Reach #6 - Lotic Checklist

<table>
<tr><td colspan="2">Name of Riparian-Wetland Area:</td><td colspan="3">Missouri River</td></tr>
<tr><td>Date:</td><td colspan="2">Reach visited 7/6 &7/7/10 – Form Completed 7/7/2010
Revisited 9/8/2010</td><td>Segment/Reach ID:</td><td>Reach #6 - River Mile 119 (Sturgeon Island) to 139 (CMR Boundary)</td></tr>
<tr><td colspan="2">ID Team Observers:</td><td colspan="3"><u>X</u> C. Krause, Hydrologist <u>X</u> V. Shea, Rangeland Management Specialist <u>X</u> A. Northerner, Range Technician (Riparian) <u>X</u> M. Forsyth, Rangeland Management Specialist <u>X</u> J. Peters, Wildlife Biologist <u>X</u> A. Ehlert, Range Technician <u>X</u> M. Philbin, Hydrologist <u>X</u> J. Sorlie, Soil Scientist <u>X</u> C. Meier, Soil Scientist <u>X</u> W. Elmore, Ecologist <u>X</u> S. Smith, Riparian/Rangeland Management Specialist & National Riparian Service Team Leader</td></tr>
<tr><td colspan="2">Assessment Procedures:</td><td colspan="3">During February 2-4, 2010, interdisciplinary (ID) Team members met with National Riparian Service Team staff, former BLM National Operations Center surface water specialist, USGS scientist, and University of Montana scientist to gain a common understanding of what is already known and review existing information. Preliminary reach breaks were agreed upon, potential and capability descriptions were discussed, and written descriptions were developed.

Predetermined stops were chosen for each reach based upon sites that were representative of larger reaches of river based upon geomorphic and vegetative characteristics, unique or critical areas, grazing allotments, and reach breaks. BLM staff has been monitoring sites on the Upper Missouri since 1990 using the Upper Missouri National Wild and Scenic River (UMNWSR) monitoring form. Depending on site location, sites are monitored on a one, three, or five year cycle. In some instances over 20 years of photographs and documentation exist and this information was heavily used in stop location selection because of the reference material available.

Interested parties, grazing permittees, and stakeholders were invited to participate every day of the assessment in July. Each day began with a review of the potential descriptions for the reach. The entire reach was examined by the ID Team by boat with stops at the predetermined locations. At each stop, the inundating discharges, flood frequency curves, and zone locations were reviewed as necessary. Photograph and GPS documentation of the site was completed and soil pits were dug and documented. Vegetation lists were completed for each zone. At the completion of each stop, the ID Team discussed their individual notes and observations. Once each reach was looked at from top to bottom, the checklist was completed

Common names for plants will be used throughout this document. For scientific names refer to the plant lists or Appendix A.

The ID Team stopped at ten locations on public land, five on the north side and five along the south side, which the group determined to be representative of the riparian-wetland plant communities occurring within Reach #6. Species diversity information (plant list) was collected for Zone 1 and 2 at nine of the locations and for Zone 3 at eight of the locations.

The following 17 questions were answered using the methodology described in Technical Reference 1737-15.</td></tr>
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Definitions:
Zone 1 - from the scour line (the lower limit of sod-forming or perennial vegetation on depositional banks) to bankfull discharge (the stream discharge generally considered to be the single discharge that is most effective for moving sediment, forming or removing bars, and forming or changing bends and meanders, all of which result in the average morphological characteristics of channels). Bankfull on this reach of the Missouri River roughly coincides with the 2-year return interval discharge, approximately 25,000 cubic feet per second (cfs) (flood frequency analysis based on period of record at Landusky gage post completion of Tiber Dam in 1956). Total period of record is 1934-2010.

Zone 2 - from bankfull to approximately the stage associated with 70,000 cfs, which is about a 10-year return interval pre Tiber Dam or a 20-year return interval post Tiber Dam (flood frequency analysis based on period of record pre and post completion of Tiber Dam in 1956 at Landusky gage (total period of record is 1934-2010)). This intermediate zone is between the frequently wetted area along the river and upland areas found on older, more elevated river terraces. This zone is dominated by plants that are equally likely to occur in wetlands or non-wetlands.

Zone 3 – from approximately the stage associated with 70,000 cfs, which is about a 10-year return interval pre Tiber Dam or a 20-year return interval post Tiber Dam (flood frequency analysis based on period of record pre and post completion of Tiber Dam in 1956 at Landusky gage (total period of record is 1934-2010)). This zone is very infrequently flooded but may contain relic riparian species such as mature cottonwoods that were established at lower elevations before the surface was moved higher through sediment accretion.

It is important to note that because the function of the river is dictated largely by attributes and process in Zones 1 and 2, the assessment was focused on conditions observed in these zones.

<u>Wetland Indicator Status Categories:</u>
OBL (Obligate Wetland) - Occurs almost always under natural conditions in wetlands.
FACW (Facultative Wetland) - Usually occur in wetland but occasionally found in non-wetlands.
FAC (Facultative) - Equally likely to occur in wetlands or non-wetlands.
FACU (Facultative Upland) - Usually occur in non-wetlands but occasionally found on wetlands.
UPL (Obligate Upland) - Occur almost always under natural conditions in non-wetlands.

The vegetation section of the PFC checklist focuses on the age class, diversity and amount of *"riparian-wetland"* vegetation present along a reach within Zone 1 and 2. The term "*riparian-wetland"* refers primarily to facultative wetland and obligate wetland plants or those that usually or almost always occur in wetland areas. It is important to note that even though plains cottonwood and green ash are considered facultative plants, meaning they are equally likely to occur in wetland or non-wetland areas, for this assessment they were considered together with other riparian-wetland vegetation and used by the ID Team for completing the PFC checklist. Both plants, and especially plains cottonwood, were found within Zone 1 and 2 and are important in determining the processes and functionality of the Upper Missouri River.

<u>Plant Composition:</u>
Dominant - this term was used to describe plants having a canopy cover greater than 25% or when only a single plant occurred within an assessment area. If the canopy cover of two or more plants made up most of the assessment area, and they were of about equal value, each was noted as a dominant plant.

<u>Vegetation Stability Class Rating:</u>
1 to 3 = Low; 4 to 6 = Medium; 7 to 10 = High
(taken from Appendix H, Monitoring Stream Channels and Riparian Vegetation-Multiple Indicators, Interagency Technical Bulletin, Version 5.0, April 2008)

<u>Soils</u>
Redoximorphic (redox) features – include gray layers and gray mottles, both of which occur when iron compounds are reduced by soil microbes in anaerobic soils. Iron, in its reduced form, is mobile and can be carried in the ground-water solution. When the iron and its brown color are thus removed, the soils show the gray color of their sand particles. The anaerobic, reduced zones can be recognized by their gray, blue, or blue-gray color. The mobilized iron tends to collect in aerobic zones within the soil where it oxidizes, or combines with additional oxygen, to form splotches of bright red-

orange color called mottles. The mottles are most prevalent in the zones of fluctuating water and help mark the seasonal high water table (BLM Technical Reference 17317-19 – Riparian-Wetland Soils).

POTENTIAL: Prior to the Pleistocene, the Missouri River flowed northeast into the Hudson Bay (Wayne et al., 1991). Continental glaciation resulted in the river being pushed southward, thereby draining into the Mississippi River.   River Miles 119 to 139 are located in the relatively young postglacial channel, which according to Scott et al. (1997), exhibits low sinuosity and is constrained by a narrow valley. See Figure 1 - Reach #6 - River Mile 119 (Sturgeon Island) to 139 (CMR Boundary).

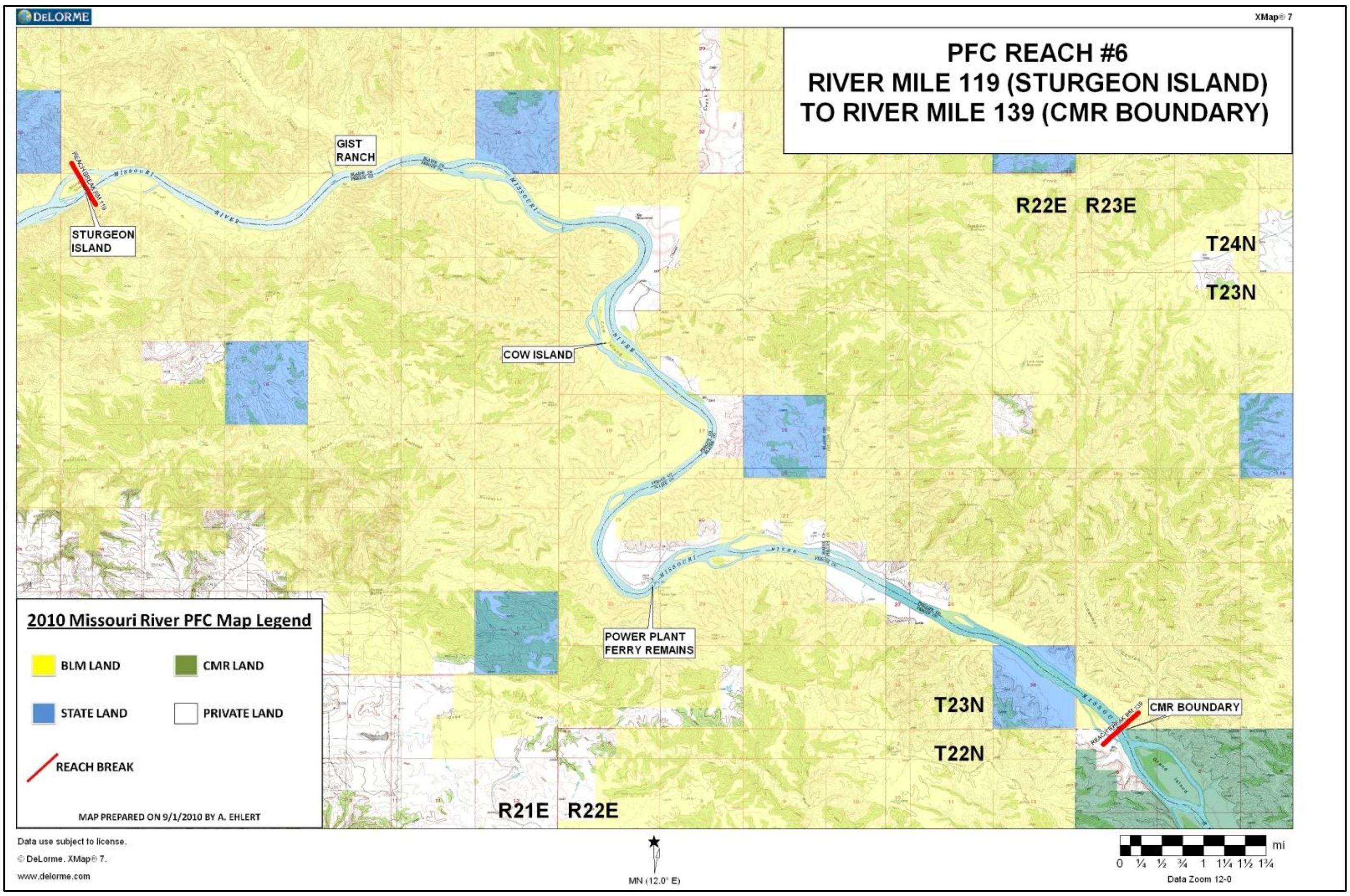


Figure 1 - Reach #6 - River Mile 119 (Sturgeon Island) to 139 (CMR Boundary)

Scott and Auble (2002) describe the postglacial Missouri River channel between Virgelle and Landusky as a series of entrenched meanders, constrained by exposures of sandstone and shale badlands. At potential, the channel would be broadly characterized by a Rosgen F- type channel as described in Rosgen (1996). Rosgen F channels are often found on entrenched landforms in highly weathered material (Rosgen, 1996). Furthermore, comparisons of detailed maps from the 1890s from the Missouri River Commission indicate that little channel migration has occurred in the last 100 years (Scott et al., 1997). The channel has also been vertically stable during that time period. Scott et al. (1997) plotted stage at peak discharge for the Fort Benton gage prior to and after the construction of Canyon Ferry Dam. There was no downward shift in the stage-discharge relation. The period of record at the Fort Benton gage goes back to 1890 and Canyon Ferry Dam was completed in 1953. The stage-peak discharge relation has also been relatively stable through the period of record at the Virgelle (1935-2010) and Landusky (1934-2010) gages. However, the stage-peak discharge relation at Landusky has been less consistent than Virgelle or Fort Benton with more active scour and fills processes. The Landusky gage is located in a more dynamic valley bottom with fine-grained substrate, so this would be expected. The point is that none of the three stream gages located on the UMNWSR indicate recent downcutting. Even though a process of channel narrowing may have been initiated since the 1800s (Scott and Auble, 2002), narrowing would not have been large enough to change the classification of the channel.

Rosgen F-type channels can be described as entrenched, meandering, riffle/pool channels on low gradients with high width/depth ratios (Rosgen, 1996). Entrenchment ratios are typically less than 1.4, which means that the flood prone width/bankfull width is less than 1.4. Scott and Auble (2002) describe the postglacial channel width as only slightly less than the valley width. Channel slopes are generally less than 0.02, and bankfull width/depth ratios are greater than 12. Reach #6 is somewhat of a transitional zone before a geomorphic break which occurs near the Charles M. Russell National Wildlife Refuge Boundary, where the valley widens substantially because of the river-level exposure of Bear Paw Shale. The width of flood prone areas does increase in this reach relative to other constrained reaches of the Upper Missouri River, and depositional features do increase in the downstream direction. However, they do not increase to the extent to change the classification of the channel. See Figure 2 - Reach #6 - River Mile 119 (Sturgeon Island) to 139 (CMR Boundary) – Aerial View.

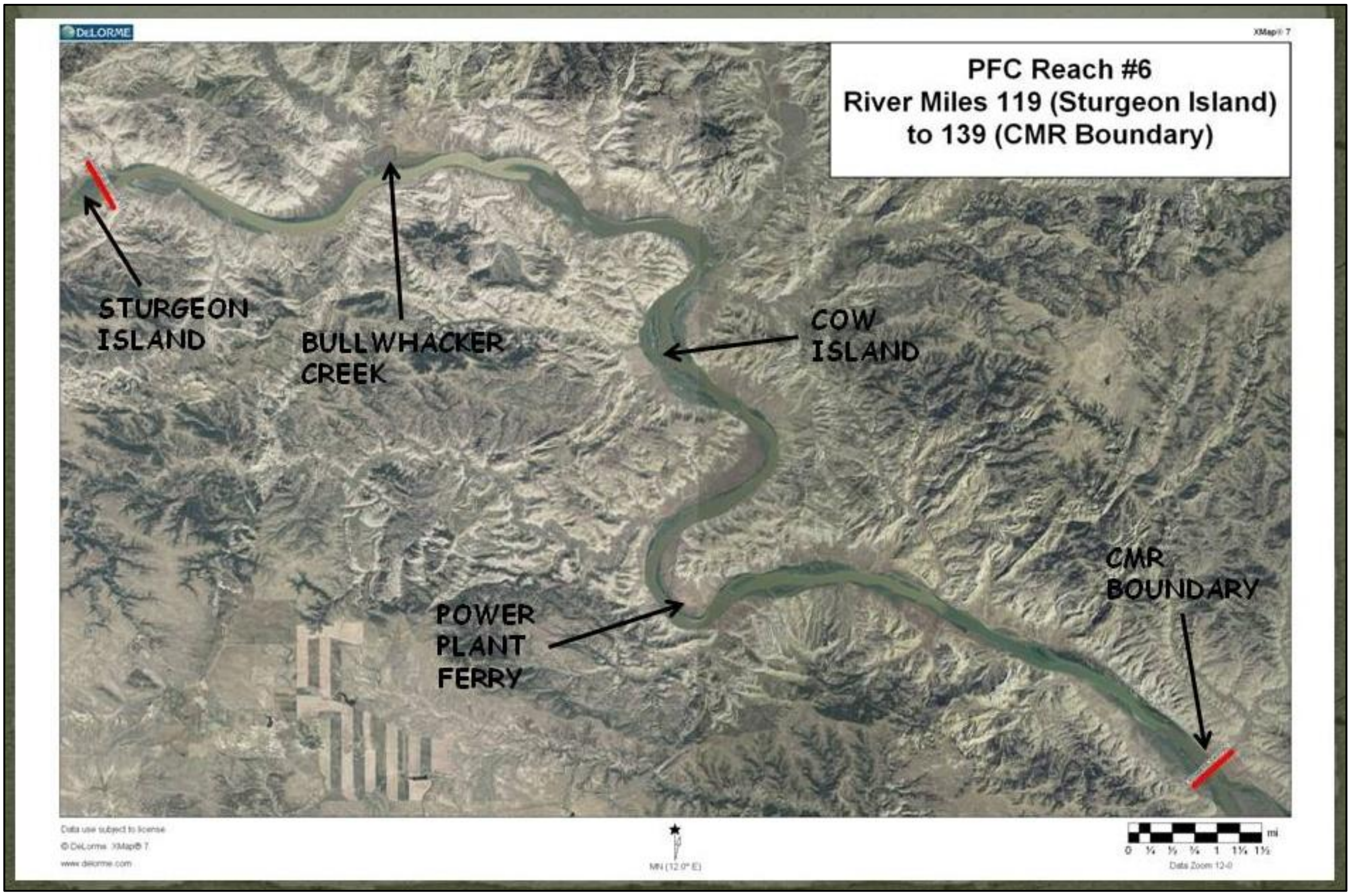


Figure 2 - Reach #6 - River Mile 119 (Sturgeon Island) to 139 (CMR Boundary) – Aerial View

Although Reach #6 is still landform constrained, as mentioned above, it is a transition zone before a major geomorphic break which occurs near the Charles M. Russell National Wildlife Refuge Boundary. Sinuosity within this reach begins to increase. As a result the gradient decreases, along with associated shear-stresses, which move substrate materials. Consequently, depositional features are far more common than other constrained reaches of the UMNWSR, and delta bars, mid-channel bars, and lateral bars are abundant. In contrast to Reach #3, where less sinuosity and steeper gradient give the river the capacity to move most materials from side drainages, the increased sinuosity and smaller gradient allow for depositional zones to be found near smaller tributaries. Therefore, increased potential exists for floodplain and riparian values within Reach #6.

Channel morphology and distribution of riparian vegetation would be strongly influenced by landform and climate through this reach. Bare moist sites suitable for cottonwood recruitment are most often met through flow induced channel change (Auble et al., 2005). Hansen (1989) describes four depositional sites which are suitable for the recruitment of pioneering species such as plains cottonwood and willow (Salix spp.). They are depositional zones such as point bars, side bars, mid-channel bars, and delta bars. Through this constrained reach, all of the fore mentioned features exist with increasing frequency in the downstream direction. Meandering, channel narrowing and flood deposition are the controlling processes for the establishment of woody vegetation, although flood deposition is still the dominant process. This results in vegetation community patterns of small numbers of linear, even–aged stands and establishment surface of mature trees well above channel bed elevation (Scott et al., 1997) for constrained zones. More diverse representation of woody riparian vegetation in terms of age-class and distribution would be evident in back channels, mid-channel bars, and depositional zones.

Because of the climate of northcentral Montana, which includes very cold temperatures, snow, and rapid warm up from "Chinook" winds, mechanical ice drives occur. The influence on riparian vegetation is substantial as vegetation between the 2- and 9- year return interval flood stage is subjected to intense physical disturbance (Scott and Auble, 2002). Depending on the flow and ice regime of prior years, seedling, sapling, and pole size cottonwoods may be found across a range of elevations. However, Scott and Auble (2002) found that all trees had established 1.75 meters above the lower limit of perennial vegetation.

Although ice drives strongly influence vegetative patterns through this constrained reach, unconstrained zones within the larger constrained zones do occur. They can be found near tributary junctions, channel islands, and overflow channels (Scott and Auble, 2002). In these unconstrained portions, recruitment of trees is less dependent on the large flood pulses because with the lateral movement and sediment aggradation, established trees are removed from the zone where they receive more frequent physical disturbance (Scott and Auble, 2002). See Figure 3 - Unconstrained Zone at Cow Island.

Figure 3 - Unconstrained Zone at Cow Island

As sediment aggrades and depositional features mature, the potential exists for more mesic riparian species. According to Hansen (1989), as the alluvial material matures there is a corresponding change in soil parameters, which provides a more suitable environment for tree species such as green ash and boxelder. Hansen (1989) describes a successional path of pioneer species such as plains cottonwood and sandbar willow followed by an understory of green ash, boxelder, chokecherry, and red-osier dogwood. Rivers which are free to move back and forth across their floodplain result in stands of vegetation in various stages of succession (Hansen, 1989). Increased potential for understory sites associated with developing riparian sites that are safe from disturbance, but maintain moist conditions, would exist within this river reach. However, physical sites capable of creating these conditions would be limited within the laterally constrained portions, and the linear stands of cottonwood may establish too high and be too open for the arid climate of the Missouri Breaks, thereby supporting drier ecological site types. The presence of cottonwood trees may not indicate that the moisture availability and physical site characteristics requirements are met for shallower rooted understory species. Understory species may tend to establish at small microsites in locations that receive both fine sediments and overland flow from the uplands. This can create small sites with clay lenses that perch water tables, which may be more conducive to the establishment of understory sites (personal communication, M. Scott (USGS) and M. Merigliano (University of Montana)). A cooperative study with the University of Montana started in 2010, looking at site conditions for late-seral, riparian woody plants on the Upper Missouri and will provide further information.

Most streambank miles through the reach would be dominated by herbaceous vegetation. Species would include a variety of Carex, Juncus, Scirpus, and Eleocharis species. The fore mentioned species would be located within zone 1, would be frequently inundated and subject to ice, and be within close proximity of summer low water levels. These species tend to be located between the 2-year flood stage and the low water level (personal observation). During periods of low flow they are very effective at capturing sediment. However, they can be vulnerable to high shear-stress, buried by sediment, or completely removed by high flow or ice depending on conditions that year.

LIMITING FACTORS: Two significant dams regulate flows on the Upper Missouri River through the Wild and Scenic reach, Canyon Ferry Dam on the Missouri and Tiber Dam on the Marias. Although the frequency of flood pulses and the timing of a snow-melt dominated hydrograph have not changed, the magnitude of large peak flows has been reduced from 40% to 50% as a result of regulation (Bovee and Scott, 2001). Examination of post dam recruitment patterns of cottonwood by Scott and Auble (2002) identified that all stands originating in the post dam period occurred within unconstrained channel reaches. Reduction in the magnitude of peak flows has resulted in establishment of stems at lower elevations that are subject to more frequent disturbance. If patterns continue, cottonwood recruitment would be limited to unconstrained reaches. In River Miles 119 to 139, this effect will be most noticeable in the constrained reaches, but more frequent unconstrained portions would be capable of maintaining cottonwood forests under lower flow regimes although in smaller amounts. The figure below shows typical existing landform, channel, and vegetative characteristics of Reach #6. See Figure 4 - Typical Existing Conditions Reach #6 - River Mile 119 (Sturgeon Island) to 139 (CMR Boundary).

Figure 4 - Typical Existing Conditions Reach #6 - River Mile 119 (Sturgeon Island) to 139 (CMR Boundary)

The possibility does exist that the capability of this reach, in terms of flow regime, may move closer to potential. Bureau of Land Management (BLM), Bureau of Reclamation (BOR), U.S. Army Corps of Engineers (USACE), and other groups and organizations have been investigating the potential for augmenting flow releases from reservoirs to mimic natural flow regimes. Social and economic constraints will not allow for a completely natural flow regime, but efforts to increase peak flows would change the capability of this system and move Reach #6 closer to potential.

A key factor affecting potential is the decrease in the magnitude of fluvial disturbances on the Upper Missouri River associated with both climatic shift and dams. A shift from wetter conditions in the mid to late 1800s combined with the effect of flow regulation has resulted in a process of channel narrowing (Scott and Auble, 2002). This affect has resulted in establishment of cottonwood trees as existing back channels have filled in. Currently, this increase in trees has mitigated the effects of the loss of trees from higher surfaces, and current amounts of cottonwood forests are similar to cottonwood forests in 1890 (personal communication, G. Auble (USGS) and M. Scott (USGS)). However, this is a one-time response as the channel would not be capable of narrowing forever.

Vegetation potential on the Upper Missouri River is also influenced by non-native plants and invasive weed species. Evidence exists that direct competition between native plants and areas dominated by exotic plants (non-native and invasive weeds) can result in the disappearance of native species. Kudray (2004) found reduced species richness was most strongly correlated with greater exotic herbaceous cover and also had a negative correlation with native woody species richness.

Five invasive weed species were documented by Kudray (2004) within the Upper Missouri River including: leafy spurge, Canada thistle, spotted knapweed, diffuse knapweed, and houndstongue. If control methods are found for the above listed weeds, particularly leafy spurge and knapweed, the capability could change. However, even with aggressive control strategies, it is highly unlikely that these weeds would be removed from the Missouri River ecosystem.

The history of the establishment and spread of invasive weed species along the Missouri River within the Monument is very similar to other western rivers, although probably more recent. Vegetation inventories completed in 1975 and 1976, which included the river corridor, major tributaries and adjacent upland areas, did not document any infestations of invasive weed species on public land (George Hirschenberger, retired BLM, personal communication). However, by 1983 the BLM had identified areas between Coal Banks Landing and the Fred Robinson Bridge where invasive weed species, mainly leafy spurge, were becoming established along the river corridor. These areas were widely dispersed and small in size and density. In that year BLM personnel chemically treated an estimated 20 acres of leafy spurge and Canada thistle on public land (John Fahlgren, retired BLM, personal communication). By 2001, compiling information collected from surveys conducted over several years, the size of infested acres on public land had grown to 615 acres. The number of new invasive weed species had also grown considerably, from two in 1983 to over 10 in 2001. Again in 2010 the BLM completed a survey for invasive weed species along the entire river corridor from Fort Benton to the boundary of the Charles M. Russell Wildlife Refuge. As Table 1 below indicates, the acres infested on public land (Zones 1 - 3) more than doubled, increasing from 615 acres in 2001 to 1,363 acres in 2010.

Table 1 - Invasive Weed Species of Concern Found Along the Missouri River

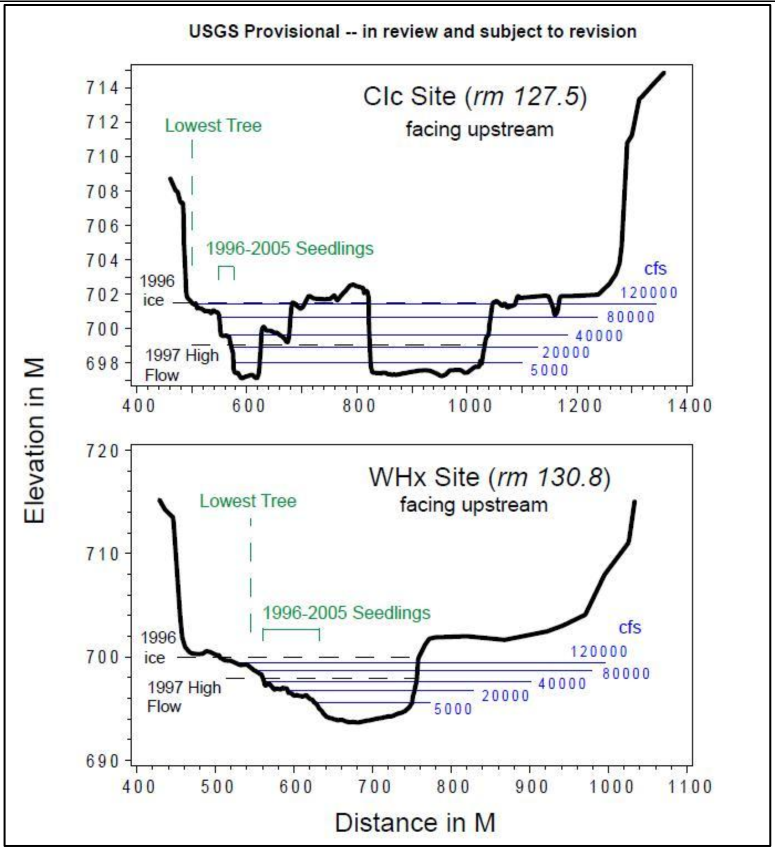
Common Name	2001 BLM Infested Acres	2010 BLM Infested Acres	Difference
Russian Knapweed	370	322	-48
Common Burdock	Not Mapped	2	
Hoary Cress	2	Trace Amount	-2
Spotted Knapweed	19	46	27
Canada Thistle***	14	280	266
Field Bindweed***	Trace Amount	9	9
Poison Hemlock***	Trace Amount	11	11
Houndstongue***	Trace Amount	40	40
Russian Olive	Not Mapped	62	
Leafy Spurge	198	586	388
Perennial Pepperweed	12	5	-7
Dalmatian Toadflax	Trace Amount	Trace Amount	0
Salt Cedar	Trace Amount	Trace Amount	0
Total Acres	**615**	**1363**	**748**
*** *Species were not completely documented in earlier surveys*			

In evaluating the health and functionality of riparian ecosystems, the kind, amount and density of vegetation plays an important role. Healthy native plant communities capture sediment aiding in floodplain development and provide a deep-binding root mass protecting banks against ice damage and water erosion. These areas are also very prone to establishment of invasive weeds and non-native plants. Invasive weeds prefer highly disturbed sites such as river banks, roadsides and camping areas. Once established, invasive weeds often out-compete and displace native vegetation creating a single species plant community often resulting in increased soil erosion, an altered nutrient cycle, and reduced biological diversity (Sheley et al., 1999).

Non-native grass species are common and abundant, especially in Zone 2 (personal observation). These include smooth brome, Kentucky bluegrass, quackgrass, crested wheatgrass, and annual bromes. Smooth brome is aggressive, competitive and can exclude all other species (Kudray, 2004). Smooth brome occurred in 69 percent of Kudray's plots. Control methods and the capability of the BLM to economically control non-native grasses are limited.

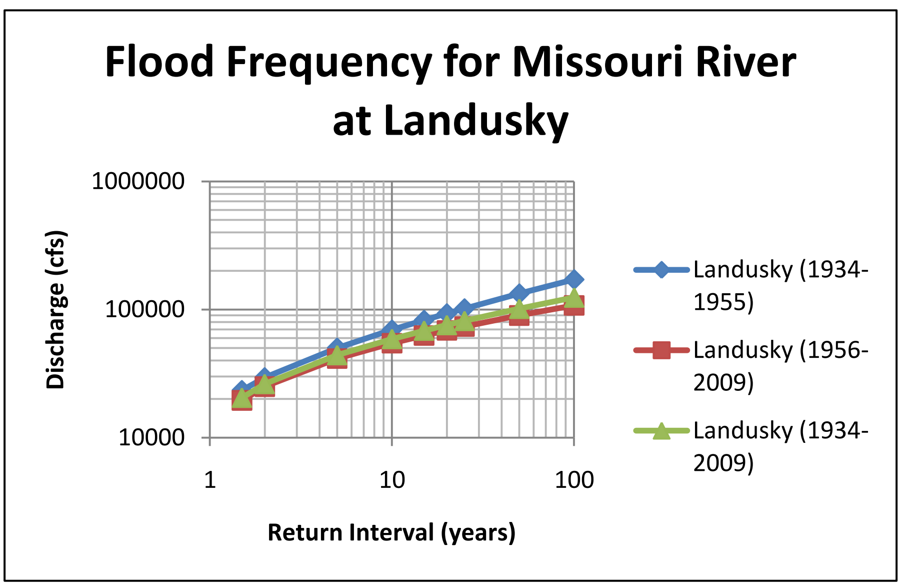
Kudray (2004) indicated that Russian olive was the only well established non-native woody species occurring along the river. Following his study, seven small infestations of salt cedar have been discovered; one at Hole in the Wall and at six sites between the PN Bridge and the CMR boundary. Salt cedar is an evergreen shrub or small tree that can quickly invade disturbed areas, rapidly spread, form dense thickets and outcompete and replace native species. The plants were removed and no other plants have been discovered during follow-up visits to the sites. Russian olive can have significant affects on riparian forests. According to Lesica and Miles (2001), Russian olive can displace native trees and shrubs and form monotypic stands, especially where the riparian zone is less dynamic. There is the possibility of Russian olive becoming the dominant or co-dominant tree on the Upper Missouri (personal communication, G. Auble (USGS)). Along the upper half of the Missouri River, which is mostly private land, it may be socially and economically impractical to control invasions of Russian olive. However, along the lower half of the Missouri River, which is largely public land, the opportunity to control Russian olive and limit its spread and establishment is still a viable option.

Yes	No	N/A	HYDROLOGICAL
X			1) Floodplain above bankfull is inundated in "relatively frequent" events **Rationale for Answer** The river channel attributes and function are within a relative range of historic conditions both vertically and morphologically. A reach scale channel narrowing process has decreased the width of the active channel, which without a corresponding decrease in channel elevation would result in greater flood prone area. During the period of record for the Virgelle and Landusky gages (1934 and 1935 respectively through 2010), the stage-peak discharge relations have been relatively stable, thereby indicating that the river has not downcut. Although a stable stage-discharge relation accompanied by channel narrowing would indicate a deeper channel, it may not be an indicator of vertical instability as much as the channel reaching a new equilibrium. The take home message is that flows of certain magnitudes inundate similar elevations as historically. Relative to the potential channel morphology of a Rosgen F-channel type, no physical channel or flood plain characteristics prohibit access to the floodplain. Evidence of floodplain inundation was also present with rack lines of debris and soils exhibiting frequently inundated and redox conditions. Because of the potential channel morphology of a Rosgen F channel (box shaped), relatively limited floodprone areas exist. However, because of the transition nature of this reach, more depositional zones and floodplains are present, and these areas are frequently inundated. Canyon Ferry Dam and Tiber Dam do regulate flows through this reach; however, the effect on "relatively frequent" events such as 2- to 5-year return intervals is less than the shift in flooding frequency of much larger events, which may be important for ecological proceses such as cottonwood recruitment.



Channel Cross Sections at Cow Island (RM 127.5) and Woodhawk (RM 130.8) (USGS Provisional – in review and subject to revision)

Somewhat limited floodprone areas exist because of the F channel type, and the floodplain areas in the above cross sections are associated with depositional zones near tributary junctions or unconstrained zones. Although they make up very small percentages of the reach as whole, based upon the flood frequency curves for the Landusky gage, they are inundated frequently. Furthermore, these types of sites exist with increasing frequency within Reach #6 relative to other constrained reaches of the UMNWSR.



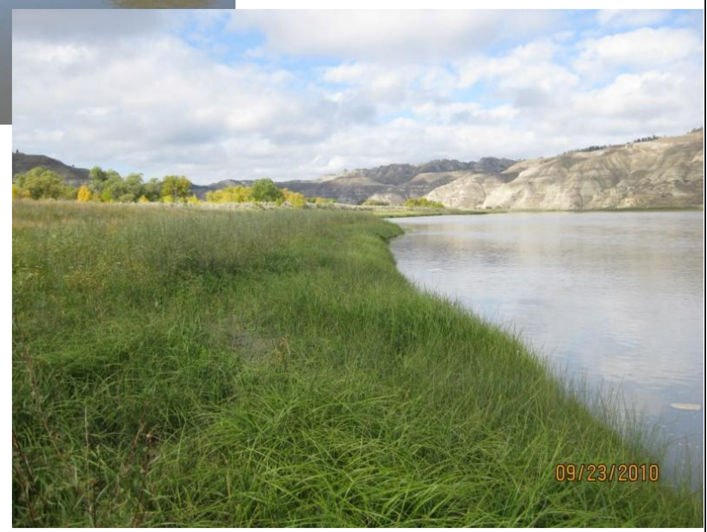
Flood Frequency Curves for the Landusky Gage

			Redoximorphic (redox) features indicating that the soils undergo periodic saturation were prevalent in both Zones 1 and 2, except on the steep erosive bends of the river. Redox features were observed from the soil surface to within 20 inches of the soil surface. The depth to these features increases as the distance from the active channel increases. The redox features observed were reduced soil matrices in Zone 1 and redox concentrations and depletions in both Zones 1 and 2.
		X	2) Where beaver dams are present are they active and stable **Rationale for Answer** Although beavers are present on the Missouri River, beavers on the Missouri do not build dams that affect channel morphology, floodplain hydrology, or alter water-table elevations.
X			3) Sinuosity, width/depth ratio, and gradient are in balance with the landscape setting (i.e., landform, geology, and bioclimatic region) **Rationale for Answer** Examination of the 1890 Missouri River Commission map, 1950's, 1980's and 2006 imagery has shown a decrease in channel width in all reaches of the UMNWSR. However, the ensuing change in width/depth ratios would not have changed the classification of the river channel. Furthermore, there have been no significant vertical shifts in the stage-peak discharge relationship at the Virgelle and Landusky gages, which would indicate vertical changes in the river. However, the stage-peak discharge relationship at Landusky has been less consistent than Virgelle with more active scour and fills processes. The Landusky gage is located in a more dynamic valley bottom with fine-grained substrate, so this would be expected. The point is that none of the stream gages located on the UMNWSR indicate recent downcutting. The river channel attributes and function are within a relative range of historic conditions both vertically and morphologically. Sinuosity is similar to that observed in the late 1800s and it is in balance with the landscape setting, given the transition from the confinement of the post-glacial Missouri River channel to the wide valley bottom type associated with the river-level exposure of Bear Paw Shale.
X			4) Riparian-wetland area is widening or has achieved potential extent **Rationale for Answer** A process of channel narrowing occurring over the last century has resulted in riparian species, such as cottonwood, becoming established on sites that were previously within the active channel. Keep in mind that the channel will not be capable of narrowing indefinitely and this may be a one-time response as the channel approaches a new equilibrium. As riparian-wetland vegetation establishes on zones that were at one time frequently flooded, subsequent sediment deposition moves them higher and drier, thereby decreasing the flooding frequency of these sites. Although there has been a net decrease in river channel, the amount of riparian-wetland area may be similar to past extents. Those areas where floodplain development was occurring, such as delta bars at the mouths of tributaries and islands, were vegetating with riparian-wetland vegetation. These zones are relatively frequent within this reach and would be leading to small increases in the size of the riparian-wetland area. The vegetation in Zone 1 is capturing sediment and being colonized by riparian-wetland plant species. The soils exhibit saturated conditions and depositional areas, although small, are

			widening. Up to the top of Zone 2, the soils are also periodically saturated and widening. However, in Zone 3 the soils are infrequently saturated. This may be because sediment accretion has moved the floodplain higher relative to the river, the flooding frequency of the magnitude flow necessary to saturate that elevation has decreased, or both.
X			5) Upland watershed is not contributing to riparian-wetland degradation **Rationale for Answer** Existing channel morphology and channel forming process did not indicate a large change in the amount of water or sediment supplied by the watershed. No evidence existed of excessive sediment deposition or scour/erosion from sediment "hungry" waters due to dam released waters. Substrate-particle sizes in Reach #6 were generally smaller than particle sizes in upstream reaches. This would be expected given that the Missouri Breaks are supplying lots of source material. Furthermore, as the sinuosity has increased and the gradient decreased, the river's ability to move these materials has decreased. Also, this reach is transitioning from a supply-limited system to a transport-limited system. Reach #6 is a transition reach. It is processing water and sediment supplied by the watershed as one would expect based upon landform, channel morphology, and source materials. Depositional areas increase in the downstream direction. Sediment inputs from smaller tributaries were able to overcome the river's capacity and competence to move the material. This condition is as expected based upon the potential sinuosity and gradient for the channel.

Yes	No	N/A	VEGETATION
X			6) Diverse age-class distribution of riparian-wetland vegetation (recruitment for maintenance/recovery) **Rationale for Answer** The herbaceous riparian-wetland plant communities observed in Zone 1 throughout the reach consisted of plants that reproduce and spread primarily by rhizomes (underground shoots). These included reed canarygrass, alkali cordgrass, rough horsetail, three-square, hardstem bulrush and alkali bulrush, woolly sedge, common reed and common spikesedge. Woolly sedge and three-square bulrush were the more dominant herbaceous riparian community type. Within Zone 1, dense communities of these rhizomatous herbaceous plants were common, indicating they are well established and expanding and thus exhibiting multiple "age-classes." Within Zone 1 and 2, for the nine sites sampled, seven contained very well developed, dense, multi-aged sandbar willow communities. These occurred at tributary junctions, side bars, islands and former islands where the back channel has filled in with sediment. Also called coyote willow, sandbar willow can form dense stands by spreading underground roots (rhizomes) and re-sprouts easily if the stems are damaged or removed (Hoag et al., 2008). Its ability to spread and form dense stands is one measure of a diverse age class.

Dense sandbar willow community at the lower end of Reach #6.



Sandbar willow, woolly sedge and three-square bulrush community at the upper end of Reach #6.

Generally, clump-type willows (yellow willow) were not common along the streambank, except at Gist Bottom (North Stop #4), where it was growing as a sub-dominant in a sandbar willow community. The yellow willows observed at Gist Bottom and at other sites along the bank were reproducing from plants that appeared to be very old and damaged by beaver and ice.

Within Zone 1 and 2 cottonwood and peachleaf willow appeared in the seedling and sapling age class, but only in trace amounts. Most trees were actively re-sprouting from beaver and ice damage and could be growing from very old and mature plants.

X

7) Diverse composition of riparian-wetland vegetation (for maintenance/recovery) (*species present*)

Rationale for Answer

In Zone 1 reed canarygrass, three-square bulrush, woolly sedge, rough horsetail and alkali cordgrass were the dominant herbaceous riparian-wetland plants. Common spikesedge, an aggressive rhizomatous species, was frequently observed along the scour line. Other herbaceous riparian species present, but in lesser amounts, included alkali bulrush, common reed and Baltic rush. The herbaceous riparian communities also contained a high percentage of non-native plants such as black medic, yellow sweetclover, cheatgrass, Kentucky bluegrass, quackgrass, smooth brome, red top, alfalfa and creeping meadow foxtail.

In this reach, sandbar willow communities were more common than the upstream reaches and were observed to be well established. The understory vegetation within these types was dominated by rhizomatous non-native plants, such as smooth brome, quackgrass, red top and Kentucky bluegrass.

			The dominant riparian tree species in Zone 1 and 2 was plains cottonwood. Also present were green ash and peachleaf willow. These species were only present in trace amounts. Invasive weeds, including Canada thistle, leafy spurge and Russian knapweed, were found at nine of ten locations. Russian olive, an invasive perennial tree or multi-stemmed shrub, was found at only one of the stops.  ***Sandbar willow community type found at South Stop #4 (Cow Island) with dense understory of smooth brome, Kentucky bluegrass, yellow sweetclover, red top and quackgrass, all non-native and invasive species.***
X			8) Species present indicate maintenance of riparian-wetland soil moisture characteristics **Rationale for Answer** Redoximorphic (redox) features indicating that the soils undergo periodic saturation were prevalent in both Zones 1 and 2 except on the steep erosive bends of the river. Redox features were observed from the soil surface to within 20 inches of the soil surface. The depth to these features increases as the distance from the active channel increases. The redox features observed were reduced soil matrices in Zone 1 and redox concentrations and depletions in both Zones 1 and 2. Facultative wet and obligate plants were also seen in both zones. Zone 1 is dominated by plants and plant communities consisting of obligate (OBL) and facultative wetland (FACW) plants. Plants noted include alkali, hardstem and three-square bulrush, common spikesedge, reed canarygrass, alkali cordgrass, rough horsetail, woolly sedge, Baltic rush and sandbar and yellow willow. Native wetland plant cover decreases from Zone 1 into Zone 2 (above bankfull). At some sites riparian-wetland plants are being replaced by non-native and invasive weed species.
X			9) Streambank vegetation is comprised of those plants or plant communities that have root masses capable of withstanding high stream flow events (*community types present*) **Rationale for Answer** Herbaceous riparian-wetland plants and plant communities noted throughout Zone 1 are strongly rhizomatous with medium to high stability ratings. There were no abnormal signs of bank

			damage (eroding/sloughing), exposed banks, sparsely vegetated or bare areas. The herbaceous plants were spaced closely together and many areas are capturing sediment. The herbaceous riparian plants with medium to high stability class ratings include reed canarygrass, alkali cordgrass, alkali and three-square bulrush, common spikesedge, rough horsetail and woolly sedge. These plants are mid- to late successional species that have established, survived and increased under adverse growing conditions from scouring by ice and water. The sandbar willow communities were well established with a dense understory of herbaceous plants. These areas were also helping to stabilize banks and capturing sediment. In combination, willows, grasses and grass-like plants (sedges, rushes, spikerush) are excellent bank stabilizers. Because their rooting characteristics are different and they become intertwined, they complement one another and add strength to areas subjected to scouring by water and ice.  ***Sandbar and yellow willow community with understory of three-square bulrush and woolly sedge in front of the Gist Bottom Primitive Boat Camp (North Stop #4). These plants are strongly rhizomatous, spreading by underground roots, and growing together provides exceptional bank stability.***
X			10) Riparian-wetland plants exhibit high vigor **Rationale for Answer** Depending on the duration of annual high flows, streambanks can be submerged for a considerable portion of the growing season. In 2010, most of Zone 1 was inundated until late July. Riparian-wetland species were observed to be emerging through deposited sediment and standing water indicating that plants are well established and possess enough stored energy in roots to initiate and maintain growth during prolonged periods of flooding. Several of these sites were checked and photographed again in September after water levels dropped exposing more of the bank. In support of earlier findings, the riparian-wetland plants were robust, had good coloration and had rapidly grown when compared to earlier pictures. Sandbar willow communities showed signs of healthy vigor as indicated by height, leaf width and color and the ability of plants to push and continue growth through thick layers of deposition. Even where there was beaver activity and ice damage to woody species, there were dead stems present, but plants were vigorously re-sprouting.

			  ***The picture on the right illustrates the rapid growth of sandbar willow that occurred by late September after being submerged until July (picture on left) (South Stop #3).***
X			11) Adequate riparian-wetland vegetative cover present to protect banks and dissipate energy during high flows (*enough*) **Rationale for Answer** The plants, plant groupings and community types observed in Zone 1 were well developed and the depositional surfaces well vegetated with riparian-wetland plants that have medium to high stability ratings. The amount of bare areas observed was normal and naturally occurring from recent sediment deposits and scouring from water and ice. The streambank riparian plants were spaced closely together and many areas were catching and depositing sediment. Sites are still capturing sediment and building with little evidence of bank instability (cutting/slumping).
		X	12) Plant communities are an adequate source of coarse and/or large woody material (for maintenance/recovery) **Rationale for Answer** Large woody material is present within the reach; however, it is not required for function. During the steamboat era, a significant amount of woody material was pulled from the Missouri River to aid in navigation. Nevertheless, not only did the river fail to degrade (downcut) as a result of this activity, but it also narrowed during the past century. Although woody material is not a driver for function on the Upper Missouri, it can play an important role in small areas for floodplain development, energy dissipation, and aquatic habitat.

Yes	No	N/A	EROSION DEPOSITION
X			13) Floodplain and channel characteristics (i.e., rocks, overflow channels, coarse and/or large woody material) adequate to dissipate energy **Rationale for Answer** The channel morphology and floodplain areas are as expected relative to potential. Although the river is relatively constrained in this reach, numerous meanders, overflow channels, and islands exist. Depositional areas on BLM lands were well vegetated with riparian vegetation. The increased roughness of these areas results in energy loss in the channel due to friction loss. Depositional zones were where expected (inside of point bars, islands, etc.), and eroding banks

			that were present were only located on the outside of meander bends where shear-stress is high because of large changes in velocity over a short distance. New depositional zones were vegetated with pioneer species such as cottonwood and sandbar willow, which provide a functional role. These species are generally the first to establish on depositional zones of coarser material. Because these species are currently established on low elevation surfaces that are subject to frequent disturbance from floods and ice, they may never become mature individuals. However, due to their stiffer stems relative to herbaceous plants, they are able to trap woody material and organic matter, and subsequently fine grained sediments, which lead to more conducive environments for sedge/rush communities and maturation of the floodplain. The increase in organic material also leads to increased water holding capacity of the floodplain. Because of the Rosgen F-type channel, floodplain areas are still somewhat limited. Mid-channel bars provide a large portion of floodplain. Although small in area, these features provide important energy dissipation in F-type channels.
X			14) Point bars are revegetating with riparian-wetland vegetation **Rationale for Answer** All depositional areas within the reach, including point bars, islands, lateral bars, and delta bars, were well vegetated with riparian-wetland vegetation including sedges, rushes, and willow within frequently inundated areas. New depositional zones were vegetated with pioneer species such as cottonwood and sandbar willow, which provide a functional role. These species are generally the first to establish on depositional zones of coarser material. Because these species are currently established on low elevation surfaces that are subject to frequent disturbance from floods and ice, they may never become mature individuals. However, due to their stiffer stems, they are able to trap woody material, organic matter, and fine-grained sediments, which lead to more conducive environments for sedge/rush communities and maturation of the floodplain.
X			15) Lateral stream movement is associated with natural sinuosity **Rationale for Answer** Examination of the 1890 Missouri River Commission map, 1950's, 1980's and 2006 imagery has shown a decrease in channel width in all reaches of the UMNWSR. However, the ensuing change in width/depth ratios would not have changed the classification of the river channel. Furthermore, there have been no significant vertical shifts in the stage-peak discharge relation at the Virgelle or Landusky gages, which would indicate vertical changes in the river. However, the stage-peak discharge relation at Landusky has been less consistent than Virgelle with more active scour and fills processes. The Landusky gage is located in a more dynamic valley bottom with fine-grained substrate, so this would be expected. Although River Reach #6 is more laterally dynamic than the upstream reaches within the confined portion of the UMNWSR, the overall character of the river is still more similar to relatively stable, entrenched meanders. Then, within these entrenched meanders, quite a bit of lateral movement is occurring near tributaries and mid-channel bars. However, the lateral movement is associated with natural sinuosity.

X			16) System is vertically stable (*not downcutting*) **Rationale for Answer** A reach scale channel narrowing process has decreased the width of the active channel, which without a corresponding decrease in channel elevation would result in greater flood prone area. During the period of record (1934 and 1935 respectively through 2010), the stage-peak discharge relation at the Landusky and Virgelle gages has been relatively stable, thereby indicating that the river has not downcut. Although a stable stage-discharge relation accompanied by channel narrowing would indicate a deeper channel, it may not be an indicator of vertical instability as much as the channel reaching a new equilibrium. The take home message is that flows of certain magnitudes inundate similar elevations as historically.
X			17) Stream is in balance with the water and sediment being supplied by the watershed (i.e., no excessive erosion or deposition) **Rationale for Answer** Existing channel morphology and channel forming processes did not indicate a large change in the amount of water or sediment supplied by the watershed. No evidence existed of excessive sediment deposition or scour/erosion from sediment "hungry" waters due to dam released waters. Substrate particle sizes were generally smaller than upstream reaches. This would be expected given that the Missouri Breaks are supplying plenty of source material. Furthermore, as the sinuosity has increased and the gradient decreased, the river's ability to move these materials has decreased. As well as this reach is transitioning geomorphicly, it is also transitioning from a supply limited system to a transport limited system. Reach #6 is a transition reach. It is processing water and sediment supplied by the watershed as one would expect based upon landform, channel morphology, and source materials. Depositional areas increase in the downstream direction. Sediment inputs from smaller tributaries were able to overcome the river's capacity and competence to move the material. This condition is as expected based upon the potential sinuosity and gradient for the channel.

Remarks (Reach #6)

<u>General Comments</u>

From Coal Banks to Grand Island, approximately 2% of cottonwood trees are less than 10 years old, 7% are 10 to 25, 31% are 25 to 50, 34% are 50 to 114, and 24% are greater than 114 years old (unpublished USGS data, in review and subject to revision). Spatial and temporal variability in the recruitment of trees means that there is no reasonable expectation of constant total area or stable age distributions (unpublished USGS data, in review and subject to revision). The process of channel narrowing that has been occurring since the late 1800s has resulted in establishment of cottonwood trees as existing back channels have filled in. This increase in trees has mitigated the effects of the loss of trees from higher surfaces, and current amounts of cottonwood forest are similar to cottonwood forest in 1890(unpublished USGS data, in review and subject to revision). However, without a change in flow regimes on the UMNWSR, the amount of cottonwood forest will decrease, and this effect will be most noticeable in the confined portions of the river.

<u>Soils Summary</u>

Zone 1 is within the active channel that is saturated/flooded with a two year return interval flow. Soils within this zone undergo continuous or periodic saturation. This zone is most often in a reduced state resulting from the soils being saturated and virtually free of elemental oxygen (anaerobic). The soils matrix is reduced and low chroma colors (gleyed/gray) are observed. When the water table drops and the soils dry out, prominent redoximorphic (redox) features such as iron concentrations and depletions, are found to the surface of the soil profile.

Overall for the reach, fines are kept in suspension in this zone due to the higher stream energy, so gravel and cobble settle out. A series of depositional events have stratified soil textures in the upper 20 inches, ranging from loamy sands to sandy clay loams (approximately 12 to 25 percent clay) with many gravels and cobbles. Below 20 inches are mainly sands, gravel, and cobble.

Zone 2 is on the floodplain above Zone 1 and is within the 10 year (pre dams) and 20 to 30 year (post dams) floodplain, which is periodically saturated during less frequent flood events. As the river and water table levels rise and fall, the soil alternates between reduced and oxidized states. Reduction occurs during saturation with water, and oxidation occurs when the soil is not saturated (USDA-NRCS 2010).

Evidence of this fluctuation is indicated by the presence of redox features within the upper 20 inches of the soil profile, which commonly include rust colored iron concentrations in the matrix, along roots and pores, and gray colored iron depletions throughout the soil matrix. The soil matrix is not reduced. The depth to redox features increases as the distance from the active channel increases. Redox features are not always present on some outside meanders because they are eroding faster than the features can form.

As the river rises during flooding events and reaches the floodplain (above bankfull) stream energy is dissipated resulting in finer textured material settling out of suspension in depositional zones. Soil textures are stratified resulting from depositional events and predominately range from sandy clay loam to silt clay loam loams (approximately 21 to 30 percent clay).

Zone 3 is on terraces above Zone 2. This zone is not frequently flooded; therefore, indicators (redox features) of recent soil wetting are not observed.

Although this zone is not frequently flooded by summer stages, it is frequently scoured by ice resulting from spring thaw ice jams resulting in areas of bare soil. Rock fragments ranging in size from gravel to stones can be deposited by ice at higher elevations than summer flows are capable of depositing.

Soil textures in this zone range from loamy sands to clayey, dependent on what type of material was deposited during past flood events and/or the parent material found on the adjacent uplands.

Vegetation

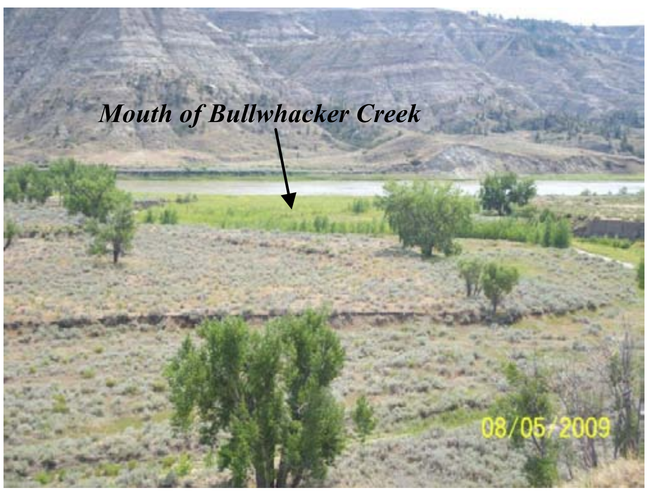
Non-native plants were common in Zone 1, especially in the understory of sandbar willow communities, and were found at all ten locations. These included black medic, yellow and white sweetclover, cheatgrass, Kentucky bluegrass, quackgrass, smooth brome, red top, alfalfa and creeping meadow foxtail.

Invasive weeds were found at nine of ten locations and included Canada thistle, leafy spurge and Russian knapweed. Russian olive, a regulated plant by the State of Montana, occurred at only one location.

Numerous small communities of common reed were present, much more along this reach than others. A warm-season perennial grass which spreads aggressively by both rhizomes and stolons and is native to the United States, common reed plants can grow six to eight feet tall along the Missouri River. A non-native version was introduced to the Unites States in the 19th century and is now found throughout the United States and is believed to be present along the Upper Missouri River (USDA, National Invasive Species Information Center). However, the differences between the native and non-native plants are very subtle and difficult to determine in the field. Due to its aggressive nature, it has become weedy or invasive in some regions and is now considered a noxious weed in some states.

Common reed community in Cow Island area.

Several photos were taken looking up Bullwhacker Creek showing a dense stand of sandbar willow and sapling, pole and mature cottonwood trees farther up the drainage. The floodplain is wider, meandering and not constrained. The area is capturing and processing large amounts of sediment from upland areas. The area near the mouth of Bullwhacker is more protected and in a safe zone away from damage by ice drives.



The picture on the left shows the diverse age class of cottonwood trees along the channel at mouth of Bullwhacker Creek. The picture on the right is taken from the river looking at the mouth of Bullwhacker Creek.

Sandbar willow community established at the mouth of Bullwhacker Creek covering a large depositional surface created after the winter of 1997/1998.

A Green ash community with all age classes represented. Site is located about one mile above Gist Bottom at North Stop #5. These site types, which are uncommon along the Missouri River, are referred to as "perched water tables". They are located at higher elevations above the river and are strongly influenced by adjacent upland areas. Characteristic of this site, green ash has established on a poorly drained, heavy clay soil. Moisture is often stored longer into the growing season and through hot, dry periods supporting a more diverse vegetation community.

<u>Grazing Allotments</u>

North Side - West Gist #06285; Little Bullwhacker #06214; Cabin Creek #05609; Antelope Creek #05610

South Side – Woodhawk #20031; Reed Coulee # 20071; DeMars #20026

<u>Wildlife Information</u>

All stops along this reach showed use of habitat by wildlife. Bald eagles and other raptors are utilizing large cottonwoods for nesting structures near the river. There are abundant migratory bird species throughout the reach, with highest density in mature woodland sites with good understory, which are not located near public use sites (campsites). There is heavy use of cottonwood and some willow by beaver, with light browsing use by deer on several woody species (See comments next paragraph). Recreational impacts to wildlife from campsites in important wildlife habitat occurs as traffic causes soil compaction, spreads invasive non-native plants, and causes disturbance to nesting, resting or feeding by wildlife species.

Use of woody species by big game was determined by clean shearing off of leaders, the absence of grazing, or even presence of livestock at most locations visited. Cattle leave abundant signs, including tracks, droppings, and mechanical damage to woody species when they have grazed an area. Livestock grazing on woody species tends to tear ends off stems and mechanically damage additional stems leaving a ragged appearance. Deer generally browse on smaller diameter leaders with clean cuts and small amounts of bark tearing. While one clean bite does not guarantee it was not livestock use, observation of multiple stems on same and adjacent woody species, tracks and animal droppings in area will usually confirm class of animal utilizing browse. The difficulty is in "quantifying" livestock vs. wildlife use in areas where both have been feeding.

SUMMARY DETERMINATION: Reach #6 was rated by the ID Team as in proper functioning condition.

In summary, key attributes and processes responsible for the rating of Proper Functioning Condition were adequate riparian-wetland species diversity, age class, vigor, cover of riparian-wetland plants with medium to high stability ratings on the streambanks, stable streambanks, and channel attributes and functions within the range of conditions appropriate for this reach.

Invasive weeds and non-native grasses were identified as the basis for not attaining a higher PFC status. Because invasive weeds and non-native plants compete with and often displace native riparian-wetland plants, they may reach a level where they affect the functional condition of the Missouri River through changes in vegetation composition, structure and streambank stability.

Functional Rating

_X_ Proper Functioning Condition

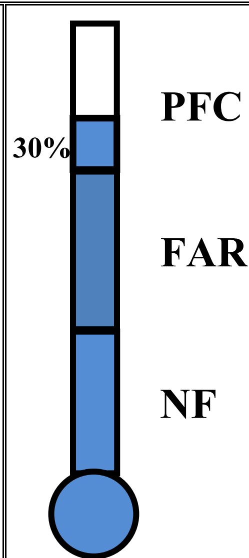
___ Functional - At Risk

___ Nonfunctional

___ Unknown

Trend for Functional - At Risk:

___ Upward
___ Downward
___ Not Apparent



Are factors contributing to unacceptable conditions outside the control of the manager?

Yes ___
No _X_

If yes, what are those factors?

___ Flow regulations
___ Mining activities
___ Upstream channel conditions
___ Channelization
___ Road encroachment
___ Oil field water discharge
___ Augmented flows
___ Other (specify)

(Revised 1998) (5/2008)

Appendix A – Plant List for Reaches #1-#6

Common Name	*Scientific Name*	AKA Name(s)
alfalfa	*Medicago sativa*	
alkali bulrush	*Scirpus maritimus*	Saltmarsh Bulrush
alkali cordgrass	*Spartina gracilis*	
Baltic rush	*Juncus balticus*	
black medic	*Medicago lupulina*	
boxelder	*Acer negundo*	
Canada thistle	*Cirsium arvense*	
cheatgrass	*Bromus tectorum*	downy brome
chokecherry	*Prunus virginiana*	
common burdock	*Arctium*	
common cattail	*Typha latifolia*	broadleaf cattail, cattail
common mullein	*Verbascum thapsus*	
common reed	*Phragmites australis*	
common spikesedge	*Eleocharis palustris*	common spikerush
creeping meadow foxtail	*Alopecurus arundinaceus*	
crested wheatgrass	*Agropyron cristatum*	
diffuse knapweed	*Centaurea diffusa*	
field bindweed	*Convolvulus arvensis*	creeping jenny, morning glory
green ash	*Fraxinus pennsylvanica*	
golden currant	*Ribes aureum*	
hardstem bulrush	*Scirpus acutus*	
houndstongue	*Cynoglossum officinale*	
Japanese brome	*Bromus japonicas*	
Kentucky bluegrass	*Poa pratensis*	
leafy spurge	*Euphorbia esula*	
narrow-leaf cottonwood	*Populus angustifolia*	
needle spikerush	*Eleocharis acicularis*	
peachleaf willow	*Salix amygdaloides*	
perennial pepperweed	*Lepidium latifolium*	
plains cottonwood	*Populus deltoides*	great plains cottonwood
poison hemlock	*Conium maculatum*	
quackgrass	*Agropyron repens*	
red-osier dogwood	*Cornus stolonifera*	
red top	*Agrostis gigantean (alba)*	
reed canarygrass	*Phalaris arundinacea*	
rough horsetail	*Equisetum hyemale*	scouringrush horsetail
Russian knapweed	*Centaurea maculosa*	
Russian olive	*Elaeagnus angustifolia*	
Sandbar willow	*Salix exigua*	coyote willow
showy milkweed	*Asclepias speciosa*	
small-fruit bulrush	*Scirpus microcarpus*	
smooth brome	*Bromus inermis*	

Common Name	***Scientific Name***	**AKA Name(s)**
spotted knapweed	*Centaurea repens*	
three-square bulrush	*Scirpus pungens*	
water birch	*Betula occidentalis*	
western snowberry	*Symphoricarpos occidentalis*	
White stem gooseberry	*Ribes inerme*	
white sweetclover	*Melilotus alba*	
woolly sedge	*Carex lanuginosa (pellita)*	
yellow willow	*Salix lutea*	
Yellow sweetclover	*Melilotus officinalis*	

Appendix B – References for Reaches #1-#6

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