The Water Quality of the Lower San Pedro River

Fiscal Year 2012-2016

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Open File Report
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Report Cover: SPSPR014.18 (Site B) upstream photo 4/5/2017

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INTRODUCTION

The Arizona Department of Environmental Quality (ADEQ) Monitoring Unit collects water quality data to assess the biological, chemical, and physical integrity of Arizona's rivers and streams to meet Clean Water Act commitments. ADEQ is required by the clean water act to provide credible data for surface water quality assessments, identify impaired waters or stressors, and determine compliance with water quality standards (§305(b) of the Clean Water Act.) ADEQ also conducts special investigations, as needed, and this study of the Lower San Pedro Wildlife area is one of these investigations. Additionally, this report intends to gather baseline data on a segment of the San Pedro River in order to meet specific objectives of the Lower San Pedro River Restoration Plan.

The Lower San Pedro Wildlife Area was put in place through the Natural Resource Damage Assessment (NRDA) program following the superfund decision in which ASARCO provided funds for mitigation and restoration of the land affected due to releases of hazardous substances into Mineral Creek. The Trustees have moved forward using this money to reestablish the lower San Pedro River, natural wildlife corridor, which requires water quality analysis to determine the health for local ecology. The Trustees are those agencies appointed to develop and implement a Restoration Plan on the San Pedro properties endowed to the State (AZGFD et al, 2012). The Trustees are those agencies involved in the monitoring and remediation of the study area, including Arizona Game and Fish, Arizona Department of Environmental Quality, Bureau of Land Management, Arizona State Land Department, and US Fish and Wildlife Service. Each agency is contributing to the restoration, monitoring and management of the San Pedro property, with the Arizona Game and Fish Department leading the on-site activities. ADEQ's contribution to the project is to conduct water quality surveys and monitor water quality trends for the Trustees, in accordance with the Restoration Plan. The river segment in the study area includes two sites on the San Pedro River on either side of an agriculture field, referred to as Wheatfields. On the southernmost side of the Wheatfields lies the first site, SPSPR015.42, which is the long-term monitoring station for trend analysis. The second site located 1mi downstream, SPSPR014.18, was selected for study during the 1st five years to determine if the irrigation return flows from the Wheatfield agricultural field was having an effect on water quality downstream. These stations were selected to monitor water quality and aquatic life conditions, as the "Trustees" pursue a restoration project within the newly formed "Lower San Pedro Wildlife Area."

This water quality report constitutes the baseline water quality survey, in accordance with the Lower San Pedro Restoration Plan. ADEQ will continue to conduct water quality surveys at the Wheatfields station (SPSPR015.42) every five years until the year 2041 and will compile a second water quality report at either the conclusion of the survey in year 2041, or at a time requested by the Trustees.

SAMPLING AND ANALYSIS METHODS

The ADEQ Standard Operating Procedures for Water Quality Sampling (ADEQ, 2015) describes the sample collection methods for water chemistry, macroinvertebrate and habitat data used in this survey. Water samples were analyzed for a standard set of core parameters including: field parameters, flow, nutrients, metals and major ions, E. coli, as well as suspended sediment concentration (Appendix F). Macroinvertebrate sampling was conducted during spring index period, with collections from riffle habitats and analyzed using ADEQ's Index of Biological Integrity, and compared to the warm water biocriteria standard (IBI>50).

The standard set of habitat measurements included in ADEQ's Stream Ecosystem Monitoring (SEM) protocol include percent fines, percent riffle, embeddedness, riparian canopy cover, percent algae and macrophyte cover, Proper functioning condition of the riparian area (PFC), Pfankuch channel stability index, as well as a list of field observable variables such as animal presence, or cut banks within the channel.

Data and statistical analysis was achieved primarily through use of rStudio. Specific tests run include Kruscal-wallis, Spearman correlations, Mann-whitney and general statistical analysis including mean, range, and standard deviation. Other analyses followed ADEQ Standard Operating Procedures for Water Quality Sampling (ADEQ, 2015).

STUDY AREA

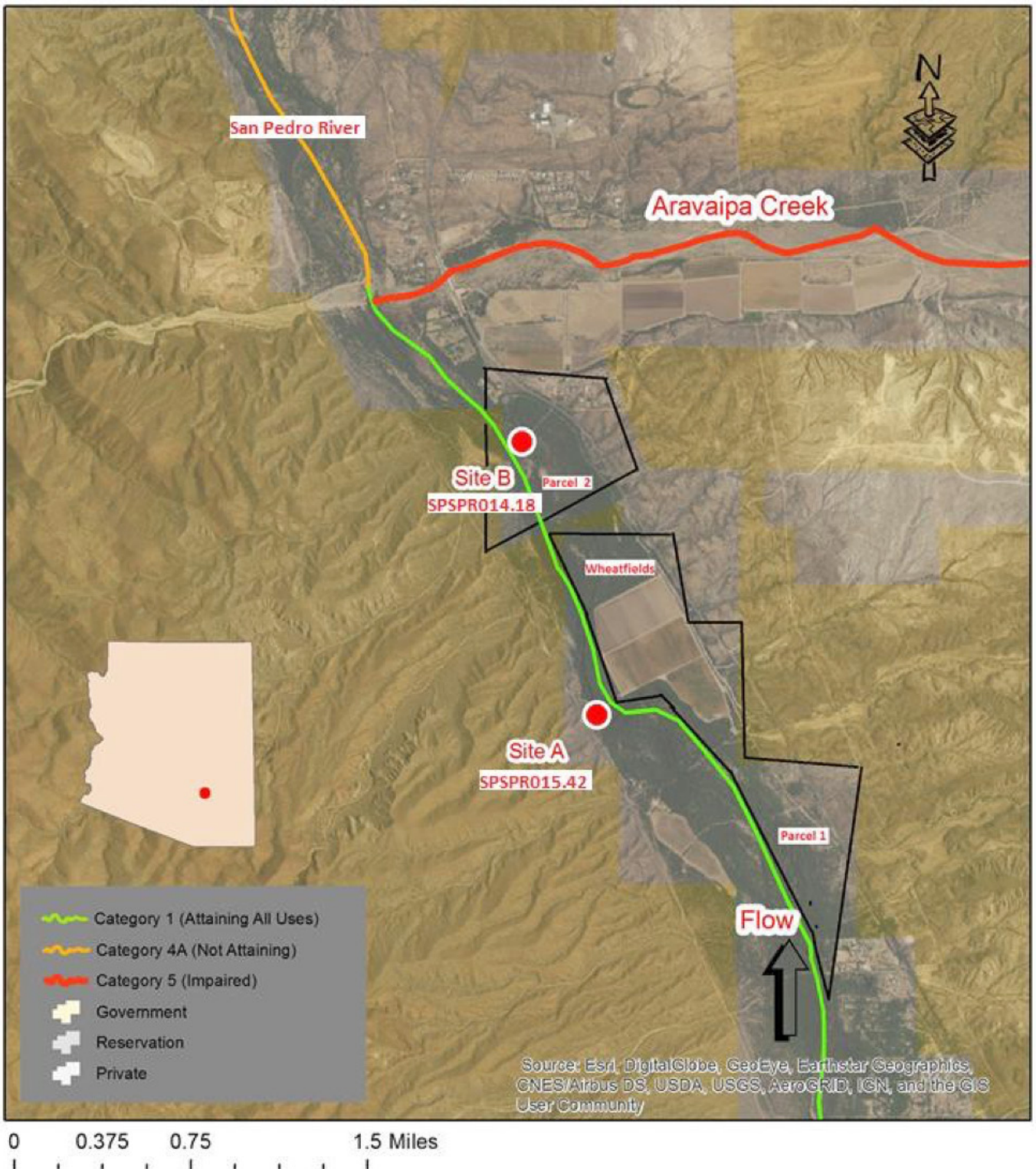

Figure 1 - Overview of Lower San Pedro River sites, with notable features labeled including the Wheatfields, AZGFD Parcels, and an inset map. (USGS, 2017)

STUDY AREA CONT.

The San Pedro River study area includes two sites on the San Pedro River on either side of an agriculture field, referred to as Wheatfields. The two sites are located in HUC AZ15050203-003 within the San Pedro River. Just north of the sites is the confluence of Aravaipa and Putnam Wash across the San Pedro which splits the reach. Site A, or SPSPR015.42, is the upstream site that will be used for long term trends, while Site B, or SPSPR014.18 will be used for determining potential impacts of irrigation return downstream. The sites are separated by an agriculture field and are 1.2miles apart. Both sites can be categorized as perennial within the overall intermittent reach of the San Pedro riparian corridor. The reach lays along AZ Highway 77, 6 miles north lies the town of Dudleyville, with the town of Mammoth 7 miles south. Each site sits at an elevation of 2200 feet. SPSPR015.42 is specifically located just west of the southwest corner of the agriculture fields, while SPSPR014.18 is more hidden away located off Highway 77 and a quarter mile west through dense thicket of tamarisk. Figure 2 shows the drainage area as set from SPSPR014.18, which is 4339.44mi2 (USGS, 2017). The headwaters of the San Pedro River is located in Sonora, Mexico. The San Pedro River flows north into southeastern Arizona meeting the Gila River at Winkelman. Its length totals at roughly 210 miles, with about 20 miles resting on the Mexico side of the border.

REFERENCE	SITE ID	SITE DESCRIPTION	LATITUDE	LONGITUDE
Site A	SPSPR015.42	San Pedro River - Above old camp grant military reservation boundary - parallel to Wheatfield	32°48'45.22"N	110°41'58.63"W
Site B	SPSPR014.18	San Pedro River - Downstream of Wheatfields Irrigation Return	32°49'45.30"N	110°42'18.10"W

Figure 2 - Lower San Pedro Watershed marke d from Site B mapped using StreamStats (Streamstats, 2017).

RESULTS

GENERAL WATER QUALITY

In the 2016 water quality assessment for the San Pedro River, this segment of the reach containing sites A & B were identified as a Category 2 "inconclusive" reach, meaning that there were some exceedances and insufficient data to determine if water quality is fully attaining all designated uses. This river reach was attaining the fish consumption and agricultural livestock watering designated uses, but inconclusive for full body contact and aquatic and wildlife-warm (A&Ww) designated uses. The parameters exceeding standards include bottom deposits (%fine sediment on the stream bottom), E. coli, selenium, dissolved oxygen, SSC, and biocriteria.

The full body contact designated use was inconclusive for E. coli in this reach of the San Pedro in the 2016 Water Quality Assessment report. There were three storm related E. coli exceedances found to be above the 235cfu/100ml standard and an insufficient number of samples to determine attainment of the full body contact use during the study period in this reach of the San Pedro River.

The aquatic and wildlife warm (chronic) designated use was inconclusive for Selenium, with one exceedance in 10 overall samples in the reach during the Assessment period.

The aquatic and wildlife warm designated use was inconclusive for dissolved oxygen (DO) with three exceedances during the assessment period that exceeded the standard of 6.0mg/L. During the study period, Site A continued to violate the DO standard in all sampling events except 2013, with an average DO (mg/L) of 4.38mg/L. Site B maintained an average of 11.65, with no values violating the DO standard during the study period.

The aquatic and wildlife warm designated use was met for suspended sediment concentration (SSC), even though there were several extreme values for suspended sediment during the Assessment period, ranging from 11,378 – 85,320mg/L. All exceedances of the SSC standard in this reach were storm-related and therefore exempt from meeting the surface water standard. SSC values collected during ADEQ low flow sample events were meeting the standard.

In terms of habitat, the percent fine sediment in the stream bottom exceeded the surface water standard at both sites during most sample events. The Bottom deposits standard was exceeded at Site A during all 5 sample events, with a range of 59.6-70% (median of 66.7%). At downstream Site B 3 of 4 percent fines values exceeded the standard, with a range of 38-73% (mean of 61%). The only acceptable value for percent fines during the study was at Site B in 2015, with an acceptable value of 38% fines. All other values exceeded the standard of 50% fines within the study area.

Biocriteria was not used in the assessment of these sites, but is a valuable parameter in assessing the condition of aquatic life in the reach. Site A did not meet biocriteria standards in 2012 and 2013 with scores of 26 and 34. All four samples met biocriteria at Site B.

FLOW REGIME

The flow within the Lower San Pedro Wildlife Area is typical of flashy desert streams, with elevated flows during monsoon season and baseflow the remainder of the year. The typical season for monsoons is mid to late summer, providing USGS with adequate flow data for the representative time frames and providing this report with a visual representation of the peak flow (Figure 15). The USGS flow gauge is located approximately 30 miles downstream from Site B.

RESULTS

FLOW REGIME CONT.

USGS 09472050 SAN PEDRO RIVER AT REDINGTON BRIDGE NR REDINGTON, AZ

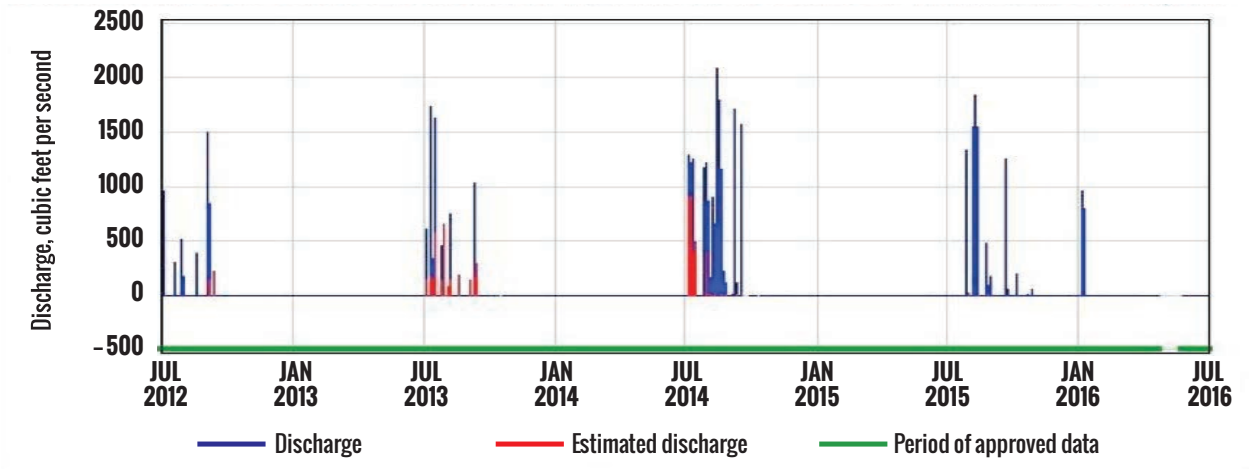

Figure 15 - USGS Stream Gauge fo r Redington Bridge, downstream of Site B showing peak flow periods for July 2012 through July 2016 .

During our study period of 2012-16, baseflow conditions were present during all sampling events. Flow was consistently similar for both sites and at low flow during all visits. The exception being the flow in 2013 being 50% less than in other sampling years. (Figure 16).

Flow at Site A had a range of 0.4 cfs up to 1.8 cfs, and an average flow of 1.3 cfs, displaying that this site can have changes in flow depending on season and rainfall. It can be noted that in 2013 there was considerably lower flow than any of the other sampling dates.

Flow at Site B had a range of 0.2 cfs to 1.4 cfs, and an average flow of 0.9 cfs, overall lower values than its sister site upstream, although the trend described through Figure 16 is constant across the sampling period.

FLOW DATA (2012–2016)

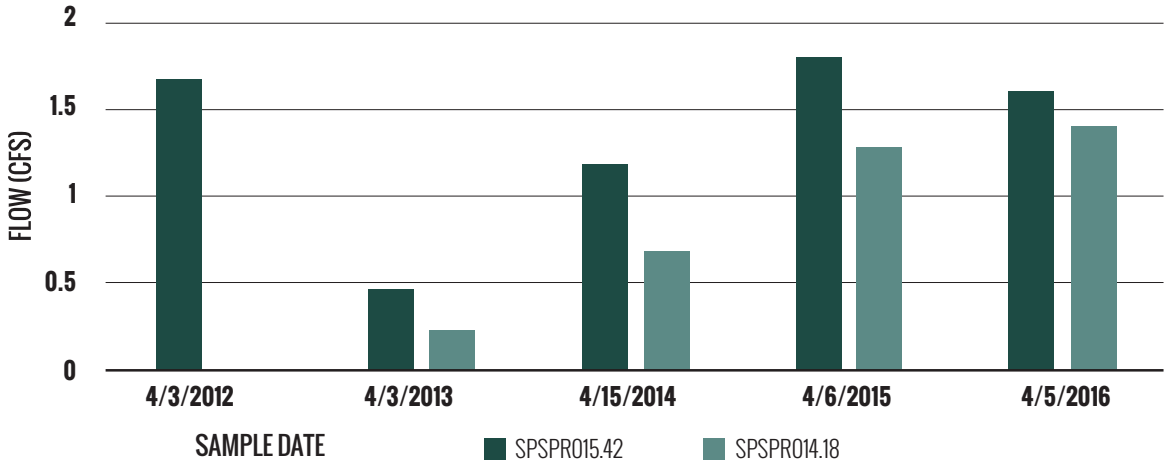

Figure 16 - Bar graph comparing flow data for two San Pedro River sites from 2012 to 2016, with Site B having a data gap in 2012 .

RESULTS

WATER QUALITY COMPARISON

The water quality for these two focus sites was generally good, with most parameters meeting water quality standards. Physically, both appear turbid with an almost milky tint, generally slow flowing, with significant channel cutting and erosion along the banks (Figure 3) . Both macrophytes and algae were found during the various spring sampling periods, although both receded or died off during the colder seasons. Small unidentifiable fish were present during later visits, as well as infrequent bullfrogs. No crayfish were observed. Generally the water at both locations has no odor, often has leaves floating on the surface or debris settled on the channel bottom. Site A was the only of the two sites to have evidence of salt crusts along the banks, as well as having several split channels along the southern border of the wheatfields.

Figure 3 - Photos of both San Pedro River sites, Site A (Left) and Site B (Right) both facing downstream, taken Fall 2017.

San Pedro water quality generally met water quality standards at both stations during the 5 sampling events. The exceptions were dissolved oxygen and E. coli. Dissolved oxygen conditions were very different between the two monitoring sites; Site A had a generally low DO, violating the standard in all sampling events except for 2013 whereas Site B met the DO standard threshold of 6mg/L for every sampling event (Figure 4). The range of DO values at Site A went from 2.99mg/L to 6.21mg/L, with an average of 4.38, while the range at Site B was 9.25mg/L to 12.6mg/L with an average DO value of 11.65mg/L. Dissolved oxygen values were significantly different between the two San Pedro River sites (Figure 5). Considering the ranges of dissolved oxygen values, Site A was generally not meeting water quality standards, while Site B was well above the recommended standard.

RESULTS

WATER QUALITY COMPARISON CONT.

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DISSOLVED OXYGEN IN mg/L (2012–2016)

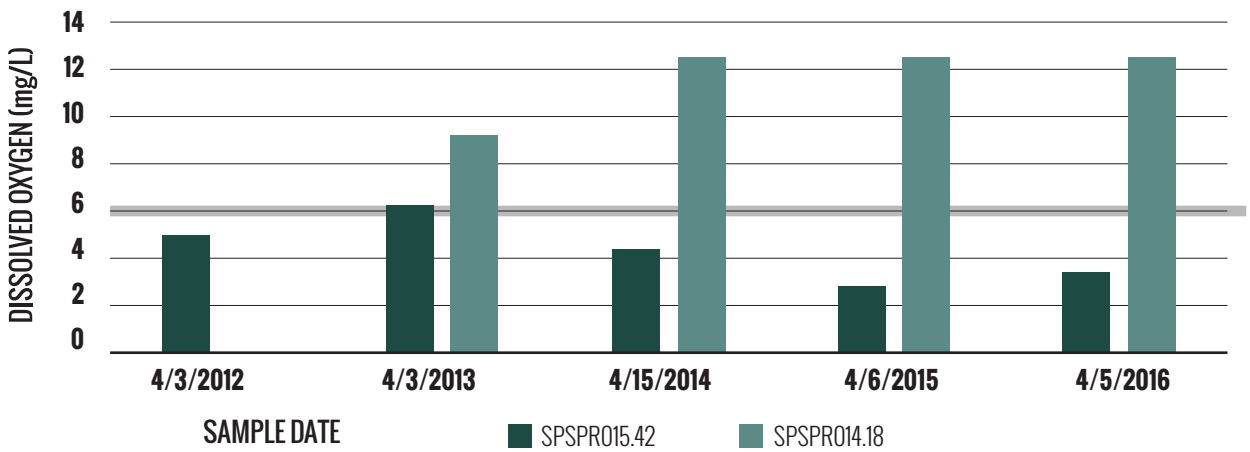


Figure 4 - Dissolved oxygen for both sites through the 2012 -2016 sampling period. SPSPR014.18 does not have a collection for 2012.

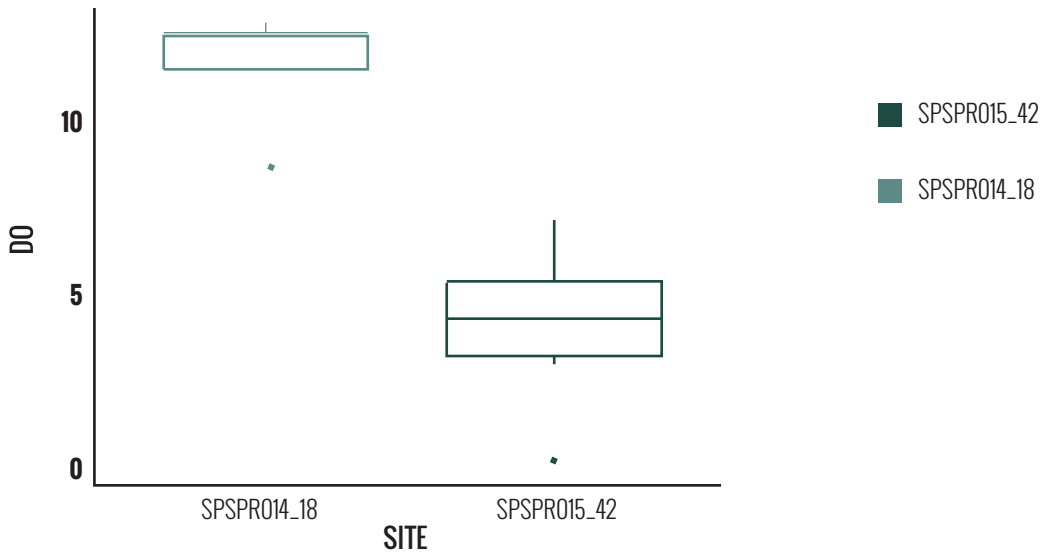


Figure 5 - Box plot comparing dissolved oxygen in mg/L between sites with Site B on the left and Site A on the right.

RESULTS

WATER QUALITY COMPARISON CONT.

There were no E. coli exceedances at baseflow during the spring 2012-2016 sampling events. The only exceedances listed in the 2016 assessment were for stormflow related bacteria exceedances. Both Site A and Site B were within acceptable standards for E. coli during the study period (Figure 6), with Site A having a range of 7.5-95.9 CFU/100mL (mean of 50.2), and Site B having a range of 7.9-21.3 CFU/100mL (mean of 16.6) (Figure 7).

E. COLI AT BOTH SITES (2011–2016)

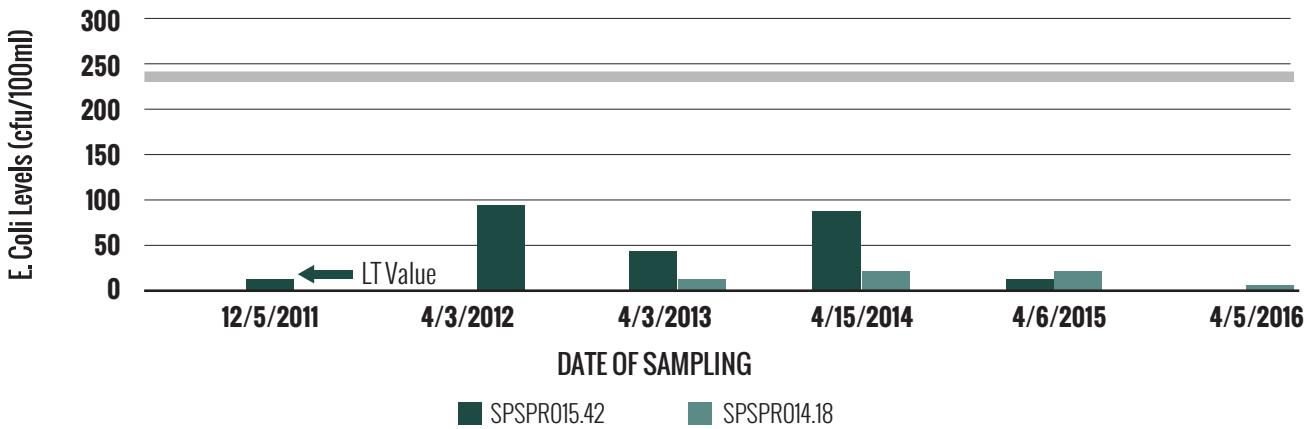


Figure 6 - Bar Graph showing the sampled values of E. coli at two San Pedro River sites, as well as the exceedance value of 235cfu/100ml during the 2012-2016 sampling period, with additional 2011 value included.

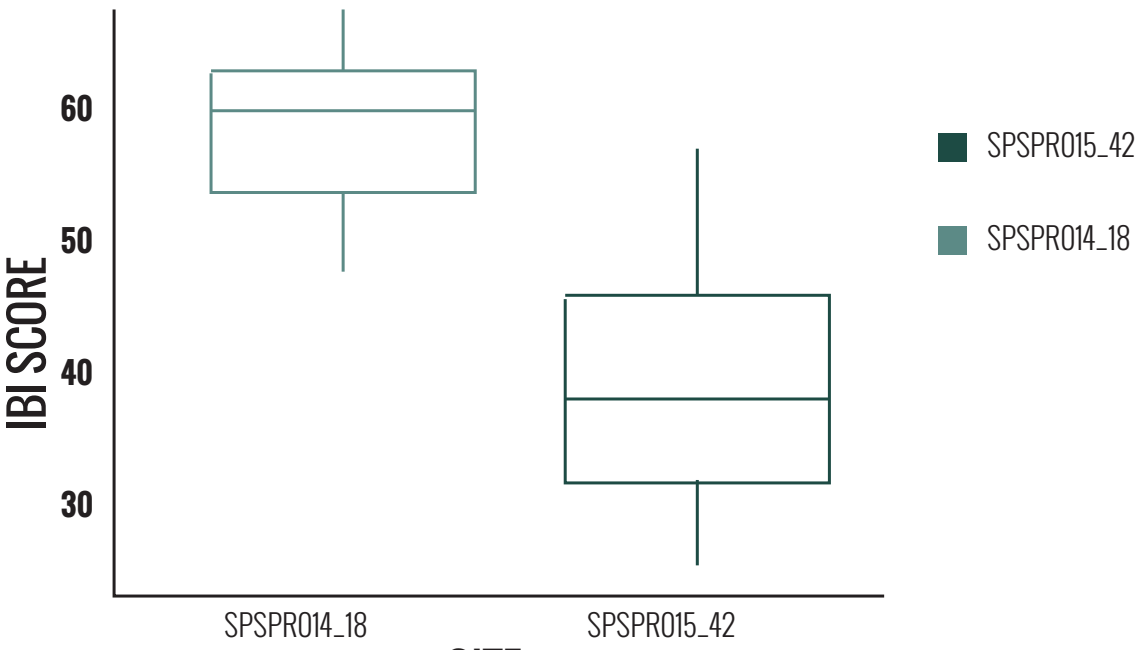


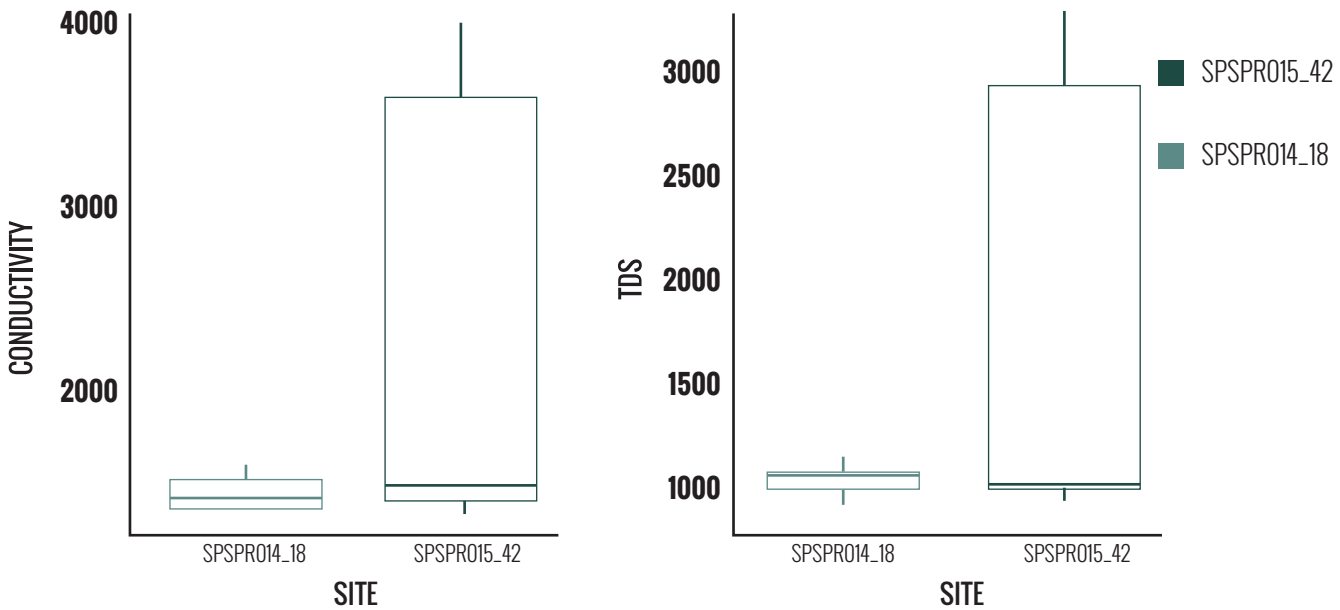
Figure 7 - Comparison of pH values between two San Pedro River sites.

RESULTS

WATER QUALITY COMPARISON CONT.

The A&Ww water quality standard for pH is 6.5-9 SU and both sites met this standard during all sample events. The range of pH at Site A was 7.2-7.72, with a median of 7.45 SU. Site B had an even smaller deviation with a median pH of 8.28 SU and a range of 8.33-8.46, getting close to the upper range of the standard of 9 SU, but still acceptable. The pH values between sites were significantly different, with downstream Site B (SPSPR014.18) having consistently greater pH values than upstream Site A (SPSPR015.42, Figure 7).

Conductivity and TDS values were not significantly different between Site A and B, although Site A had a greater range of values than Site B (Figure 8). Conductivity at both sites was elevated, with Site A having a range of 1380-4000, median of 1940 and standard deviation of 1152.5. Site B had a range of 1360- 1600 with a median of 1455 and standard deviation of 117.04 (Figure 8). While there is no water quality standard for conductivity, elevated concentrations can be harmful to the macroinvertebrates. TDS values were greater at Site A (843-2420mg/L), than Site B (839-968mg/L) (Figures 9).



Figures 8 & 9 – [Left] Box Plot comparing Conductivity between sites. [Right] Box Plot comparing Total Dissolved Solids between sites. Both graphs reflect the data taken during the 2012-2016 study period.

Site A consistently had a wider range and elevated values for electrical conductivity, as well as total dissolved solids, and generally spring flow. Site B has greater dissolved oxygen values, a higher median pH, generally meets biocriteria, and has greater per cent values for habitat. Both sites have E. coli values within the standards for non-stormflow sampling events.

The aquatic habitat between Site A and B was found to be different, with Site A having less riffle habitat (10%) than Site B (26%). The sedimentation (percent fines) and Pfankuch Channel Stability scores for both sites were similar. The contributing factors for excess sediment are likely bank erosion within the reach, and storm water runoff from the watershed. Riparian habitat conditions were different between Sites A and B according to Proper Functioning Condition (PFC) scores and percent canopy density. The riffle, run, pool composition was not very beneficial with run and pool habitat dominant at both sites.

RESULTS

MACROINVERTEBRATE & HABITAT

ADEQ utilizes benthic macroinvertebrate taxonomic data to directly assess the aquatic life designated use in wadeable perennial streams. In 2009, Arizona developed a narrative standard for macroinvertebrates. This standard is for warm water streams throughout the state (Table 2). The warm water IBI is based on nine metrics (total taxa, Hilsenhoff Biotic Index, Ephemeroptera taxa, Tricoptera taxa, Chironomidae taxa, percent Ephemeroptera, percent individuals in the dominant taxon, number of scraper taxa, and percent scrapers). Guidelines for analysis of biological data and use of the biocriteria standard are presented in the "Narrative Biocriteria Standard Implementation Procedures for Wadeable, Perennial Streams" (ADEQ, 2008c). There are both a narrative and a numeric biocriteria standard. The ADEQ narrative biocriterion reads as follows: "A wadeable, perennial stream shall support and maintain a community of organisms having a taxa richness, species composition, tolerance and functional organization comparable to that of a stream with reference conditions in Arizona." (A.A.C. R18-11-108.01). The numeric biocriteria consists of the IBI score, which must be >50 to meet the warmwater standard.

Table 2 - Macroinvertebrate index of Biological Integrity Score for Warm water.

INDEX OF BIOLOGICAL INTEGRITY SCORE	ASSESSMENT CATEGORY
Warm water	
≥ 50	Meeting biocriterion
40 – 49	Inconclusive
≤ 39	Violating biocriterion

IBI scores and the overall macroinvertebrate community was found to be in better condition at the downstream Site B, than at Site A. The IBI scores for Site A (SPSPR015.42) were violating the biocriteria standard in 2012-2013, but improved over time, while the IBI scores for Site B (SPSPR014.18) showed no trend over time (Figure 10). Site B met the biocriteria threshold in three of four sample events, only violating the biocriterion in 2014. The range of IBI scores at Site A were 26-62, with a median of 38. Site B had a range of scores from 47-66 with a median value of 61. The IBI scores were significantly different between the two sites, with the median IBI score for the downstream site B nearly 20 points greater than Site A, upstream (Figure 11).

IBI SCORES FROM (2012–2016)

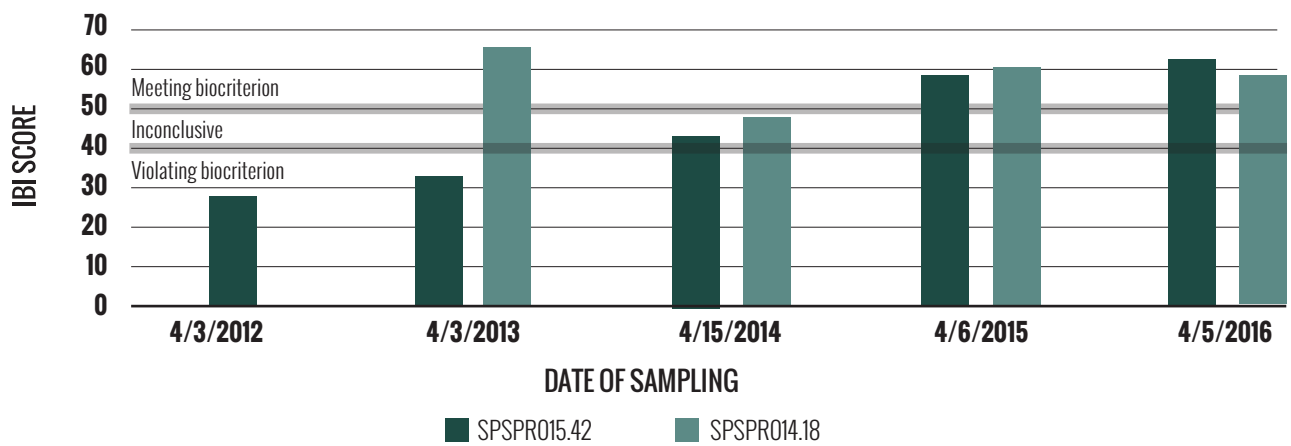


Figure 10 - Macroinvertebrate index of biological integrity (IBI) scores at two San Pedro River sites, 2012-2016.

RESULTS

MACROINVERTEBRATE & HABITAT CONT

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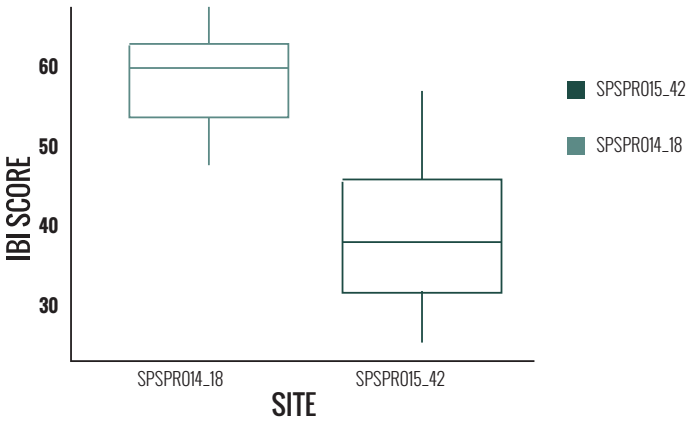

Figure 11 - Comparison of IBI scores between Sites A (SPSPR015.42) and Site B (SPSPR014.18) during the 2012 to 2016 sampling period.

IBI Score was negatively correlated with pH (Figure 12). The IBI score at Site A decreased with increasing pH (R2= 0.6). The IBI score at Site B also decreased with increasing pH (R2=0.85). These relationships suggest that the macroinvertebrate community condition is negatively affected by more basic pH environment.

IBI score was negatively correlated with dissolved oxygen (Figure 13). The relationship between dissolved oxygen (mg/L) and IBI at Site A was weakly negative, with an r squared of 0.38, compared with Site B which has a stronger negative trend of 0.66.

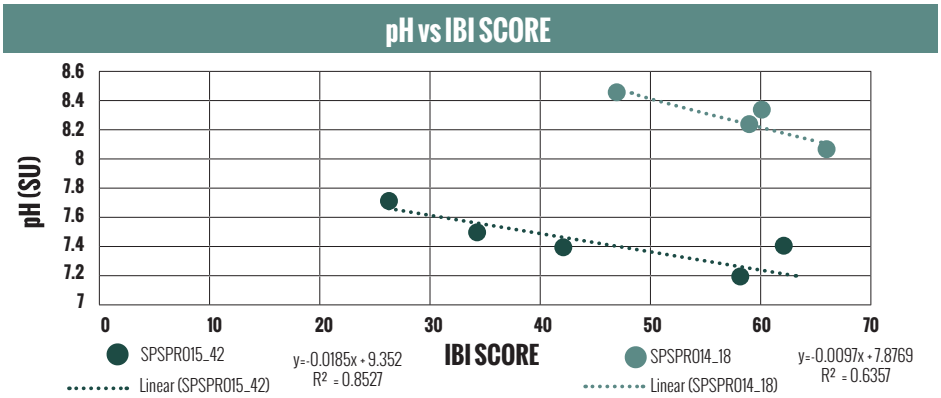

Figure 12 - Relationship between pH and IBI Score, at two San Pedro River study sites (2012 to 2016).

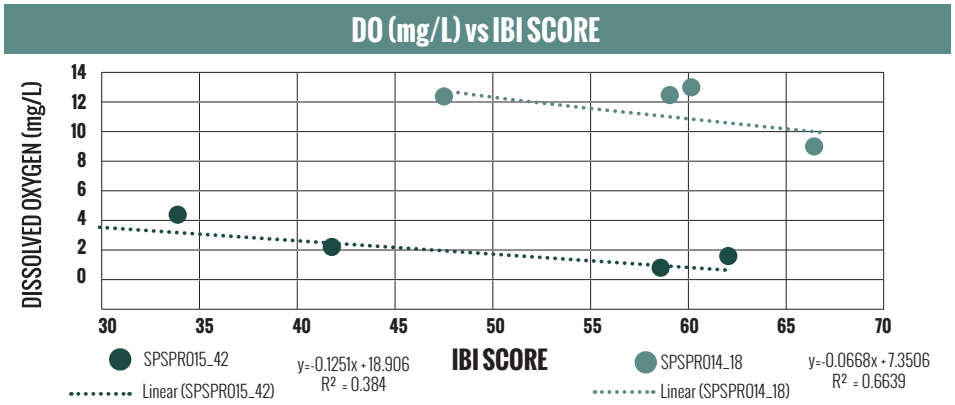

Figure 13 - Relationship between dissolved oxygen (mg/L) and IBI score, at two San Pedro River study sites (2012 to 2016).

DISCUSSION

The water quality in this reach of the San Pedro River was meeting water quality standards for a majority of parameters, but exceeding standards for E.coli, dissolved oxygen, selenium, SSC, bottom deposits, and biocriteria. The reach classified as "Category 2, Attaining some uses" in the 2016 ADEQ Water Quality Assessment report, with the fish consumption and agricultural livestock uses attaining and the full body contact and aquatic life use inconclusive. The parameters that exceeded during the study sampling period lead to the "inconclusive status" included bottom deposits, E.coli, selenium, dissolved oxygen, SSC, and IBI biocriteria score.

E. coli only exceeded the standard 235cfu/100mls during stormflow and there were no exceedances at the study sites during the 2012 to 2016 study period. This indicates that at baseflow there was generally not an E.coli bacteria problem, but during elevated flows E.coli from animal waste in the watershed is flushed into the stream. The Water Quality Assessment Report (ADEQ, 2016) recommends collecting additional E.coli samples to determine if the full body contact use is attaining or impaired.

The aquatic life use was inconclusive for selenium, with one chronic exceedance in 2012 at Site A, and some other elevated values found during stormflows. The selenium concerns are being re-evaluated, since laboratory technology has improved to provide lower detection limits and more accurate data. ADEQ conducted a TMDL in 2010 which re-evaluated the listing data used in the 2004 and 2006/08 assessments as well as collected additional higher quality data to determine that this reach was no longer violating for chronic selenium standard (ADEQ 2010). The 2016 Assessment report recommends collecting additional selenium samples to determine if the standard is now met and the aquatic life use attaining.

Dissolved oxygen is a requirement for aquatic life and was exceeding standards during the study period at our San Pedro River sites. The upstream Site A, directly adjacent the wheatfields, had low dissolved oxygen values in 4 out of 5 sampling events, while Site B had dissolved oxygen levels that were meeting the standards. The exceedances at Site A were most likely due to the fact that Site A is near the head of water, a gaining reach where anoxic groundwater becomes surface water. This low flow condition, as well as stagnant pools could contribute to low dissolved oxygen, a naturally occurring condition. The 2016 Assessment report recommends collecting additional dissolved oxygen samples to track trends.

There were some elevated suspended sediment values in storm water samples in the assessment period, but generally low SSC was found during low flow conditions at our study sites. SSC has adverse effects on macroinvertebrates communities through scouring which causes damage to macroinvertebrate gills, bodies, and their habitat. While the assessment report indicated that the aquatic life use was met for SSC, suspended sediment values are extreme during flood events and are evident in sedimentation of the stream bottom in the study reach.

There was excess sedimentation of the stream bottom, measured as percent fines (<2mm diameter). These bottom deposits values exceeded the standard at both San Pedro River monitoring sites and all sampling events except at Site B in 2015. Bottom deposits, similar to SSC, can cause adverse effects on macroinvertebrate communities by filling of interstitial spaces that smother stream bottom habitat. Bottom deposit exceedances occurred more frequently than any other exceedance and are an important concern for protecting aquatic life in the San Pedro River. The 2016 Assessment recommends continued collection percent fines data for re-evaluation of bottom deposits in the next assessment report.

There was an upward trend in macroinvertebrate IBI score over time from 2012-2016. Macroinvertebrate community conditions steadily improved every year at upstream Site A; violating the biocriteria standard in 2012-2013 and then meeting the standard in 2015-2016. The macroinvertebrate scores at downstream Site B did not violate the biocriteria standard, maintaining fair to good IBI scores throughout the study period. Elevated pH is one possible stressor; we found elevated pH correlated to lower IBI scores. Dissolved oxygen was generally not meeting the standard at the upstream site where anoxic groundwater was upwelling and influencing surface water conditions. Another possible stressor was TDS/EC which was significantly negatively correlated with IBI scores. We found significantly greater TDS and EC values at the upstream site where groundwater is upwelling than 1.5 miles downstream at Site B. We had predicted that TDS would be greater at Site B, downstream of the irrigated agricultural activities at the Wheatfields, but this prediction was proven incorrect with greater TDS at the upstream, headwater site and less TDS below the irrigation return flows downstream. The Society of Environmental Toxicology and Chemistry (SETAC) suggests that TDS has toxic effects on

DISCUSSION CONT.

macroinvertebrates when TDS values are in excess of 1340mg/L (SETAC, 2004). The elevated percentage of fine sediment was likely a major contributing factor to poor IBI scores, since macroinvertebrates require a well oxygenated substrate with open interstitial spaces. All percent fine sediment values collected at both San Pedro sites were near or greater than the 50% fine sediment bottom deposit standard. The macroinvertebrate community was altered at 40-50% fines, with losses in number of taxa in the scraper feeding group (mostly mayflies) and replacement of sensitive taxa by sand tolerant taxa (Spindler, 2004). Both chemical and physical parameters are likely stressors contributing to poor macroinvertebrate IBI scores in this reach of the Lower San Pedro River.

ADEQ intends to continue monitoring this reach of the San Pedro River as per the Trustees Restoration Plan for the full 30 year period. ADEQ will conduct the next monitoring event in 2021, with further sampling being done every five years until 2041. This ongoing sampling will fulfill ADEQ's long term commitment to the Lower San Pedro Wildlife Area and the Trustees which manage the area. These sampling time frames were established to monitor for long term trends associated with the Trustees' restoration activities.

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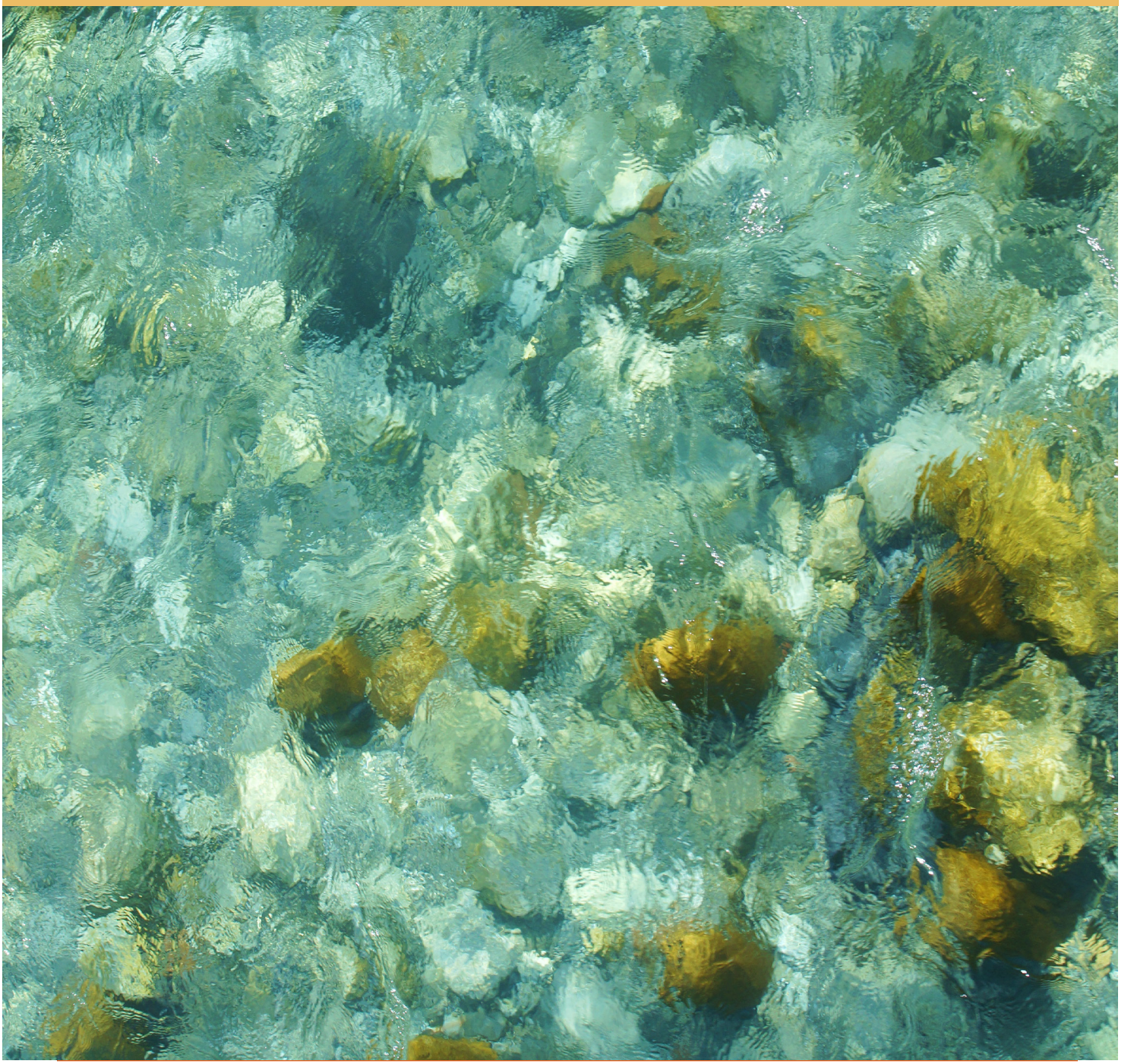
APPENDICES



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APPENDIX A
CHEMISTRY RESULTS

The water quality parameters below only list those that were considered relevant and detected within the study parameters. Other parameters sampled but left out due to data gaps, non-detects, or changes to sampling & analysis include: SSC, Arsenic, copper, boron, mercury, and chromium among a list of other values. Exceedances include, Selenium at Site A in 2012, Dissolved Oxygen at Site A for 2014-2016.

Highlighted values indicate that it is an exceedance. Chemistry results per site, for 2012-2016 sampling period.

Chemistry results per site, for 2012-2016 sampling period.

SPSPR015.42 (Site A)	TDS (MG/L)	E. Coli (cfu/100ml)	Specific conductance (UMHOS/CM)	Selenium (mg/L)	Dissolved Oxygen (MG/L)	Dissolved Oxygen (%)	pH (SU)	Turbidity (NTU)
4/3/2012	2420	95.9	4000	0.0025	4.8	52	7.7	7.8
4/3/2013	1000	49.6	1400	0	6.21	68.8	7.4	1.5
4/15/2014	843	86	1420	0.001	4.3	47.4	7.4	1.5
4/6/2015	930.5	12.2	1380	0.0011	2.9	36.5	7.2	3.7
4/5/2016	1000	7.5	1500	0.0014	3.4	42.2	7.4	1.2

SPSPR014.18 (Site B)	TDS (MG/L)	E. Coli (cfu/100ml)	Specific conductance (UMHOS/CM)	Selenium (mg/L)	Dissolved Oxygen (MG/L)	Dissolved Oxygen (%)	pH (SU)	Turbidity (NTU)
4/3/2012	NC	NC	NC	NC	NC	NC	NC	NC
4/3/2013	945	16.6	1500	ND	9.2	95.3	8	11.5
4/15/2014	839	21.3	1360	0.001	12.3	167.7	8.4	13.7
4/6/2015	968.3	20.9	1360	0.001	12.6	150.1	8.3	11
4/5/2016	966.1	7.9	1600	0.0013	12.4	152.9	8.2	16

APPENDIX B
HABITAT & IBI RESULTS

The habitat and IBI parameters selected were chosen based on their relationship with IBI and flow. Exceedances within habitat and IBI include IBI Score.

Highlighted values indicate an exceedance.

Habitat and IBI Results per site, for 2012-2016 sampling period.

SPSPR0 15.42 (Site A)	IBI Score	Habitat Ideal (%)	Total Riffle (%)	Algae Cover (%)	Macrophyte Cover (%)	Reach Fines	D50	Riffle Embeddedness (%)	PFC (%)	Pfankuck Score	Flow	Canopy %
4/3/2012	26	75	18	1	17	67.6	0.5	68	56.2	48.3	1.7	NC
4/3/2013	34	50	9.1	14	62	70	0.4	68	52.9	55.9	0.49	60
4/15/2014	42	35	24.5	24	62	66.7	0.4	88	76.4	51.6	1.2	40
4/6/2015	58	40	18.3	17	17	66.7	0.5	88	68.7	40.8	1.8	60
4/5/2016	62	50	30.3	10	39	59.6	0.2	63	75	60.5	1.6	NC

SPSPR0 14.18 (Site B)	IBI Score	Habitat Ideal (%)	Total Riffle (%)	Algae Cover (%)	Macrophyte Cover (%)	Reach Fines	D50	Riffle Embedded-ness (%)	PFC (%)	Pfankuck Score	Flow	Canopy %
4/3/2012	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	60
4/3/2013	66	50	28	16	13	68	0.1	68	41.1	50.5	0.2	75
4/15/2014	47	60	28.3	16	38	73	0.06	68	52.9	44.08	0.6	75
4/6/2015	60	60	18.5	44	41	38	14.3	88.5	62.5	49.4	1.3	75
4/5/2016	59	85	30.6	30	12	65	0.06	38	68.7	52.6	1.4	NC

IBI Correlation values.

TDS	EColi	Conduc-tivity	Selenium	Flow	Turbidity	pH	DO	DOp	pHab	pRiff	pAlgae	pMacro	pRF	D50	RiffEmbed	pPFC	pFan
-0.63	-0.86	-0.63	-0.22	-0.03	0.29	0.24	0.29	0.27	1	0.53	-0.24	0.39	-0.37	0.25	-0.08	0.11	0.04

APPENDIX C
RAW STATISTICS

Raw statistics for both sides.

	TDS (mg/l)	ECOLI (cfu/100ml)	CONDUCTIVITY (umhos/cm)	Selenium (mg/l)	FLOW (cfs)	TURBIDITY (NTU)	pH (SU)	DO (mg/L)	Do Percent (%)	IBI	Percent Habitat (%)	pAlgae (%)	Percent (%) Macrophytes	Percent (%) Riffle	D50	Riffle Embed	Percent PFC (%)	Percent fan (%)
SPSPR015.42 (Site A)																		
Range	843-2420	7.5-95.9	1380-4000	0-0.0025	0.4-1.8	1.2-7.8	7.2-7.7	2.9-6.2	36.5-68.8	26-62	35-75	1-34	17-62	9.1-30.3	0.2-0.5	63-88	52.9-76.4	48.3-60.5
Mean	1238.7	50.24	1940	0.00102	1.3	3.2	7.4	4.3	49.3	44.4	50	20.09	39.4	66.1	0.4	75	65.8	51.4
SD	663.5	40.74	1152.4	0.001	0.5	2.8	0.18	1.2	12.3	15.3	15.4	7.9	22.5	3.8	0.1	12.04	10.7	7.4
SPSPR014.1 8 (Site B)																		
Range	839-968.3	7.9-21.3	1360-1600	0-0.001	0.2-1.4	11-16	8.3-8.4	9.2-12.6	95.3-167.7	47-66	50-85	16-44	12-41	18.5-28	0.062-14.3	38-88.5	41.1-68.7	44.08-52.6
Mean	929.6	16.6	1455	0.0008	0.9	13	8.2	11.6	141.5	58	63.7	26.3	26	20.6	3.6	65.6	56.3	49.1
SD	61.3	6.2	117.04	0.0005	0.5	2.2	0.15	1.6	31.7	7.9	14.9	5.3	15.6	15.6	7.1	20.7	12.02	3.6

APPENDIX D
SITE PHOTOS

SITE A / SPSPR015.42
Upstream - Downstream

2017 (FALL)

2015 (SPRING)

2014 (SPRING)

APPENDIX D
SITE PHOTOS CONT.

SITE B / SPSPR014.18
Upstream - Downstream

2017 (FALL)

2015 (SPRING)

2014 (SPRING)

APPENDIX E

MACROINVERTEBRATE AND HABITAT EDAS REPORTS, BY SITE VISIT

These are PDF documents linked to this document. Three separate PDFs are listed; Both sites IBI*, Both Sites 2012-2015*, Both sites 2016*.

IBI REPORT, BOTH SITES, 2012-2016

Warm IBI Results

SAN PEDRO RIVER, ABOVE OLD CAMP GRANT MILITARY RESERVATION BOUNDRY

Station ID	SPSPR015.42	**Latitude:**	32.81261	**Longitude:**	-110.69797
Benthic Sample ID	3836	**Rep Num**	1	**CorrectionFactor:**	24
Invert Region:	Warm	**Collection Date**	04-03-2012		
Elevation:	2190	***Index period:***	Sp		
Habitat:	Riffle	***ActivityID:***	SPSPR015.42-04/03/2012-Riffle		

IBI:	**25.65**
Narrative Rating:	**ViolatesBiocriterion**

Valid for Assessment

Warm IBI Impairment Thresholds	
Meets Biocriterion:	>=50
Inconclusive or violates:	40 - 49
Violates Biocriterion:	<=39

Total Individuals (Raw):	571
Total Individuals (Corrected)	13704

Metric	Value	Score
Total Taxa:	14.0	37.84
Ephemeroptera Taxa:	2.0	22.22
Trichoptera Taxa:	0.0	0.00
Diptera Taxa:	6.0	60.00
% Ephemeroptera:	0.35	0.50
Scraper Taxa:	0.0	0.00
% Scraper:	0.00	0.00
% Dom01:	64.80	43.51
HBISPL:	6.589	66.75

Taxa List (Chironomids at family level): Taxa list may continue on next page.

Order:	*FinalID (genus):*	*Individ'sRaw:*	*Individs:*	*Excluded:*	*FFG:*	*Tolerance:*
	Ostracoda	8	192	0	Collector	8
	Oligochaeta	154	3696	0	Collector	8
Coleoptera	Postelichus	7	168	0	Shredder	5
Coleoptera	Hydroporinae	2	48	0	Predator	
Coleoptera	Dytiscidae	2	48	-1	Predator	7
Diptera	Trichoclinocera	2	48	0	Predator	
Diptera	Simulium	11	264	0	Filterer	6
Diptera	Dasyhelea	6	144	0	Predator	7
Diptera	Chironomidae	370	8880	0	Collector	6
Diptera	Ceratopogoninae	2	48	0	Predator	7
Diptera	Atylotus/Tabanus	2	48	0	Predator	
Ephemeroptera	Tricorythodes	1	24	0	Collector	7
Ephemeroptera	Callibaetis	1	24	0	Collector	9
Trombidiformes	Sperchon	1	24	0	Predator	
Trombidiformes	Arrenurus	2	48	0	Predator	

For additional interpretive information, see AZ DEQ. 2006. "DRAFT Technical Support Documentation for the Narrative Biocriteria Standard."

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APPENDIX E

MACROINVERTEBRATE AND HABITAT EDAS REPORTS, BY SITE VISIT CONT.

HABITAT REPORT 2012-2015

Habitat SEM Results

SAN PEDRO RIVER, ABOVE OLD CAMP GRANT MILITARY RESERVATI

Station ID SPSPR015.42 **Latitude:** 32.81261 **Longitude:** -110.69797
HabSample ID 1243 **Rep Num** 1 **Date** 04-03-2012

Field Conditions at Time of Visit

Flood Evidence (last month)	1) none	Flood Width (ft):	
Precipitation (current)	none	Precipitation (w/in 24 hrs):	none
Cloud Cover (%):	0		

Reach Observations

General appearance in the channel	3) small refuse common	Fish:	1) absent
General appearance along the banks	2) small refuse visible	Crayfish:	1) absent
Water Clarity	1) clear	Sunfish:	1) absent
Water odor	5=rotten eggs	Leapard Frogs - Alive	Dead:
Appearance at water's edge	4) banks crusted	Bullfrog Presence:	
% algae cover within 10m of the site	25	Floating leaves:	2) rare
% macrophyte cover within 10m of the site	2	Settled leaves:	3) common

Stream Type Identification

Watershed Area (Mi2):	1168	Field-Measured Slope:		Sinuosity:	
Predicted X-Section Area:	500	Regional Curve:	Central / Southern	Valley Type:	VIII

Measurements for Determining Stream Type

Bankfull Width (ft):	20	Floodprone Width:	765	Floodprone Width Method:	
BF max. Depth:	6	Actual X Section Area:	600		
Corr. Factor:	0.5	**Stream Type:**	C5	Stream Type Confidence:	
BF mean Depth:	3	BF Indicators:	6) Presence of a floodplain, 3)slope		
Depositional Features:	1) point bars				

Segment Habitat Quality

Undercut Banks:	2) rare	Root Masses	3) common
Leaf Packs:	2) rare	Submerged Logs/Snares	3) common

[redacted]

	Feet	Percent		Latitude	Longitude
Riffle:	112	30.4	Top of Reach:		
Pool:	114	31	Bottom of Reach:		
Run:	142	38.6	Reach Length:		
Riffle / Pool Ratio:	0.98245614				

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APPENDIX E

MACROINVERTEBRATE AND HABITAT EDAS REPORTS, BY SITE VISIT CONT.

HABITAT REPORT 206

Habitat SEM Results

SAN PEDRO RIVER, AT WHEATFIELDS, BLW IRRIGATION RETURN

Station ID SPSPR014.18 **Latitude:** 32.82925 **Longitude:** -110.70503
HabSample ID 1408 **Rep Num** 1 **Date** 04-05-2016

Field Conditions at Time of Visit

Flood Evidence (last month)	1) none	Flood Width (ft):	0
Precipitation (current)	none	Precipitation (w/in 24 hrs):	none
Cloud Cover (%):	0		

Reach Observations

General appearance in the channel	1) no refuse	Fish:	2) rare
General appearance along the banks	1) no refuse	Crayfish:	1) absent
Water Clarity	2) milky	Sunfish:	1) absent
Water odor	1=none	Leapard Frogs - Alive	0 Dead: 0
Appearance at water's edge	3) salt crusts numerous	Bullfrog Presence:	Absent
% algae cover within 10m of the site	60	Floating leaves:	1) absent
% macrophyte cover within 10m of the site	15	Settled leaves:	2) rare

Stream Type Identification

Watershed Area (Mi2):	#Name?	Field-Measured Slope:	0.001	Sinuosity:	1.1
Predicted X-Section Area:	500	Regional Curve:	Central / Southern	Valley Type:	VIII

Measurements for Determining Stream Type

Bankfull Width (ft):	45	Floodprone Width:	1600	Floodprone Width Method:	2) GIS estimated
BF max. Depth:	7.5	Actual X Section Area:	226		
Corr. Factor:	0.67	**Stream Type:**	C4	Stream Type Confidence:	High
BF mean Depth:	5	BF Indicators:	3) Slope break		
Depositional Features:	1) point bars				

Segment Habitat Quality

Undercut Banks:	4) abundant	Root Masses	2) rare
Leaf Packs:	1) absent	Submerged Logs/Snares	3) common

[redacted]

	Feet	Percent		Latitude	Longitude
Riffle:	31	20.7	Top of Reach:	32.82935	-110.70483
Pool:	89	59.3	Bottom of Reach:	32.82999	-110.70536
Run:	30	20	Reach Length:	300	
Riffle / Pool Ratio:	0.34831460				

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APPENDIX F

PARAMETERS ANALYZED FOR EACH WATERSAMPLE

List of parameters sampled for through ADEQ.

Chemical	Analysis Type	Method	Lab	MRL	MRL Unit	Parameter group	Holding Time
CHLOROPHYLL A (BENTHIC)	TOTAL	SM 10200H	WALKER	0.1	UG/L	CHLOROPHYLL A	NONE
CHLOROPHYLL A (WATER COLUMN)	TOTAL	SM 10200H	WALKER	0.1	UG/L	CHLOROPHYLL A	NONE
ALUMINUM	DISSOLVED	EPA 200.7	TAX	0.1	MG/L	DISSOLVED METALS	6 MONTHS
ANTIMONY	DISSOLVED	EPA 200.8	TAX	0.001	MG/L	DISSOLVED METALS	6 MONTHS
ARSENIC, INORGANIC	DISSOLVED	EPA 200.8	TAX	0.001	MG/L	DISSOLVED METALS	6 MONTHS
BARIUM	DISSOLVED	EPA 200.8	TAX	0.0005	MG/L	DISSOLVED METALS	6 MONTHS
BERYLLIUM AND COMPOUNDS	DISSOLVED	EPA 200.8	TAX	0.001	MG/L	DISSOLVED METALS	6 MONTHS
BORON (BORON AND BORATES ONLY)	DISSOLVED	EPA 200.7	TAX	0.05	MG/L	DISSOLVED METALS	6 MONTHS
CADMIUM	DISSOLVED	EPA 200.8	TAX	0.0001	MG/L	DISSOLVED METALS	6 MONTHS
CALCIUM	DISSOLVED	EPA 200.7	TAX	2	MG/L	DISSOLVED METALS	6 MONTHS
CHROMIUM	DISSOLVED	EPA 200.8	TAX	0.001	MG/L	DISSOLVED METALS	6 MONTHS
COBALT	DISSOLVED	EPA 200.8	TAX	0.0005	MG/L	DISSOLVED METALS	6 MONTHS
COPPER	DISSOLVED	EPA 200.8	TAX	0.0005	MG/L	DISSOLVED METALS	6 MONTHS
IRON	DISSOLVED	EPA 200.7	TAX	0.1	MG/L	DISSOLVED METALS	6 MONTHS
LEAD AND COMPOUND (INORGANIC)	DISSOLVED	EPA 200.8	TAX	0.0005	MG/L	DISSOLVED METALS	6 MONTHS
MAGNESIUM	DISSOLVED	EPA 200.7	TAX	2	MG/L	DISSOLVED METALS	6 MONTHS
MANGANESE	DISSOLVED	EPA 200.8	TAX	0.0005	MG/L	DISSOLVED METALS	6 MONTHS
MERCURY, ELEMENTAL	DISSOLVED	EPA 245.1	TAX	0.2	UG/L	DISSOLVED METALS	90 DAYS
MOLYBDENUM	DISSOLVED	EPA 200.8	TAX	0.0005	MG/L	DISSOLVED METALS	6 MONTHS
NICKEL	DISSOLVED	EPA 200.8	TAX	0.0005	MG/L	DISSOLVED METALS	6 MONTHS
POTASSIUM	DISSOLVED	EPA 200.7	TAX	0.5	MG/L	DISSOLVED METALS	6 MONTHS
SELENIUM AND COMPOUNDS	DISSOLVED	EPA 200.8	TAX	0.0005	MG/L	DISSOLVED METALS	6 MONTHS
SILVER	DISSOLVED	EPA 200.8	TAX	0.0001	MG/L	DISSOLVED METALS	6 MONTHS
SODIUM	DISSOLVED	EPA 200.7	TAX	0.5	MG/L	DISSOLVED METALS	6 MONTHS
STRONTIUM	DISSOLVED	EPA 200.7	TAX	0.1	MG/L	DISSOLVED METALS	6 MONTHS
THALLIUM	DISSOLVED	EPA 200.8	TAX	0.0001	MG/L	DISSOLVED METALS	6 MONTHS
VANADIUM	DISSOLVED	EPA 200.8	TAX	0.0001	MG/L	DISSOLVED METALS	6 MONTHS
ZINC	DISSOLVED	EPA 200.8	TAX	0.0125	MG/L	DISSOLVED METALS	6 MONTHS
E. COLI	NA	COLILERT	DEQ	1	CFU/100 ML	E. COLI	6 HOURS
ALKALINITY, PHENOLPHTHALEIN	TOTAL	SM 2320B	TAX	6	MG/L	INORGANICS	14 DAYS
CALCIUM CARBONATE	TOTAL	SM 2320B	TAX	6	MG/L	INORGANICS	14 DAYS
CARBONATE	TOTAL	SM 2320B	TAX	6	MG/L	INORGANICS	14 DAYS

APPENDIX F

PARAMETERS ANALYZED FOR EACH WATERSAMPLE CONT.

List of parameters sampled for through ADEQ.

Chemical	Analysis Type	Method	Lab	MRL	MRL Unit	Parameter group	Holding Time
CHLORIDE	TOTAL	EPA 300.0	TAX	2	MG/L	INORGANICS	NONE
FLUORIDE	TOTAL	EPA 300.0	TAX	0.4	MG/L	INORGANICS	28 DAYS
HARDNESS (CACO3+ MGCO3) - DISSOLVED	CALCULATED	SM 2340B	TAX	13	MG/L	INORGANICS	6 MONTHS
HARDNESS (CACO3+ MGCO3) – TOTAL	CALCULATED	SM 2340B	TAX	13	MG/L	INORGANICS	6 MONTHS
HYDROGEN CARBONATE	TOTAL	SM 2320B	TAX	6	MG/L	INORGANICS	14 DAYS
PH	TOTAL	SM 4500-H+	TAX	1.68	SU	INORGANICS	15 MINUTES
SPECIFIC CONDUCTIVITY	STANDARD	SM 2510B	TAX	2	UMHOS/CM	INORGANICS	FIELD
SULFATE	TOTAL	EPA 300.0	TAX	2	MG/L	INORGANICS	28 DAYS
TOTAL DISSOLVED SOLIDS	DISSOLVED	SM 2540C	TAX	20	MG/L	INORGANICS	7 DAYS
AMMONIA AS NITROGEN	TOTAL	SM 4500NH3D, BG	TAX	0.05	MG/L	NUTRIENTS	28 DAYS
KJELDAHL NITROGEN	TOTAL	SM 4500-NH3D, E-97	TAX	0.5	MG/L	NUTRIENTS	28 DAYS
NITRATE + NITRITE	TOTAL	SM4500 NO3E-00	TAX	0.1	MG/L	NUTRIENTS	28 DAYS
PHOSPHORUS	TOTAL	SM 4500-PE	TAX	0.1	MG/L	NUTRIENTS	28 DAYS
PERIPHYTON IDENTIFICATION	NA	NRSA 2013FOM	RHITHRON	NA	NA	PERIPHYTON ID	NONE
SUSPENDED SEDIMENT CONCENTR TION	SUSPENDED	ASTM D3977C	TRANS	1	MG/L	SSC	NONE
ALUMINUM	TOTAL	EPA 200.7	TAX	0.1	MG/L	TOTAL METALS	6 MONTHS
ANTIMONY	TOTAL	EPA 200.8	TAX	0.001	MG/L	TOTAL METALS	6 MONTHS
ARSENIC, INORGANIC	TOTAL	EPA 200.8	TAX	0.001	MG/L	TOTAL METALS	6 MONTHS
BARIUM	TOTAL	EPA 200.8	TAX	0.0005	MG/L	TOTAL METALS	6 MONTHS
BERYLLIUM ANDCOMPOUNDS	TOTAL	EPA 200.8	TAX	0.001	MG/L	TOTAL METALS	6 MONTHS
BORON (BORON AND BORATES ONLY)	TOTAL	EPA 200.7	TAX	0.05	MG/L	TOTAL METALS	6 MONTHS
CADMIUM	TOTAL	EPA 200.8	TAX	0.0001	MG/L	TOTAL METALS	6 MONTHS
CALCIUM	TOTAL	EPA 200.7	TAX	2	MG/L	TOTAL METALS	6 MONTHS
CHROMIUM	TOTAL	EPA 200.8	TAX	0.001	MG/L	TOTAL METALS	6 MONTHS
COBALT	TOTAL	EPA 200.8	TAX	0.0005	MG/L	TOTAL METALS	6 MONTHS
COPPER	TOTAL	EPA 200.8	TAX	0.0005	MG/L	TOTAL METALS	6 MONTHS
IRON	TOTAL	EPA 200.7	TAX	0.1	MG/L	TOTAL METALS	6 MONTHS
LEAD AND COMPOUNDS (INORGANIC)	TOTAL	EPA 200.8	TAX	0.0005	MG/L	TOTAL METALS	6 MONTHS
MAGNESIUM	TOTAL	EPA 200.7	TAX	2	MG/L	TOTAL METALS	6 MONTHS
MANGANESE	TOTAL	EPA 200.8	TAX	0.0005	MG/L	TOTAL METALS	6 MONTHS
MERCURY, ELEMENTAL	TOTAL	EPA 245.1	TAX	0.2	UG/L	TOTAL METALS	6 MONTHS

APPENDIX F

PARAMETERS ANALYZED FOR EACH WATERSAMPLE CONT.

List of parameters sampled for through ADEQ.

Chemical	Analysis Type	Method	Lab	MRL	MRL Unit	Parameter group	Holding Time
MOLYBDENUM	TOTAL	EPA 200.8	TAX	0.0005	MG/L	TOTAL METALS	6 MONTHS
NICKEL	TOTAL	EPA 200.8	TAX	0.0005	MG/L	TOTAL METALS	6 MONTHS
POTASSIUM	TOTAL	EPA 200.7	TAX	0.5	MG/L	TOTAL METALS	6 MONTHS
SELENIUM AND COMPOUNDS	TOTAL	EPA 200.8	TAX	0.0005	MG/L	TOTAL METALS	6 MONTHS
SILVER	TOTAL	EPA 200.8	TAX	0.0001	MG/L	TOTAL METALS	6 MONTHS
SODIUM	TOTAL	EPA 200.7	TAX	0.5	MG/L	TOTAL METALS	6 MONTHS
THALLIUM	TOTAL	EPA 200.8	TAX	0.0001	MG/L	TOTAL METALS	6 MONTHS
URANIUM (CONTENT)	TOTAL	EPA 200.8	TAX	0.0001	MG/L	TOTAL METALS	6 MONTHS
VANADIUM	TOTAL	EPA 200.8	TAX	0.0001	MG/L	TOTAL METALS	6 MONTHS
ZINC	TOTAL	EPA 200.8	TAX	0.0125	MG/L	TOTAL METALS	6 MONTHS

ADEQ
Arizona Department
of Environmental Quality

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