Section 9.0
Water Quality

Summary

Climate, geology, topography, soils, and vegetation influence the initial character and quality of water in a watershed. Thereafter, changes in water and land use through agriculture and development impact water quality by contributing excess sediments, nutrients, chemicals, and metals. Sampling in the South Arkansas River indicates good water quality, although certain parameters decline in the downstream direction. Segments of the river downstream of U.S. 285 also indicate adverse impacts from fine sediments on streambed habitat important to trout and aquatic invertebrates. These impacts arise from a combination of native soils, excessive stream bank erosion, degraded riparian habitat, and runoff from developed areas. Some of these impacts can be addressed fairly easily, such as by changing grazing practices and using construction best management practices, while others are more difficult, such as fitting stormwater detention basins into existing development.

This section discusses the natural and human factors that influence water quality and how those factors apply to the South Arkansas River watershed. The section concludes with recommendations to address existing and potential adverse conditions.

Background

Natural factors that affect the character and quality of surface waters include climate, geology, topography, soils, and vegetation. Except where indicated, the following comments are from Dunne and Leopold (1978).

- Climate and topography determine the timing and amount of precipitation. Wind and precipitation also deposit materials that may affect snowmelt water quality (Rhoades et al. 2010).
- Regional geology provides the parent material from which local soils are derived, determines the minerals and chemicals that dissolve in runoff, influences the ease with which water percolates through the earth, and affects the types and extent of vegetation.
- Topography and soils influence the rate at which precipitation runs off the land into streams and, thereby, the amount and types of materials carried into streams. Soils and soil microbes also influence the character of runoff by adding and removing materials as water moves through.
- Vegetation influences soil, and the water that moves through the soil by, removing water (transpiration), removing soil components needed for growth, depositing materials such as leaf litter that influence soil characteristics, decreasing erosion by binding soils through rooting systems, and by intercepting and dissipating the force of rainfall and surface runoff.

- The concentration of nitrate and potassium in streams are influenced by: the extent of bank stability; shading provided by riparian vegetation; human sources of pollution, such as in runoff or from grazing; and seasonal biological activity, i.e., nutrient uptake and decomposition (USFS 1990).

Water Quality Impacts in Urban Areas

Urban land use includes residential, commercial, and industrial development, roads, and water development. Adverse impacts to water quality – most often due to stormwater runoff – are described below.[1]

Impervious surface. Development increases the amount of impervious surfaces, that is, materials that cover the soil surface such as roads, buildings, and parking lots that precipitation and snowmelt cannot penetrate. These surfaces decrease or eliminate the amount of precipitation and runoff that soaks into and moves through the ground, increase the amount of water reaching surface waters, and accelerate the speed with which that water arrives (Paul and Meyer 2001). As the extent of impervious surface increases, runoff volume increases, as does the amount of pollution carried in that runoff (Brabec et al. 2002, CWP 2003).

Pollutants in runoff. Over time, most of the materials deposited on impervious surfaces are moved to local surface waters by rainfall and snowmelt, particularly during the initial stages of runoff or snowmelt ("first flush"). Materials include:

- suspended solids, inorganic and organic materials that cause turbidity and excess sedimentation (USEPA 1980). Sediments less than 63 microns in size (0.001 mm or approximately 0.000039 inch) often act as carriers of metals, pesticides, and petroleum products (Wood and Armitage 1997);
- nutrients, such as nitrates, ammonium, and phosphorus from fertilizers and animal waste;
- ions such as calcium, sodium, potassium, and magnesium (Paul and Meyer 2001);
- herbicides, insecticides and fungicides;
- organic carbon;
- metals such as copper, zinc, lead, and chromium;
- oil, grease, and other petroleum products; and
- pathogens (Novotny and Olem 1994, CWP 2003).

Last, development is often associated with increases in stream water temperatures (Allan 2004), and by the lowering of local groundwater levels by pumping water for human use as well as by decreasing infiltration of precipitation (Novotny and Olem 1994).

[1] Wastewater treatment facilities and septic systems also contribute a variety of materials (USGS 2002).

Collection and treatment of stormwater runoff. The collection and movement of stormwater in developed areas may be roughly classified as formal or informal. Formal collection involves a network of surface inlets and subsurface pipes that moves runoff from streets and parking lots to nearby receiving waters. With informal collection systems, runoff follows local topography. Depending on the volume of flows, runoff in informal systems may collect in low-lying depressions where it eventually evaporates or percolates into the ground, or it may move directly to local waterbodies through roadside ditches and swales.

The impact of formal runoff collection systems on receiving waters depends on the factors discussed above as well as the presence of structures and practices designed to treat materials carried in runoff. (See the discussion in the next paragraph.) The impact of informal runoff collection systems on receiving waters depends on a variety of site-specific factors. For instance, if flows move through vegetated ditches and swales, potential adverse water quality impacts may be mitigated by percolation and plant uptake. Similarly, if flows collect in depressions and evaporate or percolate into the ground, no adverse impacts are likely. However, if the volume of runoff is high enough to overwhelm small depressions or local ditches, erosion may result and materials carried and stored into such areas during previous events may be moved to nearby waterbodies.

For both formal and informal systems, structures and practices to address the impacts of stormwater runoff include porous pavement, subsurface storage vaults, infiltration trenches such as grass swales, wet or dry detention basins, and natural or constructed wetlands. Detention basins can be sized to address peak loads of runoff or to insure a specific length of detention (Booth and Jackson 1997). Detention time in stormwater basins and the extent of contact with soil and vegetation are critical for providing water quality benefits (Hogan and Walbridge 2007). Planning and constructing detention basins as development occurs is easier and usually cheaper than constructing them after the fact. Depending on where stormwater runoff originates and discharges, solutions farther from the river may be possible, such as “daylighting”. This involves exposing buried stormwater pipes and creating a detention basin mid-course (American Rivers 2012). However, cost, stormwater capture area, and pollutant removal should all be considered for such retrofit options (CWP 2007). To be most effective, structural changes should address higher-frequency runoff events (Walsh et al. 2005).

Stream restoration and stormwater runoff. Stream restoration efforts must be mindful of the resulting adverse impacts to receiving waters from stormwater runoff. In some situations, adverse impacts on water quality from runoff may be such that restoration efforts would be more effective if runoff is addressed rather than conditions in the stream itself. Conversely, the effectiveness of changes to in-stream habitat may be limited if poor water quality is not addressed.

Water Quality Impacts in Rural Areas

Rural land use includes agricultural operations, grazing, timber operations, mining, recreational trails, and roads (Dunne and Leopold 1978, Novotny and Olem 1994). In general, agricultural land use degrades streams by: increasing sediment, nutrients, pesticides, and herbicides; adversely affecting streamside and in-stream habitat; and altering stream flows (Allan 2004). However, impacts can vary widely, even where agricultural use exceeds 50% of land use in a watershed (Meador and Goldstein 2003). Forest management practices may impact water quality by decreasing the concentration of oxygen in nearby streams, increasing stream water temperature, and increasing the amount of sediments and nutrients, such as phosphate and nitrate, delivered to the stream (Binkley and Brown 1993). Forest roads tend to destabilize adjacent slopes, increase gullying and erosion and, therefore, increase sediment delivery to streams (Montgomery 1994). Paved roads and highways are sources of metals and petroleum products (Driscoll et al. 1990). Recreation tends to compact soils, remove vegetation, and increase erosion (Monz et al. 2013).[2]

Water Quality Regulations and Standards

The main law governing water quality is the federal Clean Water Act (CWA; 33 U.S.C. 1251, et seq.). From a regulatory perspective, water quality impacts arise from point sources and non-point sources (Novotny and Olem 1994). CWA defines point sources as any discrete conveyance such as a pipe or ditch from which pollutants are discharged (e.g., discharge from a wastewater treatment plant).[3] Non-point source pollution arises from precipitation that collects on the land surface and moves into local bodies of water (USEPA 2013b). Storm runoff from city streets is an example. The discussion of water quality in this assessment concerns only those impacts arising from non-point sources. In the project corridor, land disturbance activities may require permits from the Colorado Department of Public Health and Environment (CDPHE 2007), including requirements for stormwater management plans, and the use of best management practices (BMPs) to reduce or prevent the discharge of stormwater into local waters.[4] Some examples of BMPs include runoff containment (e.g., erosion logs, silt fence), dry and wet detention basins, treatment wetlands, and vegetated swales.

[2] Insect infestations and wildfire impacts to vegetation may also lead to increased erosion. These issues are discussed in more detail in Section 7.0, Vegetation.

[3] At present, there are four permitted point-source discharge permits in the South Arkansas River watershed: Monarch Ski Area (Permit CO0031399), Monarch Quarry (Permit COR341243), Monarch Mountain Lodge (Garfield) (Permit CO0028444), and WMC – Salida (COR900094) (CDPHE 2012b). Salida's water treatment facility is located on the Arkansas River downstream of the confluence with the South Arkansas River.

[4] Within the federal Clean Water Act, non-point source pollution is regulated under the National Pollution Discharge Elimination System (NPDES; 33 U.S.C. 1342) and the Nonpoint Source Management Program (Section 319; 33 U.S.C. 1329). NPDES governs non-agricultural, non-point source pollution in urban areas with populations greater than 10,000. In general, NPDES governs activities that disturb more than one acre of land (e.g., construction). Similar to state regulations, such activities must be permitted and are required to implement stormwater management plans and to use stormwater BMPs (USEPA 2014a). The Nonpoint Source Management Program

Surface Water Quality Standards for the South Arkansas River

Water quality standards are established by the Colorado Department of Public Health and Environment and are based on two factors: the waterbody's classification—its designated uses; and numerical water quality standards based on the waterbody's classification. The classification for the South Arkansas River (COARUA12b) is as follows:

- *Aquatic Life Cold 1* (Class I) – waters capable of sustaining a wide variety of cold water biota, including sensitive species;
- *Recreation E* (Class E) – waters used for primary contact recreation;
- *Water Supply* – waters suitable as drinking water; and
- *Agriculture* – waters suitable for irrigation of crops and as drinking water for livestock (CDPHE 2013).

No segments of the South Arkansas River are currently listed as non-attaining for the river's designated uses (CDPHE 2012a). More details regarding numerical water quality standards for the South Arkansas River are provided in Appendix E.

Water quality and sediment deposition. According to state regulations, "state surface waters shall be free from substances attributable to human-caused point source or nonpoint source discharge in amounts, concentrations or combinations which…can settle to form bottom deposits detrimental to the beneficial uses", including anaerobic sludges, mine slurry or tailings, silt, or mud (5 CR 1002-31.11). State guidance related to sediment deposition impacts to aquatic life apply to higher gradient, cobble-bed, course-grained, mountainous stream and wadeable river environments (CDPHE 2005).

Public Drinking Water Supplies in the South Arkansas River Watershed

The City of Salida receives its drinking water from surface flows from the South Arkansas River (Salida 2008b). Drinking water is routinely tested in accordance with state standards. There is some concern with contamination from upstream development, and agricultural runoff affecting water delivered by the Harrington Ditch (Salida 2013). Poncha Springs receives its drinking water from groundwater wells (Poncha Springs 2013), and the town's comprehensive plan includes concerns regarding protection of the quality of that water (Poncha Springs 2011). The Chaffee County comprehensive plan also noted water quality concerns related to "package treatment plants" and septic systems that serve rural residents (Chaffee County 2000).[5]

requires states to prepare non-point source assessment reports and to establish non-point source management programs (USEPA 2014b).

[5] Monarch Mountain Lodge was issued a notice of violation of drinking water standards in 2012 (CDPHE 2012c; Permit CO-0108420).

Water Quality in the South Arkansas River Watershed

As part of the South Arkansas River watershed assessment, water samples were collected at five locations in December 2012-January 2013, and July 2013 (Figure 9-1). The sampling locations were chosen to determine if changes in land use above and within the project corridor significantly affect water quality. Based on the results of this sampling, water quality in the South Arkansas River is good, but it declines in a downstream direction. This is true during both the winter and summer sampling periods, with the change was more dramatic during the summer. Table 9-1 presents the results of that sampling for selected parameters. Information on dissolved oxygen was not collected for this assessment, but will be collected as water quality monitoring continues. See Appendix E for more details regarding sampling protocols and sampling results at specific locations.

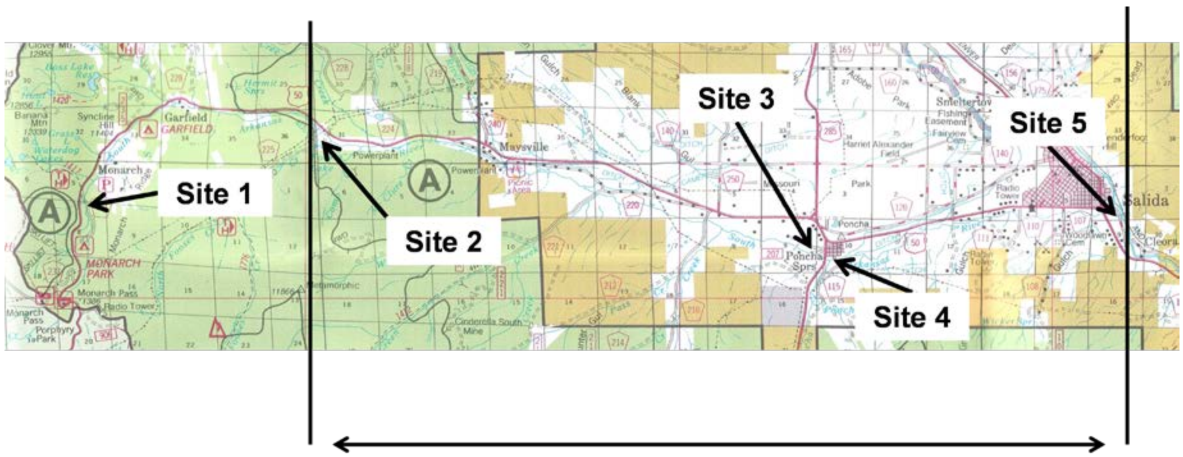

Figure 9-1. Location of water quality sampling sites on the South Arkansas River

Water Quality—
Impacts and Issues in the South Arkansas River and Watershed

Based on the dominant activities in the South Arkansas River watershed, grazing, roads, and development have the greatest adverse impacts on water quality.

Excess Sediments

Several segments of the South Arkansas River are impacted by deposition of fine sediment, mostly downstream of U.S. 285 (Figure 9-2; compare to Figure 9-3). The source of these sediments is likely some combination of stream bank erosion (Figure 9-4), impacts to riparian areas (Figure 9-5), and runoff from developed areas (Figure 9-6).

Table 9-1
Selected Water Quality Parameters in the South Arkansas River

Water Quality Parameter	State WQ Standard	Winter Range of Values	Summer Range of Values
Temperature (^{o}C)	1/	1.0 to 2.5	11.0 to 18.0
pH	2/	6.9 to 8.0	7.3 to 8.4
E. coli (count per 100 mL)	126	8.5 to 43.5	< 1.0 to 127.4
Nitrate (NO_3) (mg/L)	0.05	< 10	< 10
Zinc (µg/L)	3/	< 10	< 10
Copper (µg/L)	3/	< 10	< 10
Phosphorus (µg/L)	n/a	4 to 100	300 to 310
Sodium (mg/L)	n/a	2.7 to 9.8	1.52 to 15.8
Total Suspended Solids (mg/L)	n/a	95 to 246	78 to 358
Hardness as $CaCO_3$ (mg/L)	n/a	54 to 135	49 to 193
Conductivity (µmhos/cm)	n/a	116 to 252	81.5 to 290

1/ Winter = > 13.0 (acute), > 9.0 (chronic); summer = > 21.7 (acute), > 17.0 (chronic).
2/ pH for recreation, agriculture, and cold water aquatic life = 6.5 to 9.0; pH for drinking water supply = 5.0 to 9.0.
3/ A table value standard (TVS) based on a specific formula has been adopted (CDPHE 2012d).

During a 2012 field visit, heavy summer rains were encountered in an area of highly erodible soil on the south side of the river just east of Poncha Springs. Roads on the south side of the river intercept and concentrate hillside surface flows, direct it into roadside ditches, and deliver it directly to the South Arkansas River. Enough runoff, and the suspended sediments in that runoff, reached the river to obscure the bottom of the river at Chaffee County Road (CCR) 107, roughly five miles downstream. Although the river water was relatively clear within an hour, such fine sediments settle on the river bottom and smother trout spawning beds and aquatic insect habitat (Figure 9-2). However, intense summer thunderstorms are usually localized and unpredictable, conditions that make it difficult to track the source(s) of fine sediments and to account for the relative contribution of among the potential sediment sources. Last, debris flows are evident from steep slopes in several areas along gravel roads above the South Arkansas River project corridor.

Stormwater Runoff in the South Arkansas River Watershed

Both formal and informal stormwater collection systems exist in Salida, while routing of stormwater in Poncha Springs is informal. The most recent evaluation of Salida's formal stormwater system was conducted in 2004, but did not include areas adjacent to the South Arkansas river (i.e., U.S. 50 or the adjacent businesses or residential neighborhoods (Salida 2004). Runoff within the 2004 study area is routed to the Arkansas River. Discussions with Salida Public Works indicated that city stormwater

Figure 9-2. Excess sediments in the South Arkansas River in Salida at CCR 107 (2012)

Figure 9-3. Stream substrate in the South Arkansas River upstream at CCR 221 (2013)

Figure 9-4. Example of bank erosion along the South Arkansas River (2012)

Figure 9-5. Impact of uncontrolled livestock access to the South Arkansas River (2012)

drainage patterns for areas adjacent to U.S. 50 are not precisely known (Salmi 2014). Apparently, the most recent design documents for the highway date from 1973. These documents indicate that formal stormwater collection begins just east of Chaffee County Road 111. Flows are directed from west to east and drain to a large, vacant field in the northwest quadrant where U.S. 50 crosses the South Arkansas River. Given the size of the area into which stormwater is directed, it appears that only the highest runoff events would reach the river. Thus, the area serves as a detention basin for runoff under most precipitation events.

Figure 9-6. Slope erosion from parking area down to the South Arkansas River (2012)

Other outfalls. Pipes that drain directly into the South Arkansas River were documented during 2012 and 2013. Of the 18 outfalls identified, 4 were draining water at the time they were documented. The source of those flows could not be determined, but were not likely related to stormwater given the clarity of the flows and the lack of recent rainfall. Whether the remaining outfalls are functional is not unknown. Many, however, emerge at the river's edge where there is little or no space to address any issues that may arise (Figure 9-7).

Construction Best Management Practices

Field visits during 2012 also revealed construction practices that can lead to sediment impacts to the river (Figure 9-8). Various erosion control techniques are available in

Figure 9-7. Existing outfalls may be difficult and costly to address (2012)

Figure 9-8. Lack of appropriate erosion control during construction (2012)

such situations to minimize potential problems, such as coffer dams, silt fence, and erosion control logs. Planning documents developed by Poncha Springs and Salida note the importance of controlling non-point source pollution. In most cases, state regulations require that construction projects seek stormwater permits and that they develop stormwater management plans.

Conclusion

Although water quality in the South Arkansas River is good, conditions in the streambed, especially downstream of U.S. 285, indicate adverse impacts from fine sediment deposition. These impacts arise from a combination of native soils, excessive streambank erosion, degraded riparian habitat, and runoff from developed areas. These conditions persist because of a general lack of flushing flows. Like other watershed issues, some of these impacts can be addressed fairly easily, such as changing grazing practices and using construction best management practices, while others are more difficult, such as addressing outfalls positioned at the river’s edge.

Other aspects of water quality in watershed and river processes are detailed in the sections listed below.

- Section 4.0, Geology, Topography, and Soils
- Section 6.0, Hydrology and Flow Regime
- Section 7.0, Vegetation
- Section 8.0, Wildlife, Fish, and Aquatic Invertebrates
- Section10.0, Channel and Floodplain Processes

Restoration goals and recommendations for the South Arkansas River and watershed are discussed in Section 11.0, Establishing Watershed and Riparian Restoration Goals.

Streams are the gutters down which flow the ruins of continents.

Leopold, Wolman and Miller (1964)