

Evaluating the Effectiveness of an Oak Creek Visitor Information Campaign



Sustainable
Cities
Network

Arizona State
University

Project Cities



A Summer 2022 –
Spring 2023 Collaborative
Project with Arizona State
University's Project Cities
& ADEQ's Water
Quality Division



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Project and Community Introduction

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This report represents original work prepared for ADEQ Water Quality Division by students participating in courses aligned with Arizona State University's Project Cities program. Findings, information, and recommendations are those of students and are not necessarily of Arizona State University. Student reports are not peer reviewed for statistical or computational accuracy, or comprehensively fact-checked, in the same fashion as academic journal articles. Editor's notes are provided throughout the report to highlight instances where Project Cities staff, ASU faculty, agency staff, or any other reviewer felt the need to further clarify information or comment on student conclusions. Project partners should use care when using student reports as justification for future actions. Text and images contained in this report may not be used without permission from Project Cities.

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**ADEQ
and Project Cities**

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To access the original student reports, additional materials, and resources, visit:

links.asu.edu/PCADEQOakCreek23S-22F

ABOUT PROJECT CITIES

The ASU Project Cities program uses an innovative approach to traditional university-community partnerships. Through a curated relationship over the course of an academic year, selected community partners work with Project Cities faculty and students to co-create strategies for better environmental, economic, and social balance in the places we call home. Students from multiple disciplines research difficult challenges chosen by the community partner and propose innovative sustainable solutions in consultation with staff and leadership. This is a win-win partnership, which also allows students to reinforce classroom learning and practice professional skills in a real-world client-based project. Project Cities is a member of Educational Partnerships for Innovation in Communities Network (EPIC-N), a growing coalition of more than 60 educational institutions partnering with local government agencies across the United States and around the world.

ABOUT SUSTAINABLE CITIES NETWORK

Project Cities is a program of ASU's Sustainable Cities Network. This network was founded in 2008 to support communities in sharing knowledge and coordinating efforts to understand and solve sustainability problems. It is designed to foster partnerships, identify best practices, provide training and information, and connect ASU's research to front-line challenges facing local communities. Network members come from Arizona cities, towns, counties, and Native American communities, and cover a broad range of professional disciplines. Together, these members work to create a more sustainable region and state. In 2012, the network was awarded the Pacific Southwest Region's 2012 Green Government Award by the U.S. EPA for its efforts. For more information, visit sustainablecities.asu.edu.

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Project Cities



ABOUT ADEQ WATER QUALITY DIVISION

The Water Quality Division (WQD) plays a vital role in safeguarding public health and the environment by ensuring the delivery of safe drinking water through public water systems and by managing both existing and potential sources of surface and groundwater contamination. WQD fulfills its mission through several key functions, including regulating the treatment and disposal of wastewater, conducting comprehensive evaluations of surface and groundwater quality statewide, pinpointing water pollution issues and formulating practical solutions for their resolution, granting permits to shield Arizona's waters from pollution originating from specific sources, investigating reports of violations and complaints in adherence to Arizona's water quality regulations, and actively mitigating nonpoint source pollution to protect our precious water resources.

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Leave No Trace

Sedona Chamber of Commerce & Tourism Bureau

Arizona State Parks & Trails

United States Forest Service & Department of Agriculture

City of Sedona

United States Environmental Protection Agency

Appreciate AZ



Clean Air, Safe Water,
Healthy Land for Everyone

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Arizona Department of Environmental Quality



Proud partner of
ASU Sustainable Cities
Network
Arizona State University

Project Cities

Oak Creek Canyon

About

The **Arizona Department of Environmental Quality (ADEQ)** is a state agency established by the Arizona State Legislature in 1987 under the Environmental Quality Act of 1986.

The agency is composed of three environmental programs: **Air Quality, Water Quality and Waste.**

ADEQ is responsible for administering state's environmental laws and delegated federal programs to prevent air, water and land pollution and ensure cleanup.

Agency Functions

- ◆ Planning
- ◆ Permitting
- ◆ Compliance management
- ◆ Monitoring
- ◆ Assessment
- ◆ Cleanups
- ◆ Outreach

"Our vision is to be the No. 1 state in the nation in: balanced, leading-edge environmental protection through technical and operational excellence, and radical simplicity for customers and staff"

Mission

- ◆ ADEQ supports environmentally responsible economic growth and provides Arizonans, businesses and communities with access to information and certain financial assistance programs.
- ◆ ADEQ supports equal access, meaningful involvement and fair treatment to all people regardless of race, color, national origin, or income, with respect to developing, implementing and enforcing environmental laws, regulations and policies that protect and enhance public health and Arizona's unique environment.
- ◆ ADEQ also offers opportunities for all individuals and communities to manage their environmental exposures through the comprehensive transparent data and resources we provide.

**Information from the ADEQ website*

ADEQ Programs

Air Quality



12 programs

Water Quality



11 programs

Waste Programs



12 programs

Other Programs



8 programs

ADEQ Water Quality Division

The Water Quality Division (WQD) protects and enhances public health and the environment by ensuring healthy drinking water is provided by public water systems and by controlling current and future sources of surface and groundwater pollution.

Mission Statement

Protect and enhance public health and environment by ensuring safe drinking water and reducing impact of pollutants discharged to surface and groundwater

Fossil Creek

Responsibilities:

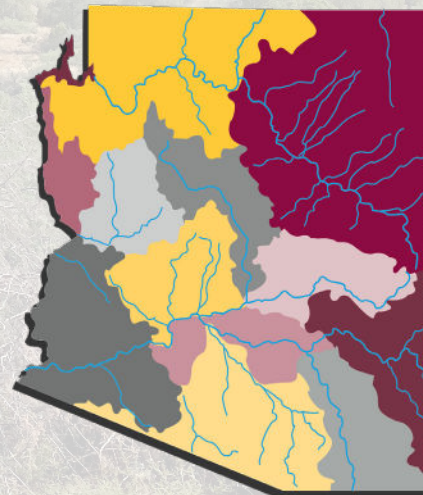
- ◆ Ensuring that Arizona's public water systems deliver safe drinking water.
- ◆ Managing the quality of water resources through partnerships within the natural boundaries of the state's watersheds.
- ◆ Regulating the discharge and treatment of wastewater.
- ◆ Monitoring and assessing the quality of surface and groundwater throughout the state.
- ◆ Identifying water pollution problems and establishing standards to address them.
- ◆ Issuing permits to protect Arizona waters from point sources of pollution.
- ◆ Investigating complaints and violations of Arizona's water quality laws, rules and permits

Water Quality Programs

- ◆ Arizona Water Watch
- ◆ Recycled Water
- ◆ Engineering Review
- ◆ Safe Drinking Water
- ◆ Groundwater Protection
- ◆ Surface Water Protection
- ◆ Monitoring Assistance
- ◆ Surface Water Monitoring & Assessment
- ◆ Operator Certification
- ◆ Watershed Protection
- ◆ Public Water System

Water Division Highlights

- ◆ **National Ground Water Association Outstanding Groundwater Remediation Project Award** for Expedited Site Characterization and Remediation of per- and polyfluoroalkyl substances (PFAS) in Groundwater Protects City of Tucson Drinking Water Wellfield in 2022
- ◆ **National Association of State Chief Information Officers (NASCIO) State Information Technology Award** for Digital Government: Government to Business Category: myDEQ Environmental Compliance Portal for Underground Storage Tank Compliance and Reporting Goes Digital in 2022
- ◆ **Arizona Forward Environmental Excellence Award of Distinction** for the Path to Protection at Oak Creek, a multi-year water quality restoration collaborative project in 2022
- ◆ **National Association of Environmental Professionals Environmental Excellence Award** for Best Available or Innovative Technology for developing and implementing tools that bring clarity and efficiency to protecting Arizona's surface waters under the federal Clean Water Act and new state program in 2022
- ◆ **Granicus Digital Government Difference Maker Award Finalist** for impacting the lives of Arizonans through Water Quality Assurance Revolving Fund (WQARF) Community Involvement in 2022
- ◆ **Environment + Energy Leader Top Product of the Year Award** for the Automated Surface Water Quality Assessment Tool in 2021
- ◆ **Granicus Digital Government Award for Superior Civic Engagement** for Automated Surface Water Quality Assessment Tool in 2021



The following report summarizes and draws highlights from work and research conducted by students in SOS 499/792 Sustainability Research for a Summer 2022 - Spring 2023 partnership between ASU's Project Cities and ADEQ Water Quality Division.

To access the original student reports, additional materials, and resources, visit:

links.asu.edu/PCADEQOakCreek23S-22F

EXECUTIVE SUMMARY

Nestled between Flagstaff and Sedona, Oak Creek Canyon is a staple in Arizona's tourism and recreation industries. With inflows from the Verde River, Oak Creek Canyon is a popular destination for both in-state and out-of-state visitors, with plenty of options for recreation, including camping, hiking, and swimming. As the City of Sedona draws in over three million visitors a year, the Canyon has become a popular tourist destination, bringing significant economic benefits to the local community while providing essential ecosystem services to regional water sources.

With an influx of visitors due to the COVID-19 pandemic, the watershed is affected by E. coli due to several pollutants, mostly caused by human activities. As visitors continue to visit the Canyon, they often leave behind trash, including diapers, which can then infiltrate and contaminate the watershed. After facilitating a series of community workshops and meetings regarding the issue of E. coli contamination in Oak Creek Canyon, key stakeholders, including the Arizona Department of Environmental Quality - Water Quality Division (ADEQ) and the City of Sedona, decided to partner with Leave No Trace to develop an educational communication campaign targeted at recreational users visiting Oak Creek Canyon. The campaign is targeted toward visitors and includes simple but effective messaging for visitors to reduce their environmental impact.

A graduate student from the School of Sustainability evaluated the campaign's effectiveness and visitor's awareness of issues in the Canyon in partnership with ASU Project Cities, starting with a pilot survey during the summer 2022 recreation season. Following the initial analysis of the campaign, undergraduate students participating in the Sustainability Undergraduate Research Experience (SURE) applied research program continued the study through fall 2022 and spring 2023. The students continued data collection with a revised survey and interviewed key community stakeholders to inform strategies and recommendations for managing E. coli contamination throughout Oak Creek Canyon.

While the students found that people recreating near water sources are relatively aware of the Canyon's water contamination risk, most recreation users do not identify E. coli as the source of water impairment. Generally, people on trails are less concerned about water quality issues, although all traces left while recreating in the watershed can potentially

enter Oak Creek. Overall, the students found high awareness about the main causes of water contamination related to recreational activities, except for diapers, and the good practices for improving water quality.

Visitors indicated the need for more education and infrastructure, such as garbage cans, pet stations, and restrooms. Based on the interviews with key stakeholders, students identified a critical need for more structured cooperation and communication among stakeholders to address water quality concerns in Oak Creek Canyon. Through greater collaboration, stakeholders can take a targeted approach to addressing issues in the Canyon through educational messaging and improved infrastructure.

KEY STUDENT RECOMMENDATIONS

Recommendations for future educational campaigns

- Target educational campaigns to people specifically recreating on trails.
- Focus communications to individuals visiting the Canyon from outside of Arizona.
- Utilize physical campaign materials, such as posters and flyers, more actively along with social media campaigns.
- Focus educational campaigns on the impacts of E. coli on the local environment, particularly related to human and animal feces.
- Increase awareness and reach of the information campaign by placing Leave No Trace signage next to trail maps.
- Increase the presence of trail stewards who can further educate behavioral campaigns to visitors in face-to-face settings.

Recommendations for infrastructure

- Increase waste collection frequency and strategically place additional receptacles in Oak Creek Canyon.
- Improve pet waste stations to provide bags, waste receptacles, and relevant information from the Leave No Trace campaign.

Recommendations for stakeholder engagement

- Improve cooperation and communication among stakeholders by increasing engagement opportunities.

ARIZONA DEPARTMENT OF ENVIRONMENTAL QUALITY PROJECTS: ALIGNMENT WITH THE UNITED NATIONS'

SUSTAINABLE DEVELOPMENT GOALS

As the leading international framework for sustainable decision-making, the 17 Sustainable Development Goals (SDGs) lay out a path for partnerships toward global peace and prosperity. The SDGs provide a set of goals and metrics for project impact to be measured, offering an illustration of the benefits experienced by the cities, towns, and students who participate in a Project Cities partnership. For details on the SDGs, visit sdgs.un.org/goals



Every project in the PC program aligns with SDGs 11 and 17.



SUSTAINABLE DEVELOPMENT GOALS

17 GOALS TO TRANSFORM OUR WORLD



TOP THREE GOALS ADDRESSED IN THE FOLLOWING REPORT

This study examines the effectiveness of a communication campaign targeted at Oak Creek Canyon recreation users to educate them about the environmental impacts of littering in the Canyon, particularly on water quality. Students surveyed recreation users to determine the effectiveness of a Leave No Trace campaign in changing future behaviors.



Goal 6: Clean Water and Sanitation

"Ensure availability and sustainable management of water and sanitation for all"

Reducing recreation user waste in the Canyon will lessen water quality impacts, improving public health and sanitary conditions.



Goal 12: Responsible Consumption and Production

"Ensure sustainable consumption and production patterns"

Educating recreation users about the impacts of waste, particularly diapers and feces, reduces ecological strains on the Canyon while encouraging responsible consumption behaviors.



Goal 15: Life on Land

"Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss."

This project advances ADEQ's efforts to restore and conserve ecosystems in the Canyon.

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PART 2:

Oak Creek Recreation Study

**MEASURING THE EFFECTIVENESS OF AN INFORMATION
CAMPAIGN ON OAK CREEK CANYON RECREATIONAL VISITORS**

**SOS 499: SUSTAINABILITY RESEARCH &
SOS 792: RESEARCH**

SCHOOL OF SUSTAINABILITY

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INTRODUCTION

Preserving a clean environment is crucial for the well-being of the Sedona and Oak Creek Canyon communities. The natural amenities in the area play an important role in economic life, ecosystem services provision, wildlife protection, and human health. The Oak Creek waters combine with the Verde River, flowing into the Salt River. Farming activities, businesses, and people operating along this course rely on these rivers for their needs, such as water supply and revenues in recreational activities related to these natural amenities. Recreational activities in the Oak Creek Canyon can increase environmental stressors, particularly littering, impacting water quality. Finding ways to keep Oak Creek clean and to balance the benefits gained from tourism with the harms related to littering and impairment of water quality is crucial for the prosperity of the Sedona community.

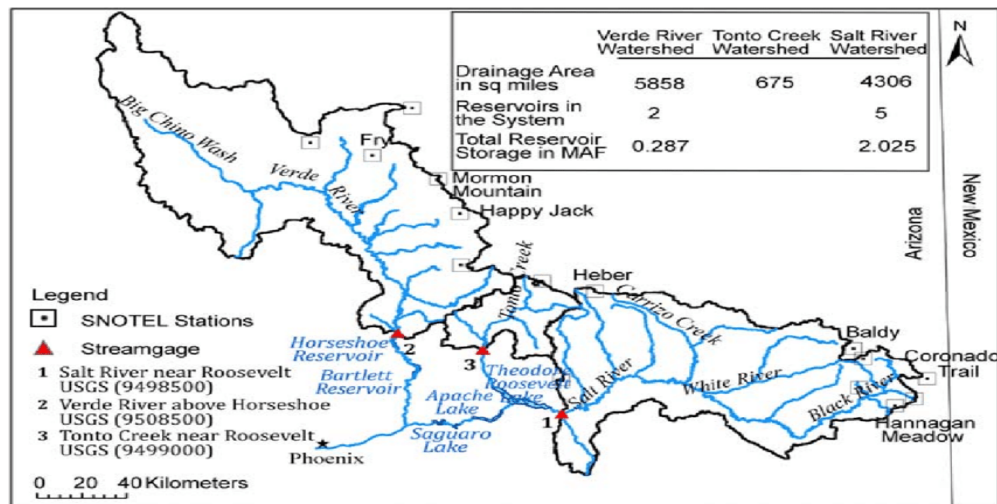


Figure 1 Map of the Verde and Salt Rivers

Editor's Note

The Sedona Sustainability Tourism Plan was released in 2019 to outline strategies for the sustainable management of Sedona's recreational sites. The Plan establishes four pillars of sustainability, including the environment, quality of life, tourism economy, and visitor experience.

In 2023, the City of Sedona launched its Tourism Advisory Board, a voluntary body of stakeholders to advise city council and staff related to tourism strategic planning, marketing, and programming.

Sedona is one of the main tourist attractions in Arizona. The Sedona community is relatively small, with 9,800 residents compared to the three

million visitors that stop by the area (Sedona, Arizona, 2023). Among these, almost 75% visit the Canyon for recreational purposes (Sedona, Arizona, 2019). Tourism is a pillar in the economic life of the Canyon, bringing one billion dollars to the region. Visitors generate 77% of the City's sales and bed taxes revenue, and the tourist industry supports over 10,000 jobs in Sedona, generating \$240 million in wages. The flow of tourists in the region provides significant economic benefits to the community. Still, a recent survey conducted for the Sedona Sustainability Tourism Plan showed that homeowners have differing opinions regarding the presence of tourism in the community, with half of the respondents in favor of the economic benefits that tourism brings, while the other half do not like the traffic and environmental degradation associated with tourism.

Editor's Note

Leave No Trace is a program of the Arizona Office of Tourism and the Leave No Trace Center for Outdoor Ethics. The partnership seeks to promote sustainable tourism throughout the state through environmental and sustainability education.

Governmental organizations, like the City of Sedona and ADEQ, implement programs for maintaining water quality with watershed improvement projects. At the same time, the Chamber of Commerce focuses on the City's economic life and the tourism industry. State and Federal Parks manage the natural amenities, and non-governmental organizations, like the Oak Creek Watershed Council, contribute to the environmental well-being with clean-up activities and citizen science projects with ADEQ for monitoring water quality and littering.

Environmental stress is one of the potential downsides of the high inflow of people in the Canyon, which can impact the ecology, especially water quality. Since the Canyon is a watershed, any traces that recreational users leave, such as litter, human and animal feces, can eventually end up in the water. Oak Creek is cyclically experiencing levels of *E. coli* in the water, which can harm people recreating in the water and lead to the temporary closure of recreation sites. Previous reports from ADEQ (2010) and the Oak Creek Watershed Council (2012) showed patterns of exceeding the federal maximum levels allowable of *E. coli* (235 MPN/100ml) during peaks of recreation activities, like high-use weekends in July. The impact of human activity on water quality is not only suggested by the correspondence between high usage periods and *E. coli*. DNA analysis of water during base flow conditions revealed that, on typical days, around 30% of *E. coli* is due to human-related sources (human, dog, horse, and cow feces). However, human contributions to *E. coli* on individual days can range between 0 to 70% (ADEQ, 2012). Those high human contributions coincide with busy tourist weekends.

To address the issue of water contamination and, more generally, littering, ADEQ launched a communication campaign targeting recreational visitors to promote behavioral changes in the Canyon. To develop this intervention tool, ADEQ collaborated with Leave No Trace to design an online communication campaign according to the needs of the City, Oak Creek Watershed Council, the Chamber of Commerce, and ADEQ. The ASU Project Cities team developed a survey to measure the reach and impact of this campaign.

LITERATURE REVIEW

Behavioral research has focused on the causes and the context under which people litter to detect effective anti-littering strategies. Scholars have identified factors that can increase littering behavior including low levels of perceived self-efficacy and locus of control, procrastination, lack of infrastructure, lack of sanctioning tools and anti-littering signs (Rangoni & Jager, 2017; Khawaja & Shah, 2013), and lack of norm in use (Cialdini et al., 1990).

Littering in National Parks is increasingly becoming an issue. The rising numbers of recreational users in natural areas contribute to the pressure on the environment, and new visitors bring habits similar to the ones they use in urban-park settings, where littering is more tolerated, and trash receptacles are more available (Brown et al., 2010).

Many protected areas invest in persuasive communication to influence visitors' behavior to address this challenge. Communication strategies are widely employed for cost efficiency (Brown et al., 2010). A common assumption is that problematic behavior is due to misconceptions; thus, educational efforts are made to inform visitors and change their behavior.

The development and assessment of communication campaigns are often made using the **Theory of Planned Behavior (TPB)** (Backman et al., 2018). **TPB** promotes a conceptual framework that identifies the cognitive structures involved in decision-making, such as attitudes, normative pressure, and perceived self-efficacy. These structures shape intentions, which precede actions and thus might predict behavior.

Measuring the effectiveness of communication on behavior can be challenging. Firstly, when evaluating an intervention's impact, the results' reliability is tied to the sampling procedures, namely the opportunity to compare groups that are identical except for the exposure to the intervention and the ability to identify all the factors that could affect the response. Secondly, when using social surveys, researchers rely on self-reported measures that do not guarantee that the intervention was effectively delivered and received by subjects and only allow measuring behavior proxies. Studies about the effectiveness of mass communication campaigns for educational purposes, such as public health and risky behavior, showed additional complexities (Alcalay, 1983). Modifying behavior that is embedded and originates from imitation or attitudes is difficult to achieve with only exposure to communication. Usually, communication effectiveness happens when the messages reinforce preexisting values and behavior (Alcalay, 1983). Communication can increase information about a subject, but this might not change attitudes or behavior. Communication effectively achieves small behavioral changes among those who have previously recognized and accepted a need for change.

Editor's Note

The [Theory of Planned Behavior](#) expands on the [Theory of Reasoned Action](#). The [Theory of Reasoned Action](#) considers an individual's pre-existing attitudes and behavioral intention to predict behaviors. The [Theory of Planned Behavior](#) includes a third variable, perceived behavioral control, as part of the predictive model.

The [mental model](#) approach is another approach for understanding decision-making processes without relying on predictive behavioral models like TPB, which focuses on the impact of communication on intentions. Mental models are the cognitive structures that are the basis of reasoning and decision-making; and are constructed by individuals from experience, perception, and their understanding of the world; they are dynamic and evolve through learning (Jones et al., 2011); thus, they can be shaped and updated when new information is available. Mental models are useful to elicit when testing the impact of communication and risk communication campaigns, which usually leverage on showing cause-and-effect dynamics. Mental model elicitation techniques are highly used to understand people's behavior when interacting with the environment and to detect misconceptions of naïve thoughts (Morgan et al., 2002). A mental model approach was adopted to show a causal

relationship between behavior and water quality.

Visitors make their decisions related to littering within the context of actions of various other actors, such as the tourist sector, governmental regulation, and land stewards. The various actors are in a so-called “action arena” in which they interact and make decisions, leading to different possible outcomes (Ostrom, 2005). To understand the context in which visitors make their decisions, the study seeks to understand the perspective of the various actors in the Oak Creek Canyon context through interviews with a selection of stakeholders with commercial, environmental, or governmental interests.

RESEARCH METHODS

The Leave No Trace communication campaign aimed to raise awareness of the effect of recreational users’ behavior—littering, human and animal feces—on water quality, emphasizing causal links between *E. coli* and littering. A mental model approach was used to see whether there were misconceptions or lack of awareness in people’s understanding of the problem of environmental degradation in the canyon and test the campaign’s effectiveness in shaping and refining people’s mental models.

A social survey (Appendix 1) was distributed to collect information about mental models and users’ preparedness in outdoor recreation, as well as demographics to help gather more updated data about the population of recreators in Oak Creek Canyon. Using a mental model framework (Findlater et al., 2019), the survey gathered information about three dimensions: awareness of the problem (*E. coli*), its causes, and effective mitigation strategies. Respondents were asked to rank the top three risks they think they face while recreating (awareness of *E. coli*), rank the top three contributors to water contamination (awareness of *E. coli* causes), and the effectiveness of mitigation strategies (good practices to reduce the impact of human activities on water contamination).

The survey was developed in English and Spanish to reach a broader pool. Data were collected between July and August 2022 at Slide Rock State Park to reach people recreating near the water and at the two shuttle stops in Sedona to reach people heading the trails. Surveys were collected in person, and disseminated QR codes in these locations,



Figure 2 Leave No Trace 2022 information campaign poster (English)



Figure 3 Leave No Trace 2022 information campaign poster (Spanish)



Figure 4 Leave No Trace 2023 information campaign social media carousel slides

allowing people to scan the codes and take the survey on their phones, with 90 total responses with a non-probabilistic sampling procedure (convenience sampling).



Figure 5 Project Cities research team distributing surveys in Slide Rock State Park during summer 2022

In March and April 2023, a slightly adjusted version of the survey (Appendix 2) was used to reduce the length to completion during four consecutive Saturdays to do in-person surveys at the Bell Rock and West Fork Trailheads. The survey was shortened based on feedback from the summer 2022 surveys, with an added open question on the perceived barriers to keeping Oak Creek Canyon clean. During spring 2023, 111 completed surveys were collected. In addition to collecting surveys during March and April 2023, students performed nine interviews via Zoom with diverse stakeholders with commercial, environmental, or governmental interests (Appendix 3). During the interviews, respondents were asked questions about the perceived problems with tourists in Oak Creek Canyon, the impact of tourism on water quality, and the potential solutions to improve water quality. All interviews are anonymized following the ASU's IRB rules on privacy protection.

FINDINGS & ANALYSIS

Recreational users' awareness of water quality issues

The base assumption for an individual's mental model about water quality and E. coli included three components: risk perception—as a measure of the awareness of E. coli as a problem, awareness of causes of water contamination, and awareness of good behavioral practices—how

Awareness	Location/Year		
	Slide Rock (2022)	Trails (2022)	Trails (2023)
E. coli	17.5%	17.5%	6.3%
Dirty water	34.9%	3.7%	17.1%

Figure 6 Awareness of *e. coli*

were compared according to the location where people were recreating (Slide Rock and Trails) as a proxy of the type of recreational users (hikers vs. swimmers) to see if there were differences in perception related to the activities performed.

About 50% of Slide Rock’s respondents indicated contaminated water, such as getting sick from *E. coli* or dirty water, among the top three risks they can face while recreating; however, there is low awareness about *E. coli* specifically (Figure 6). Moreover, people recreating on trails have lower awareness about the risk of getting sick from dirty water. It is unknown whether the information campaign caused increased awareness by visitors on the trails in 2023.

Respondents were asked to indicate the top three contributors to water contamination and whether they knew the impact of littering and pollutants related to recreational activities on Oak Creek water quality (Figure 7). Respondents seem aware of the effect of litter and feces on water quality. However, regarding diapers explicitly mentioned by the Leave No Trace communication campaign as one of the contributors to water contamination, respondents were less likely to list them among the top three contributors to water contamination. Diapers were even less frequently mentioned than control factors “Wastewater treatment plants” and “Livestock waste,” which are less concerned with Oak Creek Canyon.

Both groups have a high awareness of good practices of the impact of recreational activities on water quality (mean above four on a Likert scale, indicating agreement), having a similar understanding of the impact of their actions on water quality (i.e., the effectiveness of mitigation strategies (Figure 8)).

Item ranked among top 3 contributors	Summer 2022 (90 surveys)	Spring 2023 (111 surveys)
Litter	77%	77%
Dog poop	39%	62%
Human poop	38%	25%
Septic Systems	36%	25%
Wastewater Treatment Plans	34%	23%
Livestock Waste	32%	32%
Diapers	29%	18%

Figure 7 Main contributors to water contamination

	Mean		
	Slide Rock (2022)	Trails (2022)	Trails (2023)
Use of public toilets facilities	4.08	4.07	4.43
Use of trash receptacles	4.26	4.30	4.65
Packing out trash	4.30	4.48	4.67
Use of designated trails	4.13	4.59	4.38
Picking up dog poop	4.30	4.41	4.71
Picking up diapers	4.49	4.54	4.71
Avoid feeding wildlife	3.39	4.19	4.24
Avoid fishing	3.13	3.00	3.17
There is nothing I can do	1.90	1.85	1.49

Figure 8 "Please indicate how effective the following solutions can be in improving Oak Creek water quality"

	Exposure to messaging (2022)		Chi-Square Test	Exposure to messaging (2023)		Chi-Square Test
Awareness	Yes	No	p	Yes	No	p
Water contamination (<i>E. coli</i> or dirty water)	34.1%	37.2%	0.77	22.4%	19.2%	0.68
<i>E. coli</i>	9.1%	17.4%	0.25	6.9%	5.8%	0.81

Figure 9 General awareness

	Exposure to LNT messaging 2022		Chi-Square Test	Exposure to LNT messaging 2023		Chi-Square Test
	Yes	No	p	Yes	No	p
Awareness of the impact of litter	77.3%	63%	.14	70.7%	80.8%	.22
Awareness of the impact of dog poop	40.9%	37%	.70	58.6%	65.4%	.47
Awareness of the impact of human poop	25%	50%	.014	25.9%	23.1%	0.12
Awareness of the impact of diapers	27.3%	30.4%	0.74	19%	17.3%	0.82

Figure 10 Awareness

Exposure to the campaign	Mean		SD		T Test		
	Yes	No	Yes	No	t	p	d
Use of public toilets facilities	4.09	4.02	.971	.988	t(84)= -.330	.742	-.071
Use of trash receptacles	4.47	4.07	.667	1.078	t(84)= -2.045	.044*	-.441
Packing out trash	4.43	4.28	.818	.854	t(85)= -.852	.397	-.183
Use of designated trails	4.26	4.26	.912	.902	t(83)= -.031	.975	-.007
Picking up dog poop	4.40	4.31	1.003	1.070	t(83)= -.381	.704	-.083
Picking up diapers	4.49	4.54	.809	.636	t(86)= -.573	.568	-.132
Avoid feeding wildlife	3.86	4.12	1.138	1.138	t(83)= .826	.297	-.228
Avoid fishing	2.93	3.26	.997	1.127	t(82)= 1.435	.155	.334
There is nothing I can do	1.92	1.71	.984	1.154	t(79)= -.873	.385	-.194

T-test for independent samples, p<.05*

Figure 11 Awareness of mitigation strategies (2022)

Exposure to the campaign	Mean		SD		T Test		
	Yes	No	Yes	No	t	p	d
Use of public toilets facilities	4.44	4.44	.708	.725	t(107)= -.027	.898	.716
Use of trash receptacles	4.67	4.62	.512	.690	t(107)= .443	.150	.604
Packing out trash	4.66	4.67	.690	.550	t(108)= -.149	.534	.628
Use of designated trails	4.36	4.38	.852	.844	t(108)= -.139	.652	.848
Picking up dog poop	4.79	4.62	.590	.631	t(107)= 1.48	.030*	.610
Picking up diapers	4.75	4.65	.689	.683	t(107)= .764	.272	.686
Avoid feeding wildlife	4.21	4.25	1.048	1.046	t(107)= -.197	.848	1.047
Avoid fishing	3.24	3.10	1.186	1.053	t(105)= .645	.224	1.123
There is nothing I can do	1.59	1.40	1.043	.774	t(101)= 1.02	.079	.917

T-test for independent samples, p<.05*

Figure 12 Awareness of mitigation strategies (2023)

The Effect of Leave No Trace Communication Campaign

There is no strong empirical evidence yet on the statistical correlation between information campaigns and visitors' awareness of water quality issues. There were no differences in the awareness of the risk of water contamination (Figure 9 and 10) and of contributors of water contamination related to recreational activities, such as littering, human and pet waste, and diapers, among people that self-reported that they were exposed to the information campaign (Figures 9-12).

The information campaign is significantly correlated with visitors' awareness of trash receptacles and dog waste removal (Figure 8 and 9).

The results need to be cautiously interpreted to understand the effect of information campaigns on visitor attitudes and behaviors. The general statistical insignificance of this analysis might be attributed to several factors, including sample size and sampling procedure (non-probabilistic). A delay in the delivery of the information campaign in 2022 might also have affected the results. Also, some respondents could have confused the Leave No Trace campaign with other educational messaging that already existed in the canyon. Nevertheless, the results are consistent across the two data collection periods; namely, information campaign is not statically correlated with the awareness of most mitigation strategies. More careful research design is needed to identify information campaigns' causal effects on visitor's mitigation awareness. In both years, the respondents did not agree with the statement, "there is nothing I can do."

53% of respondents declared to have been exposed to the messaging (Figure 12). Although the campaign was designed for social media, respondents' attention was mainly grabbed by posters and flyers disseminated in the canyon, visitor centers, and near trailheads (Figure 11).

		n (2022)	%	n (2023)
<i>Age</i>	18-24	22	24.4%	15
	25-34	18	20%	28
	35-44	14	15.6%	22
	45-54	20	22.2%	19
	55-64	9	10%	16
	Above 64	5	6.5%	9
	Prefer not to answer	2	2.2%	1
<i>Education</i>	Some high school	3	3.3%	2
	High school diploma or equivalent	18	20%	4
	Some college	22	24.4%	14
	Associate degree	14	15.6%	7
	Bachelor's degree	18	20%	44
	Post-graduate degree	15	16.7%	39
<i>Gender</i>	Male	34	37.8 %	44
	Female	53	58.9%	65
	Prefer not to answer	3	3.3%	1
	Other	0	0 %	0
<i>Language (survey)</i>	English	77	85.6%	111
	Spanish	13	14.4%	0
<i>Hometown</i>	Sedona	2	2.2%	7
	Yavapai County	1	1.1%	6
	Coconino County	1	1.1%	10
	Maricopa County	32	35.6%	25
	Pima County	5	5.6%	0
	Rest of Arizona	7	7.8%	7
	Outside of Arizona	37	41.1%	51
	Outside the USA	5	5.6%	7

Figure 13 Demographics

	2022	2023
Facebook	5%	7.5%
Instagram	10%	5.3%
Poster	24%	18.1%
Friends and Family	4%	2.1%
All Trails App	16%	13.8%
Sedona Shuttle	8%	6.4%
Visitor Center	23%	10.6%
Local Transit	3.5%	2.1%
Local Business	5%	4.3%
Trails	-	24.5%

Figure 14 Information campaign reach by media

	Slide Rock (2022)		Trails (2022)		Trails (2023)	
	n	%	n	%	n	%
Exposed	28	45.9%	16	61.5%	59	53.2%

Figure 15 Information campaign reach

Most of the respondents are from the Phoenix area and from outside Arizona. Despite delivering a Spanish version of the survey, only 13 Spanish speakers were engaged due to the difficulties in interacting with Spanish speakers while distributing the survey in 2022. During the spring 2023 surveys, no Spanish speakers filled out the Spanish version of the survey. In the 2023 survey, an open-ended question on barriers to keeping Oak Creek Canyon Clean was added. The responses were grouped into different categories, including “more trash receptacles,” “lack of knowledge,” “unpreparedness,” “lack of concern,” and “overtourism” (Figure 16). The most frequent response was the call for more trash receptacles.

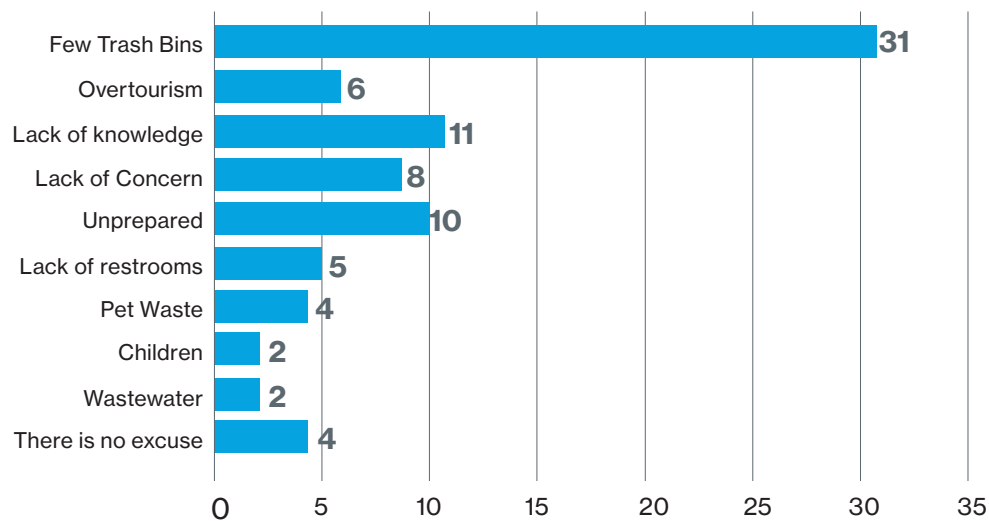


Figure 16 Barriers to keeping Oak Creek Canyon clean in Spring 2023 survey.

	Policy	Infrastructure	Education	Social
<i>Environmental Interests</i>	Seek collaboration with other entities to help enforce applicable laws.	Increase existing infrastructure (example, trash receptacles).	Share more information to educate visitors	Encourage visitors to understand the impacts of their actions.
<i>Governmental Interests</i>	Increase funding for entities concerned with Oak Creek	Promote collaboration among stakeholders to share information and access.	Educate more tourists visiting areas and the overall public.	Community collaboration and support to promote solutions.
<i>Commercial Interests</i>	Enforce rules and regulations	Increase access to resources	Fine-tune and adjust visitor education	Improve cooperation with key governmental actors.
<i>Common Solutions</i>	Partnerships for better enforcement and support	Increase access to necessary infrastructure	Education of visitors and the overall public.	Community sharing and collaboration to support change.

Figure 17 Summary of Stakeholder Perceptions in Four Key Dimensions

Stakeholder Perceptions

During Spring 2023, nine interviews were conducted via Zoom with key stakeholders around Oak Creek Canyon, including environmental, governmental, and business organizations. These organizations represent environmental, tourism, local business, and conservation interests. These interests are not mutually exclusive based on organizational affiliation.

Environmental Interests

Interviewees suggest that one key solution to promote behavioral change is to extend and strengthen collaboration with relevant stakeholder groups (1.s.a, 3.g.a, 4.c.a). One interviewee suggests they must foster collaboration with the community, homeowners associations, and other local businesses. However, they have difficulty doing this due to a lack of funding and autonomy (1.s.a). This sentiment is also identified from business interests. The other interviewee also reports needing more conversation with relevant government entities, such as the Forest Service and Arizona Department of Transportation, about road closure and littering enforcement issues (4.c.a). Retired community members are important assets to promote watershed health, and stakeholders may more actively engage with them for visitor education and information campaigns.

Interviewees also suggest that smart infrastructure should be continuously invested as it has been. For information campaigns to positively affect visitors' behaviors, public infrastructure such as restrooms and pet waste stations must be more accessible (1.s.a). The other interviewee further suggests that hard infrastructure alone cannot solve the behavioral problems and that other soft infrastructure, such as human-to-human education or well-targeted information strategy, should be simultaneously implemented to affect outcomes (8.a.a).

Education will continue to be an important tool for positive behavioral change. Experiential evidence suggests that human-to-human education is the most effective tool for change. Social trails have negatively affected the watershed's ecology, but many visitors do not recognize this issue. Thus, environmental groups believe that education will bring positive change.

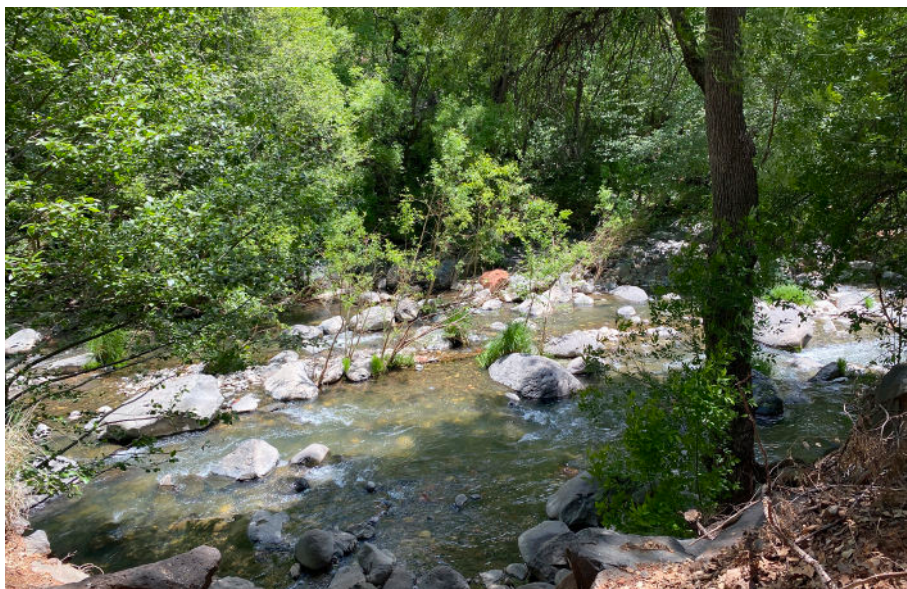


Figure 18 Oak Creek Canyon

Governmental Interests

Government entities tend to work on issues within their jurisdiction (8.a.a, 6.c.b., 7.b.a). They collaborate with a handful of organizations to mitigate littering problems. ADEQ has served as an important organization to coordinate issues related to behavioral change. Their role will be crucial to mobilizing more effective collaboration across administrative jurisdictions.

Governmental entities at various levels also recognize that hard infrastructure alone cannot solve the problem (8.a.a). Visitors need to understand why littering behavior is detrimental to watershed health because they may have unconsciously behaved in certain ways (8.a.a).

Government organizations continue to work with the Leave No Trace program by educating new employees and visitors (6.c.b). Social media has also been actively used to educate visitors about why various rules constraining behaviors are devised and enforced. They also know that many first-time visitors are less informed and educated about these issues; therefore, there is a need and strategy for educating first-time visitors.

Commercial Interests

Business interests, in general, are interested in issues directly related to their businesses, such as development and traffic. However, they are also willing to actively engage with government and non-governmental partners to manage water quality issues (4.c.a., 9.s.c). They suggest that more active enforcement is needed to bring desirable behavioral change.

They are willing to work with governmental and non-governmental organizations to coordinate water quality, quantity, traffic, and development issues. One non-profit organization suggests they are well-connected with the business community and have worked with them on trash pick up and fundraising for trail improvements (3.g.a).

Local businesses suggest various solutions based on their day-to-day observations around the Canyon. One interviewee suggests that there is no sign that visitors can be aware of environmental issues when they come into the Canyon (9.s.c). The other interviewee suggests potential issues around third-party management of trails and implications for visitor behaviors (4.c.a).

Summary Of Quantitative and Qualitative Analysis

Evidence from the quantitative and qualitative analysis shows that the information campaign alone cannot change visitors' awareness, attitudes, and behaviors in Oak Creek Canyon. There is limited statistical evidence of the effectiveness of information campaigns on visitors' awareness of problem attribution and mitigation strategies. Qualitative interviews further suggest that information campaigns should work simultaneously with visitor education, infrastructure provision, and enhanced collaboration among existing and new partners.

Quantitative results reveal that information campaigns should consider several key factors in the design and spread of information. Descriptive statistics show that information campaigns may consider strategies to reach new visitors outside Arizona. Information campaigns can fine-tune and adjust existing messages considering such factors. Qualitative evidence suggests that key non-profit organizations like the Sedona Chamber of Commerce can help promote messages to broader populations using their existing communication channels. Qualitative findings also show that a considerate and "smart" information campaign

is needed rather than just increasing the number of signage.

Greater collaboration among existing and new partners will improve the overall effectiveness of information campaigns and thus promote positive behavioral change. Stakeholders tend to work with a handful of other stakeholders within their jurisdictions. Filling gaps in the collaboration network can better spread, coordinate, manage, and target visitors' information. Thus, managing watershed problems across administrative jurisdictions may be better managed with integrated collaboration.

RECOMMENDATIONS

While visitors show decent levels of awareness about water contamination issues in the Oak Creek Canyon, some resource users have blind spots about some factors impacting water quality, including diapers. Based on the demographic characteristics of potential audiences, the following recommendations can inform future information campaigns:

- Information campaign needs to include information about multi-source contamination, given that the multiple items driving water contamination in Oak Creek.
- Focusing on information campaign strategy to recreational trails since a significant portion of visitors receives information on the trails. People recreating on trails are also less aware of water contamination risks
- The online campaign needs to target visitors from Maricopa County and other states in the U.S. since they comprise the majority of visitors
- While social media campaigns should still be relevant, placing posters and flyers in visitor centers and trails can still be the most effective way to grab the attention of visitors. Survey evidence indicates that respondents are less exposed to social media messaging than to physical media.
- Beyond information campaign, stakeholders should continue to strengthen hard and soft infrastructure including trash receptacles and educational campaigns to improve the environmental quality of the Canyon.

Our finding is coherent with existing environmental behavioral research that information is “one” of the factors that contribute to positive behavioral change, but then there are other factors that simultaneously shape environmental behaviors (e.g., hard and soft infrastructure) (Settina et al. 2020). Despite the limitation of the information campaign, our results show that there is a decent level of awareness on risk perceptions and mitigation strategies among visitors.

In spring 2023, the research was extended to broader stakeholders. Littering is part of the broader issue of environmental degradation, an example of collective action problem, where individuals have incentives to “free ride” on community effort. One of the ways to address collective action problems is to foster collaboration among stakeholders (Ostrom, 1990): a clean environment is a common good that involves all the community members and requires their coordination. Based on the interviews, the students recommend:

- Increasing waste collection frequency and strategically placing additional receptacles.
- Improving pet waste stations to provide bags, waste receptacles, and relevant information from the Leave No Trace campaign.
- Increasing awareness and reach of the information campaign by placing Leave No Trace signage next to trail maps.
- Increasing the presence of trail stewards who can further educate behavioral campaigns to visitors in face-to-face settings
- Improve cooperation and communication among stakeholders by having regular open meetings among the relevant stakeholders

CONCLUSION

An information campaign is a cost-effective policy tool to promote positive behavioral change. While the causal effect of the information campaign is still unknown, we find that there is high awareness about the causes of water contamination and the good practices for improving water quality among visitors. We find a statistically significant correlation between information exposure and a few dimensions of visitor awareness of water contamination. We also found heterogeneity among

visitor perceptions about water quality problems. People recreating near the water source are well aware of water contamination in the Canyon, whereas people recreating on trails are less aware of this issue. Future research should lay out more careful research design to test the causal effect of information campaigns on attitudinal and behavioral outcomes.

We also provided a set of policy recommendations to relevant stakeholders for future endeavors based on empirical evidence. First, we recommend that information campaigns can be further targeted to specific groups and modified to address complex problems in a cost-efficient manner. We also suggest that an information campaign is one tool in the toolkit, thus relevant stakeholders should consider how to mix and match different tools to bring positive behavioral change. We also believe that continued infrastructure investment and the inclusion of relevant stakeholders are important strategies to be added to the existing policy strategy.

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To access the original student reports, additional materials, and resources, visit:

links.asu.edu/PCADEQOakCreek23S-22F

APPENDIX 1

Survey questions Summer 2022

1. How long are you staying in the Sedona region?
 - a. One day
 - b. One night
 - c. A couple of days
 - d. Week
 - e. Resident

2. How often do you visit Oak Creek?
 - a. First visit
 - b. Every few years
 - c. Once a year
 - d. 2-5 times a year
 - e. More than 5 times a year
 - f. Every week
 - g. Other (please specify)

3. How many people are visiting Oak Creek with you today (including you)?

4. Which part of Oak Creek are you planning to visit (Select all that apply)?
 - a. Campground (Manzanita, Cave Springs, Pine Flat)
 - b. Slide Rock State Park
 - c. West Fork/Call of the Canyon
 - d. Red Rock State Park
 - e. Oak Creek Vista
 - f. Grasshopper Point
 - g. Day Use Area (Encinosa, Halfway, Banjo Bill, Bootlegger)
 - h. Other (please specify) _____

5. What activity will you be doing (Select all that apply)?
 - a. Hiking
 - b. Biking
 - c. Climbing/Canyoneering
 - d. Swimming
 - e. Fishing
 - f. Picnicking
 - g. Dog walking
 - h. Other (please specify) _____

6. Where do you live?
 - a. Sedona
 - b. Coconino County (Flagstaff area)
 - c. Yavapai County (Prescott area)

- d. Maricopa County (Phoenix area)
 - e. Pima County (Tucson area)
 - f. Rest of Arizona
 - g. Outside of Arizona
 - h. Outside the USA
7. How often do you participate in outdoor recreation (like hiking, fishing, climbing, etc)?
- a. Once a year
 - b. 2-5 times a year
 - c. More than 5 times a year
 - d. Every month
 - e. Every week
8. Are you with young children today (between 0 and 4 years old)?
- a. Yes
 - b. No
9. Are you bringing with you a bag to carry out dirty diapers?
- a. Yes
 - b. No
10. Are you with dog(s) today?
- a. Yes
 - b. No
11. Are you carrying with you a bag for dog waste?
- a. Yes
 - b. No
12. Did you get a bag at a pet waste station?
- a. Yes
 - b. No
13. Before starting your visit to Oak Creek have you (Select all that apply):
- a. Identified your itinerary (schedule of activities)
 - b. Brought a bag for trash disposal
 - c. Planned your activities
 - d. Gotten information about the area you plan to visit
 - e. Had a poop plan (checked where you can find restrooms, or have a plan for packing poop)
 - f. Checked the weather
 - g. Brought adequate water and food
 - h. Brought or consulted a map

- i. Brought a first aid kit
- j. Identified the skills and abilities of trip participants

14. What are the risks you can face while recreating in Oak Creek?
Please rank (1 to 3) your top choices

- a. Tripping/Falling _____
- b. Dehydration _____
- c. Getting E. coli _____
- d. Wildlife attack _____
- e. Hit by falling rocks _____
- f. Forest fire _____
- g. Getting sick from dirty water _____

15. I think drinking water from Oak Creek is safe

Strongly disagree Disagree Neutral Agree Strongly Agree

a. ☐ ☐ ☐ ☐ ☐

16. I think Oak Creek water is clean

Strongly disagree Disagree Neutral Agree Strongly Agree

a. ☐ ☐ ☐ ☐ ☐

17. What sources do you think are the biggest contributors to creek contamination that can cause human illness? Please rank (1 to 3) your top choices

- a. Litter _____
- b. Dog poop _____
- c. Wastewater treatment plants _____
- d. Diapers _____
- e. Septic systems _____
- f. Human poop _____
- g. Livestock waste _____

18. Please indicate how effective the following solutions can be in improving Oak Creek water quality.

Strongly disagree Disagree Neutral Agree Strongly agree

- a. Use of public toilets facilities ☐ ☐ ☐ ☐ ☐
- b. Use of trash receptacles ☐ ☐ ☐ ☐ ☐
- c. Packing out trash ☐ ☐ ☐ ☐ ☐
- d. Use of designated trails ☐ ☐ ☐ ☐ ☐
- e. Avoid feeding wildlife ☐ ☐ ☐ ☐ ☐
- f. Picking up dog poop ☐ ☐ ☐ ☐ ☐
- g. Picking up diapers ☐ ☐ ☐ ☐ ☐
- h. Avoid fishing ☐ ☐ ☐ ☐ ☐
- i. There is nothing I can do ☐ ☐ ☐ ☐ ☐

19. What is your age?

- a. 18-24
- b. 25-34
- c. 35-44
- d. 45-54
- e. 55-64
- f. Above 64
- g. Prefer not to answer

20. Which gender do you identify most with?

- a. Male
- b. Female
- c. Prefer not to answer
- d. Other _____

21. What is your highest level of education?

- a. Some high school
- b. High school diploma or equivalent
- c. Some college

- d. Associate degree
- e. Bachelor's degree
- f. Post-graduate degree
- g. Prefer not to answer

22. Have you or someone you know ever gotten sick from contaminated water after recreating outdoors?

- a. Yes
- b. No

23. Did you fill out the survey after you visited Oak Creek?

- a. Yes
- b. No

24. Did you notice litter on-site?

- a. Yes
- b. No

25. Was it easy to find waste bins?

- a. Yes
- b. No

26. Were waste bins overflowing?

- a. Yes
- b. No

27. Did you easily find restrooms?

- a. Yes
- b. No

28. Were restrooms clean?

- a. Yes
- b. No
- c. NA

29. Have you seen the Leave No Trace messages about responsible recreation in Oak Creek?

- a. Yes
- b. No

30. Where did you see the message (Select all that apply)?

- a. Instagram

- b. Facebook
- c. Poster
- d. Through friends and family
- e. All Trails app
- f. Sedona shuttle
- g. Visitor Center
- h. Local Transit
- i. Local Business
- j. Other (please specify) _____

APPENDIX 2

Updates to survey questions

- Removed question 1: How long are you staying in the Sedona region?
- Removed question 3: How many people are visiting Oak Creek with you today (including you)?
- Removed question 4: Which part of Oak Creek are you planning to visit (Select all that apply)?
- Removed question 5: What activity will you be doing (Select all that apply)?
- Removed question 12: Did you get a bag at a pet waste station?
- Removed question 13: Before starting your visit to Oak Creek have you (Select all that apply):
- Removed question 15: I think drinking water from Oak Creek is safe
- Removed question 24: Did you notice litter on-site?
- Removed question 25: Was it easy to find waste bins?
- Removed question 26: Were waste bins overflowing?
- Removed question 27: Did you easily find restrooms?
- Removed question 28: Were restrooms clean?
- Added: What are examples in which it is difficult for you or other tourists to keep Oak Creek Canyon clean?
- Added option “Trails” in question 30, “Where did you see the message? (Select all that apply):”

APPENDIX 3

Interview protocol

1. What is the importance of tourism in Oak Creek Canyon for your organization?
2. What are the main problems Oak Creek Canyon is experiencing with tourism?
3. What about littering, e-coli and water quality in the Oak Creek Canyon? How is this impacted by tourism?
4. What can be done to improve water quality in the Oak Creek Canyon?
5. What are the main barriers to improve water quality?
6. What could your organization do to help improve the water quality of Oak Creek Canyon?
7. What does your organization do to ensure tourists have the proper resources to recreate responsibly?
8. Are there any other issues related to stakeholder engagement?