# A DRAFT Study

# Of

# The Recreation Carrying Capacity

# WHITE MOUNTAIN LAKE

# Show Low, Arizona

Prepared By:

The Concerned Citizens of
White Mountain Lake

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**PURPOSE**

The purpose for the preparation of the White Mountain Lake Recreation Carrying Capacity Study is to evaluate the documented historical use of the lake, and then extrapolate the impact to water recreation, which is anticipated should the proposed Gateway Oasis Development IV project come to fruition. Recreational carrying capacity is defined as "The amount of development and activity a body of water can handle before it starts to deteriorate." The general steps to determine carrying capacity are: census watercraft use, define goals, develop and apply a carrying capacity formula, and develop a plan to optimize use.

In order to provide a conservative Recreational Carrying Capacity estimate, two sets of criteria were developed. These are: There are three different published estimates of White Mountain Lake (WML) surface area. These size estimates range from 268 acre feet to a maximum capacity of 288 acre feet. Since the lake is subject to drawdown due to irrigation requirements by the Snowflake Irrigation district and that drawdown is entirely dependent upon use factor, irrigation needs, and annual moisture received in the tributary feed, both the 268 acre feet and 288 feet will be used as in calculating a high and low carrying capacity.

Emphasis is placed on boating density methodology and other factors pertinent to WML recreation carrying capacity estimation.

**Use Characteristics:** Use characteristics are those data which indicate how the lake is being used, and by whom. Carrying capacity studies use various techniques to estimate the total number of boats, the number and types of boats in use at peak and non-peak times, and the distribution of use between residents and visitors. Studies reviewed in the present document utilized the following methods to estimate use:

- On-the-water surveying
- On-the-ground surveying,
- Parking lot vehicle counts

(See Table 1, Historical Data)

**Usable Lake Surface Area**: The most common way to calculate usable lake surface area is to subtract a shoreline buffer zone of predetermined width from the total acreage of the lake. These buffer zone widths typically range from 100 to 200 feet. Jaakson, Buszynski, and Botting (1990) also recommended buffer zones around emergent aquatic vegetation (100 feet) and marinas and public swimming beaches (400 feet). In several studies, the issue of depth fluctuation was also addressed with regard to surface area determination, since a lake with a lower depth will have a smaller total surface area. For the most conservative usable surface area calculation, the lowest lake depth should be used in conjunction with a shoreline buffer zone.

**Table 1 – HISTORICAL USE DATA**

| MONTH | Boats/Trailers | Alt Watercraft | Fishing | Vehicles |
|---|---|---|---|---|
| May 2018 | 70 | 53 | 46 | 314 |
| June 2018 | 148 | 169 | 134 | 654 |
| July 2018 | 116 | 121 | 112 | 438 |
| Aug 2018 | 76 | 73 | 38 | 364 |
| Sept 2018 | 80 | 70 | 58 | 332 |
| Apr 2019 | 9 | 27 | 4 | 125 |
| May 2019 | 58 | 50 | 29 | 392 |
| June 2019 | 189 | 192 | 80 | 855 |
| July 2019 | 237 | 220 | 163 | 1012 |
| Aug 2019 | 149 | 117 | 91 | 697 |
| Sept 2019 | 35 | 18 | 0 | 285 |
| | | | | |
| 2018 TOTAL(May-Sep) | 490 | 486 | 388 | 2102 |
| 2019 TOTAL (May-Sep) | 668 | 597 | 363 | 3241 |

As shown by the historical data comparing 2018 data versus 2019 data there has been an increase of 36% seasonal boat usage increase; 23% alternative watercraft seasonal use; daily shore and dock fishing remained the same; and parking increased 54% seasonal use. *Daily use has increased from 6.3 watercraft per day in 2018 to 8.2 watercraft per day.*

**Boating Density**: Boating density, measured in surface acres per watercraft, could be viewed as the most systematic component of the carrying capacity estimation process. Even so, optimum densities vary depending on users' preferred setting types and site-specific attributes. Basic choices for published Boating Density ranges are either the Water Recreations Opportunity Spectrum (WROS) or those published for other national entities.

There are six WROS classes: urban, suburban, rural developed, rural natural, semi primitive, and primitive. The WROS Users' Guidebook offers the following ranges of reasonable boating capacity coefficients (i.e., boating densities) for the six WROS classes:

WROS Class Range of Boating Coefficients

| | Low end of range | High end of range |
|---|---|---|
| Urban | 1 acre/boat | 10 acres/boat |
| Suburban | 10 acres/boat | 20 acres/boat |
| Rural developed | 20 acres/boat | 50 acres/boat |
| Rural natural | 50 acres/boat | 110 acres/boat |
| Semi primitive | 110 acres/boat | 480 acres/boat |
| Primitive | 480 acres/boat | 3,200 acres/boat |

National and State Published Standards

- National Recreation and Park Association (NRPA) – 4 acres/boat
- Bureau of Outdoor Recreation (BOR) – 9 acres/boat
- **Arizona Outdoor Recreation Coordination Commission – 10-20 acres/boat**
- Wisconsin Comprehensive Plan – 20-40 acres/boat
- Louisiana Parks and Recreation Commission – 20-40 acres/boat

***Since WML recreation district is within the state of Arizona this density standard of 10-20 acre feet/boat per day will be used as the maximum density for any calculations.***

***Note* that these five standards provide the more general, aggregate boating density figure, rather than a collection of boating densities specific to boating activity type.***

**Lake Physical Characteristics**: In terms of lake physical characteristics, it is known that a lake's "size, shape, and depth strongly influence recreational carrying capacity". A size-independent measure of lake shape, known as shoreline development factor (SDF), which is defined as "a measure of the degree of irregularity in the shape of the shoreline". SDF compares the actual length of the shoreline around a lake to the minimum shoreline length of a lake with the same area (i.e., if the lake were a perfect circle). (See Attached Map)

Equation 1: Shoreline Development Factor (SDF)

SDF = Length of shoreline around lake/Circumference of circle with area equal to that of lake

A higher ratio indicates a more irregular shoreline. Irregular shorelines, with their coves and inlets, "may serve to isolate impacts [but] also imply greater safety risks as well as ecological consequences".

As shown by the attached map of WML, the lake has a significant irregular shoreline.

**Use Characteristics**: Use characteristics are those data which indicate how the lake is being used, and by whom. To evaluate lake use characteristics, historical collected data will be used (See Table 1).

**Environmental Impacts**: Some of the more common impacts of boating activity are "fuel emissions from boat motors, suspension of bottom sediments, decreased water transparency, shoreline erosion, destruction of fish spawning areas, and loss of valuable fish and wildlife habitat". Portions of the lake less than 5 feet deep are most susceptible to environmental impacts, as such, a second ratio, called the shallowness ratio, is presented as follows:

Equation 2: Shallowness Ratio (SR)

SR = Area of lake less than 5 ft. deep/Total area of lake

The shallowness ratio represents the proportion of the lake bottom likely to be affected by motorized watercraft. A ratio less than 0.10 is considered low, while a ratio greater than 0.50 is considered high.

**Usable Lake Area**: Publications state that "most environmental problems associated with boating activity occur in shallow waters". Thus, in addition to considering a shallowness ratio for the lake as a whole, it is recommended that a minimum 100-foot shoreline safety/environmental protection zone be established. Usable lake area is then calculated as the difference between total lake area and the shoreline safety/environmental protection zone. As previously stated, an important point for WML is regarding water level fluctuations. When the water level drops, the usable lake area is reduced. Carrying capacity would thus be lower during periods of low lake level. It is for this purpose both the 268 surface acre feet (low point) and the 288 surface acre feet (high point) will be presented.

**Carrying Capacity Calculation**: Equations 3 and 4 below are used to calculate carrying capacity in terms of the optimal number of boats on the lake. First, the optimal number of boats is calculated, as shown in Equation 3.

Equation 3: Optimal Number of Boats on Lake

Optimal number of boats = Usable lake area/Optimum boating density, where usable lake area is the adjusted lake area (subtracting a 100-foot shoreline safety/environmental protection zone) and optimum boating density is between 10 and 20 acres per boat (based on the state of Arizona standard).

The resultant estimated carrying capacity is expressed in terms of percentage at peak use, and it is calculated as follows:

Equation 4: Percentage at Peak Use

Carrying Capacity = Estimated number of boats at peak use/ Optimal number of boats

Carrying capacity is exceeded when the percentage at peak use (see Equation 4) is greater than 100%. Two of the factors described above – lake physical characteristics and environmental impacts – are not included in the carrying capacity estimate.

**CALCULATIONS:**

SHALLOWNESS RATIO: SR = Area of lake less than 5 ft. deep/Total area of lake

For 268 acre feet
SR = 20% of 268/268
SR = 53.6 acre feet/268 acre feet
SR = .2
SR is considered to be **LOW**

For 288 acre feet
SR = 20% of 288/288
SR = 57.6 acre feet/288 acre feet
SR = .2
SR is considered to be **LOW**

**OPTIMAL NUMBER OF BOATS**
Optimal number of boats = Usable lake area/Optimum boating density, where usable lake area is the adjusted lake area (subtracting a 100-foot shoreline safety/environmental protection zone) and optimum boating density is between 10 and 20 acres per boat (based on the state of Arizona standard). In order to adjust the usable lake area, measurements were taken of the marina, launch and dock area, the designated swimming and swim dock area, and the outlet dam area including that area protected by riprap to minimize erosion of the earthen dam, and those areas less than 5' in depth. The estimated unusable area total is **53.6 acre feet**.

Optimal Number = Usable lake area/10 acres per boat
Optimal Number = 268-53.6 acre ft unusable/10 acres per boat
Optimal Number = 21 boats

Optimal Number = Usable lake area/20 acres per boat
Optimal Number = 268-53.6 acre ft unusable/20 acres per boat
Optimal Number = 11 boats

Optimal Number = Usable lake area/10 acres per boat
Optimal Number = 288-57.6 acre ft unusable/10 acres per boat
Optimal Number = 23 boats

Optimal Number = Usable lake area/20 acres per boat
Optimal Number = 288-57.6 acre ft unusable/20 acres per boat
Optimal Number = 12 boats

## RECREATIONAL CARRYING CAPACITY OF WML

(Number of boats at peak use from Table 1-Daily use has increased from 6.3 watercraft per day in 2018 to 8.2 watercraft per day.)

Carrying Capacity = Estimated number of boats at peak use/ Optimal number of boats
Carrying Capacity at 268 acre feet (10 acre ft/boat) = 8.2/21 boats
Carrying Capacity at 268 acre feet = 39% of current capacity

Carrying Capacity = Estimated number of boats at peak use/ Optimal number of boats
Carrying Capacity at 268 acre feet (20 acre ft/boat) = 8.2/11 boats
Carrying Capacity at 268 acre feet = 75% of current capacity

Carrying Capacity = Estimated number of boats at peak use/ Optimal number of boats
Carrying Capacity at 288 acre feet (10 acre ft/boat) = 8.2/23 boats
Carrying Capacity at 288 acre feet = 35% of current capacity

Carrying Capacity = Estimated number of boats at peak use/ Optimal number of boats
Carrying Capacity at 288 acre feet (20 acre ft/boat) = 8.2/12 boats
Carrying Capacity at 288 acre feet = 68% of current capacity

## EXTRAPOLATION

Using the supplied information from the developer, the first phase will develop 200 sites with two Recreational vehicles per site. This gives a total of 400 additional vehicles for any given day of the seasonal time period from May to September. *Using the same methodology as the historical data gathered, if a conservative estimate of 10% of these vehicles have watercraft for use on a lake, the daily number is 30 additional watercraft per day. This then changes the daily number from 8.2 watercraft per day to 38.2 watercraft per day and the carrying capacity percentages as follows:*

Carrying Capacity = Estimated number of boats at peak use/ Optimal number of boats
Carrying Capacity at 268 acre feet (10 acre ft/boat) = 38.2/21 boats
Carrying Capacity at 268 acre feet = **182% of daily capacity**

Carrying Capacity = Estimated number of boats at peak use/ Optimal number of boats
Carrying Capacity at 268 acre feet (20 acre ft/boat) = 38.2/11 boats
Carrying Capacity at 268 acre feet = **347% of daily capacity**

Carrying Capacity = Estimated number of boats at peak use/ Optimal number of boats
Carrying Capacity at 288 acre feet (10 acre ft/boat) = 38.2/23 boats
Carrying Capacity at 288 acre feet = **166% of daily capacity**

Carrying Capacity = Estimated number of boats at peak use/ Optimal number of boats
Carrying Capacity at 288 acre feet (20 acre ft/boat) = 38.2/12 boats
Carrying Capacity at 288 acre feet = **318% of daily capacity**

**SUMMARY:**

This document served as a review of a variety of existing literature on Recreational carrying capacity for small lakes using all manner of watercraft. From the studies outlined above, the subjective nature of carrying capacity determination can be seen, as no two studies were exactly alike. However based on extremely conservative estimates using **10% of the daily capacity of 400 RV's per day**, far less than would be considered standard, it is extremely apparent that adding even a small portion of the anticipated daily watercraft would significantly exceed standards recommended by every oversight agency.

As shown by the Capacity Calculations, historical data for the last three years averages from a low of 6.3 watercraft per day to a high of 8.2 watercraft per day. The current carrying capacity ranges between a low of **35%** to a high of **75%**. Using the standards of 10 acre ft. per watercraft as the low end and 20 acre ft. per watercraft as the high end (Arizona Outdoor Recreation Coordination Commission) with an conservative projected increase of 10% of the 400 RV slots, the calculations clearly show an increase from 6.3 watercraft/day to an average of 38.2 watercraft/day. This equates to a projected carrying capacity of **166% to 347%** above the daily carrying capacity. Far in excess of what the lake can handle safely and without suffering environmental detriment.

As shown by the spreadsheets (WMLCRID Labor budget) using the same methodology, the annual labor budget will need to be increased significantly. The projected labor budget for fiscal year 2019-2020 is $60,000. Using the same methodology as the Lake Capacity Study, the annual labor budget would be expected to increase to a minimum of **$99,000** per year to a maximum of **$218,000**. It would be anticipated that this monetary shortfall would either be borne by the 3,800 current Special Tax District members, or a stipulation be placed on the developer to make up the annual shortfall.

These conservative calculations clearly show that the maximum carrying capacity for White Mountain Lake would be overwhelmed and as a result degradation of existing wildlife (both waterfowl and aquatic mammals), recreational opportunities, shoreline erosion and resulting additional sedimentation, and environmental standards would ensue. The single boat landing cannot handle any additional launch traffic, not to mention, as shown by data collection, the lack of parking for a minimum **182% increase.**

It should be noted that the existing insurance coverage for White Mountain Lake was reviewed and insurance personnel contacted regarding the existing coverage. Current coverage is at best, a minimal coverage, with provisions covering the existing buildings, equipment and a General Liability. The premium rate is based on the size of the lake and the number of residents in WML (3,800). Neither an increased Risk of Accident nor overwhelming the capacity of the lake enters into the rate payment. At most, it was estimated that the annual rate may increase by 10%. It should be understood by the Navajo County BOS that unless steps are taken in advance and stipulations placed on the developer, the inadequate safety measures would most surely place a significant amount of Liability on the BOS.

## References

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