

<b>County</b>	Park	<b>Upstream River Mile</b>	514.6
<b>Classification</b>	PCM: Partially confined meandering	<b>Downstream River Mile</b>	511
<b>General Location</b>	To downstream of Deep Creek; Weeping wall, Jumping Rainbow; onset of spring creeks	<b>Length</b>	3.60 mi (5.79 km)

## Narrative Summary

Reach PC10 extends from the Pine Creek Bridge to below the mouth of Deep Creek. The reach is approximately 3.5 miles long, extending from RM 511.0 to RM 514.5. This is an especially unique section of the Yellowstone River where spring creeks that parallel the channel support a nationally recognized cold water fishery. The reach is also semi-confined by very coarse grained glacial alluvial terraces. Sediment recruitment from the terraces drives bar formation, resulting in locally rapid bank migration, and in some cases, threats to the spring creeks. This was exemplified during the 1996/1997 floods, when the river migrated tens of feet into high glacial terraces, delivering vast amounts of gravel to the channel. At one location near the Deep Creek confluence, a home on a ~30 foot high glacial terrace was undermined and deliberately burnt down to prevent its collapse into the river. Just downstream of this site, rapid point bar growth drove westward channel migration towards a prized spring creek, which created a real risk of Yellowstone River avulsion into that channel. Efforts to prevent an avulsion included sediment removal from the rapidly enlarging point bar, bank protection, and construction of a long floodplain dike between the spring creek and the river. This single bendway experienced approximately 750 feet of migration between 1948 and 1999, which translates to an average migration rate of 14.7 feet per year.

Approximately 14 percent of the bankline is armored, primarily by rock riprap (3,753 feet) and flow deflectors (1,197 feet). Between 2001 and 2011, the net length of bank armor increased by 1,037 feet, although 50 feet of flow deflectors were eroded out during that time. There are also over two miles of floodplain dikes in the reach, most of which run parallel to the river to isolate the spring creeks. Several thousand feet of side channels have been blocked in Reach PC10; one large channel that was blocked prior to 1950 extends downstream for several thousand feet into Reach PC11. There is a high concentration of emergent wetlands in these abandoned side channels.

The total bankfull channel area in Reach PC10 increased from 151 acres in 1950 to 191 acres in 2001, suggesting channel enlargement, either due to floods or flow concentrations in the main channel due to side channel loss and diking.

Land uses in Reach PC10 include irrigated ground, multi-use (non-irrigated and undeveloped), and exurban residential development. Whereas in 1950 there were 512 acres under flood irrigation, by 2011 that had been reduced to 17 acres. The expansion of irrigation during that time included 136 acres of sprinkler, and another 56 acres of pivot irrigation. Most of the land, over 900 acres, is used as non-irrigated agricultural land. There has also been about 180 acres of exurban development in Reach PC10, much of which is part of the Jumping Rainbow Ranch downstream of Deep Creek. Some of this development, such as the location of the house that was undermined in 1997, is in the Channel Migration Zone. In the upstream portion the reach, a gravel pit on a large point bar (RM 513.8) encroaches into the Channel Migration Zone. Because of the extensive levee construction in the reach to protect spring creeks, 38 percent of the CMZ has been restricted from the natural CMZ footprint. The reach is very popular for recreational boating and fishing; the Pine Creek Fishing Access Site is located just below the Pine Creek Bridge on the left bank.

This area of the upper Yellowstone River has seen three severe floods in the last 20 years. The 1996 and 1997 floods were very damaging, early-June events that peaked at 37,100 and 38,000 cfs, respectively. At the time, these were considered to be sequential 100-year floods. Then in late June of 2011, the river peaked at 40,600 cfs, which is currently the flood of record at Livingston. This flood exceeded a 100-year event, with both the 1996/1997 events considered to have exceeded a 75-year flood.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been relatively small in this reach. The biggest influence has been on low flows: severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 1,530 cfs to 1,480 cfs with human development, a reduction of 3.3 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 1,760 cfs under unregulated conditions to 1,680 cfs under regulated conditions at the Livingston gage, a reduction of 4.6 percent.

CEA-Related observations in Reach PC10 include:

- Extensive dike construction Floodplain dikes constructed to protect spring creek fisheries have narrowed the active meander corridor
- Exurban encroachment into the Channel Migration Zone (CMZ) has occurred on terrace surfaces
- Gravel pit and recreational pond development in a meander core may contribute to avulsion risk in the reach.
- Rapid dike construction and armoring following major flooding (1996/1997).
- Increase in primary channel length (sinuosity) with loss of side channels.
- Isolation of 38 percent of the CMZ, mostly avulsion hazard areas that support spring creeks.

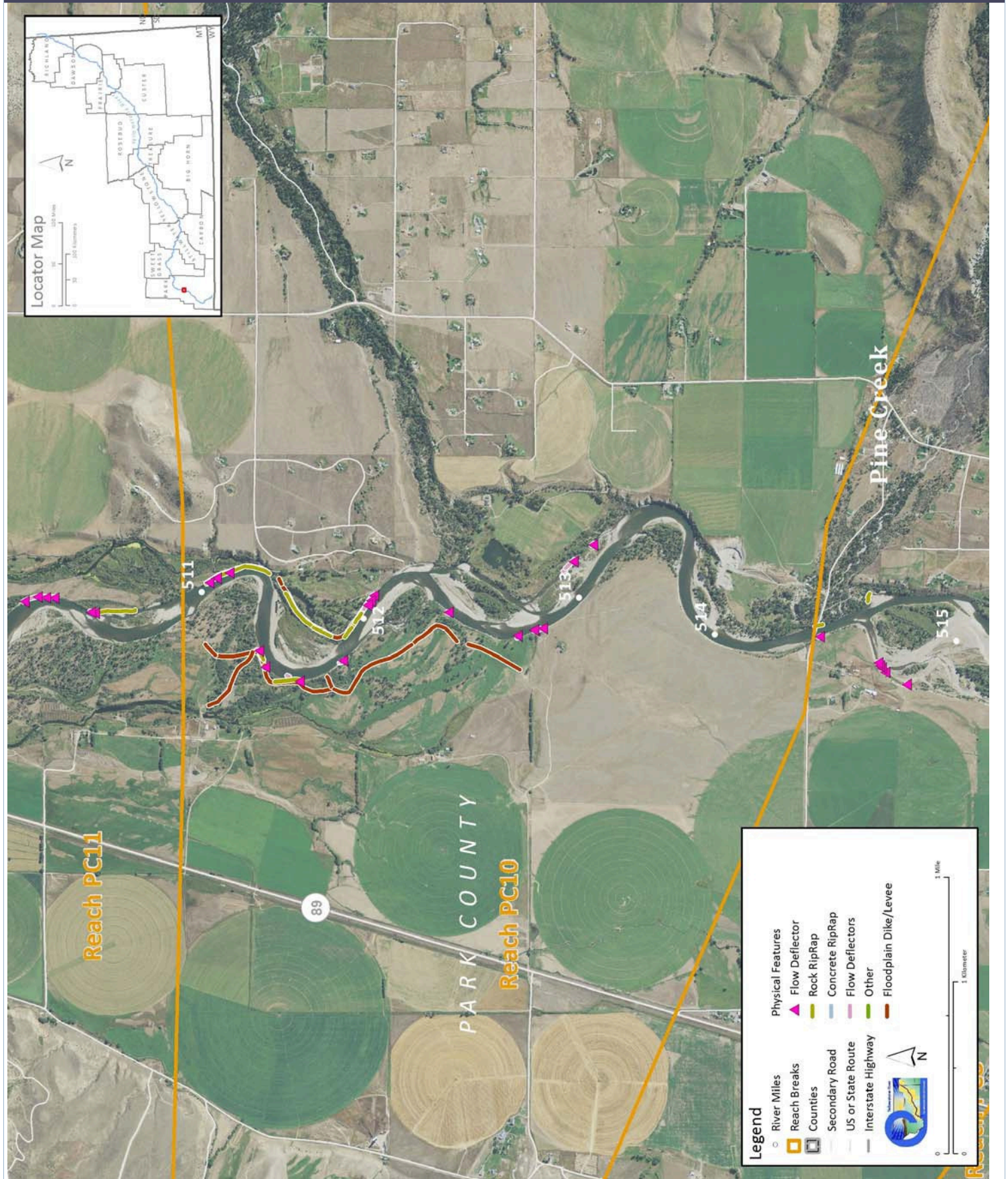
Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach PC10 include:

- Selective side channel restoration at RM 511.5 (may be difficult to reactivate side channels without affecting developed spring creek fishery)
- CMZ Management due to current restriction of 38 percent of the Channel Migration Zone

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.

<b>Discharge</b>	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)	19,500	19,400	-0.5%			
100 Year (cfs)	36,800	36,800	0.0%			
<b>Bankfull Channel Area (Ac)</b>	1950	1976	1995	2001	1950-2001	Bankful channel area is the total footprint of the river inundated at approx. the 2-year flood.
	151.0			190.6	39.7	
<b>Physical Features</b>	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	3,753	10.3%	1,086			
Concrete Riprap	0	0.0%	0			
Flow Deflectors	1,197	3.3%	-50			
<b>Total</b>	<b>4,950</b>	<b>13.5%</b>	<b>1,037</b>			
<b>Length of Side Channels Blocked (ft)</b>	Pre-1950s	Post-1950s	Numerous side channels have been blocked by small dikes.			
	7,000	1,454				
<b>Floodplain Turnover</b>	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			
Acres/Year						
Acres/Year/Valley Mile						
<b>Open Bar Area</b>	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)						
<b>Floodplain Isolation</b>	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 Year						
<b>Restricted Migration Area</b>	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.			
	252.8	38%				
<b>Land Use</b>	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)	1,329.9	1,061.1	Flood (Ac)	512.4	17.1	
Ag. Infrastructure (Ac)	30.9	54.8	Sprinkler (Ac)	0.0	135.9	
Exurban (Ac)	0.0	178.9	Pivot (Ac)	0.0	56.1	
Urban (Ac)	0.0	0.0				
Transportation (Ac)	0.8	1.0				
<b>1950s Riparian Vegetation Converted to a Developed Land Use (ac)</b>	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.	
<b>National Wetlands Inventory</b>	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	22.5	9.7	<b>236.7</b>			
Emergent	165.1	71.2				
Scrub/Shrub	49.1	21.1				
<b>Russian Olive (2001) (Appx. 100-yr Floodplain)</b>	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.			
	0.1	0.2%				
<b>Riparian Forest at low risk of Cowbird Parasitism (Ac/Valley Mile)</b>	1950	1976	2001	Change 1950-2011	Cowbirds are associated with agricultural and residential development, displacing native bird species by parasitizing their nests.	

## PHYSICAL FEATURES MAP (2011)



## CHANNEL MIGRATION ZONE MAP

