Summary of Detailed Assessment of PAC Reaches
Mario L. Sullivan, Ph.D.

The Upper Reach:

Sinuosity and Elevation Gradients:

The North Fork and South Fork are markedly steeper than the rest of the upper reach with 2.4 and 1.8% grades, respectively. The remaining upper reach is closer to a 1.0% average grade.

Sinuosity (***S***) is generally low to moderate (average = 1.2) but the South Fork has a small reach that would be considered a meandering reach (***S*** = 1.6) which appears to also contain an oxbow lake.

Hydrology:

USGS Station No. 09304115 had the most recent data within the main-stem of the upper reach but the period of record is only 2003 through 2009. During this period, the average annual CFS appears to be increasing (slope = 20.2) although a longer period would be desirable for this analysis because similar increases in flow are observed in other reaches during the same period of record. Peak discharge occurs in June with an average of about 1,487 CFS and drops to a winter base flow of about 270 CFS. In terms of average monthly flows, the upper reach is the least variable and the greatest variability in flow occurs in June (coeff. of variation = 44%).

Geologic Transitions:

While it is true that the water quality of the North and South forks, at least in terms of clarity, is protected by more resistant geological strata in the upper segments (which includes both relatively old Cambrian to Pennsylvanian rocks and relatively young basalt lava flows). However, both tributaries quickly begin to drain Mesozoic sedimentary strata (i.e. Chinle formation) that contain shales and mudstones with mobile sediments. Therefore, the forested areas and riparian zones around the upper reach are of particular importance with respect to sediment stability and maintaining water clarity.

The riverbed and tributary of the upper reaches of the North and South Forks have some glacial influence but in general, the valley fill is of Quaternary aged gravels deposited by flowing water.

Rosgen (1994) Classification:

Because of the relatively steep gradients along the upper reaches of the North and South Forks along with the relatively low sinuosity (with the exception of specific reaches), the top of the upper reach might be classified as A+ to A depending on the entrenchment of the segment of river being assessed. Given the gradient and geology, the substrates will likely be coarse sands to boulders (A1-A3) or B1a-B3a depending on local steepness. The lower segments of the upper reach are likely to be primarily classified as “B” streams due to the potential for a greater width to depth ratio.

The Middle Reach:

Sinuosity and Elevation Gradients:

The middle reach is moderately sinuous to meandering; ***S*** ranges from 1.2 to 1.5 and the average = 1.2. The average steepness from the top of the middle reach to the bottom of the middle reach is 0.73% for a relatively flat elevation gradient.

Hydrology:

USGS Station No. 09304500 appears to have a slight decline in annual average CFS during 1902-2018. Peak discharge occurs in June at an average of 1,791 CFS and drops to a winter base flow of about 308 CFS. The greatest variability in flow is observed in July (CV = 62%).

Geologic Transitions:

The top of the middle reach represents an important geologic transition into even younger Mesozoic sedimentary rocks from the Triassic and Cretaceous (i.e. Dakota sandstone, Mowery shale, and Mancos shale). Some of the members of these groups are not well consolidated and produce fine sands, silts, and muds that can be highly mobile. As the middle reach heads into Agency Park (just south of town of Meeker), the valley broadens into Quaternary aged gravel and sand valley fill from either ancient White River deposits or ancient tributary deposits. At the top of the middle reach is also where the Meeker Dome is located and the site of several water wells. While the surface geology has changed, the sediment load is still relatively low and is perhaps buffered by the broad valley and runoff is filtered through the gravel matrix. As the White River continues to flow out of Agency Park and into Powell Park, there is another significant geologic change as the river cuts through the Grand Hogback; the Grand Hogback separates Agency Park (east of hogback) and Powell Park (west of hogback). After this point, there is a substantial increase in sediment load and changes in other water quality parameters such as increases selenium (see Tobin 1993 for further details). Much of this change in water quality is probably natural and related to the draining a different set of strata (i.e. the upper Cretaceous aged William's Fork formation) as the river passes through the hogback and picks up even more sediment and chemical constituents from the unconsolidated shales and mudstones and exposed coal beds. The middle reach boundary is just west of Powell Park where there exists yet another geologic transition into the lower reach.

Rosgen 1994 Classifications:

Because the middle reach is more consistently sinuous, presumably has a broader channel, perhaps stretches within the middle reach will be classified as G depending on entrenchment. Due to the likely increase of fine sediments in the substrate, perhaps the stretches will range from G4-G5 or G4c-G6c.

<u>The Lower Reach:</u>

Sinuosity and Elevation Gradients:

The lower reach is the most sinuous on average (***S*** **=** 1.3) but ranges between 1.1 and 1.7. Stretches below Kenney Reservoir tend to be more sinuous. The average elevation gradient is relatively flat (0.33%).

Hydrology:

Between 1983 and 2019, there has been an overall decline in the average annual discharge (slope = -9.0) at USGS Station No. 09306290 in the middle of the lower reach. Perhaps some trend analysis on other major tributaries could shed some light on whether or not this trend is basin-wide or primarily in the main-stem White River. Peak discharge occurs in June at an average of 1,803 CFS and drops to a winter time base flow of about 380 CFS. The greatest variability in flow is observed in July (CV = 70%). With respect to flow variability around monthly averages, there appears to be an incredibly tight positive correlation between the middle reach and lower reach (both in the upper and middle stretches of the lower reach). This means that, for any given month, as flows in the middle reach deviate from average, there is an almost perfectly proportional response in the middle reach that also goes in the same direction. This correlation is much stronger than what we observe between flow variability in the upper reach versus the middle reach. This suggests that flow variability in the middle reach has a dominant influence on flow variability in the lower reach that appears to even swamp out variation due to the influences of Yellow Creek and Piceance Creek. Because of water withdraw from Miller Creek, we would expect a decoupling of the middle and lower reaches, particularly if there is no surface return flow from Miller Creek. However, if there is percolation through the alluvial fill in middle reach from field irrigation out of Miller Creek, then there might be a substantial amount of sub-surface return flow to the bottom of the middle reach and the top of the lower reach which could, at least in part, explain the strong hydrologic coupling between the middle and lower reach especially during a long summer (June through October).

Geologic Transitions:

The lower reach is known for its turbid waters and that is primarily due to the unconsolidated sedimentary rocks of the Williams Fork Formation (upper stretches of lower reach) and main body of the Mancos Shale (lower stretches of lower reach). Substrates in the lower reach average about 25% clay, 45% silt, and 30% sand (Tobin 1994) which puts it in a clay dominant texture by use of the soil textural triangle. The geologic setting does not change markedly until near the state line where the river cuts through another ridge that is made of relatively young strata such as the Green River Formation. Perhaps more can be done with reconciling the water clarity and sediment 303d listings in the White River with what is naturally expected.

Rosgen 1994 Classifications:

Because of its relatively shallow grade and increased average sinuosity, the lower reach will perhaps be classified as stream type E or G, depending on incision and local slope. Due to the low gradient and likely increase in fine sediments (i.e. silts and clays), the lower reach might be classified in the range of F5b, F6b or F5, F6.

The Piceance Reach:

Sinuosity and Elevation Gradients:

The average sinuosity of Piceance Creek is about 1.3 and ranges from 1.1 to 1.4. The upper stretch tends to be less sinuous. While upper Piceance creek (above where it crosses highway 13) is rather steep with a nearly 3% grade. Overall, the average grade is 1.2%.

Hydrology:

Piceance Creek appears to have unique seasonal patterns of discharge. While peak flows occur in May at 167 and 190 CFS (Station No's. 093062000 and 093062222, respectively), both the middle and lower stretches of Piceance Creek demonstrate much more variability during the winter months than other reaches in the White River. Therefore, winter time base flow might require more analysis but flows in Piceance Creek do drop in September to about 9 and 14 CFS in the middle and lower stretches respectively and then begin to rise. This pattern might be explained, at least in part, by the fact that Piceance Creek is a smaller drainage area and tends to be more sensitive (flashy) and the lower stretches might receive more precipitation in the form of rain later into the winter than some of the other reaches on the White River (particularly compared to the upper and middle reaches of the main-stem White River). Another noteworthy finding is the substantial variation in average monthly flows within Piceance Creek (CV max = 190% in lower Piceance Creek in May). This means that this stretch of Piceance Creek could be nearly dry or be flowing at double the average discharge in any give May. While flow variability decreases into the winter time, the average CV is still greater (30%-40%) than that in the White River (13%-20%).

Geologic Transitions:

The hillslopes of Piceance Creek tend to drain relatively young Tertiary sedimentary deposits; younger Uinta formation toward the tops of the ridges and older Green River formation in the lower elevations. In addition, the lower most stretches of Piceance Creek might drain some Mancos shale. In reviewing Tobin et al. (1985), sediment loads in Piceance Creek are highly variable and sensitive to flow magnitude. For example, a tributary near the upper stretches of Piceance Creek had sediment loads that ranged from 0.0 mg/L (no flow) up to 76,000 mg/L during run-off events. Furthermore, sediment loads can be highly localized; some sites from Tobin (1985) reported maximum sediment loads in the range of 100's of mg/L.

Rosgen 1994 Classifications:

Due to the variation in sinuosity and slope, Piceance Creek might be classified as a type E or G stream, depending on local slope and sinuosity. A designation of E versus G will depend on local entrenchment. Because Piceance Creek's sediment load is highly variable and the geology it drains is somewhat similar to that of the middle and lower White River, there will probably some gravels (perhaps cobbles and boulders in the steeper, upper reach) but primarily gravels, sands, and silts perhaps putting this stream in G4-G6 or G4c-G6c.

References:

Rosgen, D.L. 1994. A classification of natural rivers. Catena (22) 169 – 199.

Tobin, R. L., H.E. Stranathan, and K.J. Covay. 1985. Water-quality characteristics of streams in the piceance creek and yellow creek drainage basins, northwestern colorado, water years 1977-81. USGS Report 84-4261

Tobin, R.L. 1993. Sediment transport and water-quality characteristics and loads, White River, Northwestern Colorado, water years 1975-88. USGS Report 92-4031