CHAPTERS

CHAPTER 1:

INTRODUCTION

CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

This report concerns amended Statement of Claimant (SOC) No. 39-68704, which the U.S. Department of Interior, Bureau of Land Management ("BLM" or "United States") filed in the general stream adjudication for the Gila River System and Source ("Gila River Adjudication").[1] In SOC No. 39-68704, the BLM claims federal reserved water rights for the Aravaipa Canyon Wilderness Area ("ACWA"), which was established by federal legislation enacted in 1984 and 1990. In the Arizona Wilderness Act of 1984 ("1984 Act"), Congress designated as wilderness certain public lands known as the ACWA within the National Wilderness Preservation System.[2] In the Arizona Desert Wilderness Act of 1990 ("1990 Act"), Congress included additional public lands in the ACWA.[3] Copies of the 1984 Act and the 1990 Act are included in **Appendix A**.

In addition to its federal reserved water rights claim, BLM claims water rights within and in the vicinity of the ACWA based on state law. Although these state law based water rights were not listed as a legal basis for SOC No. 39-68704, they were listed as a legal basis to some extent in other statements of claimant filed by the BLM. Many of the water sources and places of use described in the state-based rights are also listed in SOC No. 39-68704 as "point sources" consisting of certain springs, seeps, ponds, small lakes and other naturally occurring waters. BLM is seeking a federal reserved water right for these point sources as part of SOC No. 39-68704.

In 1991, the Arizona Department of Water Resources ("Department" or "ADWR") issued a Final Hydrographic Survey Report for the San Pedro River Watershed ("San Pedro Final HSR") in which BLM's federal reserved water right claim and state-based water rights for the ACWA were analyzed. BLM filed SOC No. 39-68704 on March 28, 1991, and amended it on October 6, 1994 and February 24, 1995. On January 10, 2012, BLM amended this SOC again

[1] *In re General Adjudication of All Rights to Use Water in the Gila River System and Source,* W-1, W-2, W-3, W-4 (Consolidated), Contested Case No. W1-11-232 (Consolidated).
[2] Pub. L. No. 98-406, § 202, 98 Stat. 1485, 1491.
[3] Pub. L. No. 101-628, § 101(a)(39), 104 Stat. 4469, 4472.

pursuant to order of the Special Master for the Gila River Adjudication dated May 11, 2009 ("Third Amended Claim" or "Third Amended SOC").

By Order dated August 17, 2009, the Special Master initiated a contested case to address objections to Watershed File Report No. 115-5-19 of the San Pedro HSR related to the water rights claimed for ACWA. In this Order, the Special Master also designated seven issues for briefing, which he ruled on by Order dated November 2, 2011. By Order dated April 17, 2012, the Special Master identified five additional issues for an evidentiary hearing, which has not yet been set. By Order dated June 20, 2013, the Special Master reset the disclosure and discovery deadlines related to these five issues and set a status conference for March 27, 2014.

By Order dated August 9, 2012, the Special Master directed the Department to compile certain information related to the water rights claimed for the ACWA. The Department requested an extension of time from September 9, 2013 to February 14, 2014 to file this information. By Order dated August 14, 2013, the Special Master granted the Department's unopposed request.

Copies of the Special Master's Orders can be found on the Special Master's web site.[4] Copies of these Orders are also provided in **Appendix A** to this report.

1.2 SCOPE OF REPORT

As requested by the Special Master in his Order dated August 9, 2012, ADWR has compiled the following information:

A. A summary of the federal claims for reserved water rights as amended and all state law based water rights held or claimed by the United States within the boundaries of the Aravaipa Canyon Wilderness Area;
B. An evaluation of the methodologies used by the United States to quantify its federal and state law based claims;
C. An evaluation of the quantities claimed by the United States for its state law based water rights and claims; and,

[4] www.superiorcourt.maricopa.gov/SuperiorCourt/GeneralStreamAdjudication

D. An update of the watershed file reports associated with the Aravaipa Canyon Wilderness Area reported in the 1991 Final Hydrographic Survey Report for the San Pedro River Watershed.

August 9, 2012 Order at 3-4. This information is included in the following chapters of this report.

CHAPTER 2:

FEDERAL RESERVED WATER RIGHTS CLAIM

CHAPTER 2: FEDERAL RESERVED WATER RIGHTS CLAIM

On January 10, 2012, BLM filed its Third Amended SOC, which cross-references three attachments that contain information related to the claim. Copies of the Third Amended SOC and its attachments are provided in **Appendix B**. A summary of the Third Amended SOC is provided below, followed by descriptions of the attachments to the Third SOC.

2.1 BASIS OF CLAIM

The basis of the Third Amended SOC is listed as a federal reserved water right for instream flow on Aravaipa Creek and certain discrete or "point" water sources located within ACWA. The Third Amended SOC cites to the 1984 Act and the 1990 Act, which established the boundaries of the ACWA.

2.2 PRIORITY DATE

The Third Amended SOC identifies a priority date of August 28, 1984 for instream flows on Aravaipa Creek. The claim also identifies priority dates of August 28, 1984, and November 28, 1990, for point sources identified in Attachment C-1.

2.3 USES

The Third Amended SOC identifies the use as "Other," but does not provide a description. The Original SOC filed in March 1991 identifies the use as "Recreation, Fish & Wildlife." In section 201 of the 1984 Act, Congress found that:

> (1) the Aravaipa Canyon, situated in the Galiuro Mountains in the Sonoran desert region of southern Arizona, is a primitive place of great natural beauty that, due to the rare presence of a perennial stream, supports an extraordinary abundance and diversity of native plant, fish, and wildlife, making it a resource of national significance; and

(2) the Aravaipa Canyon should, together with certain adjoining public lands, be incorporated within the National Wilderness Preservation system in order to provide for the preservation and protection of this relatively undisturbed but fragile complex of desert, riparian and aquatic ecosystems, and the native plant, fish, and wildlife communities dependent on it, as well as to protect and preserve the area's great scenic, geologic, and historical values, to a greater degree than would be possible in the absence of wilderness designation.

2.4 SOURCES OF WATER

The Third Amended SOC identifies the sources as Aravaipa Creek, a tributary to the San Pedro River, and point sources described in Attachment C.

2.5 POINTS OF DIVERSION, MEANS OF DIVERSION, AND PLACES OF USE

The Third Amended SOC does not identify a point of diversion, but references Attachments A and C and describes the means of diversion as "Instream flow." Attachment A is a map of the geographic boundary of the ACWA. Attachment C-1 includes two tables identifying the locations of point sources. Map C-1 illustrates the locations of the point sources identified in Attachment C-1. The Third Amended SOC does not indicate a place of use other than the described points of diversion.

2.6 QUANTITIES OF USE

The Third Amended SOC claims a total annual volume of 24,799.03 acre-feet for both stream flow in Aravaipa Creek and point sources within the ACWA, and cross-references Attachments B and C. Attachment B claims a total stream flow volume of 24,600 acre-feet per year ("AFY") consisting of 9,444 acre-feet per year in base flow and an un-impounded flood flow of 15,156 acre-feet per year. Attachment C describes the quantities of water claimed from point sources. Attachment C-1 lists a total of 27 point sources with a total quantity of 199.03 acre-feet. The methodologies used by the United States to quantify its federal claims are described and evaluated in Chapter 3 of this report.

2.7 ATTACHMENTS

The Third Amended SOC incorporates information from three attachments, which are referenced throughout the claim. These attachments consist of maps, tables, and discussions of quantification methodologies.

2.7.1 Attachment A: Place of Use

Attachment A is a map showing the place of use, which is described as land within the ACWA geographic boundary defined by the 1984 Act and the 1990 Act. This map also shows the location of the USGS stream gage station 09473000 ("USGS Gage"), which the BLM used for quantification purposes. This gage is located on Aravaipa Creek approximately 6 miles downstream of the western boundary of the ACWA, near Mammoth, AZ.

On July 20, 2012, the United States filed a report that included copies of the maps and legal description of the ADWR that BLM certified on May 2, 2012. The report indicates that the certified and approved maps and legal description were transmitted to and received by the appropriate Congressional committee in June 2012. A copy of this report and its attachments are included in **Appendix B**.

2.7.2 Attachment B: Surface Water Flows

Attachment B describes the stream flow claims for Aravaipa Creek. Attachment B includes a table showing the total annual volume claimed for Aravaipa Creek, with monthly base flows and un-impounded flood flows. Attachment B indicates that BLM used records from the USGS Gage based on the years for which complete records were available: 1932-40, 1942, and 1967-84. The monthly base flows represent the median of the daily means for the month in the period of record. The total volume of the claim (24,600 acre-feet per year) represents the mean of all annual volumes for the period of record.

Attachment B also includes a second table that describes the estimated required flood flows according to return periods.

2.7.3 Attachment C: "Point" Water Sources

Attachment C describes the BLM's claims for point water sources and quantification methodology. Attachment C states that the BLM "claims discrete or 'point' water sources with[in] the ACWA," including springs, seeps, ponds, small lakes, and "[a]ny other naturally occurring waters (e.g., seasonal Cienegas, small riverside oxbow lakes, undiscovered seeps, springs, ponds, etc.) with[in] the ACWA." Attachment C-1 provides tables identifying the point sources, their respective locations, the priority date claimed for each point source, and the quantity for each point source claimed. Map C-1 illustrates the approximate locations of the point sources.

CHAPTER 3:

QUANTIFICATION METHODOLOGIES

CHAPTER 3: QUANTIFICATION METHODOLOGIES

This chapter evaluates the quantities sought and the methodologies relied upon by the United States in its Third Amended SOC. This claim is summarized in Chapter 2 of this report, and includes the following water sources within the ACWA:

- Instream flows of Aravaipa Creek
- Individual “point water sources”
  - Springs and seeps
  - Ponds and small lakes
  - Other naturally occurring waters

The instream flows claimed for Aravaipa Creek are addressed first below, followed by a discussion of the quantities claimed for the point sources.

3.1 UNITED STATES’ CLAIM FOR INSTREAM FLOWS OF ARAVAIPA CREEK

This section describes the quantities of instream flows claimed for Aravaipa Creek within ACWA and the methods used for quantification. The Third Amended SOC prescribes an instream flow regime equal to the natural flows of Aravaipa Creek consistent with the natural conditions of ACWA at the time of establishment in 1984, unaltered from human-induced impacts beyond those already in place at that time.

The United States claims an annual total volume of 24,600 acre-feet consisting of 9,444 acre-feet of total base flow distributed as a set of prescribed monthly base flows, and 15,156 acre-feet of naturally occurring, un-impounded flood flow. The United States also claims instantaneous peak flood discharges estimated to be met or exceeded on average once every 2, 10, 25, 50 and 100 years.   **Table 3-1** lists the claimed amounts including varying monthly prescribed base flows and the estimated peak flood discharges.

In a report relied upon by the United States, Swanson (2013) describes quantification of the claim for instream flows using data from the Aravaipa Creek USGS Gage.[1] The USGS Gage is a continuous recording station that in December 2008 was moved about a mile downstream to its current location shown in **Figure 3-1**, which is about six miles downstream of the west border of ACWA. The claimed amounts are derived as follows from statistical analysis of daily streamflow measurements at the USGS Gage for the 28 year available period of record prior to ACWA's establishment in 1984 (i.e. 1932-1940, 1942 and 1967-1984):

1. The quantity claimed as total annual volume is the computed mean value.
2. The quantities claimed as prescribed monthly base flows are the computed median values for each month. The quantities of monthly base flow volumes are the prescribed flows multiplied by the number of days in each month. The quantity of total base flow is the computed sum of the monthly base flow volumes.
3. The quantity claimed as un-impounded flood flow is the computed subtraction of the total base flow from the total annual volume.
4. The quantities claimed as instantaneous peak flood discharges are the computed results of flood frequency analysis.[2]

Swanson (2013) explains that the base flows claimed for each month represent the median of *all daily means* for the indicated month in the period of record. (Emphasis added) In hydrology, the term "base" flow includes streamflow originating as discharge from groundwater or river bank storage, and excludes flood flows from storm runoff. The BLM's calculations include all measurements including flood flows and therefore are more accurately described simply as "monthly median flows." Referring to the prescribed monthly flows in this manner

[1] Swanson (2013) also addresses ecological considerations related to the quantities of streamflow requested in the Third Amended SOC, as do three other reports submitted by the BLM. These reports are discussed in Section 3.3 below.

[2] Swanson (2013) at page 5 includes a table that "summarizes the statistical characteristics of the historical flood regime over the period of record up to 1984," which appears to have been the source of numbers for the Third Amended SOC. However, the 15,900 cfs discharge listed in the table for the 10-year return period is different from the 15,600 cfs value filed with the Third Amended SOC and reported by ADWR in Table 3-1 and Figure 3-46.

may help to avoid potential confusion regarding their use and interpretation. The use of median values implies that only half of the time will each month's prescribed flow be met or exceeded by measured data.

3.2 EVALUATION OF INSTREAM FLOW METHODS AND QUANTITIES

ADWR's evaluation of the Third Amended SOC for instream flows is presented in two parts. In this section, BLM's quantification of the natural flow regime is compared to the results of ADWR's independent analyses performed for this report. In Section 3.3, BLM's use of the unaltered natural flow regime at the time of establishment to prescribe the instream flow regime is evaluated. In the course of its evaluation, ADWR reviewed several published information sources in addition to those relied upon by the BLM.

As discussed below, ADWR has concluded that the methods used by the United States result in:

- Quantities not specifically applicable to the location of ACWA;
- Quantities for which interpreting compliance monitoring may be difficult or ambiguous;
- Potentially confusing use of the term "base" flows for the prescribed monthly flows;
- Quantity of total annual volume characterized in a manner better suited for a regulated watercourse than for a natural, unregulated stream; and
- Quantities of instantaneous peak flood discharges of questionable usefulness.

In addition, ADWR believes that the appropriate methodology should be corrected to:

- Quantify claimed amounts in consideration that the source of the data is from a gage that is located 6 miles downstream from the western boundary of ACWA;
- Quantify total annual volume using median value rather than mean;
- Quantify variabilities in total annual volume and monthly median flows using 25th and 75th percentile values;
- Eliminate reliance on instantaneous peak flood discharges as quantified attributes; and

- Clarify quantities that should be used to determine compliance for years having one or more months of actual flows that are less than the prescribed median monthly flows.

3.2.1 Review of Available Published Information

Included in this section are summaries of sources of available information reviewed by ADWR to understand the natural flow regime of Aravaipa Creek before and after establishment, as well as potential strategies and approaches for prescribing the appropriate instream flow regime. These reports contain information that supports ADWR's independent analysis described below.

Hydrology of Aravaipa Creek (Ellingson, 1980)

In 1980, a Master of Science thesis studying the hydrology of Aravaipa Creek was approved by the University of Arizona, Department of Hydrology and Water Resources (Ellingson, 1980). The thesis concluded that at least 80 percent of base flow in June 1979 originated as discharge from the Aravaipa Valley groundwater aquifer, and that evapotranspiration, upstream diversions and well pumpage were other important factors affecting base flow conditions. The mean annual flow for the period of record from 1967 to 1979 was found to be about ten percent lower than for the period from 1932 to 1942, and concluded not to have been primarily attributable to effects from pumping of wells. Decreases in flow were found to have been greatest during the months of January, July, August and December.

Assessment of State-Based Instream Flow Requirements for Aravaipa Creek (BLM, 1988)

In 1988, the BLM submitted an assessment report ("Assessment") supporting its 1981 application for a state-based permit for instream flows of Aravaipa Creek (BLM, 1988). The water right associated with this application is discussed along with other state-based rights in Chapter 4 of this report. The hydrologic information is described here, and the ecological information is described in section 3.3 below.

The Assessment included analysis of streamflow measurements. It described the 1980 installations of BLM-operated streamflow gaging stations at the east and west ends of Aravaipa

Canyon ("BLM East[3] and West Gages" or "BLM Gages"), *i.e.* the upstream and downstream extents of ACWA, respectively. Locations of the BLM gaging stations are shown on **Figure 3-1**. The Assessment reported that measurements at the BLM Gages between 10 and 100 cfs were of primary interest and that because the instream flow application was "for naturally occurring flows in the range of 10 to 40 cfs, the greatest accuracy was placed on measurements in this range." The Assessment reported that the USGS Gage was used to quantify streamflow because the BLM Gages had collected only seven years of data most of which "was collected in wet years and does not accurately reflect long-term averages."

<u>Geohydrology Assessment for Aravaipa Creek (Fuller, 2000)</u>

In 2000, a study was published assessing potential hydrologic and geomorphic effects on habitat conditions of Aravaipa Canyon (JE Fuller et al., 2000). The study found that due to their relatively close distance, short travel time, and minor intervening tributary contributions and diversions, the BLM West Gage and the USGS Gage produce hydrographs not showing appreciable delay. The study concluded the BLM East and West Gages likely under-predict flood flows, but they most likely better depict base flow rates in Aravaipa Canyon than does the USGS Gage. The study reported that for discharges below about 20 cfs, the USGS Gage measurements were generally lower than the BLM West Gage and were best interpreted as a minimum estimate of base flows.

The study concluded that Aravaipa Creek had experienced its lowest recorded flows between the late 1960's and mid-1970's with the year 1977 apparently marking a transition from a dry to wet cycle. The highest flows on record were found to have occurred during the 1980's and flows had dropped since that time but remained above previous levels. Aravaipa Creek has a flow pattern of wet winters from December through March, dry summers from April through early July and wet summer monsoons in late July through September. The study found that winter flood flows were less frequent but longer duration than monsoon floods and that flood flows for both winter and monsoon seasons were more frequent and of longer duration after

[3] The Assessment makes reference to "problems" with the East Gage as a reason for not including its data for analyzing instream flows and limiting its use to comparison with data from the West Gage. ADWR's use of East Gage data was also limited to comparison with the West Gage.

1977. The study concluded that base flow has been constant or increasing during the wet period, but there is potential for base flows to decrease in response to drier conditions.

This study also described the relationship between channel morphology as it is affected by flood flows, and the presence of riparian vegetation. This part of the study is discussed in Section 3.3 below.

Trends in Precipitation and Streamflow for Southeastern Arizona (Thomas and Pool, 2006)

In 2006, USGS published a study of regional trends in precipitation and streamflow for Southeastern Arizona (Thomas and Pool, 2006). The following results were gleaned from the report for the regional area which includes Aravaipa Creek:

- Winter, spring, and summer precipitation showed positive trends beginning around 1975-76.
    - The increase in winter rainfall peaked in about 1985 and showed a relatively sharp downward trend through 2002.
    - The increase in spring rainfall peaked in about 1982, gradually decreased until around 1990 and after mostly leveled off showing only a slight downward trend through 2002.
    - Summer rainfall showed a considerably smaller increase than winter or spring, peaked in around 1985 and had a gradual downward trend through 2002.
    - Fall rainfall showed no significant trend for the comparable time period.
- The period 1945-1960 is referred to as the “mid-century drought” and falls within the time period lacking streamflow records for the USGS Gage at Aravaipa Creek. Rainfall during these years showed relatively negative trends in winter, spring and fall and a marginally positive trend for summer.
- Regional analysis of streamflows showed positive trends in winter, spring and summer beginning around 1975-76, peaking around 1985 and gradually decreasing through 2002. As with precipitation, fall streamflows show little to no trend during the same period of time.

- Trend analysis of seasonal and annual average streamflow at the USGS Gage at Aravaipa Creek showed a significant trend (positive) only for spring average streamflow.

3.2.2 Comparison of BLM's Quantified Natural Flow Regime to Results of ADWR's Analysis

This section begins with a description of the approach used by ADWR for statistical analysis and descriptions of streamflow records. The results of this independent analysis are presented and then used for quantifying two distinct pre-establishment natural flow regimes: (1) using data measured at the USGS Gage downstream and (2) using data from the USGS Gage corrected from its downstream location by correlation to data recorded at the western boundary of ACWA. The ADWR results are compared to the BLM's quantification and their differences are discussed.

3.2.2.1 Statistical Approach

ADWR analyzed a series of streamflow statistics in order characterize the natural flow regime. Statistics were performed on "pre-1985" and "post-1984" paired datasets. Standard research protocols were followed for objectively comparing computed differences in statistics describing the central tendencies and measures of variability for each pair. ADWR's approach was designed to account for several common statistical characteristics of sets of streamflow data:

1. Data values cannot be negative, and they have a lower limit of zero.
2. Datasets regularly include some number of outlying data values considerably higher or lower than the typical range. Due to #1, outliers are more likely to be the high side.
3. Due to #1 and #2, the mass of data values tends to be distributed asymmetrically toward the low side and said to have a "positive skew."
4. Due to #1, #2 and #3, data values typically do not follow a normal probability distribution and do not satisfy assumptions inherent to certain statistical methods.
5. Data values are not random, but instead follow regular seasonal patterns nested within irregular multi-year trends.

6. Data values are not independent, but instead high values tend to follow other high values and low values tend to follow other low values, and are said to have "positive autocorrelation."

3.2.2.1.1 Measures of Central Tendency

The sample mean and median value are the two most commonly measures used for describing the central tendency of datasets and each is calculated for every pair of analyses performed. However, for some analyses, one or the other is a more appropriate or useful measure. The sample mean, or arithmetic average, is highly sensitive to the presence and magnitude of outlier values, which in turn exert a much greater influence on the overall mean value than do more typical data points. Generally, it is more appropriate to use the mean when the strong influence of a few observations is desirable. The mean is more useful for describing and managing available water of regulated watercourses for which the volume of streamflow available for diversion or storage is more meaningful than instantaneous streamflow rates.

The median value, the 50^{th} percentile, is the central value of the dataset when the data are ranked in order of magnitude. For an odd number of observations, the median is the data point which has an equal number of observations both above and below it. For an even number of observations, it is the average of the two central observations. The median is only minimally affected by the magnitude of a single observation, being determined solely by the relative order of observations. When a central value is desired that is not strongly influenced by a few extreme observations, the median is preferable to the mean. The median value is more useful for evaluating and managing unregulated, natural streams without significant storage and diversion capacity, such as Aravaipa Creek, for which instantaneous streamflow rates are more relevant than volumes of flow.

As described in Section 3.1, the United States relied upon the mean value to quantify total annual volume and median values to quantify monthly flows in support of the Third Amended SOC. In its independent analyses discussed below, ADWR relied upon median values to quantify central tendency for both annual volume and monthly flows.

3.2.2.1.2 Measures of Variability and Skew

The widely-used measures of variance and standard deviation are based on the computed mean and are even more strongly influenced by values of a few outlying data points. A measure of dataset variability and skew, which like the median is resistant to outlier values, is the interquartile range (“IQR”). The IQR measures the range of the central 50 percent of the data and is defined as the 75th percentile minus the 25th percentile. The 75th, 50th (median) and 25th percentiles split the data into four equal-sized quarters. The 75th percentile, also called the upper quartile, is a value which exceeds 75 percent of the data and is exceeded by 25 percent of the data. The 25th percentile or lower quartile is a value which exceeds 25 percent of the data and is exceeded by 75 percent of the data. Another outlier-resistant measure of data spread is the median absolute deviation (“MAD”), which is the median of the absolute values of all differences between each data point and the computed median of the dataset.

ADWR relied upon the 25th and 75th percentile values (i.e. IQR) to quantify variability and skew for both annual volume and monthly flows in its independent analysis discussed below. As described in section 3.1, the United States did not include quantification of variability in support of its quantification of the Third Amended SOC.

3.2.2.1.3 Test for Differences in Pairs of Datasets

The Mann-Whitney test (also known by other names including the rank-sum test) is used in hypothesis testing of analysis pairs. The Mann-Whitney test is a widely used, non-parametric test that does not assume or require any specific probability distribution of the datasets (Helsel and Hirsch, 2002).

3.2.2.1.4 Presentations of Statistical Results

Most reported statistical results for pairs of datasets in this report are provided in one or more of the following formats:

1. *Tables of Descriptive Statistics for Paired Datasets.* These tables list for both datasets the values for: Number of measurements, minimum, 25th percentile, median, 75th percentile, maximum, IQR, MAD, mean and standard deviation.

2. *Side-by-Side Box and Whisker Plots.* These plots include much of the same information as provided in the tables of descriptive statistics in a format to allow for easier visual assessment of differences between the paired results. The center line of the box is the median, the top line of the box is the 75th percentile and the bottom line of the box is the 25th percentile. The height of the box is the IQR.
3. *Time-Series Charts.* These charts show annual variations in streamflow statistics plotted with the horizontal axis aligned with the median value calculated for the pre-1985 period of record to easily show departures above and below conditions prior to establishment of ACWA. To smooth out shorter-term fluctuations and give a better sense of longer-trends, the 5-year moving average since 1967 is shown on each figure. The charts provide a more general understanding of changes with time than the comparisons between the periods of results, which are dependent on the beginning and ending years of each period.

3.2.2.1.5 Streamflow Analyses and Tests of Significance

The USGS Gage is about 6 miles downstream from ACWA, but provides the longest and most continuous data record of streamflow on Aravaipa Creek and is the only gage with an adequate period of record for analyzing characteristics of the natural flow regime of Aravaipa Creek prior to establishment in 1984. Certain characteristics of the natural flow regime at the location of the USGS Gage, such as the seasonal distributions of flows, likely would apply to ACWA with no need for adjustment or correction. Other characteristics such as the magnitudes of monthly flows and annual volumes could be improved if corrected by correlation of flows measured at the USGS Gage and the BLM Gages. The following analyses were performed in pairs of pre-1985 and post-1984 periods of record for the USGS Gage to compare characteristics of the natural flow regime considered most relevant to supporting wilderness conditions and to confirm that the present day flow regime is sufficiently similar to pre-1985 so as to allow meaningful prescription of pre-1985 flow conditions:

- Monthly Streamflows
- Seasonal Distribution of Streamflows
- Annual Streamflow Volume

- Annual Maximum Streamflow
- Annual Minimum Streamflow
- Flood Frequencies

The following analyses were performed for the BLM East and West Gages and for the USGS Gage and the BLM West Gage:

- Monthly Streamflows Compared for BLM East & West Gages
- Monthly Streamflows Compared for BLM West & USGS Gages
- Monthly Linear Regressions for Same Day Data for BLM West & USGS Gages

Each of these analyses is described below, followed by ADWR's comparison to the methodology used by the United States. Based on review of streamflow records and other available information, flows exceeding 100 cfs were identified as relatively-large flood flows.[4] Accordingly, flows with magnitudes of 100 cfs and larger were excluded from datasets used in analyses intended to characterize normal seasonal streamflows. All streamflow data were included in analyses intended to characterize total annual volume and un-impounded flood flow.

Monthly Normal Streamflows

Figures 3-2 through 3-13 show *Tables of Descriptive Statistics for Paired Datasets, Side-by-Side Box and Whisker Plots,* and *Time-Series Charts* for each calendar month. Results indicate significant increases for all months in median, as well as the 25th and 75th percentile flows since establishment of ACWA with the time-series charts showing streamflows rising in the early 1980's, peaking at around 1985 and dropping during the 1990's and 2000's.

Figure 3-14 shows calculated percentage increases, post establishment, for 25th percentile, median and 75th percentile monthly flows. The largest increases in 25th percentile flows of nearly 60 percent have occurred in July and August. Increases in median flows have ranged from less than 15 percent in the months of April, May and December to greater than 45 percent in July and August. The largest increases in 75th percentile flows of nearly 40 percent have occurred in May and June.

[4] See Fuller (2000) discussed in Section 3.3 below.

Seasonal Distribution of Streamflows

Figure 3-15 compares the seasonal distributions of streamflows. The upper portion of the figure compares seasonal percentages of normal streamflows for the winter storm months of December through March, spring months of April through June, monsoon storm months of July through September and fall months of October and November.[5] Monthly median normal streamflows calculated previously were used for the upper portion of the figure. The lower portion compares seasonal percentages of total annual volumes including flood flows. Total monthly volumes were used for the lower portion. Results indicate that seasonal percentages of both normal and flood flows have remained relatively constant as measured before and after establishment of ACWA.

Annual Streamflow Volume

Figure 3-16 shows a *Table of Descriptive Statistics for Paired Datasets, Side-by-Side Box and Whisker Plots,* and a *Time-Series Chart.* The results show non-significant changes in annual volumes since establishment. The mean annual volumes are less than 1% different, *i.e.* 24,269 acre-feet compared to 24,144 acre-feet before and after establishment. The median annual volume for the period before establishment is 15,240 AF, about 12% lower than the 17,267 AF value computed for the later period of record.

Annual Maximum Streamflow

Figure 3-17 shows a *Table of Descriptive Statistics for Paired Datasets, Side-by-Side Box and Whisker Plots,* and a *Time-Series Chart.* The results show significantly decreased annual maximum flows since establishment. For the periods before and after establishment, the mean annual maximum flows decreased by nearly one-third from 6,608 cfs to 4,633 cfs, and the median annual maximum flows decreased from 4,900 cfs to 3,445 cfs.

Annual Minimum Streamflow

Figure 3-18 shows a *Table of Descriptive Statistics for Paired Datasets, Side-by-Side Box and Whisker Plots,* and a *Time-Series Chart.* The results show significantly increased

[5] See Fuller (2000) discussed above.

annual minimum flows since establishment. For the periods before and after establishment, the mean annual minimum flows increased from 3.9 cfs to 7.2 cfs, and the median annual minimum flows increased from 3 cfs to 5.9 cfs. The significant increases in annual minimums, taken together with the significant decreases in annual maximums suggest the post-1984 period of record is characterized by less extreme variations in streamflow than the earlier period.

Flood Frequencies

Table 3-2 shows estimated flood frequencies comparisons of the streamflow magnitudes with flood return periods of ranging from 1.25 to 10 years before and after establishment. These return periods were selected because they are within the range of flood events which both shape the geomorphology of the stream channel and affect the distribution and abundance of ecosystems.[6] Results indicate that the flood flows associated with these return periods have uniformly decreased by an amount of about 15 percent. The flood return periods were predicted using the USGS PKFQWin[7] computer program.

Monthly Streamflows Compared for BLM East & West Gages

The monthly to semi-monthly flow measurements recorded at the BLM East and West Gages were compared to determine if quantification of the natural flow regime is required at both the upstream and downstream extents of ACWA, or if a single quantification can suffice. **Figures 3-19 through 3-30** show *Tables of Descriptive Statistics for Paired Datasets* and *Side-by-Side Box and Whisker Plots* for each calendar month during years for which measurements were available for both of the gages. Results indicating non-significant differences between the datasets for ten of the twelve months suggest that a single quantification of natural flow regime adequately characterizes ACWA.

[6] Swanson (2003) and the Third Amended SOC included instantaneous measurements for flood flow returns for 2, 10, 25, 50 and 100 years. Figure 3-46 compares results of ADWR analysis to these results.

[7] The PKFQWin program and documentation is available at: http://water.usgs.gov/software/.

Monthly Normal Streamflows Compared for BLM West & USGS Gages

The monthly to semi-monthly flow measurements recorded at the BLM West Gage were compared to measurements for the same period of record for the USGS Gage to determine if quantification of the natural flow regime based on USGS Gage data is fully representative of ACWA or, whether the characterization could be improved by correcting the data for location to the western extent of ACWA. **Figures 3-31 through 3-42** show *Tables of Descriptive Statistics for Paired Datasets* and *Side-by-Side Box and Whisker Plots* for each calendar month. Visual assessments of the side-by-side results indicate for all months a consistent trend of lower same-day flow measurements at the USGS Gage as compared to the BLM West Gage. These results are consistent with findings of previous studies. June was the only month with statistically significant differences; however, these results are likely due in part to much more limited numbers of measurements for the BLM West Gage as compared to the USGS Gage. Based on the visual assessments and findings of previous studies, the relationships between gage readings were further investigated via a series of linear regression analyses between same-day readings for each month during the common period of record.

Monthly Linear Regressions for Same Day Data for BLM West & USGS Gages

Simple linear regression analyses[8] were performed using same-day readings collected at the BLM West and USGS Gage during each calendar month. The regression analyses were limited to pairs of flow measurements having agreement within 50 percent. This limit was selected to exclude BLM West measurements either taken from portions of the daily hydrograph not representative of the daily mean flow as reported by the USGS Gage or otherwise somehow in error. The data pairs used in developing the twelve monthly linear correlations were found to closely match the fitted regression lines as judged by calculating their coefficients of determination, *i.e.* "R-squared" values ranging from 63 to 99 percent with an average of 84.

[8] Simple linear regression is a common technique used to examine correlation between two variables, denoted x and y. The solution is the best-fit of the data the coefficients "m" and "b" to an equation in the form of straight line, $y = mx + b$, where m is the slope and b is the y-intercept. For this analysis, x is flow measured at the location of the USGS Gage and y is value of flow corrected for location six miles upstream to the BLM West Gage.

Table 3-3 shows the 25th percentile, median, and 75th percentile monthly normal flows and total annual volumes as measured at the USGS Gage, and as correlated to the BLM West Gage. The following comparisons between these flow volumes are derived from Table 3-3:

- *Monthly 25th percentile normal flows* increase from zero to 55 percent with average 26 percent and standard deviation of 15 percent.
- *Monthly median normal flows* increase from zero to 33 percent with average 16 percent increase and standard deviation of 9 percent.
- *Monthly 75th percentile normal flows* range from a decrease of 7 to an increase of 20 percent with average 10 percent increase and standard deviation of 6 percent.
- *25th percentile total annual volume* increases 10 percent.
- *Median total annual volume* increases 8 percent.
- *75th percentile total annual volume* increases 3 percent.

Table 3-3 also presents the results of the regression equations used for correlating the measurements recorded at the location of the USGS Gage to the location of the BLM West Gage. The correlations are made by inputting a USGS Gage flow value (cfs) into the regression equation for that month and calculating the flow value (cfs) for the BLM West Gage. The total annual volumes were first converted into equivalent cfs and then correlated using the following steps:

Step 1. Apportion USGS Gage total annual volume (acre-feet per annum) to twelve monthly volumes (acre-feet per month) based on results of Department's analyses of monthly percentages prior to establishment.

Step 2. Convert USGS Gage monthly volumes to equivalent streamflows in customary units of cfs based on the number of cubic feet in an acre-foot and the number of days in each month.

Step 3. Input USGS Gage equivalent monthly streamflows into the regression equations for correlating to the location of the BLM West Gage.

Step 4. Convert BLM West Gage equivalent monthly streamflows into monthly volumes (reverse of Step #2).

Step 5. Convert BLM West Gage monthly volumes into total annual volume (reverse of Step #1).

3.2.3 Comparisons with BLM's Quantification of Natural Flow Regime

Figure 3-43 shows how the amount of information communicated for quantification of the natural flow regime or prescribed instream flow regime is vastly increased by including the 25th and 75th percentile values with the median values. Quantification using the median value alone communicates only one-half of the dataset were less and the other half more. Including the 25th and 75th percentile flows communicates the variability and skew of the dataset as well as allowing future values to be understood in context of that variability and skew.

Figure 3-44 compares claimed quantities of prescribed monthly flows to results of the ADWR independent quantification. The claimed quantities are a single line of monthly median base[9] flows recorded at the USGS Gage located 6 miles downstream of ACWA. No information is provided regarding past or expected future variability or skew in calculated monthly values, and the values are not correlated for location to ACWA. These limitations may make meaningful interpretation of future compliance monitoring difficult or time-consuming.

The ADWR results quantify the monthly median, 25th and 75th percentile normal[10] flows as correlated to the location of the western boundary of ACWA, thereby providing monthly quantities directly applicable to ACWA and including additional information on variability and skew for easier interpretation of future compliance monitoring. The BLM's claimed quantities for monthly flow generally plot between the ADWR median and 25th percentile values. Comparison of the BLM monthly flows to the comparable ADWR results for the location of the USGS Gage shows the observed differences in median values on the figure are due almost entirely to the BLM quantities not having been correlated for location to ACWA. The close agreement of median results at the USGS Gage location, considering the ADWR data is limited to flows less than 100 cfs and the USGS Gage includes all data, is indicative of the insensitivity of median values to data outliers.

Figure 3-45 shows the relationships between total annual volume as quantified by both the BLM claim and ADWR's independent analysis and the flow duration curve developed using all available data at the USGS Gage before and after establishment. This flow duration curve is used because it is judged to best estimate the likely frequencies of future annual volumes for

[9] See section 3.1 for discussion of BLM base flows.
[10] See section 3.2.2.1.5 for discussion of ADWR normal flows.

Aravaipa Creek. The figure indicates that if ADWR's median, 25th percentile and 75th percentile values were used for quantification, they would in the future likely continue to be representative of central tendency, variability and skew inherent in annual volumes, thus allowing future compliance monitoring data to be readily characterized and understood. Conversely, due to the skew and non-normality of the data, the mean annual volume would be expected on average to be met or exceeded in only about 34 percent of years and would not provide an easy basis for understanding future monitoring in context of the variability and skew inherent in the quantification. ADWR recommends that quantifying the annual volume using the median value, presented with 25th and 75th percentiles is more appropriate than use of the mean total annual volume.[11]

The United States' claim quantifies streamflow discharges estimated to have annual exceedance probabilities ranging from 50 percent (i.e. 2-year flood) to 1 percent ("100-year flood). ADWR evaluated these estimates by obtaining data for the USGS Gage from the USGS public website and, without modification, inputting that data into the USGS software. ADWR's results agree favorably with published results (Garrett and Gellenbeck, 1991, Pope et al. 1998). **Figure 3-46** shows that the claimed amounts are significantly higher than the ADWR results and the differences increase as the probabilities becomes smaller. Information was not available to evaluate the cause of these differences. Beyond their role of helping to characterize flow regime, ADWR questions the utility of including estimated flood frequencies as quantified attributes of rights to instream flows because they are the least certain characteristic of flow regime and would be expected to be the least likely to identify initial stages of adverse effects to the environment.

3.3 EVALUATION OF PRESCRIBED INSTREAM FLOW REGIME

The United States' claim prescribes an instream flow regime equal to the natural flow regime at time of establishment with "no human-induced alterations." The BLM filed expert reports, which are described below, that conclude that maintaining the natural flow in an unaltered state is required, and warn that any further human-induced alterations would have

[11] See also discussion in section 3.2.2.1.1 regarding regulated versus unregulated streams.

negative effects on the natural ecology. As discussed below, ADWR has concluded that it is not correct that *any* human-induced alterations would have negative effects as is self-evident by the degree of natural variability shown in the precipitation and streamflow records for Aravaipa Creek.

3.3.1 Expert Reports

The BLM filed the following four expert reports in support of the Third Amended SOC:

(1) Bonar & Mercado-Silva (2013). *Aravaipa Canyon Wilderness Area FRWR Claims: Protection of Fish Resources*.

(2) LowClouds Hydrology Inc. (2013). *Aravaipa Canyon Riparian Assessment in Support of Federal Reserved Water Rights*.

(3) Moore (2013). *Aravaipa Canyon Wilderness: Dependence of Recreational Values on Streamflow.*

(4) Swanson (2013). *Aravaipa Creek Arizona, Federal Reserve Water Right Claims*.

Copies of these reports are included in Appendix C.

The reports by Swanson, Bonar and Mercado-Silva and LowClouds describe various ecological factors to support claiming instream flow quantities based on the unaltered natural flow regime, which consists of both base flows and flood flows. Some of these factors include the following:

- Streamflow discharge is the predominate variable that limits and resets populations throughout entire drainage networks, the natural streamflow regimes of rivers are inherently variable and that variability is critical to ecosystem function and native biodiversity.
- For Aravaipa Creek, characteristics of the natural flow regime that must be preserved are the magnitudes, frequencies and durations for seasonal base flows, winter and monsoon flood flows, and the larger, less-frequent flood events.
- Reported characteristics of desert riparian habitats and ecosystems and their relationships to streamflow availability have been studied.
- Reported findings of fish habitat and population studies, including for Aravaipa Creek extending as far back as the 1940s, establish relationships to streamflow availability.

- Reported aquatic habitat preferences and requirements for fish species native to Aravaipa Creek establish that natural flow regimes tend to benefit native fish species over non-native species. Native fish species include two recognized as endangered, the loach minnow and spikedace, as well as a candidate for federal listing, the roundtail chub.
- Different habitats are supported by different portions of the natural flow regime. Examples include habitats in the stream channel subjected to nearly continuous inundation during times of normal flow versus habitats on floodplains subjected to periodic inundation during seasonal flooding.
- Different populations are supported by different portions of the natural flow regime. Examples include individual species during different life-cycle stages or the flourishing of some species during periods of low flows versus other species which flourish in times of high flows.

In addition to these ecological factors, the report by Moore describes the recreational values of ACWA and how they are dependent upon streamflows by analysis of visitation records and responses to visitor surveys in support of the dependence of ACWA recreational values upon streamflow. The report uses the visitor information, streamflow records and an assumed standard relationship between recreational value and streamflow to conclude that streamflow of about 23 cubic-feet per second (cfs) yields the maximum recreational value. The report concludes that the presence of water is highly important to the recreational value of ACWA.

3.3.2 Review of Available Published Information

In addition to the reports submitted by the BLM, the Department reviewed the reports described below that relate to relationships between streamflows and ecological requirements.

<u>Assessment of State-Based Instream Flow Requirements for Aravaipa Creek (BLM, 1988)</u>

In 1988, the BLM submitted an assessment report ("Assessment") supporting its 1981 application for a state-based permit for instream flows of Aravaipa Creek (BLM, 1988), which contained relevant ecologic information. It also contained hydrologic information, which is discussed in section 3.2 above.

The Assessment identified seven native fish, eight amphibian, 47 reptile, 237 bird and 46 mammal species in the canyon and included the following discussion of fish species:

> "Generally, the populations of the seven species of native fish vary in absolute numbers and in proportion with each other. The environmental factors that allow seven species to coexist in a relatively small stream are created at least in part by a complex pattern of discharge amounts. Complex environments allow species diversity to increase as no single species can specialize for all the conditions present. No other stream in Arizona supports more than five native fish species. Aravaipa Creek is unique in its diversity."

The Assessment described findings of a 1981 report which analyzed 21 years of monthly flows at the USGS Gage and evaluated the relationships between flows and habitat (Minckley, 1981). The Minckley report opined that a uniform flow of 15 cfs would "probably be disastrous" and recommended varying prescribed flows "in a pattern following the natural, unregulated flow regime." It is of note that changes to channel conditions and vegetation patterns resulting from the 1983 and 1993 flood events which occurred following publication of the Minckley report and after data collection was completed for the fish study may limit applicability of these results.

Another report published in 1983 describing a 1980-1981 fish habitat study for Aravaipa Creek (Turner et al., 1983) was appended to the BLM assessment. The habitat study used the incremental methodology,[12] presented suitable habitat versus streamflow relationship for each species and concluded that a discharge of 20 cfs provided the most suitable habitat for adult spikedace and loach minnow, and that for discharges less than 10 cfs, habitat decreased. The Assessment suggested that flows less than 10 cfs could be tolerated by the system for a limited period of time but that "extensive low flows (in excess of two per month) coupled with high summer temperatures may cause stresses on the flora and fauna from which they could never recover."

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[12]The incremental methodology is a standard approach used for establishing instream flow regimes. The method includes producing series of relationships between flow rates and available potential habitat for a given fish species.

Geohydrology Assessment for Aravaipa Creek (Fuller, 2000)

In addition to providing gage information for the USGS gage and the BLM gages, which is discussed above in Section 3.2, this study described the natural cycle of channel formation as being the result of large, devastating floods, such as the one in 1983, stripping vegetation from the channel bank and floodplain, leaving the overbank sediments susceptible to erosion during subsequent flood events until vegetation gradually recolonizes the floodplain during periods of smaller, inundating floods that do not strip the vegetation. The study concluded that more frequent, small floods generally dominate channel morphology but as shown in the historical record, less frequent, large events have the potential to significantly modify the stream channel. The study reported that major changes in channel morphology occurred during the 1963, 1983 and to a lesser extent the 1993 floods and concluded that the amount of change in channel conditions initiated by a large flood is a function of whether the flood occurred during a dry period or during a wet period. The study cited Minckley (1981) as estimating the magnitude of "destructive flooding" as any daily mean streamflow over 100 cfs, but reported observing 800 cfs flows stripping some bank-lining vegetation but not altering the overall character of the stream. The study concluded that Aravaipa Creek channel morphology and riparian habitats remain susceptible to drastic changes in response to large flood events.

3.3.3 Comments on BLM's Prescribed Instream Flow Regime

The United States' claim prescribes an instream flow regime equal to the natural flow regime at time of establishment with "no human-induced alterations." Expert reports relied upon by the BLM conclude that maintaining the natural flow in an unaltered state is required, and warn that any further human-induced alterations would have negative effects on the natural ecology.

It is a generalized overstatement to suggest that *any* human-induced alteration to the natural flow regime would result in tangible negative effects. Prescribed instream flow regimes have been developed across diverse ecological conditions allowing *some amount* of human-induced alteration to certain aspects of natural flow regimes (e.g. flood flows during specified times of year, etc.) while still providing protection to critical aspects of natural flow regimes (Annear et al., 2004, Poff et al., 1997). Records of the natural variability in precipitation and streamflow discussed in Section 3.2 provide direct evidence of a natural flow regime for Aravaipa Creek with 80 years of differing magnitudes of natural variation across annual and decadal time-scales having supported the existing wilderness ecosystem.

The Department recognizes that lack of regard for the established natural conditions through the introduction of human-induced alterations whose timing, magnitude or duration would be incompatible with natural variations and ecological needs could have the effect of altering significantly the natural flow regime and may cause serious short- and long-term negative effects. ADWR did not attempt to analyze what human-induced alterations might constitute sufficiently opportune timings, small enough magnitudes and short enough durations to make water available for other water uses without having significant adverse effects on ACWA. Such a regimen would properly be developed cautiously while including close monitoring and other safeguards.

3.4 UNITED STATES' CLAIM FOR "POINT" WATER SOURCES

As discussed in Chapter 2, the Third Amended SOC cross references Attachment C in the description of the sources of water, the points and means of diversion, and the quantities of use. Attachment C-1 contains two tables that contain information concerning certain individual "point" water sources within ACWA together with a map depicting their locations.[13] All of the claimed point sources are located on land that was acquired by the BLM for uses within the ACWA. For some of these point sources, the BLM or prior land owners also had filed SOCs based on state law, which are described in **Table 3-4**.

Two types of point sources are listed in Attachment C-1, which are described as: 1) springs and seeps, and 2) ponds and small lakes. They also include "any other naturally occurring waters (e.g., seasonal cienegas, small riverside oxbow lakes, undiscovered seeps, springs, ponds, etc.) within the ACWA." The locations for these "other" naturally occurring

[13] The map included with the Third Amended SOC could not be used to identify the precise location of the point sources because the scale of that map was too large. As part of its disclosure documents, the United States provided topographic maps of the ACWA with a smaller scale depicting the locations of many of the point sources. (USAV2-00003715, 3716). See Appendix C.

sources, however, were not specifically identified in Attachment C and no information was provided for them.

In Attachment C, BLM claims a right to use water from 27 point water sources for a total combined annual volume of 199.03 acre-feet. Because these point sources are in remote locations within ACWA with difficult access, the Department did not conduct field investigations. Also, because springs and seeps do not produce water at all times of the year, or every year, field investigations of springs and seeps would not have provided useful information. Instead, the Department performed a GIS/office assessment of all of the point sources included in the Third Amended SOC. The Department was able to identify the locations and features of the small impoundments (tanks and a reservoir) using satellite imagery. For information concerning springs and the seep, the Department relied upon information found in other ADWR reports and documents filed in the contested case for the ACWA.

Table 3-4 presents a summary of the point sources described in the Third Amended SOC and the Department's analysis of its records related to those point sources. Additionally, **Table 3-4** includes amendment and assignment information concerning filings which pre-dated BLM's acquisition of lands on which the point sources are located.

The point sources listed in Attachment C-1 are described in the following sections and depicted on **Figure 3-47**.[14] Also described are any differences between BLM's and the Department's information, and the results of the Department's GIS/office review. **Appendix D** of this report contains satellite images used in ADWR's GIS/office verification of the claimed locations and features for certain point sources. The shapefiles are included in **Appendix E**.

3.4.1 Springs

Attachment C-1 to the Third Amended SOC lists 14 springs including one seep that are claimed as point sources for ACWA. The springs are described in **Table 3-5** and numbered as site Nos. 1 through 14 for reference purposes. Four of the springs are located on lands that were

[14] ADWR prepared this figure based on the information presented in the Third Amended SOC and the topographic maps provided by the United States, described in footnote #1.

designated as wilderness in the 1984 Act (”Designated Lands”) and the remaining10 springs are located on lands that were added to the ACWA in the 1990 Act (“Expansion Lands”).[15]

The Third Amended SOC indicates that the total amount of water for springs is based on the measured flow in gallons per minute (“GPM”) with a corresponding volume per annum in acre-feet (“AFA”) using measurements made between 1986 and 2012. The claimed volumes of water range from 0.10 AFA for Lupie Seep to 80 AFA for Hanging Spring. The sum of the individual claimed amounts for the springs and seep listed in Attachment C-1 is 182.94 AFA.

All 14 claimed springs have associated state-based water rights, including 5 certificates of water right. **Table 3-4** lists the associated state-based rights filed with the Department for each of the claimed springs.

Table 3-5 presents the results of ADWR’s GIS/office review of the ACWA spring claims. Known spring locations and flow/discharge measurements that could be referenced from either Department published records or from documents filed in the contested case are presented in **Table 3-5**.[16]

Based on ADWR’s review, it appears that there are very limited, sometimes none at all, historic field measurements of spring discharge within ACWA supporting the annual discharge volumes included in Attachment C-1 to the Third Amended SOC, other than the measurements provided by the BLM. A total of 14 measurements have been reported, only four of which pre-dated the 1990 Act for springs located on Expansion Lands - North Booger (#1), East Booger (#2), Natural Boundary (#3), and Hanging (#4). In the cases of Saltuna (#5), Goat (#6), and Purgatory (#7) Springs, which are located on Designated Lands, all reported measurements occurred post-1984. ADWR was unable to find any published flow rate data for four of the claimed springs - Stone Cabin (#8), Lower Stone Cabin (#9), Lupie Seep (#10), and Buggar (#11). The last three springs listed in Table 3-5 – Janette (#12), Rock Tub (#13), and McRae (#14) are also located on Expansion Lands and their respective reported discharge measurements were taken after 1990.

[15] The springs located on Designated Lands include Saltuna (#5), Goat (#6), Purgatory (#7), and Buggar Springs (#11). Claims for Goat and Purgatory Springs were decreed as part of the PWR 107 contested case no. W1-11-1174.

[16] These records include the ADWR Water Atlas (2008), ADWR’s 2007 Report in the PWR 107 contested case, and documents provide by the United States marked as USAV2-00003651-3652, and 00003647-3648.

Additionally, the claimed quantities listed in Attachment C-1, as in the case of Buggar Spring, appear to be inconsistent with quantities described in state-based rights held by BLM as listed in **Table 3-4.** Revised CWR No. 308, for example, specifies a total of 0.05 AFA (15,000 gallons per annum) for Buggar Spring whereas Attachment C-1 to the Third Amended SOC lists the quantity as 9.05 AFA. The state-based quantities are included in **Table 3-5** for comparison purposes.

The total of the discharge measurements for each of ten springs listed in **Table 3-5** that ADWR confirmed in published reports is approximately 316 AFA, well above the claimed amount for springs listed in the Third Amended SOC.

3.4.2 Small Impoundments

A total of 13 small impoundments including one small reservoir are claimed as point sources for ACWA, which are listed in **Table 3-6** as site Nos. 15 through 27. Three of the small impoundments are located on Designated Lands and the remaining 10 impoundments are located on Expansion Lands.[17] BLM states that the amount of water claimed is the maximum capacity of each impoundment. The total combined claim associated with these point sources is 16.09 AF.

Through the use of aerial photography, the Department reviewed and verified that all claimed small impoundments were at or near their claimed location. (See **Appendix D**) However, the United States did not provide any data to support the capacities claimed.

In order to compute and verify the storage capacities for each of the claimed impoundments, the Department needed the corresponding embankment heights and/or pond depths, which could only be obtained from the state-based filings on file with the Department. The largest reported dam height from filings was used in ADWR's capacity calculations. The Department also needed the surface area for each impoundment, which the Department obtained through remote sensing analyses using GIS tools. ADWR used the following formula to calculate impoundment capacities:

[17] The three impoundments included on Designated Lands include Mesa Tank #1 (#16), Mesa Tank #3 (#24), and Adalfo Tank (#26).

Capacity (AF) = Surface Area (acres) x Height of Dam (ft) x 0.4 (shape factor)

The results of ADWR's impoundment capacity analysis are presented in **Table 3-6**. Embankment heights could only be obtained for 11 of the 13 small impoundments listed in Attachment C-1.

Based on ADWR's review, the sum of the individual estimated capacities for 11 of 13 impoundments listed in Attachment C-1 is 18.14 AF, slightly higher than the claimed amount for tanks listed in the Third Amended SOC.

CHAPTER 4:

STATE-LAW BASED INSTREAM FLOW WATER RIGHTS

CHAPTER 4: STATE-LAW BASED INSTREAM FLOW WATER RIGHTS

This chapter describes state-law based water rights related to instream flows both within and around the AWCA. BLM holds a certificate of water right ("CWR") for instream flows along Aravaipa Creek within the AWCA boundary and has a pending application for a permit to appropriate instream flows along Oak Grove Canyon near the southeastern boundary of the ACWA. The Arizona Chapter of the Nature Conservancy, Tucson, Arizona, ("TNC") holds two CWRs upstream of the ACWA eastern boundary, as well as two CWRs downstream of the AWCA western boundary.

The following sections describe the Department's instream flow program, the BLM's and TNC's CWRs, and BLM's pending instream flow application. The reaches covered by the CWRs and the pending application are depicted on **Figure 4-1**. Copies of the CWRs and the pending application are included in **Appendix F**.

4.1 DEPARTMENT'S INSTREAM FLOW PROGRAM

Pursuant to state law, the Department processes applications and issues permits to appropriate water for both diversionary uses and non-diversionary uses, which include recreation, wildlife and fish purposes. See A.R.S. §§ 45-151 to 153. Water rights for these non-diversionary uses are commonly referred to "instream flow water rights."

Under A.R.S. § 45-153, the Department must approve an application if it is in proper form and for a beneficial use, unless the proposed use conflicts with a vested water right, is a menace to public safety, or is against the interests and welfare of the public. Under A.R.S. § 45-141(B), beneficial use is the "basis, measure and limit to the use of water." Pursuant to A.R.S. § 45-161, the Department is authorized to issue a CWR when the Department determines that the appropriation has been perfected by putting the water to the beneficial uses and in the quantities authorized by the permit. The priority date for the appropriation is the determined by the date that the permit application was filed. See A.R.S. § 45-162(B).

In 1991, the Department adopted a substantive policy statement titled "A Guide to Filing Applications for Instream Flow Water Rights in Arizona ("Guide")," in which appropriate quantification methodologies were described, including the use of median streamflows.[1] The Department processed the permit and certificate applications filed by the BLM and TNC discussed herein pursuant to the 1991 Guide and the statutes in effect at the time that the applications were filed.

4.2 BLM's CERTIFICATE OF WATER RIGHT NO. 33-87114

On June 1, 1981, the BLM filed application No. 33-87114 for a permit to appropriate water for instream flows for aesthetic, recreation and wildlife purposes on Aravaipa Creek within the boundary of the ACWA. Base flow data were collected since the early 1980s from four locations. BLM relied on measurements from the BLM East and West Gages, the USGS Gage, and a fourth monitoring site upstream of the eastern ACWA boundary known as the "old school house site." All flows requested were based on mean monthly flows, and were less than the median flows available.

On March 14, 1996, the Department issued CWR No. 33-87114.0000 to the BLM for recreation and wildlife, including fish, with a priority date of June 1, 1981 for 10,840.0 acre-feet per year. The base flows requested by the BLM in the Third Amended SOC are less than the base flows included in CWR No. 33-87114.0000, in part due to the longer period of record used for the state-based water right.

4.3 BLM's PENDING APPLICATION NO. 33-96811

On July 21, 2005, the BLM filed Application No. 33-96811 for a permit to appropriate water for instream flows for fish, wildlife and recreation uses on Oak Grove Canyon, a tributary to Turkey Creek, in the amount of 92.91 acre-feet per year. Turkey Creek is a tributary to Aravaipa Creek. The application included a report entitled "Oak Grove Canyon Streamflow

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[1] As of August 2, 2012, certain streamflow data must be submitted at the same time that the instream flow application for a permit is filed. This is a departure from the process used under the 1991 Guide.

Justification for an Instream Flow Water Right," which provides average monthly streamflow data from November 2002 through July 2004 from a measuring point located within the requested reach.

The BLM amended this application three times. In November, 2005, the BLM reduced the amount requested to 93.7 acre-feet per year; in February, 2006, the BLM modified the legal description of the place of use; and in March, 2006, the BLM further reduced the amount requested to 93.4 acre-feet per year.

Two protests were filed to this application, one by the Salt River Valley Water Users' Association ("SRVWUA") on April 5, 2006, and the other by Phelps Dodge Corporation ("Phelps Dodge") on May 12, 2006. On July 18, 2011, Phelps Dodge withdrew its protest, and on August 18, 2011, SRVWUA withdrew its protest subject to certain conditions. The Department has not taken any further action on Application No. 33-96811.

4.4 TNC'S CERTIFICATES OF WATER RIGHT NOS. 33-95488, 33-95489, 33-95490, AND 33-95771

On October 31, 1990, TNC filed four applications for permits to appropriate water for instream flows for recreation and wildlife purposes, including fish, on four reaches of Aravaipa Creek. Two of the applications covered reaches upstream of the eastern boundary of the ACWA and the other two applications covered reaches downstream of the western boundary of the ACWA. Monthly flow data were collected from the same locations as those used for BLM's CWR No. 33-87114.0000, described above. TNC's requested quantities were based on a determination of median flows.

On May 29, 1996, the Department issued the following CWRs to TNC for recreation and wildlife, including fish:

1. CWR No. 33-95490.0000 in the amount of 11,213.0 AFY for a reach upstream of the eastern boundary of the ACWA.
2. CWR No. 33-94589.0000 in the amount of 13,567.5 AFY for a non-contiguous reach downstream of CWR No. 33-95490.0000 and immediately upstream of the eastern boundary of the ACWA.

3. CWR No. 33-95488.0000 in the amount of 12,634.9 AFY for a reach immediately downstream of the western boundary of the ACWA.
4. CWR No. 33-95771.0000 in the amount of 10,272.8 AFY for a non-contiguous reach downstream of CWR No. 33-95488.0000.

Each of these CWRs has a priority date of October 31, 1990, which is the date that the applications were filed.

CHAPTER 5: UPDATE OF WATERSHED FILE REPORT INFORMATION

CHAPTER 5: UPDATE OF WATERSHED FILE REPORT INFORMATION

This chapter provides a summary of watershed file report ("WFR") information related to water rights filings held or claimed by the United States within the boundaries of ACWA, that were investigated by the Department for the San Pedro HSR. The following sections describe the WFRs that are associated with the Third Amended SOC point source claims listed in Attachment C-1 and other state-based water rights filings held by the United States within ACWA.

5.1 WFRS ASSOCIATED WITH POINT WATER SOURCE CLAIMS

Using information from Table 3-4, **Table 5-1** lists the point sources and cross references them to the SOCs in which they are claimed, the state-based filings described in those SOCs, and the associated WFRs. Although these point sources were claimed by the BLM in the Third Amended SOC, they were also listed in other SOCs filed by either the BLM or its predecessor. These state-based filings are included not only in WFR 115-5-19, identified by the Special Master in his case initiation order for the ACWA contested case, but also in WFR 115-5-18 and WFR 115-5-20.

In addition to WFRs, **Table 5-1** cross-references the potential water right ("PWR") numbers assigned to each filing. The Department assigned these numbers based on the types of uses confirmed in the Department's investigation.

Each of the 27 point source claims included in Attachment C-1 was associated with WFR 115-5-19, which is associated with the Third Amended Claim. These point sources also were included in WFR 115-5-18 for SOCs claiming rights to Stone Cabin Spring (#8), Lower Stone Cabin Spring (#9), and Lupie Seep (#10); and in WFR 115-5-120 for Cave Pasture Tanks (#15). Of the 27 point sources, all but three, Hanging Spring (#4), Saltuna Spring (#5) and Purgatory Spring (#7), were found to be associated with state-based filings listed in other SOCs. Department records indicate that all of the filings for each point source have been assigned to the BLM, the current right holder of record. However, as discussed in **Section 3-4,** some of the volumes and location information in the state-based filings do not agree with the information in either the Third Amended Claim or other SOCs that were filed for the same point sources.

5.2 UNITED STATES' STATE-BASED WATER RIGHTS WITHIN ACWA NOT ASSOCIATED WITH WATER RIGHTS CLAIMS

Table 5-2 provides the results from cross-referencing ADWR's surface water rights database with the boundary for ACWA to identify state-based filings on record with the Department that are not included in water rights claims for ACWA. Table 5-2 lists 44 state-based water rights filings and cross references them to the WFRs and associated PWRs listed in the San Pedro HSR. None of these point sources are included in Attachment C-1 of the Third Amended Claim, but some of the WFRs are the same. One WFR may contain information about several water right filings based on federal reserved water rights and/or state-law based rights for a particular land-owner and/or geographic area.