

**TABLE 2-1. SUMMARY OF ADJUDICATION CLAIMS FOR PAST AND PRESENT WATER USES ON THE HOPI INDIAN RESERVATION <sup>1</sup>**

TYPES OF USE	WATER SOURCES		QUANTITY OF USE <sup>2</sup>		LOCATION				LEGAL BASIS		PRIORITY DATE	
	Hopi	United States	Hopi	United States	Diversion		Use		Hopi	United States	Hopi	United States
					Hopi	United States	Hopi	United States				
<b>Agriculture (Irrigation)</b> <sup>3,4</sup>	Springs (2004 claims)		116 AFA (16 springs at 4 gpm and 1 spring at 8 gpm)		Appendices 2 and 3 of Claim	Appendices 4 and 5 of Claim	Figures 4 and 5 of Claim	Appendix 8 of Claim				
	Washes and Minor Tributaries		28,700 AFA (average) to 49,206 AFA (maximum) <sup>5</sup>	28,489 AFA (average) to 49,136 AFA (maximum) <sup>5</sup>	Not specified							
<b>Domestic, Commercial, Municipal, and Light Industrial (DCMI)</b> <sup>3,6,7</sup>	Springs (2004 claims)		2,042 AFA (313 springs at 4 gpm, 1 spring at 6 gpm and 1 spring at 8 gpm)		Appendices 2 and 3 of Claim and Supplemental Information	Appendices 4, 5 and 7 of Claim and Supplemental Information	Appendix 1 of Claim	Appendices 1 through 3 of Claim	Federal reserved water rights doctrine; sovereign and historic guardian; owners of lands and waters under both Spanish and Mexican rule; and owner of natural resources	Federal reserved water rights doctrine and homeland purposes	Immemorial, senior to all other Indian and non-Indian claimants	Aboriginal or time immemorial
	Springs (2005 supplemental information)		553 AFA (5 springs at 4 gpm and 17 springs at 19 gpm)									
	Water from Wells (2004 claims)		1,190 AFA (165 wells at 4 gpm, 7 wells at 5 gpm, 2 wells at 6 gpm, 1 well at 7 gpm and 3 wells at 8 gpm)	1,148 AFA (178 wells at 4 gpm)								
	Water from Wells (2005 supplemental information)		6 AFA (1 well at 4 gpm and 25 with no quantity specified)									
<b>Heavy Industrial (Hopi) / Mining and Related Industry (U.S.)</b>	Groundwater	N Aquifer	4,400 AFA <sup>8</sup>	3,000 AFA	Not specified		Figure 8 of Claim	Not specified				
<b>Livestock</b> <sup>3,6</sup>	Surface Water Impoundments (Stock Ponds)		4,502 AF <sup>9</sup>	4,499 AF	Appendices 2 and 3 of Claim and Supplemental Information	Appendices 4 through 7 of Claim and Supplemental Information	Not specified					
	Springs (2004 claims)		2,132 AFA (327 springs at 4 gpm, 1 spring at 6 gpm, and 1 spring at 8 gpm)									
	Springs (2005 supplemental information)		553 AFA (5 springs at 4 gpm and 17 springs at 19 gpm)									
	Water from Wells (2004 claims)		1,137 AFA (159 wells at 4 gpm, 5 wells at 5 gpm, 1 well at 6 gpm, 2 wells at 7 gpm, and 3 wells at 8 gpm)	1,097 AFA (170 wells at 4 gpm)								
<b>Recreation</b>	Watershed Tributary to Impoundments (Lakes)	<i>Use not claimed</i>	196 AF <sup>10,11</sup>	<i>Use not claimed</i>	Appendices 2 and 3 of Claim and Supplemental Information	<i>Use not claimed</i>	Same as diversion location	<i>Use not claimed</i>				
<b>Ceremonial/Cultural</b> <sup>3,6</sup>	Springs (2004 claims)		2,206 AFA (336 springs at 4 gpm, 1 spring at 6 gpm, and 1 spring at 8 gpm) <sup>12</sup>		Appendices 2 and 3 of Claim and Supplemental Information	Appendix 4 and 5 of Claim and Supplemental Information	Not specified					
	Springs (2005 supplemental information)		553 AFA (5 springs at 4 gpm and 17 springs at 19 gpm)									

gpm = gallons per minute, AF = acre-feet, and AFA = acre-feet per year

Notes:

<sup>1</sup> A copy of the 2004 Hopi and United States adjudication claims and 2005 supplemental information is provided in Appendices A-1, A-2, and A-3, respectively, of this preliminary HSR.

<sup>2</sup> Quantities are rounded to the nearest 1 AF or AFA.

<sup>3</sup> In their 2004 claims, the Hopi and United States both claim the same 561 impoundments for livestock, 338 springs for cultural, domestic, stock and irrigation uses, and the same 206 wells for domestic and stock uses totaling 7,961 AFA and 8,044 AFA, respectively. In appendices to its claim, the United States, but not the Hopi, lists the types of use for each well and spring. Both the United States and Hopi also list a total quantity of water for each spring and well, discharge rates and yields, but do not divide the total quantity by type of use. As a result, the same quantity of water is included in the table more than once for wells and springs with multiple uses.

<sup>4</sup> Both the Hopi and United States claim a total of 38,556 acres of Reservation land have been used for crop production, of which 1,042 acres are claimed as precipitation farmed and 37,514 are claimed as farmed by irrigation (perennial, seasonal, range pasture, native or spring). Water use was not claimed by the United States for precipitation farmed fields. The claimed acreage represents a composite of previously farmed fields, not the acreage farmed in a given year.

<sup>5</sup> Quantities listed are for irrigation diversions; irrigation depletions are also claimed, but are less than diversions.

<sup>6</sup> Supplemental information was provided by the Hopi and United States in 2005 and included a total of 28 wells (3 at 4 gpm and 25 with no quantity specified, for a total of 19 AFA) and 22 springs (5 at 4 gpm and 17 at 19 gpm, for a total of 553 AFA) that were not previously claimed.

All of these springs were reportedly used for DCMI, livestock, and ceremonial/cultural purposes, and 26 of the 28 wells were reportedly used for DCMI. The use of the other two wells was not reported. For purposes of the preliminary HSR, this supplemental information was considered part of the Hopi and United States claims.

<sup>7</sup> The United States also claims 11,211 AFA for "present and future" DCMI uses based on future population projections.

<sup>8</sup> Includes 400 AFA for mining activities at Black Mesa and 4,000 AFA for slurring coal from the mine to the Mohave Generating Station.

<sup>9</sup> Represents the storage capacity of the livestock impoundments (4,363.44 AF) with the right to continuously fill, plus the capacity of 4 recreational lakes (138.8 AF) that were also claimed for stock use.

<sup>10</sup> Includes the right to continuously fill 4 recreational lakes with a combined capacity of 138.8 acre-feet and an evaporation rate of 56.8 acre-feet.

<sup>11</sup> The 4 recreational lakes were also claimed as impoundments for use by livestock.

<sup>12</sup> ADWR calculated 2,190 AFA based on the quantities claimed in gpm; rounding by the claimants explains the difference in AFAs.

**TABLE 2-2. SUMMARY OF ADJUDICATION CLAIMS FOR FUTURE (NEW OR ADDITIONAL) WATER USES ON THE HOPI INDIAN RESERVATION<sup>1</sup>**

TYPES OF USE	WATER SOURCES		QUANTITY OF USE		LOCATION				LEGAL BASIS		PRIORITY DATE	
	Hopi	United States	Hopi	United States	Diversion		Use		Hopi	United States	Hopi	United States
					Hopi	United States	Hopi	United States				
Agriculture (Irrigation)	Little Colorado River (LCR)	<i>New or additional uses not claimed</i>	21,060 AFA (plus 11,500 AF for first time reservoir filling) <sup>2</sup>	<i>New or additional uses not claimed</i>	Figures 6 and 7 of Claim	<i>New or additional uses not claimed</i>	Figures 6 and 7 of Claim	<i>New or additional uses not claimed</i>	Federal reserved water rights doctrine; sovereign and historic guardian; owners of lands and waters under both Spanish and Mexican rule; and owner of natural resources	Federal reserved water rights doctrine and homeland purposes	Immemorial, senior to all other Indian and non-Indian claimants	Aboriginal or time immemorial
	Moenkopi Wash		3,000 AFA (plus 4,200 AF for first time reservoir filling) <sup>2</sup>									
	Reservoir Evaporation		2,842 AF <sup>3</sup>									
Domestic, Commercial, Municipal, and Light Industrial (DCMI)	Groundwater <sup>4</sup>	N Aquifer	11,211 AFA <sup>5</sup>	11,211 AFA <sup>5</sup>	Not specified		Appendix 1 of Claim	Appendices 1 through 3 of Claim	Federal reserved water rights doctrine; sovereign and historic guardian; owners of lands and waters under both Spanish and Mexican rule; and owner of natural resources	Federal reserved water rights doctrine and homeland purposes	Immemorial, senior to all other Indian and non-Indian claimants	Aboriginal or time immemorial
Heavy Industrial (Mining and Related Industry)	Coal mining	Groundwater <sup>4</sup>	N Aquifer	1,600 AFA <sup>6</sup>	Not specified	Not specified	Figure 8 of Claim	Not specified				
Livestock	Not specified	<i>New or additional uses not claimed</i>	910 AFA (claim indicates this is being updated)	<i>New or additional uses not claimed</i>	Not specified	<i>New or additional uses not claimed</i>	Not specified					
Ceremonial/Cultural <sup>8</sup>	Groundwater <sup>4</sup>		12,546 AFA <sup>9</sup>									
								Tourism <sup>10</sup>				

AF = acre-feet and AFA = acre-feet per year.

Notes:

<sup>1</sup> A copy of the 2004 Hopi and United States adjudication claims and 2005 supplemental information is provided in Appendices A-1, A-2, and A-3, respectively, of this preliminary HSR.

Future uses are those uses considered new or additional to past or present uses. Past or present uses are expected to continue into the future.

<sup>2</sup> The LCR and Moenkopi projects would irrigate 7,400 and 1,200 acres, respectively.

<sup>3</sup> The total evaporation from reservoirs associated with the two irrigation projects; this number was not further subdivided by the Hopi.

<sup>4</sup> Or possibly other water sources outside of the Reservation, if necessary.

<sup>5</sup> Based on a projected population of 62,512 by year 2175 and use of 160 gallons per capita per day. United States claims 11,211 AFA for this use in the text of their claims, but 11,163 AFA in Table 4 which summarizes its claims.

<sup>6</sup> Water claimed to slurry coal from the Black Mesa Mine to the Mohave Generating Station after 2005, in addition to the 4,400 AFA already claimed for past and present mining uses.

<sup>7</sup> Includes 15,000 AFA for a coal-fired 1,200 megawatt power generating plant, and 4,000 AFA for development of other coal, oil, gas, and minerals.

<sup>8</sup> The United States does not waive its right to assert claims for religious and ceremonial uses of water, if and when evidence of such uses is made known to the United States.

<sup>9</sup> For irrigation of 3,136 acres of arable land surrounding several Hopi villages.

<sup>10</sup> The Hopi claim includes three future large-scale tourism projects, only two of which are within the scope of this report. The United States claim also includes one future tourism project as part of its heavy commercial claim, which is not within the scope of this report.

**TABLE 4-1. CLIMATE DATA FROM TUBA CITY AND KEAMS CANYON METEOROLOGICAL STATIONS <sup>1,2</sup>**

	MEAN	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
TUBA CITY	Max Temperature (°F)	45.3	52.6	61.2	69.9	79.5	89.4	93.7	91.3	84.8	72.7	57.3	45.6	70.3
	Min Temperature (°F)	21	26.2	31.7	38.5	45.9	53.9	61.7	60	52	40.5	28.8	21.3	40.1
	Total Precipitation (inches)	0.49	0.48	0.48	0.41	0.3	0.24	0.72	0.85	0.8	0.75	0.46	0.49	6.47
	Total Snowfall (inches)	1.5	0.9	0.5	0.2	0	0	0	0	0	0	1.5	1.7	6.4
KEAMS CANYON	Max Temperature (°F)	43.2	49	55.3	64.8	73.6	85	89.1	85.4	79.1	68.5	54.8	44.5	66
	Min Temperature (°F)	16.1	21.2	25.1	31.1	39	47.2	55.4	54.7	46.8	35.9	25.3	16.8	34.5
	Total Precipitation (inches)	0.77	0.8	0.87	0.54	0.39	0.3	1.24	1.61	0.88	1	0.67	0.88	9.94
	Total Snowfall (inches)	1.5	2.6	1.8	0.4	0	0	0	0	0	0.1	0.7	3.3	10.5

Notes:

<sup>1</sup>Source: WRCC (2008).

<sup>2</sup>Period of record is 1900-2007 for the Tuba City station and 1948-2007 for the Keams Canyon station.

**TABLE 4-2. ESTIMATED SURFACE WATER EVAPORATION RATES AT TUBA CITY AND KEAMS CANYON <sup>1</sup>**

	MEAN	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
TUBA CITY	Lower bound (inches)	2.28	2.82	4.55	6.21	7.90	8.95	9.14	8.31	6.61	5.30	3.09	2.31	67.47
	Upper bound (inches)	2.98	3.56	5.52	7.37	9.18	10.37	10.42	9.53	7.75	6.54	3.97	3.01	80.20
KEAMS CANYON	Lower bound (inches)	2.22	2.70	4.24	5.76	7.46	8.62	8.65	7.71	6.14	4.87	3.06	2.07	63.50
	Upper bound (inches)	2.88	3.37	5.09	6.74	8.62	9.93	9.84	8.81	7.16	5.96	3.87	2.81	75.08

Note:

<sup>1</sup>Source: ADWR (2008f).

**TABLE 4-3 GENERAL SOIL MAP UNITS ON THE HOPI INDIAN RESERVATION<sup>1</sup>**

MAP UNIT NUMBER	SOIL UNIT	ACRES	PERCENT OF TOTAL AREA	ELEVATION (feet)	SLOPE (%)	DESCRIPTION	LAND USES
1	Jocity-Polacca-Wepo	139,205	8.6%	4,800-6,100	0-3	Deep, well drained, nearly level, loamy, loamy over sandy, and clayey soils; on stream terraces, alluvial fans and flood plains.	Mainly used for grazing. A few scattered areas are used for dryland farming. These soils could be used for irrigated crops if water becomes available.
2	Jeddito-Tewa	112,838	7.0%	4,900-6,100	0-5	Deep, somewhat excessively drained and well drained, nearly level and gently sloping, loamy soils; on fan terraces and stream terraces.	Mainly used for grazing. A few scattered areas are used for dryland farming. These soils could be used for irrigated crops if water becomes available.
3	Sheppard-Monue-Nakai	694,574	42.8%	4,800-6,100	1-15	Deep, somewhat excessively drained and well drained, nearly level to strongly sloping, sandy and loamy soils; on dunes, fan terraces, and plateaus.	Mainly used for grazing. A few scattered areas are used for dryland farming. These soils could be used for irrigated crops if water becomes available.
4	Sheppard-Jocity	20,123	1.2%	4,800-5,300	0-8	Deep, somewhat excessively drained and well drained, nearly level to strongly sloping, sandy and loamy, sodic soils; on dunes, floodplains, and alluvial fans.	Mainly used for grazing. These soils could be used for irrigated crops if water becomes available and soils are reclaimed.
5	Strych-Kinan	21,436	1.3%	5,500-6,700	2-60	Deep, well drained and somewhat excessively drained, nearly level to very steep, cobbly and gravelly, loamy soils; on mesas, buttes, and fan terraces.	This unit is used for grazing.
6	Torriorthents-Badland-Rock Outcrop	74,031	4.6%	4,900-6,800	1-60	Badland, rock outcrop, and shallow to deep, well drained, nearly level to very steep, loamy and clayey soils; on highly dissected hills.	Has very limited use. It is sometimes used for grazing.
7	Begay-Penistaja-Mido	316,405	19.5%	5,800-6,800	1-15	Deep, well drained and excessively drained, nearly level to strongly sloping, sandy and loamy soils; on plateaus and dunes.	Mainly used for grazing. A few scattered areas are used for dryland farming. These soils could be used for irrigated crops if water becomes available.
8	Kydestea-Zyme-Tonalea	242,360	14.9%	5,900-6,800	5-20	Very shallow to moderately deep, well drained and excessively drained, gently sloping to steep, channery, loamy, clayey, and sandy soils; on hills and dunes.	This unit is used as grazable woodland or for firewood harvesting.
9 <sup>2</sup>	Endoaquolls-Haplofibrists-Torrifluvents	22	< 0.1%	4,800-5,000	0-3	Information unavailable.	Information unavailable.
10 <sup>2</sup>	Sheppard-Ives-Torrifluvents	820	0.1%	4,500-5,000	0-3	Information unavailable.	Information unavailable.

Notes:

<sup>1</sup>Sources: Denny (2008) and NRCS (1996 and 2007a).

<sup>2</sup>Information from the LCR Soil Survey is provisional and subject to change upon completion.

**TABLE 6-1 NRCS LAND CAPABILITY CLASS DEFINITIONS<sup>1</sup>**

CAPABILITY CLASS	DEFINITION
I	Soils have slight limitations that restrict their use.
II	Soils have moderate limitations that restrict the choice of plants or require moderate conservation practices.
III	Soils have severe limitations that restrict the choice of plants or require special conservation practices, or both.
IV	Soils have very severe limitations that restrict the choice of plants or require very careful management, or both.
V	Soils are subject to little or no erosion but have other limitations, impractical to remove, that restrict their use mainly to pasture, rangeland, forestland, or wildlife habitat.
VI	Soils have severe limitations that make them unsuitable for cultivation and that restrict their use mainly to pasture, rangeland, forestland, or wildlife habitat.
VII	Soils have very severe limitations that make them unsuitable for cultivation and that restrict their use mainly to pasture, rangeland, forestland, or wildlife habitat.
VIII	Soils and miscellaneous areas have limitations that preclude commercial plant production and that restrict their use to recreational purposes, wildlife habitat, watershed or esthetic purpose.

Note:

<sup>1</sup> Source: NRCS (2007a).

**TABLE 6-2. CHARACTERISTICS OF RANGE UNITS ON THE HOPI INDIAN RESERVATION**

GENERAL LOCATION	RANGE UNIT (No. or Name) <sup>1</sup>	TOTAL AREA (in acres) <sup>2</sup>	% OF AREA USEABLE AS FORAGE <sup>3</sup>	1996 CARRYING CAPACITY (in AUYL) <sup>3</sup>	NO. OF WATER SOURCES CLAIMED FOR STOCK USE				PERMITTEES <sup>4</sup>	
					Ponds	Wells	Springs	Total	No.	Year
District Six	Blue Point	22,098	50-75%	76.0	14	4	0	18	12	1978
	Burro Springs	52,575	75-90%	82.7	18	5	7	30	23	1978
	East Dinnebito	41,992	<50%	74.4	9	6	4	19	2	1978
	Five Houses	71,609	75-90%	298.1	46	10	30	86	15	1978
	Hardrock	62,001	<50%	201.5	29	8	19	56	29	1978
	North Oraibi	52,428	<50%	81.8	14	4	16	34	15	1978
	Polacca Wash	53,275	50-75%	119.9	13	6	5	24	14	1978
	Shongopovi	34,681	<50%	90.5	7	4	3	14	N/A	1978
	Shonto	37,597	50-75%	130.8	19	4	3	26	18	1978
	South Oraibi	31,065	<50%	94.5	7	9	2	18	3	1978
	Talahogan	47,848	75-90%	230.0	21	3	3	27	29	1978
	Toreva	26,227	75-90%	93.1	8	3	26	37	6	1978
	Tovar	36,909	50-75%	108.9	16	2	0	18	11	1978
	Upper Polacca	59,857	<50%	145.8	33	4	21	58	41	1978
	West Dinnebito	18,374	<50%	45.1	11	4	1	16	12	1978
	<b>Subtotal</b>	<b>648,535</b>	<b>N/A</b>	<b>1,873</b>	<b>265</b>	<b>76</b>	<b>140</b>	<b>481</b>	<b>230</b>	<b>N/A</b>
Hopi Partition Lands	251	28,827	>90%	176.0	18	2	6	26	6	2007
	252	43,657	50-75%	118.0	24	2	6	32	N/A	2007
	253	50,686	<50%	64.0	26	0	8	34	2	2007
	254	28,204	<50%	46.0	8	2	8	18	1	2007
	255	80,116	75-90%	301.0	24	7	10	41	11	2007
	256	46,486	>90%	169.0	26	6	4	36	10	2007
	257	42,769	50-75%	176.0	5	3	18	26	13	2007
	258	10,884	>90%	44.0	2	2	1	5	2	2007
	259	34,512	75-90%	149.0	10	1	8	19	9	2007
	260	24,473	<50%	54.0	1	0	8	9	4	2007
	261	26,829	50-75%	49.0	1	2	4	7	3	2007
	262	32,972	<50%	42.0	15	4	3	22	5	2007
	263	52,908	50-75%	95.0	15	6	14	35	6	2007
	351	27,984	<50%	86.0	13	5	12	30	6	2007
	451	12,454	<50%	39.0	3	2	0	5	4	2007
	551	55,297	>90%	228.0	9	7	3	19	18	2007
	552	35,857	>90%	135.0	8	6	13	27	9	2007
	553	35,552	50-75%	90.0	10	3	0	13	4	2007
	554	30,261	50-75%	63.0	8	1	1	10	4	2007
	555	35,673	<50%	36.0	12	3	0	15	4	2007
	556	9,868	<50%	7.0	2	1	0	3	2	2007
	557	7,905	75-90%	31.0	1	0	0	1	1	2007
	558	11,770	75-90%	64.0	3	3	4	10	5	2007
	559	27,190	<50%	77.0	6	1	8	15	7	2007
	560	5,230	N/A	N/A	1	0	0	1	N/A	2007
	561	1,444	N/A	N/A	1	0	0	1	N/A	2007
	562	22,398	75-90%	131.0	10	5	0	15	3	2007
	563	13,797	75-90%	119.0	6	1	0	7	3	2007
	564	2,782	75-90%	9.0	0	0	0	0	N/A	2007
	565	14,408	75-90%	96.0	1	4	0	5	3	2007
566	8,180	50-75%	21.0	5	1	1	7	1	2007	
567	12,963	>90%	156.0	2	0	0	2	8	2007	
568				2	1	0	3	N/A		
569				2	1	0	3	2		
570	12,901	75-90%	114.0	6	1	3	10	N/A	2007	
571	6,716	75-90%	63.0	2	1	0	3	3	2007	
572	10,080	75-90%	57.0	3	1	0	4	4	2007	
573	7,617	50-75%	33.0	2	2	1	5	2	1998	
	<b>Subtotal</b>	<b>911,651</b>	<b>N/A</b>	<b>3,138</b>	<b>293</b>	<b>87</b>	<b>144</b>	<b>524</b>	<b>165</b>	<b>N/A</b>
Moenkopi	<b>N/A</b>	<b>N/A</b>	<b>N/A</b>	<b>N/A</b>	<b>3</b>	<b>7</b>	<b>67</b>	<b>77</b>	<b>N/A</b>	<b>N/A</b>
	<b>TOTAL</b>	<b>1,560,186</b>	<b>N/A</b>	<b>5,011</b>	<b>561</b>	<b>170</b>	<b>351</b>	<b>1,082<sup>5</sup></b>	<b>395</b>	<b>N/A</b>

Notes:

- N/A = information not available.
- <sup>1</sup> From Hopi Drought Plan by DBSA (2000).
- <sup>2</sup> Calculated by ADWR GIS staff using NRCE (2005) boundary data.
- <sup>3</sup> Based on 1996 range survey by Knoll (1996).
- <sup>4</sup> Most recent data available from Hopi (2008a).
- <sup>5</sup> Forty-six (46) of these claimed water sources could not be verified by ADWR.

**TABLE 6-3. PUBLIC WATER SYSTEMS (PWS) ON THE HOPI INDIAN RESERVATION<sup>1,2</sup>**

PWS ID NO.	PWS NAME	GEOGRAPHIC AREA	WATER SUPPLY WELLS <sup>3</sup>		SOME RECENT WATER DEMANDS (AFA)			SERVICE CONNECTIONS (circa 2006)	PEOPLE SERVED (circa 2006)	CURRENT OPERATOR
			Well Name	Completion Dates	1990	2000	2004			
90400052	BIA Hotevilla (Hotevilla Day School)	Third Mesa	Hotevilla Day School #1 and #2	1957 and 1970	See Hotevilla (PWS 90400700)			18 (includes school and 11 residences)	260	BIA Keams Canyon Agency
90400054	Keams Canyon	First Mesa	Keams Canyon #2 and #3	1970 and 1976	64.2	93.7	62.6	142 (includes school, police station and post office, IHS offices, businesses, and 100 residences)	500	BIA Keams Canyon Agency
90400061	BIA Second Mesa (Second Mesa Day School)	Second Mesa	SMDS #1 (inactive) and #2	1958 and 1968	9.5	6.4	3.9	26	180 students and 40 staff	BIA Keams Canyon Agency
90400104	Upper Moenkopi	Moenkopi Area	Moenkopi #1, #2, and #3	1977, 1982, and 1991	25.0	68.2	92.4	250 (includes residential area, community service buildings, and school)	1,000	Community
90400105	Kykotsmovi	Third Mesa	Kykotsmovi #1 and #2, and Kykotsmovi Day School #3 (inactive)	1967, 1977, and 1968	69.0	67.4	62.4	250 (includes 20 businesses, 200 residences, tribal headquarters, and 2 schools)	1,650	Community
90400106	Polacca	First Mesa	Polacca #5, #6 (inactive), and #8	1986, 1986, and 1998	30.0	134.5	57.1	450 (includes First Mesa Consolidated villages, Hopi Health Care Center, and school)	3,240	Community
90400107	Lower Sipaulovi	Second Mesa	Lower Sipaulovi #1	1978	22.7	23.6	19.7	60 (includes residences and 7 businesses)	535	Community
90400259	Shungopavi		Shungopavi #1	1969	18.9	21.2	37.8	300	1,500	Community
90400260	Hopi Cultural Center		Cultural Center #1	1969	11.2	10.7	6.7	3 (includes hotel, restaurant, business and several homes)	200	Hopi Office of Facilities Management
90400316	Hopi Veterans (Civic) Center	Third Mesa	VMC #1	1977	Not available	2.5	4.9	3 (includes fitness facility, concessions, offices, and residential use)	100	Hopi Office of Facilities Management
90400393	Lower Moencopi	Moenkopi Area	<u>N Aquifer Spring</u>	1988 (chlorination and distribution system completed)	Not available			5 distribution points	200	Community
90400394	Sipaulovi - Mishongnovi	Second Mesa	Mishongnovi-Sipaulovi #1	1978	3.1	6.0	6.1	40	405	Community
90400395	Hopi High School	First Mesa	HHS #1 and #2	1985 and 1984	13.0	38.2	44.0	48 (includes school, college, and 40 residences)	760 students, 225 staff, and 150-200 residents	BIA Facilities Management
90400687	Bacavi	Third Mesa	Bacavi #1	1992	Well not completed	21.5	21.3	134	434	Community
90400688	Spider Mound	Spider Mound	Spider Mound #1 and #2 (inactive)	1994 and 2003	Wells not completed	2.4 <sup>4</sup>	2.4 <sup>4</sup>	38 (25 inactive)	150	Community
90400700	Hotevilla	Third Mesa	Hotevilla #1 and #2	1994 and 2004	25.0	4.8	24.0	144 (includes post office, community buildings, service station, residences and 5 public hydrants)	1,200	Community
<b>Total:</b>					<b>291.6</b>	<b>501.1</b>	<b>445.3</b>			

Notes:

AFA = acre-feet per year.

<sup>1</sup> Sources: Andersen (2008), Litten (1992), TetraTech (2006), Thomas (2002), and Truini and Macy (2006).

<sup>2</sup> See Hopi Well Inventory (Appendix E of this preliminary HSR) for further details.

<sup>3</sup> All wells completed in the N Aquifer, except for the Spider Mound wells completed in the D Aquifer. Lower Moencopi PWS is supplied by an N Aquifer spring.

<sup>4</sup> Approximated from TetraTech (2006) pumping rate data.

**TABLE 6-4. DATA FOR SELECT WASTEWATER TREATMENT PLANTS ON THE HOPI INDIAN RESERVATION<sup>1</sup>**

<b>FACILITY NAME <sup>2</sup></b>	<b>AREA SERVED</b>	<b>POPULATION SERVED</b>	<b>EFFLUENT VOLUME TREATED/GENERATED (acre-feet/year)</b>	<b>DISPOSAL METHOD</b>	<b>CURRENT TREATMENT LEVEL <sup>3</sup></b>	<b>LOCAL POPULATION NOT SERVED</b>	<b>YEAR OF RECORD</b>
Bacobi WWTP	Bacavi	550	62	Groundwater Discharge	Not available	70	2000
Oraibi	Oraibi	500	56	Evaporation Pond	Secondary	Not available	2000
Shungopavi WWTF	Shungopavi	400	45	Evaporation Pond	Secondary	Not available	2000
Sipaulovi WWTF	Sipaulovi	500	56	Evaporation Pond	Secondary	200	2000

Notes:

<sup>1</sup> Source: ADWR (2006).

<sup>2</sup> WWTP = Wastewater Treatment Plant and WWTF = Wastewater Treatment Facility.

<sup>3</sup> Wastewater treated to a secondary level has received biological and/or physical/chemical treatment including lagoons and trickling filters (EPA, 2008).

**TABLE 6-5. RECENT ANNUAL REVENUES OF THE HOPI TRIBE <sup>1</sup>**

YEAR	COAL-RELATED <sup>2</sup>				Abandoned Mine Land Fund Grants <sup>3</sup>	INVESTMENT EARNINGS	LEASES AND RENTALS	FEES, FINES, AND FORFEITURES	MISCELLANEOUS
	Coal Royalties	Coal Bonuses	Water Royalties	Education Fund					
1964-85	\$ 16,995,908		\$ 93,573		About \$400,000/year				
1986	\$ 3,653,978		\$ 22,398			\$ 685,000	\$ 246,000	\$ 223,000	\$ 1,980,000
1987	\$ 4,288,961		\$ 18,418						
1988	\$ 8,129,224		\$ 1,472,852						
1989	\$ 8,571,728		\$ 1,553,695						
1990	\$ 7,904,384		\$ 1,301,416						
1991	\$ 9,404,966		\$ 1,435,984						
1992	\$ 8,680,258		\$ 1,686,030						
1993	\$ 8,870,230		\$ 1,591,440						
1994	\$ 10,705,146		\$ 1,617,576						
1995	\$ 11,788,379		\$ 1,821,212						
1996	\$ 10,010,122		\$ 1,881,908						
1997	\$ 9,857,701		\$ 1,858,544						
1998	\$ 10,683,567	\$ 1,800,000	\$ 1,897,184						
1999	\$ 10,010,995	\$ 750,000	\$ 1,911,262						
2000	\$ 10,691,240	\$ 750,000	\$ 2,078,868						
2001	\$ 10,947,123	\$ 1,750,000	\$ 2,247,453						
2002	\$ 10,650,646	\$ 750,000	\$ 2,303,098			\$ 5,019,115	\$ 889,697	\$ 1,040,498	\$ 11,857,483
2003	\$ 10,329,074	\$ 750,000	\$ 2,324,692			\$ 5,974,850	\$ 662,733	\$ 379,166	\$ 1,571,451
2004	\$ 12,039,775	\$ 1,750,000	\$ 2,222,753						
2005	\$ 14,658,400	\$ 750,000	\$ 2,233,700	\$ 1,900,000					
2006	\$ 13,255,600	\$ 10,460,700	\$ 1,485,200	\$ 169,000					
2007	\$ 10,281,600		\$ 498,300	\$ 170,000					

Notes:

<sup>1</sup> Source: SWCA (2008).

<sup>2</sup> Paid by or through Peabody Western Coal Company (PWCC).

<sup>3</sup> Fees by PWCC go into a federal fund which distributes revenue to the Hopi Tribe in the form of grants.

**TABLE 6-6. RECENT ANNUAL EXPENDITURES OF THE HOPI TRIBE<sup>1</sup>**

YEAR	GOVERNMENT EXPENDITURES	EXPENDITURES FROM GRANTS AND CONTRACTS <sup>2</sup>	TOTAL EXPENDITURES <sup>3</sup>	"EXCESS REVENUES" <sup>4</sup>
1986			\$ 5,000,000	
2000			\$ 16,968,165	\$ 65,590,342
2001			\$ 18,706,964	\$ 8,202,992
2002			\$ 18,647,997	\$ 13,854,116
2003		\$ 20,907,417		
2004		\$ 31,312,811		
2005	\$ 44,200,000	\$ 18,795,526		
2006	\$ 40,500,000	\$ 19,100,882		
2007	\$ 34,300,000	\$ 20,000,000		

Notes:

<sup>1</sup> Source: SWCA (2008).

<sup>2</sup> 2007 value is estimated.

<sup>3</sup> May or may not be total of government expenditures and expenditures from grants and contracts.

<sup>4</sup> Tribe reported these as expenditures.

**TABLE 6-7. RECENT AND PROJECTED HOPI POPULATIONS**

YEAR	POPULATION OF HOPI INDIAN RESERVATION	NUMBER OF HOPI		RESERVATION ETHNICITY					DATA SOURCE
		On Reservation	Off Reservation	American Indian	White	Other	Asian / Pacific Islander	Black	
1988		9,738	1,082						Hopi (1988)
1990	7,360 <sup>1</sup>								ADOC (2005)
	8,258								Census (2007)
2000	6,315 <sup>1</sup>	10,336		94%	4%	1%	<1%	<1%	Census (2003a,b and 2007)
	6,633 <sup>1</sup>								Hopi (2004)
	10,571								Hopi (2001)
2004	11,668								Hopi (2001)
		8,000	4,000						Taylor (2004)
2006	12,000 <sup>2,3</sup>								TetraTech (2006)
2007		12,575 <sup>4</sup>							Hopi (2008b)
2010	8,629								Hopi (2004)
	13,532								Hopi (2001)
2020	11,302								Hopi (2004)
	17,322								Hopi (2001)
2030	14,771								Hopi (2004)
2040	19,222								
2050	24,745								
2100	52,639								
2175 <sup>5</sup>	62,512								

Notes:

<sup>1</sup> These reported populations appear low based on comparison to prior and later years.

<sup>2</sup> Estimated based on number of people served by public water systems on the Reservation.

<sup>3</sup> Recent tribal survey estimated that 13% of Reservation population was not enrolled in Tribe, of which 6% were non-enrolled Hopi, 6% were other American Indians, and 1% were non-Indians (SWCA, 2008).

<sup>4</sup> Tribe anticipates number of members to increase by 40 persons per quarter or 160 new members per year.

<sup>5</sup> Year that population is projected to stabilize.

**TABLE 6-8. CHARACTERISTICS OF HOUSING ON THE HOPI INDIAN RESERVATION<sup>1</sup>**

HOUSING CHARACTERISTIC		1990	2000	2004	2006	circa 2007
Type	Single Attached or Detached		80.1%			
	Mobile Home		14.9%			
	Multiple (2-9) Units		4.9%			
Occupancy	Households Occupied	75%	78%			
	Average Persons per Household	3.93				2
	New Housing Needs to Address Overcrowding		315 units			26% <sup>2</sup>
Fuel Source	Wood		29%			
	Coal		10%			
	Electric		5%			
	Other		34%			
Condition	Lacking Complete Plumbing		40%	18%		
	Repairs Needed					>50% <sup>3</sup>
	Dilapidated		447 <sup>4</sup>			2% <sup>3</sup>
Financials	Median Value		\$42,400			
	HHTA funding from Indian Housing Block Grant <sup>5</sup>				\$2.9 million	\$2.6 million
Total Units		2,476	2,464			3,061 (occupied)

Notes:

<sup>1</sup> Sources: Census (2007), Hopi (2001, 2004, and 2008b), and TDR (2008).

<sup>2</sup> Percentage of households responding to recent survey.

<sup>3</sup> Percentage of occupied housing units.

<sup>4</sup> Estimated housing units needed to replace those considered beyond structural repair.

<sup>5</sup> HHTA = Hopi Tribal Housing Authority.

**TABLE 6-9. EMPLOYMENT AND INCOME DATA FOR THE HOPI INDIAN RESERVATION<sup>1</sup>**

CATEGORY / YEAR		1986	1988	1990	1999	2000	2001	2003	2004	2005	2006	circa 2007	2008
Labor Force				2,308	3,055		3,982	3,451	3,457		2,455	2,392 to 3,879	
Women in Workforce						52 to 59%						53.0%	
Unemployment Rate			32.0%	20.5%	62.0%	18.0%	60.0%	20.9%	18.2%		10.9%	10% to 29.8%	35.6%
Jobs		1,341				1,869 to 2,700							
Employment Sectors <sup>2</sup>	Education, Health, and Social Services	27.3%				33.5 to 37%							
	Public Administration	35.0%				7 to 25.9%							
	Manufacturing	2.2%				5.5 to 40%							
	Wholesale and Retail Trade	27.3%				5 to 8.6%							
	Construction	4.5%				3 to 10.5%							
	Transportation and Utilities	1.8%				1.4 to 4%							
	Finance, Insurance, and Real Estate	0%				1 to 1.8%							
	Agriculture	1.5%				0.4 to 3%							
	Arts, Entertainment, and Recreation	0.0%				0 to 7%							
	Professional, Science, Management and Waste Services	0.0%				0 to 2.6%							
Mining	0.4%				0 to 0.6%								
Employer	Government					55%						46%	
	Private Sector					45%						54%	
Earnings	Formal Economy					\$44.8 million							
	Informal Economy <sup>3</sup>					≥\$4.2 million							
Income	Per Capita					\$8,637							
	Below Poverty Level				61.0%	38.9%							
	Median Family				\$15,875	\$22,989						\$41,250 <sup>4</sup>	

Notes:

<sup>1</sup> Sources: ADES (2008), ADOC (2008a,b), Census (2007), Hopi (1988, 2001 and 2008b), Sonoran Institute (2005), SWCA (2005 and 2008), and TDR (2000 and 2008).

<sup>2</sup> Different data sources and sector definitions may explain the range in values reported for 2000 and some of the differences between values for 2000 and 1986.

<sup>3</sup> Includes \$3.6 million in traditional arts and crafts, \$600,000 for local cattle consumption and giveaways, and an unknown amount for corn harvests.

<sup>4</sup> Households that were queried were found to have a median income of only \$9,600.

**TABLE 7-1. SUMMARY OF USGS STREAMFLOW DATA COLLECTED ON AND NEAR THE HOPI INDIAN RESERVATION<sup>1</sup>**

GENERAL AREA	STREAM	GAGE NUMBER (location) <sup>2</sup>	CONTRIBUTING DRAINAGE AREA (square miles)	PERIOD OF RECORD	NO. OF DAILY MEAN FLOW MEASUREMENTS	ANNUAL FLOW (acre-feet) <sup>3</sup>				AVERAGE SEASONAL FLOW (as % of annual flow) <sup>4</sup>				TYPICAL FLOW DURATION (% of days each year with flow) <sup>5</sup>	STREAMFLOW REGIME <sup>6</sup>
						Minimum	Median	Mean	Maximum	Winter	Spring	Summer	Fall		
PWCC Leasehold (Upper Moenkopi Wash) <sup>7</sup>	Coal Mine Wash	09401239 (near Shonto)	137	1978-82	1,623	Not calculated due to short period of record				20	11	48	21	63%	Intermittent
	Coal Mine Wash Tributary 1	09401226 (near Kayenta)	0.64	1977-81	1,461					2	4	90	4	0.3%	Ephemeral
	Coal Mine Wash Tributary 2	09401229 (near Kayenta)	0.06	1977-79	730					0	0	0	100	2.5%	Ephemeral
Hopi Washes	Dinnebito Wash	09401110 (near Sand Springs)	473	1993-06	4,594	312	2,297	2,787	6,687	6	2	73	19	100%	Perennial
	Jeddito Wash	09400583 (near Jeddito)	147	1993-05	4,445	14	145	298	1,427	0	1	89	11	0%	Ephemeral
	Moenkopi Wash	09401250 (near Moenkopi)	1,650	1973-76	1,004	Not calculated due to short period of record				11	4	76	9	93%	Intermittent
		09401260 (at Moenkopi)	1,629	1976-06	11,141	1,376	7,462	7,292	14,779	12	4	63	21	84%	Intermittent
		09401280 (at Moenkopi)	1,904	1926-40	5,206	5,412	9,780	16,345	45,858	8	2	81	10	76%	Intermittent
		09401400 (near Tuba City)	2,492	1940-78	9,824	2,181	8,838	11,165	44,482	8	2	58	33	70%	Intermittent
	09401500 (near Cameron)	2,662	1953-65	4,141	3,673	6,940	9,988	19,923	6	3	79	13	52%	Intermittent	
	Oraibi Wash	09400562 (near Talani Lakes)	635	1995-06	4,177	433	2,260	2,423	6,564	7	0	68	25	3.8%	Ephemeral
Polacca Wash	09400568 (near Second Mesa)	905	1994-06	4,438	194	2,126	2,319	6,151	3	1	68	28	100%	Perennial	
LCR Drainage	Little Colorado River	09401000 (at Grand Falls)	21,068	1925-95	13,750	18,474	160,469	194,626	588,119	38	24	30	7	80%	Intermittent
		09402000 (near Cameron)	26,459	1947-06	21,764	16,952	135,185	159,760	603,478	35	25	26	14	81%	Intermittent
		09402300 (near Desert View)	26,946	1990-06	2,038	Not calculated due to short period of record				37	23	22	18	100%	Perennial

Notes:

<sup>1</sup> Source: ADWR (2008g).

<sup>2</sup> Gage locations are shown in Figure 7-1.

<sup>3</sup> Statistics based on Calendar Year (CY) data.

<sup>4</sup> 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%.

<sup>5</sup> Based on median of daily mean flows calculated over period of record.

<sup>6</sup> 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).

<sup>7</sup> PWCC = Peabody Western Coal Company.

**TABLE 7-2. HYDROLOGIC FACTORS AFFECTING STREAMFLOWS AT USGS GAGES ON AND NEAR THE HOPI INDIAN RESERVATION <sup>1</sup>**

GENERAL AREA	STREAM	GAGE NUMBER (location) <sup>2</sup>	STREAMFLOW REGIME <sup>3</sup>	STREAMFLOW GAINS <sup>4</sup>			STREAMFLOW LOSSES <sup>4</sup>	
				Snowmelt Runoff	Storm Runoff	Baseflow	Evapotranspiration and Transmission Losses	Well Pumpage
PWCC Leasehold (Upper Moenkopi Wash) <sup>5</sup>	Coal Mine Wash	09401239 (near Shonto)	Intermittent	W,S	A	A	A	
	Coal Mine Wash Tributary 1	09401226 (near Kayenta)	Ephemeral	(W),(Sp)	S,F		A	
	Coal Mine Wash Tributary 2	09401229 (near Kayenta)	Ephemeral	(W),(Sp)	F		A	
Hopi Washes	Dinnebito Wash	09401110 (near Sand Springs)	Perennial	(W),(Sp)	S,F	A	A	(A)
	Jeddito Wash	09400583 (near Jeddito)	Ephemeral		S,F		A	(A)
	Moenkopi Wash	09401250 (near Moenkopi)	Intermittent	(W),(Sp)	(W),S,F	A	A	(A)
		09401260 (at Moenkopi)	Intermittent	(W),(Sp)	(W),S,F	A	A	(A)
		09401280 (at Moenkopi)	Intermittent	(W)	S,F	A	A	(A)
		09401400 (near Tuba City)	Intermittent	(W),(Sp)	S,F	A	A	
	09401500 (near Cameron)	Intermittent	(W),(Sp)	S,F	A	A		
	Oraibi Wash	09400562 (near Talani Lakes)	Ephemeral	(W),(Sp)	S,F		A	(A)
Polacca Wash	09400568 (near Second Mesa)	Perennial	(W),(Sp)	(W),S,F	A	A	(A)	
LCR Drainage	Little Colorado River	09401000 (at Grand Falls)	Intermittent	W,Sp	S,F		A	
		09402000 (near Cameron)	Intermittent	W,Sp	S,F		A	
		09402300 (near Desert View)	Perennial	W,Sp	S,F	A		

Notes:

<sup>1</sup> Source: ADWR (2008g).

<sup>2</sup> Gage locations are shown in Figure 7-1.

<sup>3</sup> For purposes of this HSR, ephemeral flow conditions were assumed if typical flow duration was less than 10% of year and intermittent flow conditions if flow duration was 10% or greater but less than 100% of year (perennial).

<sup>4</sup> A = all year, F = Fall, S = Summer, Sp = Spring, W = Winter, and ( ) = potential minor effect.

<sup>5</sup> PWCC = Peabody Western Coal Company.

**TABLE 7-3. ESTIMATED STREAM INFLOWS AND OUTFLOWS ON THE HOPI INDIAN RESERVATION<sup>1,2</sup>**

ESTIMATION POINT <sup>3</sup>		MEAN STREAMFLOW (in acre-feet/year)			MEDIAN STREAMFLOW (in acre-feet/year)		
		Lower Bound <sup>4</sup>	Estimated Flow	Upper Bound <sup>4</sup>	Lower Bound <sup>4</sup>	Estimated Flow	Upper Bound <sup>4</sup>
INFLOWS	I-1	500	659	868	1,180	1,440	1,770
	I-2	215	349	568	352	513	746
	I-3	124	191	295	440	559	709
	I-4	230	381	631	630	876	1,220
	I-5	256	404	639	320	501	785
	I-6	60.9	106	186	81.2	140	240
	I-7	93.7	162	282	101	159	250
	I-8	117	196	328	171	255	382
	I-9	48.8	71.9	106	141	222	349
	I-10	53	92.5	161	199	350	614
	I-11	225	378	634	828	1,280	1,960
	I-12	1.32	3.94	11.8	0.87	1.29	1.9
	I-13	2,140	3,830	6,850	2,910	4,540	7,060
		<b>Total Inflows<sup>5</sup></b>	<b>4,060</b>	<b>6,820</b>	<b>11,600</b>	<b>7,350</b>	<b>10,800</b>
OUTFLOWS	O-1	169	265	413	738	880	1,050
	O-2	80.8	135	227	273	385	543
	O-3	111	191	329	111	208	389
	O-4	886	1,250	1,760	1,000	1,520	2,300
	O-5	1,030	1,610	2,520	1,190	1,560	2,040
	O-6	1,390	1,780	2,280	1,500	2,470	4,050
	O-7	2,110	4,000	7,590	3,330	5,690	9,710
	O-8	3,340	4,710	6,630	3,240	4,230	5,530
		<b>Total Outflows<sup>5</sup></b>	<b>9,120</b>	<b>13,900</b>	<b>21,700</b>	<b>11,400</b>	<b>16,900</b>
	<b>(Total Outflows - Total Inflows)</b>	<b>5,060</b>	<b>7,080</b>	<b>10,100</b>	<b>4,050</b>	<b>6,100</b>	<b>9,500</b>

Notes:

<sup>1</sup> Source: ADWR (2008g).

<sup>2</sup> Estimated for the base period 1981-2006.

<sup>3</sup> Point locations are shown in Figure 7-6.

<sup>4</sup> Lower bound represents (-1) standard deviation confidence limit and upper bound represents (+1) standard deviation confidence limit.

<sup>5</sup> Due to Reservation boundary shape and stream locations, some outflows become inflows again over relatively short distances.

**TABLE 7-4. WATER QUALITY EXCEEDENCES AT STREAM SITES ON AND NEAR THE HOPI INDIAN RESERVATION<sup>1</sup>**

STREAM	SAMPLE SITE	MAP ID NUMBER <sup>2</sup>	WATER QUALITY STANDARD <sup>3,4</sup>			
			Primary Drinking Water	Secondary Drinking Water	Livestock Water	Irrigation
Begashibito Wash	near Mouth	13		pH, SC		
Coal Mine Canyon	at Mouth	12		SO <sub>4</sub>	F	
Dinnebito Wash	at Dinnebito Spring	19		pH, SC, SO <sub>4</sub>		
	near Sand Springs	17		pH, SC, SO <sub>4</sub> , TDS	pH, SO <sub>4</sub>	
	at Sand Valley	16		pH, SC, SO <sub>4</sub>		
	at Sweetwater Well	18		pH, SC		
Horse Corral Tributary		14		pH, SC, SO <sub>4</sub>		
Jeddito Wash	near Jeddito	24		SO <sub>4</sub>		
Moenkopi Wash	at Begashibito Wash	6		pH, SC		
	at Campfire	7		pH, SC		
	at Falls	4		pH, SC, SO <sub>4</sub>		
	at Hopi Boundary	11		SO <sub>4</sub> , TDS	SO <sub>4</sub> , TDS	TDS
	at Horse Corral Tributary	9		pH		
	at Kerley Valley	1		pH, SC, SO <sub>4</sub>		
	at Moenkopi	2		pH, SC, SO <sub>4</sub>	SO <sub>4</sub>	
	near Moenkopi	3		NO <sub>2</sub> , NO <sub>3</sub>	Fe, pH, SC, SO <sub>4</sub>	Fe, pH, SC, SO <sub>4</sub>
	at Sand Spring	8		pH		
	at Shonto Well	5		pH, SC, SO <sub>4</sub>		
Oraibi Wash	at Water Caves	10		pH, SC		
	near Forest Lake	21		SO <sub>4</sub>		
Polacca Wash	near Tolani Lake	20		SO <sub>4</sub> , TDS		
	at Highway 87	23		SO <sub>4</sub>		
Yucca Flat Wash	near Second Mesa	22		SO <sub>4</sub> , TDS	SO <sub>4</sub>	
	at CG85	15	As, B, Ba, Cd, Cr, Cu, Pb, Sb, T, U	Al, Ag, Cu, Fe, Mn, pH, SC, SO <sub>4</sub>	B, Cr, Cu, Pb	B

Notes:

<sup>1</sup> Source: ADWR (2008i).

<sup>2</sup> See Figure 7-7 for location of sample sites.

<sup>3</sup> Ag = silver, Al = aluminum, As = arsenic, B = boron, Ba = barium, Cd = cadmium, Cr = chromium, Cu = copper, F = fluoride, Fe = iron, Mn = manganese, NO<sub>2</sub> = nitrite, NO<sub>3</sub> = nitrate, Pb = lead, Sb = antimony, SC = specific conductance, SO<sub>4</sub> = sulfate, T = turbidity, TDS = total dissolved solids, and U = uranium.

<sup>4</sup> Drinking water standards from EPA (2003a), livestock standards from Soltanpour and Raley (1999), and irrigation standards from ADEQ (2007).

**TABLE 7-5. ESTIMATED SEDIMENT LOADS AT STREAM SITES ON AND NEAR THE HOPI INDIAN RESERVATION<sup>1</sup>**

STREAM	ESTIMATION SITE	MAP ID NUMBER <sup>2</sup>	DRAINAGE AREA (square miles)	MEAN ANNUAL SEDIMENT LOAD	
				in acre-feet/year <sup>3</sup>	in acre-feet/year/square mile <sup>4</sup>
Begashibito Wash	at Kletha Valley	1	498	30.7	0.062
Corn Creek Wash	at Mouth	2	875	68	0.0078
Dinnebito Wash	at Mouth	3	741	415	0.56
Jeddito Wash	on Egloffstien Butte Quad	4	145	3.79	0.026
	at Jeddito Unit	5	71.3	3.02	0.042
	at Mouth	6	1,048	198	0.19
Little Colorado River	at Cameron	7	21,764	4,730 - 5,710	0.22 - 0.26
	at Grand Falls	8	13,750	3,560	0.26
Moenkopi Wash	at Begashibito Wash	9	760	58.3	0.077
	at Moenkopi Unit	10	126	16.9	0.13
	at Mouth	11	2,623	721	0.28
Oraibi Wash	at Hard Rock	12	350	76	0.22
	at Mouth of Polacca Wash	13	718	69.2	0.096
	near Oraibi	14	494	75.5	0.15
Polacca Wash	near Highway 264	15	474	68.7	0.14
	at Mouth	16	1,070	78.4 - 509	0.073 - 0.48
	at Polacca Unit	17	876	80.6	0.092
Wepo Wash	at Wepo Unit	18	188	10.4	0.055

Notes:

<sup>1</sup> Source: ADWR (2008i).

<sup>2</sup> See Figure 7-8 for location of estimation sites.

<sup>3</sup> Assumes sediment is deposited at a bulk density of 2,100 tons per acre-foot (USDA, 1981).

<sup>4</sup> Calculated by dividing sediment load in acre-feet per year, by drainage area in square miles.

**TABLE 7-6. RECENT CONDITION OF IMPOUNDMENTS IDENTIFIED BY ADWR ON THE HOPI INDIAN RESERVATION<sup>1</sup>**

CONDITION		NUMBER OF IMPOUNDMENTS		
		Claimed	Unclaimed	Total
<i>Total Impoundment Inventory</i>		561	180	741
Means of Identification	Aerial photo analysis <sup>2</sup>	429	172	601
	Ground inspection <sup>3</sup>	128	8	136
	Unable to verify	4	---	4
Berms <sup>4</sup>	Appear adequate	274	123	397
	Breached <sup>5</sup>	237	57	294
	Degraded or eroded	44	Undetermined	44
	Under construction or removed	2	0	2
Natural Depressions <sup>4</sup>	Impoundment is natural depression with no berm	10	1	11
	Berm occurs within natural depression	4	0	4
Effects from Siltation <sup>4</sup>	Limited storage due to siltation	53	3	56
	Multiple (2 or more) impoundments at site	9	4	13
	Silt trap at site	3	1	4
Surface Area <sup>6</sup>	< 1 acre	145	82	227
	≥ 1 acre	173	41	214
Uses	Stock <sup>7</sup>	561	Undetermined	561
	Flood/erosion control <sup>8</sup>	16	3	19
	Associated with agriculture <sup>9</sup>	7	31	38
	Peabody Western Coal Company sediment pond <sup>10</sup>	8	7	15
	Recreation reservoir <sup>7</sup>	4	1	5

Notes:

<sup>1</sup> See Appendix C of this preliminary HSR for a detailed inventory of impoundments on the Reservation.

<sup>2</sup> Black and white (1997) and color (2005) aerial photography were used.

<sup>3</sup> Conducted during 2005, 2006, and 2008.

<sup>4</sup> Determined by ADWR through ground inspection and/or aerial photo analysis.

<sup>5</sup> Forty (40) breached berms were observed in the field and 254 were identified during photo analysis.

<sup>6</sup> ADWR did not estimate the surface area of impoundments with breached berms or those it could not verify, found under construction or were removed.

<sup>7</sup> All impoundments were claimed for stock use and 4 were also claimed by the Hopi as recreational reservoirs. Two of the claimed recreational reservoirs were found by ADWR in the field to be partially or completely silted in. One unclaimed impoundment (Pasture Canyon Reservoir) was determined by ADWR to be used for recreation and irrigation.

<sup>8</sup> Apparent use based on ADWR's review of berm design and location.

<sup>9</sup> Based on comparison to 2005 agricultural lands identified by ADWR (2008c).

<sup>10</sup> One claimed impoundment was a PWCC sediment pond that was removed during mine reclamation.

**TABLE 7-7. CLAIMED AND ESTIMATED CAPACITY OF IMPOUNDMENTS ON THE HOPI INDIAN RESERVATION <sup>1</sup>**

BERM CONDITION DETERMINED BY ADWR <sup>2</sup>		CLAIMED IMPOUNDMENTS				UNCLAIMED IMPOUNDMENTS			
		Number	Capacity (in acre-feet)		Estimated Surface Water Depletion <sup>7</sup>	Number	Capacity (in acre-feet)		Estimated Surface Water Depletion <sup>7</sup>
			Claimed by Hopi and U.S.	Estimated by ADWR			Claimed by Hopi and U.S.	Estimated by ADWR	
Not Breached <sup>3,4,5</sup>	< 1 acre surface area	145	2,436	122	122	82	---	33	33
	≥ 1 acre surface area	173		2,068	1,034	41	---	330	165
	<i>Subtotal</i>	<i>318</i>	<i>2,436</i>	<i>2,190</i>	<i>1,156</i>	<i>123</i>	<i>---</i>	<i>363</i>	<i>198</i>
Breached <sup>6</sup>		237	2,039	0	---	57	---	0	---
Unverified, Under Construction, or Removed <sup>6</sup>		6	24	0	---	0	---	0	---
<b>Total Inventory</b>		<b>561</b>	<b>4,499</b>	<b>2,190</b>	<b>1,156</b>	<b>180</b>	<b>0</b>	<b>363</b>	<b>198</b>

Notes:

<sup>1</sup> See Appendix C of this preliminary Hopi HSR for a detailed inventory of Reservation impoundments.

<sup>2</sup> Recent impoundment conditions are further summarized in Table 7-6.

<sup>3</sup> ADWR estimated the capacity of 64 claimed impoundments using field measurements and 254 claimed impoundments using a regression equation based on its field measurements and surface areas from ADWR photo analysis. The capacity of all unclaimed impoundments was estimated by ADWR using its regression equation and surface areas from photo analysis.

<sup>4</sup> ADWR did not attempt to reduce capacity estimates for 56 impoundments with limited storage due to siltation or 44 impoundments with degraded or eroded berms.

<sup>5</sup> Silt traps at 4 impoundment sites were not included in capacity estimates, but multiple impoundments at 13 sites were considered.

<sup>6</sup> ADWR did not estimate the capacity of impoundments with breached berms or those it could not verify, found under construction or were removed.

<sup>7</sup> ADWR estimated by assuming impoundments with <1 acre surface area fill twice a year (in spring and summer), and those with ≥1 acre surface area fill once a year. It was further assumed that 50% of the impounded water would be felt as a loss (depletion) at the drainage mouth.

**TABLE 7-8. CHARACTERISTICS OF SPRINGS IDENTIFIED BY ADWR ON THE HOPI INDIAN RESERVATION<sup>1</sup>**

CHARACTERISTIC		NUMBER OF SPRINGS		
		Claimed <sup>2</sup>	Unclaimed <sup>2</sup>	Total
<i>Total Inventory</i>		360	42	402
ADWR Means of Identification	Reports and/or topographic maps <sup>3</sup>	224	30	254
	Ground inspection <sup>4</sup>	104	12	116
	Unable to verify	32	---	32
Water Sources <sup>5</sup>	Alluvial Aquifer	24	1	25
	Colluvial Aquifer	22	1	23
	Spring Deposits	7	0	7
	T Aquifer (Mesa Verde Formation)	90	13	103
	D Aquifer	4	1	5
	N Aquifer	75	7	82
	Unknown	138	19	157
Water Quality Exceedences <sup>6</sup>	Available water quality data	72	4	76
	One or more exceedence	48	3	51
	Nitrate	22	0	22
	Sulfate	22	0	22
	Total Dissolved Solids	31	3	34
Improvements <sup>5</sup>	Some form of development	73	10	83
	Trough	39	5	44
	Spring box	21	1	22
Uses <sup>7</sup>	Ceremonial/cultural	360	1	361
	Stock	351	7	358
	Domestic	337	11	348
	Irrigation	17	8	25
	Municipal	0	0	0
Special Circumstances	Outside Reservation Boundary <sup>8</sup>	18	7	25
	Potential duplicate spring claims	6	0	6
	Also claimed as well	1	1	2

Notes:

<sup>1</sup> See Appendix D of this preliminary HSR for a detailed inventory of springs on the Reservation.

<sup>2</sup> Claimed springs include 338 springs listed in the 2004 Hopi and U.S. SOCs, plus 22 other springs that a U.S. consultant provided ADWR information on in 2005. The Hopi and U.S. anticipate amending their claims to include the other springs, so for purposes of this HSR, ADWR included them in the claimed category. Unclaimed springs include those springs ADWR identified on the Reservation that were not in the claimed category.

<sup>3</sup> List of reports included in Appendix D.

<sup>4</sup> Conducted during 2006.

<sup>5</sup> Largely determined from existing reports with some field data collected by ADWR; see Appendix D.

<sup>6</sup> Common water quality exceedences included nitrate (primary drinking water standard), sulfate (secondary drinking water and/or livestock standard), and total dissolved solids (secondary drinking water standard).

<sup>7</sup> All springs were claimed for ceremonial/cultural use and other uses for many of the springs overlap with 351 claimed for stock use, 337 claimed for domestic use, and 17 claimed for irrigation use. Reports and/or field investigations indicated that another 52 claimed springs had been used for irrigation and three had been used for municipal supply. Known uses for the potentially unclaimed springs came from these reports and ADWR ground inspections.

<sup>8</sup> Eighteen (18) claimed springs and three potentially unclaimed springs are located along Pasture Canyon outside of the Reservation boundary, 3 other unclaimed springs are located on Hopi allotted lands, and one unclaimed spring (Cliff Spring) is located on Navajo Partitioned Land east of the Reservation.

**TABLE 7-9. MEASURED DISCHARGE AND CLAIMED QUANTITY FOR SPRINGS IN THE VICINITY OF THE HOPI INDIAN RESERVATION<sup>1,2,3</sup>**

WATER SOURCE	DISCHARGE MEASUREMENTS?	CLAIMED SPRINGS <sup>4</sup>					UNCLAIMED SPRINGS <sup>4</sup>			
		Number of Springs	Measured Discharge (gallons per minute)		Claimed Quantity (gallons per minute)		Number of Springs	Measured Discharge (gallons per minute)		Total Claimed Quantity (gallons per minute)
			Range	Total	Range	Total		Range	Total	
Alluvial Aquifer	Yes	15	0 to 25	21 to 72	4	60	1	2	2	0
	No	9	---	---	4	36	0	---	---	0
Colluvial Aquifer	Yes	13	0 to 8	13 to 20	4	52	1	0.2	0.2	0
	No	9	---	---	4	36	0	---	---	0
Spring Deposits	Yes	5	0.1 to 1.2	1.5 to 4.7	4	20	0	---	---	0
	No	2	---	---	4	8	0	---	---	0
T Aquifer (Mesa Verde Formation)	Yes	67	0 to 50	99 to 202	4 to 8	272	11	0 to 8.5	18.3 to 18.4	0
	No	23	---	---	4	92	2	---	---	0
D Aquifer	Yes	3	<0.01 to 2	2 to 4	4	12	1	0.1 to 1	0.1 to 1	0
	No	1	---	---	4	4	0	---	---	0
N Aquifer	Yes	69	0 to 326	202 to 777	4 to 19	531	5	<0.01 (seeps)	<0.01 (seeps)	0
	No	6	---	---	4	24	2	---	---	0
Unknown	Yes	36	0 to 7	21 to 23	4 to 6	134	10	0 to 7.5	9.4 to 9.6	0
	No	102	---	---	4	420	9	---	---	0
<b>Total</b>		<b>360</b>	<b>0 to 326</b>	<b>360 to 1,103</b>	<b>4 to 19</b>	<b>1,701</b>	<b>42</b>	<b>0 to 8.5</b>	<b>30 to 31</b>	<b>0</b>

Notes:

<sup>1</sup> See Appendix D of this preliminary HSR for a detailed inventory of Reservation springs.

<sup>2</sup> Spring characteristics are further summarized in Table 7-8.

<sup>3</sup> Water source and discharge data largely determined from reports listed in Appendix D with some field data collected by ADWR in 2006.

<sup>4</sup> Claimed springs include 338 springs listed in the 2004 Hopi and U.S. SOCs, plus 22 other springs that a U.S. consultant provided ADWR information on in 2005. The Hopi and U.S. anticipate amending their claims to include the other springs, so for purposes of this HSR, ADWR included them in the claimed category. Unclaimed springs include those springs ADWR identified on the Reservation that were not in the claimed category.

**TABLE 7-10. CHARACTERISTICS OF WELLS IDENTIFIED BY ADWR ON THE HOPI INDIAN RESERVATION<sup>1</sup>**

CHARACTERISTIC		NUMBER OF WELLS		
		<i>Claimed<sup>2</sup></i>	<i>Unclaimed<sup>2</sup></i>	<b>Total</b>
<i>Total Inventory</i>		234	58	292
ADWR Means of Identification	Reports and/or topographic maps <sup>3</sup>	169	54	223
	Ground inspection <sup>4</sup>	51	4	55
	Unable to verify	14	---	14
Water Sources <sup>5</sup>	Alluvial/Colluvial Aquifer	33	10	43
	Bidahochi Aquifer	1	0	1
	T Aquifer (Mesa Verde Group)	24	9	33
	D Aquifer	48	12	60
	N Aquifer	61	7	68
	C Aquifer	1	0	1
	Unknown	66	20	86
Water Quality Exceedences <sup>5,6</sup>	Available water quality data	95	29	124
	One or more exceedence	85	26	111
	Arsenic	17	0	17
	Fluoride	27	5	32
	Nitrate	21	10	31
	pH	28	3	31
	Sulfate	41	11	52
	Total Dissolved Solids	69	16	85
Uses <sup>7</sup>	Domestic	178	22	200
	Stock	170	18	188
	Municipal	28	8	36
	Unspecified	2	5	7
Special Circumstances	Previously reported as abandoned	13	3	16
	Previously reported or ADWR found inactive/unused	10	5	15
	Previously reported or ADWR found dry	12	1	13
	ADWR found to be natural feature	3	0	3
	Potential duplicate well claims	6	---	6
	Also claimed as spring	1	0	1

Notes:

<sup>1</sup> See Appendix E of this preliminary HSR for a detailed inventory of wells on the Reservation.

<sup>2</sup> Claimed wells include 206 wells listed in the 2004 Hopi and United States SOCs, plus 28 other wells that the Hopi and a U.S. consultant provided ADWR information on in 2005. The Hopi and United States anticipate amending their claims to include the other wells, so for purposes of this HSR, ADWR included them in the claimed category. Unclaimed wells include those wells ADWR identified on the Reservation that were not in the claimed category.

<sup>3</sup> List of reports included in Appendix E.

<sup>4</sup> Conducted during 2006.

<sup>5</sup> Largely determined from existing reports, with some field data collected by ADWR.

<sup>6</sup> Common water quality exceedences included arsenic and nitrate (primary drinking water standards), fluoride and pH (secondary drinking water and/or livestock standards) and sulfate and total dissolved solids (secondary drinking water standards). See Appendix E.

<sup>7</sup> Claimed well uses come from the Hopi and United States, and most wells have multiple uses. Uses for the unclaimed wells come from reports and ADWR ground inspections.

**TABLE 7-11. WELL DEPTHS, WATER LEVELS AND CLAIMED QUANTITIES FOR WELLS ON THE HOPI INDIAN RESERVATION<sup>1,2,3</sup>**

AQUIFER	CLAIMED WELLS <sup>4</sup>								UNCLAIMED WELLS <sup>4</sup>						
	Total Number of Wells	Well Depth (feet bgs)		Water Level (feet bgs) <sup>5</sup>		Number of Dry Wells	Claimed Quantity (gallons per minute) <sup>6</sup>		Total Number of Wells	Well Depth (feet bgs)		Water Level (feet bgs) <sup>5</sup>		Number of Dry Wells	Total Claimed Quantity (gallons per minute)
		Range	Median	Range	Median		Range	Total		Range	Median	Range	Median		
Alluvial/Colluvial	33	3.5 to 200	97	3.1 to 83.0	45	6	4 to 5	132 to 135	10	3.5 to 191	26.5	1 to 43	11.3	0	0
Bidahochi	1	350	---	209	---	0	1	4	0	---	---	---	---	0	0
T Aquifer	24	14.5 to 730	413	10.5 to 492	195	1	4 to 8	96 to 101	9	6.5 to 950	164	7.1 to 520	133	1	0
D Aquifer	48	190 to 1,367	705	0 to 706 <sup>7</sup>	268	1	0 to 8	184 to 199	13	13.5 to 1,500	715	0 to 594 <sup>6</sup>	162	0	0
N Aquifer	61	5.5 to 1,935	745	1.7 to 1,021	353	2	0 to 8	160 to 170	7	7 to 1,790	938	4.7 to 890	130	0	0
C Aquifer	1	3,215	---	963	---	0	0	0	0	---	---	---	---	0	0
Unknown	66	7 to 1,104	31	1.6 to 254.2	56.6	2	4 to 5	268 to 271	20	12	12	---	---	0	0
<b>Total</b>	<b>234</b>	<b>3.5 to 3,215</b>	<b>---</b>	<b>0 to 1,021</b>	<b>---</b>	<b>12</b>	<b>0 to 8</b>	<b>840 to 876</b>	<b>59</b>	<b>3.5 to 1,790</b>	<b>---</b>	<b>0 to 890</b>	<b>---</b>	<b>1</b>	<b>0</b>

Notes:

<sup>1</sup> See Appendix E of this preliminary Hopi HSR for a detailed inventory of Reservation wells.

<sup>2</sup> Other well characteristics are summarized in Table 7-10.

<sup>3</sup> Well depths and water levels, in feet below ground surface (bgs), and aquifers were largely determined from reports listed in Appendix E, with some field data collected by ADWR in 2006. These data were not available for all claimed or unclaimed wells; see Appendix E for wells that had available data and dates of well development and water level measurements.

<sup>4</sup> Claimed wells include 206 wells listed in the 2004 Hopi and U.S. SOC's, plus 28 other wells the Hopi and a U.S. consultant provided ADWR information on in 2005. The Hopi and U.S. anticipate amending their claims to include the other wells, so for purposes of this HSR, ADWR included them in the claimed category. Unclaimed wells include those wells ADWR identified on the Reservation that were not in the claimed category.

<sup>5</sup> Most recent water level measurements available to ADWR are tabulated.

<sup>6</sup> The range in claimed quantities results from different values from the Hopis and United States.

<sup>7</sup> Four claimed and 1 potentially unclaimed D Aquifer wells were reportedly flowing.

**TABLE 7-12. ESTIMATES OF THE VOLUME OF WATER STORED IN THE N AQUIFER<sup>1</sup>**

YEAR	GROUNDWATER MODEL	AREA <sup>2</sup>	VOLUME OF WATER IN STORAGE (in million acre-feet)	DATA SOURCE
1964	U.S. Geological Survey (USGS)	USGS Model Area	180	Eychaner (1983)
2000	Western Navajo Hopi N Aquifer (WNHN)	Arizona	525.9	ADWR (2008h)
		Hopi Indian Reservation	159.4	
		<i>District 6</i>	61.7	
		<i>Hopi Partition Lands</i>	91.8	
		<i>Moenkopi Area</i>	5.9	
		Navajo Partition Lands	89.8	
		Other Navajo Lands in Arizona	276.7	
2004-2006 <sup>3</sup>	Peabody Western Coal Company (PWCC)	PWCC Model Area	386 <sup>4</sup>	Roemer (2007)

Notes:

<sup>1</sup> All estimates assume an aquifer specific yield of (0.1).

<sup>2</sup> See Figures 7-21, 7-26 and 7-30 for the aerial extent of the WNHN, USGS, and PWCC models, respectively.

<sup>3</sup> 2004 data from Navajo and Hopi municipal wells and 2006 data from PWCC industrial wells.

<sup>4</sup> An additional 420,000 acre-feet of water are estimated to be stored under pressure in the confined portion of the aquifer.

**TABLE 7-13. WELL WITHDRAWALS FROM THE N AQUIFER SINCE 1965<sup>1</sup>**

PERIOD	PWCC INDUSTRIAL WITHDRAWALS <sup>2</sup>			NAVAJO AND HOPI MUNICIPAL WITHDRAWALS <sup>3</sup>			TOTAL WITHDRAWALS (acre-feet)
	Average Annual (acre-foot)	Total (acre-foot)	Percentage of Total	Average Annual (acre-foot)	Total (acre-foot)	Percentage of Total	
1965-1972	808	6,460	72	309	2,470	28	8,930
1973-1984	3,878	46,540	70	1,661	19,930	30	66,470
1985	2,520	2,520	53	2,200	2,200	47	4,720
1986-2004	4,111	78,100	60	52,750	52,750	40	130,850
2005	4,480	4,480	61	2,850	2,850	39	7,330
<b>1965-2005</b>	<b>3,368</b>	<b>138,100</b>	<b>63</b>	<b>1,956</b>	<b>80,200</b>	<b>37</b>	<b>218,300</b>

Notes:

<sup>1</sup> Source: Truini and Macy (2007).

<sup>2</sup> From 8 wells completed in the confined portion of the aquifer.

<sup>3</sup> 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 7-14. PREDICTED HYDROLOGIC IMPACTS FROM FUTURE N AQUIFER DEVELOPMENT IN THE VICINITY OF THE HOPI INDIAN RESERVATION <sup>1,2</sup>**

WATER SOURCE	HYDROLOGIC IMPACT	LOCATION <sup>3</sup>	CHANGE FROM 2005 TO 2025		
			Due to PWCC Pumping	Due to Hopi and Navajo Municipal Pumping	Total Change
Springs	Decrease in Discharge	Pasture Canyon	0.00%	15.13%	15.13%
Streams	Decrease in Baseflow <sup>4</sup>	Bagashibito Wash	0.63%	0.09%	0.72%
		Chinle Wash	0.00%	0.02%	0.02%
		Dinnebito Wash	0.10%	0.08%	0.17%
		Jeddito Wash	0.27%	0.51%	0.78%
		Laguna Creek	0.02%	2.17%	2.19%
		Moenkopi Wash	0.13%	0.07%	0.20%
		Oraibi Wash	0.18%	0.50%	0.68%
		Polacca Wash	0.21%	1.83%	2.04%
Wells	Drawdown <sup>5</sup>	Chilchinbeto	-25.2 feet	17.4 feet	-7.8 feet
		Forest Lake	-91.5 feet	14.4 feet	-77.1 feet
		Kayenta	-10.8 feet	50.2 feet	39.4 feet
		Keams Canyon	3.2 feet	17.4 feet	20.6 feet
		Kykotsmovi	7.5 feet	48.3 feet	55.8 feet
		Moenkopi / Tuba City	0.0 feet	Existing wells may go dry <sup>6</sup>	---
		PWCC Leasehold	-100 feet <sup>7</sup>	Not available	Not available
		Pinon	-8.5 feet	32.8 feet	24.3 feet
		Rocky Ridge	-16.4 feet	15.1 feet	-1.3 feet
		Rough Rock	0.4 feet	1.6 feet	2.0 feet

Notes:

<sup>1</sup> Sources: GeoTrans and Waterstone (1999), GeoTrans (2005), and OSM (2008).

<sup>2</sup> Assumes PWCC pumps an average of 1,236 AFA through 2025, and Hopi and Navajo municipal pumping increases by 2.7% per year from 1996 levels.

<sup>3</sup> See Figure 7-30 for map of locations.

<sup>4</sup> Any change in streamflow related to PWCC surface water drainage controls and sediment ponds is predicted to be "so small that it would be difficult to measure, leading to the conclusion that there would be negligible impact".

<sup>5</sup> Negative (-) values indicate that water levels in the aquifer will rise due to a decrease in PWCC well pumpage and recovery of associated drawdown cones.

<sup>6</sup> Predicted to occur as early as 2011.

<sup>7</sup> Water levels are predicted to rise 100 feet or more where drawdown cones have been deepest below the leasehold.

**TABLE 8-1. ESTIMATED WATER DEMANDS OF HOPI CROPS<sup>1</sup>**

CROP <sup>2</sup>		TRADITIONAL HOPI FARMING		'MODERN' WESTERN FARMING	
Type	Typical Percentage of Total Cropped Area	Lower <sup>3</sup>	Upper <sup>3</sup>	Lower <sup>3</sup>	Upper <sup>3</sup>
Crop Irrigation Water Requirement (in acre-feet/acre/year)					
Corn	81%	0.79	1.35	2.29	3.13
Orchards	8%	2.03	2.38	2.99	3.50
Beans	7%	0.94	1.16	1.85	2.15
Melons	2%	1.82	2.12	1.81	2.12
Squash/Other	2%	1.63	1.90	1.63	1.90
Composite Irrigation Water Requirement (in acre-feet/acre/year) <sup>4</sup>					
Crop Mix	100%	0.92	1.43	2.29	3.03
Net Irrigation Water Requirement (in acre-feet/acre/year) <sup>5</sup>					
Crop Mix	100%	0.35	0.86	1.72	2.46

Notes:

<sup>1</sup> Source: ADWR (2008).

<sup>2</sup> Average crop mix based on recent and historic Hopi field surveys (ADWR, 2007; BIA, 1924-1955; Ellis, 1974; and Ferguson, 2004).

<sup>3</sup> Lower and upper estimates based on climatic data from Keams Canyon and Tuba City, respectively.

<sup>4</sup> Calculated by weighting crop irrigation water requirements by the typical crop mix.

<sup>5</sup> Calculated by reducing the composite irrigation water requirement by an annual effective precipitation of 0.57 feet. The latter is an average of the annual effective precipitation calculated for Tuba City (5.48 inches) and Keams Canyon (8.19 inches).

**TABLE 8-2. TRADITIONAL FARMING PRACTICES ON THE HOPI INDIAN RESERVATION<sup>1</sup>**

WATER SOURCE	LOCATION	TYPICAL CROPS	OCCURRENCE <sup>2</sup>	MAINTENANCE	CONSTRAINTS <sup>3</sup>
Flood Water	Floodplain along large washes	Beans, corn, cotton (minor after 1930s), melons, and squash	Previously common; rare since 1930s/1940s	Install and repair temporary water diversion structures	Channel downcutting
	Terraces adjacent to large washes		More common since 1930s/1940s		Channel migration
	Mouth of small washes (ak-chin farming)			Rare	Repair or rebuild dams after floods
	Check dams along small washes (trinchera farming) <sup>4</sup>				
Spring	Terrace gardens at or near villages	Garden vegetables and fruit trees	Common, but relatively small total acreage	Periodically clean out springs to increase flow	Limited spring discharge; hand watering <sup>5</sup>
Dry Land	Sand dunes on mesa tops and sides	Beans, corn, and fruit trees	Common to very common	Wind breaks	Dune migration; lack of rainfall

Notes:

<sup>1</sup> Source: Andersen (2008).

<sup>2</sup> Qualitative assessment of the occurrence of traditional farming practices on the Reservation based on historical references summarized in Andersen (2008). To ADWR's knowledge, Reservation-wide surveys have not been conducted to determine the acreage cropped in a given year by each farming practice.

<sup>3</sup> Extended dry periods (droughts) are a constraint that could severely affect all listed farming practices.

<sup>4</sup> In 2005, 7 claimed and 31 unclaimed impoundments were identified on the Reservation with associated farmland (see Appendix C of this preliminary HSR).

<sup>5</sup> ADWR (2007) observed hoses being used to water some gardens and wells providing supplemental water.

**TABLE 8-3. PAST AND EXISTING IRRIGATION PROJECTS ON THE HOPI INDIAN RESERVATION <sup>1</sup>**

NAME	LOCATION <sup>2</sup>	COMPLETION DATE	SYSTEM COMPONENTS	ANNUAL ACREAGE CROPPED	YEARS OPERATED	STATUS
Hardrocks <sup>3</sup>	Lower Oraibi Wash	1930s	Dam with gates and ditches to irrigate 300 acres	Unknown	Unknown; farm turned over to Hopis in 1942	Presumed lost to flooding; no dam identified along wash
Jeddito <sup>4</sup>	Jeddito Wash	1939	Dam with gates and ditches to irrigate 60 acres	0 to 63 acres	At least until 1955	Dam reported lost to flooding after 1949
Lower Dinnebito	Dinnebito Wash (18 miles southwest of Hotevilla)	1937	Concrete diversion structure with 2-mile canal to irrigate 233 acres	Up to 208 acres	1940 to 1945	System reported as "out of repair"
Pasture Canyon	Moenkopi Area	Prior to 1903, with various improvements afterward	Dams with pipeline, canal, and ditches	Approximately 155 acres in 2005	Before 1903 to present	Operational in 2008
Phillips Farm	Polacca Wash	1940	Check dam and pump lift to irrigate 50 acres	44 to 50	At least until 1954	Presumed lost to flooding; no dam identified along wash
Unnamed <sup>5</sup>	Dinnebito Wash (near Sand Springs)	circa 2000	Instream pump and drip lines	1.3 acres in 2005	Circa 2000 through at least 2005	Operational in 2005
Unnamed Dams	Orabi Wash	1897	Three dams	Unknown	Unknown	Presumed lost to flooding; no dams identified along wash
Unnamed Wells	Near Hopi fields	1893	Several wells	Unknown	Unknown	Presumed abandoned; no irrigation wells were claimed
Wepo Wash	Wepo Wash	1920s	Water spreading structure to irrigate 650 acres	46 to 523	Until 1929	Structure reported lost to flooding

Notes:

<sup>1</sup> Sources: ADWR (2007) and Andersen (2008).

<sup>2</sup> All projects located within the 1882 Reservation except for Pasture Canyon, which is located in the Moenkopi Area.

<sup>3</sup> Originally built as a Navajo farm; unknown if the Hopi ever cropped.

<sup>4</sup> Part of farm located on Navajo lands and part on Hopi lands.

<sup>5</sup> Completion date estimated by ADWR based on condition of system components observed in 2005.

**TABLE 8-4. SUMMARY OF AGRICULTURAL FIELDS SURVEYED IN 2005 BY ADWR<sup>1</sup>**

APPARENT OR OBSERVED WATER SOURCE	NUMBER OF FIELDS MAPPED	RANGE IN FIELD SIZE (acres)	TOTAL AREA (acres)	IRRIGATION SYSTEM		CROP TYPES (number of fields observed)
				Number of Fields	Type	
Surface Water Diversion/ Floodwater from Wash	130	0.01 - 20.03	316	88	Ditch	Beans (6), chili (1), corn (47), gourd (1), melons (2), mixed (6), fallow/abandoned (23), peaches (2)
				31	None	Apricots (1), beans (4), corn, (15), mixed (4), fallow/abandoned (2), peaches (1), pumpkins (1), squash (1), sunflower (1), watermelon (1)
				10	Instream pump	Corn (3), melons (1), mixed (2), fallow/abandoned (3), squash (1)
				1	Spreader dike	Corn (1)
Spring	74	0.01 - 12.63	51.4	66	Ditch	Beans (6), chili (7), corn (28), fallow/abandoned (6), melons (2), mixed (15), squash (1), unknown (1)
				7	None	Apples, (2), corn (1), mixed (1), fallow/abandoned (2), peaches (1)
				1	Hose	Mixed (1)
Precipitation/Overland Flow	305	0.01 - 26.85	284	305	None	Apples (3), apricots (6), beans (70), corn (78), gourds (5), melons (9), mixed (41), fallow/abandoned (36), unknown (10), pasture (1), peaches (28), potatoes (1), pumpkins (1), squash (4), watermelon (10), zucchini (2)
Well	5	< 0.01 - 0.04	0.08	5	Hose	Mixed (2), unknown (1), squash (1), tomatoes (1)
<i>Total</i>	<i>514</i>	<i>&lt; 0.01 - 26.85</i>	<i>651</i>	<i>514</i>	<i>Ditch, hose, instream pump, spreader dike, none</i>	<i>Apples (5), apricots (7), beans (86), chili (8), corn (173), gourd (6), melons (14), mixed (72), unknown (12), fallow/abandoned (72), pasture (1), peaches (32), potatoes (1), pumpkins (2), squash (8), sunflower (1), tomatoes (1), watermelon (1), zucchini (2)</i>

Note:

<sup>1</sup> Source: ADWR (2007).

**TABLE 8-5. HISTORIC ACCOUNTS OF THE NUMBER OF HOPI LIVESTOCK <sup>1</sup>**

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 <sup>2</sup>	1,325 <sup>2</sup>	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 <sup>3</sup>		Whitely (2004)
1880	5,000	500	CIA (1880)	1937	11,519 <sup>4</sup>	12,780 <sup>4</sup>	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 <sup>5</sup>		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 <sup>5,6</sup>		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:

<sup>1</sup> Summarized from Andersen (2008).

<sup>2</sup> 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).

<sup>3</sup> Hopi also grazed 1,300 sheep and 300 cattle on the Moenkopi Plateau and Coal Mine Mesa (Nagata, 1970).

<sup>4</sup> 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.

<sup>5</sup> Sheep units.

<sup>6</sup> Counts limited to the JUA.

**TABLE 8.6 RECENT LIVESTOCK INVENTORIES AND ESTIMATED LIVESTOCK WATER DEMANDS ON THE HOPI INDIAN RESERVATION<sup>1</sup>**

YEAR	DISTRICT 6						HOPI PARTITIONED LANDS						MOENKOPI AREA					
	Cows	Sheep	Horses	Total AUs <sup>2</sup>	Estimated Water Demand <sup>3</sup>		Cows	Sheep	Horses	Total AUs <sup>2</sup>	Estimated Water Demand <sup>3</sup>		Cows	Sheep	Horses	Total AUs <sup>2</sup>	Estimated Water Demand <sup>3</sup>	
					ADWR (AFA)	Hopi (AFA)					ADWR (AFA)	Hopi (AFA)					ADWR (AFA)	Hopi (AFA)
1984	4,824	882	226	5,329 <sup>4</sup>	72	116	1,533		23	1,562	21	34						
1985	2,566	595	206	2,972	38	65												
1991													341 <sup>5</sup>			341	5	7
1992													365 <sup>5</sup>			365	5	8
1997							1,932	1,668	152	2,539	31	55						
2003	2,396	0	111	2,535	34	38												
2004	2,166	90	15	2,207	29	36												
2005	1,945	63	21	1,987	27	38												
2006	1,574	24	14	1,598	21	31												

Notes:

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

<sup>2</sup> 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

<sup>3</sup> ADWR (2000) assumes 12 gallons per day (gpd) per cow, 12 gpd per horse, and 1.5 gpd per sheep.

The Hopi assumed 19.5 gpd per AU based on 15 gpd livestock water demand and a 30% delivery loss from the water source (DBSA, 2000).

<sup>4</sup> 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).

<sup>5</sup> Inventories were provided by the Hopi in sheep units and converted to cows and AUs by ADWR.

**TABLE 8-7. LIVESTOCK WATER SOURCES ON THE HOPI INDIAN RESERVATION<sup>1</sup>**

<b>WATER SOURCE</b>	<b>CHARACTERISTIC</b>	<b>CLAIMED</b>	<b>UNCLAIMED</b>
<b>Stock Ponds</b>	Total number	561	180
	Number that ADWR determined had breached berms, were under construction, or removed	239	57
	Number ADWR did not verify	4	---
	Claimed capacity	4,499 AF <sup>5</sup>	---
	ADWR capacity <sup>2</sup>	2,190 AF	363 AF
<b>Stock Wells</b>	Total Number	170	18 <sup>6</sup>
	Number ADWR did not verify	11	---
	Claimed quantity	680 to 705 gpm	---
	ADWR quantity <sup>3</sup>	≤197.5 gpm	≤23.5 gpm
<b>Springs</b>	Total number	351	7 <sup>7</sup>
	Number ADWR did not verify	31	---
	Number ADWR found without flow data	151	0
	Claimed quantity	1,665 gpm	---
	ADWR quantity <sup>4</sup>	359 to 1,076 gpm	4.4 to 5.4 gpm

Notes:

AF is acre-feet and gpm is gallons per minute.

<sup>1</sup> See Hopi Impoundment, Spring, and Well Inventories (Appendices C, D, and E) for further details.

<sup>2</sup> Does not include capacities for impoundments that ADWR did not verify or determined had breached berms, were under construction, or removed.

<sup>3</sup> Assumes a quantity of ≤1.25 gpm per well based on Hopi Drought Plan (DBSA, 2000); does not include wells that ADWR did not verify.

<sup>4</sup> Based on springs with reported discharge rates; does not include springs that ADWR did not verify or those without flow data.

<sup>5</sup> U.S. stockpond claims totaled 4,499 acre-feet while Hopi claims totaled 4501.8 acre-feet.

<sup>6</sup> ADWR identified another 40 unclaimed wells, but stock use was not reported.

<sup>7</sup> ADWR identified another 35 unclaimed springs, but stock use was not reported.

**TABLE 8-8. SPECIFICATIONS OF RECREATIONAL LAKES ON THE HOPI INDIAN RESERVATION<sup>1</sup>**

CHARACTERISTIC <sup>2</sup>		KEAMS LAKE	LAKE MOHO <sup>3</sup>	PASTURE CANYON RESERVOIR (unclaimed)	TWIN DAM NO. 1	TWIN DAM NO. 2	TOTALS
Location		T28N,R20E,S23	T28N,R20E,S23	T32N,R11E,S21	T28N,R20E,S13	T28N,R21E,S18	---
Water Source		Keams Canyon	Keams Canyon	Pasture Canyon	Keams Canyon		---
Surface Drainage Area (sq. miles)		5.0	5.0	3.9	3.9		17.8
Date of Construction <sup>4</sup>		1956	1956	1920s/1930s; modified in 1975 <sup>9</sup>	1956	1956	---
Hopi Claim No.		I-11-431	I-11-408	Not claimed	I-11-415	I-11-407	---
Dam Height (feet)	USDA	50	60	13	30		---
	ADWR	13.3	Not applicable	11.8 (18.3 crest height)	15.5 (22 crest height)	15 (20 crest height)	---
Lake Surface Area (acres)	USDA	2	3	36	150		191
	Hopi Claim	3.2	1.0	Not claimed	1.3 to 1.7	8.3	14.2
	ADWR <sup>5</sup>	3.6	0.9	34.0	1.2	11.6	51.3
Reservoir Capacity (acre-feet)	USDA	75	130	250	1,500		1,955
	Hopi Claim	27.8	7.4	Not claimed	11.0	92.6	138.8
	ADWR <sup>6</sup>	19.1	1.4	202	2.1	69.4	294
Annual Evaporation (acre-feet)	Hopi Claim	12.8	4.0	Not claimed	6.8	33.2	56.8
	ADWR <sup>7,8</sup>	19.1 to 22.7	4.8 to 5.7	190 to 228	6.4 to 7.6	61.5 to 73.1	281.8 to 337.1
Siltation	USDA	"Completely silted in"	"Silted in"				---
	ADWR		Silted in		Silted in		---

Notes:

<sup>1</sup> Data Sources: ADWR's Hopi Impoundment Inventory (see Appendix C of preliminary Hopi HSR), ADWR (2008f), 2004 Hopi amended claims, and USDA (1981).

<sup>2</sup> Location, water source, and drainage area from USDA (1981).

<sup>3</sup> Appears to operate as flood/sediment control structure for downstream Keams Lake; 36-inch corrugated metal pipe drop structure through embankment.

<sup>4</sup> From Hagstrom (2008).

<sup>5</sup> From field measurement or aerial photo analysis; see Appendix C.

<sup>6</sup> From field measurement or regression analysis; see Appendix C.

<sup>7</sup> ADWR (2008f) calculated average surface water evaporation rates of 5.3 to 6.3 feet at Keams Canyon, and 5.6 to 6.7 feet at Tuba City near Pasture Canyon.

<sup>8</sup> Annual lake evaporation, in acre-feet, was calculated by multiplying lake surface area by surface water evaporation rates. Since lake surface areas will vary with lake levels, annual volumes shown probably overestimate actual values.

<sup>9</sup> Mormons built an upper and middle dam on Pasture Canyon prior to 1903, and rebuilt and raised them in 1908 (Andersen, 2008). The middle dam was reportedly later abandoned, and the upper dam was rebuilt by the United States to form present day Pasture Canyon Reservoir.

**TABLE 8-9. RECENT WATER DEMAND ESTIMATES FOR RIPARIAN VEGETATION ON THE HOPI INDIAN RESERVATION**

LOCATION	AREA OF RIPARIAN VEGETATION IN 2005 (acres) <sup>1</sup>			ESTIMATED TOTAL WATER DEMAND <sup>2</sup>	EFFECTIVE PRECIPITATION <sup>3</sup>	NET WATER DEMAND (AFA) <sup>4</sup>
	Along Streams	Associated with Impoundments	Total			
District 6	4,561	177	4,738	2.3 to 4.4 acre-foot/acre/year	0.5 to 0.7 acre-foot/acre/year	7,581 to 18,478
Hopi Partition Land	8,572	825	9,397			15,035 to 36,648
Moenkopi	324	0	324			518 to 1,264
<b>Total Reservation</b>	<b>13,457</b>	<b>1,002</b>	<b>14,459</b>			<b>23,134 to 56,390</b>

Notes:

AFA = acre-feet per year

<sup>1</sup> From ADWR (2008c).

<sup>2</sup> From Cleverly and others (2006) and Shafike and Cleverly (2007).

<sup>3</sup> From ADWR (2008h).

<sup>4</sup> Net Water Demand = [ (Total Water Demand) - (Effective Precipitation) ] x Area of Riparian Vegetation.

**TABLE 9-1. SUMMARY OF ADWR'S EVALUATION OF PAST AND PRESENT TRIBAL WATER USE ON THE HOPI INDIAN RESERVATION**

TYPE OF USE	WATER SOURCE(S) UTILIZED	QUANTIFICATION			LOCATION		
		Factors	Factor Values	Quantity (AFA)	Diversion	Use	
Agriculture (Irrigation)	Springs and washes <sup>1,2</sup>	Traditional Hopi Farming (see Table 8-2)	Cropped acreage	1,000 to 9,210 acres per year (see Figure 8-1 and Section 8-1) <sup>3</sup>	350 to 7,921 <sup>4</sup>	See ADWR drainage analysis and claimed spring locations shown on maps of past and recent (2005) agricultural lands in Appendices G-1 and G-3, respectively	See maps of past and recent (2005) agricultural lands in Appendices G-1 and G-3, respectively
			Crop water demand	0.35 to 0.86 feet per year (see Section 8.1.1, Table 8-1 and Appendix F)			
		Irrigation Projects (see Table 8-3)	Cropped acreage	0 to 643 acres per year (see Table 8-3 and Section 8-1) <sup>3</sup>	0 to 1,582 <sup>4</sup>	See Figure 8-3 of the Pasture Canyon irrigation system (detailed maps of other irrigation projects not available)	
			Crop water demand	1.72 to 2.46 feet per year (see Section 8.1.1, Table 8-1 and Appendix F)			
Domestic, Commercial, Municipal, and Light Industrial (DCMI) <sup>5</sup>	Aquifers (including Alluvial/Colluvial, Bidahochi, D, N, and T) and springs <sup>1,6</sup>	Reservation population		<1,000 to 12,000 (see Section 8.2.1, Table 6-7 and Figure 8-4)	<11 to 578 <sup>7</sup> (up to 501 measured in year 2000; see Table 6-3) <sup>8</sup>	See Appendices D and E for a list of spring and well coordinates, respectively, and Figure 8-5 for a map of their locations	See Figure 4-1 for population and commercial/industrial centers
		Per capita consumption rate		10 to 43 gallons per capita per day (see Section 8-2)			
Heavy Industrial (Mining and Related Industry)	N Aquifer <sup>6</sup>	Annual pumpage from PWCC well field		40 AFA (in 1969) to 4,740 AFA (in 1982) (see Section 8.3.1)	40 to 4,740 AFA	PWCC leasehold (see Figures 6-3 and 7-30 for the locations of the leasehold and PWCC production wells, respectively) <sup>9</sup>	
Livestock	Aquifers (including Alluvial/Colluvial, Bidahochi, D, N, and T), springs, and surface water impoundments <sup>2,6</sup>	Water Demands	Head of livestock	3,501 to 8,231 animal units (1984-2006 inventories; see Table 8-6) <sup>10</sup>	47 to 179 (lower limit, see Table 8-6) <sup>11</sup>	See Appendices C, D, and E for a list of impoundment, spring, and well coordinates and Figures 7-13, 7-14, and 7-15 for maps of their locations, respectively	At or close to location of diversion
			Livestock water needs	6 to 19.5 gallons per day per animal unit (varies based on livestock type and assumed water needs of livestock; see Section 8.4.1)			
		Water Supplies	Stockpond capacity (314 claimed and 122 unclaimed impoundments)	0.01 to 186 acre-feet for individual ponds; 2,259 acre-feet total (2005-2008 measurements; see Tables 8-7 and 8-8 and Appendix C) <sup>12,13</sup>	≤2,615 (upper limit) <sup>15</sup>		
			Estimated well yield (159 claimed and 18 unclaimed wells reported to be used by stock)	≤1.25 gpm for individual wells <sup>14</sup> ; ≤221 gpm total (see Table 8-7 and Appendix E)			
Recreation	Keams and Pasture Canyons <sup>2</sup>	Lake capacity (4 claimed and 1 unclaimed lakes)		1.4 to 202 acre-feet for individual lakes; 294 acre-feet total (2005-2008 measurements; see Table 8-8 and Appendix C)	576 to 631 <sup>17</sup>	See Appendix C for a list of lake coordinates and Figure 7-13 for a map of lake locations	Same as diversion location
		Lake evaporation rate		5.3 to 6.3 feet (Keams Canyon) and 5.6 to 6.7 feet (Pasture Canyon) (see Section 8.5.2) <sup>16</sup>			
		Lake surface area		0.9 to 34 acres for individual reservoirs; 51.3 acres total (2005-2008 measurements; see Table 8-8 and Appendix C)			
Ceremonial/Cultural	Springs <sup>1,6</sup>	Measured discharge (208 claimed and 29 unclaimed springs)		0 to 326 gpm for individual springs; 390 to 1,134 gpm total (see Tables 7-8 and 7-9 and Appendix D) <sup>18</sup>	629 to 1,829 <sup>19</sup>	See Appendix D for a list of spring coordinates and Figure 7-14 for a map of spring locations	At or close to location of diversion

AFA = acre-feet per year; and gpm = gallons per minute.

Notes:

<sup>1</sup> Many springs on the Reservation have reportedly been used for multiple purposes including irrigation, domestic, livestock and ceremonies. Both the Hopi and United States claim that all springs are used by the Tribe for cultural purposes. The Hopi, but not the United States, also claim these springs are used for ceremonial purposes.

To avoid over counting, the discharge of all springs, including those with reported multiple uses, are only quantified in this table under "Ceremonial/Cultural."

<sup>2</sup> Most streams that cross the Hopi Reservation originate on and drain back to Navajo lands. Surface water supplies in Reservation streams are often unreliable due to several factors including ephemeral flow conditions, effects from frequent and long-term droughts, and elevated sediment loads. Potential, future effects from climate change may also impact streamflows. See Section 7.1.

<sup>3</sup> The upper range of annually cropped fields in Figure 8-1 (9,330 acres) was reduced by 120 acres to account for fields in the Moenkopi Area estimated to have been irrigated at that time by the Pasture Canyon irrigation project.

The same 120 acres in the Moenkopi Area was added to the area annually farmed at the Wepo Wash project during the 1920s (up to 523 acres) to calculate the upper range of irrigation project cropped acreage. The first irrigation projects were developed by the federal government in the 1890s.

<sup>4</sup> Calculated by multiplying the range in cropped acreage by the range in crop water demand. Irrigation system efficiency is not included.

<sup>5</sup> Based on the Hopi claims, DCMI is assumed to include water uses associated with the Hopi Cultural Center and other tourist activities.

<sup>6</sup> The Hopi and Navajo share the N Aquifer which underlies much of their reservations. Past and current development of this aquifer is believed to have impacted some stream baseflow and spring discharges. Tribal municipal pumping and industrial wells are expected to impact these water sources in the future. See Section 7.4.6.

<sup>7</sup> Calculated by multiplying the range in Reservation population by the range in per capita consumption and converting the results to units of AFA.

<sup>8</sup> Measured water demand for 16 public water systems currently located on the Reservation.

<sup>9</sup> Seven PWCC production wells are located on Navajo lands adjacent to the Hopi Reservation and one is located on the HPL.

<sup>10</sup> ADWR considers the historic accounts to be less reliable and so used recent inventories for quantification purposes. The lowest and highest animal units reported in District 6, Hopi Partitioned Lands, and the Moenkopi Area were added separately to calculate this range.

<sup>11</sup> Calculated by multiplying the range in head of Hopi livestock by the range in livestock water needs and converting the results to units of AFA.

<sup>12</sup> Four claimed and 1 unclaimed recreational lakes are reportedly also used by livestock. To avoid double counting, the capacity of these lakes are only quantified in this table under "Recreation." The stockpond capacity determined by ADWR in Table 8-7 (2,553 AF) was, therefore, reduced by 294 AF.

<sup>13</sup> Capacities were determined by ADWR during 2005-2008; capacities for impoundments found during that time to have breached berms or those that could not be verified, were found under construction, or removed were not determined.

<sup>14</sup> Typical yield of a stock well, as reported in a recent Hopi drought plan (DBSA, 2000).

<sup>15</sup> Calculated by adding the total stockpond capacity and the total estimated yield of stock wells. The latter was converted from units of gpm to AFA before adding to pond capacity.

<sup>16</sup> Calculated by ADWR (2008f) based on local climate data.

<sup>17</sup> Calculated by adding the total lake capacity and the total annual evaporation rate. The latter was estimated by multiplying the range in lake evaporation rate by the total lake surface area.

<sup>18</sup> Several springs verified by ADWR did not have discharge data and were not quantified, including 152 claimed and 13 unclaimed springs.

<sup>19</sup> Calculated by converting the total spring discharge in gpm to units of AFA.

**TABLE 9-2. COMPARISON OF CLAIMED QUANTITIES TO ADWR'S EVALUATION OF PAST AND PRESENT TRIBAL WATER USE ON THE HOPI INDIAN RESERVATION**

TYPE(S) OF USE	CLAIMED QUANTITY FOR PAST AND PRESENT WATER USE (AFA) (see Table 2-1)		ADWR EVALUATION OF PAST AND PRESENT WATER USE (AFA) (see Table 9-1)
	Hopi	United States	
<b>Agriculture (Irrigation)</b>	28,700 (average) to 49,206 (maximum), plus 116 from springs (based on a composite, historical cropped area of 38,556 acres) <sup>1</sup>	28,489 (average) to 49,136 (maximum), plus 116 from springs (based on a composite, historical cropped area of 38,556 acres) <sup>1</sup>	350 to 9,503 (based on the acreage irrigated in any one year)
<b>Domestic, Commercial, Municipal, and Light Industrial (DCMI)</b>	A separate quantity for each type of use was not provided <sup>2</sup>		<11 to 578
<b>Heavy Industrial (Mining and Related Industry)</b>	4,400	3,000	40 to 4,740
<b>Livestock</b>	A separate quantity for each type of use was not provided <sup>2</sup>		47 to ≤ 2,615
<b>Recreation</b>	196	Use not claimed	576 to 631
<b>Ceremonial/Cultural</b>	2,759 <sup>3</sup>		629 to 1,829
<b>Total</b>			<b>1,653 to 19,896<sup>4</sup></b>

Notes:

AFA = acre-feet per year.

<sup>1</sup> ADWR determined that there was convincing or partial evidence of historical farming on only 25,261 acres of the Reservation. If this evidence was used, the amount of water required would be less than the amount claimed.

<sup>2</sup> In their 2004 amended claims, as supplemented in 2005, the Hopi and United States claim 8,520 AFA and 8,603 AFA, respectively, for cultural, domestic, stock and irrigation uses from the same impoundments, springs, and wells. However, neither the Hopi nor United States divide the total quantities of water claimed for each type of water use from each spring and well.

<sup>3</sup> Both the Hopi and United States claim that all springs were used for cultural purposes. The Hopi, but not the United States, also claim that all springs were used for ceremonial purposes. However, most of these springs were claimed for other purposes as well.

<sup>4</sup> Less than (<) values were assumed to equal the value when calculating a total quantity.

**TABLE 9-3. ADWR'S RECOMMENDED WATER RIGHT ATTRIBUTES FOR PAST AND PRESENT TRIBAL WATER USES ON THE HOPI INDIAN RESERVATION**

TYPE(S) OF USE	WATER SOURCE(S)	QUANTITY OF USE (AFA)	LOCATION		LEGAL BASIS	PRIORITY DATE
			Diversion	Use		
Those necessary to accomplish a homeland purpose, as set forth in <i>Gila V</i>	Legal issue pending before the adjudication Court	Up to 19,896 AFA	Legal issue pending before the adjudication Court	Reservation-wide, as necessary to accomplish a homeland purpose	Implied Federal Reserved Water Right, as defined in <i>Gila III</i> and <i>Gila V</i>	Legal issues pending before the Special Master