ADEQ
Arizona Department of Environmental Quality

REACH SEGMENTATION AND DE-LIST REPORT FOR TOTAL BORON & TOTAL SELENIUM

Reach 15070201-003 Lower Gila River – Coyote Wash to Fortuna Wash

September 1, 2014

Executive Summary

A Total Maximum Daily Load (TMDL) project was launched for Reach 15070201-003 (Gila River – Coyote Wash to Fortuna Wash) in June 2012 to confirm impairment and quantify reductions necessary for exceedances of boron and selenium surface water quality standards resulting in an impaired water 303(d) listing in 2004. TMDL sampling continued through May of 2014. ADEQ has moved to administratively split the reach based on a change in hydrologic flow regime at the Castle Dome Wash (CDW) confluence. The original assessment is replaced by the set of evaluations /assessments resulting from the TMDL data set evaluated independently for each segment. The lower reach is assessed as attaining water quality standards for both boron and selenium. Because the upper reach is characterized by a different flow regime and it had not previously been sampled, it does not inherit the formerly-defined reach's listing status by default. The upper segment is evaluated as attaining selenium standards, but inconclusive status results when boron data is evaluated. Further monitoring of the upper segment under representative flow conditions is recommended due to the small size of the TMDL data set in the upper segment. The original 303(d) listing for the reach is rescinded.

Physiographic Setting

The Colorado main-stem watershed is defined by the Colorado River drainage area, from Hoover Dam at Lake Mead to the Mexico border near Yuma. It does not include the Bill Williams River drainage or the Gila River above Painted Rocks Dam. The Gila River in its lower reaches is included in the Colorado main-stem watershed. Land ownership is divided approximately as: 89 percent federal, 6 percent state, 4 percent tribal, and 1 percent private. Except for communities along the Colorado River (e.g., Yuma, Bullhead City, Lake Havasu City, Kingman), most of this 14,459 square mile watershed is sparsely populated. Yuma is the largest city in this region; Yuma's 2010 population was 93,064 (US Census Bureau, 2010).

Due in part to the sparse population, six wildlife refuges and three wilderness areas have been established in this watershed, along with several military bases with live fire exercise areas. All of these have restricted land uses. Tribal and private land is primarily along the Colorado River and lower Gila River and is intensively cultivated. Open grazing occurs across the watershed.

Elevations in the watershed range from 5,450 feet (above sea level) in the mountains near Lake Mohave to 80 feet along the Colorado River as it flows into Mexico. The area contains low desert fauna and flora, and supports warm water aquatic communities where perennial waters exist. Perennial water is limited to the Colorado main stem, with irrigation return flow providing perennial flow in the Gila River near Yuma (ADEQ, 2004).

The Gila River basin has a drainage area of approximately 57,850 square miles upstream from the United States Geological Survey (USGS) gauging station near Dome (09520500), which is approximately ten river miles upstream from its confluence with the Colorado River. The basin extends from the continental divide in west central New Mexico and includes all of southern Arizona. Major tributaries of the Gila River in Arizona include the Salt, Verde, San Pedro, and Hassayampa and Agua Fria Rivers. Generally speaking, the basin is located in the Basin and Range province of North America. Both the Colorado and Gila River in their lower reaches are a part of the Colorado Desert.

The Gila River main stem is regulated by two dams in Arizona – Coolidge Dam (1,073,600 acre-ft.) and Ashurst-Hayden Dam (no reservoir capacity). Flows upstream of Ashurst-Hayden are allocated for various other purposes, including fishery uses on the San Carlos Reservoir and agricultural irrigation in the Florence area and on the San Carlos Indian Reservation. Beyond Florence, the river bed is generally dry except where anthropogenic additions are made. Additional impoundments on major tributaries of the Gila River occur on the Salt River (total capacity 1,755,000 acre-ft.), the Verde River (317,700 acre-ft.), and the Agua Fria River (816,000 acre-ft.) (USGS, 2010). Painted Rock Reservoir on the Gila River, an impoundment northwest of Gila Bend, is dry except in high run-off years.

The Lower Gila watershed proper for this project encompasses the Gila River drainage area in the Dome and Wellton-Mohawk Valleys near Yuma. Under normal conditions, the watershed contributing area resides entirely within the boundaries of the Wellton-Mohawk irrigation District (Figure 1). Though there are no physiographic obstacles to the remainder of the Gila watershed contributing flow up to the Painted Rocks Dam and Reservoir, typically the watercourse below Painted Rocks is dry a majority of the time, flowing only in response to the most extreme precipitation events. This area receives little rainfall and some of the consistently highest insolation in the United States. The main channel of the Gila is ephemeral in the eastern region and upstream of the irrigation district boundary, and surface water flow at the Dome gauge location is almost entirely attributable to agricultural return flows and overflows from the Wellton-Mohawk and Dome Canals. The anthropogenically-altered nature of the flow regime, however, does not suggest that the reach is recently intermittent due to seasonal periodicity in the presence of flows. Daily mean flow records dating to 1905 from USGS, while exhibiting periods of no discharge in the hydrologic record, show that the frequency of no flow days tapered off largely by the end of the 1970s, and the site has exhibited only two days of mean daily flows of 0 cubic feet per second (cfs) in the last ten years. Perennial designated uses apply to the reach.

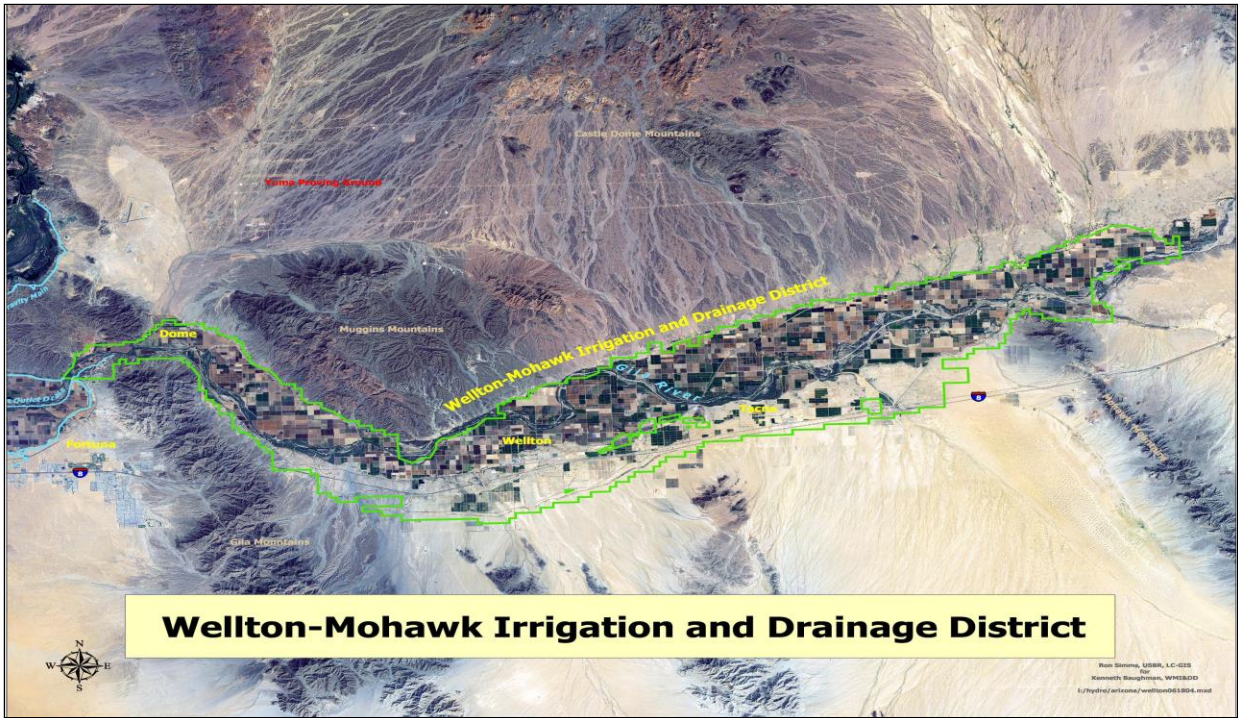

Figure 1. Lower Gila River Reach 15070201-003 and boundaries of WMI&DD.
Illustration courtesy of Wellton-Mohawk Irrigation and Drainage District

Designated Uses

Arizona applies designated uses to waterways in the state to serve as the foundation for applying numeric water quality standards. Designated uses may be broadly grouped into a human health and use class and a fish and wildlife class. Parameter standards are then developed based on existing research on toxicity and deleterious effects for each combination of parameter and designated use. Designated uses in Arizona include the following:

- Aquatic and Wildlife uses, cold water (above 5000 feet elevation) – acute and chronic (A&Wc)
- Aquatic and Wildlife uses, warm water (below 5000 feet) – acute and chronic (A&Ww)
- Aquatic and Wildlife uses, ephemeral (A&We)
- Aquatic and Wildlife uses, effluent dependent (A&Wedw)
- Full Body Contact (FBC)
- Partial Body Contact (PBC)

- Domestic Water Source (DWS)
- Agricultural Irrigation (AgI)
- Agricultural Livestock Watering (AgL)
- Fish Consumption (FC)

Any number of these may be combined to adequately and reasonably cover the uses Arizona waters may be put to, except the mutually exclusive pairings that might result (e.g., A&Ww and A&Wc would not be found together, nor would FBC and PBC). Typically, any defined Arizona stream reach might have from three to six uses associated with it. Each use has its own set of numeric water quality thresholds or standards associated with it. Dependent upon the parameter, standards may be more or less strict in certain uses than in others, and the limiting use can vary from constituent to constituent based upon the toxicity and natural distribution, among other factors, of the element in question.

Designated uses for the reach of issue include the following:

- Aquatic and Wildlife – warm water (A&Ww)
- Full Body Contact (FBC)
- Fish Consumption (FC)
- Agricultural irrigation (AgI)
- Agricultural livestock watering (AgL)

Listing

Water quality standards for a stream reach are based upon the designated uses assigned to it according to the Arizona Administrative Code Title 18, Chapter 11 (18 A.A.C. 11). This project addresses the Gila River Reach 15070201-003 in the vicinity of Yuma, Arizona for boron and selenium exceedances and Total Maximum Daily Load (TMDL) purposes.

Total boron was listed as an impairment constituent for Reach 15070201-003 in 2004 (ADEQ, 2004). ADEQ's biennial 2004 Water Quality Assessment documents summary statistics of 20 samples collected in the 1998-2002 period for the listing, with five samples exceeding the Agricultural Irrigation (AgI) designated use criteria of 1000 mg/L. Reach 15070201-003 remains on the list currently.

Total selenium was also found to be impairing Reach 15070201-003 in the 2004 assessment. With five of 20 samples from 1998 to 2002 exceeding the A&Ww chronic standard of 2 µg/l, the reach was listed for this additional impairment. The reach has continued to be listed as impaired since 2004. Though no exceedances were logged, all detection limits for seven samples were above the A&Ww chronic standard.

Data and field notes of sampling leading to the listing in 2004 were examined. The reach originally qualified for impairment based on the minimum of exceedances necessary (five) in a population of 20 samples for both selenium and boron. All sampling was done at the USGS gauge site near Dome (09520500). The frequency of exceedances in the listing assessment period (25 percent) was higher than the frequency of exceedances in USGS data from 1973-1994 (16 percent) or the frequency for this project (boron - 2.4 percent), with sizable datasets for each grouping available for consideration (22-Listing Assessment; 26-TMDL; 83-USGS). This difference suggests a change in either natural conditions or sampling conditions for the site. Examination of records and pictures from exceedance events along with the analyst's personal knowledge of these events raised doubts about the validity and representativeness of these measurements. Four of the five exceedances were recorded in sampling conducted from or very near the bank immediately under the USGS gauge house. This is important to note, because conditions at the site changed in March of 1999, at the time the first exceedance was logged. Field notes from that event note that channel alteration had occurred (likely disking/plowing/clearing of the river channel by Wellton-Mohawk Irrigation and Drainage District [WMIDD]), and the river had partially re-routed as a consequence. The main flow of the channel, consequently, was displaced away from the gauge house, and ADEQ Fixed Station Network sampling areas were not capturing the well-mixed central flow of the channel on most subsequent visits. This sampling protocol deficiency was not corrected until November of 2001, when an effort was made to sample the central flow by approaching the river from the opposite bank.

Statistical testing was done on historical boron data available from all sources. Data was grouped into three periods – USGS sampling (1973-1994), assessment period sampling (1998-2002), and TMDL project sampling (2012-2014). TMDL sampling and USGS sampling were grouped together for consideration in a follow-up analysis. Two sample t-tests were conducted comparing the means of USGS data to assessment period data. Bonferroni and Dunn-Sidak p-value adjustments were made to the dataset. Results showed that means of these two groups were significantly different at a p-value of less than 0.01 for both separate and pooled variances. Means were determined as 599 mg/L for USGS data and 856 mg/L for assessment period data. A second t- test was run pooling TMDL data with USGS data and compared with assessment period data. This test, too, showed that means were significantly different between the two groups with 95 percent confidence, with an adjusted p-value of 0.03 and 0.02 for separate and pooled variances respectively. The mean for the pooled TMDL and USGS group was 590 mg/L, while the assessment period group retained its mean of 856 mg/L. To confirm that the three groupings did not reflect three different differences or conditions, USGS data was compared to TMDL data. Means were 562 mg/L and 599 mg/L for TMDL and USGS data respectively, and p-values exceeded 0.5, indicating that there was no significant difference between these two data groupings. Thus, a different population of waters were sampled in the assessment period leading to the listing between 1998 and 2002 as compared to both the 21 year period from 1973-1994 and the TMDL sampling period after the assessment period. There is a strong implication that a difference in sampling protocols caused the difference, with the assessment period samples reflecting non-representative sampling conditions in waters that were either standing or not well-mixed. It is probable that the original listing for both boron and selenium is unsupportable because of the deficiency in the sampling protocols. Though exceedances would periodically continue to be seen using proper protocols (i.e., sampling in the thalweg of the channel at all events, as was conducted for the TMDL project), the raw number and the frequency of exceedances would not rise to the level of impairment as they did for the 2004 assessment. The existing impairment could not be confirmed for the gauge site in TMDL project sampling.

Boron, Total

Boron is a relatively common element in the earth's crust, accounting for approximately 7.5 parts per million (ppm) in the earth's igneous rocks, and an average of 100 ppm in the earth's sedimentary rocks. Thus, while it is only the 40^{th} most prevalent element in the crust for igneous rocks, it is the twentieth most prevalent element in sedimentary lithology (Hem, 1985). Boron readily forms minerals in the earth's crust, including colemanite ($Ca_2B_6O_{11}*5H_2O$), kernite ($Na_2B_4O_7*4H_2O$), and borax ($Na_2B_4O_7 \cdot 10H_2O$). Boron is associated with volcanism and fumaroles.

Boron tends to be present in soils to a higher degree in arid and semi-arid environments, due to the restricted drainage and opportunity to leach boron from soils. Though borax and borates can only be profitably mined in a few locations world-wide, they are mined extensively in the closed basins of southeastern California in an environment and climate similar to the project area. In seawater, boron constitutes an average concentration of 4.5 mg/L, the 11^{th} most prevalent element or molecule. Natural waters other than seawater typically carry some level of boron, due to its relative easy solubility in water and availability. Hem (1985) asserts that boron concentrations in river water typically exhibit levels of up to a few tenths of a milligram/liter as a minor constituent, but it can be present at levels up to several milligrams per liter. Boron is readily soluble in water. Boric acid (H_3BO_3) is a common aqueous form (also expressed as B (OH_3), and boron is rarely found in elemental form, due to its ready propensity to combine with oxygen.

Arizona has adopted numeric water quality standards for boron for FBC, PBC, DWS, and AgI designated uses. Of these, the FBC and AgI standards apply to the reach, and the AgI standard is the impaired designated use.

Selenium, Total

Selenium is a trace element essential for human health, but one which has a comparatively low toxic threshold for both humans and wildlife. This coupled with the fact that selenium can bio-accumulate through the food chain has brought selenium issues in water quality to the forefront of research in the past three decades. In 1983, a massive bird kill at the Kesterson National Wildlife Refuge in central California was traced and ultimately attributed to the presence of selenium in high concentrations in the marshes and wetlands of the refuge. Further investigation showed that the waters of the refuge largely originated from agricultural run-off from San Joaquin Valley farms. Irrigation activities have been identified as one of the prime mechanisms by which selenium is concentrated in natural waters at levels higher than are naturally found in the waters. Agricultural runoff remains today one of the primary contributors to rising selenium concentrations in national waterways where selenium is a problem.

As a metalloid, selenium shares many chemical characteristics with its cousin sulphur and may frequently be found interchangeably with sulphur in natural environments where both exist. However, selenium is not as prevalent as sulphur, comprising less than one part per million of average composition of the major geologic rock classes worldwide (Hem, 1985). It is usually found in sandstones and shales of Tertiary age, particularly of marine origin. In the continental United States, these formations are exposed in the arid and semi-arid West (Seiler, 1999). Selenium-bearing formations are not as frequently found in temperate and humid locations, in part due to paleogeographic considerations including the locations and extents of shallow seas and depositional environments in the Mesozoic era. The weathering of the source geologic units creates seleniferous soils which can be susceptible to selenium liberation upon exposure to water.

A USGS study determined that mean selenium concentrations in soils average 0.39 ppm nationwide. Ranges from other cited studies in the same report extended from less than 0.1 ppm up to 4.3 ppm. Though locations of site-specific analyses of the report were not supplied, central Arizona soils appear to typically exhibit values at 0.1 ppm and below.

Though there are no known geologic units in the project area that meet the criteria for the most susceptibility (i.e., marine units of Cretaceous/Tertiary origin and exposure to a water source), source (canal) water contains selenium in varying concentrations. Historically, the Colorado River, which supplies all Yuma-area canals and irrigation districts, has consistently demonstrated selenium levels above state chronic standards.

The most stringent applicable Arizona water quality standard for selenium is 2.0 μg/L for chronic Aquatic and Wildlife designated uses. Standards for selenium are much higher for other designated uses, ranging from 20 μg/L (AgI criteria) to 4667 μg/L (FC). The chronic A&Ww standard is the standard that has been designated as impaired.

Local Hydrology and Reach Segmentation

Precipitation in the Lower Colorado River Watershed is meager, varying from 3 to 10 inches a year. Perennial water is limited to the Colorado River main stem and its reservoirs, with groundwater interflow providing perennial flow at locations in the Gila River near Yuma. Estimated surface water resources in the Colorado – Lower Gila Watershed for non-tribal land include 375 miles of perennial channels, 145 miles of intermittent channels, and 13,545 miles of ephemeral channels (ADEQ, 2004).

There are no major perennial or intermittent tributaries joining the Gila River in the defined impaired reach from Coyote Wash to Fortuna Wash (Figure 2). These two washes, along with Castle Dome Wash (CDW) in the Hwy 95 corridor, constitute the larger ephemeral washes discharging to the Gila River in rare stormflow events. The Gila River main-stem itself would have no persisting flow were it not for specific circumstances which will be addressed shortly. Water in the Gila River channel is almost entirely surfacing groundwater flow from the fields of Wellton-Mohawk Irrigation District, where groundwater is continuously pumped and discharged to prevent saturation of the root zone for crops in the area. The Wellton-Mohawk Canal and the Gila Gravity Main Canal also provide some minor discharge to the Gila River channel in emergency spillway channels.

An extensive network of irrigation canals, laterals, and drains exists in the Yuma and Castle Dome areas (Figure 3). Water from the Colorado River, diverted at the Imperial Dam, serves to supply the Wellton-Mohawk District and four other irrigation districts in the Yuma area. The irrigation canals carry volumes of water that dwarf the flows in the Gila River main-stem in the region. The Wellton-Mohawk Canal extends for more than 18 miles and carries a historic mean discharge (1975-2011) of 539 cfs with a flow volume of 390,400 acre-feet annually. It branches into the Wellton Canal (19.9 miles in length) serving the north side and the Mohawk canal (46.8 miles in length) serving the south side in the Wellton-Mohawk valley.

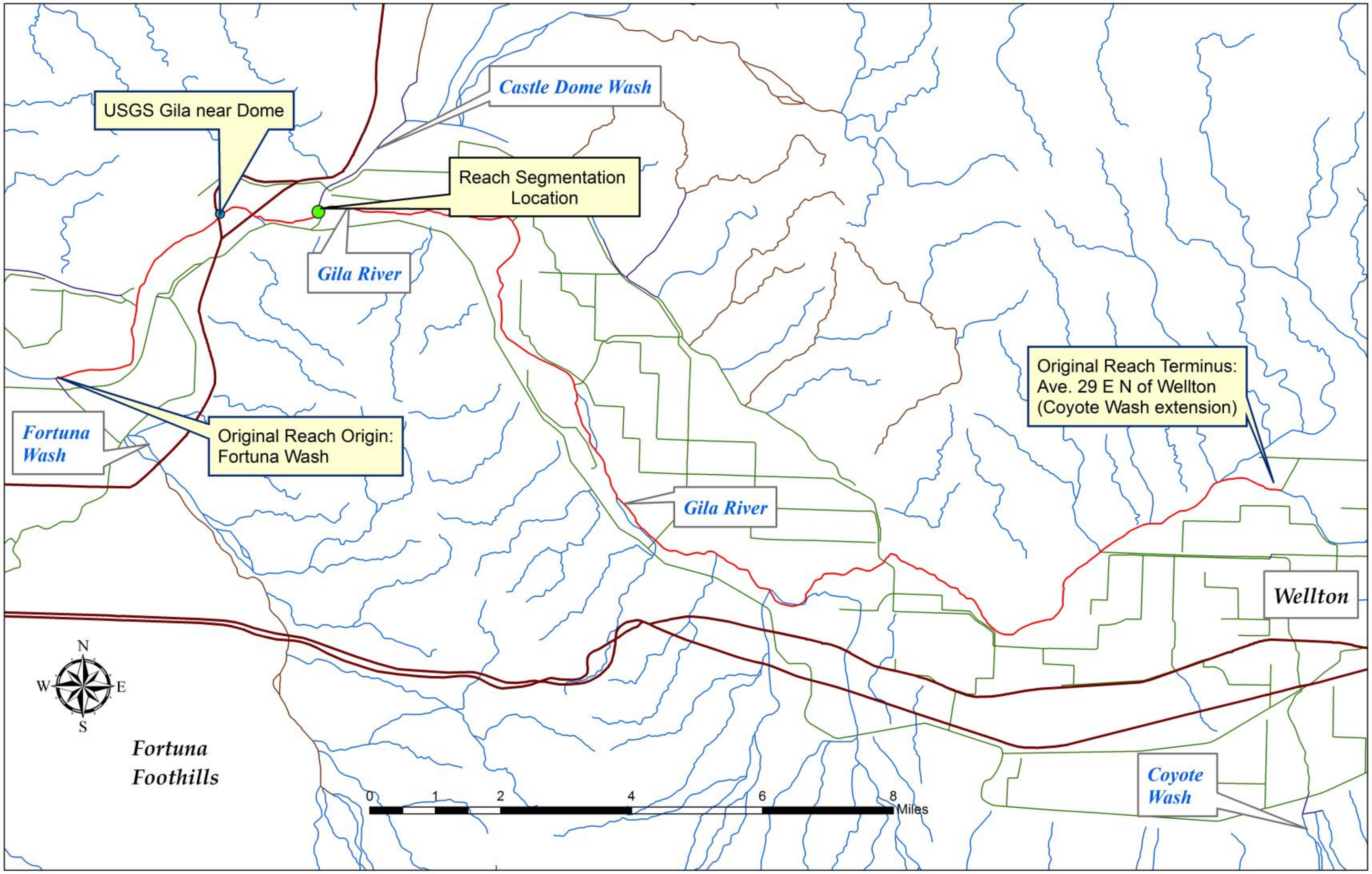

Figure 2. Area Hydrography Map and Reach 15070201-003 segmentation location. Impaired reach highlighted red.

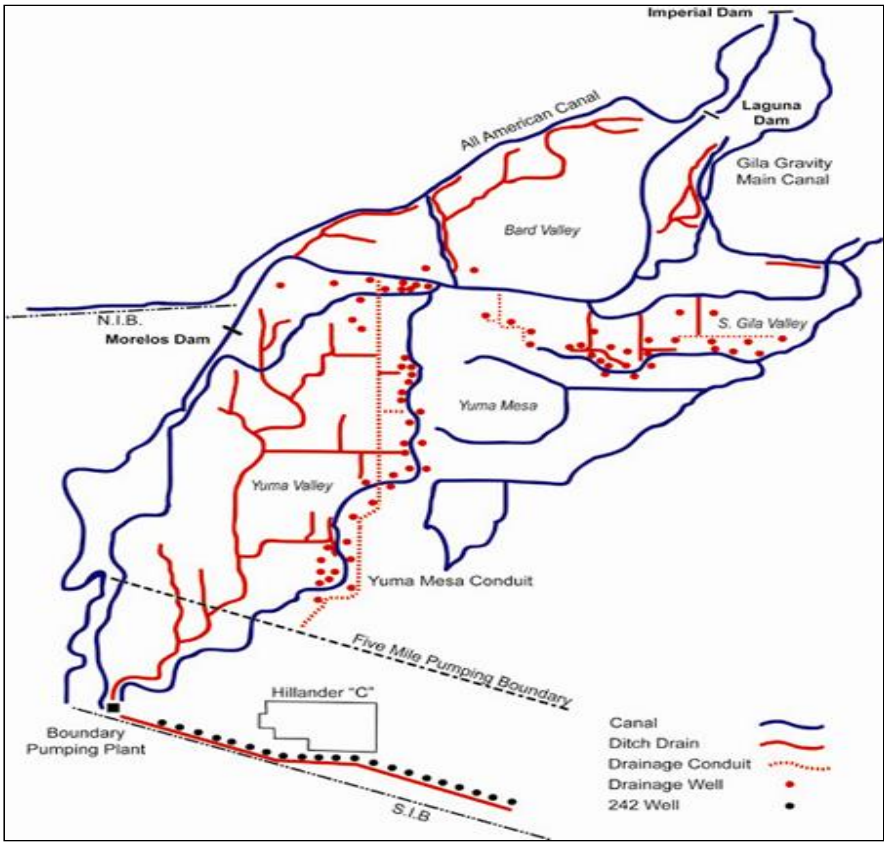

Figure 3. Yuma Vicinity Irrigation Network schematic
Wellton-Mohawk Canal origin upper far right. **See Figure 1 for W-M Canal extent and overview.**
Illustration courtesy ADWR, 2012.

At the confluence of CDW and the Gila River (River Mile 12.25, Figure 4), a change in the hydrologic regime of the Gila River occurs. Field investigation has determined that damming across the Gila River (beaver, construction remnant, or debris; origin is unclear) prevents pooled water above the obstruction from joining with water below the obstruction except in sizable storm flow events. This location coincides with a siphon crossing of the Main Drain of the Wellton-Mohawk Irrigation & Drainage District, and the damming may be an artifact or a subsequent consequence of the siphon installation (Figure 4 – note the transverse submerged linear feature of the siphon crossing connecting the two canal segments). The area has been exhaustively reconnoitered on multiple occasions, and no surface water nexus has been found between the ponds above and immediately below the siphon crossing and the CDW confluence proper. Information obtained from the Bureau of Reclamation confirms that the thalweg of the Gila River channel in this vicinity is below local water table elevations at most times, thus indicating that pooled water is partially or completely comprised of groundwater. Chemical analyses and Stiff diagrams showing relative concentrations of major inorganic ions confirm the groundwater origin of this water as compared to canal (source) water.

For the sub-reach below this location (Figure 4), flow is close to perennial due to the steady surfacing of groundwater and consistent releases from the Dome Canal. This sub-reach includes USGS Gauge 09520500, ADEQ's historic sampling location for ambient monitoring and the site upon which the original impairment assessment was based. Above the CDW confluence, flow is intermittent and trends more towards ephemeral status in nature. Sampling site CLGLR013.33, approximately one mile upstream of the confluence, showed four of eight visits with no flow, and an additional two of the eight where average flow velocities were so low (<0.1-0.2 feet per second) and flow volumes so indistinct as to be considered more representative of wetland or slough conditions than free-flowing river conditions. Samples were not taken on these events. There is no defined channel with geomorphically-identifiable features at this location in the upper sub-reach; the lack of these geomorphic channel indicators is typical as one moves further upstream. Grasses, sedges, reeds, and cattails comprise the vegetation in the cleared channel area, and in most locations at most times, the channel above the dam is dry.

The two sub-reaches thus exhibit distinctly different hydrologic flow regimes and should be considered and assessed separately. As a part of this delisting action, ADEQ will administratively split the reach at the CDW confluence and apply the same designated uses to both the upper and lower segments as currently exist for the original definition of the reach. Those designated uses consist of A&Ww, FBC, FC, AgI, and AgL.

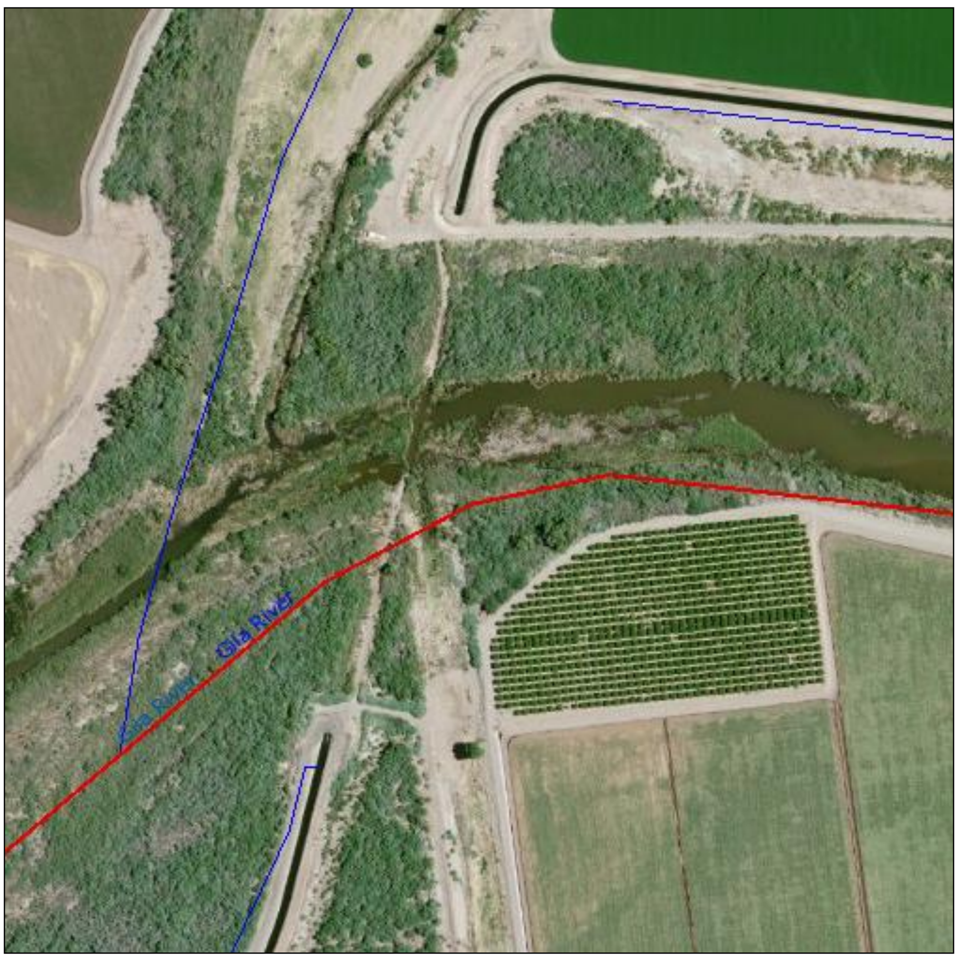

Figure 4. Local vicinity of change of hydrologic regime, Gila River at Castle Dome Wash
Red and blue lines are GIS hydrography representations in ADEQ's system. Castle Dome Wash in the upper left quadrant, with canal release water visible.

ADEQ Sampling History

303(d) Delisting: Selenium
Lower segment – Attaining
Upper segment – Attaining

Selenium sampling for the early sampling dates of the project showed periodic exceedances of the state's chronic A&Ww standard using standard laboratory analysis and lab method EPA 200.8 (Appendix A). When routine Test America lab audits required a revision of laboratory reporting limits from 2.0 µg/L to 3.0 µg/L, thereby no longer allowing for the reporting of unqualified values at certain levels above the state's standard, the impetus was given to begin to analyze samples using trace metal methods at Brooks Rand Laboratory of Seattle, Washington. Dynamic reaction cell technology (DRC) was coupled with EPA method 1638 to give trace metals analyses down to less than 1.0 µg/L. Brooks Rand Laboratory methods permitted the screening out of erroneous false positives (generally sulfur/sulfates, which can masquerade as selenium in ICP-MS methods).

After transferring labs in summer of 2013, it was noted that selenium results were consistently coming in at lower values than standard ICP-MS reporting. Project sampling was extended another two quarters to allow for an accumulation of sufficient data to make a defensible delisting decision using the new method. From July of 2013 through May of 2014, with the exception of one stormflow event, all selenium values were reported well below the state standard of 2.0 µg/L. In 33 separate samples on the originally-defined reach, the highest non-storm sample value was 1.59 µg/L. In considering all non-storm project selenium data collected after July of 2013, the highest recorded value was 1.65 µg/L. In fact, the majority of values above 1.0 µg/L for established sites in the project area after the summer of 2013 (21 of 28 samples) were collected from canal sources rather than the Gila River proper.

One major storm event in early September of 2013 provided a temporary deviation from the normal selenium loading by a factor of ten or more at the Dome gauge site. On September 9, 2013, a convergence of thunderstorms and frontal systems over the Yuma Proving Grounds (YPG) north of the study area dumped 5.4 inches of rain in a short period of time over the Yuma/La Paz county line in the Castle Dome drainage. Flow magnitudes spiked at the Dome gauge from less than 10 cfs to a peak of 2887 cfs, then subsided rapidly. Automated sample collection at the gauge allowed for sample analysis of the chemical constituents of the storm water on an hourly basis. Selenium readings ranged from 13 to 22.5 µg/L due to the storm. Brooks Rand also determined that the water was contaminated to a high degree with numerous other metals, both total and dissolved. It is surmised that overland and channel flow in the ephemeral CDW system picked up many of the contaminants from spent munitions in the open desert on the YPG. Further investigation of the storm through interviews of both WMIDD and USGS Yuma personnel and USGS historical flow records at the Dome gauge determined that this was the first large flushing storm of this variety in the area since 1997.

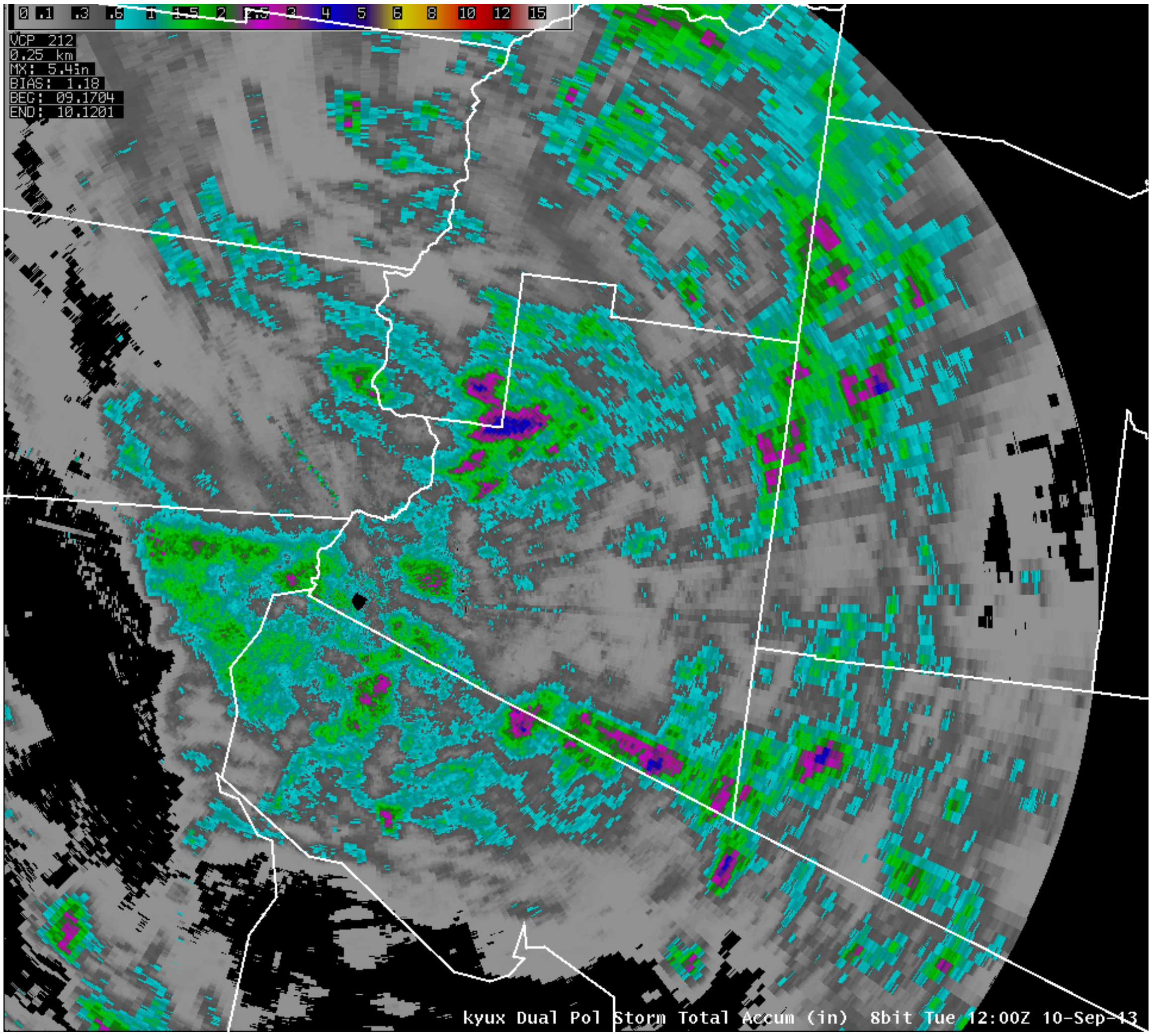

Figure 5. National Weather Service cumulative precipitation radar image for the September 9-10, 2013 storm. Yuma County is shown outlined in the center of the image. Storm total for the Castle Dome Wash cell (image upper center, blue and purple) shown in upper left corner (5.4 in.).

The five hourly values associated with this storm were the only values exceeding the chronic standard when analyzed by low-level trace metal methods. One other thunderstorm event was captured in August of 2013; all hourly values of this storm came in below the standard, as expected. Selenium concentrations tend to dilute in stormflow, with concentrations declining, contrary to the behavior of many other metals. The September 9-10, 2013 storm is an aberration, and since its duration and run-off lasted well less than 96 hours, it is not appropriate to apply chronic criteria to this transient event.

After this anomalous storm exclusion, selenium showed no exceedances of the chronic water quality criteria in the sampling dataset analyzed with the more accurate EPA Method 1638 (DRC). The splitting of the reach and consideration of project data specific to each segment of the original reach thus results in an “attainment” determination using a weight-of-evidence evaluation for each segment. The elements considered in the weight-of-evidence evaluation include evaluation of the higher quality data subset independently and the age of the measurements, with the more recent data demonstrating acceptable selenium concentrations.

Though only five samples in the upper reach and seven aggregated samples (excluding the storm) in the lower reach were collected and analyzed with low-level trace metals method, none demonstrated exceedances. This condition is consistent with the Assessment Technical Manual (ADEQ, 2014) requirement that no exceedances shall be exhibited for datasets from three to nine samples in size for a reach to be designated as achieving “Attainment” status. Thus, delisting both segments for selenium exceedances is justified.

303(d) Delisting: Boron
Lower segment – Attaining
Upper segment – Inconclusive

The new reaches after segmentation exhibit differences in the frequency of exceedances for boron. The lower sub-reach has shown only one exceedance for boron in project sampling. Representative flow has been present at all visits in the sampling phase of the project, and two of the three known hydrologic inputs, apart from the groundwater pond at the CDW confluence, mitigate existing loading. The three inputs consist of release water from the Dome Canal into CDW and two emergency spillway tributaries from major canals in the lower part of the reach. These tributaries typically contribute only “leakage” water from the main canals on the order of 1-3 cfs (averaging 2.1 cfs), but it is enough to stabilize and improve Gila River water quality in the lower segment of the reach.

After reach segmentation, the lower segment/sub-reach is attaining water quality standards for boron by Assessment Technical Manual methodology. A total of 43 separate samples (unaggregated) were collected during TMDL project sampling in the lower segment, with only one sample exceeding the AgI threshold of 1000 µg/L. By Assessment Technical Manual methodology, aggregated samples in excess of ten (which the lower reach achieves) are allowed two exceedances of a standard while still maintaining “Attainment” status.

The sites above the CDW confluence were all established beginning in 2012, solely for this TMDL project. Their original purpose for the project, once hydrologic discontinuity was recognized as a factor, was to evaluate source loading and provide background on what interflow water quality unaffected by surface water inputs was. These sites were not a part of the original impairment listing, where all exceedances were recorded in the lower segment downstream at USGS gauge 09520500; in fact, the downstream location was the only location sampled in the 1998-2002 time frame that resulted in the current impaired water listing. Consequently, the sampling history for the sites established in the upper reach is quite limited, and additional sampling in representative flow conditions is constrained by the intermittent/ephemeral character of the Gila River in this stretch.

Project sampling for the TMDL extended from June of 2012 until May of 2014, with a six month extension added to the originally-planned time frame to accommodate additional sampling needed for supplementing the dataset for a more robust analysis with lower detection limits for selenium. In this period, sample visits were made to at least one of four upper segment reach sites on eight different sampling trips (a possible total population of 32 site visits). Flowing water was sampled only six times in the upper segment (~18 percent of the time). Some of the reduced tally of site-visits was attributable to the discontinuation of sampling at the first instance of hydrologically-discontinuous flow (i.e., a dry site, or obvious ponded conditions) with the USGS gauge site on the downstream-to-upstream sampling order of a typical sampling run.

In this case, due to the difference in hydrologic regime created by the CDW impoundment, the upper segment is not considered to inherit the impairment status of the originally-defined reach by default; it should qualify for impairment based on its own deficiencies if appropriate. With the regime discontinuity resulting in reach segmentation established, the segment's collection and assessment period thus begins in 2012 when the first sample was collected. After aggregation, the intermittent upper sub-reach accounted for 3 of the 4 recorded boron exceedances in TMDL project sampling. As a separate data set, in accordance with Arizona's assessment methodology, there is insufficient data at this time to support a 303(d) listing for total boron for this segment (20 samples minimum required, unless five exceedances are logged). Data for the upper segment is presented in Appendix B.

Consequently, the upper segment shall be considered a data-gap reach with additional monitoring needs for further investigation as time, resources, and priorities permit. The status of waters needing further monitoring is considered to be "inconclusive." The upper reach will hold the status of "inconclusive" in an initial informal TMDL-originated assessment after reach segmentation, and the next formal biennial water quality assessment will confirm "inconclusive" status based on TMDL sampling. The upper sub-reach status will likely remain unchanged for the foreseeable future due to the sporadic nature of flow available for sampling, but if representative flows are available for sampling in the future, nothing precludes this reach from being listed as fully impaired for boron if further boron exceedances of the AgI designated use standard are recorded.

Figure 6. Source identification/extent visit to upper reach site CLGLR021.88, March 2014. Typical low-flow conditions for the upper reach exhibited.

Conclusions and Recommendations

In evaluating a surface water for delisting, ADEQ in accordance with Arizona Administrative Code R18-11-605(E).2.a "shall remove a pollutant from a surface water or segment from the 303(d) List based on one or more of the following criteria." The pertinent and applicable criterion subsequently listed (R18-11-605(E).2.a.ii.) states:

"The data used for previously listing the surface water or segment under R18-11-605(D) is superseded by more recent credible and scientifically defensible data meeting the requirements of R18-11-602, showing that the surface water or segment meets the applicable numeric or narrative surface water quality standard. When evaluating data to remove a pollutant from the 303(d) List, <u>the monitoring entity shall collect the more recent data under similar hydrologic or climatic conditions as occurred when the samples were taken that indicated impairment</u>, if those conditions still exist." (Emphasis added)

The Impaired Waters Rule also stipulates (R18-11-605(B).2.c. i., R18-11-605(B).2.d) the following:

> R18-11-605 *Evaluating a Surface Water or Segment for Listing or Delisting*
>
> > *B. Weight of Evidence Approach*
> >
> > > *2. The Department shall evaluate the following factors to determine if the water quality evidence supports a finding that the surface water or segment is impaired or not attaining:*
> > >
> > > > *c. Additional information that determines whether a water quality standard is exceeded due to a pollutant, suspected pollutant, or naturally-occurring condition:*
> > > >
> > > > > *i. Soil type, geology, hydrology, flow regime, biological community, geomorphology, climate, natural process, and anthropogenic influence in the watershed.*
> > > >
> > > > *d. Other water quality data …as applicable.*

Both of these statements apply to the subjects of this report and support the actions taken as a consequence. For the reasons presented in this report, ADEQ has administratively split the reach at the Castle Dome Wash confluence and retroactively assessed the TMDL data set independently for each segment. The lower reach meets the ADEQ Assessment Technical Methods manual criteria for delisting of both boron and selenium as detailed in this report. The upper segment, because it is characterized by a differing hydrologic regime and has no sampling history prior to 2012, does not inherit the impaired status of the previously-defined reach by default; its assessment is considered to begin as of the first sampling date in June 2012. Consequently, its status after consideration of its portion of the TMDL dataset is assessed as "inconclusive" for boron (three exceedances in four samples) and "attaining" for selenium (no exceedances in five samples with trace metals analysis methods). The originally-assessed Reach 003 will be removed from the 303(d) Impaired Waters List and its impairment assessment will be replaced by the above evaluations.

RECOMMENDATIONS:

The ADEQ Watershed Protection Unit recommends that the upper segment continue to be monitored for both selenium (using trace metals analysis methods) and total boron to resolve the "inconclusive" status for boron as time, resources, and priorities allow. It is also recommended that standard procedures continue to be employed on visits to the upper segment in determining whether representative flow conditions exist for sampling, with sampling abstained from if those conditions are not present at any given site on a visit.

The Watershed Protection Unit also recommends for the Ambient Monitoring group that future sampling at the USGS gauge site (Gila River near Dome 09520500) be consistently conducted in the river channel proper, and not in the dredged side channel immediately below the gauge. Non-representative flow conditions routinely prevail in this slowly-moving water in the side channel, and the original listing may well have been erroneous because of this practice. Access from the east side of the Gila River is available 200 meters downstream of the gauge directly from Hwy 95 beneath the McPhaul Bridge.

REFERENCES

Arizona Administrative Code. (2009). Title 18 Environmental Quality, Chapter 11 Department of Environmental Quality, Water Quality Standards. Supp. 03-01.

Arizona Department of Environmental Quality. (2005). *The Status of Arizona's Water Quality in Arizona -- 2004: Arizona's 2004 Integrated 305(b) Assessment and 303(d) Listing Report.* ADEQ Publication # EQR0501. Phoenix, AZ.

Arizona Department of Environmental Quality (ADEQ), 2009. *Standard Operating Procedures for Water Quality Sampling*, Arizona Department of Environmental Quality Report.

Arizona Department of Environmental Quality (ADEQ), 2014. *Surface Water Assessment Methods and Technical Support*. Phoenix, Arizona...

Arizona Department of Water Resources (ADWR), 2012. Arizona Water Atlas, Volume 7, Lower Colorado River Planning Area – Overview. http://www.adwr.state.az.us/AzDWR/StatewidePlanning/WaterAtlas/LowerColoradoRiver/documents/Volume_7_overview_final.pdf. Accessed April 18, 2012

Helsel, D.R. and Hirsh, R.M., 2002. *Statistical Methods in Water Resources*. In Techniques of Water-Resources Investigations of the United States Geological Survey, Book 4, Chapter A3, Hydrologic Analysis and Interpretation. Washington D.C., 503p.

Hem, John D., 1985. *Study and Interpretation of the Chemical Characteristics of Natural Water.* United States Geological Survey Water-Supply Paper 2254. Third Edition. Washington, D.C.

Non-point Education for Municipal Officials (NEMO), 2010. NEMO Watershed Based Plan Colorado-Lower Gila Watershed. http://nemo.srnr.arizona.edu/nemo/characterizations/ColoradoLG/Titlepercent 20Page, percent 20Acknowlegments.pdf. Accessed July, 2014.

Seiler, Ralph L. et al., 1999. *Areas Susceptible to Irrigation-Induced Selenium Contamination of Water and Biota in the Western United States.* U.S. Geological Survey Circular 1180. Carson City, Nevada.

U.S. Census Bureau, 2010. http://quickfacts.census.gov/qfd/states/04/0485540.html. Accessed April 18, 2012.

USGS, 2010. Water Data Report 2010: 09518000 Gila River above Diversions, at Gillespie Dam, AZ. URL: http://wdr.water.usgs.gov/wy2010/pdfs/09518000.2010.pdf Accessed 2-19-2012.

USGS, 2012. 09520500 Gila River near Dome, AZ. http://waterdata.usgs.gov/az/nwis/uv?site_no=09520500 Accessed April 18, 2012.

Western Regional Climatic Center (WRCC), 2012.
http://www.wrcc.dri.edu/summary/climsmaz.html, July, 2014.

Appendix A:

TMDL Project Data

Site ID	Date	Time	Type	FLOW, STREAM, INSTANTANEOUS CFS	BORON, TOTAL (µg/L)	SELENIUM, TOTAL (µg/L)
CLCDW000.59	14-MAY-2014	0730	R	3.62	160	1.28
CLGGCX30CDB	14-MAY-2014	1315	D			1.65
CLGGCX30CDB	14-MAY-2014	1315	R	1810	150	1.64
CLGGCX30CDB	14-MAY-2014	1315	S		150	
CLGLR011.17	14-MAY-2014	0830	R	3	770	0.765
CLUGL000.01	14-MAY-2014	0815	R	1.6	300	1.23
CLGLR007.11	13-MAY-2014	1400	R	7	290	1.18
CLGLR010.53	13-MAY-2014	1545	R	4.3	**1200**	1.29
CLGLR010.53	13-MAY-2014	1545	D		**1200**	1.25
CLUGI000.22	13-MAY-2014	1500	R	2.3	140	1.35
CLCDW000.59	26-MAR-2014	1010	R	5.1	ND : 200	1.14
CLGGCX30CDB	26-MAR-2014	0915	D		ND : 200	1.27
CLGGCX30CDB	26-MAR-2014	0915	R	1300	ND : 200	1.17
CLGLR011.17	26-MAR-2014	1100	R	7.9	710	0.688
CLGLR019.96	26-MAR-2014	1450	R	2.6	**2100**	ND : 0.211
CLGLR021.88	26-MAR-2014	1400	R	1.2	**2000**	ND : 0.211
CLUGL000.01	26-MAR-2014	1045	R	2.5	220	1.12
CLGLR007.11	25-MAR-2014	1300	R	11.4	590	0.379
CLGLR010.53	25-MAR-2014	1500	R	3.3	920	0.633
CLUGI000.22	25-MAR-2014	1415	R	2.4	ND : 200	1.07
CLGLR011.17	14-JAN-2014	0945	R	9.6	810	0.789
CLGLR013.33	14-JAN-2014	1045	R	7.9	970	0.546
CLGLR016.14	14-JAN-2014	1130	R	7.5	**1400**	0.383
CLUGL000.01	14-JAN-2014	0925	R	3.1	ND : 200	1.48
CLCDW000.59	13-JAN-2014	1530	R	2	ND : 200	1.37
CLGGCX30CDB	13-JAN-2014	1440	R	930	ND : 200	1.59
CLGLR010.53	13-JAN-2014	1240	R	8.3	600	1.09
CLUGI000.22	13-JAN-2014	1345	R	3	ND : 200	1.56
CLCDW000.59	20-NOV-2013	1000	R	5.9	180	1.05
CLGGCX30CDB	19-NOV-2013	1015	R	1080	160	1.09
CLGLR011.17	19-NOV-2013	1145	R	3.4	540	LT : 0.989
CLGLR013.33	19-NOV-2013	1300	R	0		
CLUGL000.01	19-NOV-2013	1205	R	3.3	200	1.02
CLGLR007.11	18-NOV-2013	1345	R	12.3	500	0.846
CLGLR010.53	18-NOV-2013	1242	R	9.6	500	LT : 0.989
CLGLR010.53	18-NOV-2013	1242	D		510	0.892
CLUGI000.22	18-NOV-2013	1440	R	3.1	160	1.13
CLGLR010.53	10-SEP-2013	0027	R	**2887**	410	**22.5**
CLGLR010.53	10-SEP-2013	0127	R	**2661**	380	**18.8**
CLGLR010.53	10-SEP-2013	0227	R	**2205**	350	**18**

Site ID	Date	Time	Type	FLOW, STREAM, INSTANTANEOUS CFS	BORON, TOTAL (µg/L)	SELENIUM, TOTAL (µg/L)
CLGLR010.53	09-SEP-2013	2227	R	**73**	490	**21.2**
CLGLR010.53	09-SEP-2013	2327	R	**1914**	550	**13**
CLCDW000.59	27-AUG-2013	0900	R	0.86	170	1.47
CLGLR010.53	27-AUG-2013	1030	R	59	790	0.767
CLGLR011.17	27-AUG-2013	0730	R	63.3	710	0.638
CLGLR013.33	27-AUG-2013	0945	R	57.4	570	0.754
CLUGL000.01	27-AUG-2013	0745	R	2.7	280	1.29
CLGLR007.11	26-AUG-2013	1430	R	14.3	430	0.814
CLGLR010.53	26-AUG-2013	1350	R	4.4	300	0.915
CLUGI000.22	26-AUG-2013	1530	R	1.3	170	1.22
CLGLR010.53	23-AUG-2013	0256	R	**87.1**	470	1.59
CLGLR010.53	23-AUG-2013	0156	R	**130.3**	530	1.1
CLGLR010.53	23-AUG-2013	0056	R	**197.6**	750	1
CLGLR010.53	23-AUG-2013	0156	S		510	
CLGLR010.53	23-AUG-2013	0356	R	**59.3**	390	
CLGLR010.53	22-AUG-2013	2356	R	**115.4**	760	1.15
CLGLR010.53	03-JUL-2013	0815	R	2.2		0.672
***CLGLR010.53**	**03-JUL-2013**	**0815**	**D**			**0.499**
CLGGCX30CDB	05-APR-2013	0950	R	1500	ND : 200	2.3
CLGLR016.14	05-APR-2013	1115	R	0.25	**2000**	6.7
CLCDW000.20	04-APR-2013	1430	R	.42	ND : 200	2.5
CLCDW000.59	04-APR-2013	1345	R	.3	ND : 200	2.4
CLGLR011.17	04-APR-2013	1000	R	3.5	610	2.5
CLGLR013.33	04-APR-2013	1130	R	0		
CLUGL000.01	04-APR-2013	0945	R	0.16	390	2.3
CLGLR007.11	03-APR-2013	1600	R	6.7	660	2.6
CLGLR010.53	03-APR-2013	1400	R	6.2	760	2.8
CLUGI000.22	03-APR-2013	1515	R	1.8	ND : 200	2.3
CLGGCX30CDB	16-JAN-2013	1010	R	879	ND : 200	1
CLGLR007.11	16-JAN-2013	0915	R	7.5	430	0.89
CLCDW000.59	15-JAN-2013	1000	R	5.2	ND : 200	.78
CLGLR011.17	15-JAN-2013	1100	R	6.8	280	1
CLUGI000.22	15-JAN-2013	1545	D		ND : 200	1.1
CLUGI000.22	15-JAN-2013	1545	R	2.8	ND : 200	.62
CLUGL000.01	15-JAN-2013	1130	R	1.2	830	2.2
CLGLR010.53	14-JAN-2013	1400	R	8.3	390	1.2
CLGGCX30CDB	20-NOV-2012	1200	R	1590	ND : 200	1
CLGLR011.17	20-NOV-2012	1020	R	2.2	410	1.1
CLGLR013.33	20-NOV-2012	1100	R	0		
CLUGL000.01	20-NOV-2012	1020	R	0.53	1400	3.2
CLGLR007.11	19-NOV-2012	1525	R	8.9	720	1

Site ID	Date	Time	Type	FLOW, STREAM, INSTANTANEOUS CFS	BORON, TOTAL (µg/L)	SELENIUM, TOTAL (µg/L)
CLGLR010.53	19-NOV-2012	1345	R	7.7	960	1.8
CLUGI000.22	19-NOV-2012	1415	R	2	ND : 200	ND : 1.0
CLGLR010.53	23-AUG-2012	0703	R	**54.4**	450	1.2
CLGLR010.53	23-AUG-2012	0803	R	**268.8**	330	ND : 20
CLGLR010.53	23-AUG-2012	0903	R	**302**	210	4.2
CLGLR010.53	23-AUG-2012	1003	R	**282.2**	ND : 200	3.1
CLGGCX30CDB	20-JUN-2012	1400	R	1750	ND : 200	3.5
CLGLR011.17	20-JUN-2012	0715	R	0.05	700	3.5
CLGLR008.81	19-JUN-2012	1000	R	1.26	1000	3.6
CLGLR010.53	19-JUN-2012	0915	R	3.3	890	3
CLGLR013.33	19-JUN-2012	1130	R	0		
CLUGL000.01	19-JUN-2012	1105	R	2.2	ND : 200	3

* - indicates date at which trace metal analyses began. All selenium data above this row of the table was evaluated by EPA Method 1638 DRC. Red table entries indicate standard exceedances. Bolded flow values indicate storm events.

Appendix B:

Gila River Flow and Boron Exceedances

Site ID	Date	Time	Reach	Stream Width-Ft	Flow, cfs	Boron, T (µg/L)
CLGLR011.17	20-Jun-12	0715	Lower	13.2	0.05	700
CLGLR011.17	20-Nov-12	1020	Lower	14.4	2.2	410
CLGLR011.17	15-Jan-13	1100	Lower	17.7	6.8	280
CLGLR007.11	16-Jan-13	0915	Lower	30	7.5	430
CLGLR007.11	3-Apr-13	1600	Lower	25	6.7	660
CLGLR011.17	4-Apr-13	1000	Lower	18.7	3.5	610
CLGLR007.11	26-Aug-13	1430	Lower	25	14.3	430
CLGLR007.11	18-Nov-13	1345	Lower	25	12.3	500
CLGLR010.53	18-Nov-13	1242	Lower	25	9.6	500
CLGLR011.17	19-Nov-13	1145	Lower	16	3.4	540
CLGLR011.17	14-Jan-14	0945	Lower	22	9.6	810
CLGLR007.11	25-Mar-14	1300	Lower	25	11.4	590
CLGLR011.17	26-Mar-14	1100	Lower	20.8	7.9	710
CLGLR007.11	13-May-14	1400	Lower	25	7	290
CLGLR010.53	13-May-14	1545	Lower		4.3	1200
CLGLR011.17	14-May-14	0830	Lower	20.3	3	770
CLGLR013.33	14-Jan-14	1045	Upper	18	7.9	970
CLGLR013.33	27-Aug-13	0945	Upper		57.4	570
CLGLR016.14	14-Jan-14	1130	Upper	51.5	7.5	1400
CLGLR016.14	5-Apr-13	1115	Upper		0.25	2000
CLGLR019.96	26-Mar-14	1450	Upper		2.6	2100
CLGLR021.88	26-Mar-14	1400	Upper	17	1.2	2000

Exceedances marked with red shading. Samples collected on same date are aggregated for assessment purposes.