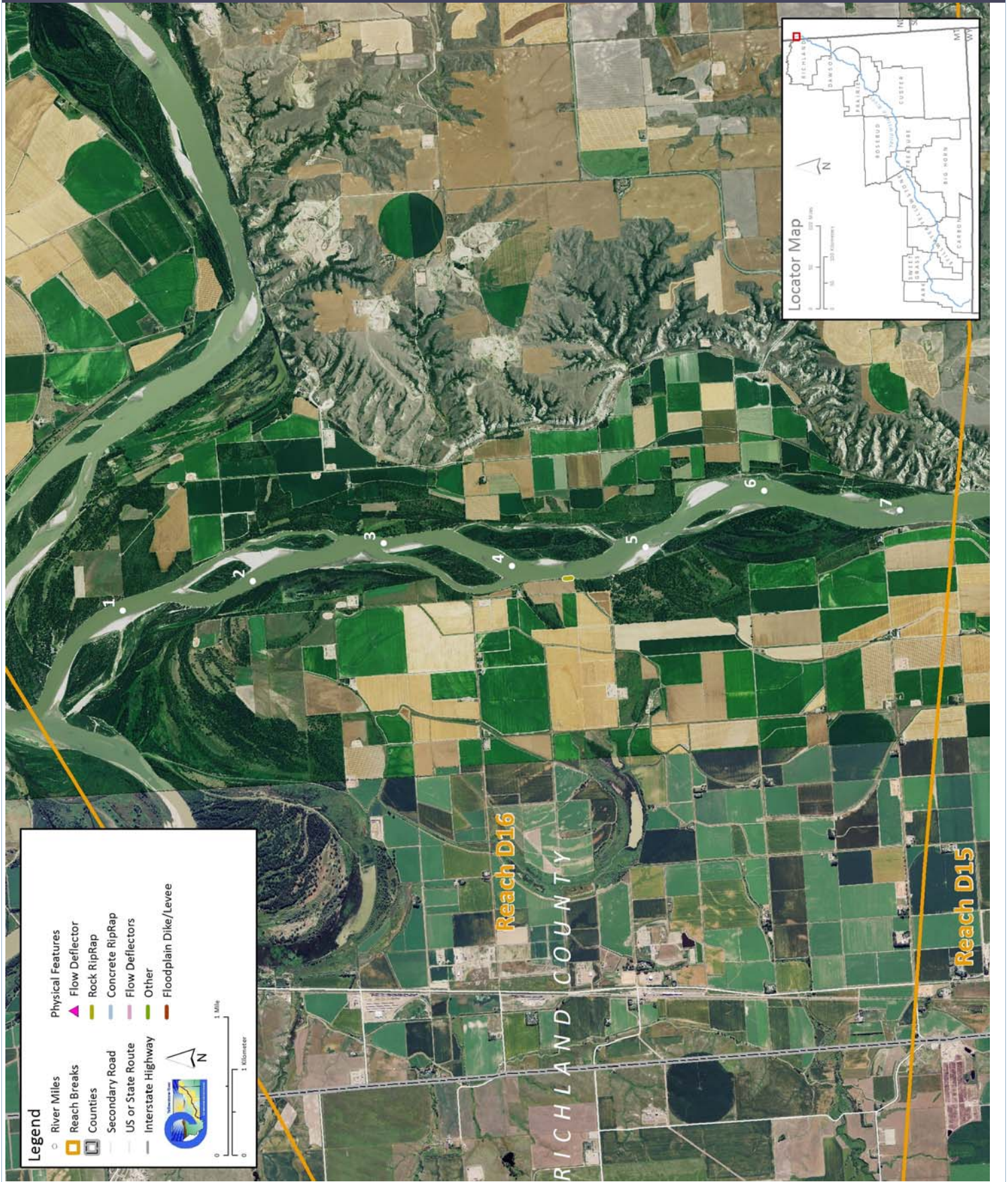
Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach D16 include:

- Drill pad considerations
- Riparian protections

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)	69,900	54,300	-22.3%			
100 Year (cfs)	143,000	134,000	-6.3%			
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.
	1,515.1		1,157.3	960.1	-555.0	
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	266	0.3%	266			
Concrete Riprap	0	0.0%	0			
Flow Deflectors	0	0.0%	0			
Total	266	0.3%	266			
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 Acres/Year Acres/Year/Valley Mile			472.19 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)	10.3	45.8	-208.4	-152.3		
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	105.9	31%				
100 Year	390.4	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.			
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)	10,472.2	14,362.1	Flood (Ac)	4,631.0	8,492.4	
Ag. Infrastructure (Ac)	87.1	270.2	Sprinkler (Ac)	0.0	0.0	
Exurban (Ac)	0.0	63.7	Pivot (Ac)	0.0	0.0	
Urban (Ac)	0.0	0.0				
Transportation (Ac)	0.0	17.9				
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.	
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	25.3	3.6	558.4			
Emergent	254.9	36.2				
Scrub/Shrub	278.2	39.5				
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.			
	3.5	0.1%				
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.	
	230.3		307.9	77.6		

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP

