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Via Overnight Courier

June 29, 2009

Herb Guenther, Director
Arizona Department of Water Resources
Attn: Adjudication
3550 N. Central Avenue, 4th Floor
Phoenix, Arizona 85012

Re: Navajo Nation Comments on the Preliminary Hydrographic Survey Report for the Hopi Indian Reservation

Dear Mr. Guenther:

On behalf of the Navajo Nation, we file the following comments.

I. INTRODUCTION

On December 31, 2008, the Arizona Department of Water Resources ("ADWR") released a *Preliminary Hydrographic Survey Report for the Hopi Indian Reservation* ("PHSR") pursuant to A.R.S. § 45-256, as part of the proceedings in the adjudication of water rights in the Little Colorado River ("LCR") basin, 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 Apache County Superior Court ("LCR adjudication"). Comments on the PHSR were initially due on March 31, 2009, PHSR § 1.4, at 1-7,[1] but that deadline was later extended by the Court to June 30, 2009. *Order Granting Expedited Joint Motion for Extension of Time to Submit Comments on the Preliminary Hydrographic Survey Report for the Hopi Reservation* (Mar. 9, 2009). The Navajo Nation now timely files its comments on the PHSR. The Navajo Nation first offers general comments on the PHSR and the role the PHSR plays in this adjudication, followed by comments that reference specific sections of the PHSR, as directed by the ADWR. *See* § 1.4, at 1-7.

[1] For simplicity, all future citations to the PHSR will only provide section and page number references.

II. PROCEDURAL BACKGROUND

Through the preparation of a PHSR, the ADWR provides "technical assistance" to the Court on aspects of the adjudication "with respect to which [ADWR] possesses hydrological or other expertise." A.R.S. § 45-256(A). The PHSR plays a critical role in the adjudication of water rights in Arizona by providing an underpinning for defining and resolving the complex issues raised by competing claims to water. *See id.* The establishment of that common foundation benefits the Court and the parties by facilitating the development of the factual record required to address the disputed claims to water rights. Thus, Arizona law mandates that the PHSR must "list all information that is obtained by [ADWR] and that reasonably relates to the water right claim or use investigated." *Id.* § 45-256(B).

Expanding on this mandate, the Court directed ADWR to "include hydrological and technical information about available surface water and groundwater supplies and resources to meet each claim" as well as "comprehensive and detailed information about historic, current and existing water uses." *Minute Entry* at 7 (July 16, 2002). The Court also directed that the PHSR include "ADWR's proposed water right attributes . . . for historic, current and existing water uses [but not] to report proposed water right attributes for proposed future water uses." *Id.* at 8 (quoting *Pre-Trial Order No. 2 Re: Content of HSRs* at 2 (Aug. 15, 1988)). The Court, however, explicitly instructed ADWR to not analyze "the feasibility, profitability or practicability of future uses of water" and to not "report proposed water right attributes for proposed future uses." *Id.* at 8-9. ADWR was nevertheless charged with providing "adequate descriptive and technical information about proposed future uses" to "'serve as a basis for evaluating claims of future uses.'" *Id.* at 8-9. The Court required ADWR to "use all available relevant technical reports and try to find the most recent reports or the ones having the most recent data or information." *Id.* at 9. The Court also encouraged the parties "to provide technical and other information to ADWR during the course of preparing the Hopi HSR." *Id.* at 10. The Court recognized that "[s]ome of the factors to be considered by ADWR as a result of this order require that ADWR undertake economic analysis and consider proposed uses of water within the Hopi Tribal lands that may not be known to ADWR." *Id.* at 11. Thus, the Court declared that it "expects that the Hopi Tribe and the United States will provide ADWR, on a cooperative and ongoing basis, with information and supporting documentation relating to the Tribe's current and future land and water use planning within the area affected by the Hopi HSR." *Id.*

The Court also explicitly directed ADWR to prepare the PHSR with an evaluation of the factors listed in *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) ("*Gila V*"). *Minute Entry* at 6 (July 16, 2002). Accordingly, the PHSR purports to include an analysis of "the tribe's history; tribal culture; geography, topography, and natural resources of the tribal lands, including groundwater availability; the tribe's economic base; past water use; and the tribe's present and projected population." § 1.3, at 1-4; *see also Gila V*, 201 Ariz. at 318-19, 35 P.3d at 79-80. The Court directed ADWR to use the *Gila V* factors in order to comply with A.R.S. § 45-256(B) in

reporting the proposed water rights attributes and examining all relevant details of the water rights claims. *Minute Entry* at 6 (July 16, 2002). Those factors, "which are not intended to be exclusive," were adopted by the Arizona Supreme Court because a "'fact-intensive inquir[y] . . . made on a reservation-by-reservation basis' . . . is the only way federally reserved rights can be tailored to meet each reservation's minimal need." *Gila V*, 201 Ariz. at 318, 35 P.3d at 79 (quoting *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 (1999) ("*Gila III*")). The *Gila V* court explained that only by examining these factors and any other relevant information can the lower court adequately determine the feasibility of proposed uses and the amount of water needed to fulfill the homeland purpose of the reservation. *Id.* at 320, 35 P.3d at 81.

III. GENERAL COMMENTS ON THE PHSR AND THE LITIGATION PROCESS

In light of the above process and framework, as a general matter the Navajo Nation asserts that there is no way to properly evaluate – and, ultimately, to litigate – the validity of the claims of the Hopi Tribe, and the United States' claims on behalf of the Hopi Tribe,[2] based on the information presented in those claims and as analyzed in the PHSR. The Hopi Tribe claimed water rights based on historical and present use as well as water for proposed future uses. *See generally* § 2.3, at 2-3 to 2-11. But while A.R.S. § 45-256(B) mandates that objections to the final Hydrographic Survey Report ("final HSR") "specifically address [ADWR's] recommendations regarding the particular water right claim or use investigated," ADWR may not make any such recommendation for claimed future uses by the Hopi Tribe. *Minute Entry* at 8 (July 16, 2002). It is, therefore, unclear how the litigating parties are to bring the proposed future uses claimed by the Hopi Tribe to issue before the Court.

It is also unclear how the *Gila V* factors integrate with the statutory scheme and the pretrial orders of the Court, and thus how litigation of even the water rights claims based on existing and historical uses will proceed. For example, pursuant to the Court's order and *Gila V*, ADWR analyzed the Hopi Tribe's history and cultural practices in the PHSR. *See* § 3, at 3-1 to 3-18, and § 5, at 5-1 to 5-14. However, those topics are beyond ADWR's special expertise in water matters, *see* A.R.S. § 45-256(A), and as such the PHSR offers no real guidance to the Court with respect to those topics. Moreover, if the Navajo Nation disagrees with any of ADWR's analysis of those topics, the Navajo Nation may offer comments but there is no mechanism to formally object to that analysis. As noted above, A.R.S. § 45-256(B) only permits objections to "specifically address [ADWR's] recommendations regarding the particular water right claim." According to the statute, objections that do not comply with that directive – that do

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[2] Because of their similarities, the Navajo Nation will hereafter refer to both the Hopi Tribe's claims and the United States' claims on behalf of the Hopi Tribe as the "Hopi claims," except where differentiation between the Hopi Tribe's claims and the United States' claims is relevant.

not specifically relate to a particular recommendation by ADWR – shall be "summarily dismiss[ed] with prejudice." *Id.* It is unclear how or if ADWR used its analysis of the *Gila V* factors as the basis for the recommendations in the PHSR. It is also unclear how that information might be used as the basis for litigation over the Hopi Tribe's claims for future uses. However, because ADWR possess no special expertise on such topics as tribal history and culture, and because no mechanism exists to object to any analysis of the *Gila V* factors in the final HSR, that analysis should not be given any evidentiary credence in future litigation over the Hopi claims.

This confusion regarding the future course of the litigation must be resolved. The confusion appears to be the result of applying a statutory process that was designed for litigation of non-Indian uses in a prior appropriation system to Indian water rights that operate differently. While the Navajo Nation commends ADWR's efforts to comply with the Court's directive in the drafting of the PHSR, the Navajo Nation asserts that the current process does not facilitate the resolution of the complex issues raised in this adjudication. The Navajo Nation recognizes that ADWR may be unable to resolve this problem, yet confusion over how this process will move forward nonetheless exists.

In addition to the confusion that exists over the process of litigating the Hopi claims, the PHSR also fails in a number of other respects. In conducting its fact-intensive inquiry pursuant to *Gila V* and the Court's direction, ADWR essentially ignored the single most important fact relating to the Hopi claims: the existence and competing water uses of the Navajo Nation. Just as the Hopi Reservation was set aside to serve as the permanent homeland of the Hopi Tribe, so too was the Navajo Reservation set aside as the permanent homeland of the Navajo Nation. *Gila V*, 201 Ariz. at 315, 35 P.3d at 76 ("We therefore hold that the purpose of a federal Indian reservation is to serve as a 'permanent home and abiding place' to the Native American people living there."). The Hopi Tribe and the Navajo Nation share – and compete for – most of the water present on the Hopi Reservation, yet the PHSR fails to give this fact any consideration, and instead analyzes the Hopi claims in a vacuum, thereby failing to adequately provide all facts "that reasonably relate[] to the water right claim or use investigated." A.R.S. § 45-256(B). Given this failure of the PHSR to recognize the Navajo Reservation's status as a permanent homeland for the Navajo people, and, therefore, to adequately explain all of the relevant facts of the Hopi claims or its past, present and future water usage, it is impossible to see how the Court or the parties can rely on the PHSR as the factual foundation for litigating the Hopi claims. It is entirely unclear how the Court could use this PHSR, and any objections to it, and move directly to a case that quantifies and prioritizes the Hopi Tribe's water rights in the LCR basin, without any consideration of the Navajo Nation's competing water uses or the Navajo Reservation's purpose as a permanent homeland for the Navajo people. *See Gila V*, 201 Ariz. at 315, 35 P.3d at 76.

Litigating this case based on the PHSR as it currently exists is also made more difficult by the fact that the Hopi Tribe has not yet identified the sources of water that would satisfy

certain of the claims which it asserts, and the PHSR does little to analyze this failure to identify water sources for the Hopi claims. For example, the PHSR does not identify the source aquifer associated with the Hopi Tribe's claim for groundwater to serve its proposed future uses, nor does the PHSR indicate the location of pumping wells for the Hopi Tribe's proposed major uses, such as a power plant. While the Court instructed ADWR to not analyze "the feasibility, profitability or practicability of future uses of water," ADWR was still charged with providing information that is "adequate to . . . 'serve as a basis for evaluating claims of future uses.'" *Minute Entry* at 9 (July 16, 2002) (quoting *Pre-Trial Order No. 2 Re: Content of HSRs* at 2 (Aug. 15, 1988)). The PHSR, however, lacks sufficient detail about the Hopi claims for future uses to serve as the basis for evaluating those claims.

Even if one could ignore the Navajo Nation's competing water uses or the Navajo Reservation's unmistakable homeland purpose when considering the Hopi claims, the PHSR also does not adequately explain the unique nature and limitations of the Hopi Tribe's water uses described in the PHSR. Much of the irrigation practiced by the Hopi Tribe can be defined as dry land farming or "native irrigation," and the washes themselves are often dry. *See generally* § 8.1, at 8-1 to 8-12. These native irrigation fields are strategically placed by Hopi farmers in areas that receive runoff and maximize stored soil moisture;[3] "water arrives at the parcels by strategic placement of the parcel rather than by conveyance of the water." *United States' Amended Statement of Claimant on Behalf of the Hopi Tribe* at 8 (Jan. 29, 2004). This type of agriculture is far different than modern agricultural systems in which regional supplies concentrated in a stream channel can be diverted and conveyed to agricultural fields. While such modern systems may be amenable to administration by water managers, the native irrigation system that strategically relies on localized water supplies that are unique to the particular field situation cannot be similarly subject to water-rights administration. Thus, the notion that native irrigation water rights on the Hopi Reservation can be aggregated and transferred from one location on the Reservation to another is extremely problematic and ignores the physical reality of water uses in the LCR basin. Such water uses should be considered *in situ*. Furthermore, these *in situ* uses are *sui generis* and do not fit traditional models of agriculture and crop water usage, yet the PHSR does not adequately address this fact.[4] The final HSR should adequately reflect and analyze the unique nature of these Hopi Tribe water uses.

The PHSR also appears to rely at least in part on a study prepared by HDR Engineering, Inc., entitled *Western Navajo-Hopi Water Supply Needs, Alternatives and Impacts* (2003) ("HDR study"). Although it is unclear to what extent ADWR relied upon the HDR study, the PHSR lists

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[3] Typical geomorphological locations of farmed fields include, but are not limited to, the base of sand dunes, within arroyos and floodplains adjacent to streams, gentle slopes below rock escarpments, and alluvial fans.

[4] See the Navajo Nation's comments on Chapter 8 of the PHSR for a further discussion of this issue.

this study among its references, at R-5, and Figure 7-21 cites the HDR study as its source. The HDR study was the subject of a protective order by the Court, prohibiting its use "in any judicial proceeding in this Adjudication by any party to this Adjudication." *Protective Order* at 1 (Dec. 31, 2001). While ADWR is not a party to this adjudication, the PHSR provides the factual record upon which the adjudication is based. *See* A.R.S. § 45-256. Thus, parties that rely on the PHSR might indirectly be using the HDR study. At a minimum, the final HSR should note the protective order and include a discussion regarding the use of the HDR study.

Lastly, as a general housekeeping comment, the appendices of the PHSR – which were only available electronically – were not globally paginated, making the task of locating pages within these appendices extremely problematic. For example, Appendix F contains a document prepared by ADWR. While this document is numbered internally, it is not globally numbered as "Appendix F-page #" nor do any of the pages of the text, tables or figures indicate that it is part of Appendix F. Thus, the task of locating a document in the appendices, or of determining which appendix a particular page is located in, is very difficult. ADWR should include global pagination for all included documents in the final HSR.

IV. COMMENTS ON SPECIFIC SECTIONS OF THE PHSR

CHAPTER 2: SUMMARY OF ADJUDICATION CLAIMS RELATED TO THE HOPI INDIAN RESERVATION

2.6 2004 UNITED STATES CLAIMS ON BEHALF OF THE HOPI

Section 2.6.6 Present and Future Domestic, Commercial, Municipal and Industrial Use

The total water demand of 11,211 acre-feet per year ("AFA") for future domestic, commercial, municipal and industrial ("DCMI") use described in this section is based on 160 gallons per capita per day ("gpcd") for a population of 62,512. However, ADWR later notes that some of this domestic demand is included more than once. § 2.8, at 2-20. The Hopi Tribe's water claim for 1,083 AFA for future tourism, § 2.9.6, at 2-24, should already be accounted for in the DCMI value. The final HSR should more clearly reflect this fact.

2.9 SUMMARY AND COMPARISON OF HOPI AND UNITED STATES 2004 CLAIMS FOR FUTURE USES

2.9.1 Future Agriculture (Irrigation)

The Hopi Tribe claims 3,000 AFA for future irrigation for the Moenkopi Irrigation Project from Moenkopi Wash. This claim may overlap with historic irrigation. The final HSR should address whether the proposed future irrigation use includes any waters already claimed for historic irrigation.

CHAPTER 3: HOPI RESERVATION LANDS

3.3 1934 ACT RESERVATION LANDS (MOENKOPI)

The PHSR overstates the holding of *Sekaquaptewa v. MacDonald*, 448 F. Supp. 1183 (D. Ariz. 1978), *aff'd in part, rev'd in part*, 619 f.2d 801 (9th Cir. 1980). In that case, the court held that the Hopi Tribe received rights to land it occupied or used at the time of the passage of the Act of June 14, 1934, 48 Stat. 960 ("1934 Act"). The court declared that the 1934 Act "protect[ed] the rights and interests of the Hopi tribe to the land they were occupying and using . . . . Inasmuch as the 1934 Act did not attempt to separate Hopi and Navajo property interests, the Hopi tribe and the Navajo tribe each received an undivided one-half interest *in these lands*." *Sekaquaptewa*, 448 F. Supp. at 1196 (emphasis added). The court did not hold that the Hopi Tribe "received an undivided one-half interest in the 1934 Act Reservation," as stated in the PHSR. § 3.3, at 3-15. Indeed, on appeal the Ninth Circuit explicitly upheld the district court on this point, declaring that the 1934 Act "cannot be read to convey to the Hopis a one-half interest in the Reservation." *Sekaquaptewa v. MacDonald*, 619 F.2d 801, 806 (9th Cir. 1980). It should also be noted that the Ninth Circuit overturned the district court on a related point, holding that for lands that the Hopi Tribe "exclusively possessed, occupied, or used in 1934," the Hopi Tribe was not limited by the 1934 Act to "an undivided one-half interest," but rather received exclusive rights to those lands. *Id.* at 808. The final HSR should more accurately state the holding of the *Sekaquaptewa* cases.

CHAPTER 6: ECONOMIC BASE

6.2 INFRASTRUCTURE AND PUBLIC SERVICES

6.2.2 Utilities

The PHSR indicates that Hopi Tribe's public water systems serve approximately 12,000 residents. Table 6-3, however, presents the factual background for that assertion, and appears to double count many people. Large student populations are indicated as being served by these water systems, and these students are almost certainly included in the counts for their home communities. Similarly, workers at tribal offices and many businesses are indicated as being served by these water systems; the population of people served by each system as stated in the PHSR far outstrips the likely number of residents served. Hopi tribal workers are almost certainly also included in the counts for their homes. The final HSR must more carefully analyze the populations being served by the Hopi Tribe's public water systems.

6.4 HUMAN RESOURCES

6.4.1 Demographics

In its amended claims, the Hopi Tribe claims future DCMI water for a population that will stabilize at 62,512 in 2175. Table 6-7. Neither the PHSR nor the Hopi claims provide sufficient documentation and methodology to support this assertion. Projecting a population 166 years into the future is, simply stated, highly questionable from a demography standpoint. Indeed, the United States Census Bureau has expressed great reservations about projecting populations even 100 years into the future, yet the PHSR does not even suggest that the Hopi Tribe's population projection of 166 years is problematic. *See* FREDERICK W. HOLLMANN ET AL., U.S. CENSUS BUREAU, METHODOLOGY AND ASSUMPTIONS FOR THE POPULATION PROJECTIONS OF THE UNITED STATES: 1999 TO 2100 (2000), http://www.census.gov/population/www/documentation/twps0038/twps0038.html ("The boldest decision was undoubtedly the one to extend the series to the year 2100. In making this decision, we were fully aware of the precarious nature of any population projection that is three human generations past the existing population base.").[5] In this respect, the PHSR fails to meet the Court's directive to analyze "the tribe's present and projected population." § 1.3, at 1-4; *see also Gila V*, 201 Ariz. at 319, 35 P.3d at 80. The final HSR must, therefore, include an adequate analysis of the Hopi Tribe's population figures.

For this section on Hopi Tribe demographics, the PHSR relies on data compiled by SWCA Environmental Consultants ("SWCA") in a report prepared for ADWR.[6] § 6.4.1, at 6-22. The SWCA 2008 report declares that a variety of statistics exist for the Hopi Tribe, but where these statistics differ, SWCA utilized the figures generated by the department or entity "closest to the source of the data" in question. SWCA 2008 at 1. However, SWCA did not appear to give any consideration to the quality of the data in question nor to the credibility of the source closest to the data. SWCA notes, for example, that the 2000 census counted 6,815 persons on the Hopi Reservation (the actual count was 6,946, of whom 6,573 were American Indians), but the Hopi Tribe, in an update to its comprehensive development plan, declared the census total an undercount and substituted a figure of 10,571 as its benchmark for 2000. Without any attempt to evaluate the accuracy of the Hopi Tribe's number, SWCA utilized 10,571 as the population of the Hopi Reservation in 2000 because the Hopi Tribe, the source of the numbers, is closest to its people.

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[5] Even though national projections draw from a larger database and are, therefore, more reliable, the Census Bureau still calculated a low, middle and high value, recognizing that projecting a century into the future is problematic.

[6] *Socioeconomic Study in Support of a Hydrographic Survey Report for the Hopi Indian Reservation* (2008). This report is referenced in the PHSR as "SWCA 2008." Thus, it is similarly referenced as such here.

Similarly, SWCA cites a 2006 study of water sources and contamination on the Hopi Reservation completed by Tetra Tech, Inc., *Source Water Assessment for Communities and Villages of the Hopi Reservation*, in which a 2006 population of 13,000 is claimed for the reservation. Again, without any critical evaluation, SWCA inserts 13,000 as the Hopi Reservation population in 2006. In the 2006 Tetra Tech report, a 93-page document prepared by water treatment experts, there are two sentences stating that 13,000 is the estimated population for the Hopi Reservation in 2006, without any indication of the source of this number nor the method by which it was derived. Besides appearing in the SWCA 2008 report, the PHSR also cites the Tetra Tech report in Table 6-7, but inexplicably reduces the Tetra Tech estimate to 12,000. In a footnote for this number, ADWR states that it represents an estimated number of persons served by public water systems on the Hopi Reservation, although no such explanation or documentation exists in the Tetra Tech report.

The update to the Hopi Tribe's comprehensive development plan, *Hopi Tunatya at 2000: The Hopi Strategic Land Use and Development Plan* (2001), which as noted above was cited in the SWCA 2008 report, was prepared by the Hopi Office of Community Planning and Economic Development and referenced in the PHSR as "Hopi (2001)." Although this document was relied on by SWCA – and thus by the PHSR – it is rife with errors. For example, on page 24, the Hopi (2001) report indicates that from 1999 to 2000, Hopi tribal enrollment grew from 10,704 to 10,870, an increase of 166 new members, which the report states is an increase of 4.75%; it is actually an increase of 1.6%. On the following page, the report notes that the 1980 census was the first census that reported populations for Indian Reservations, when a special subject report dealing with American Indians was published following the 1970 census. The Hopi Reservation total count of Indians in 1970 was 4,404 persons living in 765 households according to the Census Bureau. Inexplicably, the Hopi (2001) report indicates a total 10,757 people as the 1970 census count on the Reservation, even though the report also indicates that no reservation totals were tabulated by the Census Bureau prior to the 1980 census. For the same reason, it is unclear where the count of 9,360 persons on the Hopi Reservation in 1960 came from, though it is presented with authority in Hopi (2001).

The Hopi (2001) report also cites the 1980 and 1990 census counts of Indian persons on the Hopi Reservation as 6,606 in 1980 and 7,061 in 1990. The report does not mention, however, that following the 1977 partition of the Joint Use Area into Hopi Partitioned Lands ("HPL") and Navajo Partitioned Lands ("NPL"), the Navajo people who were counted on the Hopi Tribe's side of the line were counted as Indians living on the Hopi Reservation in 1980 and 1990. Fred Anderson, who completed a historical research report under contract to ADWR in 2008, states that 1,763 Navajos were counted in the HPL in 1980. *Historical Research for Hydrographic Survey Report of the Hopi Reservation* at 169 tbl.8. Thus, the actual count of Hopis in the pre-partition District 6 in 1980 was 4,843. The PHSR, however, ignores this information in the Anderson report. The bottom line is that SWCA, acting as ADWR's consultant, accepted highly questionable data from the Hopi Tribe because the Hopi Tribe is "closest to the source of the data," and ADWR in turn uncritically used the information passed

along by SWCA in the PHSR. Pursuant to the Court's mandate to ADWR to analyze the present and projected future population of the Hopi Tribe, the final HSR must include independent verification of data and methodologically sound calculations.

CHAPTER 7: WATER RESOURCES

7.1 STREAMS

7.1.1 Hopi Washes

The PHSR indicates several hydrologic factors affecting Hopi Reservation streamflows, determining that some of these factors have only "minor" effect. The PHSR does not include a definition for "minor" nor does it indicate whether the same definition extends to all surface water channels; what is a minor effect on the mainstem of the LCR might not be a minor effect on a tributary to one of the washes. The final HSR should explain what constitutes a "minor" effect for each surface water channel.

The PHSR indicates that a formerly perennial reach of Jeddito Wash has become ephemeral in recent years. ADWR attributes this change to the "occurrence of wet and dry periods over the region." § 7.1.1, at 7-3. The PHSR does not, however, provide sufficient background information to support this explanation. The final HSR should include a more detailed explanation for why this change is attributed solely to climate variations.

The PHSR provides no explanation for why the time period of 1981 to 2006 is used. Moreover, a number of the values presented in Table 7-3, from which the data on page 7-4 is derived, are inconsistent with some of the values shown in Figure 7.6. For example, in Table 7-3, Point I-13 has a mean flow of 3,830 AFA and a median of 4,540 AFA, while in Figure 7-6 it has a mean flow of 3,810 AFA and a median flow of 4,510 AFA. Other points have similar discrepancies. The final HSR should correct or explain these inconsistencies.

Table 7-3 also contains values that defy common sense. In Table 7-3, the mean flows are almost always less than the median flows. For example, the mean flow at I-13 is 3,830 AFA while the median flow is 4,540 AFA. Generally speaking, one would expect the mean flows to be higher because the mean is heavily influenced by a relatively small number of very high flow periods. A review of USGS gaging data presented in the table below shows that the means are larger than the medians, and it indicates that the ADWR results are highly suspect.

USGS Gage Data in the Moenkopi Area

USGS Station	Period	Mean	Median
9401260 Moenkopi at Moenkopi	1981 to 2006[7]	7,397	6,391
9401400 Moenkopi near Tuba City	1941 to 1978	11,048	9,373
9401280 Moenkopi near Tuba City	1927 to 1940	16,879	9,988

Letter from John Leeper, Civil Engineer, to Ms. Bidtah Becker, Esq. (June 26, 2009), Attachment 1.

This problem is compounded in subsequent analyses in the PHSR because ADWR developed extended records of streamflow for the gages for periods with short and/or missing records, and for a common "base period" from 1981 to 2006. Only gage number 0941260 had a complete record for the base period, and for several of the gages with missing data, ADWR used gage number 0941260 as the "Index Station" for computation of "synthetic data" (estimates of flows for periods of missing data) for the base period. These synthetic flows for the base period were then used by ADWR in a regional watershed analysis to generate flow estimates at 21 ungaged locations on the Hopi Reservation boundaries (13 inflow points and 8 outflow points). Table 7-3 in the PHSR presents the final results for the estimated mean and median annual flows from this regional analysis at the 21 ungaged locations, and in 17 of 21 cases the median flows are higher than the mean flows. In several cases, the median flow is more than twice as high as the mean flow. These projections are not only nonsensical but are inconsistent with the observed annual flows at the gaged locations, indicated in Table 7-1 of the PHSR, where only one gage – number 0941260 – exhibited a median higher than the mean, and for that one gage the median flow is less than 5% higher than the mean flow. ADWR should reexamine the data and either correct the final HSR or adequately explain the highly unusual results.

Table 7-3 further shows that the reported mean outflow at O-8 is approximately 4,710 AFA. This site is very close to the USGS gage which reports that the mean flow from 1981 through 2006 is more than 6,300 AFA. The PHSR should address this discrepancy. The PHSR also does not address the fact that the USGS gage data already reflect the effects of the current Navajo Nation and Hopi Tribe depletions upstream from the existing irrigation. It is not clear how ADWR addresses the Navajo Nation demands upstream from the Hopi Tribe. The final HSR should reflect ADWR's evaluation of the impact of upstream Navajo Nation irrigation.

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[7] The complete data set for this gage is from 1977 to 2008. For that period, the mean is 7,261 AFA and the median is 6,272 AFA.

Footnote 5 of Table 7-3 has a huge impact on the interpretation of this table and the subsequent description of the water supply on page 7-4 and other sections. The footnote indicates that some "outflows become inflows again over relatively short distances." The PHSR appears to aggregate the flows at O-7 and O-8, which essentially describe the same physical water supply that leaves the western border of the Hopi Reservation (O-7), enters the eastern boundary of Moenkopi (I-13), and then leaves the western border of Moenkopi (O-8). The interpretation on Page 7-4 implies that the "Total Outflows" is the measure of the water supply available when it is not. Table 7-3 presents the difference between the "total outflows" and the "total inflows" which creates an even more misleading characterization of the water supply that may be generated on the Hopi Reservation. The lack of analysis of the natural undepleted flows versus the depleted flows makes it difficult to uses these results in a meaningful way. The final HSR should address these discrepancies.

Please see the comments from the Navajo Nation Department of Water Resources for a lengthier discussion of the regional stream flow analysis, Attachment 1.

7.2 IMPOUNDMENTS

7.2.2 Capacity, and Appendix C

The PHSR includes estimations of the capacity of impoundments on the Hopi Reservation. These capacities were derived using formulas provided in Appendix C, at C-6. The PHSR does not, however, indicate the basis for these formulas, making it impossible to assess the validity of ADWR's impoundment capacity estimations. The final HSR should include a detailed explanation of the basis for its impoundment capacity formulas.

7.2.3 Surface Water Depletion

The PHSR indicates that ADWR utilized certain assumptions when calculating surface water depletions. The basis for these assumptions is unclear, and the PHSR does not include nor reference any hydrologic analysis to assess the validity of these assumptions. The final HSR should explain the hydrological basis for these assumptions.

7.4 AQUIFERS

7.4.6 N Aquifer

The PHSR notes the drawdown likely to occur as a result of increased pumping of wells in the N-Aquifer, as represented in Table 7-14. That table, however, uses information derived from the Final Black Mesa Project Environmental Impact Statement ("Black Mesa EIS"), and impacts are predicted only through 2025. Given the Hopi Tribe's projected population estimate of over 62,000 people in 2175, Table 6-7, the effect on springs, streamflow and water levels in

wells will no doubt increase significantly beyond that predicted in Table 7-14. Assuming the population projections are correct, which the Navajo Nation does not admit, *see* Comment re § 6.4.1, *supra*, the final HSR should reflect this fact.

CHAPTER 8: WATER DEMANDS

8.1 AGRICULTURE

8.1.1 Quantification

ADWR estimates that the net irrigation requirement for crops grown following traditional Hopi farming practices is 0.35 to 0.86 acre-feet per acre. The net amount reflects the difference between the crop water requirement and the estimated rainfall but does not include the effect of riparian salvage. In other words, the crops grown according to traditional Hopi farming techniques may actually deplete less water than the native vegetation that they are replacing. Traditional Hopi farming practices are extremely opportunistic in terms of the location of planting and how water is conserved. Thus, a standard irrigation system model may not be the best analog for these fields. For example, rainfall can be collected from a larger area and concentrated close to a single cluster of plants. These techniques magnify the impact of the rainfall. It is unreasonable to substitute a standard irrigation model on this type of farming system. Please see the attached technical memo for a lengthier discussion of this issue. Letter from Jim McCord, Ph.D., P.E., AMEC, to Ms. Bidtah Becker, Esq. (June 28, 2009), Attachment 2. The final HSR should analyze the net irrigation requirement for traditional Hopi farming practices with a more appropriate model.

Also, while ADWR calculated consumptive use for five different crops grown on the Hopi Reservation, it did not calculate consumptive use for range pasturage, as indicated in § 1-5 of Appendix F to the PHSR. The Natural Resource Consulting Engineers ("NRCE") report prepared in support of the United States' claims on behalf of the Hopi Tribe did calculate consumptive use for corn and range pasturage but not for other crops, as indicated in Appendix B to Appendix F to the PHSR. Thus, direct comparison of the ADWR and NRCE estimates of crop water use is impossible. The final HSR should explicitly compute per-acre crop water use for the same crop mix and same irrigation categories as did NRCE to facilitate checking and validation.

Calculating the crop coefficient Kc values for DRY conditions required adjustments by ADWR beyond the more standard application for modern irrigated agriculture. Standard Kc values could not be used for the dry conditions since the much of the agriculture is dryland farming and does not express a micro-climate similar to modern day agriculture. In addition, the crop coefficient must account for increase in spacing of crops as compared to modern agricultural practices. While this adjustment is likely well justified, ADWR fails to consider another adjustment to account for the fact that the widely spaced plantings will lead to a greater

water use per "plant cluster" due to each cluster being exposed to lower relative humidity. Please see the attached technical memo for a lengthier discussion of this issue, Attachment 2. The final HSR should include a detailed analysis of Kc as there are many variables used in determining this value and the methodology is unique and has not been repeated. At a minimum, ADWR should conduct a sensitivity analysis of the variables that would help better identify and quantify uncertainties in the Kc estimates.

To develop the final crop water use estimates, ADWR takes the average of ETc values calculated for Tuba City and Keams Canyon weather data and averages these values for the final ETc values. These final values are used to calculate the net irrigation water requirement. Temperature and precipitation values from the Tuba City and Keams Canyon stations are significantly different. ADWR should also weigh ETc values for irrigated crops based on proximity to each weather station. The final HSR should then include a sensitivity analysis to compare ETc values computed both ways.

ADWR estimates effective precipitation, which is subtracted from the ETc to obtain the net crop irrigation requirement. ADWR estimates that 52 - 89% of ETc is met by from annual precipitation at the Keams Canyon station, implying that 11 - 48% of ETc is acquired from surface water. The Tuba City estimate assumes that a smaller percentage of ETc is met by effective precipitation. ADWR averaged the values of effective annual rainfall to calculate the final net irrigation requirements. ADWR calculated effective precipitation from total annual rainfall rather than using the more common standard of the amount of rainfall during the growing season. ADWR adopted this alternative since the Hopi Tribe's fields are geographically situated so as to maximize effective precipitation by taking advantage of deeply stored soil moisture. While this assumption may be valid for dryland crops irrigated via the Hopi Tribe's traditional methods, for crops grown using modern-day irrigation in leveled fields, the standard approach of using only growing season precipitation might be more appropriate. The final HSR should include a sensitivity analysis to assess the impacts of ADWR's effective precipitation assumptions.

The irrigation water claim in the PHSR report has been determined based on the assumption that 643 acres were farmed using modern day irrigation practices (non-deficit irrigation, or "NDI") and that the remaining acreage was irrigated using native irrigation techniques (DRY). This is inconsistent with the definition of irrigation types as included in the Hopi Tribe's Amended Statement of Claimant, found in Appendix A of the PHSR. The 2004 Hopi Tribe claim defines"native irrigation" as lacking the use of structures for diversion. Based on irrigation types defined in the Hopi Tribe's claim, it appears that there is a range of variability in crop densities rather than only two types, NDI and DRY. The final HSR should explicitly provide some comparison between the NDI and DRY definitions and the irrigation types identified in the Hopi Tribe's claim.

The PHSR reports that crops grown in the Moenkopi area, served by the Pasture Canyon irrigation system, have a depletion rate of 1.81 acre-feet per acre. The PHSR also reports that the diversion rate for the same irrigation system is 2.01 acre-feet per acre, resulting in irrigation efficiency of 90%. This is an extremely high value compared to most modern flood irrigation systems. ADWR should reexamine these values and either correct or explain the anomalous result in the final HSR.

8.1.2 Historic (Pre-1985) and 8.1.3 Recent

ADWR reports that the Hopi Tribe and the United States "indicate that actual diversions for irrigation on the Reservation have averaged about 29,000 AFA, but are claiming the larger amount [49,200 AFA] to provide an adequate water supply during years when *less* water is available." § 8.1.2, at 8-7 (emphasis added); *see* § 8.1.3, at 8-10. It is very unlikely that the actual average diversion, even including native irrigation, was 29,000 AFA. The average water supply as described in the PHSR appears to be much less, possibly around 13,900 AFA. Any modeling results that might support a conclusion of higher diversions were not made available to ADWR. *See, e.g.*, § 8.1.1, at 8-3 ("ADWR's request for a copy of the surface water model [used by the United States 'to simulate the quantity of surface water depleted by irrigation of Hopi fields'] was denied."). In addition, some of the water diverted for native irrigation may not have reached the downstream gages used to create this analysis. The water supply on the Hopi Reservation is not fungible, but instead is highly sensitive to specific locations and practices. Simply aggregating the total acreage and the total water duty implies that there is an aggregate volume of water that can be moved around with impunity, and this is not the case. The final HSR should reflect this reality.

Also, the PHSR indicates that the Hopi Tribe is claiming larger amounts of water to provide adequate water during years when *less* water is available. This statement appears to be worded incorrectly. The final HSR should presumably indicate that more water is being claimed for the few years when *more* water is actually available.

8.1.4 Future

The PHSR uses the term "net irrigation demand" to apparently indicate the consumptive use demand of a crop which is not satisfied by precipitation. At other points in the report and accompanying documentation, ADWR appears to use the terms "net irrigation water requirement" and "supplemental irrigation demand" synonymously with "net irrigation demand." The final HSR should explicitly define and if necessary distinguish all of these terms at the beginning of the report.

The PHSR suggests that "there is enough surface water physically available for these projects." § 8.1.4, at 8-12. This statement is based on the 190,000 AFA in the LCR. However, no demonstration has been made that the water in the LCR is practically or legally available.

Without the LCR mainstem water, there may not be enough surface water available. The final HSR should reflect this.

8.3 HEAVY INDUSTRIAL

8.3.2 Recent and 8.3.3 Future

The Black Mesa EIS preferred alternative proposes to operate the Black Mesa Complex coal mines into 2026 without supplying the Mohave Generating Station, i.e. with no slurry water use. Proposed water use is estimated at 1,236 AFA for ongoing operations at the Kayenta mine, up to 505 AFA for reclamation and public use from 2026 to 2028, and 444 AFA from 2029 to 2038 for post-reclamation and public use. § 8.3.3, at 8-17. The Black Mesa EIS reports a past average usage of 3,100 AFA of N-Aquifer water for slurry of coal to the Mohave Generating Station and 1,300 AFA for other mine-related uses, for a total of 4,400 AFA. Based on the foregoing, it appears that Hopi claims for ground water at Black Mesa may be overstated in terms of both historic and future uses. This conclusion is based on the fact that seven of the eight Peabody water supply wells are on Navajo Reservation land and the claimed future 5,600 AFA for slurry to the Mohave Generating Station is nearly twice what has been required to operate the pipeline in the past. The final HSR should reflect this.

Proposed future development areas and well locations are shown on Map F from Appendix A of the PHSR. Proposed N-Aquifer wells for these developments are located further south and west than the existing Peabody wells. While studies to date have found little impact to springs and streams on the Hopi Reservation, moving the wells to the south and west closer to Hopi Reservation springs and stream segments could result in future impacts to these features. The final HSR should provide some analysis on the potential effects of these proposed wells.

The Hopi Tribe claims 6,000 AFA of groundwater for the Black Mesa Mine and another 19,000 AFA of groundwater (or off-reservation water sources) for new industrial uses; the water source for these projects is not identified beyond "groundwater." The PHSR notes a proposed 1,200 megawatt coal-fired power plant that would use 15,000 AFA and a proposed coal liquefaction plant and 300-megawatt power generating station.[8] The PHSR reports that both projects were previously abandoned due to the lack of a sustainable water supply. While ADWR was instructed to not analyze "the feasibility, profitability or practicability of future uses of water," ADWR was still charged with providing information that is "adequate to . . . 'serve as a basis for evaluating claims of future uses.'" *Minute Entry* at 9 (July 16, 2002) (quoting *Pre-Trial Order No. 2 Re: Content of HSRs* at 2 (Aug. 15, 1988)). In describing these projects, the PHSR does not provide sufficient information to evaluate the proposed future uses. These projects are very speculative, and no substantive material is provided to evaluate whether they are feasible or

[8] The PHSR does not make clear if the coal liquefaction plant and 300-megawatt power generating station account for all of the remaining 4,000 AFA claimed for future industrial use.

practical. Moreover, it is likely that the lack of a sustainable water supply is only one reason among many that led to their abandonment. For example, air quality concerns, transmission limitations, and widespread public resistance all may have factored into the fate of these projects. The final HSR should include more information on the proposed projects in order for the HSR to meet ADWR's obligation to provide information that is "adequate to . . . 'serve as a basis for evaluating claims of future uses.'" *Id.*

8.4 LIVESTOCK

8.4.2 Historic

The PHSR uses the phrase "[a]t the time of the Navajo migration" without explaining the reference. Also, the PHSR states that "[u]p to this point" there had been little development of livestock water sources, without identifying exactly what point in time is being indicated. The final HSR should explain these references.

8.6 TOURISM

The PHSR presents water demands for tourist purposes. This type of demand should be included as part of the 160 gpcd DCMI claim to avoid being double counted. *See* § 2.6.6, at 2-16. For example, the City of Flagstaff provides for thousands of tourists as part of its municipal demands. Facilities like the Tuuvi Travel Center should be included in the DCMI claim. While the PHSR later indicates that ADWR assumes that the Hopi Tribe's tourism claims are included in its DCMI claims, § 9.1.2, at 9-2 n.2, it does so in a footnote and not in its primary presentation of the Hopi claims. The final HSR should clearly reflect that the Hopi claims for water for tourist purposes should be subsumed within the DCMI amount.

8.6.3 Future

The PHSR notes that the Hopi Tribe claims 1,038 AFA for two resorts, one recently opened in Moenkopi (Tuuvi Travel Center) and a future resort in Keams Canyon. The claimed amounts for these uses are 522 AFA and 516 AFA, respectively. The Tuuvi Travel Center includes two fast food restaurants, a convenience store, smoke shop, gas station and car wash. A planned 72-acre development would include a 100-room motel and conference center, office complex and bank. Using the ADWR Generic Demand Calculator, a similar project in the Phoenix Active Management Area ("AMA") would have an annual water demand of less than 200 AFA, as follows:

Item	Units	Use Rate	Demand (AFA)
Commercial	72 acres	2.25 ac-ft/ac	162
Hotel	100 du	57 gpcd 2 c/du	12.7
Pool	5,000 ft^2	See ADWR guidance	0.8
Turf	2 ac	4.9 ac-ft/ac	11.6
Total Demand			**187.1**

gpcd – gallons per capita per day
c/du – capita per dwelling unit (room)

No information is provided for the proposed Keams Canyon resort.[9] Based on the comparison with the ADWR Generic Demand Calculator for the Phoenix AMA, the Hopi Tribe claimed amounts for these two resorts are at least twice what a similar project in the Phoenix AMA would require. The final HSR should note that fact. Of course, as described above, these projects should be included in the Hopi Tribe's DCMI claims.

8.7 CULTURAL/CEREMONIAL

8.7.2 Future

The PHSR indicates that the Hopi Tribe claims water for future irrigation demands for 3,136 acres for gardens and a 4.0 acre-feet per acre water duty for these gardens. ADWR correctly notes that the water duty should be far less. However, the PHSR ignores the fact that the water supplied to these gardens would increase the shortages for the future irrigation projects, possibly reducing their viability. Another consideration ignored in the PHSR is that many homeowners use water for outside landscaping and gardens, and such outside water use is typically included within DCMI demands. The final HSR should either integrate the garden water demand into future irrigation analysis or consider the garden water demand to be part of the DCMI demand.

8.8 RIPARIAN EVAPOTRANSPIRATION

8.8.3 Future

The PHSR reports that Arizona Water Protection Fund projects will be removing Russian olive and salt cedar along the washes. While this is important work and should be commended, replacing the exotic vegetation with native vegetation may not result in a significant change in the overall water budget. The final HSR should reflect this reality.

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[9] The PHSR indicates that ADWR is unaware of any plans for a resort in Keams Canyon, but does identify plans for a motel, restaurant, conference center and museum/cultural center at Tawaivi. § 8.6.3, at 8-26.

CHAPTER 9: ADWR'S ANALYSIS OF HOPI WATER RIGHTS AND PROPOSED WATER RIGHT ATTRIBUTES FOR PAST AND PRESENT WATER USES

9.1 SUMMARY OF ADWR'S EVALUATION OF PAST AND PRESENT TRIBAL WATER USES

9.1.4 Livestock

The PHSR includes impoundments in the livestock category, and its quantification of water use for these impoundments is based strictly on storage capacity, as indicated in Tables 9-1 and 9-2. Because this quantification is based solely on the volume of water that the impoundments can hold, ADWR does not explicitly take into account surface water depletions due to evaporation, infiltration, and stock use in determining how much water the Hopi Tribe uses for livestock. ADWR should perform independent, physically-based hydrologic analyses to test the empirical equations for depletion to impoundments, and the final HSR should reflect that.

9.2 COMPARISON OF QUANTITIES OF WATER FOR PAST AND PRESENT USES CLAIMED BY THE HOPI AND UNITED STATES TO QUANTITIES OF WATER DETERMINED BY ADWR

9.2.1 Agriculture

The PHSR describes the Hopi Tribe's claim of composite irrigated acreage of 38,556 acres. ADWR reported convincing evidence of only 25,261 acres, and estimates a total of 9,503 AFA for agriculture purposes in any year. While this analysis is much more accurate than the analyses presented by the Hopi Tribe and the United States, it still appears to be too high. The PHSR uses an "estimated crop water demand," § 9.2.1, at 9-6, but the final HSR should instead consider the specific farming practices used on all of the lands in question.

9.3 ADWR'S RECOMMENDED WATER RIGHT ATTRIBUTES FOR PAST AND PRESENT WATER USES ON THE HOPI RESERVATION

9.3.2 ADWR's Recommended Water Right Attributes and 9.3.3 Legal Issues Pending Before the Court and Special Master

The PHSR indicates that the question of whether the Hopi Tribe may receive water rights to streams that do not traverse or abut the Hopi Reservation is currently pending before the Court. On March 2, 2009, the Court ruled that "that the Hopi Tribe is precluded from asserting water right claims in this adjudication to the extent such claims seek the right to water sources located within the Little Colorado River Basin that neither abut nor traverse Hopi lands."

Minute Entry at 2 (Mar. 2, 2009). The final HSR should be amended to reflect the Court's ruling.

The PHSR indicates that water reserved for an Indian tribe to meet the homeland purpose, once recognized, may be diverted and used anywhere on the Reservation. ADWR bases this statement on *Gila V*, 201 Ariz. at 313, 35 P.3d at 74. Not only does the PHSR take this pronouncement out of its legal context, but it also ignores the well-established "no harm" rule of water law. *See generally* DAVID H. GETCHES, WATER LAW IN A NUTSHELL at 173-75 (4th ed. 2009) (changes in use of a water right may not injure other water users). Moreover, the PHSR's statement fails to take into account the unique nature and limitations of the Hopi Tribe's water uses described in the PHSR. As noted previously, much of the irrigation practiced by the Hopi Tribe can be defined as dry land farming or "native irrigation," and the washes themselves are often dry. Fields being irrigated in this manner are chosen specifically for their location; water arrives at these fields by virtue of their placement, not by conveyance of water to the fields. *United States' Amended Statement of Claimant on Behalf of the Hopi Tribe* at 8. Thus, the notion that "native irrigation" water rights on the Reservation can be aggregated and transferred from one location on the Reservation to another is extremely problematic and unrealistic. Such water uses should be considered *in situ*. The final HSR should reflect this.

Sincerely,

Scott B. McElroy
SBM/dav
cc: Bidtah N. Becker

Enc.:

Letter from John Leeper, Civil Engineer, to Ms. Bidtah Becker, Esq. (June 26, 2009), Attachment 1.

Letter from Jim McCord, Ph.D., P.E., AMEC, to Ms. Bidtah Becker, Esq. (June 28, 2009), Attachment 2

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JOE SHIRLEY, JR.
PRESIDENT

BEN SHELLY
VICE PRESIDENT

June 26, 2009

Ms. Bidtah Becker, Esq.
Water Rights Unit
Navajo Department of Justice
P.O. Box 2010
Window Rock, AZ 86515

SUBJECT: **Comments on the *Preliminary Hydrographic Report for the Hopi Indian Reservation, In re The General Adjudication of the Little Colorado River System and Source*, December 2008**

Dear Bidtah,

The objective of this memorandum is to provide Navajo Nation Department of Water Resources' comments on the Regional Stream Flow analysis (Pages 7- 1 through 7-6, Streams - Regional Stream Flow Analysis) in the *Preliminary Hydrographic Report for the Hopi Indian Reservation, In re The General Adjudication of the Little Colorado River System and Source*, December 2008..

The Arizona Department of Water Resources (ADWR) made a substantial effort to estimate the volume of water that flows into the Hopi Reservation and the volume of water that flows out of the Hopi Reservation. Table 7.3 presents the final numerical conclusions of the ADWR hydrologic analysis. Table 1 in this memorandum present selected values from ADWR's Table 7-3 *Estimated Stream Inflows and Outflows on the Hopi Indian Reservation* for the base period 1981 through 2006 and values from nearby gaged sites for the same base period.

The lack of gaged data along with the complexity of the flow regimes, make it very difficult to accurately estimate these inflows and outflows. There is no single correct or incorrect method for generating these estimates. ADWR went to great lengths to develop an appropriate methodology. Much of this methodology is described in *Stream Flow Characteristics of the Hopi Reservation* January 2008. However, in spite of the significant effort made by ADWR, the overarching concern is that several of the key technical decisions made by ADWR may have resulted in misleading values.

Attachment 1

1. Estimated mean flows are frequently less than estimated median flows

The ADWR estimate stream inflows and outflows in Table 7-3 are very unusual. In this region the mean (average) runoff volume is almost always greater than the median runoff volume. (The median flow is the flow that is available 50 percent of the time.) An inspection of more than 20 locally gaged sites verifies this observation. Intuitively this result does make sense because the average is influenced by a relatively small number of very large events. However, the ADWR estimated mean flows are frequently less than ADWR estimated median flows.

The values cited in the first paragraph on Page 7- 4 are derived from Table 7-3 *Estimated Stream Inflows and Outflows on the Hopi Indian Reservation.* Table 7-3 includes mean and median stream flows for a number of sites that are intended to reflect the points of inflow to, and the outflow from, the Hopi Reservation. For example, as presented by ADWR, the estimated mean flow at Point I-1 is 650 AFA while the median flow is 1,440 AFA. The total average inflow at all of the estimated points is 6,820 AFA while the estimated median inflow is 10,800 AFA. For this basin, this result would be very unlikely. This finding indicates that the ADWR results may be suspect.

2. The measurements at the Moenkopi Gage USGS #09401260 are unusual

The USGS Moenkopi Gage #09401260 calender year data appear to be the exception to the rule that the regional stream flow averages are greater than the regional medians. In this respect, this gage differs from every other gaging site on the Moenkopi Wash. NRCE Incorporated reports in its October 29, 2007 response to ADWR that the average record quality at this gage is poor. Even so, no clear explanation for this possible anomaly is apparent. Accurately measuring flows in the local sandy stream channels is very difficult. It is as much art as science. There are theoretically possibilities that could account for this anomalus result. For instance, it is theoretically possible that at large flows the rating curves underestimate the actual flows. This problem could result in the larger flows that should have raised the overall average having less statistical impact.

Another possibility is that the flows passing the gage occasionally become isolated from the gage's transducer. If this ever occurred, the gage would record a zero flow while the actual flow would be somewhat greater. This problem could result in some unknown number of relatively small flows that should have raised the overall average result in a lower reported average. Another possibility is sediment clogging the gage's transducer resulting in a recorded flow when actually there is no flow. Based on a field trip to this site on June 10, 2009 either problem appeared possible. Due to limited resources, unless there is an obvious problem with the data stream, the USGS only visits the site every six weeks. So these types of problems could go uncorrected for weeks.

Table 1.1 ADWR Points and Nearby Gaged Sites for the ADWR Base Period (1988 to 2006)

Site Label	Estimated Average AFA	Estimated Mean AFA
ADWR I-1	650	1,440
ADWR I-2	350	514
PWCC SW25 + SW26 +SW 155	2226	1187
ADWR I-13	3810	4510
USGS 0901260	7610	7780
ADWR O-8	4620	4140
USGS 090583	305	230
ADWR O-3	191	208
USGS 090568	305	230
ADWR O-4	1,250	1,520
USGS 090562	1520	880
ADWR O-5	1610	1560
USGS 09401110	2260	1740
ADWR O-6	1780	2460

In order to extend the USGS Gage #09401260 record ADWR appended the gage records from USGS Gages #09401280 and #09401250 to it. Because of the influence of the other two gages, the extended record resulted in an average flow greater than the median flow. However, simply appending these records together may introduce error. ADWR Figure 7.1 shows that USGS Gages #09401260 and #09401280 are in the same location. However, ADWR Figure 7.5 shows that USGS Gage #09401280 is several miles downstream from USGS Gage #09401260. This confusion is understandable because the USGS published incorrect location information for USGS Gage #09401280 that indicated that they were in the same location. The reality is that the USGS Gage #09401280 was several miles downstream. Its watershed was 17 percent greater in area, it included flows from Pasture Canyon, and it was influenced by upstream irrigation diversions. Some of these USGS gage values are shown in Table 2.

Another very unexpected result is shown in Table 1. During the base period the average estimated ADWR flow upstream from USGS Gage #090126 is 3,810 AFA while the average estimated flow downstream from USGS Gage #09401260 is 4,620 AFA. However, the flow at #09401260 during the base period is 7,610 AFA. This result indicates that the estimated flow data is not well calibrated.

Table 2. USGS Gage Data in the Moenkopi Area

USGS Station	Period	Mean	Median
9401260 Moenkopi at Moenkopi	1977 to 2008	7,261	6,272
9401260 Moenkopi at Moenkopi	1981 to 2006	7,397	6,391
9440140 Moenkopi nr Tuba City	1941 to 1978	11,048	9,373
9401280 Moenkopi Near Tuba City	1927 to 1940	16,879	9,988

3. ADWR made no attempt to census outliers

ADWR made no attempt to identify or censor outliers. It is understandable that ADWR would rely on the source data as they are without any screening that would bias the results. However, some greater screening might have eliminated data sets that resulted in suspect results.

4. Oraibe, Polacca and Dinnebito Washes data were filled with PWCC FL15 data

ADWR ran an extensive series of Pearson correlations among the gaged sites in the study area. One result is that Peabody Western Coal Company (PWCC) FL15, a gaged site on Yellow Water Wash, showed a high correlation with sites on Oraibe (USGS Gage #09400562), Polacca (USGS Gage #09400568) and Dinnebito (USGS Gage #09401110). The Pearson correlation coefficient values were 0.93, 0.94 and 0.83 respectively. Based on these high correlations, ADWR used the FL15 data in the formula for filling in the flow records for these washes during the base period.

The use of this data in this manner is completely understandable. However, the results are again suspect. As shown in Table 1, the estimated means are again less than the estimated medians. This result is surprising because between 1987 and 2002 the PWCC sites have an annual mean that is 30 percent greater than the median. In addition, the original USGS records show that the annual means for these three closest USGS gages are also approximately 30 percent greater than the medians.

Although the data collected at FL15 may have a high correlation, several aspects of that site may have made it a poor choice for this purpose. The FL15 watershed is 42.1 square miles and the stream length is 13 miles. However, Oraibe is 666 square miles and the stream length is 107 miles, Polacca is 908 square miles and the stream length is 80 miles, and Dinnebito is 491 square miles and the stream length is 89 miles. Furthermore, the data collected by PWCC may not have been mean daily values. The Peabody data may be more similar to peak discharge measurements.

One interesting comparison is that correlation coefficient between FL15 and the downstream USGS Gage #09401260 is 0.20. Evidently one is to assume that FL15 is a better hydrologic indicator for Oraibe, Polacca and Dinnebito than it is for the watershed that it is in. Another interesting comparison is that the correlation coefficient between FL15 and Jeditto Wash, which is close to the other three washes is only 0.06. The apparent correlations between FL15 and the three washes may be spurious.

5. ADWR's selected base period may not be representative

ADWR indicated that the base period was driven by the availability of data. Consequently the inflow and outflow results may not be representative. For instance, it is possible that this base period reflects a drier period. For instance, the average flow of the Little Colorado River at Cameron between 1948 and 2006 was more than 220 cfs while the average flow during the ADWR base period was less than 200 cfs. This is roughly a 10 percent difference.

6. ADWR Text Includes Numeric Discrepancies

Several of the values presented in Table 7.3 are inconsistent with some of the values shown in Figure 7.6 *Stream Inflows and Outflows on the Hopi Indian Reservation*. For instance in Table 7-3, Point I-1 has a mean flow of 659 AFA and a median of 1,440 AFA, while in Figure 7-6 it has a mean flow of 690 AFA and a median flow of 1,520 AFA And Point I-13 has a mean flow of 3,830 AFA and a median of 4,540 AFA, while in Figure 7-6 it has a mean flow of 3,810 AFA and a median flow of 4,510 AFA. Other points have similar discrepancies.

7. Impacts of existing uses on the inflows and outflows

Another issue that ADWR does not address is that the USGS gage data already reflect the effects of the current Navajo and Hopi depletions upstream from the existing irrigation. It is not clear how ADWR addresses the Navajo depletions upstream from Hopi. The impact of Navajo irrigation appears to have been ignored. The inflows and outflows values are not comparable to estimates of the natural flows.

8. Possible misinterpretation of the inflow and outflow results

Table 7-3 includes a footnote that has a huge impact on the interpretation of this table and the subsequent description of the water supply on Page 7-4 and other sections. That footnote indicates that some "outflows become inflows again over relatively short distances." It might make sense to aggregate the separate discrete flows from the five major washes to generate an estimate of the total aggregate water supply flowing onto, or off of, the Hopi Reservation. But, it is absurd to aggregate the flows at O-7 and O-8 which essentially describe the same physical water supply that leaves the western border of the Hopi Reservation (O-7), enters the eastern boundary of Moenkopi (I-13), and then leaves the western border of Moenkopi (O-8). The interpretation on Page 7-4 implies that the "Total Outflows" is the measure of the water supply available when it is not. Table 7-3 presents the difference between the "total outflows" and the "total inflows" which create an even more misleading characterization of the water supply that may be generated on the Hopi Reservation. The lack of analysis of the natural undepleted flows verses the depleted flows, makes it difficult to uses these results in a meaningful way.

Thank you for the opportunity to provide these comments. If you have any further questions please contact me at (928) 729-4004.

Sincerely

THE NAVAJO NATION

John Leeper, Civil Engineer
Water Management Branch
Department of Water Resources

(Formerly)
HYDROSPHERE
Resource Consultants

amec

28 June 2009

Ms. Bidtah Becker, Esq.
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Re: Comments on Agricultural Water Use Estimates in Preliminary Hydrologic Survey Report of Hopi Claims in Little Colorado River Basin Adjudication by the Arizona Department of Water Resources

Dear Bidtah:

This letter report summarizes my comments to date on behalf of the Navajo Nation regarding the above-referenced adjudication court filing.

SCOPE OF AMEC REVIEW

In our review of the Preliminary HSR, AMEC is focusing on hydrology issues related to claims, water supplies, and demands (in Chapters 2, 7, 8, and 9), and we offer no critical evaluation of ADWR's summary of Hopi Reservation lands, physical setting, the Hopi Tribe culture, and its economic base (addressed in Chapters 3, 4, 5, and 6). In this letter report, my technical review and comments focus in particular on the agricultural water-use category. I reviewed two broad aspects of the agricultural claims and the ADWR assessment of those claims:

a) The crop water use per acre for the various agricultural systems employed by the Hopi, and
b) The quantification of the historically irrigated acreage.

For simplicity in my citation of references herein, I employ the same reference list compiled by the ADWR in the PHSR.

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Attachment 2

AGRICULTURAL WATER DEMANDS

The PHSR was reviewed in conjunction with its associated appendices (as well as available references therein) for subject matter concerning agricultural land use and associated consumptive use values. This section provides a summary of my review with associated comments noted that either require further attention, or items that are not congruent with referenced material. Overall conclusions and suggestions for further analysis are made at the end of this section.

In Chapter 8 of the PHSR (and detailed in Appendix F), ADWR estimated agricultural water demands on the Hopi reservation by characterizing:

- the types of crops being grown,
- the net irrigation requirement of the crops (crop consumptive use demand less the effective precipitation),
- the efficiency of the irrigation system; and
- the cropped acreage.

Crop Mix and Water Demands

The ADWR notes (PHSR Table 8-1, details in Appendix F) that corn has been the most common crop grown, followed by orchards, beans, melons, and squash.

- Corn: 81.2%
- Orchards: 8.1%
- Beans: 6.7%
- Melons: 2.3% (note: usually grown in home gardens)
- Squash: 1.7% (note: usually grown in home gardens)

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The ADWR calculated consumptive use for these 5 different types of crops, but did not calculate consumptive use for range pasture (Section 1.5 Appendix F to the HSR, Consumptive Use of Crops Grown on the Hopi Indian Reservation ADWR 20008). According to the Hopi claim summarized in the PHSR (and included as part of Appendix A of the PHSR), range pasture occupied a significant acreage, 19.5% of all Hopi-identified historically farmed lands, or 7,522 acres (Section 2.3.4 HSR). In comparison, an NRCE memo (National Resource Consulting Engineers, 2007; attached as Appendix B to Appendix F of the PHSR) in support of US claim on behalf of Hopi Tribe calculated consumptive use for corn and range pasture but not for individual types of crops (Answer to Question 3 in Appendix B to Appendix F, Consumptive Use of Crops Grown on the Hopi Indian Reservation ADWR 20008). This prevents direct comparison of ADWR and NRCE estimates of crop water use. *The ADWR should augment the existing analyses by explicitly computing per-acre crop water use for the same crop mix and same irrigation categories as did NRCE to facilitate checking and validation.*

The majority of historical agricultural fields use dryland farming techniques (Appendix F, page 1-2). Dryland fields are strategically placed by the Hopi in areas that receive runoff and maximize stored soil moisture. Typical geomorphological locations of dry farmed fields include, but are not limited to, the base of sand dunes, within arroyos and floodplains adjacent to streams, gentle slopes below rock escarpments, and alluvial fans. This type of "Native" or "ak chin" agriculture is far different than modern agricultural systems in which regional water supplies concentrated in a stream channel can be diverted and conveyed to agricultural fields. While such modern systems may be amenable to administration by water managers, the Native system that strategically relies on localized water supplies that are unique to the particular field situation and location can not be similarly subject to water-rights administration. Rather, the estimated crop consumptive use for the Native systems provide an indication of the potential crop water depletions to total water yield of the wash watersheds.

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The ADWR report calculates a lower and upper confidence interval for "Native" or dry land farming and "modern day" or non-deficit irrigation farming, entitled "DRY" and "NDI" respectively (Appendix F, pages 1-4, 2-1).

Water demand for any particular crop mix involves calculating the "reference" evapotranspiration (ETo) and multiplying that by a "crop coefficient" (K_c). to yield a crop-specific estimate of evapotranspiration, ETc.

As described in Appendix F of the PHSR (Section 2.1), three models were considered to compute ETo. These models are:

- FAO-24 Blaney-Criddle: not used for final CU calculations because there was no local calibration
- 1985 Hargreaves-Samani: not used for final CU calculations because it has been shown to be less accurate in windy areas unless local calibration is available.
- FAO-56 Modified Penman-Monteith: This method incorporates winds into the ETo calculation and was therefore chosen to calculate final ETo values for the Hopi Reservation. This method is largely equivalent with the "ASCE Reference" method (ASCE-EWRI, 2005).

Even beyond the advantages of the FAO-56 method described above, it is currently the most widely accepted method for estimating crop water use (Allen et al., 1998). While in general I support ADWR's selection of the FAO-56 method for estimating crop water use on the Hopi reservation, its application to "native" Hopi farming systems is outside the range of conditions for which it was developed, imparting a large unquantified uncertainty to those estimates. The ADWR (Appendix F, Sections 1.3 and 1.4) explicitly recognizes the uncertainty in crop water use estimates due to the lack of availability of needed meteorological data, and attempts to account for that uncertainty by computing a range of CU values "that bracket the actual CU rates for crops on the Reservation." They also attempt to make adjustments to the crop coefficients to address how Native cropping systems deviate from NDI "modern" irrigated systems (Appendix

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F, Section 2.2); this adjustment for Native agriculture is based on effective ground cover and according to ADWR this adjustment method was reviewed and approved by Dr. Richard Allen (Appendix F, page 2-8), one of the co-authors of both the FAO-56 and the ASCE Reference methods.

The three models were run using the Ref-ET program developed at University of Idaho, using input data compiled by the ADWR from WRCC and the Hopi Water Resources Program. Default values were developed using FAO-56. The Penman-Monteith model requires as input: air temperature, wind speed, air humidity, and solar radiation data. Of these, only air temperature had a satisfactory period of record (>10 years). All other variables were estimated, interpolated, or calculated.

- Solar Radiation was calculated by using the difference between maximum and minimum air temperatures on any given day. An adjustment coefficient of 0.16 was used as recommended for interior, non-coastal regions.
- Dew Point (Tdew) for NDI. There appears to be a typographical error on p. 2-5 of Appendix F, Section 2.1.3.4 where ADWR imply that an increase in relative humidity would lead to a *decrease* in Tdew; this is the exact opposite of what one would expect and therefore the ADWR must have meant the increase in humidity over an NDI-cropped field would lead to an *increase* in Tdew; if this is *not* a typographical error, the ADWR needs to clarify what they mean here. In this same section, the ADWR next notes that they employed the ASCE Reference method of Walter et al. (2005) to estimate Tdew from Tmin. This methodology was chosen because much of the data for which it was developed for ASCE are specifically taken from Arizona. *This methodology described to estimate Tdew from Tmin appears reasonable for NDI crop water use estimation.*
- Dew Point (Tdry) for DRY. Because of the large data gaps in relative humidity measurements the Method Of Variance Extension, Type 1, or MOVE1, was used by the ADWR to create a relationship between Tmin and Tdew for each month to extend the record of relative humidity data. They further note that no Tdew correction is needed for

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small size and sparse cropping pattern for the DRY fields. *I recommend that the ADWR provide a "Tdew sensitivity" chart or table to illustrate the difference that results in the calculated ETo from adjusting the Tdew for two equivalent time series of climatic input data.*

Calculating the crop coefficients Kc values for DRY conditions required adjustments beyond the more standard application for modern irrigated agriculture. Standard Kc values could not be used for the DRY Native agriculture conditions since the much of the agriculture is dryland farming and does not express a micro-climate similar to modern day agriculture[2]. In addition, the crop coefficient needs to account for increase in spacing of crops as compared to modern agricultural practices. This adjustment is likely well justified, however, it is unclear whether this adjustment also accounts for the fact that the widely spaced plantings will lead to a greater water use per "plant cluster" due to each cluster being exposed to lower relative humidity. A *more detailed summary of the ADWR's method to compute Kc is recommended[3] as there are many variables used in determining this value, and the methodology is unique and has not been repeated. At a minimum, ADWR should consider a sensitivity analysis of the various variables that would help better identify and quantity uncertainties in the Kc estimates.* For example, ADWR notes (Appendix F, pages 2-8 and 2-9) that use of a single growing degree-day (GDD) curve irrespective of planting date leads to anomalous results, but I could not find an illustration of how using different GDD curves for different corn plantings may affect results. See Table 2.11 of Appendix F for ETc values for each crop under each condition.

To develop the final crop water use estimates, ADWR takes the average of ETc values calculated for Tuba City and Keams Canyon weather data and averages these values for the final ETc values. These final values are used to calculate NIWR. Temperature and precipitation values

[2] In modern-day irrigated agriculture with an adequate water supply, the micro-climate within an irrigated field is characterized by a high relative humidity compared to the background ambient conditions expected for the arid and semi-arid Hopi reservation lands.

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from these two stations are significantly different. *An alternative, and perhaps better, approach would be to weight ETc values for irrigated crops based on proximity to each weather station. The ADWR should include a sensitivity analysis to compare ETc values computed both ways.*

Effective Precipitation

Finally, ADWR needed to estimate effective precipitation, which is subtracted from the ETc to obtain the net crop irrigation requirement. Keams Canyon and Tuba City annual and effective precipitation values calculated by the ADWR are shown in the table below.

Location	Annual Rainfall	Effective Precipitation
Keams Canyon	9.97	6.48
Tuba City	8.19	5.48

As described in Appendix F (Section 2.4), ADWR estimates that 52 - 89% of ETc is met by from annual precipitation. This implies that from 11 to 48% of ETc is acquired from surface water. Note that this value is for the Keams Station. The Tuba City estimate assumes a smaller percentage of ETc met by effective precipitation. ADWR averaged the values of effective annual rainfall when calculating the final net irrigation requirements (0.57 ft). The ADWR calculated effective precipitation from total annual rainfall rather than using the more common standard of the amount of rainfall during the growing season. ADWR adopted this alternative since the Hopi fields are geographically situated as to maximize effective precipitation by taking advantage of deeply stored soil moisture. *While this assumption may be valid for dryland crops irrigated via the Hopi's unique traditional methods, for crops grown using modern-day irrigation in leveled fields (NDI), the standard approach of using only growing season precipitation may be preferred. ADWR should perform a sensitivity analysis to assess the impacts of their effective precipitation assumptions.*

With the calculated ETc and estimated effective precipitation, the net Crop Irrigation Requirement can be computed for by NDI and DRY conditions. Lower and upper limits for NDI

[3] The current presentation of Kc methods in Section 2.2 of Appendix F is quite detailed, however, it

and DRY irrigation methods as calculated by ADWR are listed in the table below (from Table 2.14 of Appendix F).

Irrigation Method	Lower Limit (ft/ac)	Higher Limit (ft/ac)
NDI	1.72	2.46
DRY	0.35	0.86

These values were calculated assuming the consumptive use for Hopi agricultural fields is 0.92 - 1.43 ft/acre and 2.29-3.03 ft/acre if water was not a limiting factor. Effective precipitation was estimated to be 0.57 ft per year as described above.

Working for the US on behalf of the Hopi tribe, NRCE conducted a consumptive use study using the Jensen-Haise model to calculate ET. The ADWR did not use this method because it is a solar radiation based model and according to Allen et al (1998) "radiation methods show good results in humid climates...but performance in arid conditions is erratic and tends to underestimate evapotranspiration." The NRCE report entitled 'Historical/Present Irrigation water uses of the Navajo and Hopi Indian Reservation within the Northern Washes of the Little Colorado River Basin' is not being made available at this time, so the methodology used to calculate consumptive use is unknown. According to Table 2.14 of Appendix F, the net crop irrigation demand for dryland "native agriculture" calculated by NRCE to support the Hopi claim.

Average (ft/acre)	Maximum (ft/acre)
0.61	0.99

The irrigation water demand in the ADWR report has been determined based on the assumption that 643 acres were farmed using modern day irrigation practices (non-deficit irrigation, or NDI) and that the remaining acreage was irrigated using native irrigation techniques (DRY). This is inconsistent with the definition of irrigation types as defined in the Hopi Claim submitted to

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proceeds in a narrative fashion that makes it difficult to evaluate, let alone reproduce, ADWR's findings.

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ADWR on 2/2/2004 (Appendix A of HSR). As defined in the 2004 Hopi claim, claimant defines an irrigation type entitled "native irrigation" as lacking the use of structures for diversion. Based on irrigation types defined in this claim it appears that there is a range of variability in crop densities rather than only two types, NDI and DRY. *The ADWR should explicitly provide some sort of cross-walk between their NDI and DRY definitions and the irrigation types identified in the Hopi claim.*

In summary, ADWR determined a net Crop Irrigation Requirement (CIR) of 0.35 to .86 acre-feet per acre for traditional farming practices and 1.72 to 2.46 acre-ft per acre for modern farming practices, compared to the claims of the Hopi (and the US on behalf of the Hopi) of 0.61 - 0.99 acre-feet per acre for traditional farming, and 1.81 acre-ft per acre for modern practices. In general, the ADWR approach that relies on the FAO-56 method should yield results superior to the Jensen – Haise method employed to develop the Hopi claim.

Agriculture in the Moenkopi Area uses more modern irrigated agricultural methods. A reservoir has been constructed along Pasture Canyon to capture spring discharge, and releases from the reservoir are used to irrigate 179 acres near Moenkopi Wash. The United States reported 2.01 acre-feet per acre are diverted for these parcels. Combining this diversion amount with the estimate of 1.81 acre-ft per acre depletion indicates a 90% irrigation efficiency. This efficiency is extremely high compared to most modern flood irrigation systems. *The ADWR should comment on this issue and determine whether such an assumed irrigation efficiency is defensible.*

Past and Present Agricultural Acreage

The last piece of the puzzle for estimating past and present agricultural water diversions and depletions is the amount of acreage cultivated annually. ADWR estimates that 63% of the reservation land (over 1 million acres) have soils that could potentially grow crops, if irrigated. Consultants working on behalf of the Hopi used aerial and satellite photography to identify all lands that had been historically or are currently being farmed. They estimated that 38,556 acres

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have been historically farmed on the Hopi reservation in 8,210 individual agricultural fields; it is important to note this is NOT what is currently being farmed.

ADWR reviewed the same photography and determined only 25,261 acres show convincing or partial evidence of farming (PHSR Appendix G). ADWR reduced the 8,210 individual agricultural fields to 2,214 by joining fields that bordered each other and reviewed 76% of the total claimed area. In their formal review, ADWR determined that:

- 11% of agricultural lands identified by Hopi consultants was found to have complete evidence of agricultural activity
- 55% was found to have partial evidence of agricultural activity in one or more years
- 34% was found to have either questionable or no evidence of agricultural activity.
- In their verification review of agricultural acreage, ADWR also undertook a topographic drainage analysis (ADWR, 2008m) to determine that surface water drainages pass through or in close proximity of most fields, and can provide a source of water.

Historic and recent data indicate that since the 1870s the total acreage farmed by the Hopi in any given year has not exceeded 9,330 acres (Table 9-1 of PHSR), and has typically ranged between 3,500 and 6,500 acres as shown in Figure 8-1 of PHSR. (Note that ADWR recorded this value as 2,000 to 7,000 acres in the ADWR report 'Identification of Recent (2005) Agricultural and Riparian Lands on the Hopi Reservation').

The ADWR annual water demand for irrigation is calculated assuming an annual farmed acreage of 1,000 – 9,853 acres. This is a very different approach than the Hopi and the U.S. are using, who are claiming water for all land that has at any point in time been farmed, 38,556 acres. This value of acreage claimed on ehalf of the Hopi Tribe should be compared to the historical agricultural water use quantities summarized in Table 9-1 of the PHSR and the following information:

- The annually cropped acreages summarized in Figure 8-1.

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- In 2005 ADWR identified a total of 5,613 acres of agricultural lands on the Reservation (PHSR Appendix G). Approximately 63% of this acreage was classified as actively farmed, 6% were left fallow during the growing season and the remaining 31% either active or fallow. Accounting for potential errors, the ADWR estimates that the total area of agricultural lands on the Reservation in 2005 is estimated to have ranged between 5,570 and 6,506 acres.

Future Agricultural Water Use

In section 8.1.4 of the PHSR, the ADWR notes that the Hopi, but not the US on their behalf, claim water for future crop irrigation beyond the historical and current uses. Those future claims include new garden plots near the Hopi villages (these uses are claimed under ceremonial / cultural uses and are suggested to be supplied by groundwater) as well as new agricultural irrigation projects supplied by surface flows in Moenkopi Wash and the mainstem LCR.

With regard to the future irrigation projects fed by surface supplies, the ADWR crop water use values for NDI should be used to estimate crop water use on a per acre basis. The ADWR correctly notes that the magnitude of the Hopi claim for the future Moenkopi Wash project appears to exceed the sustainable water yield of the wash.

With regard to the village garden plots claimed for future ceremonial / cultural uses, the ADWR notes (Section 8.7.2 of the PHSR) that the crop water use for these fields should use values computed using the DRY per-acre water use numbers. When using the DRY water use values and a reasonable value for irrigation system efficiency, the total expected water use for these cultural garden fields should be a half or lass than the amount claimed by the Hopis.

ADWR SUMMARY AND CONCLUSIONS

As summarized in Table 9-1, ADWR calculated the quantity of water used each year by the Hopi for agriculture by multiplying the range of farmed acreages in a given year (Appendix G) by the

averaged weighted consumptive use values summarized above (Appendix F). Based on these calculations, ADWR determined that traditional farming used from 350 to 7,921 AFA, and irrigation projects used from 0 to 1,582 AFA, which results in a net irrigation demand of 350 AFA to 9,503 AFA for agricultural purposes in any one year (Table 9-1). These estimates of historical agricultural water use developed by the ADWR are much smaller than the Hopi claim of approximately 28,000 to 49,000 af/yr. Based on my review of the PHSR, the ADWR's conclusions of historical water use summarized in Chapter 9 are more defensible than the historical agricultural water use claimed by the Hopi and the US on their behalf.

As described above, for future agricultural claims, the ADWR draws defensible conclusions that: (i) the Moenkopi Wash surface water yield is less than the projected demands for the claimed future irrigation project in the Wash, and (ii) the expected water use for the new ceremonial / cultural garden plots adjacent to the Hopi villages is far less than the amount claimed by the Hopis for this use.

After reviewing my comments above, please do not hesitate to call me (505-835-3026) or email (jim.mccord@amec.com) if you have any questions.

Sincerely,

by: _____
Jim McCord, Ph.D., P.E.

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