

Subject: **Powder/Tongue River Basin Plan
Storage Operation and Description
Task 2F**

Date: March 2002

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INTRODUCTION

In accordance with the scope of services, an inventory of the storage facilities located within the Powder River and Tongue River Basins was completed. This inventory is intended to be used for future planning and to provide information for water availability modeling of the basins. After consulting with State Engineer's Office personnel, HKM composed technical reports on 14 reservoirs considered significant to the basin. In addition, HKM developed summaries for 189 reservoirs detailing their tributaries, capacities, locations, and corresponding evaporative rate per year. These data comprise an effective backbone for the modeling work to follow.

Because reservoir operations are changing rapidly in the Powder/Tongue River Basin, the storage operations memorandum will probably demand updating more than most other elements of the plan. Coal Bed Methane (CBM) produced waters have been contained for the most part in small stock pond-like facilities, but larger facilities are being considered in this basin just as they are farther to the east.

STORAGE FACILITIES SELECTION

The initial selection of storage to be inventoried was based on a review of the Safety of Dams *Active Dams* database. As per requests from the State Engineer's Office and Wyoming Water Development Commission personnel, all surface water storage in structures containing more than 50 acre-feet of storage or more than 20 feet high (meeting the minimum standards for inclusion in the Dam Safety database) were selected. These selection criteria produced a set of 189 surface water storage facilities. The statistics for each of these reservoirs are presented in the summary tables following the 14 detailed reports.

State Engineer's Office Water Division Two commissioners agreed that a further set of criteria should be introduced to provide a list from which the dams of particular significance to the basin could be developed. Commissioners agreed that in almost all cases, a limit of 1,000 acre-feet capacity and "serving multiple users" produced a list of reservoirs significant to the basins. The only recommended exception was Cross Creek Reservoir, which has a normal capacity of 798 acre-feet. This inclusion brought the secondary selection list to 14.

The list of these storage facilities was submitted to the superintendent and water commissioners for verification. Individual memoranda were developed providing more detailed operational information for these significant facilities.

METHODOLOGY

Base Data

The information provided in the 14 in-depth reports and the 189 summaries that follow comes primarily from the State Engineer's Office's (SEO) Safety of Dams *Active Dams* database. This is also the primary reference tool for SEO personnel inspecting dam safety around the state. Some data are not available in that database. Associated water right information had to be culled from the SEO *Tab Books* in Water

Divisions I and II. Operational details were gleaned from interviews. Area-capacity tables, illustrations, and pictures often came from SEO Division II files or Safety of Dams office records.

Unfortunately, these sources do not agree on all points. For instance, Kearney Lake has an active capacity of 6,324 acre-feet according to the Safety of Dams *Active Dams* database, but only 6,130.55 acre-feet can be released from the dam, according to an area-capacity table on file in the SEO's Water Division II office in Sheridan, Wyoming. Similar discrepancies can be found comparing these data to water rights.

It is not within the scope of this study to resolve these conflicts. As much information as possible was provided for each of the 14 significant reservoirs. In general, when the source is other than the Safety of Dams *Active Dams* database, the source is noted.

Finally, data in this memorandum are presented as they are found in the original sources. Terminology, references, and notes are unchanged.

The following definitions provided by the U.S. Bureau of Reclamation provide a brief definition of key terms:

Active capacity. The reservoir capacity normally usable for storage and regulation of reservoir inflows to meet established reservoir operating requirements. It extends from the highest of either the top of exclusive flood control capacity, the top of joint use capacity, or the top of active conservation capacity, to the top of inactive capacity. It is also the total capacity less the sum of the inactive and dead capacities. The reservoir capacity that can be used for irrigation, power, municipal and industrial use, fish and wildlife, recreation, water quality, and other purposes.

Normal water surface. The highest elevation at which water is normally stored, or that elevation which the reservoir should be operated for conservation purposes. Usually the elevation at the top of the active conservation capacity. The maximum elevation to which the reservoir may rise under normal operating conditions exclusive of flood control capacity.

Total capacity. The reservoir capacity below the highest of the elevations representing either the top of exclusive flood control capacity, the top of joint use capacity, or the top of active conservation capacity. In the case of a natural lake which has been enlarged, the total capacity includes the dead capacity of the lake. Total capacity is used to express the total quantity of water which can be impounded and is exclusive of surcharge capacity.

Data Gathering for Storage Evaporative Losses

To understand how much water is lost to reservoir evaporation throughout the basin, it was necessary to correlate the reservoir locations in the State Engineer's Office *Tabulation of Adjudicated Surface Waters* for Divisions one and two (where applicable) and the Safety of Dams *Active Dams* database with values from the Annual Lake Evaporation Map in Larry E. Lewis' *Development of an Evaporation Map for the State of Wyoming for Purposes of Estimating Evaporation and Evapotranspiration*. This cross-correlation produced an annual loss value (in inches of water). This was then multiplied by the factors in Lewis' Table VIII, "Pathfinder Dam Annual Evaporation Distribution" to produce monthly gross evaporation in inches. The values for the months of May-September were summed, and the result was multiplied by the factors in Table IX, "May Through September Monthly Evaporation Distribution." These calculations yielded the monthly values provided in the summary tables.

Though Lewis' work was completed in 1978, and the more recent *NOAA Technical Report NWS: Evaporation Atlas for the Contiguous 48 United States* would seem like a better choice for its 1983 vintage, Lewis' work contains far more data from Wyoming. Lewis also worked with approximately as much data as is available today to compile his maps, rejecting data points on field inspection, and still had a much larger data set and one of greater duration (20 years compared with 15) than the national study draws upon.

For more detailed information, water commissioners, Safety of Dams personnel, landowners, operators, and officials familiar with the reservoirs were consulted. The documentation accompanying permits or applications for enlargement yielded the most data.

Calculations for Gross Storage Evaporative Losses

Once the Lewis evaporation numbers were obtained (inches), they were multiplied with the water area (acres) exposed to the atmosphere in an average month. To do this, HKM collected the available end-of-month storage records for the significant reservoirs identified earlier. In the case of the Powder/Tongue River Basin, records existed for Twin Lakes, Tie Hack, Healy, and Lake DeSmet reservoirs. Once an average end-of-month volume or elevation was computed for each, it was correlated with the area-capacity table to generate a corresponding end-of-month surface area in acres. Subsequent calculations can generate the gross evaporative loss in acre-feet per month:

$$Loss_{Gross} (acre - ft) = \frac{Lewis(in.) \times Area(acres)}{12(in./ft)}$$

Calculation of Net Evaporative Losses in Storage

Evaporative loss in storage isn't a simple, one-way dynamic; the same acreage of water that is exposed to the atmosphere for evaporative losses is also exposed to precipitation. To understand the net effect of these two factors, precipitation must be subtracted from the evaporative losses. This changes the calculation above in only one respect:

$$Loss_{Net} (acre - ft) = \frac{[Lewis(in.) - Precip(in.)] \times Area(acres)}{12(in./ft)}$$

This study depends on the precipitation mapping completed by Oregon State University in its Parameter-elevation Regressions on Independent Slopes Model (PRISM), which generated gridded estimates of climate parameters from historical meteorological data collected 1961-1990. The applicability of this model to mountainous terrain made it particularly apt for this basin. (See <http://www.ocs.orst.edu/prism/overview.html> for more information.) Because the PRISM data are available in a GIS format, the locations of the facilities were loaded into the same GIS to produce a corresponding monthly precipitation estimate. Figure 1 illustrates the average annual precipitation depths from PRISM.

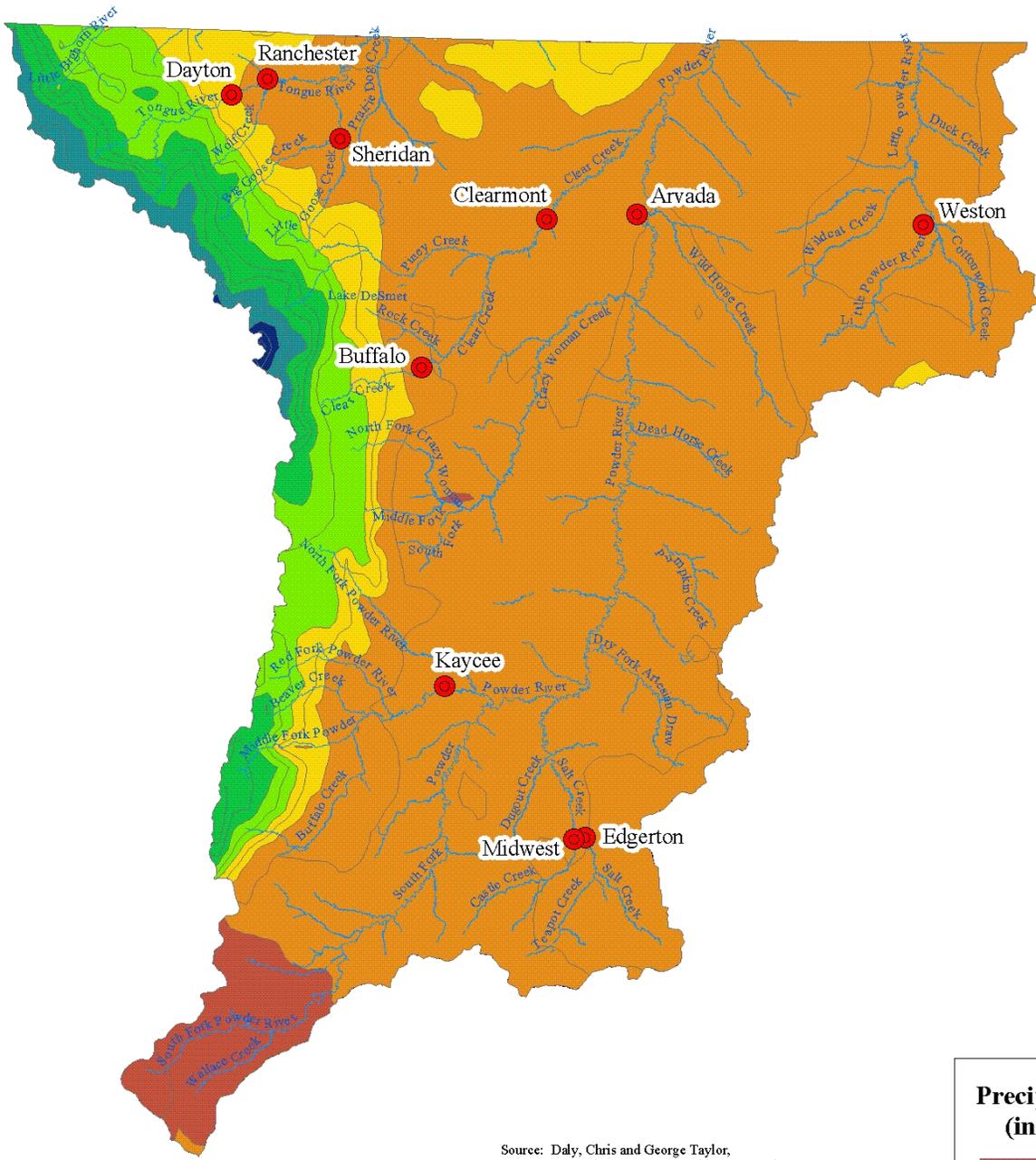
The net evaporative loss estimates are provided below the end-of-month storage summaries behind each overview of key storage facilities.

Evaporative Losses from Storage for Remaining Facilities

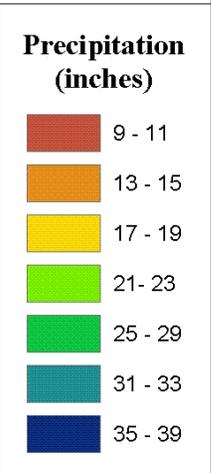
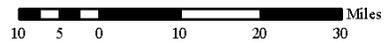
HKM divided total capacity for each of the four facilities with available end-of-month data in this basin by those monthly readings. This produced a percentage of total storage for each of the four facilities with data at the end of each month; these were averaged. For each facility with no end-of-month storage data, the average end-of-month percentage of total storage was multiplied by the facility's total storage, which was then cross-referenced with the area-capacity table to produce an estimated end-of-month area. This number was used to calculate the gross and net evaporative losses as above.

COMPACT ISSUES

The Yellowstone River Compact (1950) contains several restrictions on surface water storage. The *Wyoming Water Planning Program Report No. 10: Water & Related Land Resources of Northeastern Wyoming* provides an excellent summary of its provisions (pp. 48-51):



Source: Daly, Chris and George Taylor,
 "Wyoming Average Monthly or Annual
 Precipitation, 1961-1990." Portland,
 Oregon, April 1998.



Average Annual Precipitation



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Figure 1

Yellowstone River Compact

The Yellowstone River Compact provides a basis for dividing the waters of the Yellowstone River between the States of Wyoming, Montana, and North Dakota. The Yellowstone River Compact was negotiated in 1950 and ratified by the three states and the Federal Government in 1951. The compact establishes a commission composed of one representative each from Montana, Wyoming, and the U. S. Geological Survey to administer its provisions. Article V provides for a division of water on the following basis:

- A. *Water rights to beneficial uses of the water of the Yellowstone River system existing as of January 1, 1950, shall remain unimpaired by the terms of the compact.*
- B. *Of the unused and unappropriated waters of the interstate tributaries of the Yellowstone River, each of the signatory states is allocated sufficient water to provide supplemental water supplies to all rights existing as of January 1, 1950. The remaining unused and unappropriated water of the interstate tributaries of the Yellowstone River is allocated to Wyoming and Montana as follows:*

Clarks Fork of the Yellowstone River:

Wyoming 60% Montana 40%

Bighorn River (exclusive of the Little Bighorn River):

Wyoming 80% Montana 20%

Tongue River:

Wyoming 40% Montana 60%

Powder River (including the Little Powder River):

Wyoming 42% Montana 58%

- C. *Existing and future domestic and stock water uses including stock water reservoirs up to a capacity of 20 acre-feet are exempted from the provisions of the compact.*
- D. *The Commission is to re-examine the water allocations from "time to time" considering among other factors: "priorities of water rights, acreage irrigated, acreage irrigable under existing works, and potentially irrigable lands."*

Other provisions of the compact which affect the division and use of Yellowstone River water include:

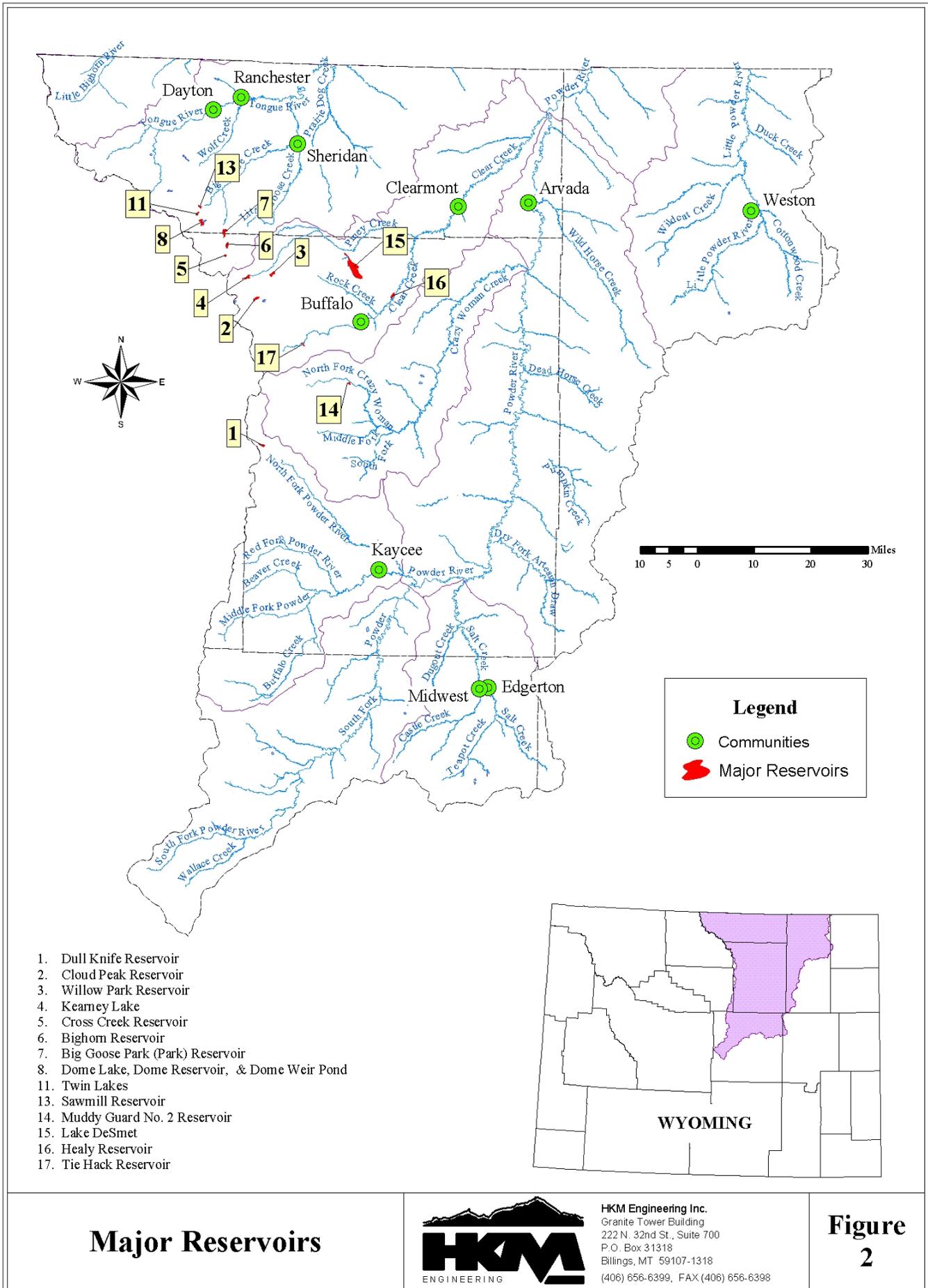
1. *Article VI -- "Nothing contained in this Compact shall be so construed or interpreted as to affect adversely any rights to the use of the waters of Yellowstone River and its tributaries owned by or for Indians, Indian tribes, and their reservations."*
2. *The water of a lower signatory State may be stored and diverted in an upper State and vice versa, and the right to acquire water rights and rights-of-way in one State for use of water in another is provided (Articles VII, VIII, and IX).*
3. *Article X provides: "No water shall be diverted from the Yellowstone River Basin without the unanimous consent of all the signatory States. In the event water from another river basin shall be imported into the Yellowstone River Basin or transferred from one tributary basin to another by the United States of America, Montana, North Dakota, or Wyoming, or any of them jointly, the State having the*

right to the use of such water shall be given proper credit therefor in determining its share of the water apportioned in accordance with Article V herein."

The significant reservoirs detailed in this memorandum are listed in the following table and illustrated in Figure 2:

Reservoir	Permit	Latitude	Longitude	Year Complete	Active Capacity (af)	Dam Height (ft)	Surface Area (acres)	Annual Net Evap. Loss (af)
BIG GOOSE PARK	6448R	44° 34' 0"	107° 12' 30"	1933	10,362	85	318	557
BIG HORN	6947R	44° 32' 3"	107° 12' 15"	1909	4,624	45	179	296
CROSS CREEK	7441R	44° 29' 52"	107° 12' 57"	1977	798	30	51	278
CLOUD PEAK	6906R	44° 24' 11"	107° 4' 46"	1958	3,570	36	174	85
DOME LAKE NO. 1	7024R	44° 35' 30"	107° 18' 47"	1907	1,506	30	96	8,372
DULL KNIFE	6915R	44° 1' 10"	107° 3' 12"	1966	4,345	80	130	170
HEALY	7290R	44° 24' 18"	106° 36' 39"	1975	5,140	50	246	205
KEARNEY LAKE	6826R	44° 27' 17"	107° 6' 58"	1928	6,324	67	193	556
LAKE DESMET	7009R	44° 30' 48"	106° 46' 30"	1921	111,827	80	2653	291
MUDDY GUARD NO. 2	7598R	44° 11' 16"	106° 45' 11"	1976	1,934	57	48	113
SAWMILL	7268R	44° 37' 32"	107° 17' 56"	1960	1,275	38	75	136
TIE HACK	9700R	44° 16' 57"	106° 55' 27"	1997	2,435	110	63	148
TWIN LAKES	6847R	44° 36' 36"	107° 18' 36"	1937	1,317	54	52	112
WILLOW PARK	6408R	44° 27' 4"	107° 1' 48"	1959	4,457	56	213	N.A.

Note: "Year Complete" refers to the end of the first construction on the facility; enlargements are not included. The information necessary to generate a net annual evaporative loss figure for Willow Park was not available.



REFERENCES

- Active Dams*, State Engineer's Office Safety of Dams Engineering Div. Database, transmitted by Larry Stockdale, Safety of Dams engineering consultant, 16 Feb. 2001.
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