

FINAL HYDROGRAPHIC SURVEY REPORT FOR THE HOPI INDIAN RESERVATION

*In re The General Adjudication of the
Little Colorado River System and Source*



Arizona Department of Water Resources

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ACRONYMS

ADOT	Arizona Department of Transportation
ADPS	Arizona Department of Public Service
ADWR	Arizona Department of Water Resources
AF	acre-feet
AFA	acre-feet per annum (year)
AFY	acre-feet per year
ALRIS	Arizona Land Resource Information System
AU	animal unit
AUYL	animal units year long
BIA	Bureau of Indian Affairs
C	Coconino Aquifer
CD	compact disk
CIR	Composite Irrigation Requirement
cords/acre	cords per acre



CU	Consumptive Use
D	Dakota Aquifer
DCMI	Domestic, Commercial, Municipal and Industrial Use
DEM	digital elevation model
EIS	Environmental Impact Statement
ET	evapotranspiration
ft ³ /acre	cubic feet per acre
gpcd	gallons per capita per day
gpd	gallons of water per day
gpm	gallons per minute
GNIS	Geographic Names Information System
GSA	Geological Society of America
GSMU	general soil mapping unit
HPL	Hopi Partitioned Lands
HRES	Hopi Tribal Office of Resources Enforcement Service
HSR	Hydrographic Survey Report
HTHA	Hopi Tribal Housing Authority
IHS	Indian Health Service
IRA	Indian Reorganization Act
IRR	Indian Reservation Roads
JUA	Joint Use Area
lb/ac	pounds per acre
LCR	Little Colorado River
LOM	Life-of-Mine
MAF	million acre-feet
MDC	Moenkopi Development Corporation
MGS	Mohave Generating Station
Mya	million years ago
N	Navajo Aquifer
NAU	Northern Arizona University
NGS	Navajo Generating Station
NIR	Net Irrigation Requirement
NOA	Notice of Appropriations
NPL	Navajo Partitioned Lands
NRCS	National Resource Conservation Service
NWIS	National Water Information System
ORM	Hopi Tribal Office of Range Management
PCDD	Planned Community Development District
PWCC	Peabody Western Coal Company
PWS	public water system
SID	Supplemental Irrigation Demand
SOC	statement of claimant
T	Toreva Aquifer
TDS	total dissolved solids
USGS	United States Geological Survey
UST	underground storage tank



VFR visual flight recognition
WWTP wastewater treatment plant

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CHAPTER 1: INTRODUCTION AND SCOPE

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1.1 INTRODUCTION

The Arizona Department of Water Resources (Department or ADWR) prepared this Final Hydrographic Survey Report (Final Hopi HSR) to address water rights claimed by the Hopi Tribe, and the United States on the Tribe's behalf, for use on the Hopi Reservation. The Final Hopi HSR was preceded by a Preliminary Hopi HSR that the Department issued on December 31, 2008.

The Department's publication of the Final Hopi HSR and the Preliminary Hopi HSR was requested by the court in a general stream adjudication entitled *In re the General Adjudication of All Rights to Use Water in the Little Colorado River System and Source*, No. 6417, pending in the Superior Court for Apache County (LCR adjudication). The LCR adjudication is a judicial proceeding and the Department is technical advisor to the LCR adjudication court. Judicial proceedings for the LCR adjudication are governed by Arizona Revised Statutes (A.R.S.) §§ 45-251 to 264. Copies of court decisions and orders relating to the water right claims for the Hopi Reservation are included in **Appendix A**.

Figure 1-1 depicts the geographic area of the LCR adjudication, which includes both Indian and non-Indian lands. The non-Indian lands are divided into the Silver Creek watershed, the Upper Little Colorado River watershed, and the Lower Little Colorado River watershed. Indian lands in the LCR adjudication include the Hopi Reservation, parts of the Navajo, Zuni, and White Mountain Apache (formerly Fort Apache) Indian reservations, and lands occupied by the San Juan Southern Paiute Tribe.¹

1.2 ESTABLISHMENT OF THE RESERVATION

The Hopi Reservation lands are located within two non-contiguous geographic areas referred to in this report as the 1882 Executive Order Reservation and the 1934 Act Reservation (collectively, the "Reservation" or "Hopi Reservation").² Lands within the 1882 Executive Order

¹ The lands occupied by the San Juan Southern Paiute Tribe are not depicted on **Figure 1-1**. The nature, location and extent of these lands are in dispute, but are believed to be generally located north of Moenkopi Village within the Navajo reservation.

² The boundary of the Hopi Reservation depicted on **Figure 1-1** is based on a map from Ebert & Associates (Ebert), a consultant to the United States.



Reservation consist of areas known as District 6 and Hopi Partitioned Lands. Lands within the 1934 Act Reservation consist of Moenkopi Village (sometimes referred to as Moenkopi Island) and allotted lands. See **Figure 1-2**. The physical and cultural setting of the Hopi Reservation lands is described further in **Appendix B**.

The 1882 Executive Order Reservation consists of approximately 2.5 million acres and was established by an Executive Order dated December 16, 1882 issued by President Chester A. Arthur. The 1882 Executive Order Reservation is surrounded by the Navajo Reservation.

For decades, the Hopi and the Navajo disputed their respective rights and interests to land within the 1882 Executive Order Reservation. The Hopi claim an exclusive interest in an area known as Land Management District 6 (District 6), which was created to implement federal grazing regulations. The area outside of District 6 is known as the Joint Use Area, which was partitioned by the Arizona federal district court into Hopi Partitioned Lands and Navajo Partitioned Lands pursuant to the Navajo-Hopi Land Settlement Act (1974 Settlement Act). See Pub. L. No. 93-531, 88 Stat. 1712, 1714 § 4(a).

In addition to lands within the 1882 Executive Order Reservation, the Hopi Reservation includes a non-contiguous area that also is surrounded by the Navajo Reservation. In 1934, Congress passed an act that withdrew certain lands for the benefit of the Navajo and “such other Indians as may already be located thereon.” Act of June 14, 1934, Ch. 521, 48 Stat. 960, 961 (1934 Act). The 1974 Settlement Act authorized both the Navajo and Hopi to bring a quiet title action, if necessary, to determine their respective interests in lands withdrawn under the 1934 Act, including Moenkopi Island. Litigation followed the partitioning of the Joint Use Area and the withdrawal of lands under the 1934 Act for several years.

The Hopi and the United States claim water rights for use within District 6, the Hopi Partitioned Land and Moenkopi Island, including allotted lands. Within the 1934 Act Reservation, in the vicinity of Moenkopi, there are several allotments that were established in the early 1900s pursuant to the Indian General Allotment Act of 1887, also known as Dawes Severalty Act. Under this Act, the President was authorized to allot reservation lands to individual Indians when advantageous for “agricultural and grazing purposes.” Act of February 8, 1887, Ch. 119, § 1, 24 Stat. 388. As part of the Indian Reorganization Act of 1934, the allotment program ended. The allotments within the 1934 Act Reservation are depicted on **Figure 1-2** and are included within



the claims filed by the Hopi and United States, which are described in **Chapter 3**. Water uses for these lands are also described in **Chapter 4**.

1.3 HISTORY OF PROCEEDINGS

In 1985, the Hopi and the United States each filed a statement of claimant (SOC) that claimed water rights for use on the Hopi Reservation. Each of these SOCs were amended several times through 2015. The Hopi and United States SOCs are summarized below and further described in **Chapter 3**, and **Tables 3-1, 3-2 and 3-3**. Also summarized are several orders entered by the LCR adjudication concerning the claims filed for the Hopi Reservation. For several years, negotiations were underway to settle the claims filed by the Hopi and the Navajo. In 2012, the settlement negotiations ended.

The original claims were filed on November 29, 1985 by the Hopi Tribe (SOC No. 39-91443) and by the United States, on behalf of both the Hopi Tribe and the Navajo Nation (SOC No. 39-91441).³ Pursuant to orders entered in 1988 and 1994 by the LCR adjudication court, on September 23, 1994, the Department filed a preliminary HSR for all tribal lands within the LCR adjudication, including the Hopi Reservation.⁴ This report was titled “Hydrographic Survey Report for Indian Lands in the Little Colorado River System” (Preliminary Indian Lands HSR), and the deadline for submitting comments on the report was December 22, 1994. On November 22, 1994, shortly before the end of the comment period, the United States filed a “Statement of Amended Claims” on behalf of the Hopi Tribe, the Navajo Nation, the White Mountain Apache Tribe and the Zuni Pueblo.⁵ Due to ongoing settlement negotiations, the deadline for submitting comments on the report was stayed by Judge Minker, then presiding over the LCR adjudication.

Judge Minker’s stay was not lifted until six years later when Judge Dawson, the next presiding judge, reopened the comment period with a deadline of June 30, 2000.⁶ The Department reviewed the comments and submitted a report to the LCR adjudication court on August 10, 2000, in which the Department recommended that separate HSRs rather than a joint HSR be prepared

³ On December 18, 1985, the Department received another copy of the United States claim that was revised to correct a typographical error.

⁴ See Pre-Trial Order No. 2 dated August 15, 1988 at 1-2, as modified by Order dated January 27, 1994.

⁵ The statement was filed in accordance with an April 18, 1994 Minute Entry of the Court, and the September 23, 1994 “Memorandum from Special Master to Water Rights Claimants in the Little Colorado River General Stream Adjudication.” Statement of Amended Claims at 2.

⁶ See Minute Entry dated May 5, 2000 at 4.



for tribal lands within the LCR adjudication, starting with an HSR for the Hopi Reservation.⁷ Subsequently, Judge Dawson directed the Department to commence the preparation of an HSR for Hopi tribal lands, and indicated that the Department would not be expected to update the Preliminary Indian Lands HSR.⁸

On January 4, 2002, Judge Dawson retired from the Superior Court.⁹ By Order dated January 17, 2002, the Arizona Supreme Court assigned Judge Ballinger to the LCR adjudication. In July 2002, Judge Ballinger ordered the Hopi Tribe and the United States, as trustee for the Hopi Tribe, to amend their SOC's for all reservation and non-reservation lands by December 20, 2002, and to submit information to the Department regarding allotted lands.¹⁰ On August 16, 2002, the United States submitted information concerning allotted lands as ordered by the Court, and stated that it was asserting "water right claims regarding the Hopi Allotted lands on behalf of the Hopi Tribe, its members and Hopi allottees." The Hopi Tribe assisted the United States in gathering information about the Hopi allotments and water uses, and joined in the United States' submittal.

On January 30, 2004, both the Hopi Tribe and the United States filed their amended claims upon court order extending the prior deadline.¹¹ By Minute Entry Order dated November 4, 2004, Judge Ballinger limited the Hopi HSR to the "main reservation lands," which do not include the Hopi Industrial Park or other lands known as the Hopi Ranches or "Hopi newly acquired lands" that were included in the 2004 amended claims. The "main reservation lands" are those lands that are depicted as the 1882 Executive Order Reservation and the 1934 Act Reservation in **Figure 1-1**.

After the 2004 amendments were filed, the Department began its investigation of the amended claims and the Hopi Tribe and the United States provided additional information in support of their 2004 amended claims. The Department issued the Preliminary Hopi HSR on December 31, 2008.

By Minute Entry Order dated March 2, 2009, with respect to surface streams within the Little Colorado River Basin, Judge Ballinger ruled that "the Hopi is precluded from asserting water right claims in this adjudication to the extent such claims seek the right to water sources located

⁷ See Minute Entry filed August 25, 2000, Attachment at 3.

⁸ See Minute Entry filed October 16, 2001 at 8-9.

⁹ See Minute Entry filed November 9, 2001.

¹⁰ See Minute Entry filed July 16, 2002 (2002 Order) at 5.

¹¹ See Minute Entry filed May 9, 2003.



within the Little Colorado River Basin that neither abut nor traverse Hopi lands.” By order dated October 25, 2011, the Arizona Supreme Court declined to take interlocutory review of Judge Ballinger’s March 2, 2009 order.

On or about March 30 and June 30, 2009, comments were filed to the Preliminary Hopi HSR by several parties. Also, on June 30, 2009, the United States amended SOC No. 39-91441, and on November 12, 2009, the Hopi Tribe amended SOC No. 39-91443, followed by the submission of additional information as requested by the Department.

On April 24, 2013, the Special Master for the LCR adjudication issued a report in contested case no. CV 6417-201, *In re Hopi Tribe Priority* (Special Master’s Priority Date Report). In this report, the Special Master entered findings of fact and conclusions of law regarding priority dates for the water right claims for District 6, the Hopi Partitioned Lands, and Moenkopi Island. On October 17, 2012, Judge Brain was appointed to replace Judge Ballinger, who had resigned. On January 17, 2014, oral argument was held before Judge Brain on objections to the Special Master’s Priority Date Report. The matter is under consideration.

On May 4, 2015, ADWR issued a 120-day notice, pursuant to Pre-Trial Order No. 6, of its intention to file the Final Hopi HSR on September 1, 2015. On June 2, 2015 both the Hopi and the United States amended their SOC’s, and ADWR requested that they provide additional information to support the amendments. Some, but not all, of the requested information was forthcoming. By ADWR notice dated August 19, 2015, the publication date for the Final Hopi HSR was extended to December 18, 2015, and on September 17, 2015, the Hopi filed a supplement to its amended claim.

1.4 SCOPE

The scope of the Final Hopi HSR is based on a 2001 decision of the Arizona Supreme Court in a case known as *Gila V*,¹² a July 2002 order issued by Judge Ballinger, and July 2013 and November 2015 orders issued by Judge Brain. Under *Gila V*, the water rights for the Hopi Reservation are to be quantified by determining the minimal need to serve the purpose of the reservation, *i.e.* as a permanent home and abiding place, also referred to as homeland purposes. *Gila V*, 35 P.3d at 76-77.

¹² *In re the General Adjudication of All Rights to Use Water in the Gila River System and Source*, 201 Ariz. 307, 35 P.3d 68 (2001).



By order filed July 16, 2002, Judge Ballinger directed the Department to prepare the Hopi HSR in compliance with *Gila V*. Judge Ballinger specifically directed the Department to include the following in the Hopi HSR:

- a. Hydrological and technical information about available surface water and groundwater resources to meet each claim;
- b. Comprehensive information about historic, current and existing water uses;
- c. A description of all statements of claimant, including amendments, filed by both the Hopi Tribe and the United States on behalf of the Hopi Tribe;
- d. A description of any statement of claimant filed by claimants other than the Hopi Tribe or the United States on behalf of the Hopi Tribe that are associated with the Tribe's reservation lands;
- e. A description of statements of claimant associated with fee owned in-holdings, if any;
- f. Any water rights claimed by the Hopi Tribe or the United States on behalf of the Hopi Tribe that may claim a priority date earlier than the date the reservation was created;
- g. Proposed water right attributes, excluding proposed future water uses; and
- h. Descriptive and technical information to serve as a basis for evaluating claims of future uses, excluding descriptions or opinions of the feasibility, profitability or practicability of future uses of water for irrigation or other uses.

2002 Order at 7-9.

By Minute Entry filed July 2, 2013, Judge Brain expressed agreement with several parties that "Hydrographic Survey Reports (HSRs) should be cut back to the minimum requirements of existing statutes." Regarding the scope of the Final Hopi HSR in particular, Judge Brain entered a Minute Entry Order dated November 10, 2015, in response to requests for clarification made by ADWR, the Hopi Tribe, and the United States. Judge Brain directed ADWR to comply with Judge Ballinger's July 16, 2002 Order, except as follows:

Future use shall be excluded from the Hopi HSR and ADWR shall have no further obligation to obtain information from the United States or the Hopi Tribe that the parties have declined to provide based on assertions that the requested information relates to future use or presents confidentiality concerns.



The court further stated that the “Hopi HSR shall clearly identify those portions of the HSR that do not contain the director’s recommendations for the water rights claims and uses investigated.”

1.5 PUBLICATION AND COMMENT

As required by Pretrial Order No. 6 in the LCR adjudication (dated July 26, 2000), the Department is taking the following steps regarding the publication of the Final Hopi HSR:

- a. A notice of publication of the Final Hopi HSR is being filed with the clerk of the Superior Court for Apache County that specifies where the Final Hopi HSR is available for inspection or purchase, the notice of commencement of the objection period, the deadline for objections, and procedures for obtaining additional information (Notice of Publication and Commencement of Objection Period).
- b. A press release is being issued that contains the information in the Notice of Publication and Commencement of Objection Period. The press release will be posted on the Department’s web site and will be published in newspapers of general circulation within the geographic boundaries of the LCR adjudication.
- c. Copies of the Notice of Publication and Commencement of Objection Period are being sent by first-class mail to those persons included on the court-approved mailing list for the LCR adjudication, the Hopi Tribe and the United States, the fee landowner and lessee located within the Reservation, and all claimants within the LCR adjudication boundaries.¹³
- d. A copy of the Final Hopi HSR is being provided to counsel for the Hopi Tribe and counsel for the United States in its capacity as trustee for the Hopi Tribe.¹⁴

Pursuant to A.R.S. § 45-256, the deadline for filing objections is 180 days from the filing date. Objections to the Final Hopi HSR must be filed and received by the court on or before

¹³ On September 13, 1925 patent number 966986 was issued to the General Conference of Mennonites of North America for a forty-acre site in the Village of Kytotsmovi. According to the patent when the “lands are no longer used for mission or school purposes said lands shall revert to the Indian owners.”

¹⁴ Both the Hopi and the United States have indicated that they filed their claims on behalf of the allottees.



Wednesday, June 15, 2016 and must comply with the requirements described in the Objection Booklet that is enclosed with the Notice of Publication and Commencement of Objection Period.



CHAPTER 2: WATER RESOURCES

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This chapter describes the availability of water resources in the vicinity of the Reservation. These resources include aquifers (**Section 2.1**), springs (**Section 2.2**), and streams (**Section 2.3**).

2.1 AQUIFERS

This chapter begins by describing aquifers that underlie the Reservation. An overview is provided first, followed by more detailed descriptions for six separate aquifers:

- Alluvial/Colluvial Aquifer
- Bidahochi Aquifer
- Toreva (T) Aquifer
- Dakota (D) Aquifer
- Navajo (N) Aquifer
- Coconino (C) Aquifer.

Aquifer descriptions include their occurrence, flow direction, and natural recharge and discharge. The D and N Aquifers have been the most heavily utilized in the region and are discussed here in more detail. For these aquifers, data are also presented on their estimated groundwater in storage and for the N Aquifer, aquifer properties and measured hydrologic impacts are also discussed.

2.1.1 Overview

Figure 2-1 is a stratigraphic column that shows the sequence of aquifers beneath the Reservation and their associated geologic strata. The shallowest aquifer occurs near surface in unconsolidated deposits of alluvium and colluvium. The C Aquifer is the deepest and occurs locally at depths of several thousand feet in limestone and sandstone. The Bidahochi, T, D, and N Aquifers are encountered at intermediate depths.

The lateral extent of these aquifers is shown in **Figure 2-2**. Only the C Aquifer is encountered beneath the entire Reservation but, as indicated above, it is several thousand feet deep. The D and N Aquifers are found beneath all but the far southwestern portions of the Reservation, whereas the Bidahochi and T Aquifers are only encountered in the southeast and northeast,



respectively. The Alluvial/Colluvial Aquifer is limited to areas of the Reservation along washes and at the base of some slopes.

Figures 2-3 and **2-4** illustrate the expected water level after 100 days of continuous pumping in wells drilled on the Reservation with yields of at least 25 gpm and 500 gpm, respectively. **Figure 2-3** indicates that wells yielding at least 25 gpm could be completed across most of the Reservation, but pumping levels would be variable, ranging from less than 100 feet below ground surface in some areas and up to 2,000 feet in others. **Figure 2-4** indicates that wells yielding at least 500 gpm could only be completed in the northeastern portion of the Reservation. Pumping levels for these wells would be expected to range from 300 feet up to 2,000 feet below ground surface.

A conceptual hydrologic model of the region is provided in **Figure 2-5**. The model shows how water is recharged to, and discharged from, three Reservation aquifers (Alluvial/Colluvial, D, and N). The model also shows the flow of water between the aquifers. Further discussion of these processes is provided below.

2.1.2 Alluvial/Colluvial Aquifer

Occurrence

Some of the unconsolidated sediments recently deposited along drainages and at the base of slopes are saturated and form local aquifers. These unconfined aquifers are relatively thin and of limited aerial extent, but can locally contain sand and gravel beds that are more permeable than the underlying bedrock (Cooley and others, 1969). Combined, the shallow aquifers are referred to here as the Alluvial/Colluvial Aquifer (**Figure 2-2**).

Flow Direction

Water in the Alluvial/Colluvial Aquifer generally flows from higher to lower ground elevations, following the surface topography of the Reservation.

Natural Recharge and Discharge

Recharge to the Alluvial/Colluvial Aquifer comes from direct precipitation, infiltration of streamflow, and discharge from adjacent bedrock springs. Discharge from the Alluvial/Colluvial



Aquifer can occur as baseflow to streams, evapotranspiration by riparian vegetation, spring discharge, and underflow. **Figure 2-6** shows the location of recent and historic perennial stream reaches on the Reservation that are fed by baseflow, and **Appendix B, Figure B-5** shows where ADWR mapped riparian vegetation on the Reservation in 2005.

2.1.3 Bidahochi Aquifer

Occurrence

The Bidahochi Aquifer is encountered beneath a relatively small area in the southeastern portion of the Reservation (**Figure 2-2**). The aquifer is generally unconfined and comprised of Tertiary-age volcanic and sedimentary rocks including basalt, rhyolitic ash, mudstone, and sandstone (**Figure 2-1**). The main water-bearing unit locally is associated with breccia-filled volcanic pipes (Farrar, 1980).

Flow Direction

ADWR does not have data on the direction of flow in the Bidahochi Aquifer beneath the Reservation.

Natural Recharge and Discharge

Most recharge to the Bidahochi Aquifer probably occurs from direct precipitation, where the Tertiary rocks are exposed at or near ground surface (ADWR, 1989). Discharge probably occurs largely as leakage to underlying aquifers and as underflow that leaves the Reservation. ADWR did not identify any Reservation springs that discharge water from this aquifer, and there are no reported perennial stream reaches in the area of the Reservation where it is encountered.

2.1.4 T Aquifer

Occurrence

The T Aquifer is encountered beneath the northeastern portion of the Reservation (**Figure 2-2**) and comprised of sandstone units within the Cretaceous-age Mesa Verde Group. These units include the Yale Point Sandstone and sandstones of the Wepo and Toreva Formations (**Figure 2-1**). Although confined conditions occur locally, the aquifer is generally unconfined and often



consists of perched water-bearing zones formed above relatively low permeability coal, siltstone, and mudstone layers. Water levels in the T Aquifer vary both vertically and horizontally and wells completed in the aquifer may yield water from several, separate zones (Levings and Farrar, 1977).

Flow Direction

ADWR does not have data on the direction of flow in the T Aquifer, but it is expected to be complex due to the occurrence of perched water-bearing zones.

Natural Recharge and Discharge

Most recharge to the T Aquifer probably occurs from direct precipitation where units of the Mesa Verde Group are exposed at or near ground surface. Some recharge to the aquifer may also occur via leakage from the overlying Bidahochi Aquifer in areas where it present. Discharge probably occurs largely from springs, baseflow to streams, and as underflow. Leakage to the underlying D Aquifer is probably limited by several hundred feet of Mancos Shale.

Perennial stream reaches in the headwaters of Moenkopi Wash are believed to have been fed by the T Aquifer (**Figure 2-6**). This reach was observed near the beginning of the 20th century during a wet period and is currently intermittent (ADWR, 2008p). The quantity of underflow that potentially leaves the Reservation from the T Aquifer has not been determined.

2.1.5 D Aquifer

Occurrence

The D Aquifer extends beneath all but the southwestern portion of the Reservation (**Figure 2-2**), and is comprised of a series of Cretaceous- and Jurassic-age sandstones. The Dakota Sandstone is the most important water-bearing unit, with water also obtained from the Entrada Sandstone and sandstones of the Morrison and Carmel Formations (**Figure 2-1**). The sandstones are separated by mudstone and siltstone layers and are locally discontinuous (Cooley and others, 1969).

The D Aquifer is generally thickest (up to 1,300 feet) near its center and thins to the southeast (700 feet) and northwest (100 feet) (Lopes and Hoffman, 1997). It is confined by mudstone and gypsum beds of the overlying Mancos Shale (Cooley and others, 1969).



Flow Direction

Water in the D Aquifer currently flows under pressure from an elevation of about 6,200 feet just east of the Reservation to an elevation of about 5,300 feet to the southwest (**Figure 2-7**). Flows are locally restricted where the sandstone units are folded or pinch out (Cooley and others, 1969).

Natural Recharge and Discharge

The total recharge to the D Aquifer has been estimated at 5,392 AFA (GeoTrans and Waterstone, 1999). Most of this recharge probably occurs outside of the Reservation along the eastern slope of Black Mesa, where units of the aquifer outcrop (Lopes and Hoffman, 1997). Recharge may also occur locally along ephemeral washes where these units are at or near ground surface. The age of water from the D Aquifer water is estimated to range from 4,000 to 11,000 years old near the main recharge area and up to 33,000 years old downgradient (Truini and Longworth, 2003).

The D Aquifer discharges water via springs, leakage to the underlying N Aquifer, baseflow to streams and as underflow along the Hopi Washes. Leakage of water from the D Aquifer to the N aquifer has apparently been occurring for thousands of years, with the area of greatest leakage in the southeastern portion of the Reservation. In this area, the N Aquifer is relatively thin and the difference in predevelopment water levels between the D and N Aquifers is small (Truini and Longworth, 2003).

Water from the D Aquifer is also discharged on the Reservation as baseflow to streams and as underflow (Cooley and others, 1969). Perennial stream reaches historically observed along Dinnebito and Jeddito Washes are believed to have been fed by the D Aquifer (**Figure 2-6**). During dry periods, discharge from the D Aquifer probably still occurs along these and the other Hopi washes as recharge to underlying alluvial aquifers. The quantity of D Aquifer water that potentially leaves the Reservation as underflow along the washes has not been determined. However, it has been estimated that a relatively large quantity of water in the alluvial aquifer is consumed locally by riparian vegetation (see **Appendix B, Figure B-5**).



Water in Storage and Well Yields

ADWR (1989) estimated the total volume of water stored in the D Aquifer at 15 million acre-feet.¹ The estimate applies to the entire LCR watershed and includes Navajo lands outside of the Reservation. More than half of the total D Aquifer water appears to be stored beneath the Reservation. The actual yield of most D Aquifer wells on the Reservation is believed to be less than 1.25 gpm (DBSA, 2000), although yields up to 20 to 25 gpm are reported in the region (ADWR, 1989 and Farrar, 1980).

2.1.6 N Aquifer

Occurrence

The N Aquifer extends beneath all but the southwestern portion of the Reservation (**Figure 2-2**), and is comprised of a series of Jurassic-age sandstones. The Navajo Sandstone is the primary water-bearing unit, with water also obtained from underlying sandstones in the Lukachukai Member of the Wingate Sandstone (**Figure 2-1**).

In the vicinity of the Reservation, the N Aquifer is generally thickest (up to 1,000 feet) in the northwest and thins to between 200 and 400 feet in the east and west and less than 200 feet in the south (**Figure 2-8**). It is confined over much of this area by siltstone and mudstone of the Carmel Formation. Unconfined conditions occur in a recharge area to the north, a discharge area to the west, and in the southeast where the N Aquifer is relatively thin and receives leakage from the D Aquifer (**Figure 2-9**).

Flow Direction

Figure 2-9 shows the general direction of groundwater flow in the N Aquifer prior to 1972, when substantial development of the aquifer began. Water levels were highest in the Shonto area, north of the Reservation, and reached an elevation of over 6,500 feet. From there, groundwater flowed to the south and west with elevations dropping to less than 4,800 feet near Moenkopi, and flowed to the northeast with elevations dropping to less than 5,000 feet.

¹ It is important to note that not all groundwater in storage is recoverable. Significant percentages of estimated volumes of stored groundwater may remain after it is no longer practicable to pump from an aquifer.



Across much of this area, water in the N Aquifer occurred under confined conditions with water levels in wells rising as much as 1,800 feet above the top of the Navajo Sandstone. Along the aquifer margins, the groundwater was unconfined with water levels in wells at or below the top of the aquifer (Brown and Eychaner, 1988). These conditions generally still occur today, although industrial and municipal pumping has locally altered water levels and associated flow directions by forming drawdown cones around well sites.

Natural Recharge and Discharge

Recharge to the N Aquifer is estimated to range from 2,600 and 20,248 AFA (OSM, 2008). Geochemical analysis and groundwater flow and transport modeling suggest that N Aquifer recharge was 50% lower from 6,000 to 11,000 years ago and 2 to 3 times higher from 11,000 to 31,000 years ago. Variations in recharge are explained by effects from glacial and post-glacial periods (Zhu and others, 1998).

Water is discharged from the N Aquifer via springs, baseflow to streams, and as underflow along the Hopi Washes. Perennial and intermittent stream reaches historically and currently observed along Moenkopi, Dinnebito, and Polacca Washes are also believed to have been fed by the N Aquifer (**Figure 2-6**). The aquifer also discharges to alluvial aquifers that underlie the Hopi Washes, although the quantity of this water that leaves the Reservation as underflow has not been determined. A relatively large quantity of water from the alluvial aquifer (from 23,200 to 56,550 acre-feet) has been estimated to be consumed each year by riparian vegetation (see **Appendix B, Figure B-5**). A portion of this likely originates from the N Aquifer.

Aquifer Properties

Figure 2-10 shows the variability in the estimated hydraulic conductivity of the N Aquifer in the vicinity of the Reservation. The hydraulic conductivity is estimated to range from 0.1 to 1.8 feet/day with the highest values in the southwest and near the center of the area. These values were input to a United States Geological Survey (USGS) groundwater flow model and are based on long-term (over 6-year) aquifer tests conducted in the PWCC well field and 40 other short-term aquifer and well tests.

Figure 2-11 shows how the transmissivity of the N Aquifer varies over the same model area. Transmissivity is a measure of an aquifer's ability to transmit water and is the product of its



hydraulic conductivity and saturated thickness. Transmissivity is an important factor in evaluating well yields and, in general, aquifers with higher transmissivities may sustain higher pumping rates. The transmissivity of the N Aquifer, as modeled by the USGS, ranges from 20 to over 1,000 feet²/day. The highest transmissivity values are located in the north where PWCC completed its well field in the N Aquifer.

As described earlier, water in the N Aquifer is encountered under both unconfined and confined conditions. Specific yield is a measure of the amount of water that an unconfined aquifer releases from storage when its water level declines. For confined aquifers, storage coefficient is a measure of the amount of water that is released from storage with a decrease in artesian pressure. In the vicinity of the Reservation, specific yield and storage values for the N Aquifer are reported to range from 0.1 to 0.15 and from 0.00022 to 0.0008, respectively (Eychaner, 1983). A practical implication of this is the relatively large drawdowns that have been measured in several wells completed in confined portions of the N Aquifer where storage coefficients are comparatively low. For a given pumping rate and aquifer transmissivity, water levels decline more quickly in wells with lower specific yield and storage coefficient values.

Yields of wells completed in the N Aquifer range from less than 5 gpm to over 300 gpm (Farrar, 1979 and 1980), with some wells in the PWCC leasehold yielding over 500 gpm. Pumping rates for municipal wells completed on the Reservation in the N Aquifer are reported to range from 8.5 to 121 gpm (Tetra Tech, 2006).

Water in Storage

The USGS estimates the volume of groundwater stored in their modeled area of the N Aquifer (**Figure 2-8**) as 180 million acre-feet (Eychaner, 1983). Other models, such as the PWCC model, simulate different sized areas and make different assumptions about aquifer thickness which result in different estimates of groundwater in storage.

The N Aquifer has been the most heavily developed of the region's six aquifers. In addition to Hopi municipal pumping, the Navajo and PWCC have several wells completed in the N Aquifer for municipal and industrial use, respectively. **Table 2-1** lists the total and average annual withdrawals from these wells since 1965, and **Figure 2-12** shows well locations and withdrawals for 2011. Over 243,660 acre-feet of water have been pumped from the N Aquifer over the period from 1965 to 2011 (Macy and Unema, 2014). From 1965 through 2005, PWCC industrial



withdrawals averaged 3,453 AFA and comprised approximately 63% of the N Aquifer withdrawals. Since the closing of the Black Mesa Mine in 2005, PWCC industrial withdrawals now average 1,255 AFA and make up only approximately 30% of the total N Aquifer withdrawals. Withdrawals for municipal use by the Navajo and Hopi now comprise 70% of the total N Aquifer withdrawals.

Macy and Unema (2014) estimate that total withdrawals from other wells completed in the N and D Aquifer are less than 1% of the total municipal and industrial withdrawals from the N Aquifer. These other wells are used for stock and domestic purposes and their flows are generally not monitored.

Measured Hydrologic Impacts from Development

Figure 2-13 shows the water level change measured by the USGS in several N Aquifer wells since aquifer development began during the early 1970s. Between 1965 and 2012, water levels generally dropped in the confined portion of the aquifer, but were little changed in the unconfined portion. The median water level change over this period was -39.1 feet for 18 wells completed in the confined aquifer and -2.1 feet for 16 wells completed in the unconfined aquifer (Macy and Unema, 2014). The largest declines were measured at municipal pumping centers and near the PWCC leasehold. A municipal well (PM2) near Keams Canyon showed a water-level decline of 205.5 feet, a USGS monitoring well (BM2) northeast of the leasehold showed a change of -91.6 feet, and a USGS monitoring well (BM6) between the leasehold and municipal well showed a change of -151.0 feet.

Once operation of the Black Mesa Mine ceased in December 2005, water levels in two N Aquifer observation wells on the leasehold rose substantially (**Figure 2-14**). Between 2002 and 2005, PWCC estimated that the static water level depth was about 1,150 feet in observation well NAVOBS3 and about 1,344 feet in observation well NAVOBS6. Due to a decrease in pumping, water levels in these wells rose by over 100 feet during the two year period.

Since the late 1980s and early 1990s, the USGS has also routinely monitored discharge from four N Aquifer springs in the vicinity of the Reservation. **Figure 2-15** shows the location of the springs and how their discharge has varied over time. Trends in measured discharges over time at the unnamed spring on Navajo land near Dennehotso and at Burro Spring do not appear to be significant (Macy and Unema, 2014). Accounting for annual and seasonal fluctuations,



discharges from Moenkopi School and Pasture Canyon Springs appear to have declined by about 7 gpm, and 10 gpm, respectively. [Note that the measuring point for Pasture Canyon Springs used in the Macey and Unema study is different from the USGS gage location.]

Figure 2-15 also shows variations in the discharge along three streams and one spring believed to be fed by N Aquifer discharge. The USGS monitors flows in Moenkopi, Dinnebito and Polacca Washes on the Reservation and flows at Pasture Canyon Spring on adjoining Navajo land.

To remove potential short-term effects from snowmelt, riparian evapotranspiration, and monsoon storms, flow data collected during November through February were analyzed separately (Macy and Unema, 2014). None of the four studied sites show significant increasing or decreasing trends in discharge measurements over the period of record. For reference, **Figure 2-15** also shows annual precipitation data from a nearby meteorological station.

2.1.7 C Aquifer

Occurrence

The C Aquifer is encountered beneath the entire Reservation (**Figure 2-2**) and consists of the Permian-age Kaibab Limestone, Coconino Sandstone, and upper Supai Formation (**Figure 2-1**). It also underlies much of the LCR Basin, extending from the Mogollon Rim in the south to an area west of the LCR River and northeast into New Mexico (Hart and others, 2002). Locally, the C Aquifer is confined by the Chinle and Moenkopi Formations which restrict downward leakage from the overlying N Aquifer.

Flow Direction

Water in the C Aquifer generally flows in a west-northwest direction across the southern portion of the Reservation. C Aquifer groundwater flows beneath the central and northern parts of the Reservation reportedly are less well defined and restricted by low permeability units. Few C Aquifer wells have been completed in the vicinity of the Reservation due to poor water quality conditions and the relatively high well construction and pumping costs associated with developing this deep aquifer (Cooley and others, 1969 and Hart and others, 2002).



Natural Recharge and Discharge

The C Aquifer water beneath the Reservation is recharged nearly 100 miles to the south along the Mogollon Rim and 50 miles to the east on the Defiance Uplift (Hart and others, 2002). Blue Springs, the major discharge area in the region, is located about 40 miles west of Moenkopi along the lower LCR (**Figure 2-6**). Due to its depth, no discharge from the aquifer occurs locally.

2.2 SPRINGS

The Hopi Tribe and the United States, on behalf of the Hopi Tribe, claim the right to utilize all flows from springs on the Reservation. Further, they claim the right to make improvements, such as constructing spring boxes or pipe collection systems, to preserve each springs utility for any use including livestock, domestic, agriculture, ceremonial, religious and cultural. Neither the Hopi nor the United States claim a specific quantity for each spring since metering data or evidence of past or present flows is generally unavailable.

In their Third Amended SOCs, the Hopi and the United States claim a total of 379 springs. Both the Hopi and United States reference the same list and maps of springs as presented in Appendices 5 and 7 of the United States Third Amended SOC. GIS shapefiles depicting spring locations and other information were provided to ADWR by the United States in support of the Hopi and United States claims.

2.2.1 Evaluation of Spring Locations

ADWR conducted an evaluation to verify the presence of claimed springs within the following sources of information at the locations provided by the United States.

- Appendix D: Hopi Spring Evaluation from ADWR's 2008 Preliminary HSR;
- USGS Topographic Series Maps (Topo Large);
- NWIS: National Water Information System (USGS Water Data);
- GNIS: Geographic Names Information System;
- Topographic Series Maps (USA Topo Maps);
- USGS Scanned Topos; and
- ESRI World Imagery and Google Earth.



ADWR considered the presence of a spring to be verified if a spring was noted as verified in Appendix D: Hopi Spring Evaluation or evidence of a spring was observed in the other maps or imagery data sources reviewed as part of this evaluation. If a spring did not meet either of these criteria, the presence of a spring was considered not verified. Information about the data sources used in this evaluation is presented below followed by ADWR's evaluation findings.

Appendix D: Hopi Spring Evaluation (ADWR, 2008p)

This document presented an inventory of springs on the Reservation and ADWR's evaluation of the claimed springs. ADWR used topographic maps, published reports, ADWR ground inspection, and/or supporting evidence from the Hopi to verify both claimed and unclaimed springs.

USGS Topographic Series Maps (Topo Large)

USGS Topo Large is a web based dynamic topographic map service that combines the best available data (Boundaries, Elevation, Geographic Names, Hydrography, Land Cover, Structures, Transportation, and other themes) that make up The National Map. Contours generated for the US Topo product are visible along with other data at scales of 1:13,500 and larger. This product is designed to provide a seamless view of the data in a geographic information system (GIS) accessible format, closely resembling the US Topo product at large scales.

NWIS: National Water Information System (USGS Water Data)

The USGS has collected water-resources data at approximately 1.5 million sites in all 50 States, the District of Columbia, Puerto Rico, the Virgin Islands, Guam, American Samoa and the Commonwealth of the Northern Mariana Islands. The types of data collected are varied, but generally fit into the broad categories of surface water and groundwater. Surface water data, such as gage height (stage) and streamflow (discharge), are collected at major rivers, lakes, and reservoirs. Groundwater data, such as water level, are collected at wells and springs.

GNIS: Geographic Names Information System

The Geographic Names Information System (GNIS), developed by the USGS in cooperation with the U.S. Board on Geographic Names, contains information about physical and



cultural geographic features in the United States and associated areas, both current and historical (not including roads and highways). The database holds the federally recognized name of each feature and defines the location of the feature by state, county, USGS topographic map, and geographic coordinates.

Other feature attributes include names or spellings other than the official name, feature designations, feature class, historical and descriptive information. The database assigns a unique feature identifier, a random number that is a key for accessing, integrating, or reconciling GNIS data with other datasets. The GNIS is the United States' official repository of domestic geographic feature names information.

ESRI Topographic Series Maps (USA Topo Maps)

This map presents land cover imagery for the world and detailed topographic maps for the United States. The map includes the National Park Service (NPS) Natural Earth physical map at 1.24 km per pixel for the world at small scales, i-cubed eTOPO 1:250,000-scale maps for the contiguous United States at medium scales, and National Geographic TOPO! 1:100,000 and 1:24,000-scale maps (1:250,000 and 1:63,000 in Alaska) for the United States at large scales. The TOPO! maps are seamless, scanned images of USGS paper topographic maps.

Scanned Topos

A digital raster graphic (DRG) is a scanned image of a USGS standard series topographic map, including all map collar information. The image inside the map neat line is georeferenced to the surface of the earth and fit to the Universal Transverse Mercator projection. The horizontal positional accuracy and datum of the DRG matches the accuracy and datum of the source map. The map is scanned at a minimum resolution of 250 dots per inch.

Utilizing the data sources described above, ADWR was able to verify the presence of 316 or about 83% of the 379 claimed springs. ADWR was unable to verify 63 claimed springs, or about 17% of the total. Of the 63 unverified springs, ADWR was not able to locate 41 springs at the claimed location during field investigations on the Reservation in 2005. ADWR was unable to verify the remaining 22 springs using the data sources listed above or due to lack of access during the 2005 field investigations. **Table 2-2** provides information on the 63 springs that were not verified during ADWR's evaluation.



2.2.2 Characteristics

Where known, water sources for most springs on and near the Reservation are from the T Aquifer (103 springs) and N Aquifer (82 springs). Other water sources include the alluvial aquifer (25 springs), colluvial aquifer (23 springs), spring (travertine) deposits (7 springs), and the D Aquifer (5 springs) (ADWR, 2008p). Some form of development was noted at 83 spring sites during ADWR's 2005 field investigations. The most common improvements were troughs (44 springs) and spring boxes (22 springs).

2.2.3 Discharge

ADWR found or collected discharge data for 208 springs (ADWR, 2008p). Measured discharges totaled from 360 to 1,103 gpm and were greatest from the N Aquifer (207 to 777 gpm) and T Aquifer (99 to 202 gpm). Discharge measurements for each individual spring ranged from 0 to 326 gpm.

The N Aquifer discharges water to several springs located along Pasture Canyon, upstream of the villages of Upper Moenkopi and Lower Moenkopi. Most spring flow occurs in the upper portion of the canyon and, since August 2004, the USGS has continuously monitored the combined discharge of the springs at its Pasture Canyon gage (see **Table 2-3 and Figure 2-6**). Before installing the gage, the USGS had measured a total spring discharge of greater than 300 gpm in this area, although measurements have generally been lower and some were apparently affected by irrigation diversions. The earliest measurements were made during 1908 and 1948 when total discharges of 224 and 210 gpm were recorded, respectively (Brown and Halpenny, 1948). Between 1948 and 1954, 13 discharge measurements were reported and averaged 177 gpm (Chambers & Campbell, 1962). The average annual flow from Pasture Canyon Springs over the period of record from 2004 to present is 226 AFA, which is equivalent to 140 gpm.

2.3 STREAMS

The Reservation is drained by five major washes – Jeddito (Jadito) Wash, Polacca Wash, Oraibi Wash, Dinnebito Wash, and Moenkopi Wash. Locations of the Hopi Washes and USGS stream gages are shown in **Figure 2-6**. Streamflow data collected from the gages are summarized



in **Table 2-3** and include the identification number, contributing drainage area, period of record, number of daily mean flow measurements taken, annual and seasonal flow statistics, typical flow durations, and streamflow regimes (perennial, intermittent, and ephemeral).

2.3.1 Streamflow Monitoring

Streamflow monitoring began in the mid-1990s in four of the Hopi Washes (Dinnebito, Jeddito, Oraibi, and Polacca). Monitoring ceased in Jeddito Wash in 2005 and in Oraibi Wash in 2013. Streamflows in Moenkopi Wash have been continuously monitored since the 1920s, and gages along Coal Mine Wash and two of its tributaries were monitored from the late 1970s through the early 1980s. Coal Mine Wash drains part of the PWCC leasehold and is a tributary to Moenkopi Wash.

Based on available USGS data, median streamflows in the Hopi Washes have ranged from a low of 145 AFA in Jeddito Wash to a high of about 10,600 AFA in Moenkopi Wash. Measured flows at these gages have been highly variable from year to year, with maximum annual flows exceeding minimum annual flows by a factor of between 6 and 22. On average, the majority (over 50%) of annual streamflow volumes have occurred during the summer in response to monsoon storms. Streamflows have usually been lowest in the spring when precipitation is also at its lowest and evapotranspiration (ET) of riparian vegetation begins.

Several hydrologic factors may affect Reservation streamflows. In addition to storm runoff and ET, factors include snowmelt, baseflow (groundwater inflow), transmission losses, and well pumpage. Storm runoff, snowmelt and baseflow can result in streamflow gains while ET, transmission losses, and well pumpage can result in streamflow losses.

2.3.2 Streamflow Regimes

Median daily flows were used to identify recent streamflow regimes at the gage sites. Available data presented in **Table 2-3** indicate that perennial flows occur along sections of Dinnebito and Polacca Washes, intermittent flows occur along Moenkopi Wash, and ephemeral flows occur along Jeddito and Oraibi Washes. It was assumed that streamflows at the gages were ephemeral if the percentage of days each year with measurable flow was typically less than 10% and intermittent if this percentage was 10% or greater but less than 100% (perennial).



Figure 2-6 shows the recent streamflow regimes based on gage data as well as historic perennial stream reaches on and near the Reservation. Maps of the latter were published in 1916, 1942 and 1969 and generally coincide with the recent intermittent and perennial streamflow regimes. One notable exception is a relatively long perennial reach identified along Jeddito Wash on the 1942 and 1969 stream maps. Recent (1993-2005) streamflow data indicates this reach of Jeddito Wash has become ephemeral.

Ephemeral stream reaches generally occur within smaller watersheds or on larger streams where baseflow contributions are minimal. Runoff is relatively low and infrequent in these reaches and results mainly from stormflow during the late summer and early fall. Intermittent reaches can occur where adjacent aquifers supply baseflow that exceeds alluvial aquifer outflows on a seasonal basis, or where tributary surface flows are significant. At higher elevations, intermittent reaches can experience runoff from snowmelt during the late winter and early spring while at lower elevations most runoff comes from summer and fall storms. Perennial reaches in the area occur immediately downstream of springs and seeps where groundwater inputs exceed ET and transmission losses.



**CHAPTER 3:
SUMMARY OF ADJUDICATION CLAIMS
RELATED TO THE HOPI INDIAN
RESERVATION**

CHAPTER 3: SUMMARY OF ADJUDICATION CLAIMS RELATED TO THE HOPI INDIAN RESERVATION

This chapter summarizes water rights claims filed in the LCR Adjudication by the Hopi Tribe and the United States, on behalf of the Hopi Tribe. A summary of claims filed by the Hopi prior to 2015, the Hopi Third Amended SOC, as well as the Tribe’s Supplement to its Third Amended SOC (“Hopi Tribe Supplement”) is provided in **Sections 3.1** through **3.3**, respectively. A summary of claims filed by the United States prior to 2015 and the United States Third Amended SOC is provided in **Sections 3.4** and **3.5**, respectively. Comparison of the Hopi Third Amended SOC as supplemented and the United States Third Amended SOC is provided in **Section 3.6**. Copies of Hopi claims, United States claims, amendments, and other supporting documentation are provided in **Appendix C**. The Hopi claims are summarized in **Tables 3-1**, the United States claims are summarized in **Table 3-2**, and the Hopi and United States claims are compared in **Table 3-3**.

3.1 CLAIMS FILED BY THE HOPI TRIBE PRIOR TO 2015

Sections 3.1.1 through 3.1.3 describe the pre-2015 SOC’s filed by the Hopi Tribe in 1985, 2004, and 2009. These claims were filed on behalf, and for the benefit, of its villages, clans and people, with a claimed priority date of time immemorial, senior to all other claimants Indian or non-Indian. These claims were founded upon the theories of: (1) the federal reserved water rights doctrine; (2) sovereign and historic guardian of its lands; and (3) owner of lands and waters under both Spanish and Mexican rule, under the Treaty of Guadalupe Hidalgo between the United States and Mexico.

3.1.1 1985 Hopi Claim (Hopi Original SOC)

On November 29, 1985, the Hopi Tribe filed its original water rights SOC (Hopi Original SOC), designated No. 39-91443, claiming 140,406 acre-feet per annum (AFA) of surface water and groundwater, plus additional water for one-time first fillings of proposed future impoundments “in, on or serving lands owned by the Hopi Tribe or allotted or assigned to its members, or that may hereafter be recognized as belonging to its members.” The claimed water uses are set forth



below and were based on past and present uses (as of 1985) as well as proposed future uses, as indicated below.

- Domestic, Commercial, Municipal and Industrial Use (DCMI):
 - 9,327 AFA (2,060 past/present + 7,267 future) based on population in 1984 and 2040 at 200 gallons per capita per day (gpcd)
- Irrigation:
 - 88,059 AFA (11,364 past/present + 76,695 future) from both surface water and groundwater
 - 9,545 AFA (186 past/present + 9,359 future) for evaporation from irrigation storage
- Livestock and water storage for stock (stockponds):
 - 1,799 AF (1,504 past/present + 295 future) from surface water and groundwater based on stocking rates
- Mining and related industry:
 - 31,445 AFA (2,325 past/present + 29,120 future) of groundwater for mining, slurry supply, and future power development
- Recreation:
 - 231 AFA (80 past/present + 151 future) for evaporation from recreational lakes
- Other future additional claimed amounts:
 - 91,330 AF for first time filling of the irrigation, recreation, and stock reservoirs

3.1.2 2004 Hopi Claim (First Amended SOC, as supplemented)

On January 29, 2004, the Hopi filed amended SOC No. 39-91443 (Hopi First Amended SOC) for 137,835 AFA of surface water and groundwater, plus additional water for first time fillings of proposed irrigation storage reservoirs “in, on or serving lands owned by the Hopi Tribe or allotted or assigned to its members, or that may hereafter be recognized as belonging to its members.” Supplemental information was also provided to the Department in 2005 regarding allotted lands. The claimed water uses were based on past and present uses (as of 2005) as well as proposed future uses, as indicated below.

- DCMI:
 - 11,211 AFA (possibly groundwater)



- Irrigation:
 - 52,206 AFA (past/present use in five washes and minor tributaries)
 - 21,060 AFA (future irrigation from main stem of the Little Colorado River (LCR))
 - 2,842 AFA (evaporation from the future storage facilities)
- Livestock and water storage for stock (stockponds):
 - 8,871 AFA (7,961 past/present + 910 future)
- Ceremonial and Subsistence Irrigation:
 - 12,546 AFA (future, possibly groundwater)
- Mining and Related Industry:
 - 6,000 AFA (4,400 past/present + 1,600 future) mining and slurry process
- Energy Resources Development:
 - 19,000 AFA (future)
- Tourism:
 - 1,594 AFA (future, possibly groundwater)
- Recreation:
 - 139 AFA (continuous fill and evaporation)
- Other (off-Reservation ranches – 26 Bar, Aja, Clear Creek, Hart, and Drye):
 - 2,366 AFA irrigation and storage
- First time filling of proposed irrigation reservoirs:
 - 15,700 AF (Reservation)
- Storage and additional future use provided for by 1996 Navajo-Hopi Settlement Act:
 - 2,089 AF

3.1.3 2009 Hopi Claim (Second Amended SOC)

On November 12, 2009 the Hopi Tribe filed amended SOC No. 39-91443 (Hopi Second Amended SOC) claiming 52,406 AFA of surface water and groundwater, plus additional water for one-time first fillings of proposed future irrigation storage reservoirs “in, on or serving lands owned by the Hopi Tribe or allotted or assigned to its members, or that may hereafter be recognized as belonging to its members.” The claimed water uses are set forth below and were based on past



and present (as of 2009) as well as proposed future uses, as indicated below. The Tribe's 2009 claim quantifies irrigation uses based on a single time period (1954-1955).

- DDMI:
 - 9,110 AFA (future)
- Irrigation:
 - 21,199 AFA (1954-1955 use in five washes and minor tributaries)
 - 192 AFA (evaporation from existing storage facilities)
- Livestock and water storage for stock (stockpounds):
 - 5,883 AFA (4,886 past/present + 997 future)
- Ceremonial and Subsistence Irrigation:
 - 4,977 AFA (future)
- Mining and Related Industry:
 - 1,736 AFA (1,236 past/present + 500 future) mining and slurry process
- Energy Resources Development:
 - 6,000 AFA (future)
- Tourism:
 - 522 AFA (future)
- Recreation:
 - 41 AFA (continuous fill and evaporation)
- Other (off-Reservation Hopi Ranches – 26 Bar, Aja, Clear Creek, Hart, and Drye):
 - 2,366 AFA Irrigation and storage
 - 380 AFA DDMI
- Storage and additional future use off-Reservation:
 - 2,089 AF
- First time filling of proposed irrigation reservoirs:
 - 333 AF (Reservation)



3.2 2015 HOPI CLAIM (Third Amended SOC)

On June 2, 2015, the Hopi Tribe filed amended SOC No. 39-91443 (Hopi Third Amended SOC) claiming 194,440 AFA plus additional water for first-time fills. On September 17, 2015, the Hopi Tribe filed a supplement to its Third Amended SOC (Hopi Tribe Supplement), which is discussed in **Section 3.3**. The Hopi Tribe Supplement increased the total amount of water claimed to 196,935 AFA. The Hopi Third Amended SOC provides information concerning the following:

- Legal Basis of Claim
- Priority Date
- Uses of Water
- Sources of Water
- Points of Diversion, Means of Diversion and Places of Use
- Quantities of Use (as supplemented)

3.2.1 Legal Basis of Claim

On behalf, and for the benefit, of the “Tribe, its villages, clans and people,” the Hopi claim the right to all groundwater and surface water “in, on, or serving lands owned by the Hopi Tribe, or allotted or assigned to its members, or that may hereafter be recognized as belonging to it or its members,” under the following theories:

- As a sovereign and historic guardian of its lands (pre-dating the United States);
- As the owner of lands and waters under both Spanish and Mexican rule, under Articles VIII and IX of the Treaty of Guadalupe Hidalgo between the United States and Mexico dated February 2, 1848 (9 Stat. 922); and
- Under the federal reserved water rights doctrine established in *Winters v. United States*, 207 U.S. 564 (1908); *Arizona v. California*, 373 U.S. 546 (1963); *Cappaert v. United States*, 426 U.S. 128 (1976); and as owner of natural resources under *United States v. Shoshone Tribe of Indians of Wind River Reservation*, 304 U.S. 111 (1938).



3.2.2 Priority Date

Based on historic occupancy and water use, the Hopi Tribe claims a water right with a time immemorial priority date, senior to that of any other claimant, Indian or non-Indian, to waters located on Hopi lands as well as water sources located outside the boundaries of the main reservation lands.

3.2.3 Uses of Water

The Hopi Tribe claims types of water uses on behalf of the Hopi Tribe in the following categories:

- DCMI
- Agriculture (Past and Present Irrigation; Livestock; Ceremonial and Subsistence Irrigation; and Water Storage)
- Present Mining Use
- Energy Resources Development
- Tourism
- Recreation
- Other Claims (Subsurface Mineral Rights; Aesthetic, Cultural and Ecological Flows; and Cultural, Religious and Ceremonial Uses)

The uses listed above are summarized in **Table 3-1** and further described in **Section 3.2.6** and **Chapter 4**. The Hopi Third Amended SOC does not update or include water right claims for lands outside of the Reservation although the Hopi reiterate their 2009 claims for off-Reservation uses at the Hopi Ranches.

3.2.4 Sources of Water

The Hopi Tribe claim a federal reserved water right to water from various surface water and groundwater sources within the Reservation, including water from springs, wells and impoundments. Surface water sources include five washes (Moenkopi, Dinnebito, Oraibi, Polacca and Jeddito), and minor tributaries that flow from north to south through the Reservation. Groundwater sources include aquifers located beneath the Reservation lands, some of which extend laterally beyond the Reservation boundaries. These water sources were discussed in



Chapter 2 of this report. The Tribe also claims water rights from water sources located outside the boundaries of the Reservation, including water from the main stem of the LCR, the Colorado River, Lake Powell, and the Coconino Aquifer.

3.2.5 Points of Diversion, Means of Conveyance and Places of Use

The Hopi Third Amended SOC does not identify any points of diversion, but instead cross-references locations of existing point sources (wells, springs and impoundments) listed in Appendices 4, 5 and 6 of the United States' Third Amended SOC. The locations of these point sources are depicted in Appendix 7 to the United States claim. The claim also does not specifically describe any means of conveyance.

The claim does indicate that the places of use are within the 1882 Executive Order Reservation and the 1934 Act Reservation (Moenkopi Island). Appendix 1 and Appendix 2 to the Hopi claim contain a series of maps depicting the locations of places of use within the Reservation.

3.2.6 Quantities of Use

The Hopi Third Amended SOC claims the following quantities of use for the Hopi Reservation based on past and present and future uses, as indicated below. The Hopi Tribe Supplement (discussed in **Section 3.3**) increased the claimed quantities for three of the types of uses. The quantities from the Hopi Tribe Supplement are also indicated parenthetically in the description that follows.

- DCMI:
 - 9,348 AFA (future)
- Irrigation:
 - 102,303 AFA - 1,182 (supplement) + 101,121 (past/present use in five washes and minor tributaries and from groundwater as necessary)
 - 192 AFA (evaporation from existing storage facilities)
- Livestock and water storage for stock (stockponds):
 - 7,184 AFA – 1,301 (supplement) + 5,883 (4,883 past/present + 1,000 future)
- Ceremonial and Subsistence Irrigation:
 - 7,385 AFA (future)



- Mining and Related Industry:
 - 1,755 AFA (1,255 present/past + 500 future) from the N Aquifer
- Energy Resources Development:
 - 27,100 AFA (future for potential solar/thermal power plant and development of coal liquefaction/gasification and secondary products)
- Tourism:
 - 1,022 AFA (future for destination resort)
- Recreation:
 - 41 AFA (Continuous fill and evaporation for Keams Lake)
- Subsurface Mineral Rights:
 - 40,295 AFA (proportional share of groundwater sources associated with the Blue Springs complex and based on the Tribe’s land area in the LCR basin)
- Aesthetic, Cultural and Ecological Flows:
 - 310 AFA – 16 (supplement) + 294 (Pasture Canyon, White Ruin Canyon, Lower LCR instream flows)

3.3 HOPI TRIBE’S SUPPLEMENT TO ITS THIRD AMENDED SOC (2015)

On September 17, 2015, the Hopi Tribe filed a supplement to its Third Amended SOC (“Hopi Tribe Supplement”). The Tribe’s updated water rights claim is for 196,935 AFA plus an additional 333 AF for irrigation storage. A copy of the Hopi Tribe Supplement is included in **Appendix C** of this report.

The Supplement increases the claimed amounts of water use in the Third Amended SOC in the following manner:

- Irrigation:
 - Included are an additional 311 acres of land requiring 1,182 AFA to irrigate. The revised total claimed amount is 102,303 AFA (101,121 + 1,182) for past and present uses.
- Livestock and water storage for stock (stockponds):



- Included are: A) an additional 396 claimed impoundments (as described in the United States Third Amended SOC) requiring 1,289 AF, and B) eight (8) previously unclaimed impoundments requiring 12 AFA of storage. Based on storage capacities, the revised total claimed amount is 7,184 AFA (4,883 + 1,289 + 12 for past/present use and 1,000 AFA for future use).
- Aesthetic, Cultural and Ecological Flows:
 - Included is an additional 16 AFA non-diversionary water right claim for instream flows in the lower LCR for White Ruin Canyon Wash. The revised total claimed amount is 310 AFA (294 + 16) for past/present uses.

Appendix 2 and Appendix 3 to the Hopi Tribe Supplement reference corrections to the locations of 91 impoundments previously included in the Hopi Third Amended SOC and eight previously unclaimed impoundments.

Table 3-1 displays how the claims filed by the Hopi Tribe have changed over time.

3.4 CLAIMS FILED BY THE UNITED STATES ON BEHALF OF THE HOPI TRIBE PRIOR TO 2015

Sections 3.4.1 through 3.4.4 describe the pre-2015 SOC's filed by the United States in 1985, 1994, 2004, and 2009. The 1985 and 1994 claims were filed for water uses located on all Indian lands within the LCR adjudication. The 1994 claim also separately described water uses for the Hopi Reservation, and was amended in 2004 and 2009.

3.4.1 1985 United States Joint Claim

On November 29, 1985,¹ the United States, in its own right and as trustee, submitted SOC No. 39-91441 on behalf of both the Hopi Tribe and the Navajo Nation, claiming a combined total of 546,872 AFA of water in the LCR watershed, plus 331,082 AF for the first-time filling of irrigation storage reservoirs and recreation lakes. The claimed priority date is time immemorial, and the basis of the claim is the federal reserved water rights doctrine.

¹ On December 18, 1985, the Department received a revised copy of SOC No. 39-91441 to correct a typographical error.



The United States' original joint claim does not list the water rights for the Hopi and the Navajo separately, but it does divide the quantities claimed based upon past and present uses (as of 1985) as well as proposed future uses, as indicated below.²

- DDMI:
 - 57,696 AFA total (4,594 past/present + 53,102 future)
 - 57,365 AFA (4,296 present/past + 53,069 future) for municipal
 - 331 AFA (298 + 33) for domestic
- Irrigation:
 - 397,594 AFA total (36,049 past/present + 361,545 future)
 - 287,910 AFA (33,190 + 254,720) for irrigation from surface water, including the LCR
 - 109,684 AFA (2,859 + 106,825) for irrigation from groundwater, including LCR alluvium
- Evaporation from Irrigation Storage:
 - 31,522 AFA (1,155 past/present + 30,367 future) of surface water plus 330,000 AF for one-time filling (future)
- Livestock and water storage for stock (stockponds):
 - 4,651 AFA total (4,356 past/present + 295 future)
 - 754 AFA (635 past/present + 119 future) for stockwatering from groundwater
 - 3,897 AF (3,721 past/present + 176 future) for stockponds from surface water
- Mining:
 - 19,514 AFA (8,449 past/present + 11,065 future)
- Energy Resources Development:
 - 33,201 AFA (129 past/present + 33,072 future)

² This information is found in a summary and report prepared by Stetson Engineers, Inc. dated September 20, 1985 and September 27, 1985 respectively, which were submitted with the claim. Attached to the Stetson report are four maps and 16 tables that provide additional information for each category of claim, including the points of diversion by reference to UTM coordinates and/or a map. The Department did not attempt to segregate the amounts claimed for the Hopi and the Navajo based on the points of diversion in the tables.



- Recreation:
 - 2,694 AF (2,316 past/present + 378 future)

3.4.2 1994 United States Revised Claim

On November 22, 1994, pursuant to court order, the United States, on its own behalf and as trustee for the Navajo Nation, the Hopi Tribe, the White Mountain Apache Tribe and the Zuni Pueblo, filed revised SOCs on behalf of Indian Lands in the Little Colorado River Basin, including SOC No. 39-91441 for the Hopi Tribe. The United States asserted tribal water rights based on federal law. The claimed water uses set forth in the filing for the Hopi Indian Reservation are set forth below, and were based on past and present as well as future uses, as indicated below.

- DCMI:
 - 6,160 AFA (1,793 past/present + 4,367 future municipal + 1,102 future commercial) based on present and future population in 2040 for communities, towns, villages, homesites and farmsteads.³
- Irrigation:
 - 75,747 AFA total (44,187 past/present + 31,560 future)
 - 58,717 AFA (42,937 past/present + 15,780 future) for irrigation from surface water, including the LCR;
 - 17,030 AFA (1,250 past/present + 15,780 future) of groundwater, including LCR alluvium
- Evaporation from Irrigation Storage:
 - 9,545 AF (186 past/present + 9,359 future) of surface water
- Livestock and water storage for stock (stockponds):
 - 4,777 AF (4,601 past/present + 176 future) from groundwater and surface runoff, including evaporation losses, based on average volume and a single annual fill of stockponds, lakes and reservoirs.
- Mining:

³ The claim indicates that 507 wells and springs had been inventoried on the Hopi Reservation for stock and domestic purposes. An additional 23 wells were identified for public water supply purposes.



- 19,514 AFA (8,449 past/present + 11,065 future) for Navajo and Hopi (combined) mining uses at the Peabody Coal mine on Black Mesa, including pipeline slurry, dust control, construction, potable purposes, evaporation from sedimentation ponds and related mining activities, together with future mining activities located throughout both reservations.
- Recreation:
 - 231 AF (80 past/present + 151 future) for camping, fishing and evaporation from recreational lakes.

3.4.3 2004 United States Claim (First Amended SOC)

On January 30, 2004 the United States filed amended SOC No. 39-91441 (United States First Amended SOC) on behalf of the Hopi Tribe. The claimed priority date is aboriginal, or time immemorial, based on the Hopi’s aboriginal presence on lands within the Hopi Reservation. The United States claims are based on the federal reserved rights doctrine under *Winters v. United States*, 207 U.S. 564 (1908), *Arizona v. California*, 373 U.S. 546 (1963), *Cappaert v. United States*, 426 U.S. 128 (1976) and *In re the General Adjudication of all Rights to Use Water in the Gila River System and Source*, 201 Ariz. 307, 35 P.3d 68 (2001). The United States claims “sufficient water to provide for the present and future water needs necessary to fulfill the purposes of the Hopi Reservation as a permanent home and abiding place for the Hopi people.” In its claim, the United States indicates that the federal government continues to investigate the Hopi water rights and that the claim may be supplemented or amended in the future.

The United States claims a federal reserved water right to water from various surface water and groundwater sources within reservation lands, including water from springs, wells and impoundments. Surface water sources include five washes (Moenkopi, Dinnebito, Oraibi, Polacca and Jeddito), and minor tributaries that flow from north to south through the reservation. Groundwater sources include the N Aquifer, which is discussed in **Chapter 2** of this report. The claimed water uses set forth in the filing are listed below, and were based on past and present (as of 2004) as well as future uses, as indicated below.

- DCMI:
 - 11,211 AFA present and future from the N Aquifer.
- Irrigation:



- 49,136 AFA for past/present irrigation from five washes that flow from north to south through the Hopi Reservation
- Livestock and water storage for stock (stockponds):
 - 8,044 AFA total for past/present use from 338 springs (2,206 AFA), 561 impoundments (4,499 AFA) and 206 wells (1,339 AFA)
- Mining:
 - 3,000 AFA for present and future use from the N Aquifer
- Other (off-Reservation uses):
 - 556 AFA for future heavy commercial use from the C Aquifer
 - 2,366 AFA for the Hopi Ranches and 2,089 AF storage

3.4.4 2009 United States Claim (Second Amended SOC)

On June 30, 2009 the United States filed amended SOC No. 39-91441 (United States Second Amended SOC) on behalf of the Hopi Tribe. The claimed priority date, the legal basis, the purpose of the claim, and the possibility that the claim would be supplemented or amended in the future is the same as that stated in the First Amended SOC filed in 2004. Also, the claimed water sources are the same as those indicated in the First Amended SOC.

The claimed water uses set forth in the filing are listed below, and were based on past and present (as of 2009), as well as future uses, as indicated below.

- DCMI:
 - 9,110 AFA from existing and future wells and springs, the N and C Aquifers as well as other minor aquifers
- Irrigation:
 - 21,199 AFA past/present irrigation from five washes that flow from north to south through the Hopi Reservation (Moenkopi, Dinnebito, Oraibi, Polacca and Jeddito)
- Livestock and water storage for stock (stockponds):
 - 4,400 AFA (3,403 AFA past/present from groundwater and surface runoff, + 997 AFA future from existing and future wells)
- Ceremonial and Subsistence Irrigation:
 - 4,977 AFA future from the N Aquifer



- Mining and Related Industry:
 - 7,736 AFA (1,236 past/present + 6,500 future) from the N Aquifer
- Other (off-Reservation uses):
 - 902 AFA (522 AFA future from the C Aquifer + 380 AFA future for the Hopi Industrial Park)
 - 1,556 AFA past/present for Hopi Ranches and 1,837 AF storage

3.5 2015 UNITED STATES CLAIM (Third Amended SOC)

On June 2, 2015 the United States filed amended SOC No. 39-91441 (United States Third Amended SOC) on behalf of the Hopi Tribe claiming a combined total of 54,574 AFA of water in the LCR watershed. The United States indicates that the federal government continues to investigate the Hopi water rights and that the claim may be supplemented or amended in the future. The United States Third Amended SOC provides information concerning the following:

- Legal Basis of Claim
- Priority Date
- Uses of Water
- Sources of Water
- Points of Diversion, Means of Diversion and Places of Use
- Quantities of Use

This section summarizes the information presented in the United States Third Amended SOC in the same order as information presented in the Hopi Third Amended SOC (as supplemented) to assist in comparison of the claims.

3.5.1 Legal Basis of Claim

The United States claims are based on the federal reserved rights doctrine under *United States v. Ahtanum Irrigation District*, 236 F.2d 321 (9th Cir. 1956), *cert. denied*, 352 U.S. 988 (1957) (recognizing Indians’ right to use water based on their right of use and occupancy); *Winters v. United States*, 207 U.S. 564 (1908), *Arizona v. California*, 373 U.S. 546 (1963) and *In re the General Adjudication of all Rights to Use Water in the Gila River System and Source*, 201 Ariz.



307, 35 P.3d 68 (2001). The United States claims “sufficient water to provide for the present and future needs necessary to fulfill the purpose of the Hopi Reservation as a permanent home and abiding place for the Hopi people.”

3.5.2 Priority Date

The United States claims a priority date of time immemorial for all claims on the 1882 Executive Order Reservation and Moenkopi Island. Although the United States Third Amended SOC acknowledges that the Special Master’s Priority Date Report dated April 24, 2013 recommends different priority dates for parts of the Reservation, the United States points out that objections by several parties to that report were argued to Judge Brain on January 17, 2014 and the matter is pending.

3.5.3 Uses of Water

The United States claims types of water uses on behalf of the Hopi Tribe in the following categories:

- DCMI;
- Heavy Industrial/Mining Related Industry;
- Livestock;
- Stockpond storage capacity;
- Past and present irrigation;
- Riparian and wetlands habitat; and
- Future irrigation/subsistence and cultural purposes

The uses listed above are summarized in **Table 3-2** and further described in **Section 3.5.6** and **Chapter 4**.

3.5.4 Sources of Water

The United States claims a federal reserved water right to water from various surface water and groundwater sources within reservation lands, including water from springs, wells and impoundments. Surface water sources include five washes (Moenkopi, Dinnebito, Oraibi, Polacca



and Jeddito), and minor tributaries that flow from north to south through the reservation. Groundwater sources include the N Aquifer, which is discussed in **Chapter 2** of this report.

3.5.5 Points of Diversion, Means of Diversion and Places of Use

The United States' Third Amended SOC does not identify points of diversion, but references locations of point sources (wells, springs and impoundments) listed in Appendices 4, 5 and 6 to the amended claim. Appendix 7 to the amended claim contains a series of maps depicting locations of existing point sources within the Reservation. The United States' Third Amended SOC does not specifically describe means of conveyance.

The United States' Third Amended SOC references Appendix 1 to the claim, which identifies the places of use as the 1882 Executive Order Reservation and the 1934 Act Reservation (Moenkopi Island). Appendices 8-10 of the United States' claim additionally show certain locations of places of use within the Reservation.

3.5.6 Quantities of Use

The United States Third Amended SOC claims the following quantities of use based on past and present uses (as of 2015), as well as future uses, as indicated below:

- DCMI:
 - 8,746 AFA future (based on present and future population in 2175)
- Irrigation:
 - 28,417 AFA past/present irrigation from five washes that flow from north to south through the Hopi Reservation and minor tributaries to the LCR
- Livestock and water storage for stock (stockponds):
 - 4,385 AFA (3,388 AFA past/present from surface water sources + 997 AFA future from existing and future wells)
- Ceremonial and Subsistence Irrigation:
 - 4,977 AFA future from the N Aquifer
- Mining:
 - 7,755 AFA (1,255 AFA past/present + 6,500 AFA future)
- Aesthetic, Cultural and Ecological Flows:



- 294 AFA past/present for riparian and wetland habitat (Pasture Canyon)

Table 3-2 displays how the claims filed by the US on behalf of the Hopi Tribe have changed over time.

3.6 SUMMARY AND COMPARISON OF HOPI AND UNITED STATES 2015 CLAIMS

This section compares the quantities of water included in the amended claims filed by the Hopi and United States, as summarized in **Sections 3.2.6** and **3.5.6**, respectively. There are significant differences between the claimed amounts, which are primarily due to different quantification approaches. The comparison is presented in **Table 3-3** of this report and is summarized below for each type of water use claimed. The claimed amounts are further described in **Chapter 4**.

3.6.1 DCMI

The Hopi Tribe and the United States claim 9,348 and 8,746 AFA, respectively, for DCMI purposes based on a projected population of 52,016 in the year 2175. However, neither the Hopi nor United States claim a separate amount for past or present DCMI use, although they acknowledge that there have been past and present DCMI uses.⁴ Instead, they each claimed multiple water uses from a group of existing springs and wells (and future wells as needed) to satisfy DCMI uses. The Hopi and the United States base their quantities of use on 160 and 150 gpcd water use rates, respectively.

3.6.2 Agricultural (Irrigation)

The Hopi Tribe and the United States claim maximum diversions in the amounts of 102,303 and 28,417 AFA, respectively, to provide an adequate water supply for irrigation purposes. They both claim amounts from the five washes and tributaries on the 1882 Executive Order Reservation. The Hopi's claim is based on a composite of 26,922 acres of land that have been irrigated at any

⁴ ADWR requested information from the Hopi and the United States regarding past and present DCMI uses, but such information was not provided.



time historically to present. The United States' claim is based on a composite of 13,032 acres of land that have been irrigated at any time historically to present.

3.6.3 Evaporation from Irrigation Storage

The Hopi claim 192 AFA for evaporation from irrigation storage. The United States does not claim an amount in this category.

3.6.4 Livestock and Water Storage for Stock (Stockponds)

The Hopi Tribe and the United States claim the right to divert and store 6,184 and 3,388 AF, respectively, for past and present livestock use. The Hopi Tribe and the United States claim an additional 1,000 and 997 AFA, respectively, for future livestock use from existing and future wells and springs. The amounts claimed are based on an estimated Reservation maximum livestock carrying capacity of 44,486 animal units with a corresponding water consumption rate of 12 gpd per animal unit.

3.6.5 Ceremonial and Subsistence Irrigation

The Hopi Tribe and the United States claim 7,385 and 4,977 AFA, respectively, for ceremonial (cultural) and subsistence purposes based on a projected population of 52,016 in the year 2175. The Hopi and the United States base their quantities of use on planned future irrigated coverage of 2,646 acres of land (for small family plots and gardens). Neither the Hopi nor United States claim a separate amount for past or present ceremonial and subsistence irrigation use although they acknowledge that such uses have taken place.⁵

3.6.6 Mining

Both the Hopi and United States claim 1,255 AFA for past and present mining needs. According to the Hopi and United States, the claimed amount is based on coal mining activities associated with Peabody Coal Company's Black Mesa Mine Complex. The Hopi Tribe and the

⁵ ADWR requested additional information from both the Hopi Tribe and the United States regarding past and present ceremonial and subsistence irrigation uses, but it was not provided.



United States claim an additional 500 and 6,500 AFA, respectively, for future mining related activities.

3.6.7 Energy Resources Development

The Hopi Tribe claims 27,100 AFA for future energy resource development. According to the Hopi, the claimed amount is based on power generation needs for a new mine and for future heavy industrial uses. The Hopi Tribe does not claim a separate amount for past or present energy resource development use. The United States does not claim an amount in this category.

3.6.8 Tourism

The Hopi Tribe claims 1,022 AFA for a future destination resort and for expansion of the Hopi Tribal Cultural Center. The Hopi Tribe does not claim a separate amount for past or present tourism use. The United States does not claim an amount in this category.

3.6.9 Recreation

The Hopi Tribe claims 41 AFA for past and present recreational use. The amount claimed is for the right to continuously fill Keams Lake to its maximum capacity. The United States does not claim an amount in this category.

3.6.10 Subsurface Mineral Rights

The Hopi Tribe claims 40,295 AFA for its proportional share of the water in/and feeding the Blue Springs complex. According to the Hopi, the claimed amount is based on the Tribe's land area in the LCR Basin. The United States does not claim an amount in this category.

3.6.11 Aesthetic, Cultural and Ecological Flows (Riparian Habitat and Instream Flows)

The Hopi Tribe and the United States claim 310 and 294 AFA, respectively, for past and present aesthetic, cultural and ecological flows. The non-diversionary amounts claimed are based on annual estimated evapotranspiration depletion rates from wetland habitats and riparian vegetation along Pasture Canyon and White Ruin Canyon wash and for instream flows in the lower Little Colorado River.



3.6.12 Total Quantities

At the bottom of **Table 3-3**, ADWR totals the past and present and future claimed quantities of use for the categories described above. The total amount claimed by the Hopi Tribe is 196,935 AFA. The total amount claimed by the United States, on behalf of the Tribe, is 54,574 AFA. The Tribe's total annual water rights claim is approximately three and a half times greater than the total presented by the United States on the Tribe's behalf due primarily to the Hopi's claim for irrigation uses.



**CHAPTER 4:
DESCRIPTION AND ANALYSIS OF
CLAIMED WATER USES**

CHAPTER 4: DESCRIPTION AND ANALYSIS OF CLAIMED WATER USES

The Hopi and United States Third Amended SOCs claim the following categories of water uses, as described in **Chapter 3**:

- Domestic, Commercial, Municipal, and Industrial (DCMI);
- Agricultural (Irrigation);
- Evaporation from Irrigation Storage;
- Livestock and Water Storage for Stock (Stockponds);
- Ceremonial and Subsistence Irrigation;
- Mining;
- Energy Resources Development;
- Tourism;
- Recreation;
- Subsurface Mineral Rights; and
- Aesthetic, Cultural and Ecological Flows (Riparian and Wetlands Habitat).

This chapter provides a description and background information for each category of water use, followed by a description of the claims and supporting information for those claims provided by both the Hopi Tribe and the United States. The findings of ADWR's review of the claims are then presented. Based on these findings, ADWR's proposed attributes for past and present uses are discussed and presented in **Chapter 5**.

4.1 DOMESTIC, COMMERCIAL, MUNICIPAL AND INDUSTRIAL USE

4.1.1 Description and Background

Domestic, commercial, municipal and industrial (DCMI) water use incorporates multiple types of non-irrigation water demands that can be supplied by individual wells or springs, or through public water systems. Generally, domestic or residential use includes water used indoors (bathing, cooking, cleaning, etc.) and water used outdoors (watering plants, swimming pools,



washing cars, etc.) (ADWR, 2015a). Commercial water use generally incorporates use within commercial or office buildings, hospitals, and schools. Industrial uses are generally quite diverse and include turf-related facilities, sand and gravel operations, large-scale power plants and cooling facilities, dairy operations, cattle feed lots, and large landscape users (ADWR, 2015b). Municipal water use includes government buildings, parks, and other public service related facilities. Municipal water systems can be used to supply domestic, commercial, and light industrial uses.

One method for determining DCMI water use is by directly measuring water deliveries from the various providers. However, not all water providers are regulated or required to report water use (e.g. domestic well owners), so directly measuring DCMI water use can be difficult. Where there are no direct measurements of DCMI water use, such as on the Reservation, DCMI water use is often estimated based on an assumed usage per person. The per person usage is represented as the number of gallons used per capita per day (gpcd) for a population within a selected geographical area or municipality. Both estimated and calculated gpcd values vary widely throughout Arizona. Because large water users such as golf courses may be served by a municipal system, gpcd rates within towns serving such large uses may be significantly higher than in towns without large water users. Some examples of calculated gpcd values within Arizona are provided below.

ADWR stated in the 2008 Preliminary HSR that in 2000, the cities of Williams and Page had an estimated per capita water use of 198 and 351 gpcd, respectively. For Flagstaff, per capita water usage was estimated at 120 gpcd in 2005 and 132 gpcd in 2002 (BOR, 2006).

The U.S. Geological Survey's (USGS) National Water-Use Information Program compiles and publishes water-use data by state and national basis every five years. The USGS works in cooperation with local, state, and federal environmental agencies to collect water-use information. According to the USGS, the total domestic per capita use in Arizona for 2010 was 147 gpcd. The USGS domestic per capita use includes self-supplied domestic and public supply uses (USGS, 2015).



4.1.2 Claimed Use and Basis

4.1.2.1 Hopi Third Amended SOC (DCMI)

In its Third Amended SOC, the Hopi claim a future DCMI water use of 9,348 AFA. The total future use claim is based on tribal-wide DCMI demands, rather than village-by-village water demands, using a per capita estimated water use.

The per capita approach used by the Hopi consists of multiplying a stable reservation population projection for the year 2175 and an assumed per capita usage rate. Hopi population projections rely on the work of experts retained by the United States, which has been updated since the Tribe filed its Second Amended SOC. The Hopi used a stable population projection of 52,016 in 2175 for the 1882 Executive Order Reservation and Moenkopi Island. This population projection does not include the Hopi Industrial Park, which is located outside of the Reservation. The population projection figure was obtained from a table identified in the claim as “Appendix 3 – Distribution of Hopi Reservation Population Projection” from an unnamed report prepared for the United States by the consulting firm, Ramboll Environ. The table lists population estimates from 2010 through 2120, with a stable population estimate in 2175 for each of 11 tribal villages and a “Total Rural Population” category.

The Hopi use a per capita usage rate of 160 gpcd, which includes residential indoor use, residential outdoor use, commercial use, light industrial use, public uses and system losses. The Hopi did not provide any documentation or information to support the 160 gpcd usage figure, although it was requested by ADWR.

4.1.2.2 United States Third Amended SOC (DCMI)

In its Third Amended SOC, the United States claim a present and future DCMI water use of 8,746 AFA. Like the Hopi, the United States also utilized a per capita approach, based on current population and a future stable population projection of 52,016 for 2175 determined by Ramboll Environ.

The claim states that the population forecast is based on the 2010 Census, demographic methodology and data, information collected from Hopi tribal reports, interviews with Hopi tribal members and employees, and other sources. According to the United States, the population



projection is based on current and future geographic distribution of villages and other population centers on the Reservation.

In support of its Third Amended SOC, the United States provided two documents: 1) “Brief Summary of Little Colorado River Basin Hopi Reservation Population Projection for Arizona Department of Water Resources,” dated August 20, 2015, from Ramboll Environ; and 2) an excerpt from the Ramboll Environ demographic report, updated in July 2015, entitled “Current Hopi Reservation Population.” ADWR requested the complete Ramboll Environ report from the United States but it was not provided.

The United States utilized a slightly lower per capita usage rate of 150 gpcd than the Hopi. The 150 gpcd rate represents several components including: residential indoor use; residential outdoor use including irrigation for landscape and gardens; commercial use; light industrial use; public use and system losses. The United States stated that this rate is based on comparisons with local area water use and state averages. ADWR requested supporting documentation, information, or data to support the 150 gpcd figure, but it was not provided.

4.1.3 ADWR Review and Findings (DCMI)

4.1.3.1 Review of Hopi Third Amended SOC (DCMI)

The Hopi claim of 9,348 AFA for DCMI water use is presented as a future use only, and is based on a future per capita use rate of approximately 160 gpcd. The Hopi stated in 2009 in their written comments to the 2008 Preliminary HSR (Hopi, 2009) that the per capita water use in Tuba City, AZ was 146 gpcd at that time. The Hopi did not provide any direct evidence or data in support of their 160 gpcd estimate, although it was requested by ADWR.

In 2009, the Community Water System Program at ADWR produced a summary report that included annual water use reporting from 2006 through 2008. The summary report included annual water demands and annual gpcd use rates for systems in the Little Colorado River Plateau Basin in Navajo County. There were four community water systems included in the summary report for this area which are in close proximity to the Hopi Reservation: City of Winslow, City of Holbrook, Sun Valley Utilities Corp. (Holbrook area), and Joseph City Utility. **Table 4-1** summarizes the gpcd values for these systems which range from 135 to 213 gpcd (ADWR, 2009). The 160 gpcd value used by the Hopi is within this range.



The Tribe's population projections relied upon the work of Ramboll Environ that included a total population estimate on the Reservation in 2015 of 8,853. Assuming a per capita use rate of 160 gpcd, and a current (2015) estimated population of 8,853, ADWR calculated that the current DCMI use would be 1,591 AFA. ADWR also calculated that the future DCMI use for the Reservation would be 7,757 AFA (9,348 AFA – 1,591 AFA).

4.1.3.2 Review of United States Third Amended SOC (DCMI)

The United States claim a present and future DCMI water use of 8,746 AFA. Although the United States describes the DCMI use as present and future, the present and future uses are not provided separately in its Third Amended SOC. The United States included irrigation for landscape and gardens in the DCMI use category while the Hopi did not. The Hopi and United States both have a separate use claim for Ceremonial and Subsistence Irrigation, which is discussed below in this chapter.

The United States Third Amended SOC is based on a per capita demand of 150 gpcd. Assuming a per capita demand of 150 gpcd, and a current estimated population of 8,853 based on the work done by Ramboll Environ, ADWR calculated that the estimated current DCMI use would be 1,489 AFA. ADWR also calculated that the future DCMI use for the Reservation would be 7,257 AFA (8,746 AFA – 1,489 AFA). In its claim, the United States indicates that it based the 150 gpcd rate on comparisons with local area water use and state averages, but it did not provide any additional information or data in support of its 150 gpcd rate and did not provide copies of the reports prepared by Ramboll Environ, although that information was requested by ADWR.

4.2 AGRICULTURAL USE (IRRIGATION)

4.2.1 Description and Background

The Hopi have a long history of farming in the region, and their water right claims in the adjudication reflect this history. The largest claims for water on the Reservation are for irrigation of agricultural lands. About 63% of the Reservation, or over 1 million acres, have been determined to have soils that could potentially grow crops if irrigated (ADWR, 2008p).

Use of Reservation land for farming has, and apparently continues to be, bound by land ownership rules (Andersen, 2008). Hopi villages reportedly have claims to the best farmland, and



clans within the villages have their own claims based on tenure. Within clans, Hopi families may own individual farm tracts and may try to have two or more fields located on different streams and/or in different areas to improve their chances for a successful crop.

Traditional and more modern (recent) farming practices have been in the past and are presently still being used by the Tribe to grow crops on the Reservation. Both farming practices are further described below.

Traditional Farming

The Hopi have a long history of growing crops in the region and have developed traditional farming practices to adapt to a limited water supply and relatively harsh climate. The latter is characterized by strong winds, early and late frosts, and a semi-arid climate. Hopi cultivation methods include, but are not limited to, diverting surface water flows onto the floodplains and terraces of large washes, placing fields at the mouth of smaller washes (ak-chin farming), and constructing check dams along small washes (Trinchera fields). Springs also have historically been developed to convey water to terrace gardens at and near the Hopi villages and to sand dunes on the sides and tops of mesas for cultivation.

Historic accounts suggest the Hopi have used these farming practices for centuries (Andersen, 2008). The Spanish reported Hopi growing a surplus of beans, corn, cotton, squash, and other vegetables as early as 1583 near the Hopi Mesas, and as early as 1604 in the Moenkopi area. Several crops including fruits (apples, apricots, and peaches), onions, peppers, and wheat were introduced by the Spanish and later adopted by the Hopi. In an early survey of the District 6 area, Mayhugh (1892) identified 12 springs and pools that he reported were being used by the Hopi to water gardens and peach orchards. Archeological evidence suggests the Hopi may have farmed other areas as far east as Canyon De Chelly, as far south as the LCR, as far west as the Kerley Valley, and the Coal Mine Mesa and Moenkopi Plateau region that currently lies on Navajo land between the Hopi Partitioned Land and Moenkopi area. The Hopi reportedly have travelled long distances to tend to individual fields. Such long distance farming included fields in the Sand Spring, Burro Spring, Coyote Spring, and Talahogan areas (Hopi, 2009).

Although traditional farming practices have been modified somewhat to incorporate new tools, similar techniques are generally still being employed (Andersen, 2008). For example, rather than using hoes to cultivate fields by hand, horses and tractors have been employed to plow or disk



fields in the spring prior to planting, during the growing season to control weeds, and in the fall after harvest.

Cultivated fields are still harvested and largely planted by hand and pesticides are generally not used. In her study of Hopi farms, Manolescu (1995) found that up to one-third of crops grown on the Reservation were lost to pests. She also found that the best fields were still those less than three acres large, located along or near streams, and hand planted. Cultivation of sand dunes is also a prevalent practice, as observed in the field by ADWR in 2005. On sand dunes, tin cans and tires have replaced rock and brush fences as wind breaks. Approximately 5,000 acres of active traditional farming were identified by ADWR during its 2005 survey.

Modern (Recent) Farming

The first attempt at more modern farming methods on the Reservation appears to be the efforts of Mormon settlers in the Moenkopi area (Andersen, 2008). Mormons were established in the area by 1875 and afterward, the Hopi began to return to fields they had previously farmed. The Hopi reportedly used traditional farming practices in and around Moenkopi, including lands that are now on the Navajo Reservation, using the relatively abundant spring water along Pasture Canyon.

Sometime before 1903, the Mormons built an upper dam and middle dam along Pasture Canyon that were raised in 1908 (Andersen, 2008). The middle dam was later abandoned, and the upper dam rebuilt by the Federal government in the 1920s and 1930s, and raised again in the 1970s to form present day Pasture Canyon Reservoir. It is unclear whether a third dam presently located along lower Pasture Canyon (Lower Lagoon Reservoir) was built by the Mormons prior to 1912 or afterward by the Federal government. Either way, by 1914, crops including corn, wheat, melons, squash, and fruit were being grown using the Pasture Canyon irrigation system. The number of acres cropped by the Hopi in the area increased from 385 in 1907 to between 600 and 860 in the 1930s, and 550 in 1963. However, it is not clear to ADWR what portions of these lands were being irrigated from Pasture Canyon Reservoir. In 1958, it was reported that the Pasture Canyon irrigation system was serving an area of approximately 300 acres, presumably below the dam, but only 40% of this area (120 acres) was being cropped at that time (Chambers & Campbell, 1962).



Agricultural lands in the Moenkopi area were surveyed by ADWR during 2005, 2006, and 2008 (ADWR, 2008p, Appendix G). Water for most fields was observed to originate as spring discharge along upper Pasture Canyon and stored downstream in Pasture Canyon Reservoir. Below the reservoir, the water is piped both below and above ground surface to a main canal that feeds a series of unlined lateral ditches. Abandoned instream pumps were also observed along Moenkopi Wash that may have previously been used to irrigate some fields in the area. A new wastewater treatment plant was being completed in 2008 near the western boundary of the Moenkopi area. According to Hopi guides, reclaimed water from the plant was planned to be used to irrigate Hopi and adjoining Navajo lands. The Tribe claims the wastewater treatment plant has been releasing water for irrigation use.

The Federal government constructed other irrigation projects on the Hopi Indian Reservation, but none have been as successful as Pasture Canyon. ADWR described several historic irrigation projects including their general location, date of completion, system components, annual acreage cropped, years in operation, and status (ADWR, 2008p). According to the Tribe, other irrigation projects that were developed, but not listed in ADWR (2008p) included Begashibito 2, Upper Kerley Valley, (joint Hopi/Navajo), Oraibi Delta (joint Hopi/Navajo), Polacca Wash 1, Polacca Wash 35, and Polacca Delta (joint Hopi/Navajo). The irrigation projects were generally completed between the 1890s and 1940 and all appear to have been lost by 1960, either through flooding, abandonment, or both. More recently (circa 2000) an irrigation system was completed along Dinnebito Wash (near Sand Springs), referenced in the Hopi Third Amended SOC as “historic project DW 10,” consisting of an instream pump and drip lines. The current acreage claimed to be served by this project is approximately 70 acres.

4.2.2 Claimed Use and Basis

Claims in the Hopi Third Amended SOC and Supplement and United States Third Amended SOC for past and present irrigation represent a composite of all lands the Hopi and United States determined, through analysis of historic aerial photographs and field surveys, to have been farmed on at least one occasion. The acreage claimed represents the total acreage of all the fields that show visible evidence of cultivation.



4.2.2.1 Supplement to Hopi Third Amended SOC (Agricultural Use)

Acreage

In the 2015 supplement to the Hopi Third Amended SOC (Hopi Tribe Supplement), the Hopi claim the right to annually irrigate a composite total of 26,921.9 acres of land. The past and present claimed acreage information is presented in Table 2 of the Hopi Tribe Supplement and includes an additional 311 acres not identified in the Hopi Third Amended SOC. Table 2 references acreage described in the United States Third Amended SOC and identified by ADWR in the 2008 Preliminary Hopi HSR (ADWR, 2008p). Table 2 lists six categories of irrigated lands and corresponding acreages as described below:

- **13,031.6 acres** –described in the United States Third Amended Claim;
- **1,853.3 acres** - identified by ADWR (2008p) as having “Complete Evidence” and not included in the United States claim;
- **11,658.5 acres** - identified by ADWR (2008p) as having “Partial Evidence” and not included in the United States claim;
- **67.5 acres** - “Historic project DW10” acreage on Dinnebito Wash and not included in the above categories or previously verified by ADWR;
- **172.7 acres** - “Additional Historic Irrigated Acreage (HIA) from New Aerial Imagery, Current Irrigation;” and
- **138.3 acres** - “Additional Historic Irrigated Acreage (HIA) from New Aerial Imagery, Recent Irrigation.”

The Tribe provided ADWR with GIS shapefiles depicting the irrigated acreage for each category listed above. The Hopi Third Amended SOC did not include any historical aerial imagery data associated with the claim, instead relying on supporting data in the United States claim and on the Preliminary Hopi HSR classification system and imagery analysis determinations.¹

The Hopi Tribe Supplement explains how the Tribe digitized additional historic irrigated acreage from 2010 Bing aerial imagery obtained by using GIS software. This imagery is shown in Appendix 1 to the Hopi Tribe Supplement. (See Hopi, 2015 (Supplement) at p. 6, n. 5)

¹ The Preliminary Hopi HSR contains Appendix G-1, Verification of Claimed Agricultural Lands on the Hopi Indian Reservation.



Quantity of Use

As described in **Chapter 3**, the Hopi claim a diversion volume of 102,303 AFA, based on a claimed water duty of 3.80 acre-feet per acre of surface and groundwater to irrigate the 26,921.9 acres of agricultural lands described above.² To ADWR's knowledge, the quantity of irrigation water applied to cultivated fields, in any of the categories claimed, has not been measured directly by the Tribe.

4.2.2.2 United States Third Amended SOC (Agricultural Use)

Acreage

The United States' agricultural claims represent a composite of all lands that they determined, through analysis of aerial photographs, had at one time been farmed on the Reservation. The United States claims the right to annually irrigate a total of 13,032 acres of land. The past and present claimed acreage information is presented in Table 1 of the United States Third Amended SOC. Table 1 presents information for six classes of irrigation, which are based on water source and crop, in the five main washes and minor tributaries on the Reservation. The six classes of irrigation and corresponding acreages listed in the United States claim are as follows:

- **Perennial Irrigation (264 acres)** - irrigation with perennial spring water conveyed and stored in permanent structures;
- **Seasonal Irrigation (4,294 acres)** – irrigation with seasonal surface water conveyed by permanent or temporary structures or by pumping;
- **Range / Pasture Irrigation (3,483 acres)** – irrigation with seasonal surface water to improve range for pasture conveyed by permanent or temporary structures;
- **Native Irrigation (4,791 acres)** – irrigation with seasonal surface water with minimal or no conveyance structures to cropped areas, which are strategically placed;
- **Well Irrigation (17 acres)** – irrigation with water from a well conveyed through a system of pipes and/or open ditches; and

² See Table 2, Hopi, 2015 (Supplement).



- **Spring Irrigation (183 acres)** – irrigation from “perennial” groundwater, obtained and distributed from a spring.

The United States provided ADWR with GIS shapefiles (digitized irrigated acreage coverages) containing polygons of historic and/or currently irrigated agricultural fields and aerial imagery used as the basis for determining agricultural activity. Appendix 8 to the United States claim contains a series of maps depicting the irrigated acreage on the Hopi Reservation, based on the United States’ aerial photo interpretations.

Digital ortho-rectified aerial photography datasets spanning eight decades, from the mid-1930s through the 2010s, used in support of the United States claim, were made available to ADWR for analysis. The photography was prepared and georeferenced and indexed by National Resources Consulting Engineers, Inc. (NRCE). The United States aerial photography datasets include the following coverage dates:

- 1934-1935 SCS (Soil Conservation Service) images;
- 1952 GS-WG images³
- 1954-1955 Army Map Services (AMS) images;
- 1974 Joint Use Area (JUA) images;
- 1980 National High Altitude Photography (NHAP), precursor to National Agriculture Imagery Program (NAIP) images; and
- 2010 and 2013 NAIP images.

The United States Third Amended SOC states that “use of aerial photos from 1952, 1954, and 1955 provided for delineation of the native irrigation fields, while use of photos from 1934, 1952, 1954, 1955, 1974, 1980, 2010 and 2013 allowed delineation of fields in the five other irrigation classes.”

Quantity of Use

Estimated irrigation depletion and diversion amounts from the five washes and other minor tributaries are presented in Table 2 of the United States Third Amended SOC. Table 2 lists

³ ADWR was unable to determine the originator of these images.



irrigation depletions and diversion amounts for the five washes and tributaries in both average and maximum years. The United States claims the maximum diversion amount “in order to provide a water supply for the maximum irrigated acreage in years that the water is available.”

Table 2 of the United States Third Amended SOC lists average and maximum irrigation depletion amounts for the five washes and minor tributaries totaling 14,148 AFA and 20,626 AFA, respectively. The table also lists average and maximum irrigation diversion amounts for the five washes and minor tributaries totaling 19,440 AFA and 28,417 AFA, respectively. The United States claims the maximum irrigation diversion total of 28,417 AFA for past and present irrigation on the Reservation.

4.2.3 ADWR Review and Findings (Agricultural Use)

4.2.3.1 Review of Supplement to Hopi Third Amended SOC (Agricultural Use)

Acreage

The past and present irrigated acreage claims listed in the Hopi Third Amended SOC and Supplement were verified by ADWR via an office GIS aerial photo interpretation evaluation (ADWR 2015 GIS Verification). The ADWR 2015 GIS Verification evaluated the GIS polygons for claimed agricultural fields associated with the six categories of irrigated lands described in **Section 4.2.2.1**, in conjunction with the multiple years of aerial photography provided by the United States as described in Section 4.2.2.2. ADWR’s findings are presented below and summarized in **Table 4-2** provides claim acreage not verified by ADWR.

(1) United States Third Amended Claim Acreage (13,031.6 acres)

Approximately 13,022 acres or 99.9% of lands claimed by the United States, and referenced by the Hopi Tribe, have evidence of previous agricultural activity. Approximately 10 acres of land (or roughly 0.1%) show no evidence of historic agricultural activity as observed in the provided aerial imagery.

(2) ADWR (2008) Complete Evidence Acreage (1,853.3 acres)

All of the 1,853.3 acres claimed by the Hopi, and previously classified by ADWR in the Preliminary Hopi HSR as irrigated based on ‘Complete Evidence,’ are re-verified as having evidence of previous agricultural activity.



(3) ADWR (2008) Partial Evidence Acreage (11,658.5 acres)

Approximately 11,007.8 acres or 94% of lands claimed by the Hopi, and previously classified by ADWR in the Preliminary Hopi HSR as irrigated based on ‘Partial Evidence’, are re-verified as having evidence of previous agricultural activity. Approximately 650.7 acres were found to have either less than 50% agricultural activity observable in the provided aerial images, or were identified by ADWR as non-agricultural uses.

(4) Historic Project DW 10 Acreage (67.5 acres)

All 67.5 acres claimed by the Hopi were verified as having evidence of previous agricultural activity.

(5) Additional Historic Irrigated Acreage (HIA) – Current Irrigation (172.7 acres)

All 172.7 acres claimed by the Hopi were verified as having evidence of previous agricultural activity.

(6) Additional Historic Irrigated Acreage (HIA) – Recent Irrigation (138.3 acres)

All 138.3 acres claimed by the Hopi were verified as having evidence of previous agricultural activity.

The Hopi claimed, and ADWR evaluated, a composite total of all lands that were believed to have been irrigated at any time during the last approximately 80 years. The maximum total acreage that is believed to have been irrigated in any one period is 9,553 acres in the 1954-1955 timeframe, as claimed by both the Hopi and the United States in their 2009 Second Amended SOCs. That number of acres is consistent with the historical research conducted by Andersen (2008) who found that the maximum acreage irrigated in any one year was approximately 9,300 acres.

Quantity of Use

The Hopi claim a total of 26,921.9 acres of irrigated acreage within the six categories of irrigated lands described in **Section 4.2.2.1**. The total corresponding annual diversion volume claimed is 102,303 acre-feet based on a 3.80 acre-foot per acre water duty that is derived from



ADWRs findings in the Preliminary Hopi HSR. That report estimated agricultural water demands on the Reservation utilizing the following factors:

- the type of crops being grown;
- the net irrigation requirement of the crops (*i.e.*, the amount of water needed to supplement local precipitation);
- the efficiency of the irrigation system; and
- the cropped acreage.

Recent and historic surveys of Hopi fields indicate that corn has typically been the most common crop grown on the Reservation, followed by orchards, beans, melons, and squash. Using local climate data and accounting for the traditional farming practices of the Hopi, (ADWR, 20081) estimated the water demands for these crops. Results were summarized in Table 8-1 of the Preliminary Hopi HSR, which included a range of values that accounted for variations in climate across the Reservation and whether the crops were grown using traditional Hopi farming practices or through more modern agricultural methods. Table 8-1 also included composite and net irrigation requirements based on a typical crop mix for the Reservation and accounted for the effective precipitation in the area.

The composite irrigation requirement was defined in the Preliminary Hopi HSR as the irrigation requirement of different crop types weighted by their percentage in the crop mix. Net irrigation requirement (NIR) was calculated by reducing the composite irrigation requirement by the annual effective precipitation.

ADWR determined in the Preliminary HSR that crops grown following traditional Hopi farming practices had an NIR of 0.35 to 0.86 acre-feet per acre. If the same crop mix were grown using more modern agricultural methods, the NIR would increase to between 1.72 and 2.46 acre-feet per acre. The lower NIR calculated for traditional farming practices reflected the Hopi's ability to adapt to a limited, local water supply using a variety of strategies. A copy of ADWR's crop water demand study was provided in Appendix F of the Preliminary Hopi HSR.

DOWL, a water resources consultant to the Hopi Tribe, calculated the "full-supply" water duty per acre based on the following: 1) calculation of an average NIR value; 2) calculation of overall irrigation efficiency; and 3) calculation of a water duty to be applied Reservation-wide, on



a per-acre basis, to all past and present irrigation categories described in the claim. DOWL's quantification methodology is summarized below.

- 1) DOWL's quantification relies on use of the lower and upper NIR estimates for modern farming listed in Table 8-1 of the Preliminary Hopi HSR in order to calculate an average NIR value as follows:

$$\text{AVERAGE NIR} = 1.72 \text{ (lower)} + 2.46 \text{ (upper)} / 2 = 2.09^4$$

- 2) DOWL's overall irrigation efficiency calculation for the Reservation is as follows:

$$\text{OVERALL IRRIGATION EFFICIENCY} = 0.85 \text{ (irrigation conveyance efficiency)} \times 0.65 \text{ (on-farm efficiency)} = 0.55$$

- 3) DOWL's water duty calculation is as follows:

$$\text{WATER DUTY} = 2.09 \text{ ac-ft./acre (NIR)} / 0.55 \text{ (overall irrigation efficiency)} = 3.80 \text{ ac-ft./acre}$$

Once the water duty is determined, it is multiplied by the total number of irrigated acres for all of the irrigated lands listed in Table 2 in the Hopi Tribe Supplement in order to determine the total claimed annual diversion volume. The total claimed irrigated acreage from all six irrigation categories is 26,921.9 acres. The Hopi calculated total corresponding annual diversion volume of 102,303 AF as follows:

$$\text{AVERAGE ANNUAL DIVERSION VOLUME} = 3.80 \text{ ac-ft./acre} \times 26,921.9 \text{ acres} = 102,303 \text{ acre-feet}$$

The Hopi Third Amended SOC does not utilize or reference the range of NIR values for traditional Hopi farming practices (between 0.35 to 0.86 acre-feet per acre) from the Preliminary Hopi HSR. In its comments on the Preliminary Hopi HSR, the Tribe states "historic irrigation on the Hopi Reservation has included both traditional farming as well as irrigation projects which have higher NIR values and depletions" (Hopi, 2009 p.20) .

⁴. See Hopi Third Amendment at p. 32, n. 12; Table 2, Hopi Supplement at p. 7.



In 2010 ADWR received an updated consumptive use report, prepared under contract, in support of its work to finalize the Hopi HSR at that time. This report, entitled *Response to Comments on the Preliminary Hopi HSR Related to Consumptive Use of Water by Crops*, is provided as **Appendix D**. The original Appendix F of the Preliminary Hopi HSR is included as an appendix to the 2010 report.

The 2010 report responds to comments received by ADWR on the Preliminary Hopi HSR related to consumptive use (CU) of water by crops. In response to the comments received, the updated report describes changes made to ADWR's original CU calculation methods and provides revised results for Supplemental Irrigation Demand (SID), defined as the CU less the effective precipitation. These revised numbers are provided in **Table 4-3**.

As described above, the Hopi water resources consultant calculated an overall irrigation efficiency of 0.55 for all irrigated acres claimed by the Hopi. ADWR believes that this value is not unreasonable for modern irrigation, but that it should not be applied to acres irrigated using traditional farming practices. ADWR considers modern irrigation as equivalent to the perennial and spring classes and traditional irrigation as equivalent to the seasonal, range, and native classes, as described in the United States Second Amended SOC. ADWR is using the irrigation classes from the United States Second Amended SOC because those classes were used to describe the maximum acreage believed to have been irrigated in any one period.

As noted by DOWL, the overall irrigation efficiency is comprised of the irrigation conveyance efficiency and the on-farm efficiency, with the conveyance efficiency very much dependent on the length of the canal (FAO, 1989). The majority of traditionally farmed acres claimed in the Second Amended SOC have no conveyance systems and are instead strategically placed to intercept flowing water. Traditionally farmed acres have virtually no conveyance losses and their conveyance efficiency would be equal to 100%. ADWR believes that the conveyance efficiency that should be applied to traditional acres in aggregate should not be less than 90% (0.90).

Hopi traditional farming methods “have resulted in an agricultural efficiency known in few other places on earth.” (Wall and Masayeva, 2004.) For more than 1,000 years the Hopi have adapted their farming practices and their crops, most notably corn, to make the best use of a limited amount of moisture. Hopi corn can be planted at depths exceeding 10-inches in order to access residual moisture from winter rains (Collins, 1914). Corn roots are reported to reach depths of



greater than 10 feet (Brew, 1979) and may extend horizontally up to three feet from the stalk (Benson, 2010). Through the spacing of their plantings, the Hopi take full advantage of the adaptations of their crop. Much of the water that would be considered “lost” because it percolated too deeply into the soil, or too far from the plant, in a modern field, is captured in a traditional field. ADWR believes that the on-farm efficiency that should be applied to traditional acres in aggregate should not be less than 80% (0.80).

Based on the discussion above and using the updated SID values from Crowley (2010), ADWR believes that the water duty for modern acres and traditional acres should be 4.33 and 0.93 acre-feet per acre, respectively. The calculations are summarized in Table 4-4.

4.2.3.2 Review of United States Third Amended SOC (Agricultural Use)

Acreage

The United States claims a composite total of 13,032 acres of agricultural land. As described in **Section 4.2.3.1** above, ADWR determined that approximately 13,022 of the 13,032 acres, or 99.9% of the lands claimed by the United States, had evidence of agricultural activity.

Quantity of Use

ADWR requested supporting documentation for the volume of water claimed by the United States for past and present irrigation. ADWR was supplied with a draft memorandum that provided “...a summary of a draft report...” The draft memorandum was marked “Attorney-Client Communication, Confidential, Privileged Information.” ADWR is unable to assess or rely on the information provided in the draft memorandum and therefore presents no findings.

4.3 EVAPORATION FROM IRRIGATION STORAGE

4.3.1 Description and Background

Irrigation reservoirs are used to capture stream runoff and baseflow throughout the year so that greater volumes are available for irrigation use during the growing season. Water evaporates from the surface of such reservoirs resulting in a net loss to the system.



4.3.2 Claimed Use and Basis

4.3.2.1 Hopi Third Amended SOC (Irrigation Storage Evaporation)

The Hopi claim the right to store 333 AF of water flowing from springs and surface runoff in two irrigation reservoirs above Pasture Canyon in Moenkopi Island. The two reservoirs are identified in the claim as Pasture Canyon and Lower Lagoon, with claimed surface areas of 32 acres and 16 acres, respectively. The Hopi Tribe claims 192 AFA for evaporation losses from these two reservoirs calculated using a net evaporation rate of 4 feet per year.

4.3.2.2 United States Third Amended SOC (Irrigation Storage Evaporation)

The United States does not claim evaporative losses from irrigation reservoirs on behalf of the Hopi Tribe.

4.3.3 ADWR Review and Findings (Irrigation Storage Evaporation)

Pasture Canyon Reservoir, readily visible on Google Earth® imagery, appears at least 50% full in five different images between 1997 and 2014, and is approximately 32 acres in size. Lower Lagoon, also visible on Google Earth® imagery, has less than one acre of water visible in the 1997 image and no water visible in the 2007, 2010, 2012, or 2014 images, and appears to be approximately 10 acres in size.

In the Preliminary HSR, ADWR estimated the gross monthly rates of surface water evaporation on the Reservation using the Penman method and measured or estimated values for wind speed, dew point, temperature, and minimum and maximum air temperature. Evaporation rates were calculated for the Tuba City and Keams Canyon areas and are listed in **Appendix B (Table B-2)**. These calculations indicate that the gross annual rates of surface water evaporation on the Reservation ranges from 63.5 inches (5.3 feet) to 80.2 inches (6.7 feet) (ADWR, 2008p).

Mean annual precipitation in the vicinity of the Reservation is shown in **Figure B-4** for the period 1971-2000 and **Appendix B (Table B-1)** lists precipitation and snowfall data from the Tuba City and Keams Canyon meteorological stations. In Keams Canyon, annual precipitation has averaged 9.94 inches since 1948, with the average monthly precipitation ranging from 0.30 inches in June to 1.61 inches in August. In Tuba City, annual precipitation has averaged 6.47 inches since



1900, with the average monthly precipitation ranging from 0.24 inches in June to 0.85 inches in August (ADWR, 2008p).

ADWR calculated the net annual evaporation in inches based on the following formula:

$$\text{Net Annual Evaporation} = \text{Gross Mean Annual Surface Evaporation} - \text{Mean Annual Precipitation}$$

Using the above formula, ADWR calculated lower and upper bound net annual evaporation at Tuba City and Keams Canyon. The calculations indicate that net annual rates of surface water evaporation on the Reservation range from 53.56 inches (4.5 feet) to 73.73 inches (6.1 feet) (**Table 4-5**). The Hopi claim an annual net evaporation rate of 48 inches (4.0 feet) related to the Pasture Canyon and Lower Lagoon reservoirs, which is supported by ADWR’s calculations.

4.4 LIVESTOCK AND WATER STORAGE FOR STOCK (STOCKPONDS)

4.4.1 Description and Background

The Hopi Land Use and Development Plan (Hopi, 2001) indicated that grazing is the “principal activity” on approximately 1,565,590 acres of Reservation land used for agriculture and range. NRCS (1996) reported that about 85% of the 1882 Reservation land base is used throughout the year for grazing. Based on reservation boundary data from NRCE (2005), this equals about 1,326,000 acres of rangeland (ADWR, 2008b).

For the purpose of range management, Reservation lands have been divided into 53 tracts known as range units (Hopi, 1998). Fifteen range units are located in District 6 and 38 range units are located in the Hopi Partitioned Lands (**Figure B-15**). Characteristics of the units are listed in **Table B-5** including their name and number, acreage, and percentage of area useable as forage. To ADWR’s knowledge, separate range units have not been established in the Moenkopi area. However, the Hopi claim that stock were in the Moenkopi area based on water uses from ponds, wells and springs (ADWR, 2008p).

Regulation of livestock on the Reservation is described in *Tribal Ordinance 43–Control of Livestock and Grazing on the Hopi Reservation*. The ordinance governs “the allocation of grazing and accommodation permits to, and the use of the Hopi Reservation for grazing purposes by tribal members and Accommodation Agreement (Navajo) signatories, and shall otherwise control the



presence of livestock on the Hopi Reservation” (Hopi, 1998). Provisions of the ordinance are carried out by staff of the Hopi Tribal Office of Range Management (ORM) and Hopi Resources Enforcement Services (HRES) (ADWR, 2008p). The Hopi Tribe enforces grazing regulations on the Reservation pursuant to a contract with the U.S. Department of the Interior (Hopi, 2009).

Available data indicate that the Hopi have grazed livestock since at least 1775 and the number of Hopi livestock has varied substantially over time. Livestock water demands are expected to have varied as well, but were probably greater in the past than recent demands due to reported greater numbers of Hopi livestock in the past (ADWR, 2008p).

Other than domestication of turkey, the raising of livestock was not an aboriginal activity of the Hopi. With the Spanish introduction of sheep, goats, cattle, horses, and burros, herding of livestock, particularly sheep, became an important part of Hopi subsistence. Livestock eventually replaced hunting as the main source of dietary protein, while wool became a preferred weaving material (ADWR, 2008p).

4.4.2 Claimed Use and Basis

4.4.2.1 Hopi Third Amended SOC (Livestock and Stockponds)

Livestock Watering (Hopi)

The Hopi Tribe claims 1,000 AFA of water use to support the maximum carrying capacity of livestock within the 1882 Reservation and Moenkopi Island. The primary source of water for the livestock demand is groundwater from existing and future wells, with additional water from springs. The Hopi claim references Appendices 4 and 5 to the United States claim, which list the wells and springs.

The Tribe states that rangeland covers 1,622,455 acres of land with a maximum carrying capacity of 44,486 animal units (AU). The Hopi claim includes a consumptive use rate for cattle of 12 gallons per animal unit per day (gpAUD) that is based on ADWR’s revised Standard Water Use Quantities, dated January 2006 (described further in **Section 4.4.3.1**). Further, the Hopi claim a diversion rate of 20 gpAUD based on a 60% water use efficiency to account for evaporation, spills and other losses from wells. The 60% efficiency assumes the use of metal drinker tanks to store stock well water, although such water also is stored in earthen facilities. If earthen facilities



continue to be used for livestock storage in the future, the Tribe asserts the right to use more than the 20 gpaud rate and more than 1,000 AFA due to decreased efficiency. As discussed further in **Section 4.4.3.1**, this claim appears to be for future uses.

Water Storage for Stock (Hopi)

Additionally, the Hopi claim the right to divert and deplete 4,883 AFA for livestock consumption based on water stored in past and present stockponds served by surface flows. The Hopi claim the right to maintain each water storage facility at its described location and dimensions and fill each facility to its full capacity when the stated source of supply is available. The Hopi Tribe also claims the right to construct future stockponds as needed to satisfy the claimed livestock consumption demand.

The Hopi Third Amended SOC includes a list and mapped locations of 608 livestock water storage impoundments. The information provided also includes the claimed capacity for each impoundment, location coordinates, and ArcGIS shapefiles with impoundment locations as points.

Appendix 3 of the Hopi 2015 amended claim includes a report prepared for the Hopi Tribe titled *Hopi Indian Reservation Livestock Impoundments* dated May 29, 2015 that was prepared by DOWL of Billings, Montana. This report, among other things, describes the methodology used in 1991 and 1992 to identify and analyze impoundments. The following information is a brief synopsis of the methodology discussion in the DOWL report.

For the DOWL report, black and white 1991 aerial photography prints at a scale of 1:24,000 were examined under stereoscope. The historic maximum controlled water level, corresponding surface area, and depth were determined. Color infrared imagery from 1980 was used to supplement this information. A field investigation of sample impoundments was conducted in July 1991 to obtain ground-verified information. The field information was used to calibrate the physical parameters identified in the aerial photography interpretation.

The capacity of each impoundment was calculated using the following formula:

$$C = A \times D \times 0.4$$

Where:

C = Capacity

A = Area

D = Depth



0.4 = Volume conversion factor for water impoundments utilized by the Soil Conservation Service (now Natural Resources Conservation Service) and the Montana Water Rights Claim Examination Manual.

The only exception to the use of the 0.4 volume conversion factor was where the pit was cone-shaped. In those cases, a factor of 0.33 was used. The claim does not specify which impoundments had capacity calculations based on the 0.33 instead of the 0.4 factor.

The number of impoundments for use by livestock claimed by the Hopi in its Third Amended SOC (608) was less than the number of impoundments claimed by the United States (1,001). The impoundments claimed by the United States are described in **Section 4.4.2.2**. The Tribe submitted supplemental information to ADWR on August 31, 2015 that revised the number of impoundments and storage capacities. The Hopi Tribe Supplement states:

The Tribe and the United States worked cooperatively to explain the discrepancy in the number of impoundments claimed. The Tribe and the United States determined that the discrepancy arose because their respective experts had slightly different definitions of impoundments. For example, Hopi experts only claimed impoundments used for stockwater whereas United States experts claimed any impoundment verified, even if the use was for purposes other than stockwater. Therefore, the Hopi claim for stockwater impoundments is generally a subset of the United States claim as approximately 600 of the Hopi impoundments claimed are also part of the United States claim for impoundments for stockwater use. The approximately 400 remaining federal claims for impoundments are additional impoundments comprised of 180 impoundments found by ADWR in 2008 during field work and the remainder identified by the United States during field work from 2007 – 2015.

Based on the impoundments claimed by the United States, the Hopi revised its Third Amended SOC by: (1) correcting locations of previously identified impoundments; (2) adding impoundments claimed by the United States but not previously claimed by the Hopi Tribe; and (3) adding impoundments previously unclaimed by either party. The corrections and additions are summarized below:

- 40 impoundments had incorrect locations due to GIS projection issues, with no additional volume added to the Hopi claim;



- 396⁵ impoundments were added that were previously claimed by United States but not by the Hopi, which resulted in an increase of 1,289 AF of storage capacity;
- 8 new impoundments identified by the Hopi based on more recent aerial photography, which resulted in an increase of 12 AF of storage capacity.

The Hopi submitted a revised list and printed maps that corrected the locations for 40 impoundments, and identified the additional 404 impoundments with capacities and coordinates. ADWR received GIS shapefiles for the eight (8) new impoundments identified by the Tribe but did not receive GIS shapefiles for the 396 impoundments previously claimed by the United States but not by the Hopi.

As indicated above, the addition of the 404 impoundments increased the Hopi water storage claimed amount by 1,301 AF (1,289 AF + 12 AF). The Hopi Third Amended SOC as supplemented includes 1,012 impoundments with capacities that total 6,184 AF (4,883 + 1,301) for past and present livestock consumption. The Hopi claim the right to divert surface flows in the amount of 6,184 AFA to fill livestock impoundments to their stated capacities whenever the source of supply is available.

4.4.2.2 United States Third Amended SOC (Livestock and Stockponds)

Livestock Watering (United States)

The United States claims the right to divert and deplete 997 AFA for livestock purposes from existing wells and/or future wells that will be drilled on the Reservation, springs, and stockponds. The wells, stockponds and springs are identified in Appendices 4, 5, and 6 to the claim. The livestock watering claim is based on 1,622,455 acres of rangeland with a maximum carrying capacity of 44,486 AU, which are the same numbers used by the Hopi for its claim. Like the Hopi claim, in addition, the United States claim is based on a 12 gpaud cattle consumption rate, and a diversion rate of 20 gpaud based on a 60% water use efficiency to account for evaporation, spills and other losses. As with the Hopi claim, the United States claim for livestock watering appears to be for future use as described in **Section 4.4.3.2**.

⁵The Hopi claim nine impoundments not claimed by the United States and the United States claim six different impoundments not claimed by the Hopi. The net result is three additional impoundments thus making the total additional impoundments count 396 instead of 393.



Water Storage for Stock (United States)

In their 2015 amended claim, the United States claims 3,388 AF to fill each impoundment to its full capacity when the water supply is available. The majority of impoundments are utilized for livestock. However, a few impoundments have additional reported uses such as recreation and irrigation. The United States also claims the right to repair, maintain, and replace existing impoundments, and the claim is not intended to prevent the construction of new impoundments in the future.

In Appendix 6 of the United States 2015 amended claim, the United States provided a list of 1,001 total impoundments that included the U.S. Label ID, Plate Number, location coordinates, area in acres, capacity in acre-feet, and water use. The United States also provided ArcGIS shapefiles for the 1,001 impoundments with locations as polygons.

4.4.3 ADWR Review and Findings (Livestock and Stockponds)

4.4.3.1 Review of Hopi Third Amended SOC (Livestock and Stockponds)

Review of Livestock Watering (Hopi)

The Hopi claim of 1,000 AFA for stockwatering appears to be for future use due to the following: (1) the Tribe's assertion that 1,000 AFA is based on a maximum future carrying capacity of 44,486 AU, rather than the current or maximum past number of AU; and (2) the Tribe's statement that this claim is for well water stored in metal tanks which are not reported to be in wide use at this time on the Reservation. ADWR recognizes that livestock are currently being watered on the Reservation by means of stockponds.

The Hopi state in their 2015 amended claim that the Reservation contains 1,622,455 acres of rangeland. The Hopi claim did not contain any documentation or information to support their stated rangeland acreage.

In the Hopi Strategic Land Use and Development Plan (Hopi, 2001), the Tribe stated that grazing occurred on 1,565,590 acres of Reservation lands. NRCS (1996) reported approximately 1,326,000 acres of rangeland within the Reservation. In the 2008 Preliminary HSR, ADWR estimated that between 819,000 and 1,326,000 acres of the 1882 Executive Order Reservation were useable as range (ADWR, 2008b).



The Hopi claim a maximum carrying capacity of livestock within the 1882 Reservation and Moenkopi Island of 44,486 AU. The Hopi 2015 amended claim did not contain any documentation, data, or information to support their stated maximum carrying capacity.

Table B-5 provides the carrying capacity of each range unit based on a 1996 range survey. Carrying capacity has been defined by the Hopi (1998) as “the maximum stocking rate possible without inducing damage to vegetation or related resources.” Carrying capacity is expressed in the table as the number of animal units that can be grazed on an area of range over a year, or Animal Units Year Long (AUYL). To account for the forage needs of different livestock, the Hopi assumed the following factors when calculating AUYL on the Reservation:

- 0.8 Horse or Burro = 1 AUYL
- 1 Cow = 1 AUYL
- 4 Sheep or Goats = 1 AUYL.

Carrying capacity can vary from year to year due to overgrazing by livestock and/or from natural factors such as drought, fire, and grazing by native animals. Since 1984, actual carrying capacities on the 1882 Executive Order Reservation have ranged from 5,000 to 12,250 AUYL and potential carrying capacities have ranged from 10,000 to 24,529 AUYL (ADWR, 2008b). Carrying capacity data for the Moenkopi area are currently not available to ADWR (ADWR, 2008p).

The Hopi do not provide any current or historic counts or estimates of animal units for the Reservation in their Third Amended SOC, which appears instead to be based on future uses. **Table 4-6** lists historic accounts of the number and type of livestock grazed on the Reservation (ADWR, 2008p). These accounts were summarized from Andersen (2008). Based on these accounts, the estimated historic maximum number of animal units on the Reservation was approximately 21,500 AU in 1887.

Recent inventories of Hopi livestock are listed in **Table 4-7** (ADWR, 2008p). Between 1984 and 2006, the maximum reported number of animal units on the Reservation was approximately 6,900 AU in 1984. These numbers are all much less than the 44,486 AU claimed by the Hopi apparently for future uses.

The Hopi claim includes a consumptive use for cattle of 12 gpaud that is based on ADWR’s revised Standard Water Use Quantities, January 2006, which is a document that ADWR provides



to assist applicants seeking to appropriate surface water pursuant to state law. This document sets forth quantities of water that ADWR considers reasonable for certain beneficial uses in most cases. For stockwatering use, ADWR considers 12 gpaud to be reasonable consumptive use rate for cattle and horses.

The Hopi Tribe claims a diversion rate of 20 gpaud based on a 60% water use efficiency to account for evaporation, spills and other losses from wells. The Tribe did not provide any additional documentation or information in support of this diversion rate.

Review of Water Storage for Stock (Hopi)

The Hopi claim the right to divert and deplete 6,184 AFA for livestock consumption from surface sources that have been stored in past and present stockponds. The underlying premise associated with water storage claims is that the water is stored temporarily for an associated beneficial use. Water storage itself is not the use of this water. The consumption of water by stock is the actual water use associated with storage in stockponds. ADWR believes that there is an overlap between the claimed amounts for livestock watering and the claimed amounts for water storage for stock.

In its Third Amended SOC and its Supplement, the Hopi claimed a total of 1,012 water storage impoundments. ADWR conducted a review of claimed impoundments using ArcGIS. No field verification was conducted as part of this review process.

ADWR's review consisted of determining the presence of impoundments, either constructed or natural, on the land surface. ADWR staff looked for evidence of water storage on GIS-based aerial imagery and topographic maps at the identified location. Evidence generally consisted of a visible water surface, pronounced vegetation, presence of berms, earthen dams or other water retention structures, and visible scarring, discoloration or depressions resulting from standing water. ADWR did not attempt to verify the surface area or the depth of each impoundment as both the Hopi and United States claimed the right to repair, maintain and fill each impoundment to its stated claimed capacity. Impoundments identified to be wastewater sewage ponds were eliminated from consideration as a livestock related impoundment.

ADWR used the following GIS-based imagery and topographic maps for the review of impoundments:

- 2007 Color NAIP imagery



- ESRI World Imagery
- ESRI USA Topo Maps

ADWR's review determined that seven of the 1,012 total impoundments that were reviewed did not have visible evidence to be classified as a water storage impoundment. The total capacity for these seven impoundments without visible evidence of a water storage impoundment is 9.015 AF. This represents a reduction in water storage capacity of approximately 0.15% (9.015 AF/ 6,184 AF). **Table 4-8** lists the claimed impoundments without visible evidence of water storage.

ADWR's review determined that the volume for a reservoir in the Pasture Canyon area reservoir was double-counted. In the Hopi Tribe Supplement, the Hopi stated that, "FC I0411, an impoundment claimed in the Pasture Canyon area, appears to duplicate amounts previously claimed by the Tribe in its 3rd Amended SOC." The stated capacity for the Pasture Canyon reservoir is 212 AF. A reduction of 212 AF is approximately 3.4% of the total storage capacity (212 AF/ 6,184 AF).

ADWR's review of the Hopi claimed use for water storage for stock (stockponds) identified a lack of evidence to support 9.015 AF of claimed capacity and double counting of 212 AF for impoundment FC-I0411 (Pasture Canyon reservoir) for a total reduction of 221.015 AF. This is 3.6 % of the total claimed capacity of 6,184 AF, which the Hopi claim on an annual basis.

4.4.3.2 Review of United States Third Amended SOC (Livestock and Stockponds)

Review of Livestock Watering (United States)

The United States relied upon the same information and data as the Hopi for its 2015 amended claim for livestock watering use. The United States claim on behalf of the Hopi is only 3 AFA less than the Hopi for livestock use. ADWR's review and findings discussed for the Hopi claim in the previous section are the same for the United States claim.

Review of Water Storage for Stock (United States)

The United States claimed a total of 1,001 water storage impoundments with a storage capacity of 3,388 AF. ADWR completed a review of the unique polygons for the 1,001



impoundments submitted by the United States using GIS-based imagery and topographic maps and the methods described above in **Section 4.4.3.1** for determining the presence of impoundments. ADWR's review determined seven of the 1,001 total impoundments did not have visible evidence of water storage. The total volume of water claimed for these seven impoundments was 9.015 AF, which resulted in a reduction in capacity claimed by the United States of approximately 0.27% (9.015 AF/ 3,388 AF). **Table 4-8** lists the claimed impoundments without visible evidence of water storage.

There is a large difference in the total claimed stockpond impoundment capacity between the Hopi at 6,184 AFA and the United States at 3,388 AFA, despite generally similar stockpond impoundment counts of 1,012 for the Hopi and 1,001 for the United States and nearly complete overlapping of the claimed locations. ADWR evaluated the Hopi and United States claims for the 608 impoundments claimed by both parties and found that the average of the impoundment capacities claimed by the Hopi was approximately 8.0 AF while the average of the impoundment capacities claimed by the United States was approximately 3.5 AF.

The United States provided both areas and capacities for each of the 608 impoundments so ADWR was able to determine an average depth for each impoundment. These average depths ranged from 1.0 to 7.2 feet with an overall average depth of 1.86 feet.

The Hopi Tribe only provided the capacity of each impoundment. ADWR attempted to assess the average depth of the impoundments as claimed by the Hopi by assuming that the surface area provided by the United States was approximately correct. Based on this assumption, ADWR determined the average depths ranged from 0.023 feet to 167.9 feet with an overall average depth of 5.6 feet. Because the Hopi did not provide the surface areas of their claimed impoundments, ADWR cannot conclusively resolve the discrepancy in the total claimed capacities of the two datasets.

4.5 CEREMONIAL AND SUBSISTENCE IRRIGATION USE

4.5.1 Description and Background

The Hopi people have a long agricultural history. Although subsistence agriculture is not as prevalent as it was in the past, traditional agricultural practices still exist at many Hopi households. The Hopi state almost 40% of households farm crops for ceremonial and subsistence



use. Further, 78% of people not currently cultivating crops reported that they would like to have a garden plot or a field for farming. According to the Hopi, drought and lack of land are the principal reasons for not farming.

4.5.2 Claimed Use and Basis

4.5.2.1 Hopi Third Amended SOC (Ceremonial and Subsistence Irrigation)

In their Third Amended SOC, the Hopi Tribe claims 7,385 AFA of groundwater use for future irrigation of small garden plots for ceremonial and subsistence purposes, in addition to past and present agriculture water use discussed in **Section 4.2**. The claimed use is based on stable population and total number of households projected for the Hopi villages with 25% of the households carrying out ceremonial and subsistence farming and each participating household requiring 0.8 acres. Additionally, the Tribe relied on a CIR⁶ of 25.08 inches and efficiency of 75%.

Information provided by the Hopi in support of its claim indicates that the estimates of households carrying out ceremonial and subsistence farming is based on information gathered in a household survey conducted between 2005 and 2006. Experts retained by the Tribe surveyed households on the Hopi Reservation during the summers of 2005 and 2006. The survey included households in 12 villages.

The survey broke down the Hopi population into three categories. Group 1 included those currently engaged in farming dryland or irrigated gardens away from their home. Group 2 included those Hopi households engaged in irrigated gardens near their homes. Group 3 included those Hopi households not engaged in subsistence farming at the time of the survey.

The Tribe's claim related to ceremonial and subsistence farming is for new water use to irrigate garden plots not adjacent to people's homes. The household survey responses indicated that 80% of Group 1 households would want an additional garden plot if it were available. Further, 10% of Group 2 households would want such a garden plot if it were available. Finally, 78% of the Group 3 households indicated that they would like to engage in ceremonial and subsistence farming away from their homes, but a large majority of the Group 3 households wanted only very

⁶ The Hopi claim did not define "CIR". ADWR believes that "CIR" is composite irrigation requirement.



small plots. The Tribe, therefore, estimated that only 10% of the Group 3 households would irrigate a larger ceremonial and subsistence garden plot.

The estimate of 25% of households relied upon by the Tribe for new ceremonial and subsistence irrigation is a combination of the above percentages from households in Groups 1, 2 and 3. The Tribe based its stable population number on the United States' population projections as described previously in **Section 4.1**. The Hopi did not provide any additional documentation or information related to ceremonial or subsistence irrigation use.

4.5.2.2 United States Third Amended SOC (Ceremonial and Subsistence Irrigation)

In its Third Amended SOC, the United States claims 4,977 AFA of groundwater use for future irrigation of small family garden plots near the villages for subsistence and cultural purposes. The United States indicates that its claim is identical to its Second Amended SOC filed in 2009 which did not include any supporting documentation. The United States did not provide any additional documentation or information related to ceremonial or subsistence irrigation use in its Third Amended SOC.

4.5.3 ADWR Review and Findings (Ceremonial and Subsistence Irrigation)

ADWR believes that there potentially may be some overlap between the volumes claimed for future DCMI and the volumes claimed for future ceremonial or subsistence gardening. The claimed gpcd rate for DCMI, as stated by both the Hopi and the United States, includes outdoor residential water use.

4.6 MINING USE

4.6.1 Description and Background

As noted in **Appendix B**, coal deposits beneath upper Black Mesa have been leased and commercially developed on a large scale by Peabody Western Coal Company (PWCC). Known as the Black Mesa Complex, the operation consisted of the Black Mesa and Kayenta Mines (**Figure B-16**). The Black Mesa Mine began operations in 1970 and produced about 4.8 million tons of coal annually until operations ceased in December 2005. The coal from this mine was crushed and piped as slurry to the Mohave Generating Station (MGS) near Laughlin, Nevada. MGS was



closed in December 2005 due to air quality concerns. The Kayenta Mine opened in 1973 and has produced about 7.5 million tons of coal annually. This coal has been transported 100 miles by conveyor belt and electric train to the Navajo Generating Station (NGS) near Page, Arizona.

The Black Mesa region contains the most extensive coal reserves in Arizona. Stated estimates of coal resources within the Black Mesa area range from 3.6 to 20 billion tons. The Tribe is currently only leasing a small portion of these extensive coal resources and as a result, additional coal resources are available for future mining.

4.6.2 Claimed Use and Basis

4.6.2.1 Hopi Third Amended SOC (Mining)

In its 2015 amended claim, the Hopi Tribe claims 1,255 AFA of groundwater use for past and present coal mining needs at the Peabody coal mine at Black Mesa. The amount of water claimed is based on the “latest records available for current use.”

In support of the present mining use claim, the Hopi relied on information reported in a USGS report, “Groundwater, Surface-Water, and Water Chemistry Data, Black Mesa Area, Northeastern Arizona 2011-2012.” The 1,255 AFA figure is an annual average of the Industrial pumping category from 2006–2011 on page 5, Table 1 of the report. The Industrial category represents metered pumping from the confined part of the aquifer by PWCC.

In its 2015 amended claim, the Hopi Tribe also claims 500 AFA of water use for activities related to a possible future coal mine. Details regarding the specific water needs or uses related to a future mine were not known at the time the Hopi 2015 amended claim was filed.

4.6.2.2 United States Third Amended SOC (Mining)

Like the Hopi, in its 2015 amended claim, the United States claims 1,255 AFA for past and present mining operations at the Black Mesa Complex. The United States, as the Hopi, indicated that the amount claimed is based on the “latest records available for current use.” The United States also claims 6,500 AFA to support a future coal mine and mine mouth power plant located at the future mine site.



4.6.3 ADWR Review and Findings (Mining)

4.6.3.1 Review of Hopi Third Amended SOC (Mining)

ADWR reviewed the USGS report “Groundwater, Surface-Water, and Water Chemistry Data, Black Mesa Area, Northeastern Arizona 2011-2012” submitted by the Hopi and verified that the annual average of the Industrial pumping figure of 1,255 AFA was accurate for the 2006–2011 reported usage. The Hopi did not provide details describing the quantification of its claimed future use.

4.6.3.2 Review of United States Third Amended SOC (Mining)

The United States’ claim is the same as the Hopi for past and present mining use, and ADWR’s review and findings discussed for the Hopi claim immediately above are the same for the United States claim. The United States quantified its claimed future use, which also included a power plant, but did not provide any supporting documentation.

4.7 ENERGY RESOURCES DEVELOPMENT USE

4.7.1 Description and Background

The Hopi claim describes two potential future energy development projects and estimated water use for each. The two future projects are: (1) a solar/thermal power plant, and (2) a coal liquefaction/gasification facility and related secondary manufacturing.

4.7.2 Claimed Use and Basis

4.7.2.1 Hopi Third Amended SOC (Energy Resources Development)

The Hopi claim a total of 27,100 AFA for future energy resources development. The Hopi claim 6,500 AFA of water use related to development and operation of a 1,500 megawatt solar power plant. The anticipated water use is associated with wet cooling of a concentrated solar facility. The Hopi estimate that the wet cooling process would require from 800 to 1,000 gallons of water per megawatt hour.



The Hopi also claim 20,600 AFA of water use from groundwater and other water sources related to the development and operation of a no-liquid-discharge coal liquefaction/gasification facility (CLG) and secondary manufacturing. The Hopi state that CLG facility would require 12,600 AFA, which may also be used to produce primary products such as natural gas, liquid fuels, and naphtha. In addition, the Hopi estimate that the development of businesses related to secondary manufacturing from these primary products would require between 6,000 to 8,000 AFA.

4.7.2.2 United States Third Amended SOC (Energy Resource Development)

The United States did not claim a use for future energy resource development.

4.7.3 ADWR Review and Findings (Energy Resource Development)

The Hopi did not provide documentation to support the quantity claimed for energy resource development.

4.8 TOURISM USE

4.8.1 Description and Background

According to the Hopi Comprehensive Economic Development Strategy, revised July 31, 2014, tourism is important to the regional economy. The presence of many natural wonders, including the Grand Canyon, Petrified Forest, and Meteor Crater bring visitors to the region, as well as US Highway I-40. In addition, there are 26 Hopi and 3 non-Hopi companies located in northern Arizona that conduct tours in the region.

The Hopi Cultural Center Hotel and restaurant and the Moenkopi Legacy Inn and Suites are locations for visitor information and education, and a place for the Hopi artisans to gain greater exposure for their work. State Route 264 between Moenkopi and Keams Canyon has been designated as the Hopi Arts Trail with a brochure identifying all businesses along the route.

The Moenkopi Legacy Inn was completed in 2011 and it features a conference center and an outdoor swimming pool. The intent is to make the hotel a gateway to the villages and mesas with guided tours.



4.8.2 Claimed Use and Basis

4.8.2.1 Hopi Third Amended SOC (Tourism)

According to the Hopi Third Amended SOC, “[t]ourism is the most important non-industrial, non-governmental source of income in northern Arizona.” In its Third Amended SOC, the Hopi Tribe claims 1,022 AFA for a future destination resort with the potential for a recreational vehicle (RV) park, golf course and other destination resort amenities, possibly at Keams Canyon, and for the expansion of the Hopi Tribal Cultural Center. The claim does not include the possible hotel, casino, golf course and RV park at the Hopi Industrial Park in Winslow due to the limited scope of the Final HSR.

4.8.2.2 United States Third Amended SOC (Tourism)

The United States Third Amended SOC did not include a claim for water use related to tourism.

4.8.3 ADWR Review and Findings (Tourism)

ADWR believes that potentially there may be some overlap in the volumes claimed for future DCMI and the volumes claimed for tourism. The claimed gpcd rate for DCMI includes commercial water uses that could be associated with tourism related facilities or activities, such as a hotel or RV park.

4.9 RECREATION USE

4.9.1 Description and Background

Keams Canyon is located in the southeastern portion of the Hopi Reservation and is within the Polacca Wash watershed. Keams Lake is located within Keams Canyon in the northwest portion of Section 28, Township 28 North, Range 20 East. Keams Lake is used for recreational purposes such as camping and fishing.



4.9.2 Claimed Use and Basis

4.9.2.1 Hopi Third Amended SOC (Recreation)

In its Third Amended SOC, the Hopi Tribe claims 41 AFA of water use for recreational purposes at Keams Lake. The Hopi claim the right to continuously fill Keams Lake to its maximum capacity of 27.8 AF and also claim evaporative losses of 12.8 AFA.

To determine annual evaporative losses, the Hopi provided a surface area of 3.2 acres for Keams Lake and a net evaporation rate of 4 feet per year. No information was provided regarding how the capacity of Keams Lake was determined.

4.9.2.2 United States Third Amended SOC (Recreation)

The United States Third Amended SOC did not include a claim on behalf of the Hopi Tribe for recreation water use.

4.9.3 ADWR Review and Findings (Recreation)

ADWR reviewed ESRI World Imagery to verify the existence of Keams Lake. Review of the 2013 imagery verified the existence of a feature with a visible water surface at the location listed by the Hopi. Google Earth[®] imagery shows an impoundment of varying size at this location in 1997, 2007, 2010, and 2013. Based on ADWR's review of the ESRI World Imagery and Google Earth[®], the stated surface area of Keams Lake of 3.2 acres appears reasonable.

The Hopi claim the same annual net evaporation rate of 4 feet for Keams Lake as listed in the Hopi claim for evaporation from irrigation storage. ADWR's review and associated analysis of the net annual evaporation rate is presented in **Section 4.3**. In summary, the analysis indicates that net annual rates of surface water evaporation on the Reservation may range from 53.56 inches (4.5 feet) to 73.73 inches (6.1 feet). The evaporation rate of 4 feet used by the Hopi is less than this range.

Although the United States did not include a claim on behalf of the Hopi for recreation water use, ADWR's review of impoundments claimed by the United States indicates the presence of an impoundment in the same location as Keams Lake. The United States' ID number for this



impoundment is I1130. Associated information provided by the United States for this impoundment indicates that the surface area is 2.94 acres and the capacity is 6.065 AF.

The Hopi state in their Third Amended SOC that Keams Lake is not included in the livestock water storage claim. ADWR confirmed that this statement was correct when the Third Amended SOC was filed. However, when the Hopi supplemented their water storage claim by adding 396 additional impoundments that were previously claimed by the United States but not by the Hopi (see **Section 4.4**), impoundment I-1130 was included as one of the additional impoundments added to the Hopi water storage claim. The Hopi supplemental claim included 6.065 AFA for this impoundment, as compared to the fill-volume of 27.8 AF claimed in the Hopi Third Amended SOC.

4.10 SUBSURFACE MINERAL RIGHTS USE

4.10.1 Description and Background

The Little Colorado River flows southeast to northwest in northeastern Arizona to its confluence with the Colorado River in Grand Canyon National Park. The Little Colorado River does not cross Hopi Reservation lands; however, the river does cross Navajo Nation lands in the southwestern and western portions of the Navajo Reservation.

The base flow of the Little Colorado River near its confluence with the Colorado River is sustained by the C aquifer (see **Section 2.1.7**) which discharges into the underlying Redwall-Muav aquifer and ultimately into the Little Colorado River. Blue Spring is the largest of several springs that discharge into the Little Colorado River and is located approximately 13 miles upstream from the confluence with the Colorado River on Navajo Nation land. The series of springs are often referred to as “Blue Springs” (Leake, 2005).

4.10.2 Claimed Use and Basis

4.10.2.1 Hopi Third Amended SOC (Subsurface Mineral Rights)

In its 2015 amended SOC, the Hopi claim 40,295 AFA of water for the Tribe’s proportional share of the Blue Springs complex. The Tribe’s claim is for both instream flows and consumptive use and it asserts the right to transfer this claimed use for consumptive or non-consumptive



purposes. The Hopi cited three USGS reports that provide information in support of their Third Amended SOC related to water use associated with subsurface mineral rights. The reports are Hart (2002), Leake (2005) and Bills (2007).

These USGS reports indicate that groundwater that discharges from Blue Springs is derived from the Redwall-Muav aquifer, which underlies the C aquifer. All of the groundwater in the Redwall-Muav aquifer occurs from downward leakage from overlying formations through faults, fractures, or other geologic structures. Groundwater migrates laterally and vertically through the aquifer to reach the discharge area for these springs. One USGS report lists the flow of Blue Spring at about 95 cubic feet per second (cfs) or 68,777 AFA with a combined flow from all springs in this lower reach of the Little Colorado River of about 237 cfs or 171,580 AFA (Bills, 2007). The other two USGS report estimates the discharge from Blue Spring and other springs in the area to be 164,000 AFA (Leake, 2005, Hart, 2002).

The Hopi state in their 2015 amended claim that, “Water, like oil and gas, is a mineral in the broader sense of the word.” The Hopi cite several legal references in support of this statement. The Hopi claim that water is a mineral under the Navajo Hopi Land Dispute Settlement Act of 1974 (1974 Settlement Act) and they are therefore entitled to a proportional share of that mineral resource. The Hopi define their proportional share as 25% based on the Hopi Tribe’s land area in the LCR basin compared to the land area of the Navajo Nation in the LCR basin.

4.10.2.2 United States Third Amended SOC (Subsurface Mineral Rights)

The United States Third Amended SOC did not include a claim related to subsurface mineral rights water use.

4.10.3 ADWR Review and Findings (Subsurface Mineral Rights)

The Hopi Third Amended SOC is based on its proportional share of the “Blue Springs complex.” The Hopi did not provide information or documentation to define or describe which springs constitute this complex.

ADWR’s review and interpretation of the USGS reports cited by the Hopi indicate that the Blue Springs complex likely refers to all springs in the lower reach of the Little Colorado River that are in the vicinity of Blue Spring. As stated above, the USGS estimates discharge from Blue Springs and other springs in the area (the Blue Springs complex) to range from 164,000 AFA to



171,580 AFA. Using these USGS estimates of flows, the Hopi claimed proportional share of 25% of the total discharge would be 41,000 AFA to 42,895 AFA. The Hopi claim of 40,295 AFA falls below this range.

4.11 AESTHETIC, CULTURAL, AND ECOLOGICAL USE

4.11.1 Description and Background

Water flows in the lower Little Colorado River have long held tremendous cultural and religious significance for the Hopi people. In addition, the Pasture Canyon and White Ruin Canyon Wash areas provide continuing ecological, spiritual and cultural significance to the Tribe. The wetlands in these areas are important sources of fish, wildlife and plant materials for Hopi ceremonial, cultural, and everyday uses, and for the Hopi arts and crafts industry.

Riparian vegetative species identified on the Reservation include cottonwood, willow, Russian olive, and salt cedar. The latter two are invasive species that are not native to the area (ADWR, 2008p). In comments to the Preliminary HSR, the Hopi identified alkali sacaton and camelthorn as other vegetative species that are found in riparian areas on the Reservation (Hopi, 2009). Riparian vegetation relies on water from both precipitation and underlying alluvial aquifers (ADWR, 2008p).

4.11.2 Claimed Use and Basis

4.11.2.1 Hopi Third Amended SOC (Aesthetic, Cultural and Ecological Flows)

In its Third Amended SOC, the Hopi Tribe claims 294 AFA of water use for riparian and wetland habitat in Pasture Canyon, which is located in Moenkopi Island. The Hopi state that Pasture Canyon is a unique ecosystem that has great historic and present significance to the Hopi Tribe. The Hopi also assert a non-diversionary claim to protect the aesthetic, cultural and ecological flows of Pasture Canyon and White Ruin Canyon Wash.

The Hopi state that the average annual depletion within Pasture Canyon is 267 AFA for riparian vegetation and wetlands. However, the Hopi claim a maximum of 294 AFA for riparian and wetland habitat when such water is available. The Hopi did not provide documentation or information in support of their claimed volume for depletion within Pasture Canyon. The Hopi



Tribe did clarify, however, that the wetland and riparian areas of Pasture Canyon are separate and apart from certain nearby agricultural fields that are subject to irrigation, and the Hopi 2015 amended claim referenced maps found in Appendices 9 and 10 to the United States Third Amended SOC.

The Hopi Tribe also claim a non-diversionary right to protect White Ruin Canyon Wash, which is located near the headwaters of Moenkopi Wash. In the Hopi Tribe Supplement, the Hopi claim 16 AFA (rounded) for flows in White Canyon Ruin Wash and cite a report, *White Ruin Canyon Discharge Reconnaissance 14 August 2015: Preliminary Draft Report*, submitted by Stevens Ecological Consulting. This report briefly discusses flow measurements taken on August 14, 2015, summarizes findings, and estimates total annual discharge.

The Hopi Tribe claims a non-diversionary right for instream flows in the lower Little Colorado River. The Hopi state that this area holds tremendous cultural and religious significance for the Hopi people. The quantity of water claimed by the Hopi was not known at the time the 2015 amended claim was filed.

4.11.2.2 United States Third Amended SOC (Aesthetic, Cultural and Ecological Flows)

In its Third Amended SOC, the United States claims 294 AFA of water use for riparian and wetland habitat in Pasture Canyon. The United States provides a map of Pasture Canyon in Appendix 9 to its claim, and another map that also delineates nearby agricultural lands in Appendix 10 to its claim. Like the Hopi, the United States notes that the average annual depletion within Pasture Canyon is 267 AFA, and claims a maximum of 294 AFA for riparian vegetation when such water is available. The United States did not provide documentation or information in support of its claimed volume for depletion within Pasture Canyon.

However, the United States clarifies that springs that are located in Pasture Canyon are part of the water supply calculated for its past and present irrigation claim, and that reservoirs within Pasture Canyon are included in the United States list of impoundments in Appendix 6 to its claim. According to the United States, these springs and reservoirs are not included twice in its claim.



4.11.3 ADWR Review and Findings (Aesthetic, Cultural and Ecological Flows)

4.11.3.1 Review of Hopi Third Amended SOC (Aesthetic, Cultural and Ecological Flows)

As stated above, the Hopi did not provide any documentation, data, or calculations to demonstrate how the annual depletion of 267 AFA or a maximum of 294 AFA for riparian and wetland habitat in Pasture Canyon was determined. ADWR evaluated this claimed water use utilizing riparian area acreage values referenced in the Hopi 2015 amended claim and estimates of water use by riparian vegetation as described below.

In its 2015 amended claim, the Hopi reference a map of Pasture Canyon, identified as Appendix 10 of the United States 2015 amended claim, which delineates the areas that serve as the basis for the Hopi riparian and wetland habitat. The United States provided ArcGIS shapefiles that depict approximately 72.1 acres riparian areas and associated vegetation.

ADWR estimated the water demand of riparian vegetation to range from 2.3 to 4.4 AFA (ADWR, 2008p). This estimate is based on an evapotranspiration study conducted in New Mexico under similar climatic conditions (Cleverly and others, 2006 and Shafike and Cleverly, 2007).

ADWR calculated the estimated riparian vegetation water use by multiplying the number of acres of riparian vegetation by the lower and upper range of the estimated water demand per acre. Based on these calculations, ADWR determined that estimated water use for the Pasture Canyon riparian area would be 165.7 AFA to 317.0 AFA. The maximum Hopi claim of 294 AFA for riparian vegetation falls within the ADWR calculated range.

The report cited by the Hopi to support their claim to a non-diversionary right to protect White Ruin Canyon Wash is labeled “Preliminary Draft.” ADWR is unable to rely on the information provided in the draft report and therefore presents no findings with regard to that claim.

As stated above, the Hopi did not provide any flow volumes claimed for the lower Little Colorado River for aesthetic, cultural, and ecological water use. Nor did they provide any documentation, data, or calculations. As a result, ADWR was unable to conduct a review or present any findings related to the lower Little Colorado River.



4.11.3.2 Review of United States Third Amended SOC (Aesthetic, Cultural and Ecological Flows)

As stated above, the United States also did not provide any documentation, data, or calculations to demonstrate how the annual depletion of 267 AFA or a maximum of 294 AFA for riparian and wetland habitat in Pasture Canyon was determined. Since the United States claim is identical to the Hopi claim for riparian and wetland habitat in Pasture Canyon, ADWR utilized the same review and findings as provided in **Section 4.11.3.1**.



**CHAPTER 5:
PROPOSED WATER RIGHTS ATTRIBUTES
AND FUTURE USES**

CHAPTER 5: PROPOSED WATER RIGHTS ATTRIBUTES AND FUTURE USES

This HSR concludes by determining and describing ADWR's proposed water right attributes for past and present water uses on the Reservation (**Section 5.1**). This is followed by a summary of claimed future water uses on the Reservation (**Section 5.2**), which does not include proposed water rights attributes or descriptions or opinions of feasibility, profitability or practicability, and by a discussion of claimed water storage (**Section 5.3**).

For purposes of this HSR, ADWR took into consideration the decision of the Arizona Supreme Court in *Gila V*, and the orders of the LCR adjudication court filed on July 16, 2002, July 2, 2013 and November 10, 2015, which are discussed in **Chapter 1**. Copies may be found in **Appendix A**.

In **Chapter 3**, ADWR categorized the Hopi Tribe and United States Third Amended SOCs into 11 types of water uses. These SOCs are summarized in **Tables 3-1** and **3-2** respectively, and compared in **Table 3-3**. Some of the types of uses were based solely on past and present uses, future uses, or a combination of past and present uses and future uses, as indicated for the types of uses listed below:

- Domestic, Commercial, Municipal, and Industrial (DCMI) (future);
- Agricultural (Irrigation) (past/present);
- Evaporation from Irrigation Storage (past/present);
- Livestock and Water Storage for Stock (Stockponds) (past/present and future);
- Ceremonial and Subsistence Irrigation (future);
- Mining (past/present and future);
- Energy Resources Development (future);
- Tourism (future);
- Recreation (past/present);
- Subsurface Mineral Rights (past/present); and
- Aesthetic, Cultural and Ecological Flows (past/present).

ADWR is only proposing water right attributes for those types of uses that are based in whole or in part on past and present uses.



5.1 WATER RIGHTS ATTRIBUTES FOR PAST AND PRESENT USES

In the following sections, ADWR provides information and recommendations regarding the water right attributes listed below for past and present uses in the Third Amended Claims filed by the Hopi and the United States:

- Legal Basis;
- Priority Date;
- Types of Use;
- Water Source;
- Points of Diversion;
- Places of use; and
- Quantity of Use.

5.1.1 Legal Basis

The legal basis of the claims filed by the Hopi and the United States are described in **Sections 3.2.1** and **3.5.1** respectively. The legal basis of the claims is a matter for decision by the LCR adjudication court, and is beyond the scope of this HSR.

5.1.2 Priority Date

Based on historic occupancy and water use, the Hopi Tribe claims a water right with a time immemorial priority date, senior to that of any other claimant, Indian or non-Indian, to waters located on Hopi lands as well as water sources located outside the boundaries of the main reservation lands. The United States also claims a water right with a time immemorial priority date for the entire Reservation.

On July 31, 2013, the Special Master issued a report in which the Special Master concluded that the priority date for District 6 is time immemorial, for the Hopi Partitioned Lands is December 16, 1882, and for Moenkopi Island is June 14, 1934. Objections were filed and argued to Judge Brain on January 17, 2014. The matter is under consideration.

The priority dates for the water rights claimed by the Hopi and the United States are before the LCR adjudication court for decision. This is a legal matter that is beyond the scope of this HSR.



5.1.3 Types of Use

The Hopi Tribe and/or the United States claimed past and present and future uses for the following seven types of use:

- Agricultural (Irrigation) – Hopi and United States;
- Evaporation from Irrigation Storage – Hopi;
- Livestock and Water Storage for Stock – Hopi and United States;
- Mining – Hopi and United States;
- Recreation - Hopi;
- Subsurface Mineral Rights - Hopi; and
- Aesthetic, Cultural and Ecological Flows – Hopi and United States.

5.1.4 Water Source

ADWR evaluated the availability of surface water and groundwater for the Reservation, both of which had been claimed by the Hopi and the United States. ADWR’s review of water resources is set forth in **Chapter 2**. The Hopi Tribe additionally claims off-reservation surface water sources from the Blue Springs Complex located on the Navajo Reservation. The availability of surface water and groundwater sources are affected variously by drought, location, and water quality considerations.

Legal issues also affect the availability of certain water sources. *See e.g.* LCR adjudication court Minute Entry order dated March 2, 2009, discussed in **Chapter 1** and included in **Appendix A** where the court held that the Hopi are precluded from claims to water from surface streams that do not abut or traverse Hopi lands. Also see *Gila III*, in which the Arizona Supreme Court stated “[a] reserved right to groundwater may only be found where other waters are inadequate to accomplish the purpose of a reservation.”¹ Whether the Hopi and United States are entitled to groundwater in order to accomplish the purpose of the Reservation is matter for the LCR adjudication court, and is beyond the scope of this report.

¹ *In re the General Adjudication of All Rights to Use Water in the Gila River System and Source*, 195 Ariz. 411, 420, 989 P.2d 739, 748, ¶ 28(1999).



5.1.5 Points of Diversion

The Hopi Third Amended SOC does not identify any points of diversion *per se*, but instead references locations of point sources listed and depicted in certain appendices of the United States Third Amended SOC. The United States Amended SOC also does not identify any points of diversion *per se*, but instead references locations of point sources listed in certain appendices of the its claim.

5.1.6 Places of Use

The places of use claimed by the Hopi and the United States include District 6, Hopi Partitioned Land, and Moenkopi Island. ADWR's proposed water right attributes are presented separately for each place of use where appropriate. For example, the quantity of water use for Agricultural (Irrigation) was divided among the three places of use based on where each field is located.

5.1.7 Quantity of Use

As discussed in **Chapter 4**, ADWR evaluated the seven types of claimed past and present uses in order to quantify the water right attribute for each type of use. A discussion of the water right attributes quantification proposed for each type of water use, based on the review and findings from **Chapter 4**, follows below. **Table 5-1** includes ADWR's proposed quantities of use for past and present water uses on the Reservation.

5.1.7.1 Agricultural (Irrigation) – Hopi and United States

In its Third Amended SOC and Supplement, the Hopi Tribe claims a total water use of 102,303 AFA for irrigation purposes on 26,921.9 acres of land. In its Third Amended SOC, the United States claim a total water use of 28,417 AFA for irrigation purposes on 13,032 acres of land.

As discussed in **Chapter 4**, ADWR reviewed the claimed acreages and verified 26,271 acres claimed by the Hopi and 13,022 acres claimed by the United States. However, the verified acres represent a composite of the lands that are believed to have been irrigated at any time during approximately the last 80 years. Instead of the composite acreage claimed by the Hopi and the United States, ADWR recommends that the water right attribute for agricultural uses be based on



the maximum acreage believed to have been irrigated in any single year, which is 9,553 acres as claimed by the United States and Hopi in their Second Amended SOC's.

ADWR further believes that an appropriate water right attribute for lands irrigated on the Hopi Reservation must recognize that both modern and traditional farming practices have been and continue to be in use. ADWR calculated that the water duties for modern acres and traditional acres are 4.33 and 0.93 acre-feet per acre, respectively. Applying these water duties to 424 acres using modern farming practices and 9,129 acres using traditional farming practices, as claimed in the Second Amended SOC's of the Hopi and United States, results in a total water use of 10,325 AFA. Based on these calculations, ADWR proposes a water right attribute for agricultural use of 10,325 AFA.

ADWR determined the location of the claimed acreages so that the total proposed water right attribute of 10,325 AFA could be presented separately for each of the three places of use, District 6 lands, Hopi Partitioned Lands (HPL), and Moenkopi Island. For each of these places of use, ADWR determined the total number of modern and traditionally farmed acres and their associated quantity of use. The results are presented below (acres and volumes have been rounded to the nearest whole number) as well as in **Table 5-1**:

District 6	82 modern acres	353 AFA water use
	6,211 traditional acres	<u>5,776</u> AFA water use
	Sub-total	6,129 AFA water use
HPL	0 modern acres	0 AFA water use
	2,625 traditional acres	<u>2,442</u> AFA water use
	Sub-total	2,442 AFA water use
Moenkopi	342 modern acres	1,481 AFA water use
	293 traditional acres	<u>273</u> AFA water use
	Sub-total	1,754 AFA water use

5.1.7.2 Evaporation from Irrigation Storage – Hopi Tribe

In its Third Amended SOC, the Tribe claims 192 AFA for evaporation losses from two reservoirs, Pasture Canyon and Lower Lagoon, based on a net evaporation rate of 4 feet per year.



In **Chapter 4**, ADWR determined that the claimed annual evaporation rate of 4 feet was less than the range of 4.5 to 6.1 feet calculated by ADWR. In addition, ADWR verified the existence of Pasture Canyon and Lower Lagoon in Moenkopi Island. Based on these findings, ADWR proposes a water right attribute of 192 AFA for past and present evaporation from irrigation storage.

5.1.7.3 Livestock and Water Storage for Stock – Hopi Tribe and United States

In its Third Amended SOC and Supplement, the Hopi Tribe claim a total water use of 6,184 AFA for livestock purposes based on the capacities of 1,012 past and present impoundments. In its Third Amended SOC, the United States claims a total water use of 3,388 AFA for livestock purposes based on the capacities of 1,001 past and present surface impoundments.

As described in **Chapter 4**, the impoundments claimed by the Hopi and United States almost completely overlapped. The United States provided both water surface areas and capacities for all of its claimed impoundments. The Hopi Tribe only provided the capacity of each impoundment. ADWR evaluated the claimed capacities and concluded that the United States claimed capacity of 3,388 AF for livestock purposes is more representative of actual historical and current conditions.

As further discussed in **Chapter 4**, ADWR identified eight (8) impoundments that do not meet the criteria to be classified as an impoundment for livestock purposes and, therefore, the associated storage volume should be subtracted from the United States claimed volume of 3,388 AF. Seven (7) of the impoundments claimed by the United States, with a total volume of 9.015 AF, did not have visible evidence of water storage to be classified as a water storage impoundment (see **Section 4.4.3.2**). In addition, the United States and the Hopi claimed Pasture Canyon reservoir, with a capacity of 212 AF, as a water storage impoundment for livestock purposes. ADWR concluded that the primary purpose is storage for agricultural purposes and therefore it should not be classified as a water storage impoundment for livestock purposes. ADWR subtracted the claimed volumes of the eight impoundments (221 AF) from the claimed total volume which resulted in a water right attribute of 3,167 AFA for past and present water storage for livestock purposes.



ADWR determined the location of each of the 993 impoundments so that the total proposed water right attribute of 3,167 AFA could be presented separately for each of the three places of use, District 6 lands, HPL, and Moenkopi Island. For each of these places of use, ADWR determined the total number of impoundments and associated volume within each of the three places of use. The results are presented below (the volumes have been rounded to the nearest whole number) as well as in **Table 5-1**:

District 6	542 impoundments	1,391 AFA capacity
HPL	439 impoundments	1,749 AFA capacity
Moenkopi	12 impoundments	27 AFA capacity

5.1.7.4 Mining – Hopi Tribe and United States

In their Third Amended SOCs, the Hopi Tribe and the United States claim 1,255 AFA of water use for current coal mining purposes. In **Chapter 4**, ADWR determined that the quantity claimed was supported by data contained in a USGS report. Based on this finding, ADWR proposes a water right attribute of 1,255 AFA for past and present mining.

5.1.7.5 Recreation – Hopi Tribe

In its Third Amended SOC, the Hopi Tribe claims 41 AFA of water use for recreational purposes at Keams Lake. The Hopi claim the right to continuously fill Keams Lake to its maximum capacity of 27.8 AF and also claim evaporative losses of 12.8 AFA.

ADWR reviewed aerial imagery and verified the existence of Keams Lake with a visible water surface within the Hopi Partitioned Lands. Since the lake is currently filled, the water required to maintain Keams Lake is limited to replenishment due to evaporative losses. In **Chapter 4**, ADWR determined that the claimed annual evaporation rate of 4 feet was less than range of 4.5 to 6.1 feet calculated by ADWR. In addition, ADWR determined that the claimed surface area of 3.2 acres was reasonable. Based on these findings, ADWR proposes a water right attribute of 13 AFA (rounded) for past and present recreation. ADWR is not proposing a separate water right attribute related to continuous fill of Keams Lake.



5.1.7.6 Subsurface Mineral Rights – Hopi Tribe

In their Third Amended SOC, the Hopi claim 40,295 AFA of water for the Tribe's proportional share of the Blue Springs complex. The Tribe's claim is for both instream flows and consumptive use and it asserts the right to "transfer" this claimed use for consumptive or non-consumptive purposes. The Blue Springs complex is located off Hopi Reservation in the lower Little Colorado River area. The Little Colorado River does not cross Hopi Reservation lands. The Hopi claim is based on the partitioning of the Joint Use Area between the Hopi Tribe and Navajo Nation according to the 1974 Settlement Act. This claim is also based on the Tribe's assertion that subsurface water conforms to the definition of a mineral and therefore is subject to the 1974 Act.

There are multiple legal issues associated with claimed water use for subsurface mineral rights as listed above. These legal issues are matters for decision by the LCR adjudication court, and therefore beyond the scope of this HSR.

5.1.7.7 Aesthetic, Cultural and Ecological Flows – Hopi Tribe and United States

In their Third Amended SOCs, the Hopi Tribe and the United States claim a maximum of 294 AFA of water use for riparian and wetland habitat in Pasture Canyon, which is located in Moenkopi Island. In **Chapter 4**, ADWR determined that the claimed amount fell within the range of 165.7 AFA to 317.0 AFA calculated by ADWR for the number of acres of riparian vegetation and wetlands claimed by the Hopi and United States. Based on this finding, ADWR proposes a water right attribute of 294 AFA for aesthetic, cultural and ecological flows in Pasture Canyon.

In its Third Amended SOC and Supplement, the Hopi claim 16 AFA (rounded) for flows in White Ruin Canyon Wash. As stated in **Chapter 4**, ADWR is unable to rely on the information provided in the draft report related to measurement of flows in White Ruin Canyon Wash and therefore presented no findings with regards to this claim. ADWR is not proposing a water right attribute related to flows in White Ruin Canyon Wash.

In addition, in its Third Amended SOC the Hopi claim a non-diversionary water right for instream flows in the lower Little Colorado River for aesthetic, cultural and ecological flows. ADWR is not proposing a water right attribute related to this claim because it is not quantified and it raises legal issues that are matters for decision by the LCR adjudication court, and therefore beyond the scope of this HSR.



5.2 SUMMARY OF FUTURE WATER USES

ADWR provided descriptive and technical information related to future water uses in **Chapters 2 and 4** of this HSR, but is not proposing water right attributes for those future water uses. The descriptive and technical information presented, including the estimated quantity of water to be used for each future use, was based on information provided to ADWR by the Hopi Tribe and the United States. The types of water use based in whole or in part on future water uses are listed below:

- Domestic, Commercial, Municipal, and Industrial (DCMI) – Hopi and United States;
- Livestock and Water Storage for Stock (Stockponds) – Hopi and United States;
- Ceremonial and Subsistence Irrigation – Hopi and United States;
- Mining – Hopi and United States;
- Energy Resources Development - Hopi; and
- Tourism – Hopi.

The total future water use claimed in the Hopi Tribe's Third Amended SOC and Supplement is 46,355 AFA. The total future water use claimed in the United States Third Amended SOC is 21,220 AFA. **Table 3-3** provides the estimated quantity of water for each future use as claimed by the Hopi and United States.

5.3 CLAIMED WATER STORAGE

In its Third Amended SOC, the Hopi claim the right to store 333 AF of water in Pasture Canyon and Lower Lagoon Reservoirs. ADWR has assigned water right attributes for evaporation from these reservoirs and for the irrigated lands served by the water stored in these reservoirs. ADWR believes the right to store water in these reservoirs should be recognized, but that no quantity of use should be assigned to that right.



TABLES

TABLE 2-1. WELL WITHDRAWALS FROM THE N AQUIFER SINCE 1965¹

PERIOD	PWCC INDUSTRIAL WITHDRAWALS ²			NAVAJO AND HOPI MUNICIPAL WITHDRAWALS ³			TOTAL WITHDRAWALS (acre-feet)
	Average Annual (acre-feet)	Total (acre-feet)	Percentage of Total	Average Annual (acre-feet)	Total (acre-feet)	Percentage of Total	
1965-2005	3,453	138,100	63	2,005	80,200	37	218,300
2006-2011	1,255	7,530	30	2,972	17,830	70	25,360
2011	1,390	1,390	31	3,090	3,090	69	4,480
1965-2011	3,368	145,630	60	1,956	98,030	40	243,660

Notes:

¹ Source: Macy and Unema (2014).

² From 8 wells completed in the confined portion of the aquifer.

³ From approximately 70 wells, most of which are completed in the confined portion of the aquifer with a few completed in the unconfined portion. These wells are operated by the Navajo Tribal Utility Authority (NTUA), Bureau of Indian Affairs (BIA), and the Hopi Tribe. Does not include domestic and stock well withdrawals estimated to total less than 1% of the industrial and municipal withdrawals.



TABLE 2-2. CLAIMED SPRINGS NOT VERIFIED BY ADWR

UNITED STATES THIRD AMENDMENT CLAIMED INFORMATION					ADWR FINDINGS ²
Hopi Label	US Label	Name	Use ¹	Claim Verification Method	
S-1-339	S016	Unnamed	C/ D/ S	GNIS Verified	Spring 06-094-04.13X11.05-1 mentioned in NRCE comment is classified as a well in NWIS. May have been a match with GWSI & NWIS Site No. 361603110591101 (01 058-13.19x16.00) but ADWR did not find spring at claimed location.
S-2-21	S0215	Two Headed Snare	C/ D/ S	NRCE Verified	Previously reported as a well; ADWR did not find spring at claimed location (Hopi Preliminary HSR, 2008, Appendix D, Table D-1)..
S-2-23	S0217	Looking Woman	C/ D/ S	HKM Review Verified	ADWR did not find spring at claimed location.(Hopi Preliminary HSR, 2008, Appendix D, Table D-1).
S-2-8	S022	Unnamed	C/ D/ S	HKM Review Verified	ADWR did not find spring at claimed location (Hopi Preliminary HSR, 2008, Appendix D, Table D-1).
S-2-26	S0220	Narrow Neck	C/ D/ S	HKM Review Verified	ADWR did not find spring at claimed location (Hopi Preliminary HSR, 2008, Appendix D, Table D-1).
S-2-10	S024	Blue Moenkopi	C/ D/ S	HKM Review Verified	ADWR did not find spring at claimed location (Hopi Preliminary HSR, 2008, Appendix D, Table D-1).
S-3-28	S032	Many Sheep	C/ D/ S	HKM Review Verified	ADWR did not find spring at claimed location (Hopi Preliminary HSR, 2008, Appendix D, Table D-1)
S-3-227	S037	4M-207	C/ D/ S	Range Use Map Verified	ADWR did not find spring at claimed location (Hopi Preliminary HSR, 2008, Appendix D, Table D-1).
S-3-228	S038	4M-58	C/ D/ S	ADWR Verified	Previously reported as a well; ADWR did not find spring at claimed location. (Hopi Preliminary HSR, 2008, Appendix D, Table D-1).
S-4-343	S0450	Unnamed	C/ D/ S/ IRR	HKM Review Verified	ADWR did not find spring at claimed location (Hopi Preliminary HSR, 2008, Appendix D, Table D-1).
S-4-345	S0452	Unnamed	C/ D/ S/ IRR	HKM Review Verified	ADWR did not find spring at claimed location (Hopi Preliminary HSR, 2008, Appendix D, Table D-1).
S-4-346	S0453	Unnamed	C/ D/ S/ IRR	HKM Review Verified	ADWR did not find spring at claimed location (Hopi Preliminary HSR, 2008, Appendix D, Table D-1).
S-4-350	S0457	Unnamed	C/ D/ S/ IRR	HKM Review Verified	ADWR did not find spring at claimed location (Hopi Preliminary HSR, 2008, Appendix D, Table D-1).
S-4-351	S0458	Unnamed	C/ D/ S/ IRR	HKM Review Verified	ADWR did not find spring at claimed location (Hopi Preliminary HSR, 2008, Appendix D, Table D-1).
S-4-218	S046	3-GS-77-6	C/ D/ S	ADWR Verified	ADWR notes that claim name is believed to be incorrect; claimed location places spring in residential area; ADWR did not find spring at claimed location (Hopi Preliminary HSR, 2008, Appendix D, Table D-1).
S-4-360	S0467	Eagle Nest, Talakwava	C/ D/ S	HKM Review Verified	ADWR did not find spring at claimed location (Hopi Preliminary HSR, 2008, Appendix D, Table D-1).
S-5-209	S0521	1A-82	C/ D/ S	HKM Review Verified	ADWR did not find spring at claimed location (Hopi Preliminary HSR, 2008, Appendix D, Table D-1).
S-6-229	S0633	4M-66	C/ D/ S	ADWR Verified	ADWR did not find spring at claimed location (Hopi Preliminary HSR, 2008, Appendix D, Table D-1).



TABLE 2-2. CLAIMED SPRINGS NOT VERIFIED BY ADWR

UNITED STATES THIRD AMENDMENT CLAIMED INFORMATION					ADWR FINDINGS ²
Hopi Label	US Label	Name	Use ¹	Claim Verification Method	
S-6-248	S0634	4T-519/BM OBS 5	C/ D/ S	HKM Review Verified	ADWR did not find spring at claimed location (Hopi Preliminary HSR, 2008, Appendix D, Table D-1).
S-6-47	S068	2 Sheep	C/ D/ S	HKM Review Verified	ADWR did not find spring at claimed location (Hopi Preliminary HSR, 2008, Appendix D, Table D-1).
S-9-340	S0938	Iskasokpu, Burping Coyote	C/ D/ S	ADWR Verified	ADWR did not find spring at claimed location (Hopi Preliminary HSR, 2008, Appendix D, Table D-1).
S-10-147	S1027	Chief, Monwisva	C/ D/ S	ADWR Verified	ADWR did not find spring at claimed location. (Hopi Preliminary HSR, 2008, Appendix D, Table D-1).
S-10-205	S1032	Skull	C/ D/ S	ADWR Verified	ADWR did not find spring at claimed location (Hopi Preliminary HSR, 2008, Appendix D, Table D-1).
S-10-235	S1037	6H-7	C/ D/ S/ IRR	GNIS Verified	ADWR did not find spring at claimed location. (Hopi Preliminary HSR, 2008, Appendix D, Table D-1)
	S1040	6M-302A	C/ D/ S	NRCE Field Work Verified	Claim name doesn't match 1960's report; ADWR did not find spring at claimed location (Hopi HSR, 2008, Appendix D, Table D-1).
S-10-250	S1045	6-F-1	C/ D/ S	GNIS Verified	ADWR did not find spring at claimed location. (Hopi Preliminary HSR, 2008, Appendix D, Table D-1). No match in NWIS for a well named 06 094-06.58X07.57. Not shown on topo or listed in GNIS.
S-10-251	S1046	6K-305-94	C/ D/ S	Range Use Map Verified	Previously reported as a well; ADWR did not find spring at claimed location. (Hopi Preliminary HSR, 2008, Appendix D, Table D-1).
S-10-309	S1048	Unnamed	C/ D/ S	HKM Review Verified	ADWR did not find spring at claimed location. (Hopi Preliminary HSR, 2008, Appendix D, Table D-1).
S-10-316	S1050	Monowopsa, Owl Corner	C/ D/ S	HKM Review Verified	ADWR did not find spring at claimed location. (Hopi Preliminary HSR, 2008, Appendix D, Table D-1).
S-10-317	S1051	New Water	C/ S	TJ Ferguson Verified	ADWR did not find spring at claimed location. (Hopi Preliminary HSR, 2008, Appendix D, Table D-1).
S-10-318	S1052	Big Water, Wokokova	C/ S/ IRR	HKM Review Verified	ADWR did not find spring at claimed location. (Hopi Preliminary HSR, 2008, Appendix D, Table D-1).
S-10-319	S1053	Sand Water	C/ S/ IRR	HKM Review Verified	ADWR did not find spring at claimed location. (Hopi Preliminary HSR, 2008, Appendix D, Table D-1).
S-10-321	S1055	Many Wind Water, Hucatwebah	C/ D/ S	HKM Review Verified	Claimed site located adjacent to impoundment. Spring maybe dry; ADWR did not find spring at claimed location (Hopi Preliminary HSR, 2008, Appendix D, Table D-1).
	S112	Unnamed	C/ D/ S	NRCE Verified	ADWR did not find spring at claimed location. (Hopi Preliminary HSR, 2008, Appendix D, Table D-1).
S-11-171	S1124	06A-24	C/ S	Range Use Map Verified	ADWR did not find spring at claimed location. (Hopi Preliminary HSR, 2008, Appendix D, Table D-1).
	S1127	07H-27A	C/ D/ S	NRCE Field Work Verified	ADWR did not find spring at claimed location. (Hopi Preliminary HSR, 2008, Appendix D, Table D-1).
	S1131	Unnamed	C/ D/ IRR	TJ Ferguson Verified	ADWR did not find spring at claimed location. (Hopi Preliminary HSR, 2008, Appendix D, Table D-1).



TABLE 2-2. CLAIMED SPRINGS NOT VERIFIED BY ADWR

UNITED STATES THIRD AMENDMENT CLAIMED INFORMATION					ADWR FINDINGS ²
Hopi Label	US Label	Name	Use ¹	Claim Verification Method	
S-11-314	S1132	Unnamed	C/ D	HKM Review Verified	ADWR did not find spring at claimed location. (Hopi Preliminary HSR, 2008, Appendix D, Table D-1). "Spring" 06 093-11.40X12.75-2 mentioned in NRCE comment is classified as a well in NWIS.
S-4-352	S0459	Unnamed	C/ D/ S/ IRR	ADWR Verified	Location listed in Hopi Preliminary HSR, 2008, Appendix D, Table D-1 differs from claimed location.
S-13-249	S139	6-2B-4-8	C/ D/ S	HKM Review Verified	ADWR did not find spring at claimed location. (Hopi Preliminary HSR, 2008, Appendix D, Table D-1).
S-14-252	S1415	6M-38	C/ D/ S	HKM Review Verified	Probably a match with NWIS Well Site No. 353801110265001 (06 113-11.08X08.01). ADWR noted site was reviously reported as a well and did not find spring at claimed location (Hopi Preliminary HSR, 2008, Appendix D, Table D-1).
S-12-327	S1211	Tishepi	C/ D/ S	GNIS Verified	Name (Tishepi Spring) in GNIS database only. Not plotted on any topo. Not in Topo Large. No feature visible in imagery.
S-9-88	S091	Mumurva, Monusva	C/ D/ S/ IRR	QUAD Verified	No spring labeled on topo. GNIS label Mumurva is a populated place name.
S-10-408	S1059	Unnamed	C/ S	ADWR Verified	Spring presence not verified in 2015 ADWR review of Appendix D: Hopi Spring Inventory, maps or imagery
	S1049	Sand	C/ D/ S	Range Use Map Verified	Spring presence not verified in 2015 ADWR review of Appendix D: Hopi Spring Inventory, maps or imagery
	S0945		C/ D/ S/ IRR	NRCE Field Work Verified	Spring presence not verified in 2015 ADWR review of Appendix D: Hopi Spring Inventory, maps or imagery
	S096	Unnamed	C/ D/ S	NRCE Verified	Spring presence not verified in 2015 ADWR review of Appendix D: Hopi Spring Inventory, maps or imagery
	S098	06M-63	C/ D/ S	Range Use Map Verified	Spring presence not verified in 2015 ADWR review of Appendix D: Hopi Spring Inventory, maps or imagery
S-9-324	S0934	Gray, Masiipa	C/ D/ S/ IRR	HKM Review Verified	Spring presence not verified in 2015 ADWR review of Appendix D: Hopi Spring Inventory, maps or imagery
S-9-326	S0936	Songoopa, Sand Grass	C/ S	Range Use Map Verified	Spring presence not verified in 2015 ADWR review of Appendix D: Hopi Spring Inventory, maps or imagery
	S0915	Unnamed	C/ D/ S	Range Use Map Verified	Spring presence not verified in 2015 ADWR review of Appendix D: Hopi Spring Inventory, maps or imagery
S-8-84	S081	JUA-5B-1-332	C/ D/ S	HKM Review Verified	ADWR unable to access claimed spring location (Hopi Preliminary HSR, 2008, Appendix D, Table D-1).
S-5-57	S059	Round Rock	C/ D/ S	HKM Review Verified	ADWR unable to access claimed spring location (Hopi Preliminary HSR, 2008, Appendix D, Table D-1).
S-6-69	S0619	Salt Seep	C/ D/ S	HKM Review Verified	ADWR denied access during field visit (Hopi Preliminary HSR, 2008, Appendix D, Table D-1).
S-4-347	S0454	Unnamed	C/ D/ S/ IRR	HKM Review Verified	Spring presence not verified in 2015 ADWR review of Appendix D: Hopi Spring Inventory, maps or imagery



TABLE 2-2. CLAIMED SPRINGS NOT VERIFIED BY ADWR

UNITED STATES THIRD AMENDMENT CLAIMED INFORMATION					ADWR FINDINGS ²
Hopi Label	US Label	Name	Use ¹	Claim Verification Method	
	S0468A	Spring 1		Field Verification	Spring presence not verified in 2015 ADWR review of Appendix D: Hopi Spring Inventory, maps or imagery
	S0482	Culvert Spring	-	HKM Review Verified	Spring presence not verified in 2015 ADWR review of Appendix D: Hopi Spring Inventory, maps or imagery
	S0515		C/ D/ S	NRCE Verified	Spring presence not verified in 2015 ADWR review of Appendix D: Hopi Spring Inventory, maps or imagery
	S023	Unnamed	C/ D/ S	NRCE Verified	Spring presence not verified in 2015 ADWR review of Appendix D: Hopi Spring Inventory, maps or imagery
S-3-31	S035	Owl	C/ D/ S	HKM Review Verified	ADWR unable to access claimed spring location during field visit (Hopi Preliminary HSR, 2008, Appendix D, Table D-1).
S-2-25	S0219	Side Wash	C/ D/ S	HKM Review Verified	ADWR unable to access claimed spring location (Hopi Preliminary HSR, 2008, Appendix D, Table D-1).
S-14-195	S144	Kalbito #2	C/ D/ S	QUAD Verified	Named as a well on Topo. No spring shown in Topo Large.
S-14-200	S149	Wolf Pass	C/ D/ S	GNIS Verified	Identified in GNIS and shown on topo as Wolf Pass Well. Feature class in GNIS is listed as well.

Notes:

¹ C = cultural; D = domestic; S = stock; IRR = irrigation

² Based on ADWR's review of Appendix D: Hopi Spring Evaluation from ADWR's 2008 Preliminary HSR; USGS Topographic Series Maps (Topo Large); National Water Information System (NWIS, USGS Water Data); Geographic Names Information System (GNIS); Topographic Series Maps (USA Topo Maps); USGS Scanned Topos; and ESRI World Imagery and Google Earth imagery.



TABLE 2-3. SUMMARY OF USGS STREAMFLOW DATA COLLECTED ON AND NEAR THE HOPI INDIAN RESERVATION

GENERAL AREA	STREAM	GAGE NUMBER (location) ¹	CONTRIBUTING DRAINAGE AREA (square miles)	PERIOD OF RECORD	NO. OF DAILY MEAN FLOW MEASUREMENTS ²	ANNUAL FLOW (acre-feet) ³				AVERAGE SEASONAL FLOW (as % of annual flow) ⁴				TYPICAL FLOW DURATION (% of days each year with flow) ⁵	STREAMFLOW REGIME ⁶
						Minimum	Median	Mean	Maximum	Winter	Spring	Summer	Fall		
PWCC Leasehold (Upper Moenkopi Wash) ⁷	Coal Mine Wash	09401239 (near Shonto)	137	1978-82	1,623	433	775	858	1,365	20.3	9.9	48.5	21.3	60%	Intermittent
	Coal Mine Wash Tributary 1	09401226 (near Kayenta)	0.62	1977-81	1,461	0.0	2.9	24.1	69.5	2.0	4.0	90.1	3.9	3.6%	Ephemeral
	Coal Mine Wash Tributary 2	09401229 (near Kayenta)	0.57	1977-79	730	Not calculated due to short period of record				0.0	0.0	0.0	100.0	1.2%	Ephemeral
Hopi Washes	Dinnebito Wash	09401110 (near Sand Springs)	473	1993-2015	8,206	311	3,070	3,100	7,405	10.4	1.9	75.2	12.5	100%	Perennial
	Jeddito Wash	09400583 (near Jeddito)	147	1993-2005	4,412	14	145	298	1,426	0.0	0.6	88.3	11.1	3.3%	Ephemeral
	Moenkopi Wash	09401250 (near Moenkopi)	1,575	1973-76	1,004	Not calculated due to short period of record				11.3	4.0	75.6	9.0	91%	Intermittent
		09401260 (at Moenkopi)	1,629	1976-2015	14,249	1,376	6,023	6,480	14,117	12.2	4.2	65.8	17.8	79%	Intermittent
		09401265 (at Pasture Canyon Springs)	135	2004-2015	4,140	172	231	226	251	27.6	24.2	22.1	26.1	100%	Perennial
		09401280 (at Moenkopi)	1,904	1926-40	5,206	5,423	10,606	16,870	45,827	7.7	1.7	81.1	9.5	74%	Intermittent
		09401400 (near Tuba City)	2,492	1940-78	9,824	2,185	8,543	10,831	44,573	7.7	1.6	57.7	33.0	65%	Intermittent
	09401500 (near Cameron)	2,662	1953-65	4,141	3,681	6,936	9,988	19,909	5.9	2.8	78.5	12.8	51%	Intermittent	
	Oraibi Wash	09400562 (near Tolani Lakes)	635	1995-2013	6,728	50	1,998	2,365	6,559	15.2	0.3	67.4	17.0	10.6%	Ephemeral
Polacca Wash	09400568 (near Second Mesa)	905	1994-2015	7,895	192	2,541	3,007	9,701	10.9	1.1	73.9	14.1	94%	Perennial	
LCR Drainage	Little Colorado River	09401000 (at Grand Falls)	21,068	1925-95	13,750	18,512	160,358	194,601	587,714	38.4	24.4	30.3	6.9	61%	Intermittent
		09402000 (near Cameron)	26,091	1947-2015	25,021	16,987	132,631	153,042	603,062	35.1	24.0	27.7	13.3	62%	Intermittent
		09402300 (near Desert View)	26,972	1990-2015	5,294	204,303	252,881	283,296	436,188	32.1	21.2	28.4	18.3	100%	Perennial

Notes:

¹ Gage locations are shown in Figure 2-6.

² Daily Flow Measurements Count thru 12/01/2015

³ Statistics based on Calendar Year (WY) data

⁴ Calculated using average monthly streamflows measured over station's available period of record. Winter season assumed to include months of January, February, and March; spring includes April, May, and June; and so on. Due to rounding, sum of seasonal flows may not equal 100%.

⁵ Based on median of daily mean flows calculated over period of record.

⁶ For purposes of this HSR, ephemeral flow was assumed if the typical flow duration was less than 10% and intermittent flow was assumed if the flow duration was 10% or greater but less than 100% (perennial).

⁷ PWCC = Peabody Western Coal Company.



TABLE 3-1. SUMMARY OF HOPI TRIBE ADJUDICATION CLAIMS FOR PAST AND PRESENT AND FUTURE WATER USES¹

TYPE OF USE	CLAIMED QUANTITIES OF USE ²							
	1985 Claim		2004 Claim (1st Amendment and 2005 Supplemental Information)		2009 Claim (2nd Amendment)		2015 Claim (3rd Amendment as supplemented)	
	Past and Present (AFA)	Future (AFA)	Past and Present (AFA)	Future (AFA)	Past and Present (AFA)	Future (AFA)	Past and Present (AFA)	Future (AFA)
Domestic, Commercial, Municipal, and Industrial (DCMI)	2,060	7,267	0	11,211	0	9,110	0	9,348
Agricultural (Irrigation)	11,364	76,695	52,206	21,060	21,199	0	102,303 ³	0
Evaporation from Irrigation Storage	186	9,359	0	2,842	192	0	192	0
Livestock and Water Storage for Stock (Stockponds)	1,504	295	7,961	910	4,886	997	6,184 ³	1,000
Ceremonial and Subsistence Irrigation	0	0	0	12,546	0	4,977	0	7,385
Mining	2,325	29,120	4,400	1,600	1,236	500	1,255	500
Energy Resources Development	0	0	0	19,000	0	6,000	0	27,100
Tourism	0	0	0	1,594	0	522	0	1,022
Recreation	80	151	139	0	41	0	41	0
Subsurface Mineral Rights	0	0	0	0	0	0	40,295	0
Aesthetic, Cultural and Ecological Flows (Riparian Habitat and Instream Flows)	0	0	0	0	0	0	310 ³	0
Other (Off Reservation Uses)	0	0	2,366	0	2,366	380	0	0
Subtotals	17,519	122,887	67,072	70,763	29,920	22,486	150,580	46,355
Total Claim	140,406		137,835		52,406		196,935	
	<i>Also claimed is a one-time volume of 91,330 AF for first-time filling for irrigation storage reservoirs, recreational lakes and stockponds from LCR, five washes, and groundwater sources.</i>		<i>Also claimed are one-time volumes of: (1) 15,700 AF for first-time filling for irrigation storage reservoirs; and (2) 2,089 AF for storage and additional future use on Hopi Ranches.</i>		<i>Also claimed are one-time volumes of: 1) 333 AF of storage in reservoirs in Moenkopi Island; 2) a one-time volume of 2,089 AF for storage and additional future use on Hopi Ranches.</i>		<i>Also claimed is 333 AF of storage in reservoirs in Moenkopi Island.</i>	

Notes:

¹ Copies of the 1985, 2004, 2009, and 2015 Hopi adjudication claims are provided in Appendix C of this report.

² Quantities are rounded to the nearest 1 AF or AFA.

³ Water rights claimed amount listed in Hopi Tribe's Supplement to its Third Amended SOC. (See Table 1 - Quantification.) Following are the original 2015 claimed quantities for each use with the supplemental amount shown afterwards in parentheses: Irrigation - 101,121 (1,182); Livestock and water storage for stock (stockponds) - 4,883 (1,301); Aesthetic, Cultural and Ecological Flows - 294 (16).



TABLE 3-2. SUMMARY OF UNITED STATES ADJUDICATION CLAIMS ON BEHALF OF THE HOPI FOR PAST AND PRESENT AND FUTURE WATER USES¹

TYPE OF USE	CLAIMED QUANTITIES OF USE ²									
	1985 Claim ³		1994 Claim ⁴		2004 Claim (1st Amendment)		2009 Claim (2nd Amendment)		2015 Claim (3rd Amendment)	
	Past and Present (AFA)	Future (AFA)	Past and Present (AFA)	Future (AFA)	Past and Present (AFA)	Future (AFA)	Past and Present (AFA)	Future (AFA)	Past and Present (AFA)	Future (AFA)
Domestic, Commercial, Municipal, and Industrial (DCMI)	4,594	53,102	1,793	5,469	0	11,211	0	9,110	0	8,746
Agricultural (Irrigation)	36,049	361,545	44,187	31,560	49,136	0	21,199	0	28,417	0
Evaporation from Irrigation Storage	1,155	30,367	186	9,359	0	0	0	0	0	0
Livestock and Water Storage for Stock (Stockponds)	4,356	295	4,601	176	8,044	0	3,403	997	3,388	997
Ceremonial and Subsistence Irrigation	0	0	0	0	0	0	0	4,977	0	4,977
Mining	8,449	11,065	8,449 ⁵	11,065 ⁵	0	3,000	1,236	6,500	1,255	6,500
Energy Resources Development	129	33,072	0	0	0	0	0	0	0	0
Tourism	0	0	0	0	0	0	0	0	0	0
Recreation	2,316	378	80	151	0	0	0	0	0	0
Subsurface Mineral Rights	0	0	0	0	0	0	0	0	0	0
Aesthetic, Cultural and Ecological Flows (Riparian Habitat and Instream Flows)	0	0	0	0	0	0	0	0	294	0
Other (Off Reservation Uses)	0	0	0	0	2,366	556	1,556	902	0	0
Subtotals	57,048	489,824	59,296	57,780	59,546	14,767	27,394	22,486	33,354	21,220
Total Claim	546,872		117,076		74,313		49,880		54,574	
	<i>Also claimed are one-time volumes of: (1) 1,082 AF for filling of recreational lakes; and (2) 330,000 AF for filling of irrigation storage reservoirs.</i>				<i>Also claimed is a one-time volume of 2,089 AF for storage and additional future use on Hopi Ranches.</i>		<i>Also claimed is a one-time volume of 1,837 AF for storage and additional future use on Hopi Ranches.</i>			

Notes:

¹ Copies of the 1985, 1994, 2004, 2009, and 2015 United States adjudication claims on behalf of the Hopi Tribe are provided in Appendix C of this report.

² Quantities are rounded to the nearest 1 AF or AFA.

³ Amounts listed reflect the United States' joint claim on behalf of the Navajo Nation and Hopi Tribe.

⁴ Report of Supplemental Water Claims by the United States of America for the Indian Lands in the Little Colorado River Basin. Amounts listed in table reflect the United States' specific (proportional) claim on behalf of the Hopi Tribe.

⁵ Amount listed reflects the United States' combined claim on behalf of the Navajo Nation and Hopi Tribe.



TABLE 3-3. COMPARISON OF HOPI TRIBE AND UNITED STATES ADJUDICATION CLAIMS FOR PAST AND PRESENT AND ADDITIONAL FUTURE WATER USES ¹

TYPE OF USE	2015 CLAIMED QUANTITIES OF USE					
	Hopi Third Amendment (as supplemented)			United States Third Amendment on behalf of Hopi Tribe		
	Past and Present (AFA)	Future (AFA)	TOTAL (AFA)	Past and Present (AFA)	Future(AFA)	Total (AFA)
Domestic, Commercial, Municipal, and Industrial (DCMI)	0	9,348	9,348	0	8,746	8,746
Agricultural (Irrigation)	102,303	0	102,303	28,417	0	28,417
Evaporation from Irrigation Storage ²	192	0	192	0	0	0
Livestock and Water Storage for Stock (Stockponds)	6,184	1,000	7,184	3,388	997	4,385
Ceremonial and Subsistence Irrigation	0	7,385	7,385	0	4,977	4,977
Mining	1,255	500	1,755	1,255	6,500	7,755
Energy Resources Development	0	27,100	27,100	0	0	0
Tourism	0	1,022	1,022	0	0	0
Recreation	41	0	41	0	0	0
Subsurface Mineral Rights	40,295	0	40,295	0	0	0
Aesthetic, Cultural and Ecological Flows (Riparian Habitat and Instream Flows)	310	0	310	294	0	294
Total Claim	150,580	46,355	196,935	33,354	21,220	54,574

Notes:

¹ Quantities are rounded to the nearest 1 AF or AFA.

² The Hopi also claim 333 acre-feet for filling two reservoirs in the Moenkopi Island.



TABLE 4-1. ANNUAL GPCD RATES FOR COMMUNITY WATER SYSTEMS IN THE LITTLE COLORADO RIVER PLATEAU BASIN IN NAVAJO COUNTY^{1, 2}

Facility	GPCD			
	2006	2007	2008	Annual Average
City of Winslow	154	247	238	213
City of Holbrook	133	135	137	135
Sun Valley Utilities	168	162	124	151
Joseph City Utility	NF	NF	NF	NA

Notes:

¹ Based on water pumped from wells or diverted from streams. Does not include effluent reuse.

GPCD is calculated by dividing demand (in gallons) by 365 and by the population served by the system.

² (ADWR, 2009)

NF = Not Filed



**TABLE 4-2. CLAIMED IRRIGATED ACREAGE
NOT VERIFIED BY ADWR**

HOPI TRIBE THIRD AMENDED SOC (AS SUPPLEMENTED) CLAIMED INFORMATION		ADWR FINDINGS ¹	
Hopi (GIS) Field Label	Hopi (GIS) Field Acres	2015 Field Verification ID ²	Acreage Not Verified
19	11.51	19-66	7.18
		19-65	4.32
23	52.14	23-133	52.11
31	21.62	31-183	5.63
		31-180	0.60
		31-182	0.26
73	6.83	73-866	2.48
75	6.13	75-880	6.13
91	304.45	91-956	7.30
92	183.51	92-963	139.65
102	73.00	102-988	72.96
124	25.49	124-1133	3.98
137	39.48	137-1187	2.90
140	79.84	140-1265	35.09
171	5.46	171-1545	0.21
173	133.64	173-1660	9.91
176	73.64	176-1683	0.31
178	8.32	178-1745	2.16
181	1.31	181-1769	0.19
183	8.25	183-1830	0.31
183	8.25	183-1832	0.21
184	501.87	184-1866	1.80
187	7.91	187-2151	1.42
188	138.86	188-2181	60.36
		188-2180	15.47
189	1.98	189-2208	0.96
194	122.69	194-2431	0.32
206	18.06	206-2481	9.25
207	4.12	207-2484	0.16
208	30.66	208-2496	0.36
211	27.51	211-2563	22.89



Table 4-2

**TABLE 4-2. CLAIMED IRRIGATED ACREAGE
NOT VERIFIED BY ADWR**

HOPI TRIBE THIRD AMENDED SOC (AS SUPPLEMENTED) CLAIMED INFORMATION		ADWR FINDINGS ¹	
Hopi (GIS) Field Label	Hopi (GIS) Field Acres	2015 Field Verification ID ²	Acreage Not Verified
214	114.11	214-2586	24.57
		214-2592	4.96
8	4.77	8-30	4.77
12	284.56	12-37	5.60
		12-40	0.53
21	118.64	21-76	4.06
22	2,932.19	22-123	8.59
24	49.71	24-134	49.67
32	278.99	32-387	0.83
33	107.88	33-497	0.03
		33-498	0.01
58	8.44	58-749	3.57
60	1.00	60-762	0.65
		60-761	0.02
92	183.51	92-960	1.39
94	164.00	94-973	3.85
		94-971	0.78
104	12.75	104-997	0.32
111	2.42	111-1064	0.99
117	4.75	117-1097	0.52
124	25.49	124-1123	0.31
137	39.48	137-1198	3.51
		137-1212	1.36
138	11.17	138-1226	0.25
140	79.84	140-1258	0.25
145	32.28	145-1303	11.01
168	7.36	168-1534	0.43
		168-1513	0.29
		168-1517	0.23



**TABLE 4-2. CLAIMED IRRIGATED ACREAGE
NOT VERIFIED BY ADWR**

HOPI TRIBE THIRD AMENDED SOC (AS SUPPLEMENTED) CLAIMED INFORMATION		ADWR FINDINGS ¹	
Hopi (GIS) Field Label	Hopi (GIS) Field Acres	2015 Field Verification ID ²	Acreage Not Verified
173	133.64	173-1661	0.002
176	73.64	176-1728	0.46
		176-1690	0.20
		176-1729	0.19
		176-1684	0.01
		176-1725	0.003
178	8.32	178-1741	0.43
		178-1740	0.12
		178-1742	0.02
180	2.11	180-1756	0.26
		180-1758	0.16
		180-1759	0.11
181	1.31	181-1767	0.18
		181-1765	0.01
		181-1767	0.01
182	82.59	182-1801	1.61
184	501.87	184-1864	0.68
		184-1921	0.40
		184-1867	0.09
188	138.86	188-2172	4.74
		188-2185	3.68
		188-2181	0.34
		188-2164	0.33
		188-2189	0.09
		188-2195	0.06
		188-2196	0.03
192	26.11	192-2231	0.06
		192-2232	0.001
194	122.69	194-2267	0.46
		194-2263	0.28
198	5.64	198-2455	1.08



Table 4-2

**TABLE 4-2. CLAIMED IRRIGATED ACREAGE
NOT VERIFIED BY ADWR**

HOPI TRIBE THIRD AMENDED SOC (AS SUPPLEMENTED) CLAIMED INFORMATION		ADWR FINDINGS ¹	
Hopi (GIS) Field Label	Hopi (GIS) Field Acres	2015 Field Verification ID ²	Acreage Not Verified
202	25.51	202-2471	22.83
204	0.68	204-2473	0.49
		204-2475	0.18
205	4.03	205-2478	3.92
208	30.66	208-2511	0.04
		208-2512	0.02
		208-2510	0.002
210	49.53	210-2553	0.66
214	114.11	214-2571	0.40
215	80.16	215-2611	5.21
Total			650.06
UNITED STATES THIRD AMENDED SOC CLAIMED INFORMATION		ADWR FINDINGS ¹	
United States Field ID	United States (GIS) Field Acres	2015 Field Verification ID	Acreage Not Verified
OID: 1763; Field #914, SENE	4.61	D-224	4.61
OID: 1764; Field #914, SWNW	3.59	D-225	3.59
OID: 2544; Field #736, NWNW	1.72	A-528	1.72
Total			9.93

Notes:

¹ Based on ADWR's 2015 composite aerial photo interpretation and verification analysis.

² During its 2008 analysis of claimed acreage for the Preliminary Hopi HSR, ADWR merged smaller fields prior to analysis. In 2015, the Hopi provided ADWR with the merged fields in support of their claimed acreage, which ADWR unmerged prior to analysis. ADWR may report multiple fields as being "not verified" for a single field claimed by the Hopi.



**TABLE 4-3. REVISED SUPPLEMENTAL IRRIGATION DEMAND (SID)
ESTIMATES FOR AGRICULTURE ON THE HOPI INDIAN RESERVATION**

Hopi and United States Irrigation Class ¹	ADWR Irrigation Class	Lower Limit (ft/yr)	Upper Limit (ft/yr)	Average (ft/yr)
Perennial and Spring	Modern	2.06	2.7	2.38
Seasonal, Range and Native	Traditional	0.36	0.98	0.67

Notes:

¹ Irrigation classes found in the Hopi and United States Second Amended SOCs.



TABLE 4-4. CALCULATION OF WATER DUTIES

ADWR Irrigation Class	Irrigation Conveyance Efficiency	On-farm Efficiency	Overall Efficiency	Average SID (AF/Acre)	Water Duty (AF/Acre)
Modern	85%	65%	55%	2.38	4.33
Traditional	90%	80%	72%	0.67	0.93



TABLE 4-5. NET ANNUAL SURFACE WATER EVAPORATION

STATION	GROSS MEAN ANNUAL SURFACE WATER EVAPORATION (INCHES)		MEAN ANNUAL PRECIPITATION (INCHES)	NET ANNUAL SURFACE WATER EVAPORATION (INCHES)	NET ANNUAL SURFACE WATER EVAPORATION (FEET)
Tuba City	Lower bound	67.47	6.47	61.00	5.1
	Upper bound	80.20	6.47	73.73	6.1
Keams Canyon	Lower bound	63.50	9.94	53.56	4.5
	Upper bound	75.08	9.94	65.14	5.4



TABLE 4-6. HISTORIC ACCOUNTS OF THE NUMBER OF HOPI LIVESTOCK ¹

YEAR	SHEEP AND GOATS	CATTLE, HORSES, AND OTHERS	REFERENCE	YEAR	SHEEP AND GOATS	CATTLE, HORSES, AND OTHERS	REFERENCE
1775	All villages had an "abundance of sheep" and "some cattle" with more cattle and a "good herd of horses" at Orabi.		Adams (1963)	1890	22,500	5,000	CIA (1890)
late 1770s	Few hundred head		John (1966)	1891	8,000	500	Clemmer (1995)
1780	300 sheep and a few horses, mostly at Walpi; no cattle.		Twitchell (1918)	1892	8,000	500	Clemmer (1995)
1782	All pueblos had herds of sheep, horses, burrows and cows.		Whitely (2004)	1893	2,000		Clemmer (1995)
1852	Raised goats, sheep, and some burrows but "scarcely any horses and mules".		Schoolcraft (1854)	1895	8,000	500	Clemmer (1995)
1858	Large flocks of sheep near Mishongnovi		Ives (1861)	1901	55,500 ²	1,325 ²	McIntire (1968)
1870	Small flocks of sheep		CIA (1870)	1902	20,000	1,365	Clemmer (1995)
1872	Depleted sheep herds due to drought; used goat's milk		CIA (1872)	1917	25,000		Whitely (2004)
1878	5,000	500	CIA (1878)	1929	21,700	8,100	Hoover (1930)
1879	5,000	500	CIA (1879)	1930	20,511 ³		Whitely (2004)
1880	5,000	500	CIA (1880)	1937	11,519 ⁴	12,780 ⁴	McIntire (1968) and Nagata (1970)
1881	10,600	705	CIA (1881)	1938	17,812	3,448	Page (1938)
1882	10,600	1,584	CIA (1882)	1943	13,627	2,200	McIntire (1968)
1884		1,750	CIA (1884)	1945	23,627 ⁵		Day (1945)
1885	6,000	510	CIA (1885)	1950	6,992	3,369	McIntire (1968)
1886	25,000	1,200	CIA (1886)	1960	9,619		Whitely (1988)
1887	21,500	16,050	CIA (1887)	1961	6,060	2,270	Arizona Commission of Indian Affairs (1961)
	25,000		Clemmer (1995)	1964	6,090	2,520	McIntire (1968)
1888	16,500	930	CIA (1888)	1965	6,600	1,000	Clemmer (1995)
	18,000		Clemmer (1995)	1973	2,056 ^{5,6}		Smitherman (1973)
1889	6,000	6,750	CIA (1889)	1980	1,000	8,500	Clemmer (1995)
	6,000		Clemmer (1995)	1981	1,000		Whitely (1988)

Notes:

- ¹ Summarized from Andersen (2008).
- ² Presumably includes District 6 and the entire Joint Use Area (JUA); the latter consists of Hopi and Navajo Partitioned Lands. Hopi sheep herding in Moenkopi Area was "virtually nonexistent" (Nagata, 1970).
- ³ Hopi also grazed 1,300 sheep and 300 cattle on the Moenkopi Plateau and Coal Mine Mesa (Nagata, 1970).
- ⁴ Reference indicated that counts seem high. Nagata (1970) reported that the Hopi also grazed 100 sheep, 300 cattle, and 40 horses on the Moenkopi Plateau and Coal Mine Mesa.
- ⁵ Sheep units.
- ⁶ Counts limited to the JUA.



TABLE 4-7. RECENT LIVESTOCK INVENTORIES ON THE HOPI INDIAN RESERVATION ¹

YEAR	DISTRICT 6				HOPI PARTITIONED LANDS				MOENKOPI AREA			
	Cows	Sheep	Horses	Total AUs ²	Cows	Sheep	Horses	Total AUs ²	Cows	Sheep	Horses	Total AUs ²
1984	4,824	882	226	5,329 ³	1,533		23	1,562				
1985	2,566	595	206	2,972								
1991									341 ⁴			341
1992									365 ⁴			365
1997					1,932	1,668	152	2,539				
2003	2,396	0	111	2,535								
2004	2,166	90	15	2,207								
2005	1,945	63	21	1,987								
2006	1,574	24	14	1,598								

Notes:

¹ Inventory data sources include Bell and Norstog (1985), Hopi (2008a and 2008c), and Talashie (1985).

² Animal Units (AUs) are calculated by the Hopi (1998) as follows:

4 Sheep/Goat = 1 AU

1 Cow/Cattle = 1 AU

1 Horse/Burro = 1.25 AU

³ Of the 5,329 AUs counted in District 6 during 1984, 278 grazed in unfenced farmed areas, 2,442 grazed in fenced farm areas, and 2,609 grazed on unfarmed rangeland (Bell and Norstog, 1985).

⁴ Inventories were provided by the Hopi in sheep units and converted to cows and AUs by ADWR.



TABLE 4-8. CLAIMED IMPOUNDMENTS NOT VERIFIED BY ADWR¹

UNITED STATES THIRD AMENDMENT CLAIMED INFORMATION					
Hopi Label	Site ID	Use	Verification Method	Surface Area (acres)	Capacity (acre-feet)
FC-I0962	I0962	STOCK	USGS Quad Map	2.552	5.161
FC-I0968	I0968	STOCK	USGS Quad Map	1.715	3.281
UNC-O-10/ FC-I0976	I0976	STOCK	2007 COLOR AERIAL PHOTO VERIFIED	0.142	0.192
UNC-O-12/ FC-I1254	I1254	STOCK	2007 COLOR AERIAL PHOTO VERIFIED	0.105	0.136
UNC-D-08/ FC-I1252	I1252	STOCK	2007 COLOR AERIAL PHOTO VERIFIED	0.103	0.133
UNC-M-29/ FC-I0630	I0630	STOCK	2007 COLOR AERIAL PHOTO VERIFIED	0.057	0.068
UNC-M-30/ FC-I0631	I0631	STOCK	2007 COLOR AERIAL PHOTO VERIFIED	0.039	0.044
TOTALS				4.713	9.015

Notes:

¹ Based on ADWR's review of 2007 Color NAIP imagery, ESRI World Imagery, and ESRI USA Topo Maps.

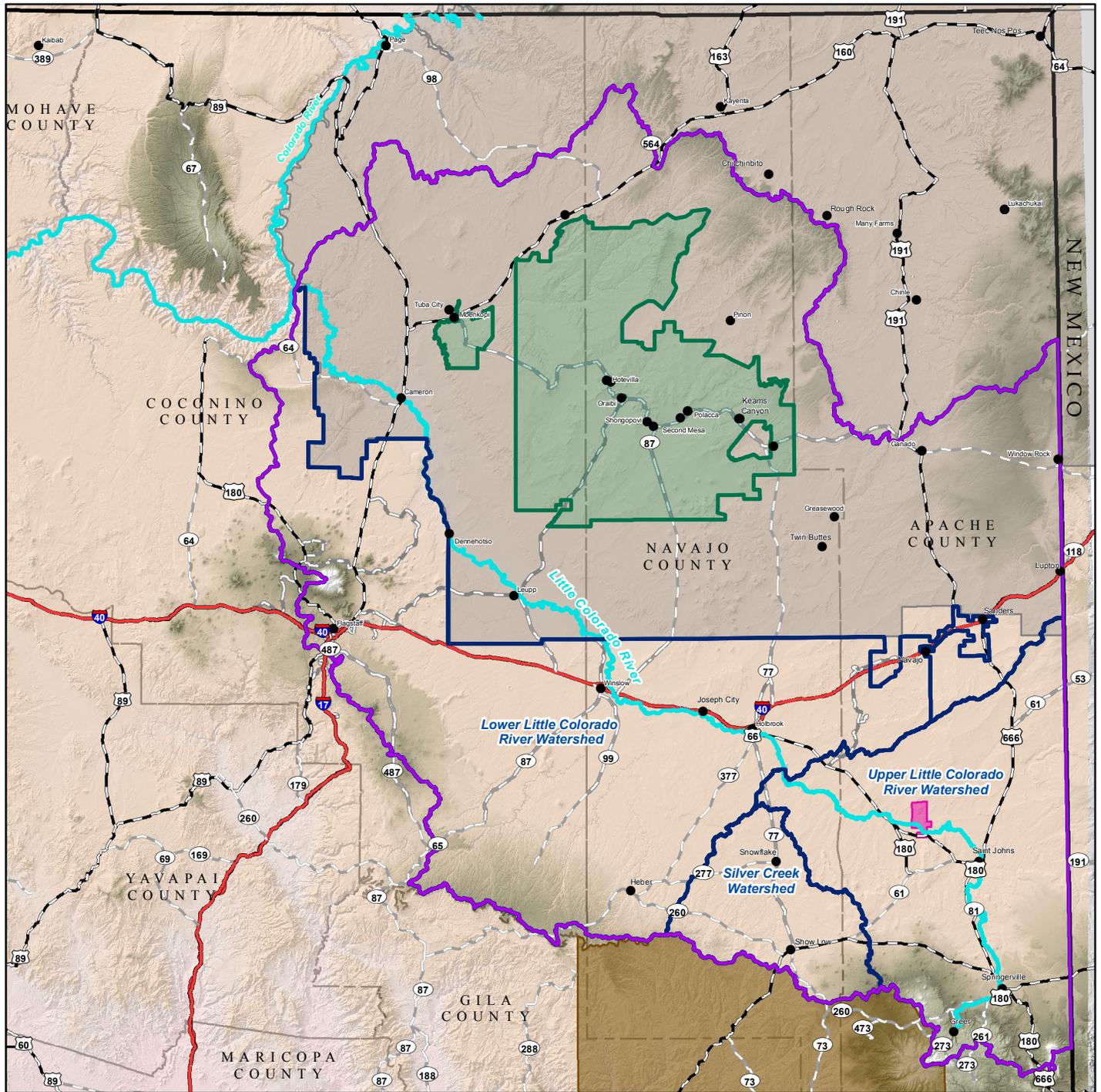


**TABLE 5-1. PROPOSED WATER RIGHT ATTRIBUTES FOR PAST AND PRESENT WATER USES
ON THE HOPI INDIAN RESERVATION**

TYPE(S) OF USE	LEGAL BASIS	WATER SOURCES	POINTS OF DIVERSION	PLACES OF USE	PRIORITY DATES	QUANTITY OF USE (AFA)
Agricultural (Irrigation)	Legal basis of the claims is a matter for decision by the LCR adjudication court, and is beyond the scope of this HSR	Groundwater and surface water	Throughout the Reservation	District 6	Unresolved matter pending before the Court	6,129
				Hopi Partioned Lands (HPL)	Unresolved matter pending before the Court	2,442
				Moenkopi Island	Unresolved matter pending before the Court	1,754
Evaporation from Irrigation Storage				Moenkopi Island	Unresolved matter pending before the Court	192
Livestock and Water Storage for Stock (Stockponds)				District 6	Unresolved matter pending before the Court	1,391
				Hopi Partioned Lands (HPL)	Unresolved matter pending before the Court	1,749
				Moenkopi Island	Unresolved matter pending before the Court	27
Mining				Hopi Partioned Lands (HPL)	Unresolved matter pending before the Court	1,255
Recreation				Hopi Partioned Lands (HPL)	Unresolved matter pending before the Court	13
Aesthetic, Cultural and Ecological Flows (Riparian Habitat and Instream Flows)		Moenkopi Island	Unresolved matter pending before the Court	294		
Subsurface Mineral Rights	Unresolved legal matter	Unresolved legal matter	Unresolved legal matter	Unresolved legal matter	Undetermined	
TOTAL						15,246



FIGURES



Legend

- LCR Adjudication Area Boundary
 - Watershed Boundary
 - City/Town
 - Major River
 - Interstate Highway
 - U.S. Route
 - State Highway
 - Local Roads
 - County
 - State Boundary
- Indian Reservations
 - Hopi
 - White Mountain Apache
 - Navajo
 - Zuni

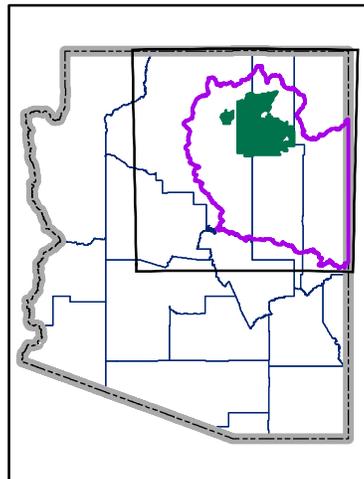
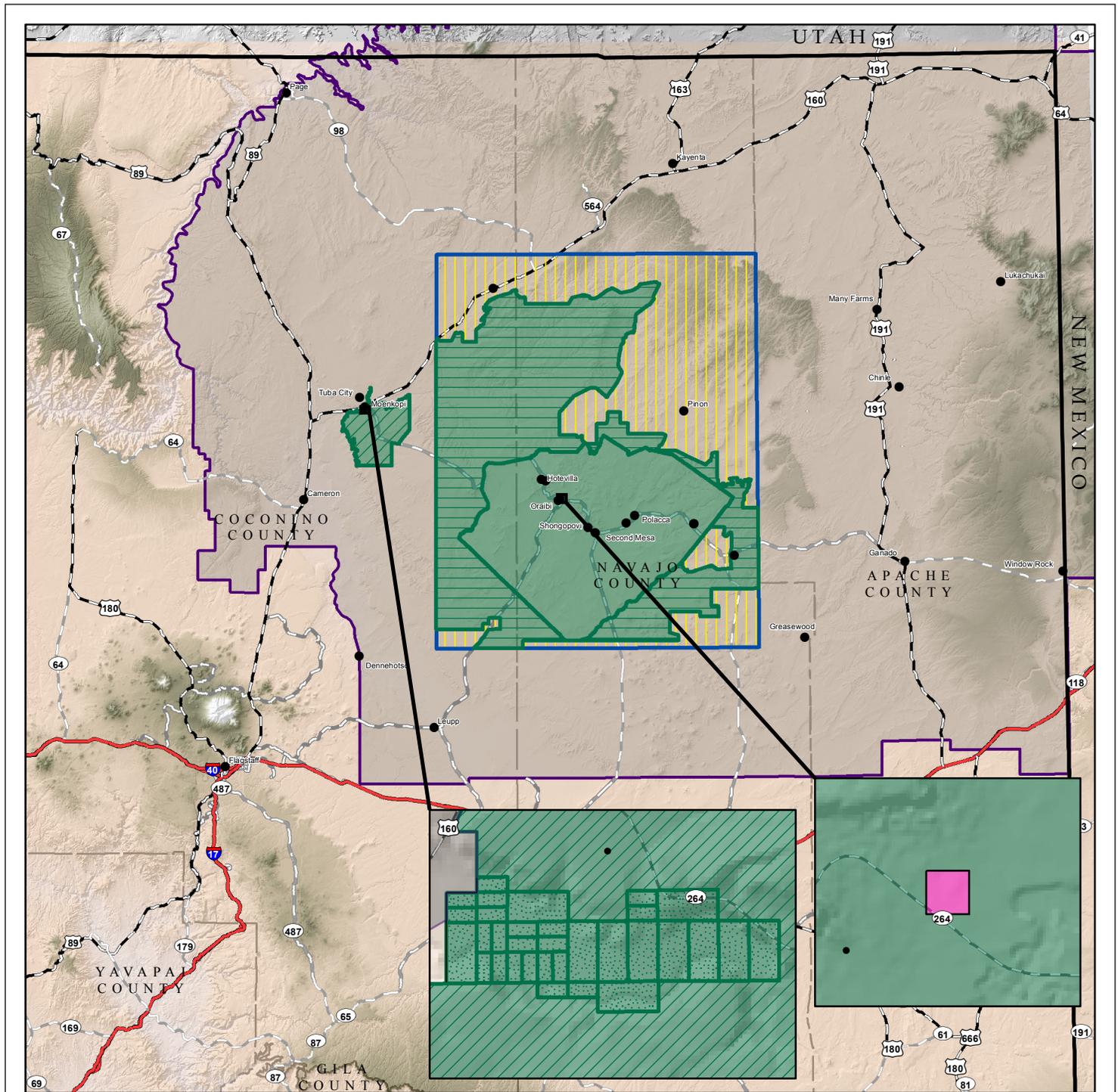


Figure 1-1

Location of the Hopi Indian Reservation Within the LCR Adjudication Area

**Final Hopi HSR
December 2015**





Legend

- Town
- ↗ Interstate Highway
- ↘ U.S. Route
- ↖ State Highway
- ↙ Local Roads
- County
- ▭ State Boundary
- Hopi District 6
- Hopi Partitioned Land
- Hopi Moenkopi Area
- Hopi Allotment
- Navajo Lands
- Navajo Partitioned Land
- 1882 Executive Order
- Reservation Boundary
- 1934 Ad Reservation Boundary
- Inholding

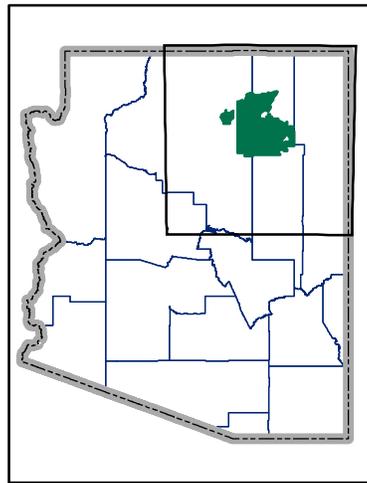
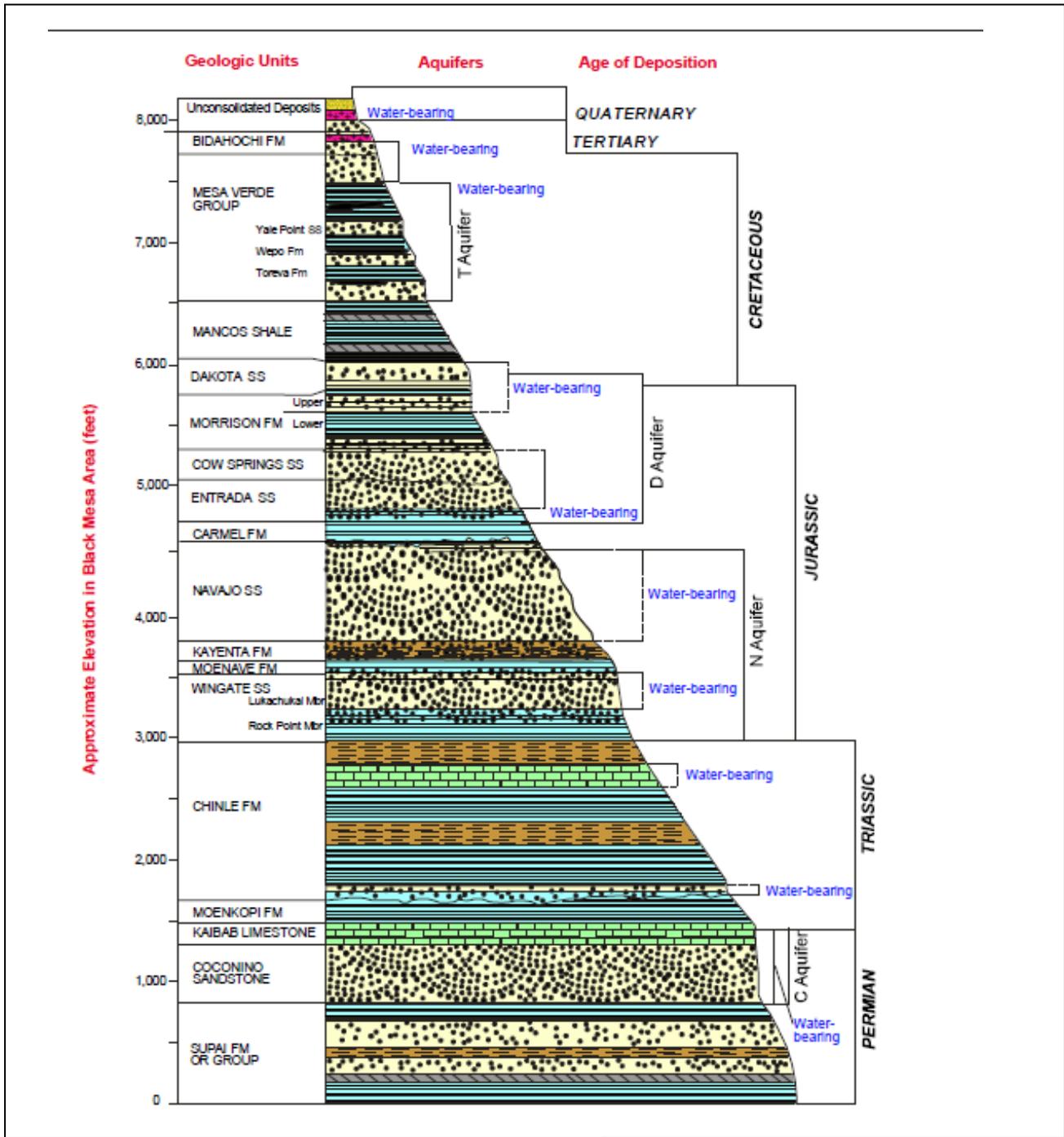


Figure 1-2

Hopi and Navajo Indian Reservations

Final Hopi HSR
December 2015





Rock Types

-  Alluvium/Colluvium
-  Volcanic Rock
-  Coal
-  Sandstone
-  Siltstone
-  Siltstone, Mudstone
-  Shale
-  Limestone

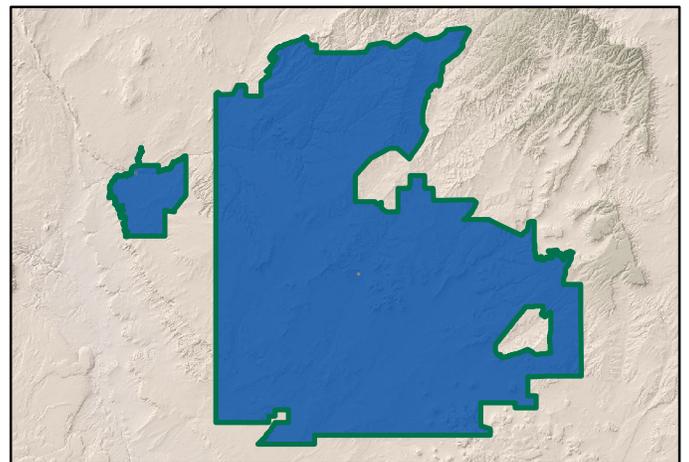
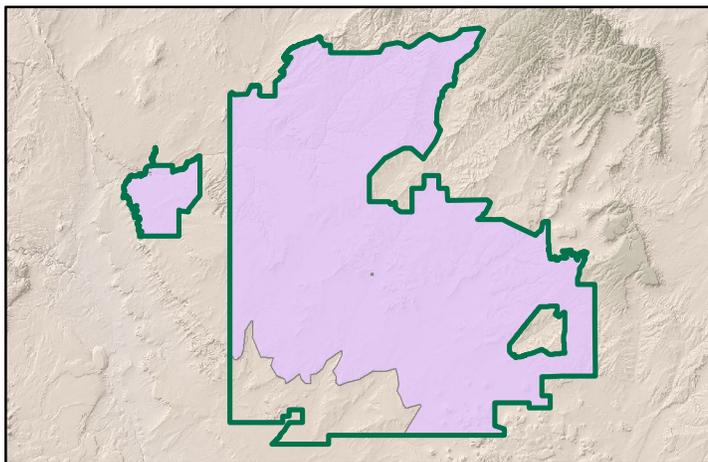
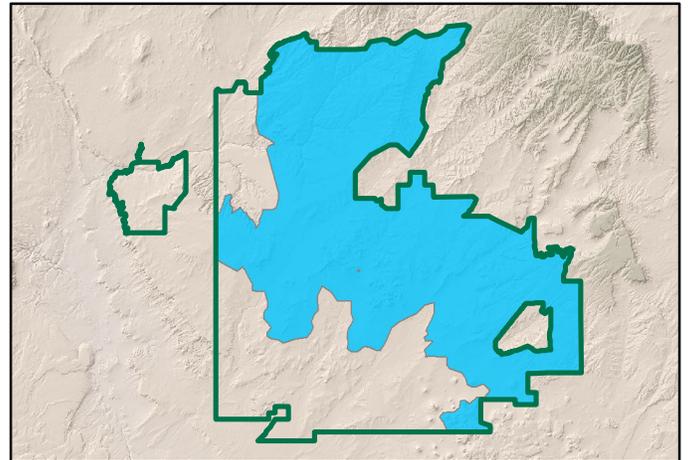
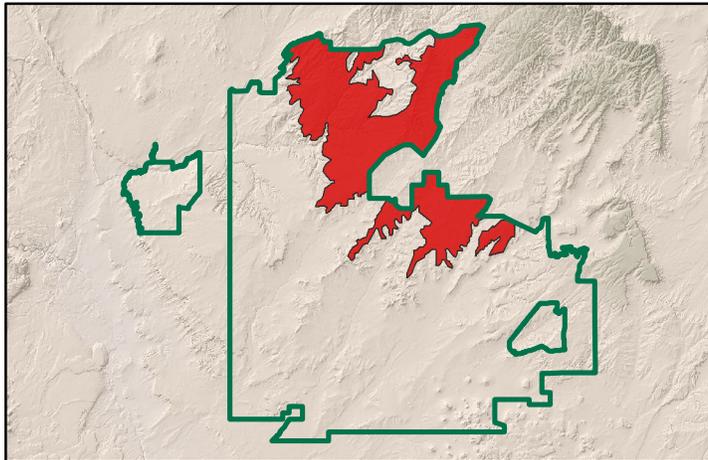
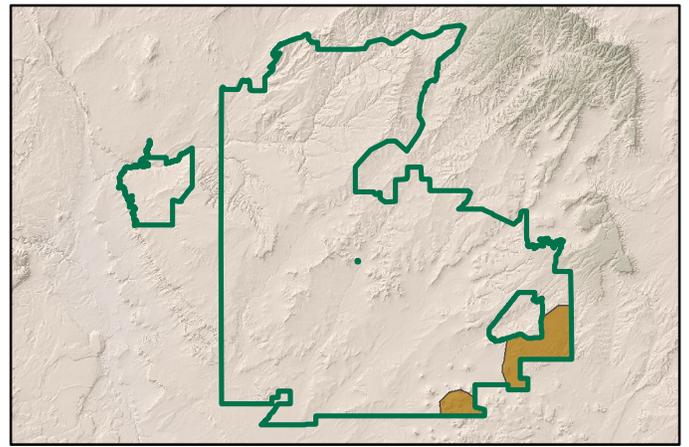
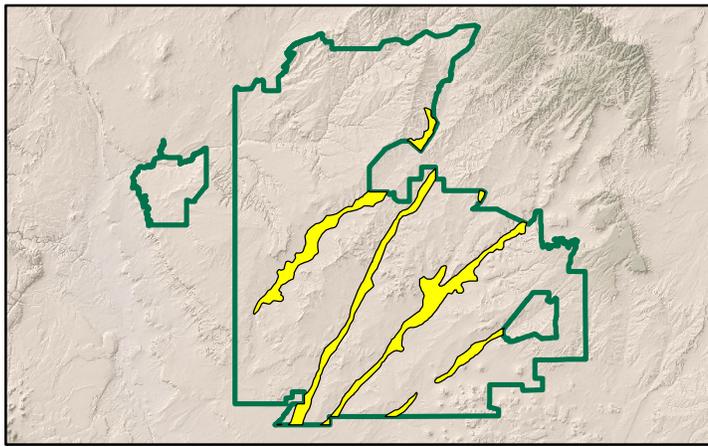
Source: GeoTrans and Waterstone (1999)

Figure 2-1

Important Geologic Units and
Aquifers Underlying the Hopi Indian
Reservation

Final Hopi HSR
December 2015





Legend

- Alluvial/Colluvial Aquifer
- Bidahochi Aquifer
- T Aquifer
- D Aquifer
- N Aquifer
- C Aquifer
- Hopi Reservation

Sources:

1. ADWR (1989)
2. Hopi (2001)
3. Richards and others (2000)
4. Truini and Longworth (2003)

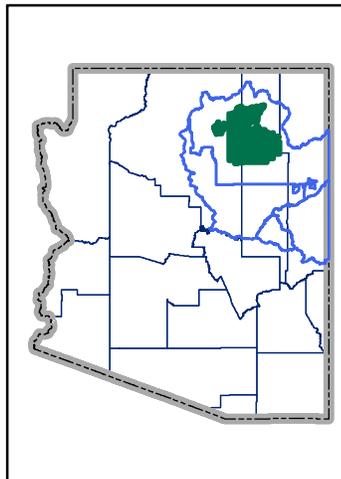
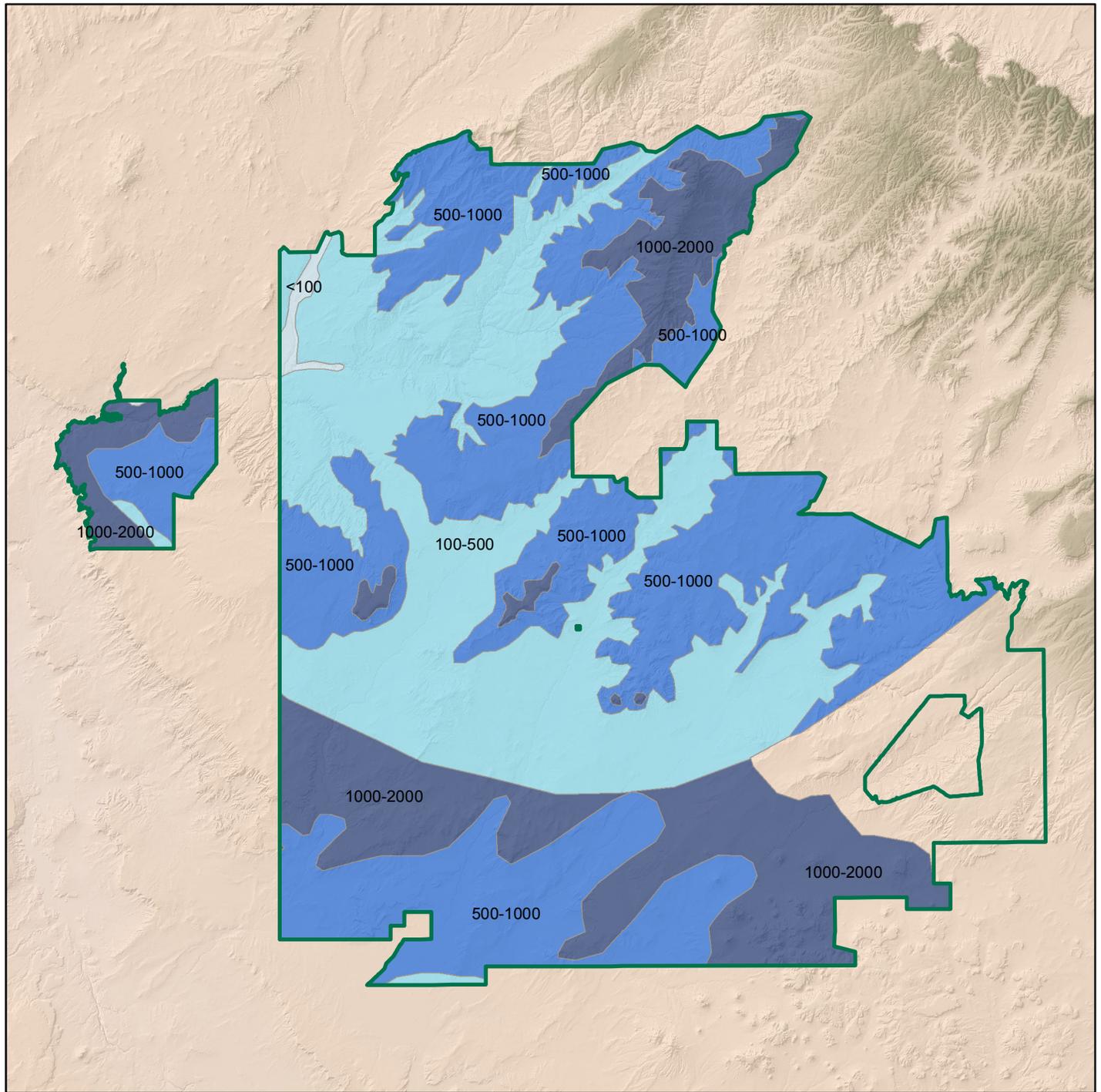


Figure 2-2

Lateral Extent of Aquifers
Beneath the Hopi
Indian Reservation

Final Hopi HSR
December, 2015





Legend

Water Level in Well

- <100 feet
- 100-500 feet
- 500-1,000 feet
- 1,000-2,000 feet
- Hopi Reservation

Source:
 McGavock and Edmunds (1974)
 Original scale 1:375,000

Notes:
 (1) Numbers indicate approximate range of water level, in feet below land surface, after 100 days of continuous pumping at 25 gallons per minute.
 (2) Levels reflect the first aquifer encountered that would yield the specified amount.

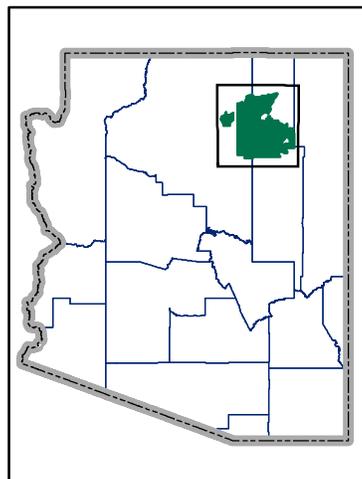
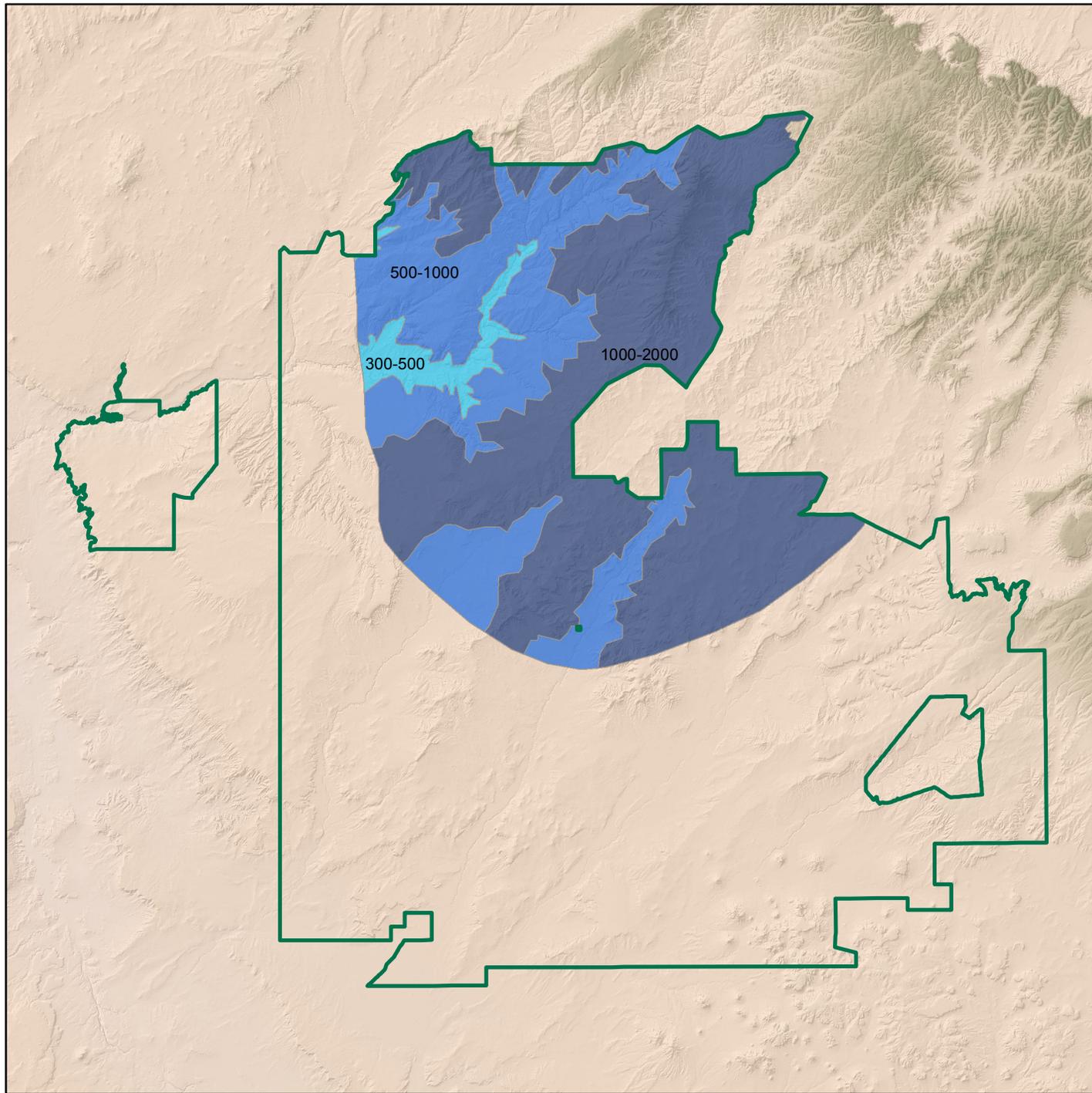


Figure 2-3
 Estimated Pumping Water Level in Wells Yielding at Least 25 gpm on the Hopi Indian Reservation

Final Hopi HSR
 December 2015





Legend

Water Level in Well

- 300-500 feet
- 500-1,000 feet
- 1,000-2,000 feet
- Hopi Reservation

Source:
 McGavock and Edmunds (1974)
 Original scale 1:375,000

Notes:
 (1) Numbers indicate approximate range of water level, in feet below land surface, after 100 days of continuous pumping at 25 gallons per minute.
 (2) Levels reflect the first aquifer encountered that would yield the specified amount.

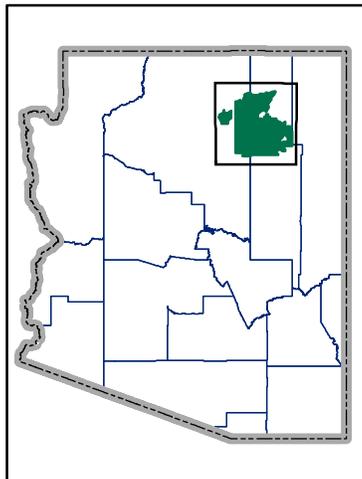
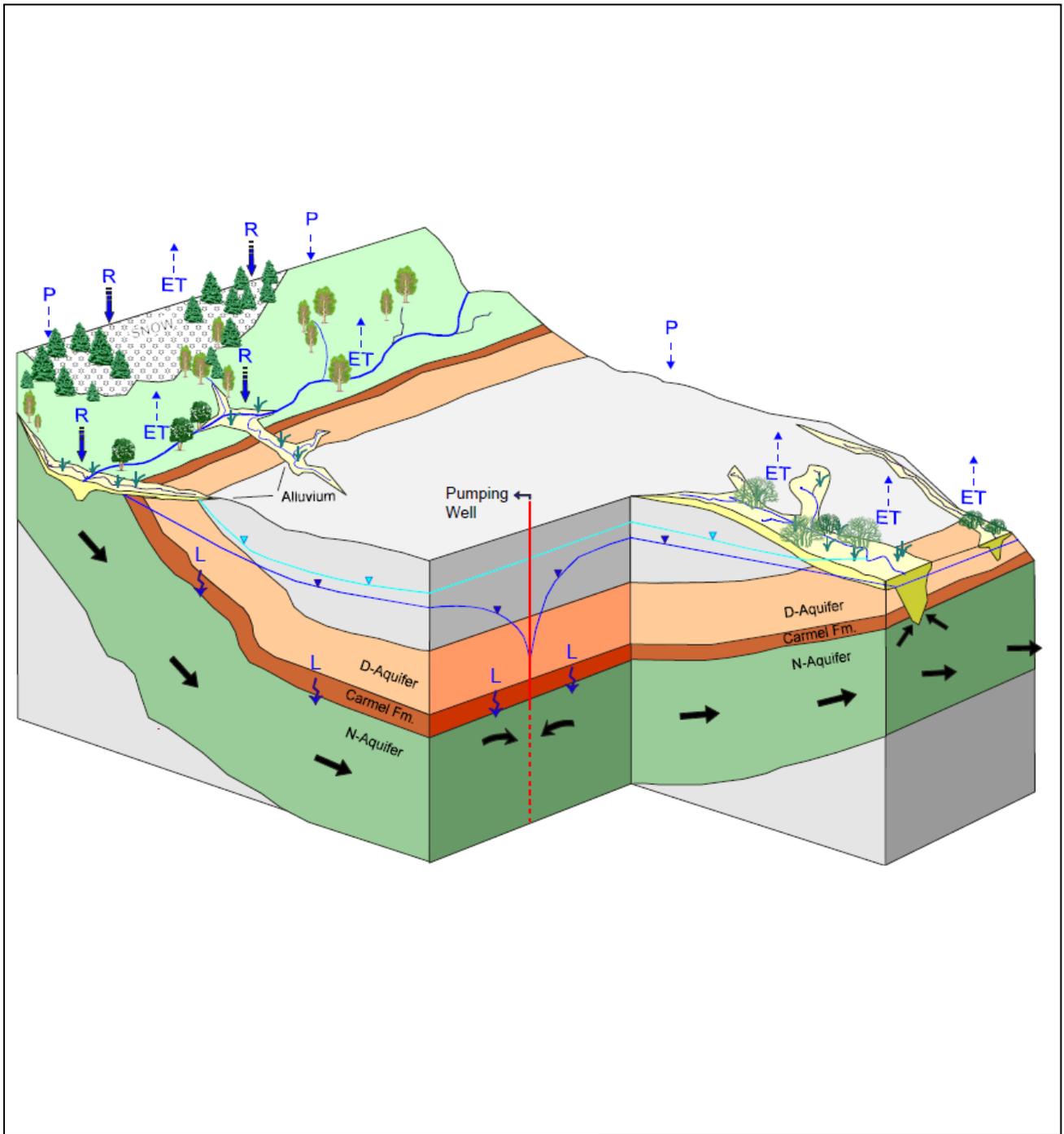


Figure 2-4
 Estimated Pumping Water Level in Wells Yielding at Least 500 gpm on the Hopi Indian Reservation

Final Hopi HSR
 December 2015





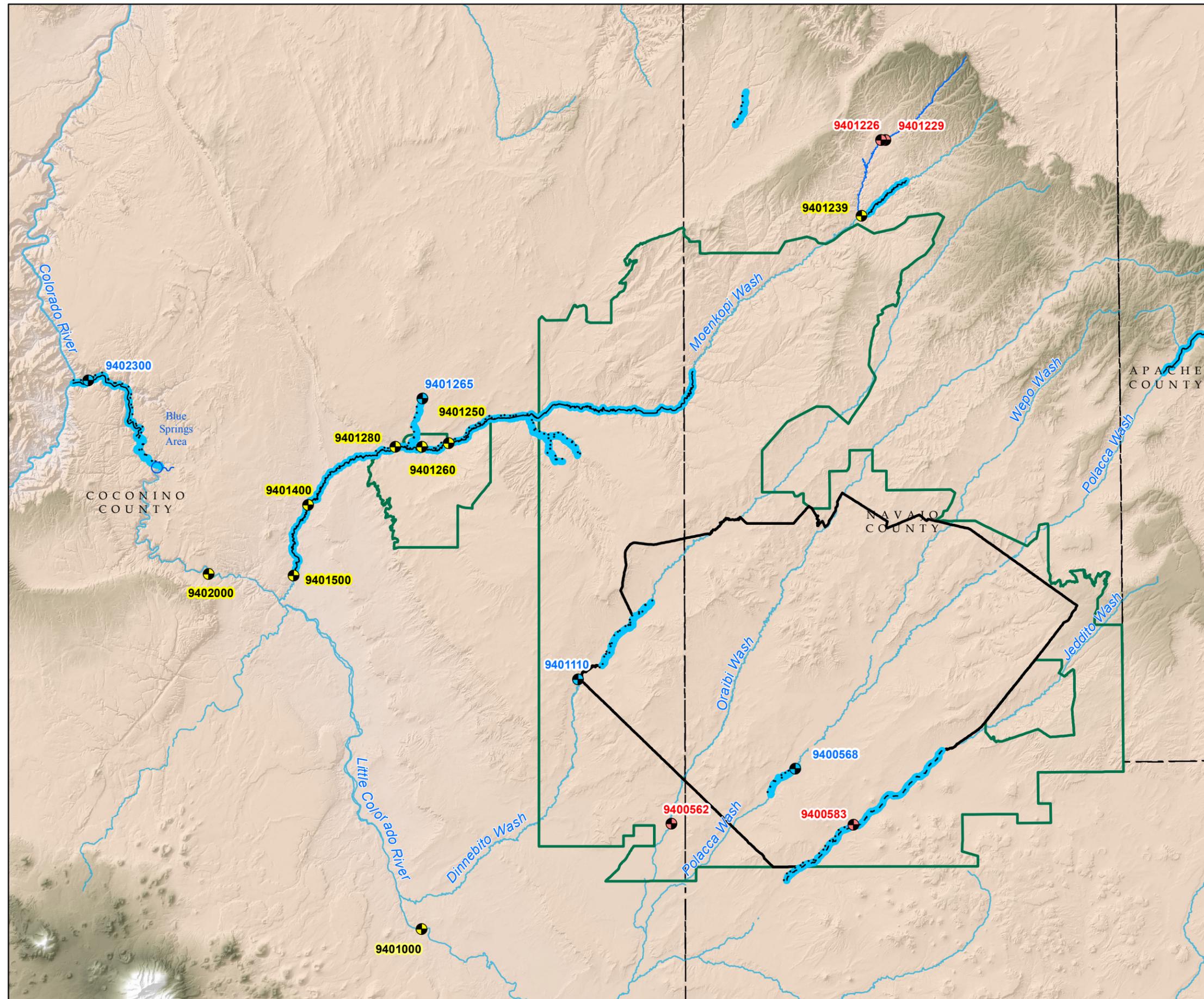
- Legend**
-  Stream
 -  N-Aquifer Potential Surface
 -  D-Aquifer Potential Surface
 -  ET
 -  P
 -  R
 -  L
 -  Groundwater Flow Direction

Source: GeoTrans and Waterstone (1999)

Figure 2-5
 Conceptual Hydrologic Model for
 Three Aquifers Beneath the Hopi
 Indian Reservation

Final Hopi HSR
December 2015





Legend

Recent Streamflow Regime

- Ephemeral
- Intermittent
- Perennial

Historic Perennial Streamflow

- Historic Perennial Reach
- ⋯ Cooley and Others (1969)
- - - Hack (1942)
- ~ Gregory (1916)

— Stream

▭ Hopi Reservation

▭ Hopi District 6

▭ County

Source: USGS

0 10 20 Miles

N

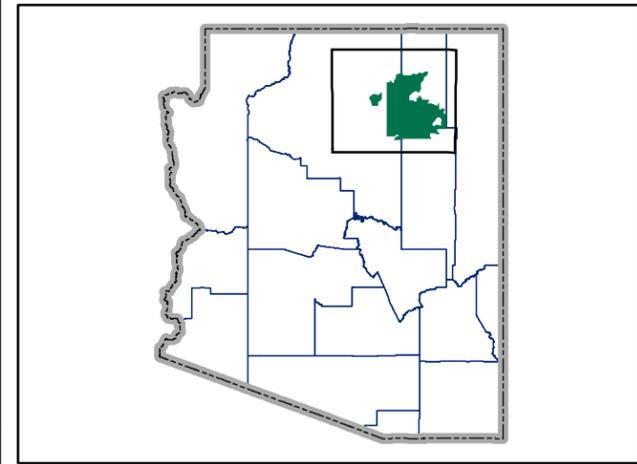
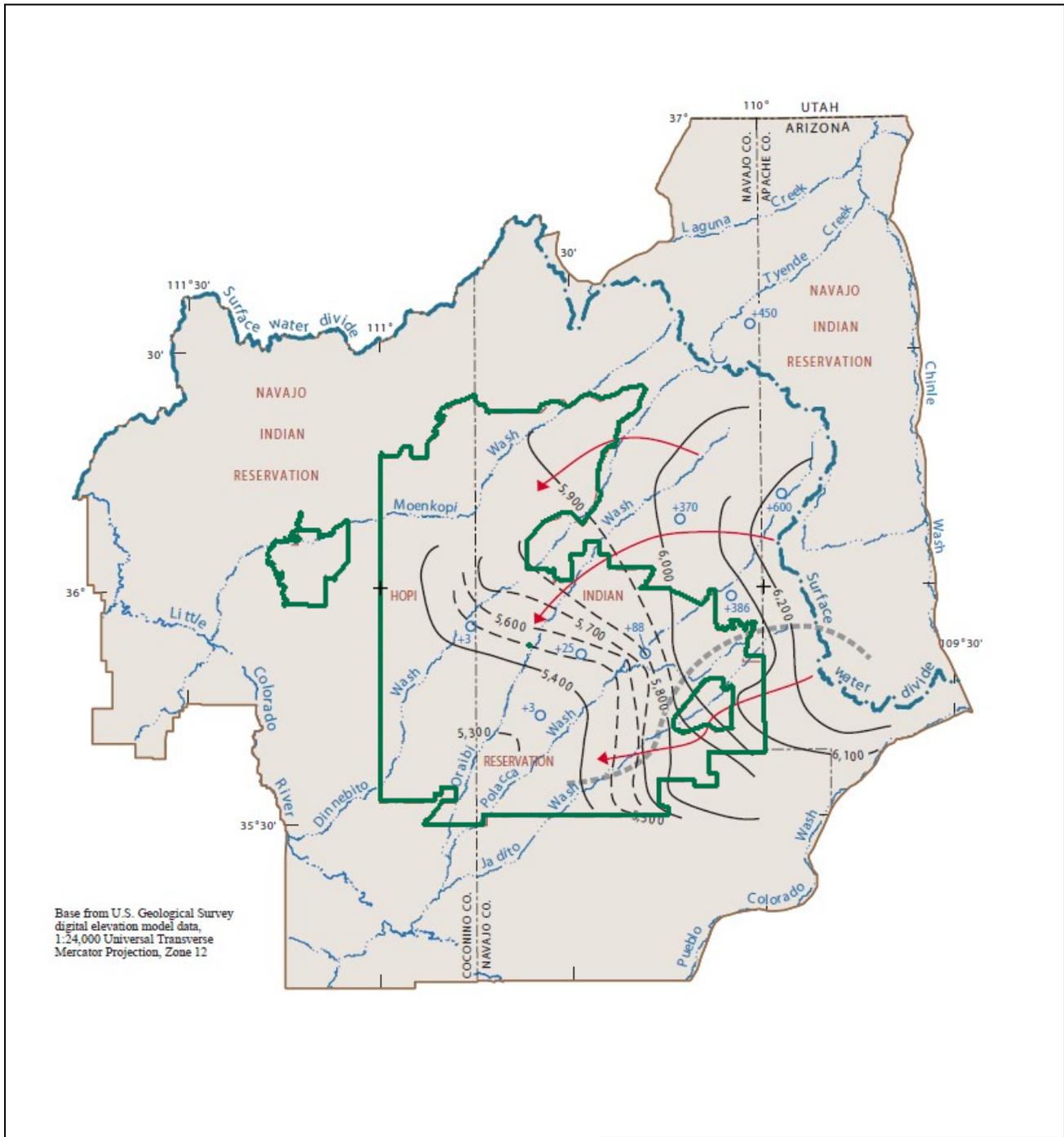


Figure 2-6
 Historic Perennial Stream Reaches and Recent Streamflow Regimes in the Vicinity of the Hopi Indian Reservation



Legend

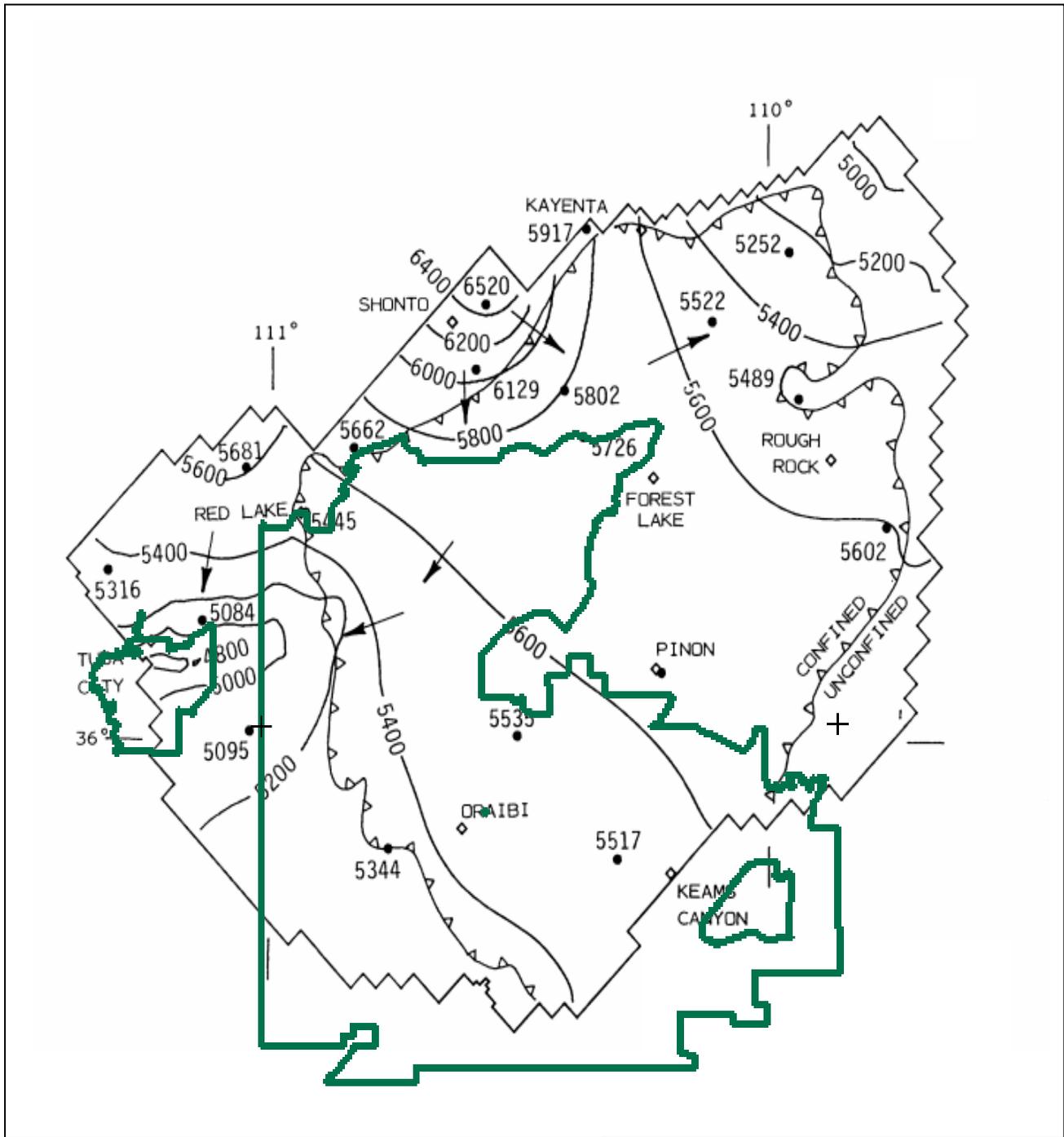
- 6,000 — POTENTIOMETRIC CONTOUR—Shows the altitude at which the water level would have stood in a tightly cased well, 1951–61, in feet above mean sea level. Dashed where approximately located. Contour interval 100 feet
- APPROXIMATE SOUTHEAST LIMIT OF THE NAVAJO SANDSTONE
- +370
○ DIFFERENCE BETWEEN POTENTIOMETRIC SURFACE OF THE D AQUIFER AND PRESTRESS WATER LEVEL IN THE N AQUIFER—in feet. Data for N aquifer from Thomas (2002).
- ↖ General Direction of Flow
- ▭ Hopi Reservation

Source: Truini and Longworth (2003)

Figure 2-7
D Aquifer Water Levels in the Vicinity of the Hopi Indian Reservation

Final Hopi HSR
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- 200 — LINE OF EQUAL SATURATED THICKNESS — Shows approximate generalized saturated thickness. Interval 200 feet
- ▲▲▲▲▲ APPROXIMATE BOUNDARY BETWEEN CONFINED AND UNCONFINED CONDITIONS
- BOUNDARY OF MATHEMATICAL MODEL

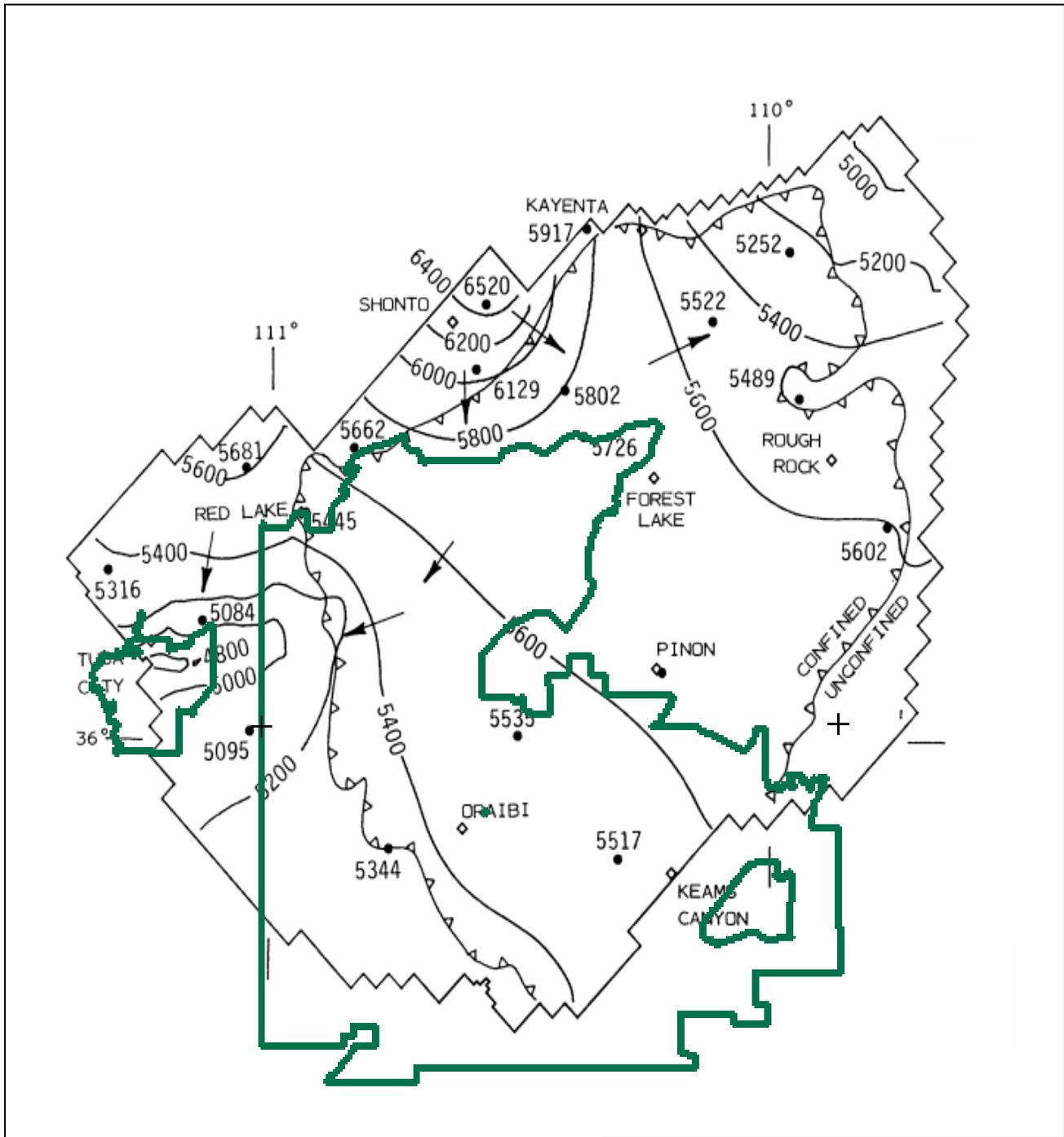
Hopi Reservation

Figure 2-8
 “Predevelopment” N Aquifer Saturated Thickness in the Vicinity of the Hopi Indian Reservation

Final Hopi HSR
December 2015

Source: Brown and Eychaner (1988)





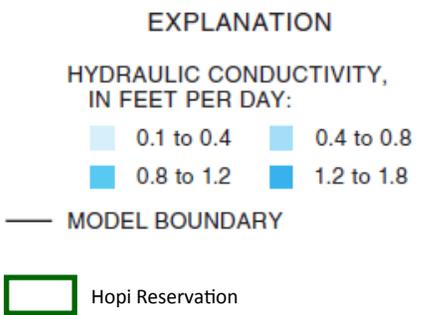
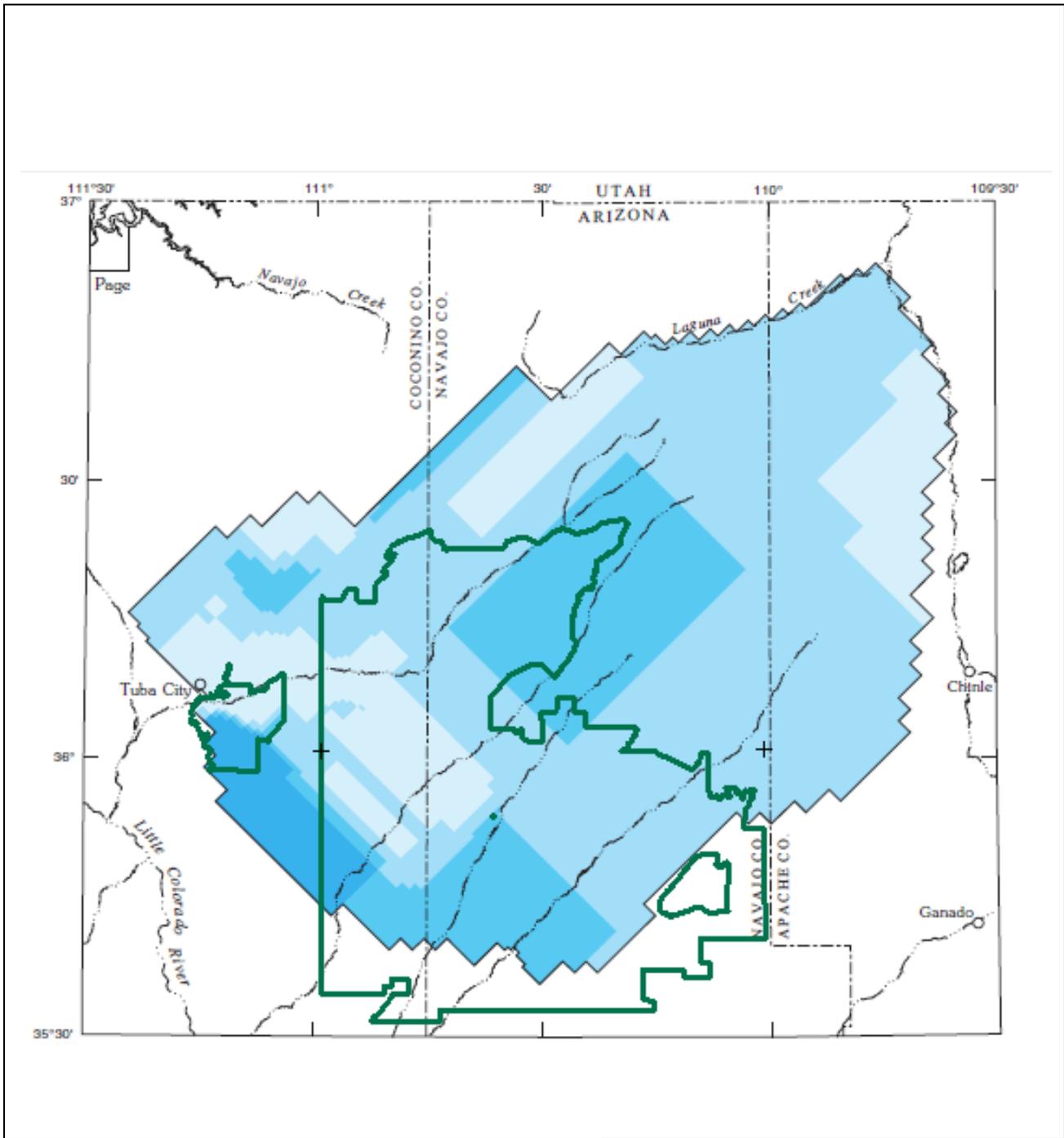
- 5600 — LINE OF EQUAL SIMULATED WATER-LEVEL ALTITUDE—
Contour interval 200 feet. Datum is sea level
- ▲▲▲▲▲ APPROXIMATE BOUNDARY BETWEEN CONFINED AND UNCONFINED CONDITIONS
- 6520 WELL IN WHICH DEPTH TO WATER WAS MEASURED—
Measurement was made before 1965 or during assumed local equilibrium before 1972. Number, 6520, is altitude of water level in feet above sea level
- GENERALIZED DIRECTION OF GROUND-WATER MOVEMENT
- BOUNDARY OF MATHEMATICAL MODEL
- Hopi Reservation

Source: Brown and Eychaner (1988)

Figure 2-9
 “Predevelopment” N Aquifer Water Levels and Flow Directions in the Vicinity of the Hopi Indian Reservation

Final Hopi HSR
December 2015





Source: Thomas (2002)

Figure 2-10
 USGS Simulation of N Aquifer
 Hydraulic Conductivity in the
 Vicinity of the Hopi Indian
 Reservation

Final Hopi HSR
December 2015



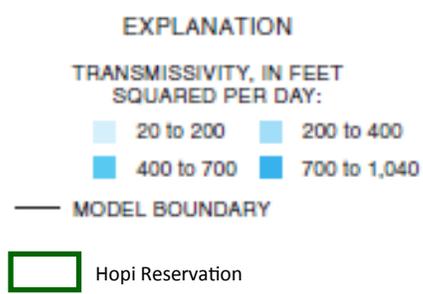
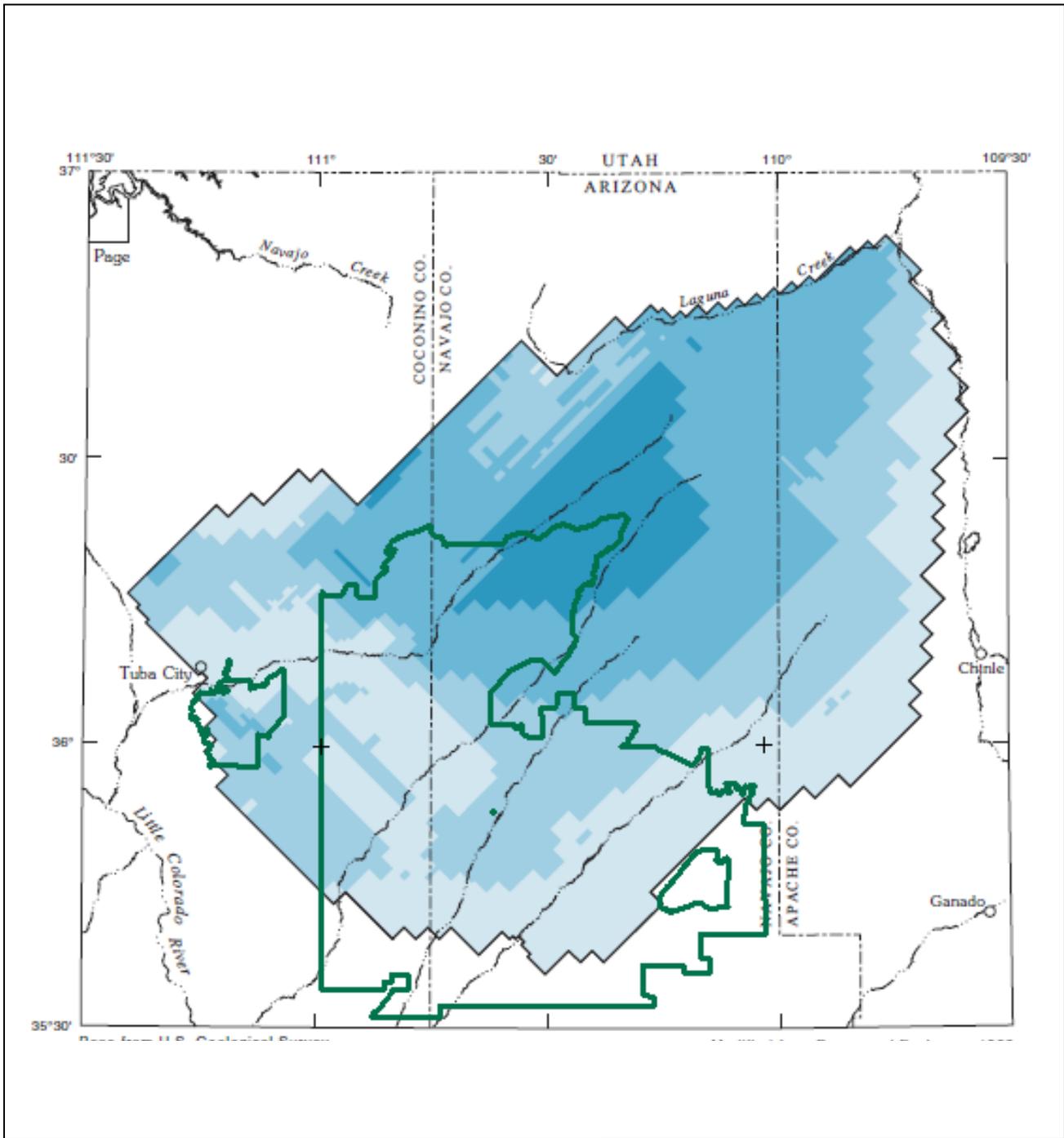
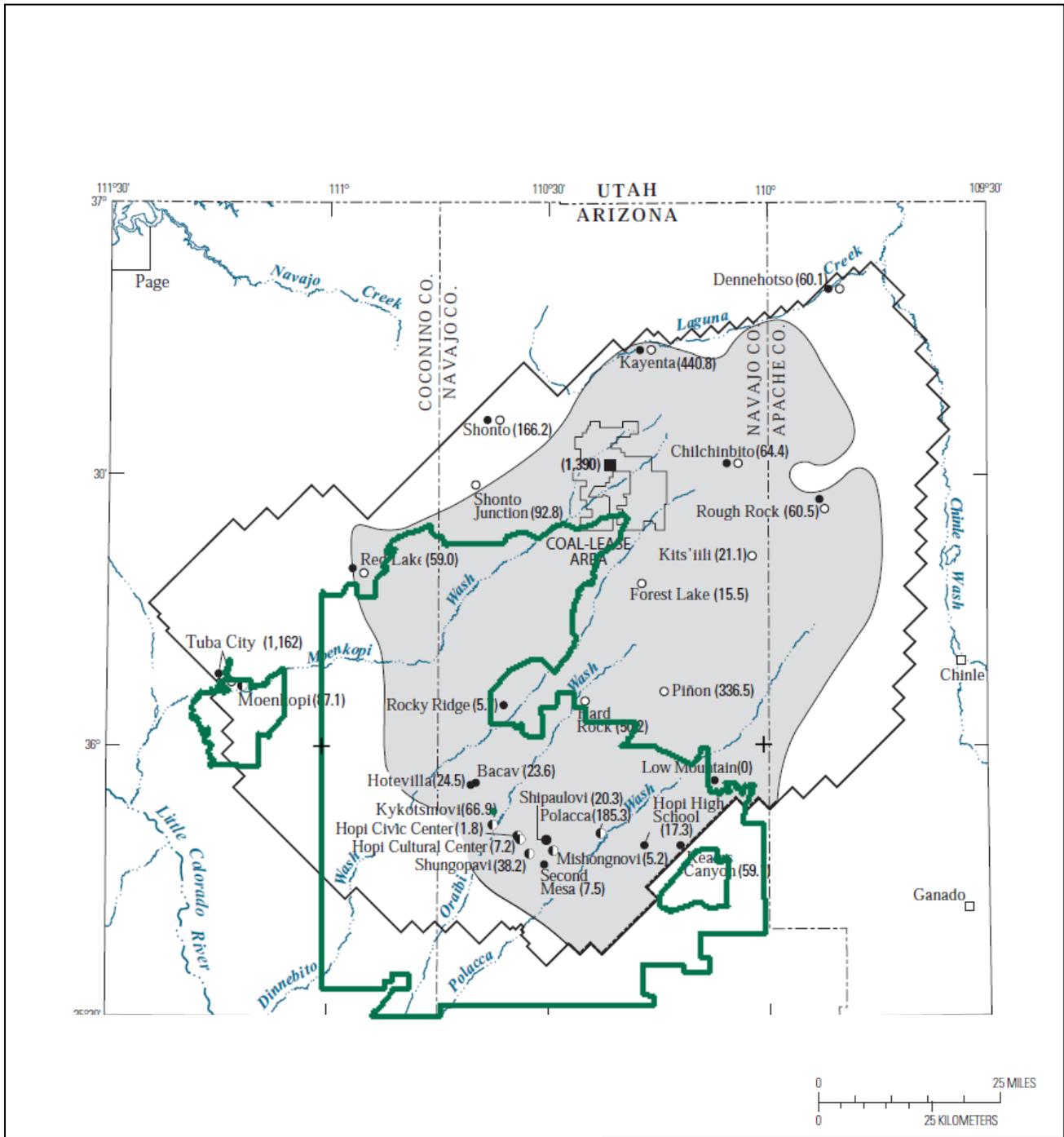


Figure 2-11
 USGS Simulation of N Aquifer
 Transmissivity in the Vicinity of the
 Hopi Indian Reservation

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Source: Thomas (2002)



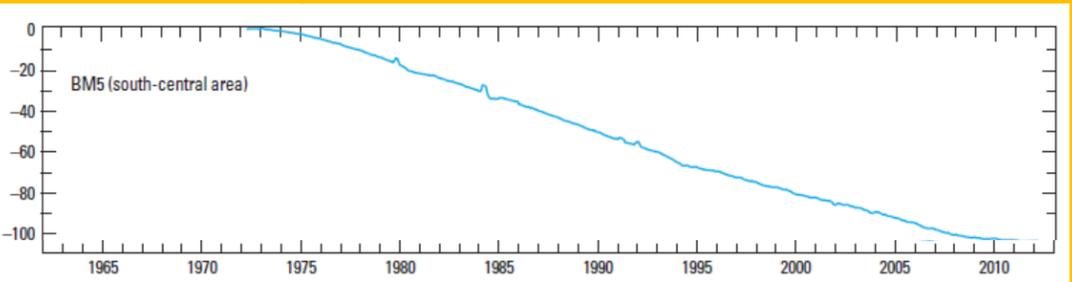
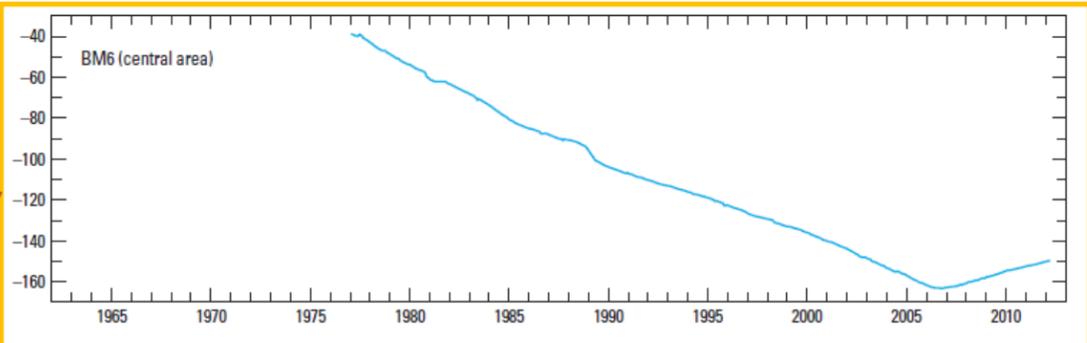
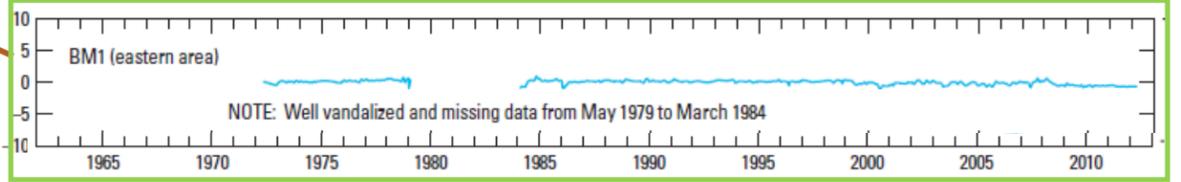
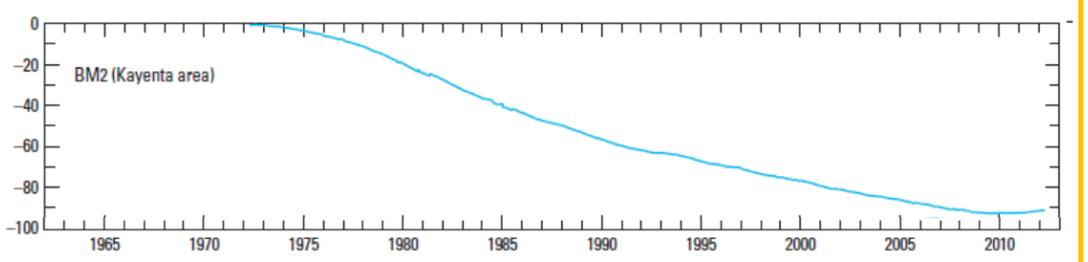
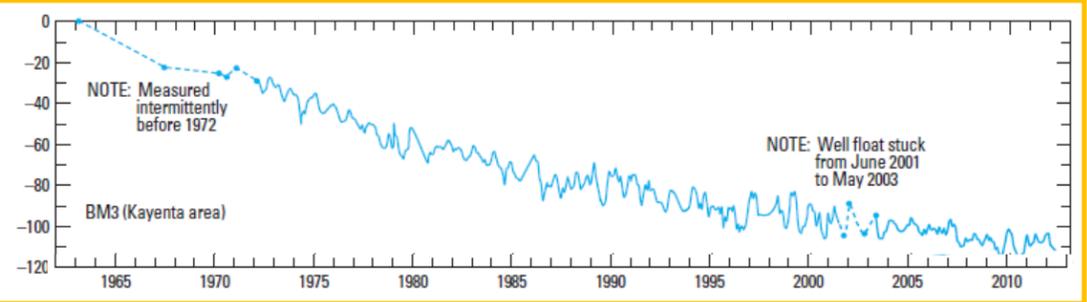
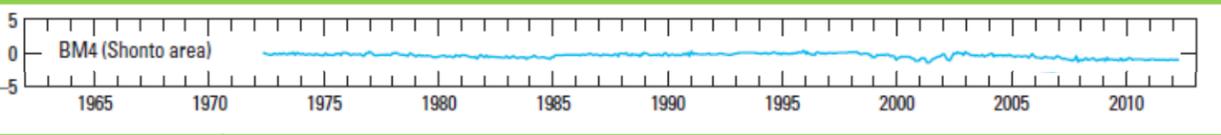
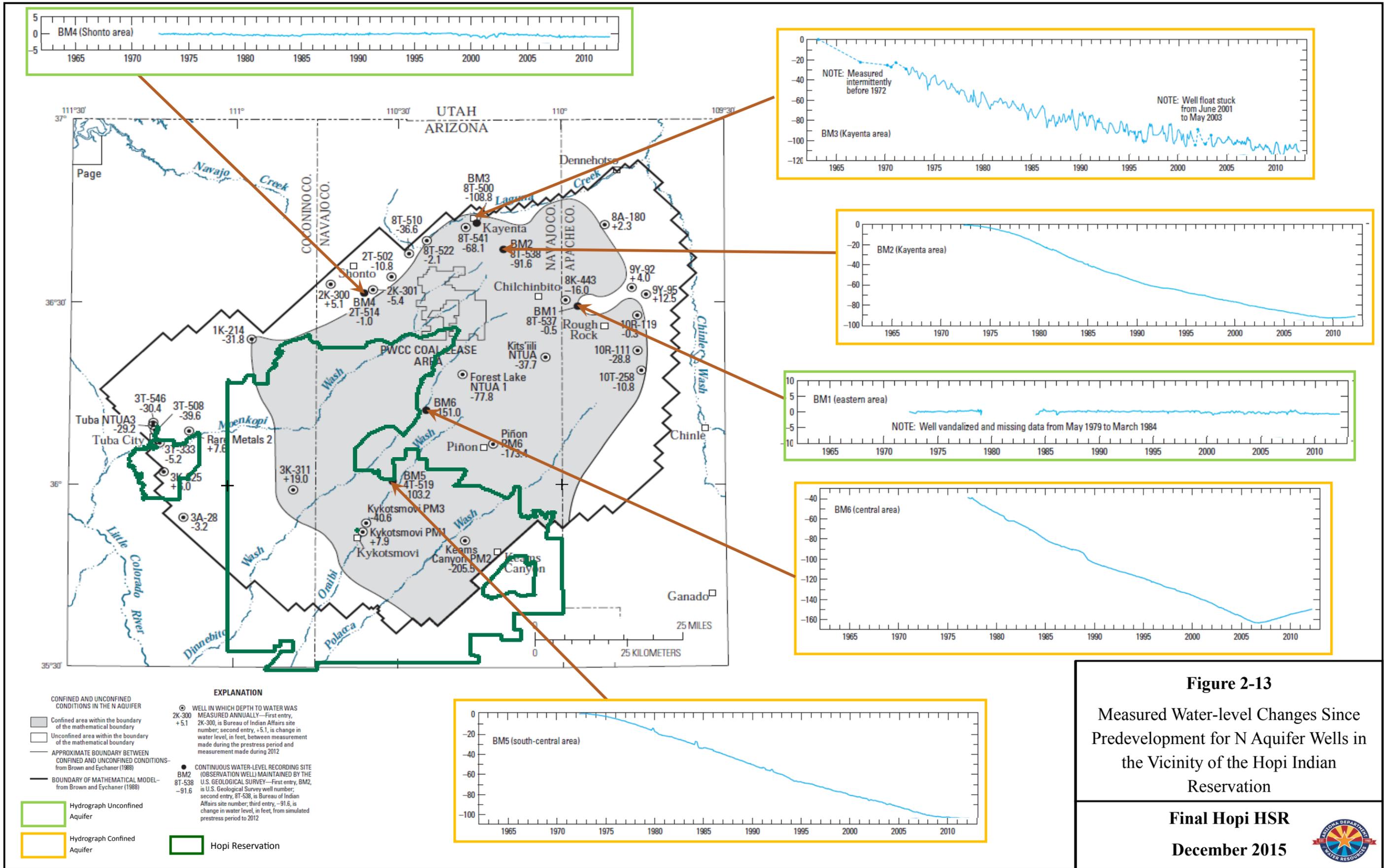
- CONFINED AND UNCONFINED CONDITIONS IN THE N AQUIFER WITHIN MODEL BOUNDARY**
- Confined
 - Unconfined
- APPROXIMATE BOUNDARY BETWEEN CONFINED AND UNCONFINED CONDITIONS—**
From Brown and Eychaner (1988)
- BOUNDARY OF MATHEMATICAL MODEL—**
From Brown and Eychaner (1988)
- Hopi Reservation
- EXPLANATION**
- WELL-SYSTEM OWNER**
- Bureau of Indian Affairs
 - Navajo Tribal Utility Authority
 - ◐ Hopi Tribe
 - Peabody Western Coal Company
- Piñon (336.5) WITHDRAWALS FROM THE N AQUIFER—Piñon, well-system name; 336.5, total withdrawal in acre-feet for 2011. The total is cumulative at locations served by multiple wells

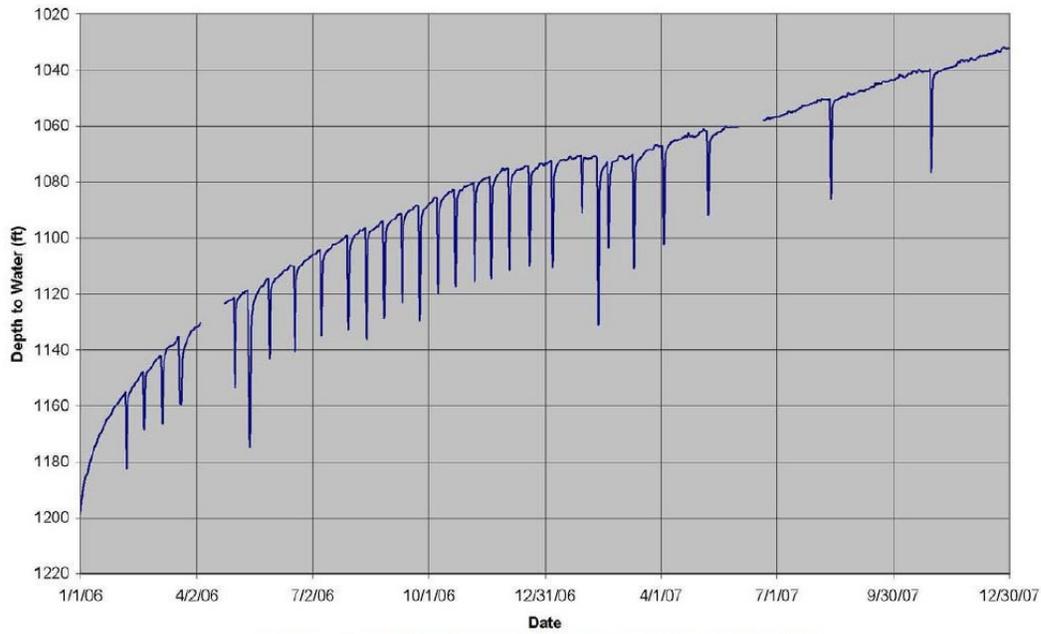
Figure 2-12
2011 N Aquifer Well Withdrawals in the Vicinity of the Hopi Indian Reservation

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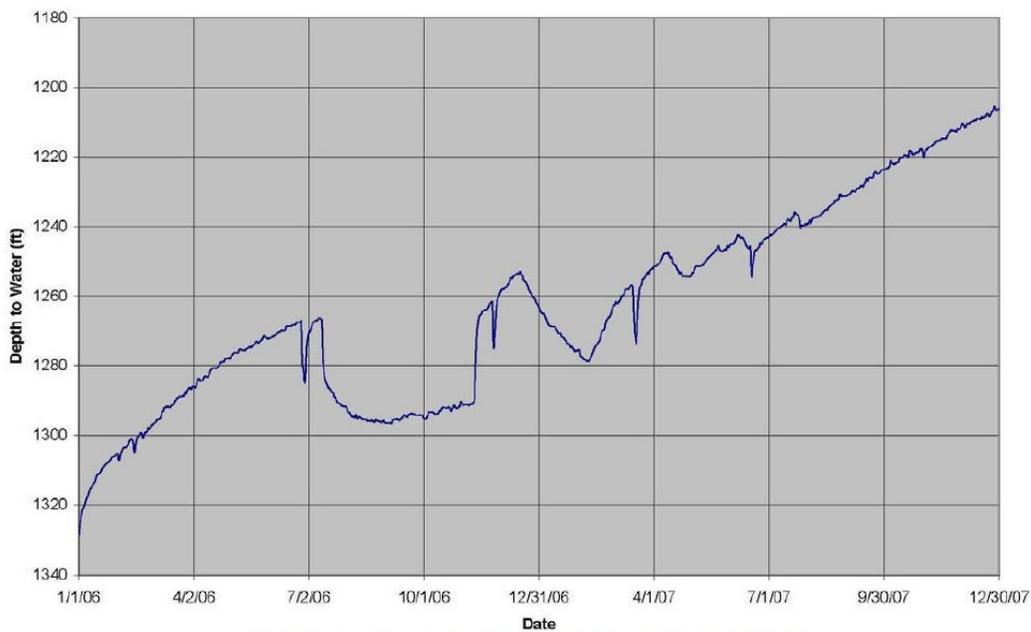


Source: Macey and Unema (2013)





Hydrograph
for PWCC
Observation
Well
NAVOBS3



Hydrograph
for PWCC
Observation
Well
NAVOBS6

Figure 2-14
Water Level Rise Measured in Two
PWCC N Aquifer Wells

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Source: Cochran (2008)



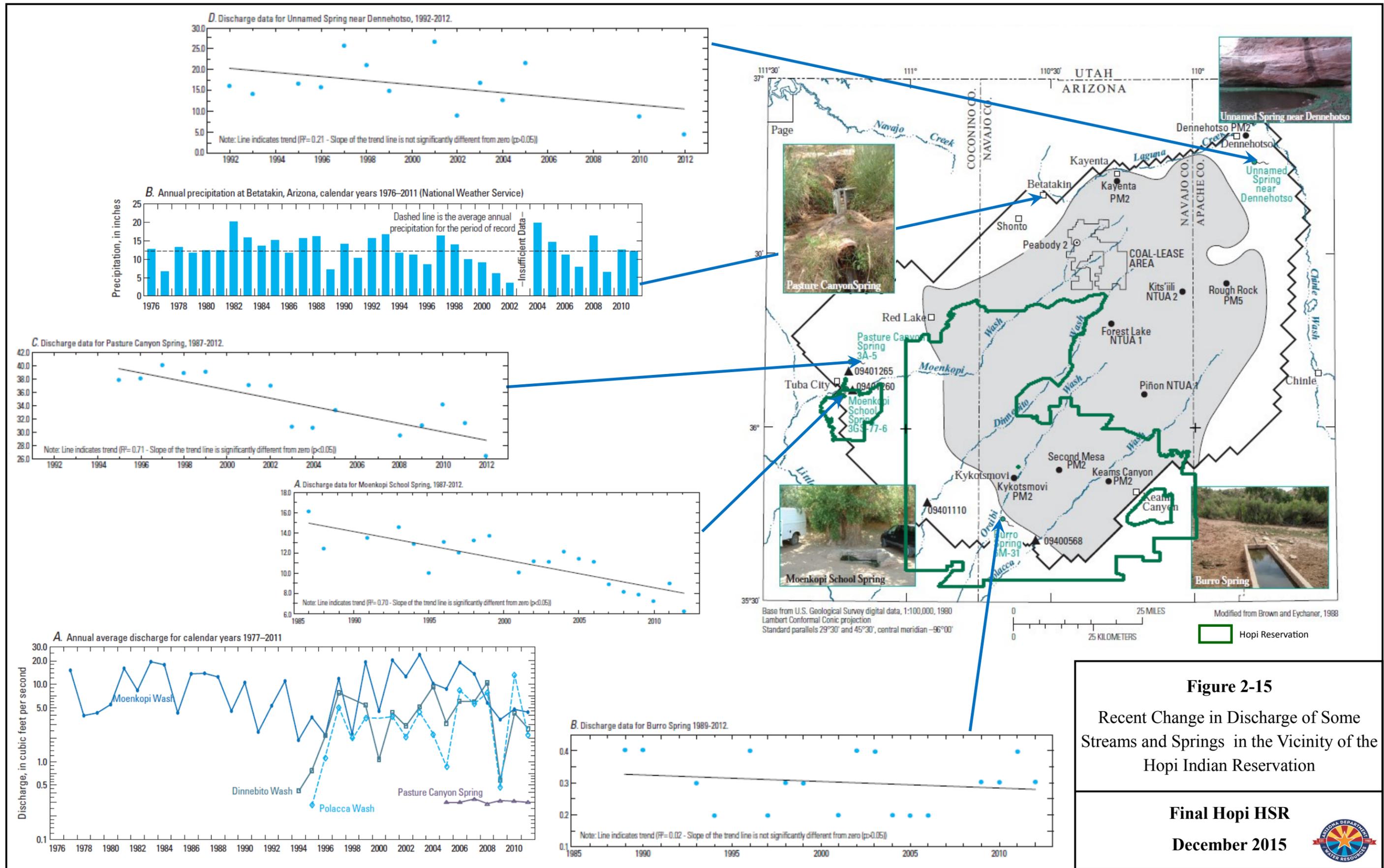


Figure 2-15
Recent Change in Discharge of Some
Streams and Springs in the Vicinity of the
Hopi Indian Reservation

Final Hopi HSR
December 2015



APPENDICES
(DVD)