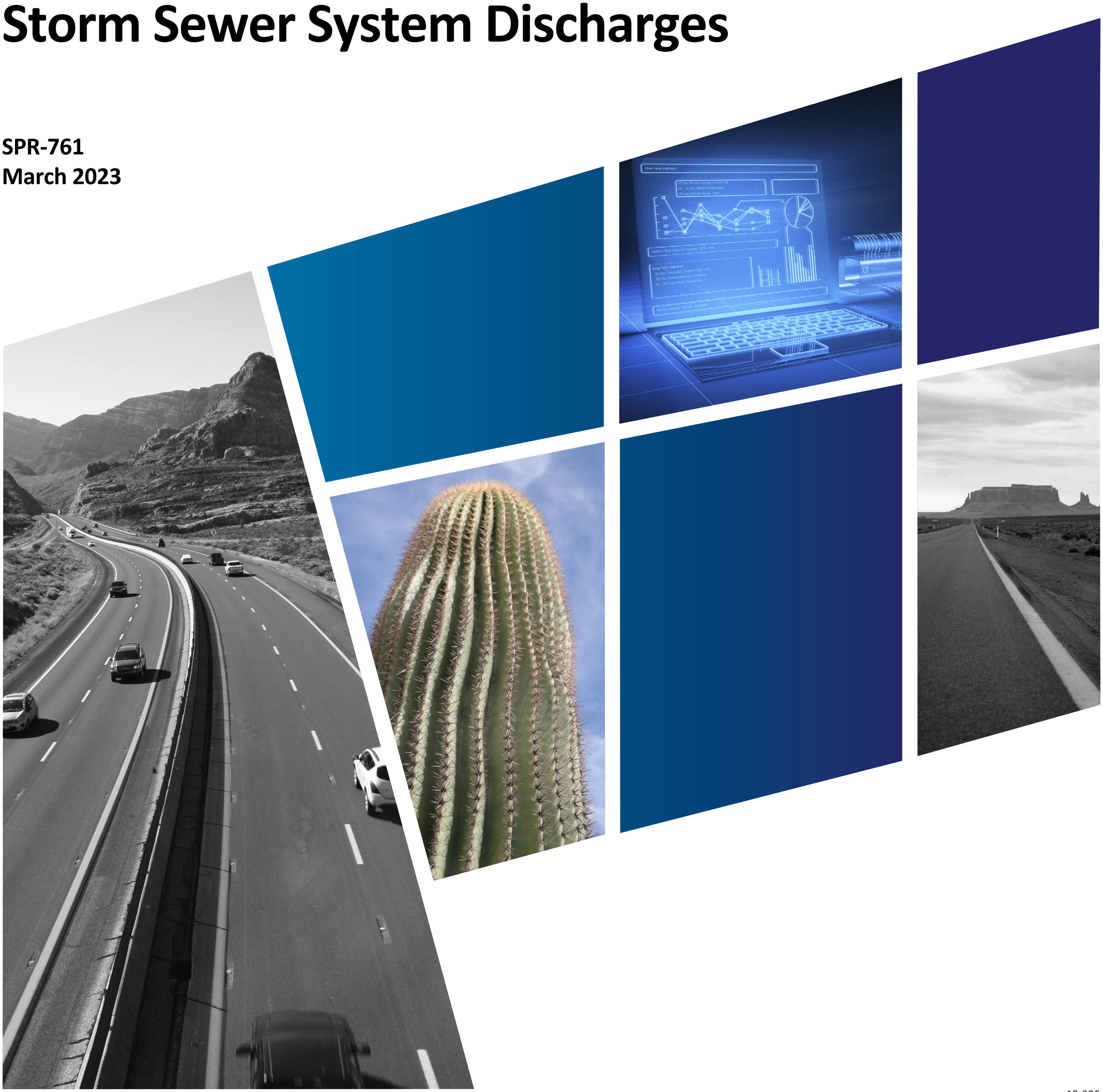
Evaluating Total Maximum Daily Load Pollutants from ADOT's Storm Sewer System Discharges

SPR-761
March 2023



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ADOT Arizona Department of Transportation Research Center

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16. Abstract

In accordance with the requirements of the Clean Water Act, discharges from municipal separate storm sewer systems (MS4s) to the waters of the U.S. are regulated for pollutants. ADOT holds an MS4 permit and is therefore responsible for the quality of water discharged from its storm sewer system. ADOT is currently named as a contributor of the pollutants specified in five Total Maximum Daily Loads (TMDLs). This means that ADOT must prove the extent to which discharges from ADOT's storm sewer system contribute to the impairment of a body of water with a TMDL. ADOT needs stormwater quality information that provides data on whether the types of specified pollutants are being discharged in ADOT's MS4; on the amount of each pollutant, if present; and on sources or potential sources of actual pollutants found.

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SI* (MODERN METRIC) CONVERSION FACTORS				
APPROXIMATE CONVERSIONS TO SI UNITS				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa
APPROXIMATE CONVERSIONS FROM SI UNITS				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)

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ACRONYMS AND ABBREVIATIONS

ac-ft/yr	acre-feet per year
ADEQ	Arizona Department of Environmental Quality
ADOT	Arizona Department of Transportation
cfs	cubic feet per second
cfu	colony-forming units
CGP	Arizona Stormwater Construction General Permit
E. coli	*Escherichia coli*
EIA	effective impervious area
EMC	event mean concentration
EPA	U.S. Environmental Protection Agency
FBC	full-body contact
G-org/yr	billions of colony-forming units per year
HEC-HMS	hydrologic engineering center, hydrologic modeling system
kg/day	kilograms per day
lbs/yr	pounds per year
MDL	method detection limit
mg/L	milligrams per liter
MPN/100 mL	most probable number per 100 milliliters
MS4	municipal separate storm sewer system
MST	microbial source tracking
PBC	partial body contact
ROW	right-of-way
SAP	sampling and analysis plan
SSC	suspended sediment concentration
TMDL	total maximum daily load
µg/L	micrograms per liter
USGS	U.S. Geological Survey
WLA	waste load allocation

INTRODUCTION

The Arizona Department of Transportation (ADOT) holds a permit from the Arizona Department of Environmental Quality (ADEQ) that regulates the amount of pollution in stormwater discharges from ADOT roadways and property. Among other elements, the permit requires ADOT to comply with total maximum daily load (TMDL) limitations that restrict the amount of pollutants allowed to be discharged from ADOT property. These TMDL limitations aim to improve impaired water bodies that are overly saturated with pollutants and in need of intervention to improve water quality.

ADEQ studies the quality of water bodies in Arizona to assess pollutants that could impact designated uses (recreational, fishing, drinking water, etc.) and highlight exceptionally good water quality that should be preserved. These studies help to prioritize water bodies that need extra measures of protection and water bodies that need a combined regional effort to improve their water quality. Water bodies deemed impaired have surpassed a threshold of pollution for a certain analyte, such as *Escherichia coli (E. coli*), and require the state to take action to reduce that pollutant. ADEQ TMDL reports can result in a TMDL limitation that is applied to a segment of a water body or an entire watershed.

ADEQ TMDL reports outline pollutants of concern in specific water bodies, as well as waste load allocation (WLA) limits for runoff from named entities like ADOT. The entities named in TMDL reports are required to limit the amount of the named analyte that can leave their property or facility. ADEQ sometimes makes a blanket requirement to reduce or eliminate the pollutant and at other times provides a quantitative amount of the pollutant that can be released by each entity. These measures aim to reduce the downstream load of the pollutant so the water quality can gradually improve. Entities named in TMDL reports are required to devise their own assessments and control measures to reach ADEQ's pollutant loading limitations.

ADOT is named as a significant contributor of pollutants to five watersheds regulated by a TMDL limitation, including Oak Creek, Granite Creek, the San Pedro River, the Little Colorado River, and the Gila River. ADOT was named as contributing *E. coli* to Oak Creek, Granite Creek, and the San Pedro River; *E. coli* and suspended sediment concentration (SSC) to the Little Colorado River; and selenium and boron to the Gila River.

The list below outlines the pollutants of concern for each watershed. A more in-depth look at ADEQ's TMDL reports is presented in the technical memorandum for Task 1 of this study (Review TMDLs: Gather and Review Existing Data) and in the figures provided as part of Task 3 of this study. A high-level view of figures depicting the five regulated watersheds and ADOT's highways within them are included in the appendix.

Gila River:

- Total boron WLA: 1,000 micrograms per liter (µg/L)
- Total selenium WLA: 2.0 µg/L
- Potentially associated highways: SR-85 and I-10

Little Colorado River:

- *E. coli* WLA: 235 colony-forming units (cfu)/100 mL
- SSC WLA: not listed in TMDL document, but the standard is a median of 25 milligrams per liter (mg/L) for a four-sample minimum
- Potentially associated highways: SR-77, SR-277, SR-260, SR-180A, SR-61, US-60, and US-180

Granite Creek:

- *E. coli* WLA: 235 cfu/100 mL
- Potentially associated highways: SR-89 and SR-69

San Pedro River:

- *E. coli* WLA: 235 cfu/100 mL
- Potentially associated highways: SR-77, SR-80, SR-82, SR-90, and SR-92

Oak Creek:

- *E. coli* WLA: exempt
- Potentially associated highways: SR-89A and SR-179

This study was conducted to understand the quantity of the pollutants of concern, if any, that ADOT is contributing to each water body. The research team assessed ADOT's infrastructure and contribution areas, and collected samples of stormwater sheet flow runoff from the associated highways. Sampling data were analyzed using the simple method, and infrastructure was assessed to determine loading concentrations. Pollutant loads and yield calculations were then used to prioritize each watershed based on ADOT's contribution of pollutants to the impaired named water bodies.

The prioritization rankings and recommendations in this study are designed to help ADOT allocate appropriate control measures to reduce pollutants leaving the right-of-way (ROW) and entering impaired waterways. This study is intended to help ADOT personnel assess watershed pollutant loading and apply appropriate control measures.

RECOMMENDATIONS

Several strategies were considered to target the removal and/or reduction of *E. coli* and suspended sediment from the Oak Creek and Little Colorado River watersheds, respectively. Given the lack of point sources for both *E. coli* and suspended sediment, implementing controls within each watershed depends primarily on non-structural control measures rather than structural control measures. Six control measures are documented in the technical memorandum (Task 7.2) of this study (Treatment Plan).

These treatment strategies were developed with a focus on the watersheds' characteristics and the pollutants identified as 'medium' priority in Table 6 of this report; however, these treatment recommendations can be applied across ADOT's highway system.

Recommendation #1 – Modify Design Standards to Increase Infiltration

Review ADOT's engineering design standards and priorities for construction and redevelopment projects to promote infiltration within the Little Colorado and Oak Creek watersheds and modify where needed. Infiltration and flow velocity reduction efforts should focus on using basins and roadside ditches where available ROW exists, routing stormwater flow to nearby basins or ditches where topography allows and using outlet structures equipped with weir features and permeable floors.

By reducing flow velocity and using pervious structures, there is greater opportunity for infiltration, settling of pollutants, and increased evaporation volume. To ensure these structures function properly, all structural control features should be inspected, cleaned, and maintained on an as-needed basis. This includes timely removal of collected sediment and debris from ditches, basins, and outlet structures.

This control is anticipated to have a minimal capital cost, minimal operations and maintenance efforts, and a high degree of effectiveness.

Recommendation #2 – Establish Targeted Area Inspection Program

Consider developing and implementing a targeted inspection program for district field personnel that focuses on recognizing potential *E. coli* and sediment sources, and on assessing drainage infrastructure conditions for their pollutant reduction capabilities.

The inspection program could consist of an initial field screening assessment designed to identify, map, and prioritize areas with a higher likelihood of contributing pollutants of concern, as well as the locations of critical drainage infrastructure such as basins and outlet structures. During the initial assessment, ADOT may consider identifying initial cleaning or maintenance needs and whether specific tools, equipment, and/or procedures are needed to perform cleaning and maintenance activities.

After the initial assessment, a preliminary inspection frequency, such as twice per year, could be implemented. After the initial assessment period, the inspection frequency could then be modified based on observations. The efficacy of this control is dependent on the identification of potential maintenance or cleaning needs, as well as prompt mitigation of those issues.

This control is anticipated to have a minimal-to-moderate capital cost, minimal-to-moderate operations and maintenance efforts, and a moderate degree of effectiveness.

Recommendation #3 – Establish Targeted Area Maintenance Program

Consider developing and implementing a targeted maintenance program for field personnel at Oak Creek and the Little Colorado River that is focused on providing prompt maintenance and cleaning activities for potential pollutant sources, areas, and structures. The focus of this effort is educating ADOT personnel on how to respond to work orders submitted in response to the inspection program and ensuring that proper equipment and practices are employed when performing cleaning and maintenance.

Building on needs identified during the targeted area inspection program, each structure or area will have recommended tools, equipment, and/or procedures to perform maintenance and cleaning efforts. Specific maintenance and cleaning equipment and procedures would be based on site constraints and needs of individual structures. When a maintenance or cleaning need is identified, ADOT may evaluate necessary efforts and allocate resources to perform the work as soon as practicable.

This control is anticipated to have a minimal capital cost, minimal-to-moderate operations and maintenance efforts, and a moderate degree of effectiveness.

Recommendation #4 – Implement Targeted Area Staff Training Program

Consider training field personnel on the impact of sediment on stormwater quality; the importance of promptly addressing water quality issues; and how to perform area and structure inspections, how to perform maintenance and cleaning, and how to document field activities.

This training program could consist of both desk- and field-based portions. To comply with municipal separate storm sewer system (MS4) permit requirements, training could be administered and documented annually.

This control is anticipated to have a minimal capital cost, minimal operations and maintenance efforts, and a moderate degree of effectiveness.

Recommendation #5 – Provide Public Education

Consider providing public education on pollution associated with sediment and *E. coli* within target watersheds. Public education is often a crucial component of stormwater improvement programs because it is effective in implementing awareness and change over a large area.

Providing informative public education and outreach helps the layperson understand the importance of stormwater quality and the actions they can take to reduce pollutant loading. Inviting the public to help ADOT identify and address potential pollutants could be beneficial, particularly in remote areas. Specific messaging campaigns could be coordinated with local MS4s, as well as other programs such as Adopt-A-Highway and Keep Arizona Beautiful.

This control is anticipated to have a minimal to moderate capital cost, minimal operations and maintenance efforts, and a moderate-to-low degree of effectiveness.

Recommendation #6 – Conduct Follow-Up Studies

MST Marker Testing

Consider performing microbial source tracking (MST) testing on stormwater discharges, specifically sampling runoff from only ADOT ROWs. Testing could be performed at multiple locations with a target of three samples per wet season for a minimum of two wet seasons. By performing MST testing on ADOT-only discharges, ADOT may be able to identify the species contributing to the *E. coli* load to better target *E. coli* sources and removal efforts. Suggested host groups for analysis include: human, racoon, skunk, elk, dog, and deer. Coordination with area MS4s (Sedona, Northern Arizona University, Coconino County, and/or Yavapai County) could be considered.

Pollutant Transport Model for Little Colorado River

A fate and transport model assesses how pollutants change and where they go as they move through the environment. Given the relatively long distance between SR-77 and the impaired stretch of the Little Colorado River, as well as the abundance of undeveloped land between the two, developing a fate and transport model could help inform whether ADOT's stormwater discharges, and the pollutants suspended within that stormwater, reach the Little Colorado River.

Identify Non-Designated Public-Used Roadside Stop Areas Where Controls and/or Facilities Could Be Provided

ADOT provides pull-out locations throughout the roadway system to support ADOT maintenance activities, material and equipment staging, and other safety needs. These pull-outs are intended for ADOT use only; however, the traveling public may also use them when a roadside stop or rest area is not available. Therefore, the roadside pull-out areas have the potential to introduce pollutants to the ADOT ROW due to human activities, and from roadside sediment being tracked onto the roadway from unauthorized vehicles as they re-enter the travel lanes. The research team identified four major pull-out locations within the Little Colorado River study area. Evaluating these locations—and to a lesser extent other smaller, less established pull-out locations—could help ADOT understand why vehicles are using the pull-out locations, consider options for developing more established rest areas, evaluate possible site improvements, and identify public messaging needs that could reduce the potential for unauthorized pull-out use to reduce the pollutant introduction to the travel way.

FINDINGS

This study assesses the contribution of stormwater runoff from ADOT properties on pollutant loading in each impaired waterway. The research team analyzed stormwater runoff from ADOT properties using five assessment criteria. To help ADOT determine the sites of highest priority for action, the five assessment criteria are ranked as a low, medium, or high priority based on the point-weighting scheme described below.

1. Event mean concentrations (EMCs) of specific pollutants of concern (Criterion 1) were determined by analyzing the results of sampling in each of the five watersheds and the hydrographs from sampled storms. EMCs are the total mass load of a pollutant parameter divided by the total volume of runoff water discharged during an individual storm event. EMCs were assigned zero or four points based on whether they exceeded the WLA for the site.

2. ADOT's contribution to the pollutant loading—which is documented in ADEQ's TMDL reports (Criterion 2)—was calculated based on EMCs from ADOT property. Pollutant load is the amount (mass) of a pollutant that is discharged into a water body during a period of time (i.e., tons of sediment per year). Load contributions were given zero, one, or two points based on contributing less than one percent, one to two percent, or more than three percent, respectively, to overall pollutant loads in the impaired water body segment.

3. The amount of pollutant load generated from the area of ADOT ROW was compared to the yield described in ADEQ's TMDL report (Criterion 3). The yield represents the amount of pollutant load generated based on a unit-area basis, calculated by dividing the total pollutant load by the area contributing to the drainage. In the prioritization scheme, yields are a binary category, with one point assessed if they were greater than the TMDL target yield outlined in ADEQ's TMDL report and zero points if yields are lower.

4. Comparing historical sampling data from ADOT to the research team's sampling results (Criterion 4) gives more context for the current study's findings. Historical data comparisons were assigned one point if the sampling geometric mean was higher than the historical geometric mean, and zero points if they were lower.

5. Distance from the ADOT ROW to the impaired portion of each water body is the final comparison criterion (Criterion 5). The distance that stormwater runoff travels is important because, in some cases, infiltration and evaporation reduce or eliminate the quantity of stormwater (and any potential pollutants it may be carrying) from the ROW. Given the absence of an explicit distance limitation within TMDL standards, the criterion for proximity to the impaired segment is based on requirements from the 2020 Arizona Stormwater Construction General Permit (CGP) instead. The CGP describes additional requirements for projects located within 1/4 mile upstream of protected surface waters due to a higher potential for discharges from those sites to impact water bodies. Therefore, this study assigns three points if an ADOT ROW is within 1/4 mile upstream of an impaired segment.

Overall, EMCs and proximity to impaired water bodies—Criteria 1 and 5, respectively—are the most heavily weighted criteria in this evaluation. The EMCs show samples that exceed the identified concentration limit for the pollutant of concern listed for the TMDL. The proximity to the impaired water body determines the potential for those pollutants being transported to the water.

Tables 1–5 present the results of the analysis for each criterion. Cells highlighted in pink indicate where one or more points were assigned. The number of points for each criterion was then summed. A priority level was then assigned based on the number of points for each criterion, divided into high (>10), medium (5–10), or low (<5) priority categories.

For example, for boron shown in Table 1, the EMC (Criterion 1) was 62 percent less than the WLA specified in the TMDL report. The contribution to load allocation (Criterion 2) was 0.004 percent of the annual load allocation described in the TMDL report. The ADOT yield (Criterion 3) was 86 percent less than the target yield called for in the TMDL report. The geometric mean (Criterion 4) of the 2021 data set was 99 percent lower than the ADEQ historical geometric mean. The proximity to the impaired segment (Criterion 5) was not less than 0.25 miles. None of these criteria warranted any points being assigned. With a point total of 0, the assigned priority level is low.

Table 6 shows the accumulated points and their respective priority ranking for each pollutant in each watershed. This ranking system allows ADOT to assess which highways may need more control measures to reduce target pollutants. This helps ADOT prioritize funding, time, and labor, and shows the steps they plan to take to reduce pollutants as required by ADEQ.

Table 1. Prioritization Evaluation for Gila River Drainage Basin

Parameter	Criterion 1: EMCs	Criterion 2: Contribution to Load Allocation	Criterion 3: Yields	Criterion 4: Historical versus 2021 Data	Criterion 5: ADOT ROW Proximity to Impaired Segment <0.25 mi.	Total Points	Priority Level
Boron	62% less than TMDL WLA	Contributing 0.004% to annual load allocation	86% less than target yield	Geometric mean 99% lower than ADEQ historical data geometric mean	No	0	Low
Selenium	50% less than WLA	Contributing 0.1% of annual load allocation	233% greater than target yield	Geometric mean 93% lower than ADEQ historical data geometric mean	No	1	Low

Note: Highlighted cells indicate where one or more points were assigned.

Table 2. Prioritization Evaluation for the Little Colorado River Drainage Basin

Parameter	Criterion 1: EMCs	Criterion 2: Contribution to Load Allocation	Criterion 3: Yields	Criterion 4: Historical versus 2021–2022 Data	Criterion 5: ADOT ROW Proximity to Impaired Segment <0.25 mi.	Total Points	Priority Level
E. coli	26% less than WLA	Contributing 0.26% to annual load allocation (mid flows)	420% greater than target yield (mid flows)	Geometric mean 91% lower than ADEQ historical data geometric mean	No	1	Low
SSC	561% greater than WLA	Contributing 7.6% of annual load allocation (mid flows)	5307% greater than target yield (mid flows)	Geometric mean 83% lower than ADEQ historical data geometric mean	No	7	Medium

Note: Highlighted cells indicate where one or more points were assigned.

Table 3. Prioritization Evaluation for Granite Creek Drainage Basin

Parameter	Criterion 1: EMCs	Criterion 2: Contribution to Load Allocation	Criterion 3: Yields	Criterion 4: Historical versus 2021–2022 Data	Criterion 5: ADOT ROW Proximity to Impaired Segment <0.25 mi	Total Points	Priority Level
E. coli	52% less than WLA	Contributing 0.41% of annual load allocation	47% lower than target yield	Geometric mean 76% lower than ADEQ historical data geometric mean	Yes	3	Low

Note: Highlighted cells indicate where one or more points were assigned.

Table 4. Prioritization Evaluation for San Pedro River Drainage Basin

Parameter	Criterion 1: EMCs	Criterion 2: Contribution to Load Allocation	Criterion 3: Yields	Criterion 4: Historical versus 2022 Data	Criterion 5: ADOT ROW Proximity to Impaired Segment <0.25 mi.	Total Points	Priority Level
E. coli	97% less than WLA	Contributing 0.07% of annual load allocation	99% lower than target yield	Geometric mean 98% lower than ADEQ historical data geometric mean and 99% lower than MS4 historical data geometric mean	Yes	3	Low

Note: Highlighted cells indicate where one or more points were assigned.

Table 5. Prioritization Evaluation for Oak Creek Drainage Basin

Parameter	Criterion 1: EMCs	Criterion 2: Contribution to Load Allocation	Criterion 3: Yields	Criterion 4: Historical versus 2021–2022 Data	Criterion 5: ADOT ROW Proximity to Impaired Segment <0.25 mi	Total Points	ADOT Priority
E. coli	21% less than WLA	Contributing 1.73% of annual load allocation (mid flows)	98% lower than target yield	Geometric mean 62% higher than ADEQ historical data geometric mean but 76% lower than MS4 historical data geometric mean	Yes	5	Medium

Note: Highlighted cells indicate where one or more points were assigned.

Table 6. Summary of Criteria Scores and Priority for Pollutant Load Reduction for ADOT ROWs

Criterion	Gila River: Boron	Gila River: Selenium	Little Colorado River: *E. coli*	Little Colorado River: SSC	Granite Creek: *E. coli*	San Pedro River: *E. coli*	Oak Creek: *E. coli*
1. EMCs	0	0	0	4	0	0	0
2. Contribution to WLA (percent)	0	0	0	2	0	0	1
3. ROW Yield versus Target Yield	0	1	1	1	0	0	0
4. ADEQ Historical data Comparison	0	0	0	0	0	0	1
5. MS4 Proximity	0	0	0	0	3	3	3
Total Score	**0**	**1**	**1**	**7**	**3**	**3**	**5**
Priority	Low	Low	Low	**Medium**	Low	Low	**Medium**

METHODS

The research team reviewed the five TMDL documents from ADEQ to determine which highways had drainage that could contribute to the impaired water body segments. Highways within the watersheds were narrowed down to one highway per watershed that were most likely to contribute to the water body segment regulated by the TMDL document. The Gila River TMDL document specifically named SR-85. The remaining four watersheds each had one highway that was closest in proximity and likely to receive discharge. The Little Colorado River and the San Pedro River were both closest to SR-77, and Granite Creek and Oak Creek were both within one-quarter mile of SR-89 and SR-89A, respectively.

The research team identified sampling locations where runoff from the site was comprised of only ADOT ROW drainage and no additional stormwater entering the sampling site. Maps of these sampling areas were generated to show land cover, soils, proximity to the impaired segment, and the specific drainage basin of the sample location. These drainage basins were small compared to the overall area contributing to the impaired water body segments, but showed which portions of the ROW drained to the sample location to ensure that samples did not contain run-on from outside the ROW.

A sampling and analysis plan (SAP) was created to ensure consistent sampling techniques that accurately reflected similar techniques used by ADOT personnel in MS4 sampling and ADEQ personnel in their TMDL sampling. The SAP also outlined at what rain threshold the sampling teams would be deployed and how the storms would be assessed. Encroachment permits were applied for in all five sampling sites to ensure that regional managers were aware of the work being performed. Sampling was performed on the side of roadways during or directly after rain events, and all five sites included constructed weather monitoring equipment that needed to be conveyed to ADOT personnel. The permits ensured sampling crews were aware of ADOT requirements for PPE and/or emergency contact information.

Rain gauges were installed at all five locations to ensure accurate and specific rain monitoring, and the Gila River and Little Colorado River sites both had concrete pads, metal cabinets, Isco Avalanche autosamplers, and solar panels installed. This equipment was installed, and the SAP was implemented from July 2021 to February 2022. Tables 7-11 below outline the sampling results for all five watersheds.

Table 7. Sample Results for Gila River Sample Site

Sample ID	**GR07242021-01**	**GR08102021-01**	**GR08152021-01**	**GR09022021-01**
Date	7/24/2021	8/10/2021	8/15/2021	9/1/2021
Boron (mg/L) original	BDL	0.097	0.063	BDL
Selenium (µg/L) original	0.97	BDL	1.2	0.79

BDL = Below Detection Limit

Table 8. Sample Results for Little Colorado River Sample Site

Sample ID	**LC09262021-01 - 04**	**LC10052021-01 - 04**	**LC10262021-01**	**LC02172022-01**	**LCR20220224-01**
Date	9/26/2021	10/5/2021	10/26/2021	2/17/2022	2/24/2022
SSC (mg/L, Fine)	17.3	64	43	300	160
SSC (mg/L, Coarse)	18.4	21	59	25.2	5.59
E. coli (MPN)	261.3	298.7	11.6	1.0	<1.0

Table 9. Sample Results for Granite Creek Sample Site

Sample ID	**GC07292021-01**	**GC08092021-01**	**GC20220224-01**
Date	7/29/2021	8/9/2021	2/24/2022
E. coli (MPN/100mL)	200	120	19

Table 10. Sample Results for San Pedro Sample Site

Sample ID	**SP02162022-01**	**SPA102232022-01**	**SPA202232022-01**
Date	2/16/2022	2/23/2022	2/23/2022
E. coli (MPN/100mL)	6.3	2.0 **A7**	8.5 **A7**

A7 Micro sample received without adequate headspace.

Table 11. Sample Results for Oak Creek Sample Site

Sample ID	**OC09012021-02**	**OC10052021-01,02,03**	**OC02232022-01**
Date	9/1/2021	10/5/2021	2/23/2022
E. coli (MPN)	6.3	437.4	60 **A7 D1**

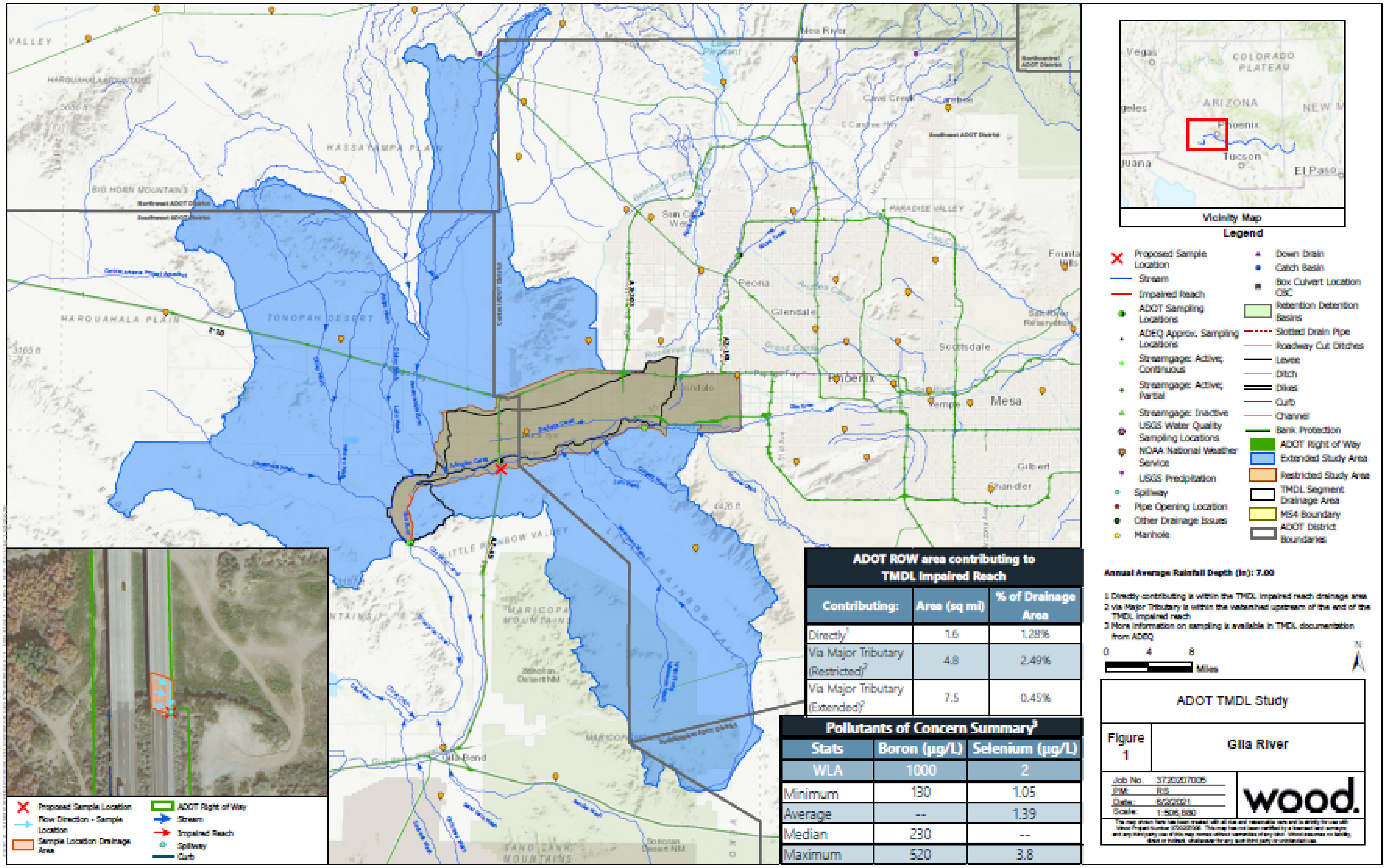
A7 Micro sample received without adequate headspace.
D1 sample required dilution due to matrix.

Statistical Analysis

EMC values were calculated from the sample results to show the concentration of each named pollutant in ADOT runoff. These values are helpful to compare to the WLA set in the TMDL documents to understand how much ADOT is contributing to the impaired water segments. The sampling locations were chosen carefully to ensure EMCs are only showing ADOT's contribution, but they also only show results from a single moment in time. Hydrographs were modeled from the telemetry devices stationed at each site to provide the amount of runoff generated in each storm event to better narrow down annual pollutant loading.

The pollutant load was divided by the area of contributing drainage to get the pollutant yield. Pollutant yield can be compared regardless of the drainage area size, which can help determine the areas with more critical need for pollutant reduction efforts. These calculations were used to understand how ADOT roadways were affecting the pollutants in downstream waterbodies and give context to ADOT requirements outlined in the TMDL documents.

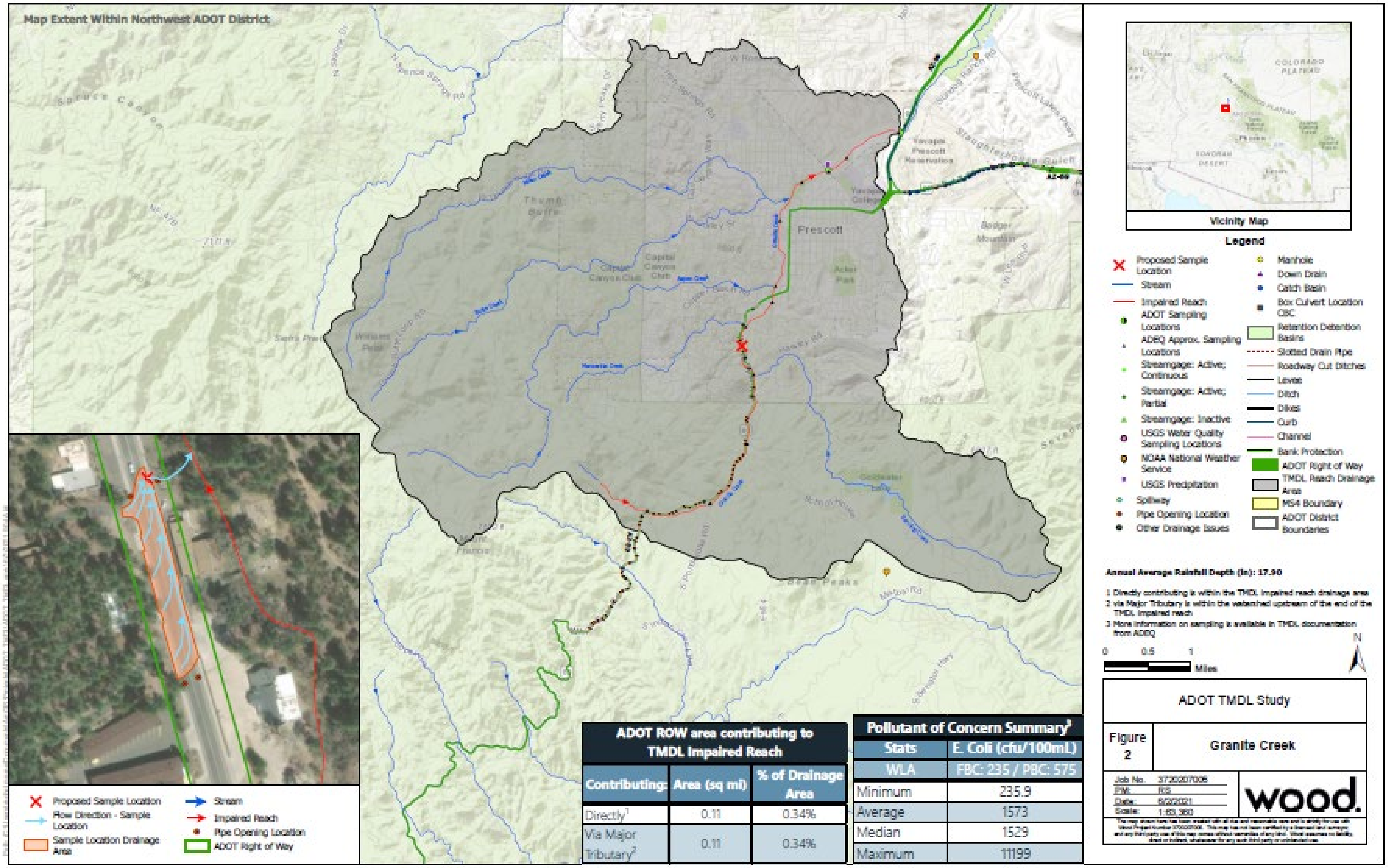
APPENDIX: WATERSHED FIGURES



ADOT ROW area contributing to TMDL Impaired Reach		
Contributing:	Area (sq mi)	% of Drainage Area
Directly[1]	1.6	1.28%
Via Major Tributary (Restricted)[2]	4.8	2.49%
Via Major Tributary (Extended)[2]	7.5	0.45%

Pollutants of Concern Summary[3]		
Stats	Boron (µg/L)	Selenium (µg/L)
WLA	1000	2
Minimum	130	1.05
Average	--	1.39
Median	230	--
Maximum	520	3.8

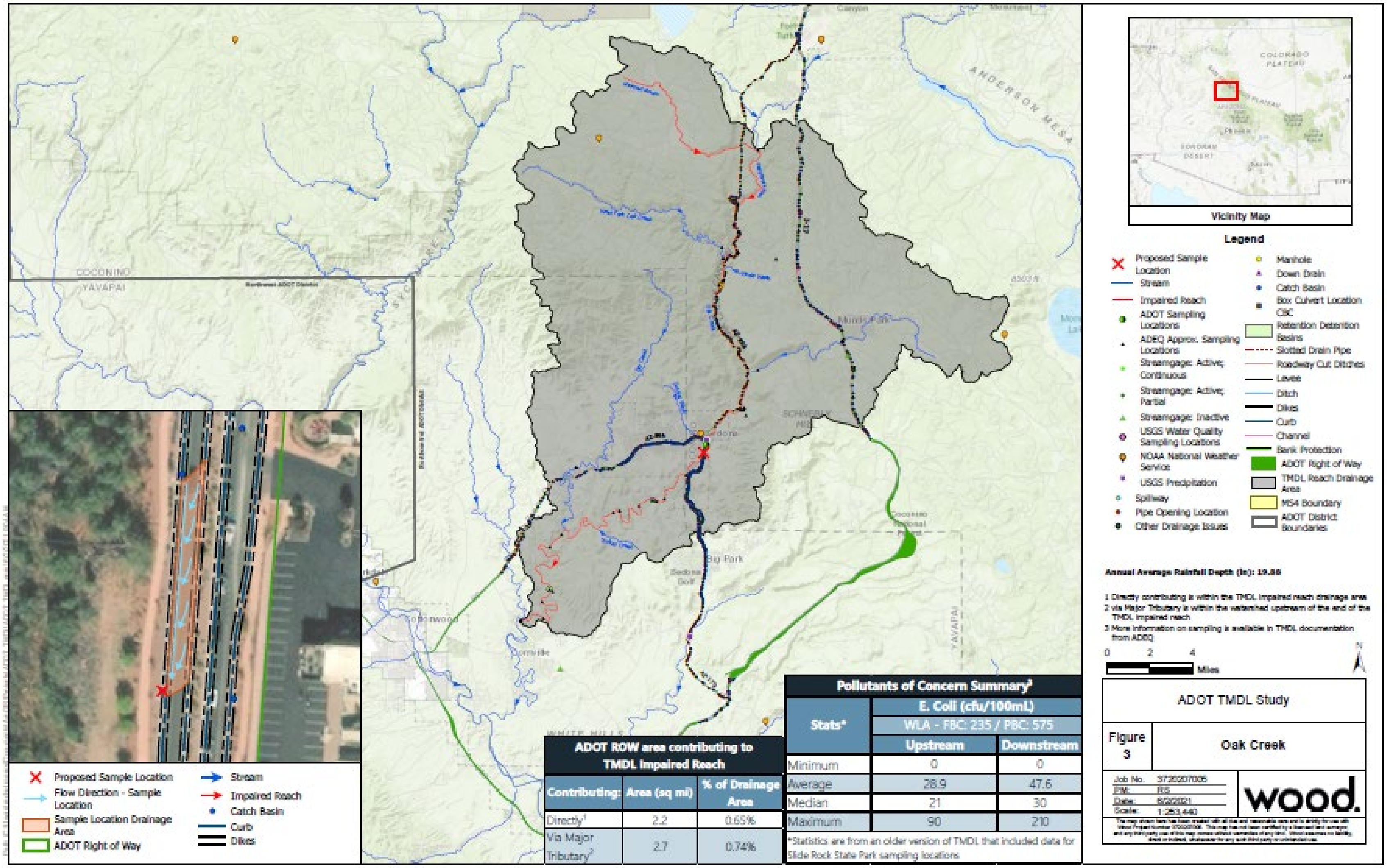
Figure 1. Gila River Watershed



ADOT ROW area contributing to TMDL Impaired Reach		
Contributing:	Area (sq mi)	% of Drainage Area
Directly[1]	0.11	0.34%
Via Major Tributary[2]	0.11	0.34%

Pollutant of Concern Summary[3]	
Stats	E. Coli (cfu/100mL)
WLA	FBC: 235 / PBC: 575
Minimum	235.9
Average	1573
Median	1529
Maximum	11199

Figure 2. Granite Creek Watershed

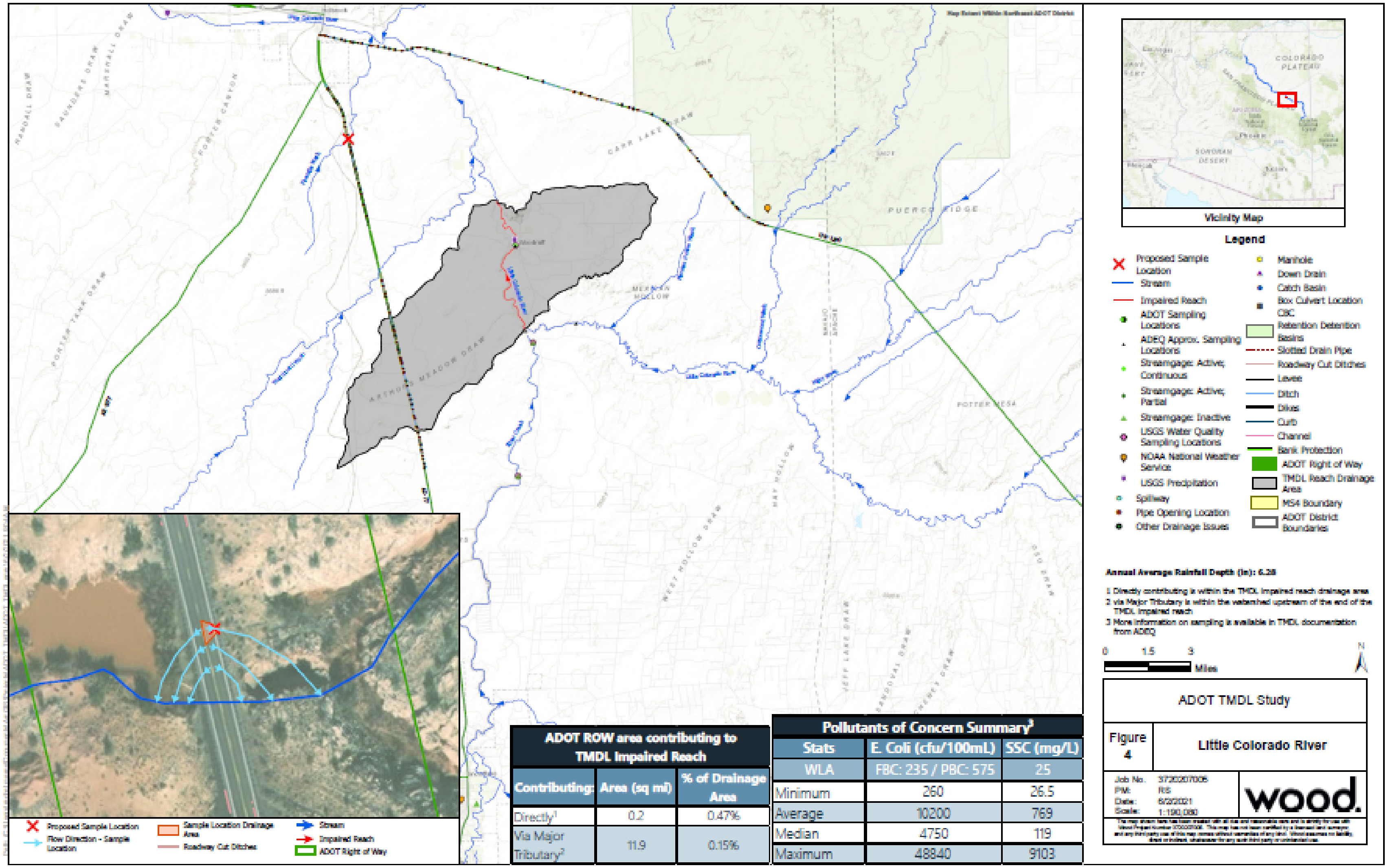


ADOT ROW area contributing to TMDL Impaired Reach		
Contributing:	Area (sq mi)	% of Drainage Area
Directly[1]	2.2	0.65%
Via Major Tributary[2]	2.7	0.74%

Pollutants of Concern Summary[3]		
Stats*	E. Coli (cfu/100mL)	
	WLA - FBC: 235 / PBC: 575	
	Upstream	Downstream
Minimum	0	0
Average	28.9	47.6
Median	21	30
Maximum	90	210

*Statistics are from an older version of TMDL that included data for Slide Rock State Park sampling locations

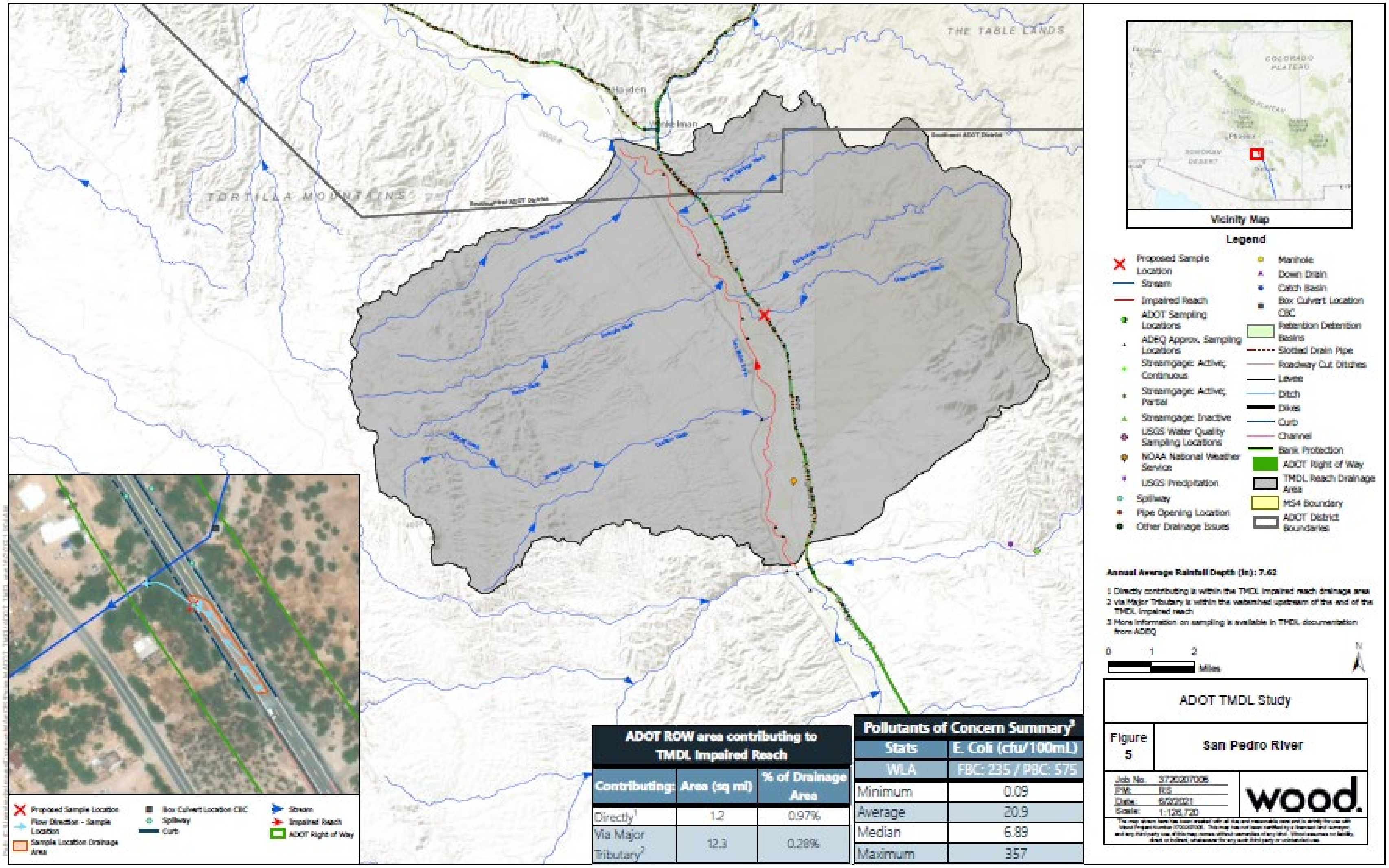
Figure 3. Oak Creek Watershed



ADOT ROW area contributing to TMDL Impaired Reach		
Contributing:	Area (sq mi)	% of Drainage Area
Directly[1]	0.2	0.47%
Via Major Tributary[2]	11.9	0.15%

Pollutants of Concern Summary[3]		
Stats	E. Coli (cfu/100mL)	SSC (mg/L)
WLA	FBC: 235 / PBC: 575	25
Minimum	260	26.5
Average	10200	769
Median	4750	119
Maximum	48840	9103

Figure 4. Little Colorado River Watershed



ADOT ROW area contributing to TMDL Impaired Reach		
Contributing:	Area (sq mi)	% of Drainage Area
Directly[1]	1.2	0.97%
Via Major Tributary[2]	12.3	0.28%

Pollutants of Concern Summary[3]	
Stats	E. Coli (cfu/100mL)
WLA	FBC: 235 / PBC: 575
Minimum	0.09
Average	20.9
Median	6.89
Maximum	357

Figure 5. San Pedro River Watershed