APPENDIX B – BOULDER RIVER WATERSHED DESCRIPTION

B1.0 INTRODUCTION

This appendix describes the physical, ecological, and cultural characteristics of the Boulder River watershed and the Boulder-Elkhorn TMDL Planning Area (TPA). The TPA boundary and the watershed boundary are the same.

B2.0 PHYSICAL CHARACTERISTICS

The following information describes the physical characteristics of the Boulder River watershed.

B2.1 LOCATION

The Boulder River watershed is located in Jefferson County. The total extent is 487,142 acres, or approximately 760 square miles. The watershed is located in the Missouri Headwaters Basin (Accounting Unit 100200) of southwestern Montana, as shown on **Figure A-1**. The watershed is coincident with the 1002006 fourth-code watershed.

The Boulder River watershed is located in the Middle Rockies Level III Ecoregion. Three Level IV Ecoregions are mapped within the watershed (Woods *et al*., 2002), as shown on **Figure A-5** in **Appendix A**. These include: Elkhorn Mountains-Boulder Batholith (17ai), Townsend Basin (17w), and Townsend-Horseshoe-London Sedimentary Hills (17y). The watershed is bounded by the continental divide to the west, Boulder Hill to the north, the Elkhorn Mountains to the northeast, and Bull Mountain to the southwest.

B2.2 TOPOGRAPHY

Elevations in the watershed range from approximately 1,304 to 2,868 meters (4,275 - 9,415 feet) above mean sea level (**Appendix A**, **Figure A-6**). The lowest point is the confluence of the Boulder River and the Jefferson Slough; the highest point is Crow Peak, at the northeast corner of the watershed. Much of the watershed is rugged and mountainous, with three distinct valleys: Elk Park, a long, narrow valley drained by Bison Creek; the Boulder Valley near the Town of Boulder, a high basin hemmed in by mountains; and the Boulder River valley below Elkhorn Creek, a broad river valley opening to the Jefferson River Valley. The uplands are characterized by steep-sided valleys with gently sloping ridgelines and peaks. Rugged alpine topography is limited to the very highest elevations.

B2.3 GEOLOGY

Figure A-7 in **Appendix A** provides an overview of the geology, based on a geologic map of Montana (Ross, *et al*., 1955). These data provide the basis for the figure, however, discussion of the geology is based on a more recent map (Vuke et al., 2007), for which geographic information systems (GIS) data are not released.

B2.3.1 Bedrock

The bedrock of the watershed includes Precambrian (Belt Series), Paleozoic and Mesozoic sedimentary rocks, granitoid rocks of the Boulder batholith, and Cretaceous to Tertiary volcanic rocks. The sedimentary rocks are mainly present north of the Boulder River and east of Elkhorn Creek, and at the mouth of the Boulder River. These rocks are deformed into a series of folds related to the Helena Structural Salient. Intrusive and volcanic rocks are widely distributed through the Boulder, Elkhorn and Bull mountains.

B2.3.2 Basin Sediments

Tertiary and Quaternary sedimentary deposits are concentrated in the valleys. The Tertiary sediments are commonly fine-grained with isolated bodies of coarser material. Tertiary sediments commonly occur in benches or dry terraces. Quaternary sediments include fluvial, colluvial, glacial and proglacial deposits.

B2.4 Soils

The USGS Water Resources Division (Schwarz and Alexander, 1995) created a dataset of hydrology-relevant soil attributes, based on the USDA Natural Resources Conservation Service (NRCS) STATSGO soil database. The STATSGO data are intended for small-scale (watershed or larger) mapping, and is too general to be used at scales larger than 1:250,000. Therefore, it is important to realize that each soil unit in the STATSGO data may include up to 21 soil components. Soil analysis at a larger scale should use NRCS SSURGO data. The soil attributes considered in this characterization are erodibility and slope.

Soil erodibility is based on the Universal Soil Loss Equation (USLE) K-factor (Wischmeier and Smith, 1978). K-factor values range from 0 to 1, with a greater value corresponding to greater potential for erosion. Susceptibility to erosion is mapped on **Figure A-8** in **Appendix A**, with soil units assigned to the following ranges: low (0.0-0.2), moderate-low (0.2-0.29) and moderate-high (0.3-0.4). Values of >0.4 are considered highly susceptible to erosion. No values greater than 0.34 are mapped in the watershed.

The majority of the watershed (57%) is mapped with moderate-low susceptibility soils. Roughly similar percentages are mapped with moderate-high susceptibility (19.5%) and low susceptibility (23.5%) soils.

Comparison of **Figures A-7** and **A-8** in **Appendix A** demonstrates that soil erodibility is related to geology. Soils with low susceptibility to erosion generally correspond to the areas underlain by the granitoid rocks of the Boulder Batholith, and the moderate-low susceptibility soils correspond to areas underlain by volcanic rocks. Moderate-high susceptibility soils are mapped in the valleys and in areas underlain by sedimentary rocks.

Due to the relatively large areas of the soil units, the slopes as mapped with the STATSGO data are generalized. **Figure A-8**, which is based on STATSGO data, maps the majority of the watershed with slopes of between 31° and 40°. However, **Figure A-9** (**Appendix A**), which shows slope interpreted from a 30-meter digital elevation model, illustrates that the watershed is characterized by locally very steep slopes along valley margins, with generally rounded mountaintops.

B2.5 Surface Water

The Boulder River flows a distance of approximately 80 miles. Hydrography of the watershed is illustrated on **Figure A-10** in **Appendix A**. The National Hydrography Dataset medium resolution data (United States Department of Interior, Geological Survey, 1999) includes 374 miles of named streams, with a total of 1,042 miles of streams mapped in the watershed. This data is compiled at 1:100,000.

B2.5.1 Stream Gaging Stations

The United States Geological Survey (USGS) maintains two gaging stations within the watershed, as detailed below in **Table B-1**. The gauging stations are shown on **Figure A-10** in **Appendix A**.

Table B-1. Stream Gages in the Boulder River Watershed

Name	Number	Drainage Area	Agency	Period of Record
Cataract Creek near Basin, MT	06031950	30.6 miles2	USGS	1973-2008*
Boulder River near Boulder, MT	06033000	381 miles2	USGS	1929-1972; 1985-2008

* Annual peak data

B2.5.2 Streamflow

Streamflow data are based on records from the USGS stream gage on the Boulder River near Boulder (**Table B-1**), and is available via the USGS NWIS website (United States Department of Interior, Geological Survey, 2008). Flows in the Boulder River vary considerably over a calendar year. A hydrograph summarizing flows at this station is provided in **Figure B-1** of this document. The hydrograph is based on monthly mean flows.

Flow is variable from year to year, but on average (over a 75-year period of record), peak flows occur in May (456 cubic feet per second, or cfs). The highest recorded flow of 7,000 cfs occurred in May 1981.

Mean low flow occurs in January (26 cfs). Late summer (August and September) mean flows are nearly as low as mean flow in winter (December – February). Mean flows in October and November have been slightly higher (35 to 36 cfs). During the period of record annual peaks have ranged from 7,000 cfs (May 22, 1981) to 267 cfs (May 3, 2000). Peak annual flows have not occurred earlier than April 23, nor later than July 7.

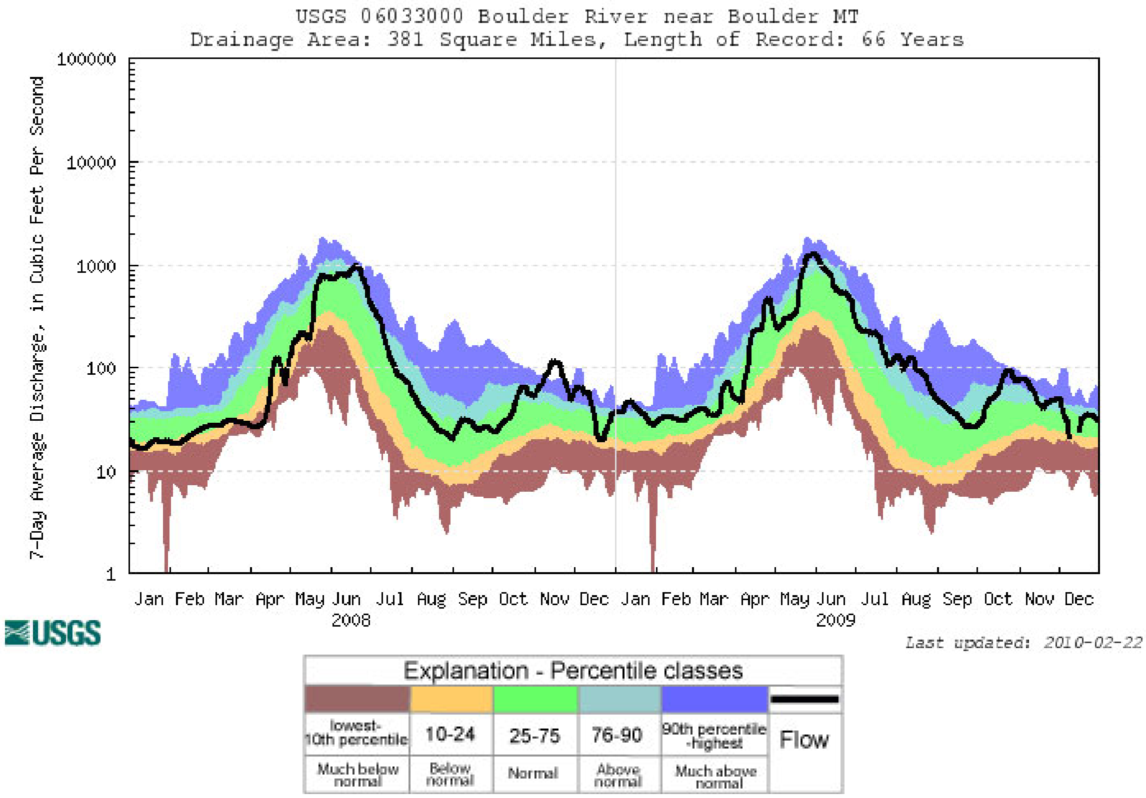

Figure B-1. Monthly Mean Flows of the Boulder River

B2.5.3 Surface Water Quality

As summarized in **Table B-2**, surface water quality data are collected from three stations in the watershed, dating to 1997. Six other stations have water quality data beginning with 1997, but discontinued in 1999, 2002 or 2004. Parameters include: pH; specific conductance; temperature; hardness as $CaCO_3$; major, minor and trace inorganics; radionuclides; and sediment.

Table B-2. Water Quality Stations in the Boulder River Watershed

Name	Number	Drainage Area	Agency	Period of Record
Boulder River above Kleinsmith Gulch	06031450	-	USGS	1997-1994
Boulder River at Basin	06031500	219 miles2	USGS	1997-1999
Basin Creek at Basin	06031600	-	USGS	1997-2008
Cataract Creek near Basin	06031950	30.6 miles2	USGS	1997-1999
Cataract Creek at Basin	06031960	-	USGS	1997-2008
Boulder River near Basin	06032000	292 miles2	USGS	1997-1999
High Ore Creek near Basin	06032300	8.86 miles2	USGS	1997-2002
Boulder River below Little Galena Gulch	06032400	318 miles2	USGS	1997-2008
Boulder River near Boulder, MT	06033000	381 miles2	USGS	1997-1999

B2.6 Groundwater

B2.6.1 Hydrogeology

No studies of the hydrogeology were identified. Kendy and Tresch (1996) described the groundwater system of the Boulder Valley in general terms, assuming that groundwater flow within the valley is typical of intermontane basins. Groundwater is presumed to flow towards the center of the basin from the head and sides, and then down valley along the central axis.

The average groundwater flow velocity in the bedrock is probably several orders of magnitude lower than in the valley fill sediments. However, zones of carbonate dissolution and faulting/fracturing may produce significant quantities of groundwater. The hydrologic role of the structural geology (faults and folds) is uncertain. No studies of the bedrock hydrogeology were identified.

Natural recharge occurs from infiltration of precipitation, stream loss, and flow out of the adjacent bedrock aquifers. Flood irrigation is an additional source of recharge to the valley aquifers, particularly on the benches that flank the modern floodplain.

B2.6.2 Groundwater Quality

The Montana Bureau of Mines and Geology (MBMG) Groundwater Information Center (GWIC) program monitors and samples a statewide network of wells (Montana Bureau of Mines and Geology, 2008). As of March 2008, the GWIC database reports 590 wells within the watershed (Montana Department of Natural Resources and Conservation, 2008).

The water quality data include general physical parameters: temperature, pH and specific conductance, in addition to inorganic chemistry (common ions, metals and trace elements). MBMG does not analyze groundwater samples for organic compounds.

Kendy and Tresch (1996) report that groundwater of the northern Boulder Valley is characterized by a calcium-bicarbonate chemistry, with dissolved solids ranging from 250-500 milligrams per liter (mg/L). Dissolved solids are lower (<250 mg/L) to the south, where the basin sediments are thickest. In the southern third of the basin, groundwater is characterized by a mixed (Ca, Mg or Na) sulfate chemistry with dissolved solids ranging from 250-500 mg/L.

There are six public water supplies within the watershed, all of which use groundwater for their supply. Water quality data are available from these utilities via the SDWIS State database (Montana Department of Environmental Quality, 2008), although these data reflect the finished water provided to the public, not raw water at the source.

B2.7 Climate

Climate in the area is typical of mid-elevation intermontane valleys in western Montana. Precipitation is most abundant in May and June. Annual average precipitation ranges from 11 to 45 inches in the Boulder River watershed. The mountains receive most of the moisture, and the Boulder Valley below Elkhorn Creek receives the least. The precipitation data (**Appendix A, Figure A-11**) is mapped by Oregon State University's PRISM Group, using records from NOAA stations (PRISM Group, 2004).

See **Table B-3** for climate summaries; **Figure A-11** in **Appendix A** shows the distribution of average annual precipitation.

B2.7.1 Climate Stations

National Oceanographic and Atmospheric Administration (NOAA) currently operates one weather station in the watershed. The USDA Natural Resources Conservation Service (NRCS) operates three SNOTEL (SNOpack TELemetry) snowpack monitoring stations within the watershed. **Figure A-11** in **Appendix A** shows the locations of the NOAA and SNOTEL stations, in addition to average annual precipitation. Climate data are provided by the Western Regional Climate Center, operated by the Desert Research Institute of Reno, Nevada.

Table B-3. Monthly Climate Summary: Boulder

Boulder, Montana (241008) Period of Record : 7/1/1948 to 12/31/2005

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Ave. Max. Temp (F)	33.2	38.6	44.7	54.9	64.2	72.7	82.5	82.0	71.1	59.4	42.9	34.9	56.7
Ave. Min. Temp. (F)	9.3	14.1	19.0	27.1	35.2	42.5	47.7	45.9	36.9	28.2	18.3	11.5	28.0
Ave Tot. Precip. (in.)	0.46	0.32	0.50	0.79	1.78	2.05	1.37	1.24	1.02	0.56	0.51	0.44	11.03
Ave.. Snowfall (in.)	7.3	3.6	6.3	3.8	0.4	0.1	0.0	0.0	0.1	0.4	3.9	5.3	31.2
Ave Snow Depth (in.)	3	1	1	0	0	0	0	0	0	0	1	2	1

B3.0 Ecological Parameters

B3.1 Vegetation

The primary cover in the uplands is conifer forest. Conifers are dominated by Lodgepole pine, giving way to Douglas fir at lower elevations, with lesser amounts of White pine, Western larch and juniper. The valleys are characterized by grassland and irrigated agricultural land, with minor shrublands. Landcover is shown on **Figures A-12** and **A-13** in **Appendix A**. Data sources include the University of Montana's Satellite Imagery land Cover (SILC) project (University of Montana, 2002), and USGS National Land Cover Dataset (NLCD) mapping (Montana State Library, 1992).

B3.2 Aquatic Life

Native fish species present in the watershed include: westslope cutthroat trout, mountain whitefish, mottled scuplin, longnose dace and longnose sucker. Westslope cutthroat trout are designated "Species of Concern" by Montana Department of Fish, Wildlife and Parks (FWP).

Introduced species are also present in streams, including: brook, rainbow, brown and Yellowstone cutthroat trout. Data on fish species distribution are collected, maintained and provided by FWP (Montana Department of Fish, Wildlife and Parks,2006). Fish species distribution is shown on **Figure A-14** in **Appendix A**.

B3.3 Fires

The United States Forest Service (USFS) Region 1 office and the USFS remote sensing applications center provide data on fire locations from 1940 to the present. Two fires are identified for this period, both of which burned in 2000. The High Ore fire burned 7,824 acres of the watershed north of Boulder. The Boulder Hill fire burned 1,830 acres northeast of the Town of Boulder (**Appendix A, Figure A-15**).

B4.0 CULTURAL PARAMETERS

The following information describes the social profile of the Boulder River watershed.

B4.1 POPULATION

An estimated 2,300 persons lived within the watershed in 2010 (Montana Department of Natural Resources and Conservation, 2008). Population estimates are derived from census data (United States Census Bureau, 2010), based upon the populations reported from census blocks within and intersecting the watershed boundary (**Appendix A, Figure A-16**). Basin and Boulder had reported populations of 212 and 1,183 in the 2010 census, respectively. The remainder of the population is sparsely distributed. Much of the watershed is unpopulated.

B4.2 TRANSPORTATION NETWORKS

The watershed is bisected by Interstate 15 and Montana Route 69. The network of unpaved roads on public and private lands will be further characterized as part of the source assessment. No active railways are present in the watershed. The Great Northern Railway branch to Butte formerly bisected the watershed where Interstate 15 now exists.

B4.3 LAND OWNERSHIP

Land ownership data are provided by the State of Montana CAMA database via the NRIS website (Montana Department of Natural Resources and Conservation, 2008) (**Table B-4**). Slightly more than one-half of the watershed is administered by the USFS, and 8% by the U.S. Bureau of Land Management. Private lands comprise 37% of the watershed, and Montana State Trust Lands occupy 5% of the watershed. Land ownership is shown on **Figure A-17** in **Appendix A**.

Table B-4. Land Ownership

Owner	Acres	Square Miles	% of Total
Private	180,448	281.9	37%
U.S. Forest Service	249,016	389.1	51%
U.S. Bureau of Land Management	41,362	64.6	8%
State Trust Land	14,876	23.2	5%
State Department of Corrections	1,393	2.2	0.3%
Total	487,142	761.2	—

B4.4 LAND USE & COVER

Land use within the watershed is dominated by forest and agriculture (**Table B-5**). Agriculture in the lowlands is primarily related to the cattle industry: irrigated hay and dry grazing. Information on land use is based on land use and land cover (LULC) mapping completed by the USGS in the 1980s. The data are at 1:250,000 scale, and are based upon manual interpretation of aerial photographs. Agricultural land use is illustrated on **Figure A-13** in **Appendix A**. Potential sources of human impacts (wastewater discharges, livestock feeding areas) are illustrated on **Figure A-18** in **Appendix A**.

Table B-5. Land Use and Cover

Land Use	Acres	Square Miles	% of Total
Evergreen Forest	256,516.6	400.8	52.66%
Grasslands/Herbaceous	154,348.5	241.2	31.68%
Shrubland	52,338.7	81.8	10.74%
Pasture/Hay	8,680.3	13.6	1.78%
Small Grains	3,843.4	6.0	0.79%
Transitional	2,999.3	4.7	0.62%
Deciduous Forest	2,223.5	3.5	0.46%
Woody Wetlands	2,177.9	3.4	0.45%
Fallow	1,096.2	1.7	0.23%
Commercial/Industrial/Transportation	981.6	1.5	0.20%
Row Crops	849.5	1.3	0.17%
Emergent Herbaceous Wetlands	474.1	0.7	0.10%
Low Intensity Residential	145.4	0.2	0.030%
Urban/Recreational Grasses	136.8	0.2	0.028%
Open Water	112.2	0.2	0.023%
High Intensity Residential	98.7	0.2	0.020%
Bare Rock/Sand/Clay	95.4	0.1	0.020%
Mixed Forest	16.0	0.0	0.003%
Perennial Ice/Snow	6.3	0.0	0.001%
Quarries/Strip Mines/Gravel Pits	0.4	0.0	0.000%

Berkas *et al*. (2005) report that roughly 3,500 acres upstream of the Boulder River near Boulder gage are irrigated with surface water diversions. Additional information on agricultural land use can be obtained from Department of Revenue data. The Department of Revenue assigns a predominant agricultural use only if more than 50% of a given parcel is so used, and then the entire acreage is ascribed to that use. A total of 6,754 acres of irrigated land is reported in the watershed. The dominant designated agricultural use is grazing, corresponding to 152,508 acres (238 square miles) or 31% of the watershed area (Montana Department of Natural Resources and Conservation, 2008).

B4.5 Mining

Mining remains an important economic activity within Jefferson County, although not in the Boulder River watershed. Mining and milling were widely performed within the watershed, as was some smelting. Waste rock and tailings are still present in many locations. Like many Montana mining districts, much of the metal production began in the 1860s with gold-bearing placers. Later, lode deposits of lead, zinc, gold and silver came to be of importance. Iron-bearing ore was mined in the Elkhorn district to provide flux to the East Helena smelter.

B4.5.1 Historic Activity

The environmental impacts of abandoned and inactive mines in the watershed have been widely studied by the MBMG and USGS (Metesh et al., 1994; Metesh et al., 1995; Metesh et al., 1998; Nimick et al., 2004), among others). The influences of historic mining are most concentrated in the Basin and Cataract Creek drainages. Numerous reclamation projects were completed in the 1990s and 2000s (Montana Department of Environmental Quality, 2009; Nimick, 2006).

DEQ Remediation Division data on abandoned mine locations are plotted on **Figure A-18**.

B4.5.2 Modern Activity

The Basin Creek Mine property, located near the divide between Basin and Tenmile Creeks, is now owned by Montana DEQ, and is operated as the Luttrell Depository. This facility provides encapsulated disposal for mine and mill waste from former mining sites in the region. Active open-pit mines (Golden Sunlight; Montana Tunnels) are located immediately outside the Boulder River watershed, but no large-scale mining operations are identified within the watershed.

B4.6 Timber Harvests

No maps of timber harvests were identified during the compilation of this watershed description. However, the 'transitional' classification in National Land Cover Dataset (NLCD) is commonly applied to harvested or burned areas. The size and distribution of areas in the watershed with this classification are consistent with timber harvests. A total of 3,000 acres are mapped 'transitional' in the 1992 NLCD data, primarily in the headwaters regions of the Boulder River. Inspection of aerial photographs reveals that additional areas appear to have been harvested since that date.

B4.7 Wastewater

The MPDES reports several regulated discharges within the watershed, both wastewater and stormwater. The towns of Boulder and Basin are sewered. Boulder's wastewater treatment facility discharges to the Boulder River, and therefore has a MPDES permit. Basin's facility (aerated lagoon with infiltration/percolation cells) discharges to groundwater rather than surface water. Wastewater treatment for other communities and rural residences is provided by on-site septic tanks and drainfields.

Septic system density is estimated from the 2000 census block data, based on the assumption of one septic tank and drainfield for each 2.5 persons (Montana Department of Natural Resources and Conservation, 2007), and that sewer systems correspond to incorporated communities. Septic system density is classified as low (less than 50 per square mile), moderate (51 to 300 per square mile) or high (greater than 300 per square mile). Nearly all of the watershed is mapped as low septic system density, with very limited areas of moderate (215 acres) and high (47 acres) density. The high and moderate density locations are found primarily around Boulder and Basin. Community sewers (727 acres) are only mapped at Boulder; the sewer system at Basin is not mapped. Septic system density is illustrated on **Figure A-18** in **Appendix A**.

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