APPENDIX J – BROWNS GULCH SEDIMENT ASSESSMENT

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ACRONYMS

Acronym	Definition
DEQ	Department of Environmental Quality (Montana)
FWP	Fish, Wildlife & Parks (Montana)
NRCS	Natural Resources Conservation Service
PIBO	PACFISH/INFISH Biological Opinion
RM	River Mile
TMDL	Total Maximum Daily Load
USFS	United States Forest Service
WRC	Watershed Restoration Coalition

Browns Gulch upstream of Telegraph Gulch Confluence (Pioneer Technical Services, Inc. et al., 2011)

J1.0 INTRODUCTION

Browns Gulch is a tributary to Silver Bow Creek in Silver Bow County, Montana. The assessment unit (MT76G003_040) includes the full stream length of 18.1 miles from the headwaters to the mouth (Silver Bow Creek) which is located ½ mile west of Ramsey, Montana. As a large tributary to Silver Bow Creek, the Watershed Restoration Coalition (WRC) and the Mile High Conservation District have spent significant resources to investigate water quality and possible impairments in the drainage. Additional studies have also been completed for riparian and fish habitat assessments by state and federal agencies. The purpose of this report is to compile and present available data for the watershed with the express purpose of making an impairment determination.

J2.0 PHYSICAL WATERSHED CHARACTERISTICS

A map of Browns Gulch identifies the spatial location of some data presented in this report (**Figure J2-1**).

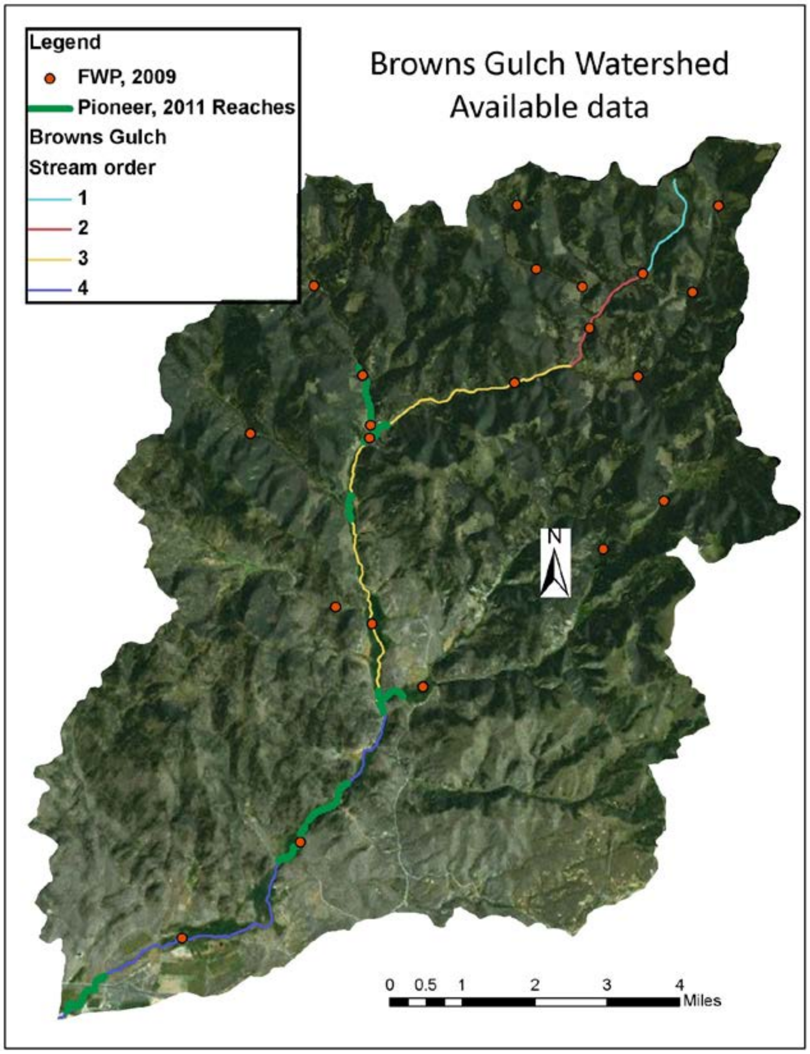

Figure J2-1. Map of Browns Gulch with Stream Order and Sampling Sites (Liermann et al., 2009; Pioneer Technical Services, Inc. et al., 2011)

As summarized in the Natural Resources Damage Program of the State of Montana Department of Justice report from 2005, the Browns Gulch sub-watershed is located in the northeastern portion of the Silver Bow Creek watershed and covers 84.5 square miles (54,380 acres), making it the third largest sub-watershed in the study area. The sub-watershed consists of two distinct ecological settings; a forested montane region, and a drier valley foothill region. Mean elevation is 6242 feet above sea level and average annual precipitation is approximately 16.8 inches/year.

Land ownership is approximately 52% private, 47% United States Forest Service (USFS), and 1% state. Land use is primarily agricultural in the lower elevation, valley foothill portions of the sub-watershed. Coniferous forest covers much of the higher elevation, montane portion of the watershed (USFS ownership). Several tributary streams contribute significant flow to Browns Gulch. These include Meadow Gulch, Telegraph Gulch, Flume Gulch, American Gulch, Alaska Gulch, Hail Columbia Gulch, Bull Run Creek, and Orofino Gulch.

J2.1 Soils/Sediment

Underlain by the Lowland Creek volcanics, the soils are derived from the geologic parent material of ash-fall tuffs that weather to coarse and fine grained sediments. The saprolite (lower zone of soil profile) contains 30–50% clay, which is unusual for this area (Ruppert, Dave E., personal communication 2012). Soils were likely developed as part of extensive beaver complexes, contain high organic matter, and are highly erosive (Pioneer Technical Services, Inc. et al., 2011). Field observations support the notion that the land clearing period in the late 1800s in the basin may have been accompanied by accelerated sediment loading to the stream bottoms. This includes fan-shaped deposits at the mouth of tributaries, and exposures of gray sands in the banks that overlie beaver dam remnants (Pioneer Technical Services, Inc. et al., 2011). The uplands have been partially or entirely recolonized by timber and loading rates have likely been significantly reduced. However, sediment loads generated during that period may still be working through the system.

Investigations as part of the Silver Bow Creek remediation determined that there is no evidence of an alluvial fan at the confluence of Browns Gulch and Silver Bow Creek (Montana Department of Environmental Quality, 2003). From this 2003 study, Wolman pebble counts and bulk samples found no systematic variation along the study reach in Silver Bow Creek which included where Browns Gulch enters Silver Bow Creek. Upstream of the confluence, Browns Gulch is a low gradient, meandering channel flowing through a relatively wide valley. Based on field observations, the authors determined that the material carried by the downstream portion of Browns Gulch is fine-grained, and, therefore provides primarily suspended sediment loads to Silver Bow Creek (Montana Department of Environmental Quality, 2003). However, instream Total Suspended Solids sampling (n=21) indicated that suspended sediment is not a chronic condition in Browns Gulch and that the stream does not deliver a large suspended sediment load to Silver Bow Creek (KirK Environmental, LLC, 2006).

Sedimentation impacts are evident in the Rosgen data from reaches throughout Browns Gulch. KirK Environmental, LLC (2006) noted that in performing Rosgen surveys and during general hydrologic measurements that large deposits of silt and sand were observed in the streambed in the form of elongated dunes or slugs of fines on top of coarse substrate. The (KirK Environmental, LLC, 2006) report also stated that D_{50} values were often much smaller than reference data in the upper reaches of Browns Gulch but their impairment determination was based on the assumption that the headwaters have a gravelly substrate potential (KirK Environmental, LLC, 2006).

J2.2 Hydrology

Browns Gulch is a 4^{th} order stream at the mouth (Silver Bow Creek) and encompasses a drainage area of 84.5 mi^2. Synoptic flow data for the lower watershed below Bull Run Creek indicate that much of the lower length of Browns Gulch loses water to the alluvial aquifer. The authors also determined that Browns Gulch is responsible for approximately 26% of the flow in Silver Bow Creek below the Creek (Montana Department of Environmental Quality, 2003). This is in agreement with Montana Department of Environmental Quality (DEQ) data. Silver Bow Creek has been sampled by DEQ (Remediation Division) immediately upstream and downstream of the confluence with Browns Gulch since 2007. In six September events, Browns Gulch was only observed to be discharging to Silver Bow Creek in three events. In instances where Browns Gulch was flowing, it comprised 12–32% (mean = 21.1%) of the flow in Silver Bow Creek below the confluence. Irrigation withdrawals during summer low flow often dewater Browns Gulch in the lower segment as was observed in three of the DEQ sampling events on Silver Bow Creek. This condition was documented by stream measurements done by KirK Environmental, LLC

(2006) and the WRC in 2010 and 2011 in the reaches downstream of the largest irrigation diversions. Dewatering in the lower reaches of Browns Gulch has been listed as one of the key resource concerns in the Silver Bow Restoration Plan for fish habitat (Natural Resources Damage Program, 2005).

J2.3 Rosgen Classification

From KirK Environmental, LLC (2006): Surveyed tributary and headwater reaches of Browns Gulch exhibit B or Eb type channel forms. Middle and lower watershed reaches of Browns Gulch exhibit F and Gc channel types and appear to be highly altered over natural conditions. Stream channel incisement is common on these reaches and the channels are accordingly entrenched and in some circumstances are gullies. Under improved conditions these lower F and Gc channel reaches may have the potential to be C or E type channels, which are more typical of this type of physiographic setting under less altered conditions (**Table J2-1**). The two lowest survey sites, BG3 and BG1 show signs of significant substrate siltation. Sources of anthropogenic sediment in the watershed are numerous and suggest that under less impaired conditions average substrate (D_{50}) would be significantly coarser in the lower watershed.

Table J2-1. Rosgen Level II Characterization (WRC Survey) (KirK Environmental, LLC, 2006)

Site	Rosgen Level III	Substrate Class Potential	Channel Class Potential	Entrenchment Ratio	Width/ Depth Ratio	Sinuosity	Channel Slope	D50 (mm)	Notes
BG01	F6	3/4/5	E5 or C5	1.4	10.6	1.8	0.0031	0.062	
BG03	F6	3/4/5	E5 or C5	1.5	11.5	1.5	0.0038	0.5	
BG06	G5c	3/4/5	E5 or C5	1.1	7.7	1.3	0.0043	0.5	W/D fits G
BGDM	G4c	3/4/5	E5 or C5	1.5	6.0	1.4	0.004	4	W/D fits G
BG12	B4c	3/4	E4 or C4	1.8	6.7	2.3	0.017	5.6	W/D fits G or E; entrenchment fits B

J2.4 Riparian Conditions

From KirK Environmental, LLC (2006): Major factors affecting riparian condition include land and water use management, road and irrigation infrastructure, and noxious weed infestation. The riparian conditions in Browns Gulch itself are more variable than the tributaries. Dominant impairments to riparian condition identified in the riparian assessment include channel incisement, bank instability and excessive lateral erosion, woody riparian vegetation clearing, heavy browsing and lack of reestablishment of woody vegetation, and absence of vegetation with a binding root mass.

From Pick and Kellogg (2006): Overall, only about 16% of the total length evaluated (70,460 feet) was found to be in the Sustainable (desirable) category. Fifty-four percent of the assessed length was Sustainable, At-Risk, while the balance, some 30% or nearly one-third of the assessed length was ranked Not Sustainable. Several reasons are responsible for the latter categories' significant presence: bank instability and slumping due to excessive saturation during the irrigation season; lack of durable and strongly rooted vegetation (woody and herbaceous plants); loss of floodplain due to channel incisement and avulsion (process whereby a new channel is spontaneously created by the force of water as the old channel is abandoned); and the impacts of the Superfund fill on the lowest reach.

J2.5 Fish Surveys

In the Silver Bow Creek drainage, Browns Gulch has been identified as one of a few potential trout refugia that are capable of restocking Silver Bow Creek. Fish inventories in the Browns Gulch basin have focused on characterization of trout speciation and genetic purity.

A 2009 Fish, Wildlife & Parks (FWP) fish population and riparian habitat assessment observed that fish populations were dominated by non-native eastern brook trout (*Salvelinus fontinalis*). In the mainstem of Browns Gulch, fish populations generally decline downstream (Liermann et al., 2009). Native westslope cutthroat trout (*Oncorhyncus clarki lewisi*) were present only in the tributaries and in the upper reaches of the mainstem of Browns Gulch near and above Telegraph Gulch (Liermann et al., 2009).

Liermann et al. (2009) performed fish surveys and riparian assessments at six sites on the mainstem of Browns Gulch. Fish habitat was rated fair in the lower sampling sites (River Mile [RM] 2.6 and 5.3) and good in the middle and upper sampling sites with the exception of RM 16.5, which was rated fair. Common remarks for downgrading from good to fair included excessive fine sediment in the streambed along with poor riparian health/lack of shading. The assessments of fish habitat and riparian health (based on the Natural Resources Conservation Service [NRCS] method) were acknowledged by the author as being relatively limited and subjective based on the NRCS assessment method. However, they are included here as they are useful in describing the results of fish sampling.

On the mainstem of Browns Gulch, Liermann et al. (2009) noted that fish habitat was most usually limited by fine sediment accumulation in the streambed. The following were excerpted directly from Liermann et al. (2009):

RM 2.6: Fish habitat at RM 2.6 was limited by high fine sediment accumulation and an overall lack of woody shrubs along the streambanks. Channel substrate consisted mostly of sand and silt, and areas suitable for trout spawning were largely absent.

RM 5.3: Fish habitat at RM 5.3 was rated only fair (score: 3 points out of a potential of 10), and was limited by high fine sediment accumulation and a lack of habitat complexity. Channel substrate was again comprised primarily of sand and silt, and areas suitable for trout spawning were absent.

RM 8.8: Fish habitat was rated good at RM 8.8, but was limited by a lack of woody vegetation along the streambanks that would have increased shade and cover, as well as added to habitat complexity. Fine sediment accumulation was also notable in the reach, but was not as severe as at downstream reaches.

RM 11.6: Fish habitat was rated as good but was limited by relatively high fine sediment accumulation. Spawning substrate suitable for trout was present throughout the reach, but it tended to be quite embedded.

RM 13.9 and 16.5: Fine sediment accumulation was not observed in the stream bottom at these sampling locations.

J2.6 Roads

The Pioneer Technical Services, Inc. et al. (2011) report does include some coarse evaluations of sediment deposition from roads to Browns Gulch and a few tributaries. However, it was not meant to be a comprehensive analysis of the entire basin. The objective was to identify potential restoration projects. However, roads do have an influence on the total sediment load to Browns Gulch and are considered a source area.

Appendix E of Montana Department of Environmental Quality, Planning, Prevention and Assistance Division (2010) contains an aerial assessment of roads that was used for Total Maximum Daily Load (TMDL) development on tributaries in the Upper Clark Fork drainage. This assessment did not include Browns Gulch but following the methodology provided in this appendix, it was determined that there are 183 road crossings of perennial and intermittent streams in the Browns Gulch drainage (2.6 miles of road per square mile in the drainage). Sixty-five and one-half percent of the road network is within 100 feet of a stream. The estimated existing sediment load to Browns Gulch is 252.5 tons/year based on a mean sediment load of 1.38 tons/crossing.

J3.0 Comparison to TMDL Targets

Table J3-1 includes the sediment and habitat targets for sediment impaired tributaries in the Upper Clark Fork River watershed developed for the 2010 TMDL document (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, 2010). Morphology and pool habitat targets were kept the same for Browns Gulch, but pebble counts were changed to reflect the highly erosive soils in the Elkhorn Mountains-Boulder Batholith level IV ecoregion which includes much of the Browns Gulch drainage. These targets were developed by compiling pebble count statistics for other sediment-impaired streams that drain from the Elkhorn Mountains-Boulder Batholith level IV ecoregion. These streams are in the Big Hole and Jefferson River drainages as well as the Little Blackfoot River and Boulder River watersheds. The 25th percentile of these data was used to identify the target for high gradient streams and the 35th percentile was used for the low gradient streams. Most of the available data from this compilation were from high gradient systems. Therefore the 35th percentile was used for low gradient stream reaches assuming that diminished transport capacity translates to higher natural accumulations of fine sediment in low gradient reaches.

Table J3-1. Browns Gulch Sediment and Habitat Targets

Sediment and Habitat Water Quality Target	High Gradient Reaches (>2% slope, including Rosgen A and B stream types)	Low Gradient Reaches (<2% slope, including Rosgen C and E stream types)
Morphology		
Width/Depth Ratio	≤15	≥12–≤22
Entrenchment	1.4–2.2	≥2.2
Substrate Composition		
Browns Gulch, Pebble Count, % <2mm	≤18	≤20
Browns Gulch, Pebble Count, % <6mm	≤31	≤36
Pool Habitat		
Residual Pool Depth (feet)	≥0.8	≥1.0
Pool Frequency (per 1,000 feet of stream)	≥15	≥12

DEQ has not conducted sediment or habitat assessments in the Browns Gulch drainage, but data collection efforts by the WRC, the Mile High Conservation District, and PACFISH/INFISH Biological Opinion (PIBO) Effectiveness Monitoring Program included metrics used by DEQ to assess stream health. In **Table J3-2**, data relevant to DEQ's assessment method has been compiled.

Table J3-2. Compilation of Sediment and Habitat Field Study – Selected Data for Browns Gulch (Target Exceedances Are in Bold)

Site Information					Morphology		Substrate Composition[b]		Pool Habitat	
DEQ Reach	Data Source[a]	Collection Date	Site ID	Gradient Category	W/D Ratio	Entrnch. Ratio	<2mm (%)	<6mm (%)	Residual Pool Depth (ft)	Pool Frequency (per 1000')
BRWN 09	WRC	2011	BG01	Low	**10.6**	**1.4**	**84.0**	**96.0**	*NR*	*NR*
BRWN 09	WRC	2011	BG03	Low	**11.5**	**1.5**	**74.0**	**80.0**	*NR*	*NR*
BRWN 06	WRC	2011	BG06	Low	**7.7**	**1.1**	**59.0**	**69.0**	*NR*	*NR*
BRWN 05	WRC	2011	BGDM	Low	**3.0**	**1.5**	**32.0**	**52.0**	*NR*	*NR*
BRWN 04	WRC	2011	BG12	Low	**6.7**	**1.8**	**43.0**	**47.0**	*NR*	*NR*
BRWN 04	PIBO	2008	237	Low	**26.1**	*NR*	*NA*	*NA*	1.18	24.20
BRWN 03	WRC	2011	BG16	High	10.5	1.5	*NA*	*NA*	*NR*	*NR*
BRWN 03	PIBO	2008	2635	High	8.85	*NR*	*NA*	*NA*	**0.49**	49.56

[a] Greenline information comparable to DEQ methods was not collected by others
[b] WRC – 100 pebbles from 1 transect at a riffle; PIBO – 100 pebbles from 20 transects (5 per transect) from all stream features (*NA*=not applicable); *NR* = not recorded

Comparing the compiled data in **Table J3-2** with the Upper Clark Fork TMDL Planning Area sediment and habitat targets in **Table J3-1** for low gradient streams, none of the measured width/depth ratios or entrenchment ratios met the targets. Pebble counts (<2mm, <6mm) were also all above targets for Browns Gulch. The single pool frequency measurement from a low gradient stream did meet the target. For high gradient streams, targets were met for width/depth ratio, entrenchment ratio and pool frequency.

J4.0 PHOTOS

There are extensive photos available in the 2011 report prepared for the Mile High Conservation District and the WRC as well as in Pick and Kellogg (2006).

J5.0 SUMMARY

For the purpose of impairment determination, data for Browns Gulch are compiled and presented in this report. There is evidence of erosion and deposition of fine sediment occurring in Browns Gulch and is most evident downstream of the Telegraph Gulch confluence. A notable source of fine sediment to the Browns Gulch is Hail Columbia Gulch, a tributary in the lower drainage. Low flows and channel alteration are well documented in the lower segment of the stream corridor and dewatering prevents Browns Gulch from flowing to Silver Bow Creek in some years. Browns Gulch likely has higher natural sediment loads compared with other sub-watersheds in the Upper Clark Fork sub-basin, but is also at a higher risk of erosion given the nature of its soils and existing land uses. Land clearing and removal of the beaver population in the late 1800s in Browns Gulch and its tributaries likely accelerated mass wasting in sub-watersheds with highly erosive soils, and evidence of poor benthic substrate quality was observed throughout the mainstem. While stabilization has occurred since that period, current land use is still contributing fine sediment at loads greater than would naturally occur. Significant improvement is possible by limiting fine sediment deposition to Browns Gulch.

The FWP report from 2009 (Liermann et al., 2009) identified fine sediment accumulation as a condition limiting fish habitat at several locations in the lower segment of the Browns Gulch assessment unit. A comparison between sediment and habitat metrics collected by WRC and USFS (PIBO) and targets for Upper Clark Fork tributaries do indicate that sediment deposition is impairing beneficial uses in Browns Gulch.

J6.0 REFERENCES

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