Prepared for:
New Mexico Interstate
Stream Commission

Defining Gila Watershed Hydrologic, Aquatic, and Riparian Baseline Conditions

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Literature and Data Summary and Data Gaps

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1.0 Introduction

1.1 Objectives

This report is a summary and assessment of literature, acquired data, other information, and data gaps for the Gila Watershed in southwestern New Mexico. It is the third deliverable (Task 1c) of a larger effort with the overall objectives of producing key elements of an ecological baseline analysis and begins defining certain hydroecological[1] relationships for the Gila watershed. These tasks and products are intended to support 1) AWSA project evaluation, and 2) future environmental compliance needs for projects proposed under the Arizona Water Settlements Act of 2004 (AWSA, P.L. 108-451). There are three main tasks, described below that are intended to gather and format certain data pertaining to these objectives, and construct a predictive hydrologic model of the upper Gila River, including its main tributaries (West, Middle, and East Forks). While it is difficult to fully anticipate all the potential project evaluation and environmental compliance needs, it is our intent to provide a body of information on the physical, natural, and human environments such that project evaluation and compliance tasks in the future may be streamlined. In addition, as currently contracted, we focus our efforts on the Gila River Watershed, especially the river through the Cliff-Gila Valley, although several datasets and literature we have compiled and provided (e.g., water quality) contain data for the San Francisco River Watershed.

2.0 Assessment Approach

2.1 Background

This summary of literature is intended to provide a review of published documents pertaining to the natural resources and physical environment of the Gila River, with particular focus on the Cliff-Gila Valley. Key data gaps are identified, and an integrated analysis of how missing information may limit certain inferences and conclusions is provided. Task 1 under the current Tetra Tech contract (14061; Task Order GR-13-1) has included a comprehensive compilation of watershed-level data that describe the physical and human environments (Task 1a, Tetra Tech 2013a) and known biological data within the Gila Watershed (Task 1b; Tetra Tech 2013b). Task 1c (this report) provides a review of existing literature and studies, and identifies perceived data gaps.

2.2 Task 1 – Existing and Relevant Data and Literature

Under this task, the initial steps of this project included compiling, organizing, and reviewing the relevant existing data and literature to produce the background and baseline information for the remaining project tasks. Preceding this Tetra Tech project, NMISC had funded a project that resulted in compiling a catalog of 972 publications, reports, journal articles, and books of previously completed work within the Gila River Watershed and other parts of southwest having

[1] The term *ecohydrology* is used to describe a technical approach for characterizing and quantifying relationships between hydrologic (and hydraulic) conditions and ecological processes, organisms, and habitat conditions (e.g., Newman et al., 2006); a flow-ecology relationship. See also Section 2.1.5.

potential relevance to aid consideration and assessments of alternative actions under the AWSA.[2] That effort did not include a compilation of any data. As such, the early tasks for this project have included compiling relevant existing data on the physical, biological, and other geospatial conditions within the Gila River Watershed to allow an assessment of how such conditions have changed over time and may be affected in the future by potential AWSA projects. In support of this effort, relevant existing literature compiled by the earlier project and new literature identified by Tetra Tech staff has been and is continued to be reviewed to enhance the background and baseline information of value for ongoing AWSA considerations. The following briefly describes these project subtasks.

Task 1a – Watershed Data

Under this subtask Tetra Tech compiled, organized, formatted, and provided initial quality control reviews of existing and relevant watershed data that describe the natural resources and physical environment not included in Task 1b (below). The report of this effort, including electronic copies of the compiled data, was submitted to NMISC in January 2013. That report provided a detailed description of each dataset acquired, its contents, date ranges, data source and citation information, the QC process and its findings, and documentation of all necessary formatting.

Task 1b – Biological Data

The goals of Subtask 1b were similar to that above, in that they included acquiring, compiling, organizing, performing quality control checks, and format available data but this subtask focused on the aquatic biota and related environmental factors within the Gila drainage system. The objectives of the data QC process for this subtask extended beyond purely preparing the data for inclusion in the Task 2a geodatabase, it included critically evaluating the comparability and consistency among some datasets expected to be used in subsequent analyses, which may include qualitative, parametric, nonparametric, or multivariate statistics conducted during a later project. Additional considerations included the seasonality of data collection periods, sampling methods used to collect the data, units used to report/summarize the data, and habitat/species aggregation. The results of this task were summarized in draft report submitted, with electronic copies of the compiled data, to ISC in April 2013. That report detailed all data acquired with a description of the dataset and its contents, date ranges, data source and citation information, the QC process and its findings, and documentation of all necessary formatting. As with the physical data described in the previous section, some data sets could not be obtained, as described in that report

Task 1c Literature Summary and Data Gaps

This subtask is addressed in the following sections of this report. It includes a review of key literature and data compiled that focus on the natural resources and physical environment

[2] http://www.awsaplanning.com/Proposals_for_projects.html

relationship along the Gila River watershed system. The review focuses particularly on information pertaining to the Cliff-Gila Valley, with additional information included for both upstream and downstream reaches and areas outside the system, as appropriate. It includes references on the foundation and contemporary theory of stream, riparian, and montane ecology, particularly as it applies to the arid southwest. It provides information on the status of both federal and state listed threatened and endangered species of potential concern to AWSA development activities. Cultural resources are not considered.

Based on this literature and data review, key data gaps are identified in this report, and descriptions are provided on how missing information (spatial, temporal, functional, etc.) may limit certain inferences and conclusions. Geographic Information Systems (GIS) analyses and maps are used to evaluate the spatial distribution of known datasets, research and survey efforts, and sampling locations to help discern where data gaps may exist and how future efforts could augment these known gaps. Where appropriate, elements of Task 1a and 1b are again included within this report deliverable. All compiled literature is provided on the accompanying DVD, as possible, in portable document format (PDF).

2.3 Task 2 – Integrated Geodatabase and Retrospective Remote Sensing Analysis

This task has been omitted from this work order.

2.4 Task 3 – Hydrology for the Upper Gila Watershed

Task 3a – Develop Pre- and Post-Whitewater Baldy Complex Fire HEC-HMS Models for Ungaged Basins

Please note that Tasks 3a and 3b below are closely related. We therefore provide a step-wise addendum (following Task 3b description) that integrates the assumptions and goals of both subtasks.

The goals of Task 3a are to develop a reliable method to estimate hydrographs in the upper Gila basin where no stream gage data exists – a necessary aspect of an ecohydrological approach. An HEC-HMS model (USACE 2010a) is being developed for all hydrologic modeling. The pre-fire model would be used for calibration and the post-fire model is intended to predict near-term, altered hydrographs due to fire impacts. Specifically, it is hypothesized that watershed conditions should recover such that hydrology in the upper reaches and potentially the Cliff-Gila Valley should return to pre-fire patterns in approximately 3-5 years. Thus, the pre-fire HEC-HMS model becomes a more relevant baseline beyond this period. In the intervening years, however, post-fire effects are central to an altered hydrology and thus the ecological processes in the watershed. Much of the post-fire hydrology remains uncertain (with respect to future climate-change conditions) but experience and professional inference with previous fires (i.e. the Wallow and Los Conchas fires) suggest the 3-5 year recovery time is a reasonable supposition. Results of the HEC-HMS modeling will be integrated with known hydrology in gaged reaches (Task 3b; MEI 2006) for a holistic treatment of the basin and a spatially distributed future derivation of ecohydrology relationships.

Task 3b – Develop Hydrology for Ungaged Reaches and Integrate the Results with Existing Hydrology in and Downstream of the Cliff-Gila Valley

The goal of this task is to develop hydrology at discrete locations, where no gage data exists, that roughly correspond to past biological sampling. Spatial coincidence with past biological sampling accords the ability to better understand and characterize the ecohydrological relationships in the upper reaches of the Gila River and potential inputs to downstream reaches, including the Cliff-Gila Valley. Hydrology from the upper basins will be integrated with the known downstream hydrology (MEI 2006) as this provides a more comprehensive hydrological account of the basin. In this way, subsequent tasks can evaluate the implications of different water management scenarios and the potential effects they may pose to the aquatic system.

Addendum for Tasks 3a and 3b

The following describes the study plan and step-wise process for Subtasks 3a and 3b:

Purpose

a) Develop an appropriately discretized (sub-divided) HEC-HMS model to evaluate pre-fire, post-fire recovery, and post-fire (hydrologically recovered) hydrology in the ungaged portions of the upper basin;

b) To develop a mean annual hydrograph for all three (3) burn conditions at up to eight (8) locations that provides daily mean stream discharge values;

c) To utilize the modeled discharge values and biological sampling data (collected in Task 1) to begin to establish ecohydrological relationships. Refinement and specific analysis of such relationships will occur through pending work orders.

Process

a) *HEC-HMS model (Task 3a)* – develop a pre-fire model and calibrate it to the existing USGS gage at Gila, NM. This model will also represent the post-fire recovery model (i.e. the return of the system's hydrologic behavior to baseline conditions);

b) *HEC-HMS model (Task 3a)* – Alter the parameters of the calibrated, pre-fire HEC-HMS model to reflect changes from the Whitewater-Baldy Fire to produce a fire runoff hydrology;

c) *Hydrographs (Task 3b)* – Develop a calibrated pre-burn hydrology (daily mean annual hydrograph) based on USGS Gila gage data for dry, normal, and wet scenarios;

d) *Hydrographs (Task 3b)* – Develop a pre-burn hydrographs for eight (8) sites strategically located in proximity to historic biological sample sites using gage data and an aerial interpolated prorating method. Again, these hydrographs are also likely to represent post-fire recovery conditions and thus an appropriate baseline after the fire recovery period (3-5 years);

e) *Hydrographs (Task 3b)* – Compare storm event results of the HEC-HMS burn model to those of the USGS Gila gage (pre-burn) in order to develop an understanding of the impacts that the burn has on the hydrology;

f) *Hydrographs (Task 3b)* – Apply the results of the burn impact evaluation to increase the runoff volume of the pre-burn average annual hydrograph to develop a post-fire (pre-recovery) average annual hydrograph at the USGS Gila gage location;

g) *Hydrographs (Task 3b)* – Develop post-burn (pre-recovery) average annual hydrographs for each of the eight (8) ungaged sites, based on the post-burn average annual hydrograph (at Gila gage location) and an aerial interpolated prorating method. This is important to better define the potential effects the fire will have, during the recovery period, on the hydrology and thus the expected changes this represents to aquatic habitat and ecology during fire recovery.

Note: Significant changes in habitat and physical conditions could occur as a result of, for example, debris and ash flows. These conditions could last for months or years after the altered fire hydrology has returned to normal. These processes could not only affect habitat structure but also water chemistry, nutrient dynamics, primary productivity, etc. Only additional sampling, during and after the recovery process, can address these questions and may be further addressed in additional scope development in the future.

2.5 Future Tasks - Ecohydrology

The flow regime is one of the most important variables in stream and river ecosystems because it is a significant determinant of the physical, chemical, and biological characteristics of streams (Poff et al. 1997). In fact, the alteration of flow regimes is regarded by many to be the single greatest and persistent threat to ecological integrity (Poff et al. 2007, Bunn and Arthington 2002, Naiman et al. 2002, Ward et al. 1999, Lundqvist 1998, Poff et al. 1997, Sparks 1995, and Naiman et al. 1995). Alterations in hydrology, including stream flow variability, can alter these characteristics and impact stream ecosystem structure and function (Poff et al. 2006a, 2006b, 2007). As a result, there is an increasing consensus that ecologically sound flow regimes are needed to support stream and watershed health (Poff et al. 2010, Postel and Richter 2003), and that the 'natural flow regime', defined as the historic range of variability in the magnitude, timing, duration, frequency, and rate of change of flows (Poff et al. 1997, Carlisle et al. 2010a), should be the foundation for assessing flow alterations and determining ecological flow needs within a management context.

Understanding the relationships between flow conditions, including components and ranges of naturally occurring variability in flow, and biological communities is the realm of ecohydrology. Together with regional factors such as climate and the geomorphic landscape, the natural flow regime of a system defines the types of aquatic habitats (e.g., stream geomorphology, substrate types) and water quality conditions (e.g., temperature, dissolved oxygen regime, sediment delivery, etc.) within which biological communities develop. Aquatic organisms evolve life history strategies in response to the natural flow regime and these associated environmental conditions (Bunn and Arthington 2002). As a result, deviations from the natural range of flow conditions can elicit direct and indirect responses in a variety of biological and ecological processes such as growth, reproduction, and survival, as well as in structural manifestations of these processes such as distribution and abundance, through changes in tolerance levels, habitat preferences, seasonal dynamics, food resources, and other adaptations to prevailing habitat conditions (e.g., Poff et al. 1997, Bunn and Arthington 2002, Annear et al. 2004, Poff and Zimmerman 2010).

Preserving or restoring critical parts of the natural flow regime are now recognized as essential for maintaining biological integrity and desirable ecosystem functions and services (e.g., Postel and Richter 2003). To assess and manage a system with these goals, information is needed on how key organisms (populations) within any particular system depend on and respond to flow conditions, and which seasons or types of flow patterns are particularly important to critical life history functions for those key species. A decade ago, concepts about the types of flows needed to preserve ecological integrity, and more specifically the flow needs of various species to support critical life history functions were “largely a series of untested hypotheses” (Bunn and Arthington 2002). Much more investigation over the past decade has expanded the base of knowledge available to help direct management assessments (see for example Monk et al 2007, Dewson et al. 2007, Armanini et al. 2010, Carlisle et al. 2010b, McManamay et al. 2011, Kiernan et al. 2012, Cooper and Merritt 2012, Mims and Olden 2012 and 2013). Many states also have incorporated a process for determination of flows regarded as protective of designated uses into their permitting regulations (MacDonnell 2009), or have engaged in a process for investigating regionally relevant flow needs for environmental preservation (e.g., Apse et al. 2008, DePhillip and Moberg 2010, Kennen and Riskin 2010, Blann and Kendy 2012, Tetra Tech 2012) in balance with human use needs (Annear et al. 2004). Still, each stream/river system represents a unique set of climate and landscape factors that combine to characterize the river’s natural flow regime and its ecological components. It is therefore the advancements in developing an applicable framework for assessing flow regimes and ecological needs for those flows that is also valuable. One such framework, the Environmental Limits of Hydrologic Alteration (ELOHA) (Poff et al. 2010), is based on several keys assumptions: (1) every river is unique with its own natural flow regime; (2) classes that are hydrologically similar may represent similar ecological groups; and (3) classes are potential management units, with specific environmental flow rules. From this basis, empirical relationships that characterize biological responses to particular flow alterations within a particular river system or class can be developed, and form the basis for effective flow management (Arthington et al. 2006).

Baseline assessments provide critical inputs for the exploration and establishment of relationships between a river systems’ biota and various flow parameters. This information can then be used to identify the most responsive and sensitive species, determine biologically important seasons and the most influential flow parameters, and of course ultimately, support quantitative assessment of flow needs. The approach for such baseline assessments draw upon the Ecological Risk Assessment framework (U.S. EPA 1998), in that they specifically evaluate the responses and potential adverse ecological effects from exposure to one (or more) stressors.

The scope of a baseline assessment that would be needed in a particular situation would depend, in part, on the range and types of existing environmental, biological, and flow data already available, as well as the conditions of the stream reach or river system of interest, including the existence and types of others stressors, existing water uses, etc. In general, the scope of a baseline assessment can be informed by the component processes of the ELOHA framework (Poff et al. 2010), which include: (1) building a hydrologic foundation which consists of gathering flow data and modeling to build or develop baseline hydrographs; (2) classification of natural flow regimes; (3) determination of flow alteration; (4) development of causal relations between alterations in flow regime and the responses of aquatic communities and; (5) involving stakeholders to determine societal values, management needs and acceptable ecological conditions (Figure 1.1).

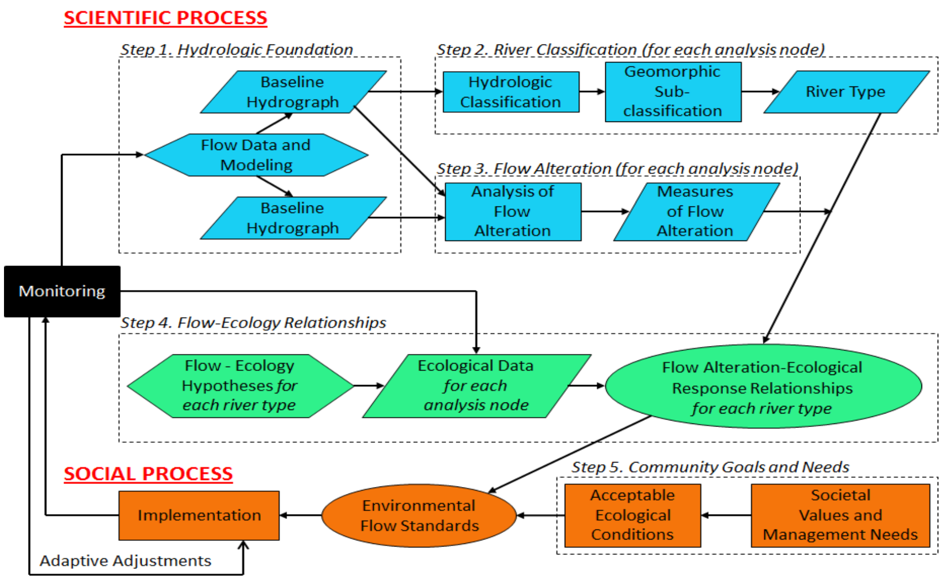

Figure 1.1 The ELOHA Framework modified from Poff et al. (2010).

The first four (4) elements of the ELOHA framework highlight the major categories of information that would be needed to assess responses to and potential impacts from projects or actions that would alter the flow regime in the Gila River. These include: 1) flow data and model outputs that will support the development of baseline hydrographs and characterization of hydrologic alterations; and 2) biological data for key aquatic communities (e.g., benthic macroinvertebrates, fish), collected from appropriate locations and within relevant times frames, that could be combined with hydrologic results to develop exposure/response relations between a range of different parameters of flow alterations and key biological responses. One of the primary goals of this report is to describe the range (including spatial and temporal distributions) of existing data that would be applicable to this kind of flow-related risk assessment, and from this compilation highlight data gaps that might limit ability to conduct such a risk-based assessment of flow alteration effects. This information can be used to recommend a scope of supplemental baseline assessment, with the goal of implementing a risk assessment characterizing types of altered flows, a range of flow-ecology responses, and associated assessment of the likely ecological implications of various anticipated flow changes in the Gila system. Overall, an ecohydrologic baseline assessment can be anticipated to include the following components:

- Establish additional study sites for co-located hydraulic modeling and biological sampling. Specific needs for timing (season) of collections, and locations of sampling sites will be informed by the gaps analysis of this report. Co-location of biological and hydraulic sites is essential to support development interpretation of biological responses to flow alterations. This is in contrast to much of the existing data, for which locations of hydrologic data and biological samples are disparate, and require substantial interpolation and extrapolation to compare responses.

- Develop a watershed problem formulation on which to base objectives for assessment of AWSA project alternatives, and to identify key ecological resources at risk and associated relevant information.

- Document and synthesize life history and habitat preferences for key biotic resources relative to hydrology and other abiotic characteristics within reaches potentially affected by the AWSA water development alternatives.

- Document and synthesize baseline physical, chemical, and other abiotic conditions, including variability, along reaches potentially affected by AWSA project alternatives.

- Characterize how AWSA water development alternatives for the Gila/Cliff Valley can affect or mitigate flow-related impacts, or enhance sustainable water uses and ecological resources.

- Report potential risks, effects, and uncertainties involved with various AWSA project alternatives.

The tasks that the NMISC funded and that we are summarizing in this report included our efforts to define and then obtain existing data that would be needed for future evaluations the NMISC may seek to conduct of potential effects (impacts and benefits) of AWSA projects that would use or manage flows in the Gila River. These include both determinations of ecological conditions and biological relationships with flow. The actual pursuit of such an ecohydrologic, risk-oriented assessment has not yet been funded, although the current tasks are intended to support such an assessment. One of the primary goals of this report is to describe the extent (including spatial and temporal distributions) of such existing data and to identify data gaps. From this compilation, we highlight perceived data gaps that might limit the ability to conduct such a risk-based assessment of flow-alteration effects. We have used this information to recommend a scope of supplemental baseline assessment, with the goal of implementing a risk assessment characterizing types of altered flows, a range of flow-ecology responses, and associated assessment of the likely ecological implications of various anticipated flow changes in the Gila system. In the sections that follow, we summarize the data we have compiled to date and the perceived data gaps. Please note that there are additional categories included in Tasks 1a and 1b not included in the following sections of the Task 1c report, such as United States census data and flood control infrastructure; it was our judgment that these are less relevant to the goals of this project and future assessments.

3.0 Information Review, Summary, and Data Gaps Assessment

3.1 Literature Compilation

Organization of the earlier information catalog sponsored by NMISC to aid consideration of alternative actions under the AWSA included information on demographics, economics, ecology, hydrology, geohydrology, geology, terrestrial vegetation, threatened and endangered species, various animal groups, water quality, wetlands, and riparian, among many others. Tetra Tech has reviewed much of this catalog to identify and review information of particular relevance to the needs of this project's and NMISC's goals of aiding the assessment of potential AWSA projects. In doing so, Tetra Tech deemed it appropriate to re-categorize a selection of information in the earlier catalog, where appropriate, to allow a consolidation of some reference categories and subdividing others to better address the ecological and hydrological objectives of the Tetra Tech project, and to better incorporate the existing information as well as new information compiled by Tetra Tech. This task was completed by developing a new literature database using Microsoft Access. To aid information input and retrieval, this database includes input and report forms with the data table. Information category fields used in the earlier compilation have been retained and an additional information category field was added to the database for the new classification categories. For new information and references added by Tetra Tech, not all fields from the older information compilation have been populated in the Access database (similarly, not all fields in the earlier compilation contained information). This Tetra Tech literature database currently includes the following categories:

- Birds
- Demographics
- Ecology
- Economics
- Endangered_Threatened_Spp
- Endangered_Threatened_Spp/AZ
- Endangered_Threatened_Spp/Birds
- Endangered_Threatened_Spp/Fish
- Endangered_Threatened_Spp/Mammals
- Endangered_Threatened_Spp/NM
- Endangered_Threatened_Spp/Plants
- Endangered_Threatened_Spp/Reptiles_Amphibians
- Fisheries

- Fisheries/AZ
- Geology
- Geomorphology
- Hydrogeology
- Hydrology
- Invertebrates
- Land Management
- Mammals
- Reptiles_ Amphibians
- Riparian_Wetlands
- Terrestrial_Vegetation
- Water Quality

All literature that has been compiled by Tetra Tech, which also includes the "Southwest NM catalog pages in PDF format" available from the AWSA "Information Compilation" internet site[3], are included on the DVD attached to the back cover of this report. The Access database cataloging this literature is also included on that DVD.

3.2 Data Compilation

All data described in Section 2.2, and in the following sections, have been provided with previous reports under Tasks 1a (watershed-level data) and 1b (known biological data). Again, our data compilation has been intended to gather, organize, and format the data for inclusion in a geodatabase (Task 2a), where possible and appropriate, and for future ecohydrology analyses. The data we have compiled can be used for ecohydrology investigation utilizing existing data only, to help to establish new study sites where additional biological sampling is needed and could occur, , and for project evaluation and environmental compliance purposes. Our goal under this subtask has been to gain an understanding of the spatial, temporal, and functional distribution and domains of these various datasets and assess any perceived data gaps that may exist, as presented in the following sections.

[3] http://www.awsaplanning.com/Information_compilation.html

3.3 Physical Environment

3.3.1 U.S. Geological Survey Stream Gage Data

3.3.1.1 Summary

There are 20 U.S. Geological Survey (USGS) stream gages in the Gila-San Francisco Watershed with varying periods of records and discharge intervals (USGS NWIS and IDA4). Various water quality data are also available for five of the gaging stations. Data downloaded, included where available, daily mean values, peak values, and water quality data. Continuous data (15-min. interval) are available for some stations if required in the future. Where the period of record indicates through the *present*, this date is as of January 6, 2013 (Tetra Tech 2013a). As additional data becomes available, and deemed useful for model calibration or other future analyses, it will be obtained and appended to the appropriate dataset. Geographic information systems (GIS) were used to create geospatial data of gage locations.

3.3.1.2 Data Gaps Assessment

Of the 20 regional gages located in New Mexico, four (4) are mainstem gages of the Gila River (Fig. 3.1):

- Gila River near Gila, NM (USGS 09430500)
- Gila River near Cliff, NM (USGS 09431000)
- Gila River near Redrock, NM (USGS 09431500)
- Gila River Below Blue Creek, near Virden, NM (USGS 09432000)

Fifteen (15) additional gaging sites are either canals, ditches, or minor tributaries to the mainstem Gila River. One site (Gila River near Virden, NM; USGS 323922108571901) was a water quality sampling site in 1993. The mainstem Gila gages constitute a fairly well spatially distributed series of gages in the lower reaches beginning at the upstream end of the Cliff-Gila Valley. While these gages are well suited to monitor flows into and through the lower Gila, the upper Gila and its major tributaries (West, Middle, and East Forks) remain ungaged. For our purposes in pending tasks (see section 2.5), this represents a spatial data gap for developing flow-ecology relationships (or ecohydrology) of the upper watershed, in that there is a missing part of the overall equation – the estimation of a hydrograph. As such, any comparative ecohydrology analyses between the lower and upper reaches are not possible using only existing biological data. This is likely to be of some importance when one considers that, after drying events occur in the lower reaches, the upper reaches can serve as significant source populations for aquatic faunal and floral recolonization. In addition, if future water development projects under the CUFA were conceived to divert from the upper reaches, where flow-ecology relationships are poorly (or not at all) understood, it would be difficult to fully assess the implications of such a project. Lastly, a significant proportion of the existing biological data

[4] USGS NWIS is the National Water Information Service and IDA is the Instantaneous Data Archive.

resides in the upper reaches and we are therefore building a hydrologic model (see Task 3 in Section 2.4) to supplement existing stream gage data and eventually a more reasonable estimate of the flow-ecology relationships in upper reaches.

3.3.2 Meteorological Data – Precipitation, Snow Depth, Snow Water Equivalent, and Air Temperature

3.3.2.1 Summary

Meteorological data was obtained using HydroDesktop 1.5.12 (Ames et al. 2012; http://hydrodesktop.codeplex.com/). HydroDesktop is an open source, GIS enabled application capable of multi-parameter search, visualization, analysis, and download utilities for a wide variety of data related to meteorology, water quality, and water resources in general. HydroDesktop allows the user to define a search area and enter keywords for search criteria. It then queries source-data servers, retrieves the results, and presents them in a standard format. To date, we have obtained snow depth, snow water equivalent, precipitation, and air temperature data from as far back as January 1980 (Tetra Tech 2013a).

3.3.2.2 Data Gaps Assessment

Snow depth stations are fairly well distributed within the Gila Watershed; however, these stations have data that are essentially random measurements with significant gaps in measurement intervals. It has been, therefore, difficult to track the accumulation amounts (and therefore melt rates) from a given storm or series of storms over the watershed useful for the construction of the HEC-HMS model (USACE 2010; Task 3 in Section 2.4).

Snow water equivalent stations are fewer in number (5 versus 9 for snow depth) and less well distributed throughout the watershed. These data, however, are routinely measured throughout a given station's period of record. Given the interval gaps of snow depth data and fewer snow water equivalent stations, this has proven to be a substantial data gap in hydrologic model calibration. To solve this problem, we are testing several approaches whereby snow is being converted to precipitation and initial abstractions are then being applied at a daily time step rather than a curve function (since snow accumulation and melt rate dynamics are not well represented throughout the basin). Both precipitation and temperature data are fairly well represented in the Gila Watershed.

3.3.3 Surficial Geology and Soils

3.3.3.1 Summary

A number of datasets were obtained from the USGS, the New Mexico Energy, Minerals & Natural Resources Department, U.S. Department of Interior Office of Surface Mining, Reclamation & Enforcement, and the New Mexico Mining and Minerals Division. These include active mines, coal mine permit boundaries, volcanic vents, faults, and geologic formations.

Two soils datasets have been obtained (1994 STATSGO and 2004 SSURGO). These datasets are primarily being used in the hydrologic model creation, as knowledge of soil characteristics is important for rainfall-runoff and infiltration processes. Both datasets were obtained from the Natural Resource Conservation Service (NRCS) Soils Data Mart at http://soildatamart.nrcs.usda.gov/Default.aspx and provided as part of Task 1a (Tetra Tech 2013a).

3.3.3.2 Data Gaps Analysis

The 1994 STATSGO soils data is a fairly course dataset that is primarily designed for resource planning, management, and monitoring at regional, multicounty, river basin, and state scales. This soil survey product is not designed for use as a primary regulatory tool in permitting or siting decisions, but may be used as a reference source. Analysis of the overlayed data should be on a map-polygon basis. Unfortunately, large portions of the more resolved 2004 SSURGO data of the Gila drainage (Grant and Catron Counties) remain unmapped.

3.3.4 Whitewater-Baldy Complex Fire

3.3.4.1 Summary

The USDA Forest Service, Gila National Forest has produced several mapping products of the 2012 Whitewater-Baldy Complex Fire. Dated December 5, 2012, these data included the fire perimeter, burn severity mapping, and aerial treatment completed (further described in Tetra Tech 2013a).

3.3.4.2 Data Gaps Assessment

There few apparent data gaps here. The primary gaps we perceive are the areas of "Unknown" burn severity. Of these areas, the most relevant and important is the area to the east of Mogollon Creek, at the southernmost extent of the fire (≈4,300 acres [1,740 ha]). The burn severity mapping may have been updated to include these areas since we obtained these data (December 2012). It may be necessary to obtain an updated version of the burn severity mapping in the future.

3.3.5 Hydrographic Surveys

3.3.5.1 Summary

In May of 2010, cross-section surveys were completed as part of a Gila River HEC-RAS (USACE 2010b) hydraulic model constructed by Tetra Tech, Ft. Collins office for the NMISC to support an on-going groundwater study. There were a total of 567 points (X, Y, Z) on 28 cross-sections surveyed that span areas within the Cliff-Gila Valley from just above Mogollon Creek to approximately 4.4 miles downstream of the Mangas Creek confluence with the Gila River. A survey grade GPS unit was used for data collection (Tetra Tech 2013a).

3.3.5.2 Data Gaps Assessment

There are no other recent cross-section survey data along the Gila River. If additional study sites are considered for future hydraulic modeling and biological sampling (Section 2.5), additional cross-section/topographic surveys at these sites must be completed.

3.3.6 Elevation Data

3.3.6.1 Summary

The elevation datasets we have obtained are described as follows:

1. *USGS National Elevation Dataset (NED)* – Two NED data products have been acquired: the 1 arc-second (about 30-meter resolution) and the 1/3 arc-second (about 10-meter resolution). The NED is a seamless dataset with the best raster (or gridded) elevation data for the coterminous United States. The 1 arc-second is included in the National Hydrography Dataset Plus Version 2 (NHDPlusV2; McKay et al. 2012, described later) and the 1/3 arc-second for New Mexico has been downloaded by USGS quads and provided on disk.
2. *2010 LiDAR data* – LiDAR elevation data was collected for use in a hydraulic model constructed by Tetra Tech. The model and LiDAR data includes the Cliff-Gila Valley from just above Mogollon Creek to approximately 4.4 miles downstream of the Mangas Creek confluence with the Gila River. There was also orthophotography collected during the LiDAR data collection (Tetra Tech 2013a). These data were used to support a HEC-RAS model built by Tetra Tech in 2010.

3.3.6.2 Data Gaps Assessment

Both NED datasets provide a full coverage of the watershed but at less resolution than the LiDAR data. These data are useful for many types of analyses and environmental compliance purposes but are typically not adequate for hydraulic modeling needs. As with the cross-section data, there is no known additional LiDAR data beyond that described above. Similarly, if additional, co-located hydraulic modeling and biological sampling sites are considered in future tasks, it is possible that additional LiDAR could be extremely helpful. Thus, the lack of additional LiDAR is not necessarily considered a data gap; however, if no LiDAR data were collected at future modeling sites, simple cross-section surveys would need to be supplemented with additional data points in the floodplain to produce a topographic map of the site. Nonetheless, a topographic survey is likely much less costly than LiDAR data collection given the canyonized nature (thus requiring a helicopter data collection platform) of some potential study sites.

3.3.7 Hydrology, Hydraulics, Geomorphology, and Sediment Transport

3.3.7.1 Summary

At this time, the key information on hydrology, hydraulics, geomorphology, and sediment transport come from a report prepared for the NMISC by Mussetter Engineering, Inc. (MEI 2006). The goal of this report was to provide a sound basis for determining the potential geomorphic effects to the Gila River due to an additional annual diversion of up to 14,000 acre-feet of water resulting from the implementation of the CUFA. MEI (2006) provides an in-depth review and analysis of several factors that influence the geomorphic character of the Gila River (further described in Tetra Tech 2013a).

Although this study is a rigorous and comprehensive analysis, it was not intended to provide detailed ecohydrology relationships. As part of our on-going project, Tetra Tech is currently building on the MEI (2006) results in creating a new hydrologic model whereby hydrographs can be generated in ungaged reaches of the upper Gila Watershed. Data utilized in MEI (2006) have already been obtained (USGS stream gages) and are supplemented with data during the period between 2006 and the present.

The 2010 HEC-RAS hydraulic model produced by Tetra Tech extends from just above Mogollon Creek to approximately 4.4 miles downstream of the Mangas Creek confluence with the Gila River. The model and geospatial output from the model have been compiled and created. The geospatial representations were processed with the RASMapper utility and the original LiDAR surface used for the model itself for all flow profiles (75, 250, 500, 750, 1,000, and 3,000 cfs). The output products for each flow profile were provided and further explained with Task 1a (Tetra Tech 2013a).

3.3.7.2 Data Gaps Assessment

The full extent of the 2010 HEC-RAS model is generally limited to the Cliff-Gila Valley. The model output should still be valid if and until any substantial river planform changes occur due to large magnitude discharge events or fire-related debris flows (pers. comm. M. Harvey). We would therefore have a solid basis for establishing flow-ecology relationships within the confines of the HEC-RAS model boundary. Again, if additional study sites (co-located hydraulic modeling and biological sampling) were considered in the future, other models, including the topographic surveys discussed previously, would need to be constructed. If significant planform changes do occur, this model and any flow-ecology relationships derived from it, are still quite useful for baseline (e.g., pre-fire) conditions.

3.3.8 National Hydrography Dataset Plus Version 2

3.3.8.1 Summary

The National Hydrography Dataset Plus Version 2 (NHDPlusV2) is the most recent release of a widely used suite of geospatial data that describe the hydrologic settings and various parameters for the United States. Developing NHDPlusV2, and its predecessors, has been a collaborative effort between the USGS and U.S. Environmental Protection Agency (USEPA). Additional information, tools, exercises, training opportunities, news, and the latest NHDPlus data can be found at http://www.epa.gov/waters.

3.3.8.2 Data Gaps Assessment

The NHDPlusV2 has been downloaded for the Lower Colorado, subsections 15a and b, and for the Rio Grande, subsection 13a. Collectively, these subsections cover the Gila-San Francisco Watershed and beyond, and have been provided in their unaltered entirety (Task 1a; Tetra Tech 2013a). Also provided was the National Watershed Boundary (WBD) dataset. Together, these data are useful for general mapping and map production, watershed and sub-watershed delineations, elevation (and derivatives such as slope and aspect), and other hydrologic information contained in the extensions. Supporting documentation also provided included:

- NHDPlusV2 User Guide
- NHDPlusV2 metadata (.xml format)
- NED Data dictionary
- NED metadata (ESRI shapefile format)
- WBD metadata (.xml format)
- USGS Scientific Investigations Report 2009–5233 (Johnston et al. 2009).

In terms of data gaps, the NHDPlusV2 is complete and, again, covers the entirety of the Gila (and San Francisco) watershed.

3.3.9 Orthophotography

3.3.9.1 Summary

Orthophotography (ortho rectified aerial photography) have been assembled for use throughout this project. It is our intent to gather as much historical and contemporary datasets as possible for purposes such as general mapping, display, photo interpretation, and remote sensing analyses. Locating, obtaining, post-processing, and analyses of these data is a considerable task. To date, we have acquired orthophotography from the National Agriculture Imagery Program (NAIP; USDA APFO) for 2009 and 2011 for the region and a statewide orthophotography dataset for 2005-2006 (NMOSE). We have also downloaded historical orthophotography from the New Mexico Resource Geographic Information System (RGIS) at the University of New Mexico (http://rgis.unm.edu/) for 1996. The native format of these historical RGIS datasets are by digital ortho quarter quadrangle (DOQQ).

3.3.9.2 Data Gaps Assessment

Data gaps in the coverage of the older orthophotography are somewhat discontinuous. For the 1996 data, there are some missing DOQQs. While some are not located along the Gila River or its tributaries, and therefore are not of particular importance, some are located along these watercourses. This constitutes a data gap in that historical planform changes cannot be characterized within these missing areas. This, however, should not prove to be a serious problem as the relative area covered by a given DOQQ is, by comparison to the overall river system, relatively small. While there may be additional/earlier ortho rectified imagery available from other sources, 1996 appears to be earliest available from RGIS.

3.4 Human Environment

3.4.1 Irrigation Infrastructure and Water Use

3.4.1.1 Summary

Irrigation Infrastructure – The only irrigation infrastructure data we have been able to obtain came from Mr. Paul Harms of the NMISC (P. Harms (a) pers. comm.). Mr. Harms has kindly provided geospatial data for 2010 on croplands throughout the Gila-San Francisco Watershed; however, there are no features that depict the irrigation infrastructure that supply the cropland polygons. Fortunately, each parcel of cropland has an attribute that names the specific ditch that feeds it and whether it was irrigated during the 2010 water year. With this information, and an overlay with contemporary orthophotography, we should be able to digitize most or all the irrigation infrastructure. In combination, these two datasets (cropland and infrastructure) will provide a reasonably comprehensive geospatial account of the irrigation infrastructure in the Gila Watershed. As of May 10, 2013, geospatial data for 2011 was not prepared for release (P. Harms (b) pers. comm.) but may be available in the future.

Water Use – Mr. Harms also provided data on consumptive use for the Gila and San Francisco Basins for water years 2010 (NMISC 2012) and 2011 (NMISC 2013). These data and reports were compiled pursuant to Article VII of the Consolidated Decree entered by the United States Supreme Court in Arizona v. California, 547 U.S. 150 (2006) and provide annual records of irrigated acreage and surface and groundwater consumptive uses (irrigation, stock, domestic, municipal and industrial purposes, and reservoir and stock tank evaporation).

In addition, we also obtained a two documents (report and maps) produced for the NMISC by AMEC Earth and Environmental, Inc. (AMEC 2010). AMEC (2010) is a synthesis entitled Regional Water Demand Study for Southwest New Mexico Catron, Grant, and Luna Counties and provides a detailed analysis of historic use and future predictions of water demand through the year 2050 in terms of scaled population growth metrics and the additional water provided under the AWSA.

Lastly, we obtained two Bureau of Reclamations documents (USBR 1987 and 2010). USBR (1987) states a purpose of providing a summary of the most recent planning information available on the water supply alternatives, their costs, environmental impacts and effects, and related financial aspects for the Upper Gila Water Supply Study authorized by the Colorado River Watershed Project Act (CAP; P.L. 90-537); a precursor to the AWSA (Utton Center 2012). The second document (USBR 2010) is a brief summary of water supply studies conducted by Daniel B. Stephens & Associates, Inc., Intera Incorporated, Water Resources Research Institute, S.S. Papadopulos & Associates, Inc., and Balleau Groundwater, Inc. This summary, and the studies it examines, investigates the geohydrologic conditions and groundwater supply trends and issues for select areas within the AWSA planning area. In short, there is information on both surface water and groundwater and therefore applicable to both.

3.4.1.2 Data Gaps Assessment

There appears to be fairly robust account of water use in recent times within the Gila and San Francisco Watersheds – at least in terms of the categorical consumptive uses detailed in the NMISC reports (NMISC 2012 and NMISC 2013). The principal gap is the lack of explicit mapping of irrigation infrastructure.

3.4.2 Permitted Wells and Points of Diversion

3.4.2.1 Summary

The New Mexico Office of the State Engineer's (NMOSE), Water Rights Reporting System (WRRS; http://nmwrrs.ose.state.nm.us/nmwrrs/index.html) was accessed on Jan 2, 2013 to determine all permitted wells and points of diversion (POD) locations. The database query produced 5,546 locations for the Gila and San Francisco Watersheds (see Tetra Tech 2013 for further explanations).

We again accessed the WRRS to update these records on May 14, 2013, which produced 5,905 records and on Oct 11, 2013. The latter query produced a total 6,583 records for the Gila-San Francisco Watershed. This is 1037 additional well/POD locations.

3.4.2.2 Data Gaps Assessment

These data obviously change through time – some permits close and new permits are issued. We also note a single well record apparently incorrectly coded as located in the Gila-San Francisco Watershed or a data entry error in the PLSS location (WR File No. GSF 02860 1). This dataset is complete but should be updated periodically if needed.

3.4.3 Gila National Forest

3.4.3.1 Review and Summary

A variety of geospatial data was obtained from the USDA Forest Service (USFS) Geospatial Clearinghouse for the Gila National Forest located at:
http://www.fs.usda.gov/detail/r3/landmanagement/gis/?cid=stelprdb5203027
Although the Gila National Forest data contains a variety of physical, man-made, ecological, etc. features, we evaluate these data as separate entity for organizational purposes. A detailed description of all Gila National Forest data can be found in Tetra Tech 2013a.

3.4.3.2 Data Gaps Assessment

In terms of the Gila National Forest, these data are complete. Should these data be used in future analyses (either as part of our efforts or environmental compliance purposes) updated information should be obtained if it exists.

3.5 Natural Environment

3.5.1 Vegetation Communities

3.5.1.1 Review and Summary

Only limited data on vegetation communities along the Gila River appears to exist, as indicated in our Task 1b report (Tetra Tech 2013b). Identified data include those from the Kansas Biological Survey providing limited wetland and riparian vegetation location information (but no species information) from 2006 surveys and a brief 2010 publication on wetlands along the Gila River. Kindscher et al.'s (2010) report includes information from the 2007 surveys summarized by average percent cover over a number of sites (divided into upstream and downstream reaches) but no spatial account on a site-by-site basis.

We also have compiled course-resolution geospatial vegetation data for the State of New Mexico from the New Mexico Resource Geographic Information System Program (RGIS; http://rgis.unm.edu/), including information on general vegetation associations (montane grassland, coniferous woodland, juniper savannah, etc.), hence, are of limited use to aid in potential AWSA project evaluations or to determining ecohydrological relationships for the Gila River.

In addition, we have compiled information from the Gila National Forest including canopy cover, dominance types, and vegetation size map units. These data characterize the existing floristic composition and vegetation structure occurring at given locations and times for forests and grasslands of the Gila National Forest at the time the source satellite images were acquired (Tetra Tech 2013a). Canopy cover defines percentages of grass/forbs, shrubs, and trees from 0-60+ percent. Dominance type defines vegetation communities within each map unit and vegetation size describes tree diameter, where applicable. The purpose of these data is to depict and label the location boundaries of vegetation classes. This dataset can be used to provide vegetation information for landscape-level forest planning and analysis for watershed areas within the Gila National Forest.

3.5.1.2 Data Gaps Assessment

Very limited vegetation information, having low resolution, appears to exist for the Gila River watershed. The mapping process used by the Forest Service for their lands in the Gila National Forest conformed to their established national guidelines. There are additional datasets for vegetation, ecological characteristics from the Forest Service but these would require additional research on the methods, and relational database tables available for the coded values in the shapefile attribute tables. Additional data sources of data, which have not been fully assessed because such efforts would extend beyond the ecohydrological objectives for this project, include Natural Heritage New Mexico, New Mexico Rare Plant Technical Council, USDA NRCS Plants Database (http://plants.usda.gov/java/), agency reports/publications, and the primary literature.

3.5.2 Noxious Weeds and Invasive Plants

3.5.2.1 Review and Summary

Data for 32 species of noxious weeds and invasive plants for New Mexico have been compied from the USDA NRCS Plants Database (http://plants.usda.gov/java/). Unfortunately, this listing cannot be limited by county or watershed distributions. The 32 species were listed in our Task 1b report (Tetra Tech 2013b).

3.5.2.2 Data Gaps Assessment

The NRCS database provides state-level lists only. Additional data compilation efforts on the distribution and abundance of these species, including contacting local Soil and Water Conservation Districts for the potential availability of location-specific inventories, would be required to determine the known extent to which noxious weeds and invasive plants occur in the Gila Watershed and what may be required for environmental compliance needs, as many of these species thrive on the disturbances that a potential water development project can produce (e.g., perennial pepperweed). In addition, a greater understanding of the distribution and abundance of species such as saltcedar would be important for riparian analyses and water budgets. Such sources of data have not been fully assessed because such efforts would extend beyond the ecohydrological objectives for this project.

3.5.3 National Wetlands Inventory

3.5.3.1 Review and Summary

The 2012 USFWS National Wetlands Inventory (NWI) was downloaded from the NWI website (http://www.fws.gov/wetlands/) and mosaicked into two seamless datasets (wetlands and riparian areas) for the southwest New Mexico region (New Mexico State Plane West, NAD83;Tetra Tech 2013b). The USFWS characterizes the NWI dataset, in part, as "…geospatially referenced information on the status, extent, characteristics and functions of wetlands, riparian, deepwater and related aquatic habitats in priority areas to promote the understanding and conservation of these resources. … This data set represents the extent, approximate location and type of wetlands and deepwater habitats in the conterminous United States…."

3.5.3.2 Data Gaps Assessment

We understand that additional wetland rapid assessments are currently underway in the Gila Watershed by the NMED and Natural Heritage New Mexico (E. Muldavin, 2012 pers. comm.). These data, once completed, could supplement the NWI information. However, since these data do not directly relate to the establishment of ecohydrological relationships, our processing and consideration of these data has not continued.

3.5.4 Threatened and Endangered Species

3.5.4.1 Review

Tetra Tech's Task 1b report (Tetra Tech 2013b) noted that the USFWS sent NMISC the species listed under the Endangered Species Act that may be affected by implementation of the AWSA Based on this list and other USFWS and NMDGF online compilations, Table 2.1 in the Task 1b report presented the federal and state listed threatened and endangered species within the New Mexico counties overlapping the Gila Watershed (Grant, Hidalgo, Catron, and Sierra). The Task 1b report emphasized that although a species is cited by the USFWS or the NMDGF, as occurring in these counties, it does not mean that each species necessarily occurs within the Gila Watershed or the area of potential AWSA developments.

Table 3.1 presents the information from Table 2.1 of the Task 2b report, plus it includes an additional column that indicates whether the species, from the county lists used to develop the

Table 3.1 Species having Federal and/or New Mexico status as Endangered, Threatened, or Candidate, those with designated Critical Habitat in counties overlapping the Gila River Watershed, and likelihood of being a potential regulatory concern for developing AWSA projects.

		Federal Listed				NM Listed		
Common Name	**Scientific Name**	**Endangered**	**Threatened**	**Candidate**	**Critical Habitat in AWRA Project Area**	**Endangered**	**Threatened**	**A Potential Regulatory Concern for Potential ASWA Projects**
	Fish							
Chihuahua chub	*Gila nigrescens*	X			No	X		No
Gila chub	*Gila intermedia*	X			Yes	X		Yes
Gila topminnow	*Poeciliopsis occidentalis occidentalis*	X			No		X	Yes
Loach minnow	*Tiaroga cobitis*	X			Yes	X		Yes
Spikedace	*Meda fulgida*	X			Yes	X		Yes
Gila trout	*Oncorhynchus gilae*		X		No		X	Yes
Headwater chub	*Gila nigra*			X	No	X		Yes
Roundtail chub	*Gila robusta*			X	No	X		Yes
White sands pupfish	*Cyprinodon tularosa*				No		X	No
	Amphibians							
Chiricahua leopard frog	*Lithobates chiricahuensis*		X		Yes			Yes
Lowland leopard frog	*Lithobates yavapaiensis*				No	X		Yes
Sonoran desert toad	*Ollotis alvaria*				No		X	No
	Reptiles							
New Mexico ridgenose rattlesnake	*Crotalus willardi obscurus*		X		No	X		No
Brown (Mexican) gartersnake	*Thamnophis eques megalop*			X	No	X		Yes
Reticulate gila monster	*Heloderma suspectum suspectum*				No	X		No
Gray-checkered whiptail	*Aspidoscelis dixoni*				No	X		No
Slevin's bunchgrass lizard	*Sceloporus slevini*				No		X	No
Mottled rock rattlesnake	*Crotalus lepidus lepidus*				No		X	No
Mountain skink	*Plestiodon callicephalus*				No		X	No
Narrowhead garter snake	*Thamnophis rufipunctatus rufipunctatus*				No		X	Yes
Green rat snake	*Senticolis triaspis intermedia*				No		X	No
Canyon spotted whiptail	*Aspidoscelis burti stictogrammus*				No		X	No
	Birds							
Southwestern willow flycatcher	*Empidonax traillii extimus*	X			Yes	X		Yes
Least tern	*Sternula antillarum athalassos*	X			No			No
Aplomado falcon	*Falco femoralis septentrionalis*	X			No	X		No
Whooping crane	*Grus americana*	X			No			No
Mexican spotted owl	*Strix occidentalis lucida*		X		Yes			Yes
Yellow-billed cuckoo	*Coccyzus americanus occidentalis*			X	No			Yes
Northern beardless tyrannulet	*Camptostoma imberbe ridgwayi*				No			No
Common ground-dove	*Columbina passerina pallescens*				No	X		Yes
Thick-billed kingbird	*Tyrannus crassirostris*				No	X		No
Buff-collared nightjar	*Caprimulgus ridgwayi ridgway*				No	X		No
Brown pelican	*Pelecanus occidentalis carolinensis*				No	X		No
Arizona grasshopper sparrow	*Ammodramus savannarum ammolegus*				No	X		No
Elegant trogon	*Trogon elegans canescens*				No	X		No
Common black hawk	*Buteogallus anthracinus anthracinus*				No		X	Yes
Varied bunting	*Passerina versicolor versicolor*				No		X	No
Neotropic cormorant	*Phalacrocorax brasilianus*				No		X	No
Bald eagle	*Haliaeetus leucocephalus alascanus*				No		X	Yes
Peregrine falcon	*Falco peregrinus anatum*				No		X	Yes
Arctic peregrine falcon	*Falco peregrinus tundrius*				No		X	No
Broad-billed hummingbird	*Cynanthus latirostris magicus*				No		X	No
Costa's hummingbird	*Calypte costae*				No		X	No
Lucifer hummingbird	*Calothorax Lucifer*				No		X	No
Violet-crowned hummingbird	*Amazilia violiceps ellioti*				No		X	No
White-eared hummingbird	*Hylocharis leucotis borealis*				No		X	No
Yellow-eyed junco	*Junco phaeonotus palliates*				No		X	No
Whiskered screech-owl	*Megascops trichopsis asperus*				No		X	No
Baird's sparrow	*Ammodramus bairdii*				No		X	No
Abert's towhee	*Melozone aberti aberti*				No		X	Yes
Gould's wild turkey	*Meleagris gallopavo mexicana*				No		X	No
Bell's vireo	*Vireo bellii arizonae; medius*				No		X	Yes
Gray vireo	*Vireo vicinior*				No		X	Yes
Gila woodpecker	*Melanerpes uropygialis uropygialis*				No		X	Yes
	Mammals							
Black-footed ferret	*Mustela nigripes*	X			No			No
Mexican gray wolf	*Canis lupus baileyi*	X			No	X		Yes
Mexican long-nosed bat	*Leptonycteris nivalis*	X			No	X		No
Lesser long-nosed bat	*Leptonycteris curasoae yerbabuenae*	X			No		X	No
Jaguar	*Panthera onca arizonensis*	X			No			No
Arizona shrew	*Sorex arizonae*				No	X		No
Arizona montane vole	*Microtus montanus arizonensis*				No	X		No
Spotted bat	*Euderma maculatum*				No		X	Yes
Western yellow bat	*Lasiurus xanthinus*				No		X	No
Southern pocket gopher	*Thomomys umbrinus emotus*				No		X	No
White-sided jack rabbit	*Lepus callotis gaillardi*				No		X	No
	Invertebrates							
Hacheta Grande woodland snail	*Ashmunella hebardi*				No		X	No
Shortneck snaggletooth snail	*Gastrocopta dalliana dalliana*				No		X	No
Mineral Creek mountainsnail	*Oreohelix pilsbryi*				No		X	No
New Mexico hot springsnail	*Pyrgulopsis thermalis*				No		X	Yes
Gila Springsnail	*Pyrgulopsis gilae*				No		X	Yes
	Plants							
Todsen's pennyroyal	*Hedeoma todsenii Irving*	X			No			No
Zuni fleabane	*Erigeron rhizomatus*		X		No			No

table, are likely to occur within any area where AWSA project influences or compliance requirements may occur. While our project focuses particularly on areas of the Cliff-Gila Valley, this assessment extends beyond it because considerations of special status species would extend beyond this boundary for any potential developments within the Cliff-Gila Valley or elsewhere associated with AWSA related projects in New Mexico. The table also identifies those species having federally designated Critical Habitat in the Gila Watershed and it includes the State of New Mexico listed threatened and endangered species within the area.

The following subsections present brief introductions to the federal and New Mexico listed species potentially encountered during development of yet to be defined AWSA project alternatives. Review information includes the status and distribution of the federally listed species, and State of New Mexico listed species potentially encountered in the areas surrounding a future New Mexico AWSA project. These species could require special consideration, depending on the project(s) selected for implementation. Information is provided regarding life history and habitat requirements These discussions are ordered by taxonomic groups, rather than by federal and New Mexico listing groups, as presented Table 3.1 . This review included a review of all species included in a December 12, 2012 letter to the NMISC from the U.S. Fish and Wildlife Service listing species that occur in the region and that "need to be considered relative to any actions that may be implemented as part of the AWSA." For those federally listed species not expected to be encountered or otherwise potentially affected by a possible AWSA project, as shown in Table 3.1,brief presentations on the biology and known distribution of these species, which form the bases for the conclusion presented in that table, are appended at the end of this report.

To a large part, the following species summaries are extracted from USFWS documents and other sources cited, typically only with slight editing. This is done to limit the potentials for altering the information presented by the agencies and sources cited. These summaries are not presented as original assessments or discussions.

Fishes

Gila chub (*Gila intermedia*) – This species was listed as endangered with critical habitat defined in the Federal Register on November 2, 2005 (USFWS 2005). It is also listed as endangered by the State of New Mexico. Historically, the Gila chub lived throughout the Gila River basin in southern Arizona, southwestern New Mexico, and northeastern Sonora, Mexico. It is still present through the majority of its historical range, but often in small, fragmented populations, at risk from known and potential threats and from random events such as drought, flood events, and wildfire. The primary threats to Gila chub include predation by and competition with nonnative species, including fish in the family *Centrarchidae* (*Micropterus spp.*, *Lepomis spp.*), other fish species, as well as bullfrogs (*Rana catesbeiana*) and crayfish (*Orconectes virilis*). These fish are also threatened by habitat degradation due to surface water diversions and ground water withdrawals. Secondary threats include other sources of habitat alteration, destruction, and fragmentation. Sublette et al. (1990) considered the species to extirpated from New Mexico. Nevertheless, AWSA project considerations and developments would need to address environmental regulatory concerns for this species.

Gila chub commonly inhabit pools in smaller streams, springs, and desert wetlands (i.e., cienegas). They can survive in small artificial impoundments and man-made ponds. Gila chubs are highly secretive, preferring quiet, deeper waters, especially pools or by remaining near cover that can include terrestrial vegetation, boulders, and fallen logs. Spawning probably occurs over beds of submerged aquatic vegetation or root wads. The USFWS (2005) defined the Gila chub's primary constituent elements for habiat to include:

1. Perennial pools, areas of higher velocity between pools, and areas of shallow water among plants or eddies all found in headwaters, springs, and cienegas, generally of smaller tributaries;

2. Water temperatures for spawning ranging from 17 to 24 °C (62.6 to 75.2 °F), and seasonally appropriate temperatures for all life stages (varying from approximately 10°C to 30°C).

3. Water quality with reduced levels of contaminants, including excessive levels of sediments adverse to Gila chub health, and adequate levels of pH (e.g., ranging from 6.5 to 9.5), dissolved oxygen (e.g., ranging from 3.0 to 10.0) and conductivity (e.g., 100 to 1,000 mmhos).

4. Food base consisting of invertebrates (e.g., aquatic and terrestrial insects) and aquatic plants (e.g., diatoms and filamentous green algae);

5. Sufficient cover consisting of downed logs in the water channel, submerged aquatic vegetation, submerged large tree root wads, undercut banks with sufficient overhanging vegetation, large rocks and boulders with overhangs, a high degree of streambank stability, and a healthy, intact riparian vegetation community;

6. Habitat devoid of nonnative aquatic species detrimental to Gila chub or habitat in which detrimental nonnatives are kept at a level that allows Gila chub to continue to survive and reproduce; and

7. Streams that maintain a natural flow pattern including periodic flooding.

Loach minnow (*Tiaroga cobitis*) – The listing of this species was changed from Threatened to Endangered on February 23, 2012. At the same time, approximately 983 kilometers (610 miles) were designated as critical habitat critical habitat for the species in Apache, Cochise, Gila, Graham, Greenlee, Pinal, and Yavapai Counties, Arizona, and Catron, Grant, and Hidalgo Counties in New Mexico (USFWS 2012a). Among other rivers, loach minnow populations are now restricted to portions of the Gila River and its tributaries, the West, Middle, and East Fork Gila River. It is also listed as endangered by the State of New Mexico. AWSA project considerations and developments would need to address environmental regulatory concerns for this species.

Loach minnow are found in small to large perennial streams and use shallow, turbulent riffles with primarily cobble substrate and swift currents. They use the spaces between and on the lee (sheltered) side of rocks for resting and spawning. Spawning occurs in late March to early June, when water temperature warm (Sublette et al. 1990). Flooding may stimulate spawning or enhance recruitment. It is rare or absent from habitats where fine sediments fill these interstitial spaces. Based on the best scientific and commercial information available for loach minnow, the USFWS (2012a) developed generalized ranges in their habitat parameters within streams or rivers to include:

1. Shallow water generally less than 1 m (3.3 ft) in depth;

2. Slow to swift flow velocities between 0 and 80 cm per sec (0.0 and 31.5 in. per sec);

3. Pools, runs, riffles and rapids;

4. Sand, gravel, cobble, and rubble substrates with low or moderate amounts of fine sediment and substrate embeddedness, as maintained by a natural, unregulated flow regime that allows for periodic flooding or, if flows are modified or regulated, flow regime that allows for adequate river functions, such as flows capable of transporting sediments;

5. Water temperatures in the general range of 8 to 25°C (46.4 to 77°F);

6. Low stream gradients of less than approximately 2.5 percent; and

7. Elevations below 2,500 m (8,202 ft).

Spikedace (*Meda fulgida*) – This species also had its listing changed from Threatened to Endangered on February 23, 2012 and had Critical Habitat designed at the same time as completed for loach minnow, as described above (USFWS 2012a). It is also listed as endangered by the State of New Mexico. Approximately 1,013 kilometers (630 miles) were designated as critical habitat for spikedace in the same counties listed above for loach minnow. Spikedace were once common throughout much of the Gila Watershed. Habitat destruction, competition, and predation by nonnative aquatic species reduced its range and abundance. Spikedace are now restricted to portions of the upper Gila River (Grant, Catron, and Hidalgo Counties, New Mexico) and several creeks in Arizona. AWSA project considerations and developments would need to address environmental regulatory concerns for this species.

Spikedace are found in moderate to large perennial streams, where they inhabit shallow riffles (those shallow portions of the stream with rougher, choppy water) with sand, gravel, and rubble substrates. Specific habitat for this species include shear zones where rapid flow borders slower flow; areas of sheet flow at the upper ends of mid-channel sand or gravel bars; and eddies at downstream riffle edges. Recurrent flooding and a natural flow regime are very important in maintaining the habitat of spikedace and in helping maintain a competitive edge over invading nonnative species. On the Gila River in New Mexico, flows fluctuate seasonally with snowmelt, causing spring pulses and occasional floods, and late-summer or monsoonal rains produce floods of varying intensity and duration. These high flows likely rejuvenate spikedace spawning and foraging habitat.

Spawning typically occurs from mid-March to May (Sublette et al. 1990). Spikedace eggs are adhesive and develop among the gravel and cobble of the riffles following spawning (USFWS 2012a). Spawning in riffle habitat ensures that the eggs are well oxygenated and are not normally subject to suffocation by sediment deposition due to the swifter flows found in riffle habitats. However, after the eggs have adhered to the gravel and cobble substrate, excessive sedimentation could cause suffocation. Larval and juvenile spikedace occupy peripheral portions of streams that have slower currents. In general, larval spikedace are found in velocities of 8.4 cm per second (3.3 in. per sec) while juvenile spikedace occupy areas with velocities of approximately 16.8 cm per second (6.6 in. per sec). Once they emerge from the gravel of the spawning riffles, spikedace larvae disperse to stream margins where water velocity is very slow or still. Larger larval and juvenile spikedace (those fish 25.4 to 35.6 mm [1.0 to 1.4 in] in length) occurred over a greater range of water velocities than smaller larvae, but still occupied water depths of less than 32.0 cm (12.6 in). Juveniles and larvae are also occasionally found in quiet pools or backwaters (e.g., pools that are connected with, but out of the main river channel).

Based on the compiled information, the USFWS (2012a) identify appropriate sites for breeding, reproduction, or development of offspring for spikedace to include:

1. Sand, gravel, and cobble substrates;
2. Riffle habitat;
3. Slower currents along stream margins with appropriate stream velocities for larvae;
4. Appropriate water depths for larvae and juvenile spikedace;
5. Flow velocities that encompass the range of 8.5 cm per sec (3.3 in. per sec) to 57.9 cm per sec (22.8 in. per sec); and
6. Streams with a natural, unregulated flow regime that allows for periodic flooding or, if flows are modified or regulated, a flow regime that allows for adequate river functions, such as flows capable of transporting sediments.

Gila topminnow (*Poeciliopsis occidentalis occidentalis*) – This is one of two subspecies of Sonoran topminnow, the other being Yaqui topminnow, (*P. o. sonoriensis*), both of which were listed as endangered within the U.S. portion of their range in 1967 with no critical habitat designation (Weedman 1998). The State of New Mexico lists the species as threatened. The original recovery plan for the Sonoran topminnow was approved on March 15, 1984, and a draft revision of that plan, including only the Gila topminnow within the U.S., was completed by the USFWS in 1998 (Weedman 1998). Historically, Gila topminnows were widespread in the Gila River drainage below about 1,500 meters (4,921 ft) elevation and from the San Francisco River at Frisco Hot Springs, New Mexico, west to the mainstem Gila River near Yuma, Arizona. This species was apparently extirpated from New Mexico (lower San Francisco and probably Gila rivers), but it has been reintroduced in 1989 in the Redrock Wildlife Management Area of the

Gila River in Grant County.[5] Sublette et al. (1990) considered the species to be extirpated from New Mexico. Despite this, AWSA project considerations and developments would need to address environmental regulatory concerns for this species

The Gila topminnow typically inhabits lower-elevation springs, streams, and the margins of larger bodies of water, where it shows an affinity for areas containing emergent or aquatic vegetation. It tends to congregate in shallower waters or near the surface of deeper waters. In areas were cold temperatures occur regularly, these topminnows are generally restricted to waters that do not freeze, such as constant-temperature springs or areas fed or influenced by them. They give birth to live young, with the number of young varying due to fluctuating habitat conditions and adult size. The major reason for the demise of the Gila topminnow is considered to be the introduction of mosquito fish (*Gambusia affinis*), which prey on the topminnow, and also due to alterations to the Frisco Hot Springs in New Mexico, which affected spring flows and shallow streamside habitats.

Gila trout (*Oncorhynchus gilae*) – This native fish inhabits streams of the Mogollon Plateau of New Mexico and Arizona, was originally listed by the USFWS under the ESA as endangered in 1973. Subsequently, the USFWS considered down-listing the species to Threatened in 1987, but due to destructive storm flows and wildfire events in the watershed, and due to limited success meeting hatchery goals to reintroduce the species in additional Gila tributaries, the down-listing was delayed until 2006 (USFWS 2006a). Gila trout are currently listed as Threatened by New Mexico. Its current distribution in New Mexico include Main Diamond Creek, South Diamond Creek, and Black Canyon on the East Fork Gila River; Upper White Creek, Whiskey Creek, Lower Little Creek, and Upper Little Creek on the West Fork Gila River; Mogollon Creek on the main steam of the Gila River; Spruce Creek and Big Dry Creek on the San Francisco River; and McKnight Creek on the Mimbres River (USFWS 2002a). AWSA project considerations and developments would need to address environmental regulatory concerns for this species.

The species lives in moderate- to high-gradient perennial mountain streams above 1,660 m (5,400 ft) elevation, which typically flow through narrow, steep-sided canyons and valleys having water temperatures below 25^{o} C (77^{o} F), with clean gravel substrates for spawning, continuous stream flow of sufficient quantity to maintain adequate water depth and temperature, and pool habitat that provides refuge during low flow conditions and periods of thermal extremes (USFWS 2002a). Spawning typically occurs during the Spring and Summer in New Mexico (Sublette et al. 1990). Feeding requirements include habitats with abundant invertebrate prey. Cover habitat typically consists of undercut banks, large woody debris, deep pools, exposed root masses of trees at the water's edge, and overhanging vegetation (USFWS 2002a).

Headwater chub (*Gila nigra*) – Ancestrally, this species is thought to have originated through hybridization of roundtail (*G. robusta*) and Gila chubs (*G. intermedia*), and is morphologically intermediate to these species; it was partitioned out as a separate species from roundtail chub in 2000.[6] The USFWS (2006b) found that protection under the Endangered Species Act for the headwater chub is justified but its listing was precluded by higher priority listing actions.

[5] http://www.bison-m.org/booklet.aspx?id=010565
[6] http://www.bison-m.org/booklet.aspx?id=010146#ref_1

Instead, this chub was added to the candidate species list and additional listing considerations would be prioritized, with its status monitored annually. New Mexico lists both the headwater and roundtail chub as endangered. The headwater chub occurs in parts of the West Fork, Middle Fork, and East Fork of the Gila River (in New Mexico in Catron, Grant, Sierra, and Socorro counties) and parts or most of three river systems in Arizona, the Verde River, Tonto Creek, and San Carlos River (New Mexico Department of Game and Fish [NMDGF] 2006a). Potential AWSA project considerations and developments would need to include environmental regulatory concerns for this species.

Headwater chub usually are found in large pools associated with cover such as undercut banks or deep waters created by obstructions such as trees or rocks in the middle to headwater reaches of medium-sized streams of the Gila River basin from elevations of 925 to 2,000 m (3,035 to 6,651 ft). Typical adult microhabitat consists of deep, nearshore pools adjacent to swifter riffles and runs. Spawning typically occurs from late spring into summer (NMDGF 2006a). This chub is threatened primarily by predation and competition with nonnative fishes, habitat destruction due to dewatering, impoundment, channelization, and channel morphology changes caused by the alteration of riparian vegetation. Other threats include watershed degradation from mining, livestock overgrazing, roads, water pollution, human development, and groundwater pumping.

Roundtail chub (*Gila robusta*) – This is currently a Candidate species under the Endangered Species Act and New Mexico lists it as Endangered. In the same USFWS 2006b announcement finding that protection of the headwater chub is justified, the USFWS concluded that the listing of the Lower Colorado River basin population of the roundtail chub did not warrant further consideration at that time since its population was not discernible from the population in the upper basin. In 2009 the USFWS reversed that finding, concluding that the Lower Colorado River basin population was discernible from that of the upper basin population, and again listed the Lower Colorado River basin population a candidate species since its range had been reduced by approximately 68 to 82 percent.

Roundtail chub generally are found in "deep complex pool systems," where a few deep (greater than 1 m) pools with cover (boulders, woody debris) are intermixed with riffles, runs, and eddies (NMDGF 2006a). As for the headwater chub, spawning typically occurs from late spring into summer. Populations of this fish once occurred throughout the mainstem of the Gila and San Francisco rivers in southwestern New Mexico, but recent records indicate the species may still exist there as only very low numbers, based on its sporadic collections since 1994 (NMDGF 2006a). AWSA project considerations and developments would need to address environmental regulatory concerns for this species.

Amphibians

Chiricahua leopard frog (*Lithobates chiricahuensis*) – This frog was listed as Threatened in 2002 with critical habitat designed over approximately 10,386 acres (4,187 hectares) in 39 units in 2012 (USFWS 2012b). New Mexico includes this frog as "Species of Greatest Conservation Need" (SGCN).[7] Its range includes central and southeastern Arizona, west-central and

[7] http://www.bison-m.org/booklet.aspx?id=020025

southwestern New Mexico, and into Mexico. Chiricahua leopard frog populations appear to exist in each of the forks of the upper Gila River: (1) small populations have been documented near the mouth of Turkey Feather Canyon and upstream from the mouth of White Creek along the West Fork of the Gila River, but their status has not been evaluated since 2001; (2) Egg masses and calls were reportedly detected in the Meadows along the Middle Fork of the Gila River; (3) populations have been found along Main Diamond Creek, in Black Canyon near its confluence with the East fork, and in Black Canyon near the confluence with Aspen Creek, none are known from the East Fork Gila River; and (4) Blue Creek on the lower mainstem of the Gila River (USFWS 2007). AWSA project considerations and developments would need to address environmental regulatory concerns for this species.

The life history of this species consists of eggs and larvae that are entirely aquatic and adults that are primarily aquatic but may be terrestrial at times. Their populations at elevations below 1,798 m (5,900 ft) tend to lay eggs from spring through late summer, with most breading activity taking place before June. Populations above 1,798 m bred in June, July, and August. Breeding in the early part of the year appear to be limited to sites where water temperatures do not get too low, such as spring-fed sites. At sites with warm springs, Chiricahua leopard frog may lay eggs year-round. Depending on water temperature, eggs can hatch in approximately 8 to 14 days, and the tadpoles remain in the water to feed and grow, with the tadpoles becoming juvenile frogs in 3 to 9 months. They are active both day and night. Their diet primarily includes invertebrates such as beetles, true bugs, and flies, but also may include fish and snails.

Lowland leopard frog (*Rana yavapaiensis*) – The species is listed by New Mexico as endangered, it is thought to rarely enter southwestern New Mexico. Historically, it lived along streams flowing off the Mogollon Rim in the San Francisco and Gila Rivers. The last specimens observed in New Mexico were seen in Guadalupe Canyon during April 1985; the species apparently has been extirpated from New Mexico.[8] AWSA project considerations and developments would need to address environmental regulatory concerns for this species.

Lowland leopard frogs are aquatic and normally found at elevations below 1,500 m (4,921 ft) in small to medium-sized streams and occasionally in small ponds. They often concentrate near deep pools in association with root masses of large riparian trees. In New Mexico, this species inhabits riparian areas in areas of grasslands, chaparral, and evergreen woodlands. Associated vegetation includes the Arizona sycamore (*Platanus wrightii*), seep-willow (*Baccharis glutinosa*), other trees and shrubs, and various forbs and graminoid (grass-like) plants.

Reptiles

Brown (Northern Mexican) garter snake (*Thamnophis eques*) – This snake is federally listed as a candidate species (USFWS 2012c) and by New Mexico as an endangered species. Higher priority listing actions, including court-approved settlements, court-ordered and statutory deadlines for petition findings and listing determinations, emergency listing determinations, and responses to litigation, continue to preclude the proposed and final listing rules for this species. It has been reported at locations from central Arizona and southwestern New Mexico southward

[8] http://www.bison-m.org/booklet.aspx?id=020030

in the highlands of western and southern Mexico. In New Mexico, the species is known primarily from the lower Gila Basin, with occurrences documented along Duck and Mule creeks in Grant County and near Virden in Hidalgo County. Historically, the northern Mexican garter snake had a limited distribution in New Mexico that consisted of scattered locations throughout the Gila and San Francisco headwater drainages in Grant and western Hidalgo Counties.[9] A single photo-vouchered record of a northern Mexican garter snake specimen exists from August 2002. This specimen was observed in a debris pile along the Gila River off Highway 180 in Grant County, New Mexico. Subsequent searches were conducted in the same vicinity in 2006 and 2007, but no individuals were observed. Additionally, Albuquerque BioPark biologists found five male and two female Northern Mexican garter snakes along the Gila River in 2013.[10]

The USFWS (2012c) considers the following historical populations to be extirpated from New Mexico: (1) Mule Creek; (2) the Gila River, 5 miles (8 km) east of Virden; (3) Spring Canyon; (4) the West Fork Gila River at Cliff Dwellings National Monument; (5) the Tularosa River at its confluence with the San Francisco River; (6) the San Francisco River at Tub Spring Canyon; (7) Little Creek at Highway 15; (8) the Middle Box of Gila River at Ira Ridge; (9) Turkey Creek; (10) Negrito Creek; and (11) the Rio Mimbres. In addition, the USFWS (2012) considers the current status as unknown in several areas of Arizona and New Mexico where the species is known to have historically occurred along perennial or intermittent stream reaches and lentic wetlands: (1) the downstream portion of the Black River drainage from the Paddy Creek confluence; (2) the downstream portion of the White River drainage from the confluence of the East and North forks; (3) Big Bonito Creek; (4) Lake O'Woods near Lakeside; (5) Spring Creek above the confluence with Oak Creek; (6) Bog Hole Wildlife Area; (7) Babocomari River; (9) Arivaca Cienega; and (10) Gila River at Highway 180. Potential AWSA alternative developments would need to assess potential environmental impacts to this species.

This species is associated with a variety of habitats, but most of the range is centered on the lower parts of highland areas and adjacent basins. Habitats in which the species has been found include woodlands of pines (*Pinus spp.*) and oaks (*Quercus spp.*), grasslands with mesquites (*Prosopis spp.*), and low to middle elevation watercourses in which cottonwoods (*Populus spp.*), willows (*Salix spp.*), and other riparian plants are found. In New Mexico, the three areas where this species has been found are of the riparian type, as described above at elevations of 1,300-1,800 m (4,265-5,906 ft). Whatever the terrestrial habitats may be in an area of occurrence, the Mexican garter snake is typically an aquatic species. Stream situations frequented by the species in New Mexico are generally characterized by shallow, slow-moving, and at least partially vegetated bodies of water such as around springs (e.g., Mule Creek).

Narrowhead garter snake (*Thamnophis rufipunctatus rufipunctatus*) – This species is New Mexico listed as threatened. Its key habitat including all areas of regular occurrence, including Gila and San Francisco rivers and their major tributaries, ranging down the Gila River to the Arizona border to about 4,265 feet (1,300 meters) and up to 7,545 feet (2,300 meters) or higher,

[9] http://www.bison-m.org/booklet.aspx?id=030265
[10] http://newswatch.nationalgeographic.com/2013/07/15/finding-of-rare-gartersnake-underscores-need-to-protect-new-mexicos-gila-river/

where coniferous woodlands and forests are the dominant upland vegetation.[11] It is a highly aquatic species of garter snake, typically inhabiting clear, cool, rocky streams. Often, riparian growth in such areas consists of Arizona alders (*Alnus oblongifolia*), willows (*Salix* spp.), narrowleaf cottonwoods (*Populus angustifolia*), and Arizona sycamores (*Platanus wrightii*). Although the narrowhead garter snake frequently basks along the shore, when disturbed it almost invariably slides into the water and dives to the bottom. They are an uncommon species in Gila National Forest. AWSA project considerations and developments would need to address environmental regulatory concerns for this species.

The following species are listed as threatened by the New Mexico Department of Game and Fish. Table 3.1 indicates whether these species are likely to be encountered in areas included under the AWSA project consideration or development; footnotes for each species provides a link to the New Mexico Department Game and Fish Bison-M Species Booklets where additional information about each species status, distribution, and habitat relationships can be obtained.

- Slevin's bunchgrass lizard (*Sceloporus slevini*)[12]
- Mottled rock rattlesnake (*Crotalus lepidus lepidus*)[13]
- Mountain skink (*Plestiodon callicephalus*)[14]
- Narrowhead garter snake (*Thamnophis rufipunctatus rufipunctatus*)[15]
- Green rat snake (*Senticolis triaspis intermedia*)[16]
- Canyon spotted whiptail (*Aspidoscelis burti stictogrammus*)[17]

Avifauna

Southwestern willow flycatcher (*Empidonax traillii extimus*) – is a subspecies in one of the ten North American species in the genus *Empidonax*, has been listed by both the USFWS and the State of New Mexico as Endangered, with the federal listing effective March 29, 1995.[18] Its breeding range includes far western Texas, New Mexico, Arizona, southern California, southern portions of Nevada and Utah, southwestern Colorado, and possibly extreme northern portions of the Mexico (USFWS 2002b). The Gila Valley has been identified as a stronghold for the taxon with the area containing one of the largest known flycatcher populations. In 2002, the Upper Gila Recovery Unit held 187 known nesting territories, with the recovery goal being 325 territories for reclassification. This recovery unit includes the Gila River from Mogollon Creek

[11] http://www.bison-m.org/booklet.aspx?id=030270
[12] http://www.bison-m.org/booklet.aspx?id=030060
[13] http://www.bison-m.org/booklet.aspx?id=030175
[14] http://www.bison-m.org/booklet.aspx?id=030195
[15] http://www.bison-m.org/booklet.aspx?id=030270
[16] http://www.bison-m.org/booklet.aspx?id=030370
[17] http://www.bison-m.org/booklet.aspx?id=030490
[18] http://www.bison-m.org/booklet.aspx?id=040521

(NM) to Duncan (AZ), plus additional drainage areas in Arizona. AWSA project considerations and developments would need to address environmental regulatory concerns for this species.

The Southwestern willow flycatcher breeds in dense riparian tree and shrub communities associated with rivers, swamps, and other wetlands, including lakes and reservoirs, in southwestern North America, and winters in southern Mexico, Central America, and northern South America. It usually nests near surface water or saturated soils. Historically, the southwestern willow flycatcher probably nested primarily in willows, buttonbush (*Cephalanthus occidentalis*), and seepwillow (*Baccharis sp.*), sometimes with a scattered overstory of cottonwood (*Populus sp.*). Stoleson et al. (1998) found differences between occupied and unoccupied habitats on the Gila River, NM; occupied sites had greater foliage density, greater canopy cover, and greater numbers of trees than unoccupied sites. Unoccupied sites had fewer shrubs and saplings, more open canopies, and greater variability in these characteristics. In the Cliff-Gila Valley, the Nature Conservancy, Gila National Forest, and the U-Bar Ranch all have conducted habitat restoration projects to benefit this species, whereas downstream along the Lower Gila Box, the Bureau of Land Management has enhanced riparian patches toward the same goal.

Mexican spotted owl (*Strix occidentalis lucida*) – This owl was listed as Threatened under the Endangered Species Act on March 16, 1993 by the USFWS (2004). The State of New Mexico lists it as a species of greatest conservation need in the Comprehensive Wildlife Conservation Strategy for New Mexico (NMDGF 2006b); this provides the species full protection under the federal listing. The largest populations of Mexican spotted owls are located along the Mogollon rim, central Arizona; Gila National Forest, western New Mexico; and in the Sacramento Mountains of New Mexico.[19]

Critical habitat for the Mexican spotted owl was designated on August 31, 2004 (USFWS 2004) and includes three recovery units within the Gila National Forest. Two of these in areas are potentially affected by the AWSA. Both are north of Silver City in the Gila Mountains and contain ponderosa pine, mixed-conifer, spruce-fir, and stringers of deciduous riparian forests. Areas within the region not included in the critical habitat designation include: Unit UGM–5a, Gila National Forest, Catron, and Grant Counties and Unit UGM–6. Gila Mountains, Catron County Unit WUI project areas, State, private, and Tribal lands are not designated as critical habitat. AWSA project considerations and developments would need to address environmental regulatory concerns for this species.

Mexican spotted owls are dependent on the presence of large trees, snags, down logs, dense canopy cover, and multi-storied conditions within predominantly mixed-conifer and pine-oak habitats, where it is occasionally seen in summer and winter, and occasionally seen as transient in areas of ponderosa/ oak forests, mixed conifer forests, spruce/fir forests and cliffs/open skies near ponderosa pine forests with oak understory.

Yellow-billed cuckoo (*Coccyzus americanus occidentalis*) – In 2000 the USFWS determined that the yellow-billed cuckoo is warranted for listing as federal candidate, but the final listing is

[19] http://www.bison-m.org/booklet.aspx?id=041375

precluded due to other higher priority actions to amend the Lists of Endangered and Threatened Wildlife and Plants (USFWS 2001). While NM provides complete protection of this species under the current federal classification, it provides no additional protection under state statues.[20] Of particular note, the federal status applies to the population in the western part of New Mexico only.

Cuckoo habitat appears to be restricted to moist river bottoms to meet humidity levels required for successful breeding. Sites occupied by cuckoos generally have taller trees, thicker cover in the upper and middle layers of the canopy, and sparser shrub layers; in contrast, unoccupied sites consistently appear to have very little canopy and higher densities of small trees, mostly nonnative tamarisk. Cuckoos may prefer riparian areas that are dominated by native species with a multistoried structure and high, dense canopies for nesting and an open understory for foraging. They breed in San Juan, Dry Cimarron, Rio Grande, Pecos, Mora, Canadian, San Francisco, and Gila valleys. In 1986, it was reported as fairly common in cottonwood habitats from the Redrock area at least as far upstream as the confluence of the Gila River and Mogollen Creek, 12 km (7.5 miles) north of Cliff. As such, AWSA project considerations and developments would need to address environmental regulatory concerns for this species.

In addition to the above, the following New Mexico listed species may also occur with areas potentially affected by AWSA projects:

- Common black hawk (*Buteogallus anthracinus anthracinus*)[21]
- Bald eagle (*Haliaeetus leucocephalus alascanus*)[22]
- Peregrine falcon (*Falco peregrinus anatum*)[23]
- Baird's sparrow (*Ammodramus bairdii*)[24]
- Bell's vireo (*Vireo bellii arizonae; medius* [NM])[25]
- Gray vireo (*Vireo vicinior*)[26]
- Gila woodpecker (*Melanerpes uropygialis uropygialis*)[27]

Mammals

Mexican gray wolf (*Canis lupus baileyi*) – This species had been listed by both the USFWS and the State of New Mexico as Endangered, with the federal listing effective March 11, 1967. The New Mexico listing included Grant, Hidalgo, and Sierra counties.[28] The historic range of the

[20] http://www.bison-m.org/booklet.aspx?id=040250
[21] http://www.bison-m.org/booklet.aspx?id=040040
[22] http://www.bison-m.org/booklet.aspx?id=040370
[23] http://www.bison-m.org/booklet.aspx?id=040384
[24] http://www.bison-m.org/booklet.aspx?id=041785
[25] http://www.bison-m.org/booklet.aspx?id=042190
[26] http://www.bison-m.org/booklet.aspx?id=042200
[27] http://www.bison-m.org/booklet.aspx?id=042520
[28] http://www.bison-m.org/booklet.aspx?id=050866

gray wolf once included nearly the entire state of New Mexico, apparently excluding the eastern counties of Eddy, De Baca, Harding, and probably Colfax and Chaves counties. On January 24, 1998, the USFWS designated the Blue Range Wolf Recovery Area to consist of the entire Apache and Gila National Forests in east-central Arizona and west-central New Mexico and classified wolves to be reestablished in the areas as a nonessential experimental population under section 10(j) of the Endangered Species Act of 1973 (USFWS 1998).[29] AWSA project considerations and developments would need to address environmental regulatory concerns for this species

Spotted bat (*Euderma maculatum*) – A New Mexico listed threatened species that also may be encountered by potential AWSA project alternatives.[30] As such, AWSA project considerations and developments would need to address environmental regulatory concerns for this species

Invertebrates

No invertebrate species are listed under the Endangered Species Act for this area. There are five species in the New Mexico counties overlapping the Gila River Watershed that are listed as threatened by the New Mexico Department of Game and Fish and two of these may be encountered during the development of potential AWSA projects. These species may require additional consideration by the State of New Mexico for certain environmental compliance efforts:

- New Mexico hot springsnail (*Pyrgulopsis thermalis*)[31]
- Gila Springsnail (*Pyrgulopsis gilae*)[32]

3.5.4.2 Summary

The previous subsections presented brief introductions to the following federal and New Mexico listed species potentially encountered during development of AWSA project alternatives. These species could require special consideration, depending on the project(s) selected for implementation.

- Federal and New Mexico Listed Endangered Species
  - Fishes
    - Gila chub (*Gila intermedia*), with critical habitat in the Gila Watershed
    - Loach minnow (*Tiaroga cobitis*), with critical habitat in the Gila Watershed
    - Spikedace (*Meda fulgida*), with critical habitat in the Gila Watershed
  - Birds
    - Southwestern willow flycatcher (*Empidonax traillii extimus*)
    - Aplomado falcon (*Falco femoralis septentrionalis*)

[29] http://www.fws.gov/southwest/es/mexicanwolf/pdf/10(j)_Final_Rule.pdf
[30] http://www.bison-m.org/booklet.aspx?id=050095
[31] http://www.bison-m.org/booklet.aspx?id=060180
[32] http://www.bison-m.org/booklet.aspx?id=060280

- Federal Listed Endangered and New Mexico Listed Threatened Species
  - Fishes
    - Gila topminnow (*Poeciliopsis occidentalis occidentalis*)
- Federal Listed Endangered Species, with no New Mexico Listing
  - Birds
    - Mexican spotted owl (*Strix occidentalis lucida*), with critical habitat in the Gila Watershed
  - Mammals
    - Mexican gray wolf (*Canis lupus baileyi*)
- Federal and New Mexico Listed Threatened Species
    - Gila trout (*Oncorhynchus gilae*)
- Federal Listed Threatened Species, with no New Mexico Listing
  - Amphibians
    - Chiricahua leopard frog (*Lithobates chiricahuensis*), with critical habitat in the Gila Watershed
  - Birds
    - Mexican spotted owl (*Strix occidentalis lucida*)
- Federal Candidate Species
  - Birds
    - Yellow-billed cuckoo (*Coccyzus americanus occidentalis*)
- Federal Candidate and New Mexico Listed Endangered Species
  - Fishes
    - Headwater chub (*Gila nigra*)
    - Roundtail chub (*Gila robusta*)
  - Reptiles
    - Brown (Mexican) gartersnake (*Thamnophis eques megalop*)
- New Mexico Listed Endangered Species, with no Federal Listing Status
  - Amphibians
    - Lowland leopard frog (*Lithobates yavapaiensis*)
  - Birds
    - Common ground-dove (*Columbina passerina pallescens*)
- New Mexico Listed Threatened Species, with no Federal Listing Status
  - Reptiles
    - Narrowhead garter snake (*Thamnophis rufipunctatus rufipunctatus*)
  - Birds
    - Common black hawk (*Buteogallus anthracinus anthracinus*)
    - Bald eagle (*Haliaeetus leucocephalus alascanus*)
    - Peregrine falcon (*Falco peregrinus anatum*)
    - Abert's towhee (*Melozone aberti aberti*)
    - Bell's vireo (*Vireo bellii arizonae; medius*)
    - Gray vireo (*Vireo vicinior*)
    - Gila woodpecker (*Melanerpes uropygialis uropygialis*)
  - Mammals

- Spotted bat (*Euderma maculatum*)
- Invertebrates
  - New Mexico hot springsnail (*Pyrgulopsis thermalis*)
  - Gila Springsnail (*Pyrgulopsis gilae*)

3.5.4.3 Data Gaps Assessment

Reasonably comprehensive information is available on the general biological requirements and life history attributes for the Federal and New Mexico listed species of potential concern included in the above discussion. While useful information exists on the general distribution and abundance of listed species in the Gila River watershed over time, especially for listed fish species, less certainty exists regarding specific recent locational distributions and numeric abundances of these species within the Gila River Watershed. For most fish and wildlife species, population distributions fluctuate annually, seasonally, and, commonly, daily due across their ranges to localized changes in habitat conditions resulting from natural or human causes. Examples of such fluctuation for fish can be seen for the Gila River in the often extreme annual differences in the proportions of native to nonnative species across twenty years of collections at the Gila River sites presented by Propst et al. (2009).

Except for selected fish species, as described below, there is a general lack of site-specific analyes for the Gila River system directly linking listed species to discharge and flow regimes in the river. Specific information is lacking, however, to link the abundance of individual federal and state listed populations to significant alterations in seasonal discharge volumes and flow velocities. Methods to complete such assessments were discussed in Section 2.4, above.

3.5.5 Fishes

3.5.5.1 Review

Copies of information that this project has compiled, as reflected in our project's literature database, includes agency file reports, project reports, and published articles on fish in the Gila River starting with collections of Koster in 1948. This includes early articles that address the taxonomic differences among the collected fish species (e.g., Miller and Hubbs 1960). Another addressing fish parasites in the Gila River fish (Wier et al. 1963) and options for fish barriers in the upper Gila River drainage as well as elsewhere in the West (Riley and Clarkson 2005, Faush et al. 2009). Additional literature has also be compiled on the general ecological relationships for fisheries in arid southwestern rivers, often focusing more on rivers in Arizona, including the Gila River downstream from New Mexico (e.g., Allison 2000, Desert Fishes Team 2004,); on fire effects to fish (Dunham et al. in press, Rinne and Carter 2008, Rinne and Miller, undated manuscript). For example, the analyses by Rinne and Miller (2006) concluded that the causes for the decline of native fish in the arid southwestern rivers is the combination of habitat alteration and the introduction of native species, with the hydrograph, geomorphology, and management being critical features in delimiting native fish assemblages.

Payne et al. (2006) conduct an assessment of existing data on fish habitat and instream flows of the Gila River. Their effort included evaluating an instream flow study conducted by the USFWS in the 1980s, correcting deficiencies in that study where possible, and developing recommendations to help guide additional instream flow analysis. Their ultimate study goal was aid NMISC to develop a water management strategy that meets the state's water needs and produce the least impairs the habitat of important fishes inhabiting the Gila River. A number of "inconsistencies and anomalies" were evident in the USFWS analyses, which could not be corrected as the needed field data for the early study were missing. The study reviewed the habitat suitability curves for loach minnow and spike dace, concluding that the USFWS curves were likely reasonable general representations, but that the models should be field tested to better ensure that they are adequate for the relationships in the Gila River. Also, Payne et al. (2006) concluded that the HSC curves for suckers should be revised to account for the numerous curve anomalies. Mapping in the 2006 study found significant differences in habitat distribution from what could be determined using limited information available from the 1980s. Due to the (1) missing field data, (2) needs for field verification of the HSC models, and (2) questionable mapping results from the earlier study, Payne et al. (2006) provided a draft study plan to correct the identified deficiencies.

Pilger et al. (2010) investigated the diets of fish in the Gila River of New Mexico, reporting that both native and non-native fish fed across trophic levels, with adult native suckers consuming more algae and detritus then smaller native fish, including suckers; adult non-native small mouth bass, yellow bullhead, and two species of trout preyed on small-bodied fishes and aquatic invertebrates more so than did small- and large-bodied native fishes. This study concluded that although predation on juvenile native fish might threatened the persistence of native fishes, the highly diverse diets of the non-native predators may lessen such potentials, depending on the prevailing environmental conditions.

We also compiled a selection of NMDGF reports of fish collections for the Gila River dating from 1955 to 2010, the key information from which were summarized by Stefferud et al. (2011) and others we cite below. Stefferud et al. (2011) concluded that (1) fish community assemblies and recruitment of native species in the Gila River was strongly and primarily affected by mean annual discharge and secondarily by location and densities of nonnative predators (mainly smallmouth bass); and (2) spatially variable responses of native fish assemblages pointed to native fish being jeopardized where key habitats were lost or flow regimes unnaturally altered, particularly during low flow when native recruitment can be low and nonnative predation can be high, but large bodied native fish can escape predation pressure during such period due to their body size and the ability to rely on occasion high discharge years for successful recruitment.

Key information and data our project has compiled on fish collections within the Gila River system came from the University of New Mexico Museum of Southwestern Biology (MSB), the collections of Western New Mexico University (WNMU), the USFWS, various summary reports from the New Mexico Department of Game and Fish, and other reports and literature sources referenced in the following discussion. Supplemental information on life history and spawning habitats for select fish species came from Sublette et al. 1990, as well as from the literature on federal and state listed fish species cited above.

The databases obtained from MSB and WNMU include information on field collection locations ranging from some with specific georeferenced locations to others with only narrative location descriptions. As introduced in the previous subsection, most fish tend to be highly mobile organisms and this can greatly bias a given sampling effort – certain methods, sampling times and/or intervals, and random chance variation can ultimately be deterministic in the number of fish caught. As such, knowing the presence or absence and the relative abundance of fish species along a reach over time tends to be more germane for some management and assessment goals relative to knowing the numbers captured at specific locations and times. Therefore, for all field capture data for fish we simply assigned information both for general descriptions of sample locations in the original data and for the specific capture locations (defined by coordinates) to one of six designated river reaches within the Gila River and its major tributaries . These six designated reaches are the West Fork, Middle Fork, East Fork, Upper Gila River, Cliff-Gila Valley, and Lower Gila River (Fig. 3.10). Field collection information and data for tributaries within each of these six subreaches were also included within each of these appropriate subreaches. Coded values were applied to represents each given reach in the compiled datasets. This approach allows for summarization of species collection data by subreach, which can help provide a framework for better understanding the spatial distribution of a given species along the Gila River system.

The combined MSB and WNMU datasets include 38 species of fish and 1,957 records; sample dates range from 1943-2010. The MSB database includes data for individual fish counts by sampling events; however, at least for some entries, these *may* represent voucher specimens only. In contrast, the WNMU database includes only records that individual specimens had been collected on a given date at a particular location, not numbers of fish collected; perhaps recording only the voucher species received from the individual collections submitted. Paroz et al. (2010) contains information from NMDGF fish studies, including number of fish collected by species from specific sampling locations and dates from 2005 to 2008 for the West, Middle, and East Forks of the Gila River. The USFWS dataset includes information on number of fish collected by species and sampling date and Gila trout stocking records during 2011, all at geospatially defined locations. Propst et al. (2009) present additional summary information from NMDGF on whether individual fish species were captured (i.e., presence/absence information) from 1988 to 2008 at five locations along the Gila River system; they also provide summary information by year for the five locations on total fish captured, area sampled, percent and density of both native and nonnative fish in the collections, as well as other summary information. In addition, most of the data summarized in that report was additionally analyzed in a separate report (Propst et. al. 2008), which we highlight at the end of this section. In general, fish collections from the Gila River system have been made in the spring, summer, or fall; however, the collection times vary among studies, locations, and years.

Table 3.1 in the Task 1b report compiles a summary of collection information from these five data sources (Tetra Tech 2013b). Table 3.2, below, provides a simplified characterization of this information. Across all of the compiled information and for the reach designations we defined for this assessment (which, as a reminder, also include confluent tributaries to each reach, since many fish species typically can and do move into and out of attached tributaries), 21 fish species were captured from the West Fork, 20 from the Middle Fork, 26 from the East Fork, 23 from the Upper Gila River, 21 from the Cliff-Gila Valley, and 22 from the Lower Gila River. Thus, fish species richness varies minimally among sites over the period of the collection records.

Table 3.2 Summary of fish collection information from Gila Watershed*.

Scientific Name	Common Name	TSN	West Fork Gila River & Tributaries	Middle Fork Gila River & Tributaries	East Fork Gila River & Tributaries	Upper Gila River & Tributaries	Gila River, Cliff-Gila Valley & Tributaries	Lower Gila River & Tributaries
NATIVE SPECIES								
Federal & NM Endangered Listings								
Gila intermedia	Gila Chub	163560		+				
Meda fulgida	Spikedace	163583	**++++**	**+++**	+++	+++	**++++**	**+++++**
Rhinichthys cobitis	Loach Minnow	163388	**+++**	+++	+++	++	**+++**	**+++**
(synonym: *Tiaroga cobitis)*								
Federal & NM Threatened Listings								
Oncorhynchus gilae	Gila Trout	161985	**+++**		**+++**			++
Federal Candidate & NM Endangered Listings								
Gila nigra	Headwater Chub	689138	**+++**	**++**	**++**			
Gila robusta	Roundtail Chub	163558	++	++	++	++	++	++
Other Native Species								
Agosia chrysogaster	Longfin Dace	163533	**++++**	**+++**	**++++**	++	**+++**	**+++++**
Catostomus insignis	Sonora Sucker	163905	**++++**	**++++**	**++++**	**+++**	**++++**	**+++++**
(synonym: *Pantosteus insignis*)								
Catostomus clarkii	Desert Sucker	163901	**++++**	**+++**	**++++**	++	**++++**	**+++++**
(synonym: *Pantosteus clarki(i)*)	(synonym: Gila Mountain Sucker)							
Rhinichthys osculus	Speckled Dace	163387	**++++**	**+++++**	**+++**	+	+	+
NON-NATIVE SPECIES								
Ameiurus melas	Black Bullhead	164039	+	++	++	++	**+**	+
Ameiurus natalis	Yellow Bullhead	164041	**+++**	**+++**	**++**	++	**++**	**++**
Catostomidae Family	Sucker	163892			+++			
Catostomus commersonii	White Sucker	553273			++			++
Cottus bairdii	Mottled Sculpin	167237						+
Cyprinella lutrensis	Red Shiner	163792	+			++	**+**	**+++++**
Cyprinus carpio	Common Carp	163344					**+**	++
Dorosoma cepedianum	Gizzard Shad	161737			++			
Fundulus grandis	Gulf Killifish	165651				+		
Gambusia affinis	Western Mosquito Fish	165878	**++**	**+++**	**+++**	+	**++++**	**++++**
Ictalurus chihuahua	Chihuahua Catfish	163996			**++**			
Ictalurus lupus	Headwater Catfish	164001			+		+	
Ictalurus punctatus	Channel Catfish	163998			**++**	**++**	**+**	**++++**
Ictalurus sp.	Catfish	163996			+			
Lepomis cyanellus	Green Sunfish	168132	**+**	**++**	**++**	**+**	**++**	++
Lepomis macrochirus	Bluegill	168141		+		+		+++
Lepomis megalotis	Longear Sunfish	168153				+		
Menidia beryllina	Inland Silverside	165993			++	+++		
Micropterus dolomieu	Smallmouth Bass	550562	**++**	**+++**	**++**	++	**+**	**++**
Micropterus punctulatus	Spotted Bass	168161				+	**+**	
Micropterus salmoides	Largemouth Bass	168160	+	+	**+**	+	+	++
Notemigonus crysoleucas	Golden Shiner	163368						+
Oncorhynchus gilae X mykiss	Gila-Rainbow Trout Hybrid		**+++**					
Oncorhynchus mykiss	Rainbow Trout	161989	**+++**	**++**	**+**	**+**	+	
Oncorhynchus sp.	Trout	161974	++	**+**				
Pimephales promelas	Fathead Minnow	163517	**+**	**+**	++	+	+++	**+++**
Pylodictis olivaris	Flathead Catfish	164029			+	+	**+**	**++**
Salmo trutta	Brown Trout	161997	**+++**	**++**	**+++**			
Total Number of Species Collected			21	20	26	23	21	22

* Count range for individuals collected: + = <10; ++ = 10 - 100; +++ = >100 - 1000; ++++ = >1000 - 5000; +++++ = >5000; bold and underline = indicate the species was captured in the reach after 2003 in any of the five datasets. Data sources: UNM Museum of Southwest Biology database; Western New Mexico database; Paroz et al. (2010); Propst et al. (2009); and USFWS capture records for 2011.

For the federal listed endangered species over this period, the Gila Chub has been collected from only the Middle Fork of the Gila River with a low abundance and frequency of collection and no collections for the past 10 years. Spikedace has a relatively high frequency of collection and abundance throughout the river system, with the largest populations generally found in the two lower reaches of the Gila River and in the West Fork. Loach minnow showed moderate populations throughout the river system. During the past ten years, however, both of the latter two species has been collected only from the West Fork and lower two reaches of the Gila River, plus from the East Fork for spikedace.

In the past 10 years, the federally threatened Gila trout has been captured in moderate densities from the West Fork and East Fork Gila River; earlier over the period of record it was also captured in relatively low densities from the Lower Gila River subreach.

The federal candidate and New Mexico listed endangered headwater chub has been collected in low to moderate densities from all three of the Gila River forks. While the similarly listed roundtail chub had been reportedly collected in low densities from all six of the defined reaches, it has not been reported in any collections from the system over the past 10 years; this may be due to the taxonomic split of the two species in 2000, as described in Section 3.5.5.1.

Four additional native species have been reported in the capture records for the Gila River system during the period of record: longfin dace, Sonora sucker, desert sucker, and speckled dace. All four have been collected in moderate to very high abundance over the last ten years from all three forks of the Gila River. Of these, only the Sonora sucker has been collected from the upper Gila reach in the last ten years and in moderate numbers. Longfin dace, Sonora sucker, and desert sucker have been collected in all three of the defined reaches of the mainstem Gila River in the past 10 year in moderate to very high abundances. While speckled dace was collected in very low numbers from the three mainstem reaches during the earlier years of the period of record, it has not been reported as collected from any of these reaches during the past 10 years.

Twenty-eight non-native fish taxa have been reported from the Gila River system, with 10 taxa not being recorded in collections during the past 10 years. Interestingly, of these, only rainbow trout, channel catfish, and green sunfish have been reported in collections from the upper Gila River reach over the past 10 years; each having low to very low abundances. We hypothesize that this likely relates to the canyon conditions existing in this reach. Green sunfish have been reported as having low to very low abundance in collections from all reaches except the lower Gila River reach over the past 10 years. Red shiner during this period have shown very high abundance in collections from the downstream Gila River reach and very low abundances upstream in the adjoining Cliff-Gila Valley reach; there are no reported collections from any of the reaches upstream. Yellow bullhead, mosquito fish, smallmouth bass, and brown trout have shown moderate to very low population abundance in collections from all reaches, except the upper Gila River reach over the past ten years. The exception to this is mosquito fish, which have had high abundances over this period in the two downstream Gila River reaches. Channel catfish abundance have ranged from low to very low in collections over the past 10 years in reaches from the East Fork through the Cliff-Gila Valley and high abundance in the Lower Gila River Reach.

As previewed above, Propst et al. (2008) analyzed 19 years of NMDGF collection data from the Gila River system, particularly to assess how flow regimes link to native versus nonnative fish population dominance. They reported that native fish density was greatest during the wet period occurring at the start of the study, which then shifted to non-native dominance during the dry period over the end of the study. From these data, they suggest "that the chronic presence of nonnative fish, coupled with naturally low flows, reduced abundance of individual species and compromised persistence of native fish assemblages." Further, they concluded that a natural flow regime alone would not ensure the persistence of native fish population assemblages along the Gila River. Instead, they state that active management to maintain natural flow regimes and to control nonnative fish species in their "strongholds" is critical to maintaining dominance of native populations in the upper reaches of the Gila River system and other similar rivers.

3.5.5.2 Data Gaps Assessment

Fish collections in the Gila River system have occurred since at least the 1940s. They have occurred over a diversity of locations by a diversity of biologists. They have likely included the use of a number of different methods, but that cannot be specifically defined because for much of the compiled data and information, methods are not completely described. Catch per unit effort is not provided for most of the available data. Only limited data may qualify for statistical analysis, if required assumptions can be met. Nevertheless, the available dataset would appear to provide a robust basis for qualitative analysis and comparisons, including presence or absence of fish taxa in the reaches, broad scale spatial changes, and their relative abundances over time, as we present above. From that information, it would be reasonable to target specific reaches and the species they hold

Available information and data are insufficient, however, to allow quantification of potential impacts or beneficial mitigation actions that address flow alterations For resident fish species in the Gila River system, specific relations of flow regime to population densities or life history requirements have not been completed and are unlikely to be derived successfully using existing information and analyses, or extrapolation from closely related species in the literature. Section 2.5 introduces some general approaches to complete such assessments in the future.

3.5.6 Macroinvertebrates, Periphyton, and Diatoms

3.5.6.1 Review and Summary

For potential ecohydrological analyses, we acquired benthic sampling data from the NMED for periphyton, diatoms, and aquatic macroinvertebrates, as described in our Task 1b report (Tetra Tech 2013b). Macroinvertebrates, Periphyton, and diatoms, can be used as important environmental indicators because these taxa are well suited to characterize fundamental aquatic processes within a stream. Further, certain indices (e.g., derived from macroinvertebrates) are useful for assessing stream structure and function (e.g., Vannote et al. 1980). Lastly, these organisms typically display a measurable response to change, and knowledge about the natural abundance, distribution, and temporal/seasonal fluctuations can readily indicate alterations in aquatic ecosystems and their responses to disturbance regimes.

Macroinvertebrates are particularly important indicators because they can be defined by functional feeding groups, habits, and habitat types. Functional feeding groups, and their presence/absence in a given reach, can be thought of as an expression of the energy gradients within the larger system – different organisms occupy different reaches in response to the local food resources and substrates available and thus a characterization of a particular reach. These attributes allow for stream structure and function (e.g., producer/consumer community type, flow regime, etc.) to be inferred through a comparative analysis (over space, time, seasons, disturbance patterns, etc.) of the macroinvertebrate community. The following provides a brief categorical description of functional feeding groups, habits, and habitat types:

Functional Feeding Group	Description
Collector	Collect fine particulate organic matter (FPOM) from the stream bottom.
Filterer	Collect fine particulate organic matter (FPOM) from the water column using a variety of filters.
Piercer-Predator	Feed on other consumers, or plant material, using piercing mouth part.
Predator	Feed on other consumers.
Scraper	Scrape algae and associated material.
Shredder	Consume leaf litter or other course particulate organic matter (CPOM).

Habit	Description
Burrower	Inhabit fine sediment of streams and lakes. Some construct burrows which may have sand walls extending above the surface, others ingest their way through the sediment.
Climber	Adapted for living on vascular hydrophytes or detrital debris with modifications for moving vertically on stem type surfaces.
Clinger	Taxa have behavioral and morphological adaptations for attachment to surfaces in stream riffles and wave swept littoral zones of lakes.
Skater	Adapted to "skate" on the surface film of the water.
Sprawler	Inhabit the surface of floating leaves of vascular hydrophytes or fine sediments, usually with modifications for for staying on top of the substrate and maintaining the respiratory surfaces free of silt.
Swimmer	Adapted for swimming, usually cling to submerged rocks or plant material between short bursts of swimming.

Habitat	Description
Lentic (Ln)	Lentic
Lentic - Erosional (Ln - er)	Lentic - erosional
Lentic - Littoral (Ln - li)	Lentic - littoral

Lentic - (Ln - lm)	Lentic - limnetic
Lentic (Ln - lt)	Lentic - littoral
Lentic (Ln - vh)	Lentic - vascular hydrophytes
Lotic (LT)	Lotic
Lotic - depositional (LT - dp)	Lotic - depositional
Lotic - erodional (LT - er)	Lotic - erosional

The above information was used, with additional information, to develop benthic macroinvertebrate stream condition indices for wadable streams in New Mexico, which included data from 12 Gila River watershed locations, with three sites along its mainstem (Jacobi et al. 2006). This report includes no specific data for invertebrates at sampling sites within the report. Previously, Jacobi et al. (1998) investigated the development of an index of biotic integrity for New Mexico, that report includes single collections of aquatic macroinvertebrates from seven sites in the Gila River watershed, including two sites on the mainstem of the Gila River; these sample data are included in the report. An additional reference has been identified, a thesis from NMSU characterizing the spatial distribution of benthic macroinvertebrates within a desert section of the Gila River in New Mexico (Fuller 2003), but this thesis has not been obtained for review and, by its title, would appear to focus on sites downstream from the canyon reach of the Gila River. Jacobi and Carey (1986, 1996) and Cary and Jacobi (2008) have completed a series of collections of stoneflies in the parts of New Mexico and Arizona, including samples from the Gila River; these results provide general presence/absence, on stoneflies and limited ecological information. The completed literature review for the Gila River completed previously to this Tetra Tech project included six references related to invertebrate analyses in the southwest, none specifically related to the Gila River Watershed.

3.5.6.2 Data Gaps Assessment

The principal temporal data gap is the lack of samples from the spring and summer seasons. This is a potential concern because most periphyton species, including diatoms, have a relatively short life cycle (many less than a week) and many taxa may only be present during particular seasons. The temporal data gaps for macroinvertebrates are generally the same as for the diatoms. There are no consistent and recent samples from stations during the spring and summer seasons. Many macroinvertebrates have a one-year life cycle; however, in streams and rivers that have a high disturbance regime, like those in the Gila Basin, many macroinvertebrates have a life cycle considerably shorter than one year so that they can quickly recolonize areas that are frequently disturbed. A portion of the macroinvertebrate community, which may be significant, could be missed if seasons other than fall are not represented. Therefore, additional sampling during spring and summer is needed to fully capture the range of flow conditions and taxa that may be present, and how this relationship changes seasonally. This comparative approach will aid in potentially determining the most appropriate time for diversions and those times to be avoided.

Limited macroinvertebrate data exist for the Cliff-Gila Valley, 720 invertebrates have been identified at two sites. This limits the analyses possible for developing ecohydrological relationships. Collection of additional data in the future, likely after the river reestablishes a new qusi-equilibrium following the disturbances caused by watershed fires and severe flushing over the the past couple of years, would help to fill this data gap better establish present-day baseline conditions that for forecasting of future conditions over different flow scenarios.

The Middle Fork has no known periphyton sampling, a spatial data gap that may need to be addressed in the future.

3.5.7 Water Quality, Nutrients, and Contaminants

3.5.7.1 Review and Summary

The Task 1b report (Tetra Tech 2013b) reports that water quality data collected from 1976 to 2011 have been compiled for the Gila River and San Francisco rivers for 175 sites. While most of these data were collected by NMED, 97 sites around the confluence of the three major upper forks came from Nation Park Service 1976 samples. A map showing the distribution of the sample locations was included in the Task 1b report. Based on this information, NMED concluded that eight of the Gila River have water qualities that do not support the attainable uses for these surface waters, as defined by New Mexico Water Quality Standards. As such, based on water quality data collected by the NMED, Total Maximum Daily Loads were established for each tributary to address water quality exceedances and impairments. Table 3.3, below, describes each impairment of these Gila River tributaries, the designated uses threatened by the

Table 3.3 Tributaries to the Gila River having TMDLs for stream impairments status (from NMED).

Tributary	Impairment	Designated Use	Contaminant Source	Management Measures
Black Canyon Creek	Temperature	Domestic Water supply	Forest management	Plant woody riparian species
		High quality coldwater fishery	Removal of riparian vegetation	River restoration such as reconfiguration of sinuosity, installation of root wads and plantings to lower width to depth ratio
		Irrigation	Recreational Activities	Relocation of recreation sites
		Livestock watering		
		Wildlife habitat		
		Secondary contact		
Canyon Creek	Plant Nutrients	High quality coldwater fishery	Natural	Filter strip or vegetated buffer
			Rangeland	Detention basins
			Road maintenance/runoff	Reduced and efficient application of fertilizer
			Removal of riparian vegetation	Maintain healthy riparian ecosystem
			Streambank destabilization	
Canyon Creek	Turbidity	High quality coldwater fishery	Natural	Protection and/or development of healthy riparian buffer strips
			Rangeland	Placement of silt fences between roads and watercourses
			Road maintenance/runoff	Placement of straw mulch on soils
			Removal of riparian vegetation	
			Streambank destabilization	
East Fork of the Gila River	Chronic Aluminum	Domestic Water supply	Natural	Wetland treatment
		High quality coldwater fishery	Rangeland	Improve pH
		Irrigation	Removal of riparian vegetation	Sulfate and Sulfate reducing bacteria
		Livestock watering	Forest management	Stormwater management and construction BMPs
		Wildlife habitat		
		Secondary contact		
Mogollon Creek	Chronic Aluminum	High quality coldwater fishery	Rangeland	Filter strip or vegetated buffer
			Resource extraction	Management of fertilizer and road salt applications
			Unknown	Address placement of mine tailings and holding ponds
			Streambank modification/destabilization	
			Forest management	
Mangus Creek	Plant Nutrients	Marginal coldwater fishery	Natural	Filter strip or vegetated buffer
		Warmwater fishery	Rangeland	Detention basins
		Primary Contact Recreation	Hydromodification	Reduced and efficient application of fertilizer
			Removal of riparian vegetation	Maintain healthy riparian ecosystem
			Streambank modification/destabilization	
			Unknown	
Sapillo Creek	Total Organic Carbon	High quality coldwater fishery	Unknown	Protection and/or development of healthy riparian buffer strips
			Hydromodification	Placement of silt fences between roads and watercourses
			Road maintenance/runoff	Placement of straw mulch on soils
			Removal of riparian vegetation	
			Streambank modification/destabilization	
			Upstream impoundment	
			Nuisance algae	
Sapillo Creek	Turbidity	High quality coldwater fishery	Unknown	Protection and/or development of healthy riparian buffer strips
				Placement of silt fences between roads and watercourses
				Placement of straw mulch on soils
Taylor Creek	Chronic Aluminum	Domestic Water supply	Natural	Wetland treatment
		High quality coldwater fishery	Rangeland	Improve pH
		irrigation	Recreation	Sulfate and Sulfate reducing bacteria
		livestock watering	Upstream impoundment	Stormwater management and construction BMPs
		Wildlife habitat		
		Secondary contact		
Taylor Creek	Temperature	High quality coldwater fishery	Natural	Plant woody riparian species
			Rangeland	River restoration such as reconfiguration of sinuosity, installation of root wads and plantings to lower width to depth ratio
			Recreation	Relocation of recreation sites
			Upstream impoundment	

impairment, the source of the contaminant, and management measures that could improve the impairment. The water quality impairments listed for Gila River tributaries are chronic aluminum (East Fork of the Gila River , Mogollon Creek and Taylor Creek), plant nutrients (Canyon Creek, Mangus Creek), temperature (Black Canyon Creek, Taylor Creek), total organic carbon (Sapillo Creek), and turbidity (Canyon Creek, Sapillo Creek). While some of these impairments are caused by natural sources and processes, they can be exacerbated by anthropogenic activities. For example, chronic aluminum impairment can be due to geologic sources and often correlates with increased turbidity. However, as pointed in the respective TMDLs for the tributaries, poor land management and fire suppression tends to reduce the regenerative abilities of the landscape, negatively impact riparian areas, and contributed to soil erosion and increased turbidity; all of these, in turn, can increase aluminum concentrations.

The Gila River Watershed has been the focus of a number of water chemistry studies conducted from 1940-1998 that examined various constituents and/or factors influencing surface and groundwater quality. Water quality over temporal and spatial scales, as well as the effects of processes such as land use, fire, phreatophyte removal, precipitation, and discharge on water quality, have been examined and some of these results are reviewed below as an to overview of the processes occurring in the Gila Watershed.

Hem (1950) studied water quality of the Gila River basin above Coolidge Dam, Arizona by examining surface and groundwater samples collected between 1940 and 1944. Twedt (1984) examined water quality in the Upper Gila Water Supply Project. From 1986-1997, both Pierce (1986; 1987; 1991a, b; 1993a, b, c, d) and Smolka (1987a, b; 1991; 1996; 1997a, b) conducted reconnaissance surveys of creeks within the Gila Watershed, as well as other neighboring watersheds. Ditmore (1998) conducted a special Water Quality Survey of the Iron, Taylor, Hoyt, Black Canyon, and Sapillo Creeks.

Laney and Hjalmarson (1977) collected water quality data from 1964-1972 to define changes caused by phreatophyte removal. They found that fluctuations in dissolved-solids in the alluvial deposits and Gila River are large. Evapotranspiration was reduced and baseflow increased after phreatophyte removal which should in turn cause a less rapid increase in dissolved-solids in the ground water. However, evaporation of ground water occurred even after phreatophyte removal. Phreatophyte removal also caused no significant change in the specific conductance of water in the alluvial deposits.

Flooding was found to increase turbidity and concentrations of chloride, ammonia, nitrate and phosphate while major cations decreased and trace elements did not change or decreased slightly (Rampe et al. 1984).

Temporal trends for 19 water chemistry constituents and turbidity for 13 sites in the Gila River Basin in Arizona and New Mexico were examined by Baldys et al. (1995). In general, the chemical constituents decreased in concentration temporally. Increased concentrations were generally in three areas in the basin at Pinal Creek above Inspiration Dam, at sites above reservoirs and at sites on the main stem of the Gila River from Gillespie Dam to the mouth.

Earl (1999) found that fire events increased the concentrations of nutrients, cations, anions, alkalinity and conductivity while dissolved oxygen and percent saturation of oxygen decreased in four streams.

Acuna and Dahm (2006) examined linkages between landscape cover features and water chemistry and whether drainage size influenced the temporal variability in the water chemistry of streams. Most chemical constituents corresponded to geological features at the basin scale while others corresponded to riparian features, specifically total suspended solids and phosphate. The relationship between land cover and water chemistry differed between baseflow and monsoonal conditions which suggested that seasonal changes in hydrologic routing and water sources significantly impact water chemistry and suggests that climate change could also influence water chemistry. Temporal variability in chemistry increased with spatial scale most likely due to the variety of contributing water sources and the effect of dilution and concentration in each spatial scale.

3.5.7.2 Data Gaps Assessment

The water chemistry sample sites and years sampled between 1976-2011 were presented in the Task 1b report (Tetra Tech 2013b). This information shows that chemical constituents were not consistently sampled at regular intervals and samples were not consistently collected for all chemical constituents at each sampling location. Some sampling sites were sampled more frequently and for more analytes; some chemical constituents were analyzed more frequently than others across sites. These inconsistencies produce gaps in the data over the sites and sampling intervals.

Sampling and analysis of large suites of analytes over many sites is an expensive endeavor and may not need to be accomplished on a regular basis, unless there are conditions and circumstances that warrant such efforts. This can be particularly true for more remote areas of the Gila and San Francisco Watersheds, for example. Thus, it is not entirely correct to say that there is a data gap because a given site has not been sampled for a number of years or for a particular constituent; however, impairment status is an indicator of potential problems and such areas typically should scrutinized more carefully. From an ecological perspective, nutrient dynamics are important drivers of stream structure and function; as such they typically should be monitored more regularly and not lumped in with larger suites of analytes that need not be tested for at closer intervals (e.g., pesticides, herbicides, etc.). It is fair to note, however, that the bulk of the water quality sampling and analyses conducted in the past has been to assess whether water quality conditions in the system comply with state and federal requirements. Such monitoring typically does require the same frequency of sample and analyses that can be required for ecological or other research efforts.

Overall, there is a robust body of knowledge and data on the water quality of the Gila River watershed. Although concentrated in certain areas, the spatial distribution of the known data is fairly widespread and the period of record is extensive. The lower Gila River has been sampled less frequently; yet a more frequent sampling and assessment schedule likely could produce an improved characterization of potential inputs from agricultural sources (e.g., irrigation returns and grazing). A more frequent (and perhaps synoptic surveys) of nutrients could aid in enhancing the understanding ecohydrological relationships and processes with the system.

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Appendix A

Appendix A

ESA Listed Species from County Lists Overlapping the Gila River Watershed Not Requiring Additional Analyses for Compliance Considerations

This appendix provides brief discussion on the biology and known distributions of species listed under the Federally Endangered Species Act to describe for each the bases for not expecting to be encountered or potentially affected by a possible AWSA projects, as shown in Table 3.1 of this report.

Chihuahua chub (*Gila nigrescens*) was federally listed as threatened under the Endangered Species Act in in 1983 (USFWS 1983) and is listed as endangered by the state of New Mexico. Its historic range included the Mimbres River, Rio Casa Grandes, Rio Piedras Verdes, Arroyo del Aguila, Rio San Miguel, Rio Santa Maria, Rio del Carmen, and Rio Janos and within the Laguna Bustillos Basin in the States of Chihuahua, Mexico. It is presently endemic only to a two-mile stretch of the Mimbres River and two short (100 yards) spring-fed tributaries just north of the town of Mimbres, New Mexico.[33] As such, potential AWSA developments in the Gila Watershed, on the west side of the Continental Divide from the Mimbres River on the eastside. As such, potential AWSA project developments are likely neither to encounter nor to need address environmental regulatory concerns for this species

White sands pupfish (*Cyprinodon tularosa*) – This species is not currently listed under Endangered Species Act by the USFWS, but is listed as threatened by the State of New Mexico. The species is endemic to south-central New Mexico. It is restricted to the Tularosa Basin, where it is found in Malpais Spring and the Lost River (Otero County), and Mound Springs (Lincoln Coounty).[34] Potential AWSA project developments are likely neither to encounter nor to need address environmental regulatory concerns for this species.

Sonoran desert toad (*Ollotis alvaria*) – This species is listed by New Mexico as threatened, it is restricted to Hidalgo County, along the Arizona border (northward to the vicinity of Rodeo) and eastward locally to near Animas and southeast of the Animas Mountains in lower Deer Creek. Areas of key habitat for this species in NM include the above localities, plus others such as Guadalupe Canyon and the Cloverdale region; reaches the eastern limit of its range in New

[33] http://ecos.fws.gov/docs/life_histories/E028.html
[34] http://www.bison-m.org/booklet.aspx?id=010360

Mexico.[35] Potential AWSA project developments are likely neither to encounter nor to need address environmental regulatory concerns for this species.

New Mexico ridgenose rattlesnake (*Crotalus willardi obscurus*) – This snake is federally listed as threatened and listed by New Mexico as endangered, it is endemic to New Mexico and the San Luis Mountains of adjacent Chihuahua, Mexico (USFWS 1978, 2012c). This rattlesnake is known only from the Animas and very locally in the Peloncillo mountains (Hidalgo County), which are the key habitat areas for the species in the state. Potential AWSA project developments are likely neither to encounter nor to need address environmental regulatory concerns for this species.

Reticulate Gila monster (*Heloderma suspectum suspectum*) – is listed as endangered by the State of New Mexico, reaching the eastern edge of its range in southwest New Mexico where it is known from Hidalgo, Grant, Luna and perhaps Dona Ana counties. The species was first reported from New Mexico in 1951 and is common only at Redrock Wildlife Area in Grant County and at Granite Gap in Hidalgo County; the one specimen found in Dona Ana county is thought to be an escaped or intentionally liberated specimen.[36] Potential AWSA project developments are likely neither to encounter nor to need address environmental regulatory concerns for this species.

Gray-checkered whiptail (*Aspidoscelis dixoni*) – listed as endangered by the State of New Mexico, and is known from only two localities, one in southwestern New Mexico and the other in Trans-Pecos Texas in Presidio County, which is the major area of occurrence for this species. In New Mexico this lizard is known only from Hidalgo County, where apparently confined to its key habitat in the vicinity of Antelope Pass in the foothills of the Peloncillo Mountains; there is also one record from northeast of Animas, which may indicate the existence of a population in that area.[37] Potential AWSA project developments are likely neither to encounter nor to need address environmental regulatory concerns for this species.

Least tern (*Sternula antillarum athalassos*) – also sometimes known as the Interior least tern, has been listed by both the USFWS and the State of New Mexico as Endangered, with the federal listing effective May 28, 1985 (USFWS 1985a). This species apparently has not been recorded along the Gila River; its distribution is along the more eastern portions of New

[35] http://www.bison-m.org/booklet.aspx?id=020095
[36] http://www.bison-m.org/booklet.aspx?id=030135
[37] http://www.bison-m.org/booklet.aspx?id=030465

Mexico.[38] Potential AWSA project developments are likely neither to encounter nor to need address environmental regulatory concerns for this species.

Aplomado falcon (*Falco femoralis septentrionalis*) has been listed by both the USFWS and the State of New Mexico as endangered, with the federal listing effective March 27, 1986.[39] Since the species is considered to extirpated, on July 26, 2006, the USFWS listed the species in New Mexico and Arizona as a Nonessential Experimental Population. This species apparently has not been recorded along the Gila River; its distribution is along the more eastern portions of New Mexico (USFWS 2006c). Potential AWSA project developments are likely neither to encounter nor to need address environmental regulatory concerns for this species.

Whooping crane (*Grus americana*) – has been listed by both the USFWS and the State of New Mexico as Endangered, with the federal listing effective March 11, 1967. This species was formerly widespread in North America, but through historic times, it has declined to the point that at present it breeds only in Wood Buffalo National Park in the Northwest Territories in Canada. From there it migrates through the Great Plains to winter on the Texas coast at Aransas National Wildlife Refuge. Beginning in 1975, an experimental population produced at Grays Lake National Wildlife Refuge, Idaho, migrated southward to winter in New Mexico and adjacent areas. Although the species now occurs in New Mexico (the result of the so-called Grays Lake NWR experiment), the only indication of prior occurrence is in the form of unverified reports in Dona Ana County in the 1850s, Roosevelt County in 1938, and Union County in the 1960s.[40] In New Mexico, the whooping cranes generally occur on Bosque del Apache National Wildlife Refuge or State game refuges during fall and winter (USFWS 1997). This species has not been recorded along the Gila River. Potential AWSA project developments are likely neither to encounter nor to need address environmental regulatory concerns for this species.

Northern beardless tyrannulet (*Camptostoma imberbe ridgwayi*) – is listed as Endangered by New Mexico and is included for consideration under the Federal Migratory Bird Treaty Act. In New Mexico, its population appears to be limited to generally only a few pairs in Guadalupe Canyon.[41] Potential AWSA project developments are likely neither to encounter nor to need address environmental regulatory concerns for this species.

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[38] http://www.bison-m.org/booklet.aspx?id=042070
[39] http://www.bison-m.org/booklet.aspx?id=040380#ref_26
[40] http://www.bison-m.org/booklet.aspx?id=040220
[41] http://www.bison-m.org/booklet.aspx?id=040020

Thick-billed kingbird (*Tyrannus crassirostris*) – is listed as Endangered by New Mexico and also is included for consideration under the Federal Migratory Bird Treaty Act. The species appears to be reasonably common in Mexico, but in peripheral areas, it is often local and rare. Thick-billed kingbirds are regular summer residents in Guadalupe Canyon and Animas Mountains in extreme southwestern New Mexico and into adjacent areas of Arizona. Most recently, breeding in the US appears to be centered in sycamore riparian habitats at Sonoita Creek (near Patagonia), in Sycamore Canyon (Pajarito Mountains), and Guadalupe Canyon (east of Douglas).[42] Potential AWSA project developments are likely neither to encounter nor to need address environmental regulatory concerns for this species.

Buff-collared nightjar (*Caprimulgus ridgwayi ridgwayi*) – is listed as Endangered by New Mexico and is included for consideration under the Federal Migratory Bird Treaty Act. It occurs in summer from southeastern Arizona and extreme southwestern New Mexico southward to Honduras and Guatemala. In New Mexico, it occurs almost exclusively in Guadalupe Canyon (Hidalgo County), which is the key habitat area for the species in the state.[43] Potential AWSA project developments are likely neither to encounter nor to need address environmental regulatory concerns for this species.

Brown pelican (*Pelecanus occidentalis carolinensis*) – had been listed under the Endangered Species Act as Endangered, but was subsequently determined to having been recovered and delisted by the USFWS (2006d); it remains listed as Endangered by the State of New Mexico. Sighting records include 13 New Mexico counties, with most from large lakes or along major rivers, including in the San Juan, Gila, Rio Grande, and Pecos drainages. Due to the rarity of the species in New Mexico, next to nothing is known about its habits in the state. Since the reliable records are all of solitary birds, generally in sub-adult plumages, near water, it is speculated that most occurrences in the state would be of storm-driven birds that moved inland under duress.[44] Potential AWSA project developments are likely neither to encounter nor to need address environmental regulatory concerns for this species.

Arizona grasshopper sparrow (*Ammodramus savannarum ammolegus*) – is listed as Endangered by New Mexico and is included for consideration under the Federal Migratory Bird Treaty Act. In New Mexico, it is known to breed only in the southern Animas Valley and the western Playas Valley, both on the privately owned Gray Ranch in Hidalgo County.[45] Potential

[42] http://www.bison-m.org/booklet.aspx?id=041055
[43] http://www.bison-m.org/booklet.aspx?id=041235
[44] http://www.bison-m.org/booklet.aspx?id=041400
[45] http://www.bison-m.org/booklet.aspx?id=041846

AWSA project developments are unlikely to encounter nor to need address environmental regulatory concerns for this species.

Elegant trogon (*Trogon elegans canescens*) – is listed as endangered by New Mexico and is included for consideration under the Federal Migratory Bird Treaty Act. It is often common in Mexico, but in the United States, it is local and uncommon. In New Mexico, it occurs rarely and irregularly in the southwestern most part of the state; a vagrant was confirmed near the Cornudas Mountains (Otero County) and another pair in the Animas Mountains (Hidalgo County).[46] Potential AWSA project developments are likely neither to encounter nor to need address environmental regulatory concerns for this species.

Black-footed ferret (*Mustela nigripes*) – was listed in 1967 under the Endangered Species Act as Endangered.[47] Although it has been delisted by the state of New Mexico, it continues to receive full protection by the state under its federal listing. The historic and presumably present range stretches from southern Alberta and Saskatchewan, Canada through twelve western states including Arizona, New Mexico, and Texas at its southern limit. The black-footed ferret could potentially occur anywhere there are prairie dog colonies of sufficient size. No records are known from its formerly extensive range in southern New Mexico, and since black-tailed prairie dogs are largely eliminated there, it seems unlikely that any ferrets survive. A re-introduced population of black-footed ferrets occurs in Colfax County. If any natural populations survive in New Mexico, they would most likely occur in the northwestern part of the state.[48] AWSA project developments are likely neither to encounter nor to need address environmental regulatory concerns for this species.

Mexican long-nosed bat (*Leptonycteris nivalis*) – has been listed by both the USFWS and the State of New Mexico as Endangered, with the federal listing effective 1988 (USFWS 1988). The range of the Mexican long-nosed bat occurs mainly from the southern Trans-Pecos region of Texas to Guatemala; the species is known in New Mexico from single specimens taken in July 1963 and September 1967 in Guadalupe Canyon in the southernmost Peloncillo Mountains.[49] Long-nosed bats are well-known pollinators of agaves, as well as organpipe, saguaro, and cardon cacti. In New Mexico, this species inhabits upper desert, scrub-pine oak woodlands in or near mountainous areas. Characteristic vegetation in these areas includes agaves (*Agave spp.*), junipers (*Juniperus spp.*), oaks (*Quercus spp.*), and Mexican pinyon (*Pinus cembroides*). AWSA

[46] http://www.bison-m.org/booklet.aspx?id=042165
[47] http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=A004
[48] http://www.bison-m.org/booklet.aspx?id=050225
[49] http://www.bison-m.org/booklet.aspx?id=050060

project developments are likely neither to encounter nor to need address environmental regulatory concerns for this species.

Lesser long-nosed bat (*Leptonycteris curasoae yerbabuenae*) – has been listed by the USFWS as Endangered in 1988 (USFWS 1988) and the State of New Mexico as Threatened. This bat species occurs from South America north through Mexico to southern Arizona and southwestern New Mexico; populations in the United States represent the northern extent of the species' range. In New Mexico, this bat is known from the Animas, Peloncillo, and Big Hatchet mountains and adjacent valleys in southern Hidalgo County. Caves and rock fissures are the only known day roost sites in New Mexico, but the species is also known to roost in trees, mines, culverts, and buildings elsewhere in its range. AWSA project developments are likely neither to encounter nor to need address environmental regulatory concerns for this species.

Jaguar (*Panthera onca arizonensis*) – has been listed by the USFWS as Endangered and the State of New Mexico as restricted, but with full protection under the federal listing, which became effective March 28, 1972 (USFWS 2012d). The historical range of the jaguar included portions of the States of Arizona, New Mexico, Texas, and Louisiana and extended south to include central Mexico through Central America and into South America as far as northern Argentina; the United States no longer contains established breeding populations, which probably disappeared in the 1960s.[50] A single jaguar was photographed in 1967 the Peloncillo Mountains and another was photographed in the Baboquivari Mountains one month later. AWSA project developments are likely neither to encounter nor to need address environmental regulatory concerns for this species.

Arizona shrew (*Sorex arizonae*) – is not listed by the USFWS under the Endangered Species Act,[51] but is listed as Endangered by the State of New Mexico. The range of this species includes southeastern Arizona, southwestern Chihuahua, and New Mexico. In New Mexico, the Arizona shrew is known only from the Animas Mts. (Hidalgo County), where two specimens have been taken.[52] AWSA project developments are likely neither to encounter nor to need address environmental regulatory concerns for this species.

Arizona montane vole (*Microtus montanus arizonensis*) – formerly a Candidate species under the Endangered Species Act, it is not currently listed by USFWS.[53] It is listed as Endangered by

[50] http://www.bison-m.org/booklet.aspx?id=050315
[51] http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=A09F
[52] http://www.bison-m.org/booklet.aspx?id=050685
[53] http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=A0EQ

the State of New Mexico. This vole has been recorded from British Columbia south to east-central California, Arizona, and New Mexico. This Arizona subspecies is restricted to the White Mountains of eastern Arizona and adjacent portions of the Gila National Forest in New Mexico.[54] It is known only from Catron County where they have been documented at Centerfire Bog, Jenkins Creek, Flanagan Spring, Romero Creek, SA Creek, and the upper San Francisco River. AWSA project developments are likely neither to encounter nor to need address environmental regulatory concerns for this species.

Todsen's pennyroyal (*Hedeoma todsenii Irving*) – was given an Endangered status and Critical Habitat was designated on January 19, 1981 (USFWS 1981). This plant was designated as endangered because of its extremely restricted range and small population size. The State of New Mexico lists Todsen's pennyroyal as endangered (Sivinski and Lightfoot 1995). Todsen's pennyroyal grows in gypseous-limestone soils on north-facing slopes in piñon-juniper woodland. Low number of populations, low sexual reproduction, low genetic diversity, poor dispersal, fire, insect predation, and disease are potential natural threats. There are no imminent threats to this species from present land management activities. It is known from 18 sites in the San Andres and Sacramento mountains of south-central New Mexico. AWSA project developments are likely neither to encounter nor to need address environmental regulatory concerns for this species.

Zuni fleabane (*Erigeron rhizomatus*) – was listed as Threatened by the USFWS on April 26, 1985, noting that about 20 populations were know and all are located in New Mexico (USFWS 1985b). Populations are known only on the Cibola National Forest in areas south of Fort Wingate in McKinley County, and on the Cibola National Forest and adjacent areas administered by the Bureau of Land Management (BLM) northwest of Datil in Catron County. Since the known locations of this species include federally managed lands, the agencies are well aware of its management needs, Critical Habitat was not designated for this species. AWSA project developments are likely neither to encounter nor to need address environmental regulatory concerns for this species.

[54] http://www.bison-m.org/booklet.aspx?id=050841