



Oak Creek Surface Water Quality Report for 2020
Oak Creek Watershed Council
Year of the Novel Coronavirus & the Heightened Impact on Recreation

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Executive Summary

This report is crucial to understand surface water quality issues throughout Oak Creek Canyon, Arizona. This effort will allow land managers and agencies to look at data collected from multiple sources across the watershed at once and make inferences about similar streams in Arizona that see high amounts of recreation. Water quality assessment was achieved by monitoring *E. coli* and turbidity over the study to investigate if during the summer or peak season there are more recreationalists tied to spikes in *E. coli* concentrations. The study led to the conclusion that humans when recreating may have an impact on the water quality of Oak Creek and the overall impact shows exceedances are more frequent during holiday weekends and potentially increasing with COVID-19 visitation records.

Ambassadors sampled from May 23, 2020—Memorial Day Weekend—through September 12, 2020, a week after Labor Day Weekend. Samples were collected through two projects: Tuesday sampling days (64 samples including duplicates) taken at about the same time as Slide Rock State Park collects their samples (84 samples including duplicates), and Weekend sampling days (79 samples including duplicates) taken at various high-use locations within Oak Creek Canyon. Ambassadors were also collecting trash and visitor data over weekends during the study and removed over 1,600 pounds of trash. The percent exceedance of the 227 total samples collected within the watershed for the *E. coli* standard was 5% indicating that a majority of the time during the study the sites met water quality standards of < 235 MPN/100mL.

Continued conservation to protect Oak Creek requires collaborative efforts to keep up with increases in visitation and recreation. More common messaging, in multiple languages, about Leave No Trace principles must be made available as well as consideration to the capacity of people visiting Oak Creek and its watershed. And ongoing collective data collection for water quality sampling, trash and fecal matter collection, and visitor-use impact analysis is needed.

Introduction

In an effort funded by the Sedona Chamber of Commerce and Tourism Bureau (SCC & TB), the Oak Creek Watershed Council (OCWC) has been tasked to develop systems and goals to monitor and report water quality in high visitor areas in Oak Creek Canyon, Arizona. Oak Creek is a tributary of the Verde River, a part of the Lower Colorado River Basin with a watershed draining 465 square miles and contributing 61,600 acre-ft/yr to the Verde River (Figure 1; USGS, 2006).

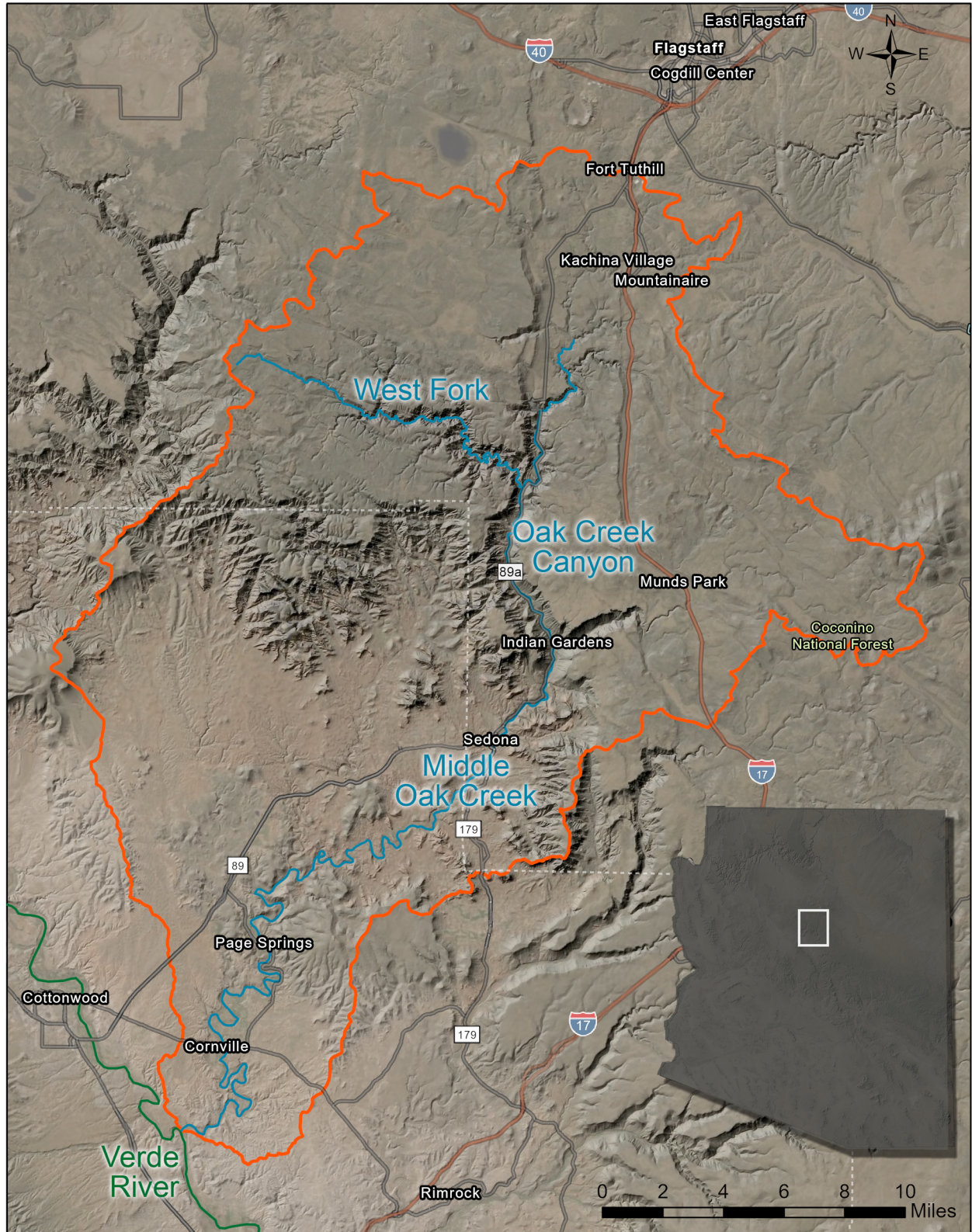


Figure 1. Map of Oak Creek watershed. The watershed boundary is shown in orange, Oak Creek is shown in blue, and Verde River is shown in green.

Included in these efforts is an expansion of monitoring and sampling across Oak Creek, including analysis of data collected by multiple sources including Friends of the Forest (FOF) and Slide Rock State Park (SRSP). In the past, the OCWC had only been sampling in upper Oak Creek Canyon, with other groups like FOF sampling from above SRSP to Crescent Moon (middle Oak Creek). With these expanded efforts and a grant from the Arizona Department of Environmental Quality in 2020, OCWC has been able to sample at multiple day-use sites in Oak Creek Canyon, collecting surface water quality and turbidity samples during high-use times. All samples taken will help inform the Sedona Chamber of Commerce and Tourism Bureau, land managers, land agencies, and OCWC about *Escherichia coli* (*E. coli*) exceedances in relation to water quality, as well as helping gauge the effectiveness of pullout closures, trash clean up and pet waste station monitoring as a part of a grant from Arizona Department of Environmental Quality (ADEQ).

The data in this report will examine 227 total water quality samples, collected by OCWC and SRSP, and processed for *E. coli* and turbidity throughout Oak Creek Canyon. A comparison between three sample sites from 2019 and 2020 will show that exceedances have increased from 2019 to 2020 mainly due to congestion and increased recreation over already high use weekends such as holiday weekends. It is important to understand *E. coli* is a naturally occurring bacteria in water bodies. Although naturally occurring, *E. coli* exceedances due to stormwater events, recreation, and litter are harmful to human health. The Arizona Water Quality Standard for full body contact of *E. coli* bacteria is set at a maximum of 235 colony forming units (cfu) per 100 milliliter (mL) water per single sample, or a monthly mean of 126 cfu. During the course of this study there were nine exceedances of *E. coli* sampled by OCWC and two exceedances sampled by SRSP.

It is important to note that there were no flood events on Oak Creek during the study period (May–September). The USGS streamgage (Figure 2) shows a relatively consistent flow of 30 cfs throughout the entire sampling period, indicating that samples were collected during baseflow. Therefore, the exceedances captured in this season cannot be attributed to storm events and are much more likely attributable to high-impact recreation. Figure 3 shows the flood activity and associated discharge that occurred on Oak Creek during all of 2020.

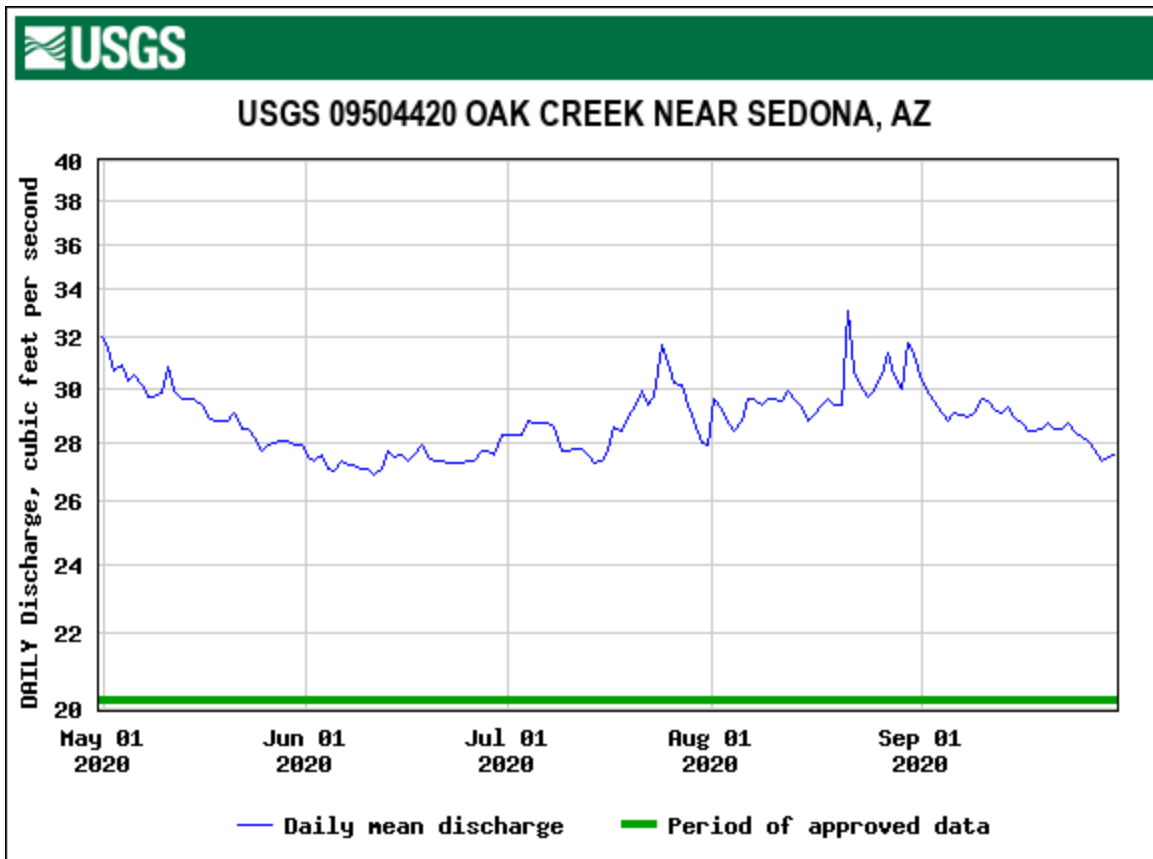


Figure 2. USGS discharge data on Oak Creek near Sedona from May–September. Shows a relatively consistent flow throughout the entire sampling season.

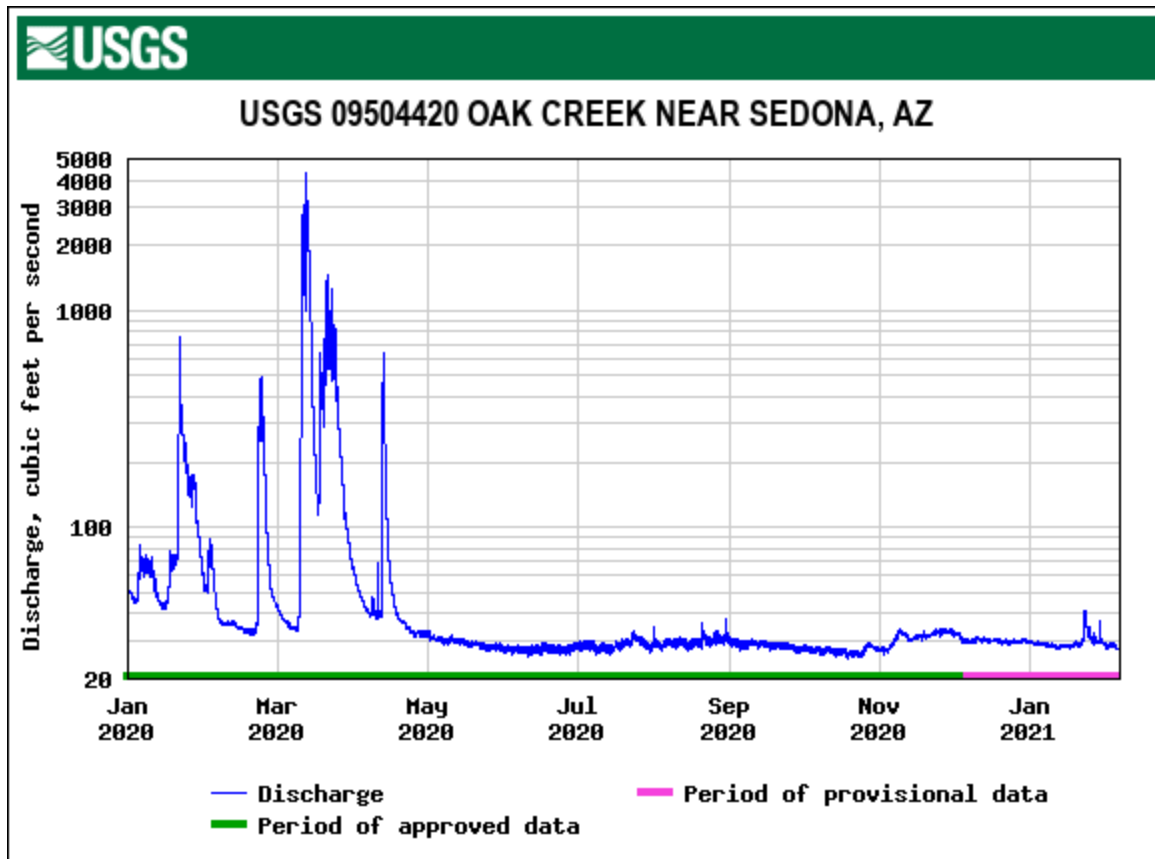


Figure 3. USGS discharge data on Oak Creek near Sedona from January 2020 – January 2021. Shows peak storm flow during the first four months of the year and a relatively consistent flow throughout the following months.

Other efforts have been made to try to reduce human-caused sources of *E. coli*, yet *E. coli* exceedances remain a problem especially where there is concentrated recreation in the creek, such as at Grasshopper Point. Through a project called Canyon Patrol, Ambassadors were working to reduce *E. coli* loads into Oak Creek every Saturday and Sunday throughout the study period by removing trash left behind by recreators in parking pullouts, day use sites, and along the creek. Over the course of the study period, the Ambassadors removed 1,634 pounds of trash including 166 diapers and 413 glass bottles.

Methods

OCWC Weekend Sampling

In 2020, an ADEQ grant allowed for Oak Creek Ambassadors to sample water quality at seven day use sites in Oak Creek Canyon over high-use weekends. However, with the increase in recreation seen due to the novel Coronavirus, each weekend was a particularly high-use time on Oak Creek. OCWC sampled over 11 dates from Memorial Day Weekend to Labor Day Weekend. The seven weekend sampling sites were Cave Springs, Gabion

Pool, Bootlegger, Banjo Bill, Halfway, Grasshopper Point, and Midgley Bridge (Figure 4). Samples were collected in 100 mL IDEXX bottles along with a turbidity sample collected at each site, and a duplicate sample collected each sampling day for quality assurance purposes. Samples were placed on ice and brought to Natural Channel Designs Laboratory in Flagstaff where Ambassadors processed and analyzed *E. coli* bacteria concentrations using the IDEXX QuantiTray method and found turbidity by using a HACH turbidimeter in the field.

Simultaneously, Ambassadors were patrolling Oak Creek each weekend. This project is in partnership with the Arizona Department of Environmental Quality and U.S. Forest Service under the Oak Creek Watershed Restoration Action Plan (OCWRAP). Stated in the OCWRAP are plans to close approximately half of the 60 unauthorized roadside pullouts and rehabilitate adjacent unauthorized social trails. It is important to note that the closure of these pullouts and rehabilitation of social trails is beneficial to the health of Oak Creek through reduced erosion and sedimentation, indirectly reducing *E. coli* contamination.



Figure 4. Map of OCWC surface water quality sampling sites. Yellow stars indicate the weekend sampling sites and red stars indicate the Tuesday sampling sites.

OCWC Tuesday & Slide Rock State Park Sampling

Oak Creek Ambassadors were tasked with sampling water quality near the headwaters of Oak Creek and along West Fork by the Sedona Chamber of Commerce & Tourism Bureau. Slide Rock State Park and, in the past, Friends of the Forest sampled Oak Creek on Tuesdays. Therefore, with OCWC sampling on the same day as these other groups, our data would be used to better understand potential sources of *E. coli* contamination and areas of concern.

Samples were collected in IDEXX 100 mL sample bottles each Tuesday morning from June 2 through September 8. The four sample sites were Pine Flats Subdivision (from the bridge), Oak Creek above the confluence with West Fork, West Fork above the confluence with Oak Creek, and West Fork at the second creek crossing (along the West Fork trail; Figure 4). Initially, there were three sampling sites. The fourth site, Oak Creek above the confluence with West Fork, was added on the 12th week of sampling and only four samples were recorded for this site. Duplicate samples were collected for quality assurance each day of sampling. Turbidity samples were collected for each sample site and Ambassadors used a portable HACH turbidimeter in the field.

Samples were taken to SRSP to be processed in the State Park's facility. The data was recorded on paper and picked up by Ambassadors the following week where it was then recorded onto Google Sheets and entered into ADEQ's Data Portal.

Slide Rock State Park has collected surface water quality data at SRSP on Tuesday mornings for years. The State Park samples for *E. coli* at five locations: highway bridge, foot bridge, large pool, middle slide, and upstream. SRSP takes one duplicate each day of sampling alternating between the different sites. Samples are processed in the State Park's lab facility and results are recorded on paper.

Results

OCWC Weekend Results

During the entire study the percent of exceedances of *E. coli* bacteria found across all seven sites, 79 total samples, was 11%. That indicates that 89% of the data points analyzed from this study show water quality below and within the 235 MPN/100 mL recreational water quality standard for *E. coli* in surface waters. This represents that the watershed, although highly utilized by human and wildlife traffic, measured *E. coli* bacteria exceedances 11% of the time between the 11 weekend sampling dates from May and September 2020.

The geometric mean analysis of all sample sites shows that *E. coli* numbers stayed well below the 235 MPN/100 mL standard during this study (Table 1). The "GR" (Grasshopper

Point) site had the highest geometric mean value for *E. coli* at 107.98 MPN/100 mL. Grasshopper Point, with three exceedances, had the most occurring number of exceedances in this study including one duplicate sample. Banjo Bill (site “BB” in Table 1) had the lowest geomean of 17.69 MPN/100 mL although, as seen in Figure 5B, Banjo Bill was the site of the single highest exceedance recorded at 2419.9 MPN/100 mL. Banjo Bill was a site that consistently showed low values for *E. coli* until this singular exceedance event on 9/5/2020. The sampler’s notes recorded that there were about 10 swimmers and one dog directly upstream of the sample site.

Turbidity measures in Arizona rivers tend to be less than 20 NTU normally, and Oak Creek is known for its clear and pristine water. Exceedances above normal, >20 NTU, were not seen during this study (Table 1). Because there were no storm events during the sampling season, low turbidity values were expected (Figures 2 and 3).

Table 1. All Oak Creek samples taken by OCWC results, including *E. coli* and turbidity minimums, maximums, and geometric means. Site names are in order as follows, Pine Flat, Cave Springs, Gabion Pool, Oak Creek above the confluence, West Fork above the confluence, West Fork at the second crossing, Bootlegger, Banjo Bill, Halfway, Grasshopper Point, and Midgley Bridge.

Site	<i>E. coli</i> (MPN/100 mL)			Turbidity (NTU)		
	Max	Min	Geomean	Max	Min	Geomean
PF	50.4	2	13.83	0.68	0.38	0.46
CS	316.9	2	45.85	5.12	0.51	1.34
GP	193.5	6.3	44.16	5.55	0.51	1.44
OCC	93.3	33.1	52.67	0.77	0.43	0.53
WFC	96	9.8	32.2	14.4	0.47	1.07
WF2	116.2	11	34.26	5.47	0.31	0.94
BL	125.9	5.2	20.17	1.67	0.48	0.84
BB	>2419.9	3.1	17.69	0.88	0.47	0.64
HW	499.6	5.1	44.28	1.8	0.52	0.97
GR	1986.3	14.6	107.98	2.92	0.97	1.53
MB	307.6	9.6	46.94	1.13	0.59	0.87

Results show that in the peak recreational time period of May through September 2020, *E. coli* numbers stayed below the recreational water quality maximum of 235 MPN/100 mL 89% of the time (Figure 5 A and B). Exceedances were seen in May, July, August, and September at Halfway, Grasshopper Point, Cave Springs, Midgley Bridge, and Banjo Bill.

An exceedance occurred over most major holiday weekends of the summer but was not limited to holiday weekends as recreation was extremely high during most weekends. The single two highest exceedances occurred at Banjo Bill and Grasshopper Point, both over Labor Day Weekend and had values at 2419.9 and 1986.3 MPN/100 mL on 9/4/2020 and 9/5/2020, respectively.

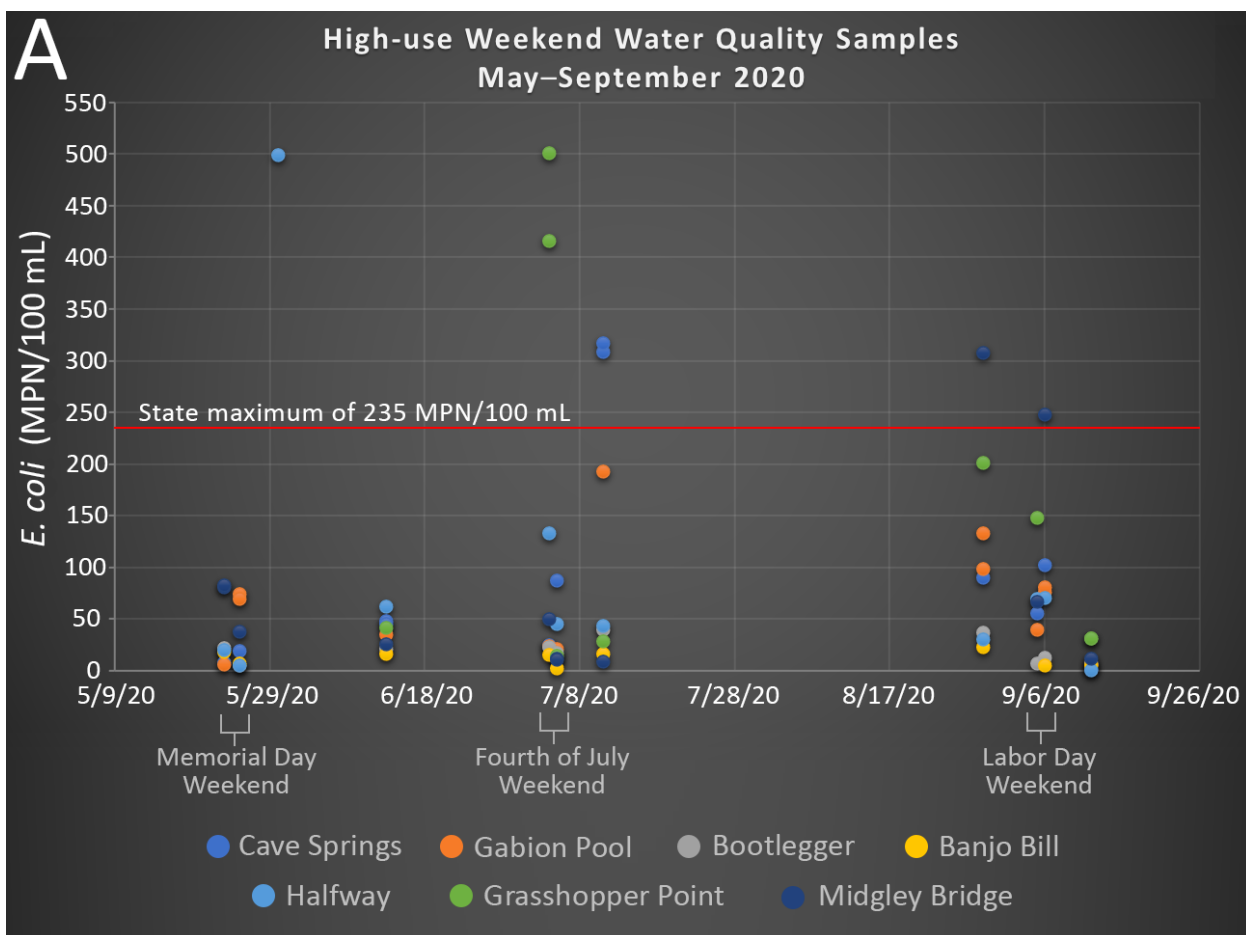


Figure 5A. OCWC Weekend samples with holiday weekends labeled. Exceedances are clearly marked as above the red line indicating the state maximum of 235 MPN/100 mL. Extreme exceedances are shown in Figure 5B. below.

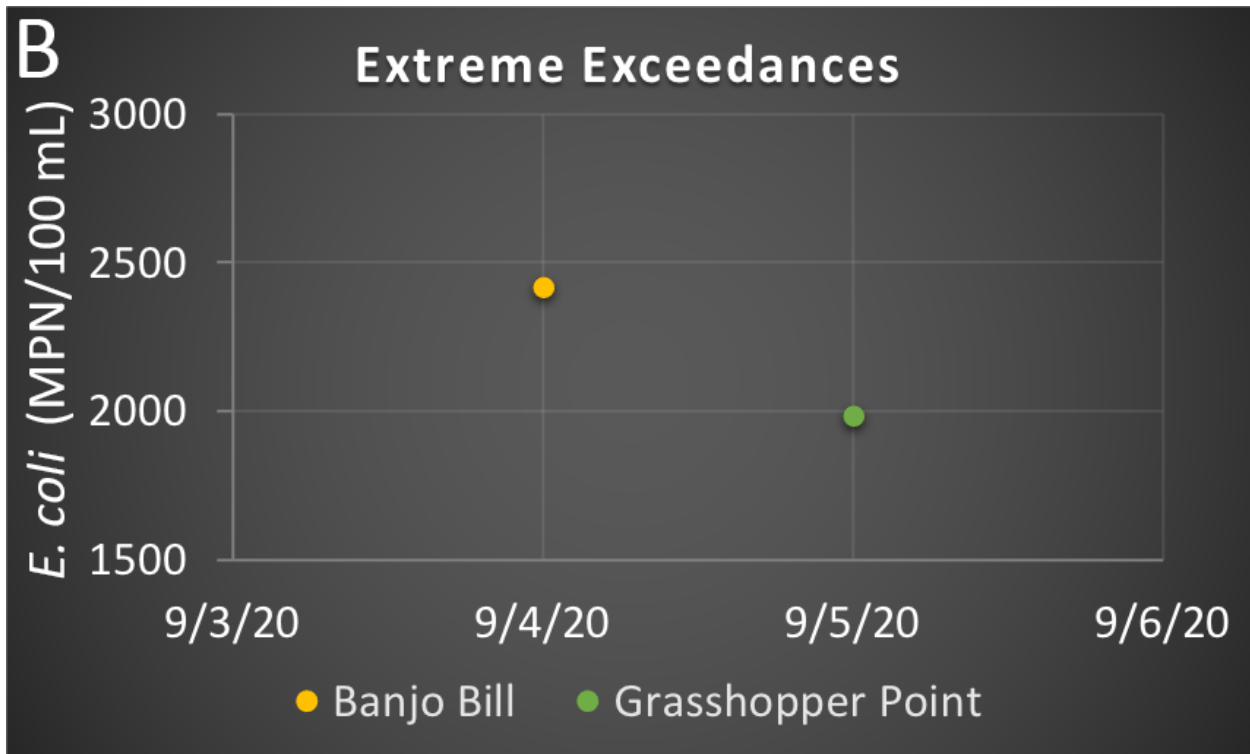


Figure 5B. OCWC weekend sample extreme exceedances. Both exceedances captured over Labor Day Weekend 2020.

When Oak Creek Ambassadors were not sampling water quality, a grant from ADEQ allowed them to collect trash data from parking pullouts and day use sites in Oak Creek Canyon. This measure effectively kept potential sources of *E. coli* from entering the creek. However, some sites proved to be difficult locations for accessing such as Midgley Bridge and Grasshopper Point with limited parking spots and gated entryways. Therefore, trash pick up at these areas were less frequent and so recorded total trash removed from these areas is lower (Table 2). Table 2 shows sampling sites such as Cave Springs and Halfway, two locations where exceedances were seen, with over 200 pounds of trash collected at each. Encinosa, a site where no water quality samples were taken, had the most amount of trash collected with over 400 pounds (Table 2).

Table 2. Trash collected (in pounds) by Ambassadors at various locations in Oak Creek Canyon in 2020. Locations *without* asterisks indicates it as a sampling site as well as a trash pick up site. A single asterisk indicates a sampling location that was difficult to access for trash pickup. A double asterisk indicates trash pick up sites that were not sampled for water quality.

Location	Trash collected in pounds
Pine Flat	86.77
Cave Springs	206.56
Gabion Pool*	43.42
West Fork*	23.75
Bootlegger	45.51
Banjo Bill	58.73
Halfway	246.34
Manzanita**	121.85
Encinoso**	401.67
Oak Creek Visitor Center**	252.4
Grasshopper Point*	100.94
Midgley Bridge*	46.27
Total Trash Collected	1634.21

It is likely that some sites had more trash left behind than others because of the availability of parking. For example, Halfway, Encinoso, and Oak Creek Visitor Center have multiple parking pullouts nearby as well as a designated parking area. This allows for more visitors to access one area, creating congestion, and leaving behind more trash. Bootlegger and Banjo Bill are two examples where there is not much available parking outside of the designated parking areas — except for the rare occurrences over very high use times when people were parking dangerously off of highway 89a but not in designated pullouts — and less trash was found at these sites overall (Table 2). It is important to note that sites difficult to access may not have had as many visits from personnel to remove trash and that locations like Grasshopper Point and Midgley Bridge likely had more trash left behind than was recorded and removed by OCWC Ambassadors.

Table 3. Comparing 2019 data collected by Friends of the Forest Sedona and 2020 data collected by Oak Creek Watershed Council at three similar sampling sites. Duplicate samples were averaged with corresponding samples for both data sets. Red boxes indicate exceedances.

Friends of the Forest Sedona 2019			Oak Creek Watershed Council 2020		
Halfway	Grasshopper Point	Midgley Bridge	Halfway	Grasshopper Point	Midgley Bridge
191	167.1	119.7	20.1	42.3	82.3
164.8	83.85	86.1	5.1	458.6	37.9
70.5	93.8	59.6	499.6	14.6	25.8
108.5	86.3	123.1	62.4	28.8	50.4
165.15	129.5	117.8	133.4	201.4	11.55
97.8	57.65	30.7	45.7	148.3	9.6
148.1	136.7	142.4	44.1	1986.3	307.6
109.8	83.5	72	30.9	31.3	67
107.3	132.3	142.4	69.7		248.1
59	160.5	162.25	70.8		12.2
251.3	146.7	124.2	9.8		
119.6	198.1	270.35			
170.2	156.55	144			
141.5	212.85	203.7			
139	152.5	161.5			

In 2019, surface water quality samples were collected by FOF on Tuesday mornings from May through September at five locations distributed from Oak Creek Canyon to Middle Oak Creek. Three sample sites, Halfway, Grasshopper Point and Midgley Bridge, overlapped between FOF and OCWC in 2019 and 2020 (Table 3). There were five exceedances captured in 2020 by OCWC and two exceedances captured by FOF in 2019. FOF took more samples but sampled on Tuesdays so the numbers are not indicative of weekend visitation. However, the weekend visitation was captured by OCWC and shows exceedances of much higher MPNs. In contrast to the extremity of exceedances, the geometric mean of FOF samples is 123.4 MPN/100 mL whereas the geometric mean of OCWC samples is only 59.05 MPN/100 mL. So, while 2020 captured more exceedances more often and of higher concentrations than 2019, the general concentration of *E. coli* in Oak Creek appears higher in 2019 than 2020.

OCWC Tuesday & Slide Rock State Park Results

Each Tuesday morning from June 2nd through September 8th, both Oak Creek Watershed Council and Slide Rock State Park collected water quality samples. Altogether, there were 148 samples collected within 15 weeks. The percent of exceedances of *E. coli* bacteria

found across all nine sites is 1%. That indicates that 99% of the data points analyzed from this study show water quality below and within the 235 MPN/100 mL recreational water quality standard for *E. coli* in surface waters. Separately, OCWC did not capture any exceedances during the study but SRSP captured two exceedances on 9/8/2020 at two different but adjacent locations.

However, these samples are not indicative of high recreation. Instead, they serve as a baseline for summertime water conditions, without flood events in Oak Creek.

The geometric mean analysis (Table 1) shows Pine Flat, the farthest most upstream sample, had the lowest geomean and maximum values recorded for *E. coli* with 13.83 and 50.4 MPN/100 mL, respectively.

Oak Creek above the confluence (site “OCC” in Table 1) had the highest geomean of the four Tuesday sites. However, only four samples were collected for site “OCC” since it was added on the 12th week of water quality sampling. Just upstream of this sampling site is one of the first access points to Oak Creek along the West Fork Trail near the Mayhew Lodge Ruins (Figure 4). The trash data from West Fork and notes taken by the Ambassadors indicate there being frequent sightings of dog poop, both bagged and not bagged, near the ruins. Therefore, some sources of *E. coli* contamination could have occurred from people and dogs along the West Fork Trail.

West Fork above the confluence (site “WFC” in Table 1) had the largest maximum turbidity value, 14.4 NTU, of any of OCWC’s samples. Still below 20 NTU, it is worth noting since the water directly drains into Oak Creek. The samplers frequently noted the amount of green algae at the sampling site.

All 64 samples collected by OCWC are well below the state maximum of 235 MPN/100 mL (Figure 6). The highest *E. coli* value recorded came from West Fork at the Second Crossing (Figure 6). The sampler’s notes recorded that people crossed the creek while the sample was collected.

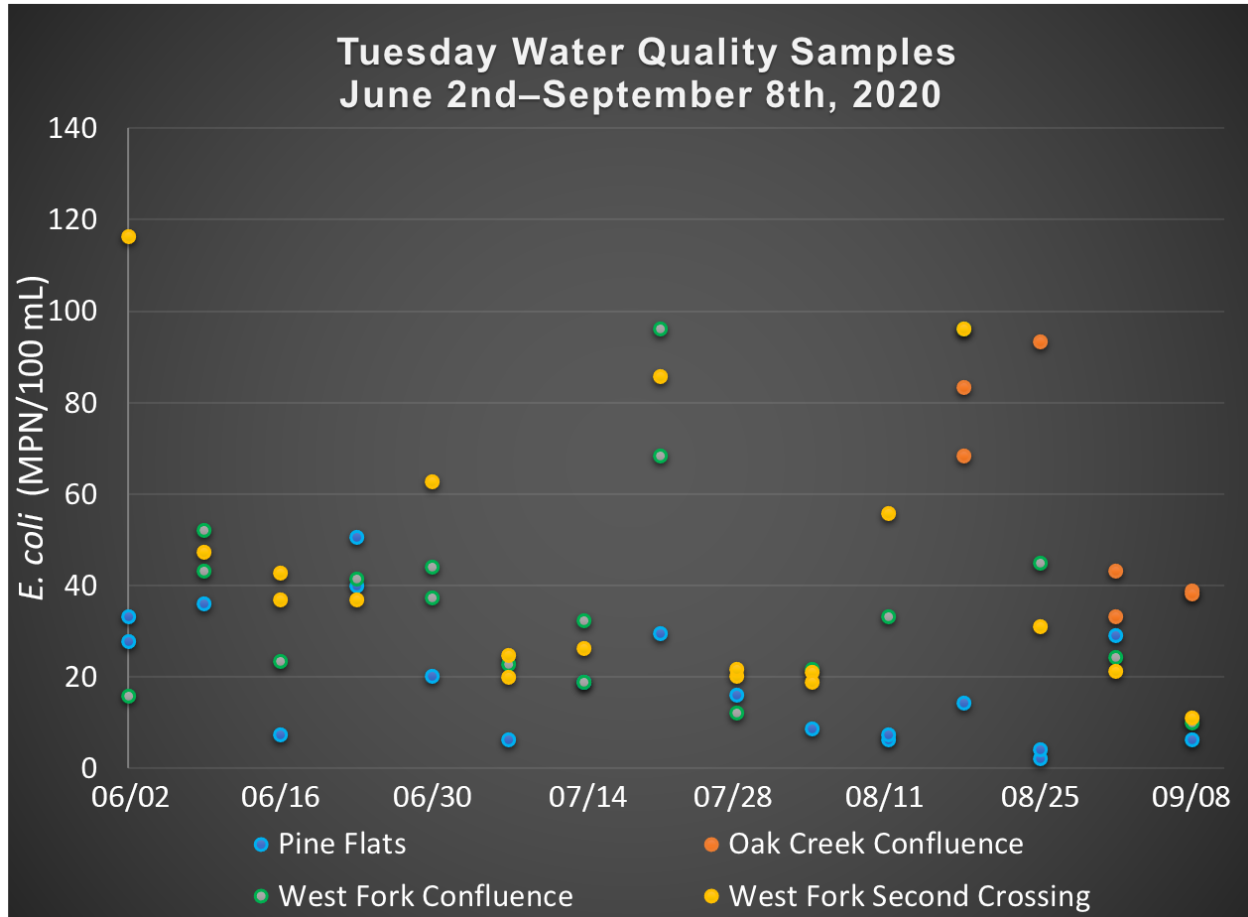


Figure 6. OCWC samples collected Tuesday mornings from June through September. Oak Creek Confluence site was added with only four sampling dates left.

OCWC data alone (Figure 6) show zero exceedances. But when looked at alongside SRSP data, there were two exceedances (Figure 7). Both exceedances were captured by SRSP on the same day and at sampling sites adjacent to each other.

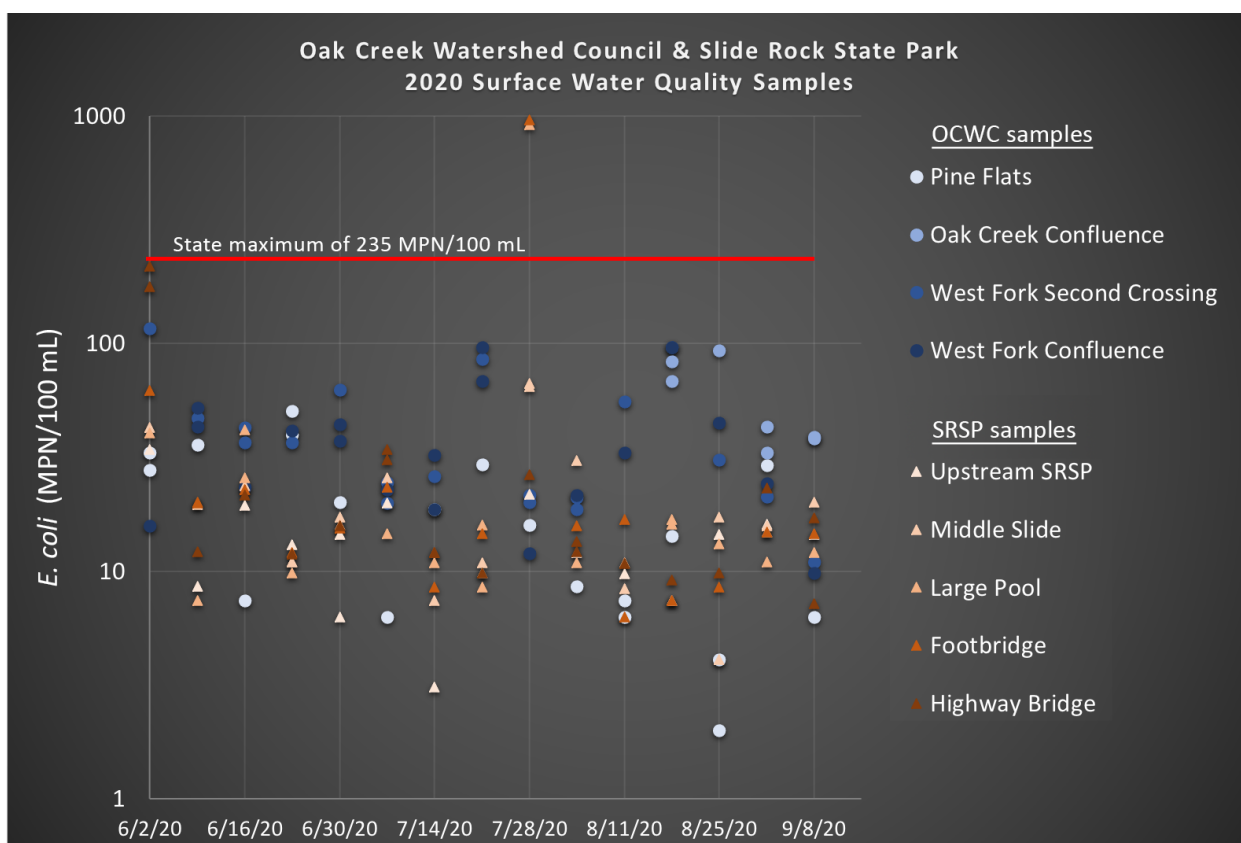


Figure 7. The graph shows all 148 water quality samples collected by OCWC and SRSP on a logarithmic scale.

Majority of the water quality samples collected were between 10 and 100 MPN/100 mL (Figure 7). There are a few samples that come close to being exceedances, captured on 6/2/2020, but are just below the 235 MPN/100 mL maximum. Two exceedances were captured at different locations that are just upstream and downstream of each site. It is possible the same source of *E. coli* bacteria was the cause for each exceedance. With OCWC and SRSP samples compared together as they are in Figure 7, it is apparent that for each day of sampling OCWC usually had higher concentrations of *E. coli* than SRSP collected.

Conclusions

During the 2020 season, our findings included:

- Weekend samples taken by OCWC showed exceedances for the standard of water quality for full body contact 11% of the time between May–September. Tuesday samples taken by OCWC and SRSP showed exceedances for the standard of water quality for full body contact 1% of the time.
- Analysis between weekday and weekend differences showed that *E. coli* numbers at all sites tend to be lower during off peak recreational time periods (weekdays).

During the entire study the percent of exceedances of *E. coli* bacteria found across all sites was 5%. That indicates that 95% of the data points analyzed from this study show water quality below and within the 235 MPN/100mL recreational water quality standard for *E. coli* in surface waters. This represents that the watershed, although highly utilized by human and wildlife traffic, measured *E. coli* bacteria exceedances less than 5% of the time between May and September 2020.

- Exceedances tended to happen more frequently during high-use holiday weekends but were not limited to holiday weekends since *E. coli* exceedances did occur on non-holiday weekends.
- Unprecedented visitation was observed by OCWC Ambassadors, local residents, and land managers alike. The increase in visitation is most likely due to the COVID-19 pandemic, restricting other activities, and work from home implementations.
- Weekend sampling is most useful in terms of understanding how recreation affects water quality.

Recommendations

Based on our findings and observations of increased visitation to Oak Creek, presence of trash, and overall stress Oak Creek and its watershed faces in terms of water quality, we recommend that continued and increased collaboration with stakeholders is key. This includes:

- Common messaging about leave no trace practices, that is inclusive for a diversity of people (i.e. signage in multiple languages), and focuses heavily on removing human-brought litter (including diapers, dog poop bags, glass bottles, and other food and packaging products).
- Consideration and regulations in regard to the capacity of people visiting Oak Creek and its watershed.
- Ongoing data collection for water quality sampling, trash and fecal matter collection, and visitor-use impact analysis.
- Projects that require collaboration from multiple agencies in terms of reaching the same goals and objectives. This may include providing more restroom areas for recreators, places to throw trash away, etc...
- Increase land stewardship for visitors and locals alike.
- Promote both youth and adult citizen science programs.

References

Blasch, K.W., Hoffmann, J.P., Graser, L.F., Bryson, J.R., and Flint, A.L., 2006, Hydrogeology of the upper and middle Verde River watersheds, central Arizona: U.S. Geological Survey Scientific Investigations Report 2005–5198, 102 p., 3 plates.