

CARRYING CAPACITY  
of  
NORTH LAKE LEELANAU

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## SUMMARY AND CONCLUSIONS

Factual data of North Lake Leelanau were collected and employed to evaluate the *carrying capacity* of the lake. This study indicated that recreational quality (safety and satisfaction) requires 37 acres of lake surface for each boat and that environmental protection of the lake requires 33 acres of lake surface for each boat. Based on the slightly more stringent recreational quality requirement, no more than 68 boats should be in active use on North Lake Leelanau at any time.

Three counts of active boats on the lake were made on different days in 1996. These counts ranged from 50 to 78 active boats. One count made in 1997 found 85 active boats.

This work strongly suggests that North Lake Leelanau is being used at or above its prudent boat carrying capacity. Addition or enlargement of any boat launch sites, marinas, resorts, camp grounds or keyholing sites will further jeopardize recreational and environmental conditions of the lake. Several facilities are already present that generate a localized concentration of watercraft which present some safety concerns.

## INTRODUCTION

Carrying capacity is the number of boats that can use a lake at any one time with minimal environmental damage to the lake and provide safe and enjoyable recreational use. The Planning & Zoning Center of Lansing, Michigan has developed a method of evaluating any lake to determine, objectively, its carrying capacity. That method is described in a manual entitled *Carrying Capacity Analysis & Ordinances Providing Lake Access Regulations* published in 1994 by that center.

The authors collected the information required to carry out the evaluation described in the manual and carried out the procedures described therein. The data used, calculations made and evaluation forms completed for the evaluation are presented in this report.

## LAKE CHARACTERISTICS

Lake Size	2950 acres
Lake area less than 5 feet deep	420 acres
Lake volume	5260 million cubic feet
Shoreline length	15 miles
Number of shoreline properties	475
Number of riverfront properties	63

The lake morphology values were obtained by planimeter measurements of a bathymetric map of Lake Leelanau. The number of properties is found by review of tax maps in the County Equalization Department.

## MOORING SITES

The term "moorings" as used here includes all motorized boats which are present or have access to the water at a site during the boating season. This includes parking spaces at launch ramps, boat hoists, mooring buoys, boat houses, beached boats and trailered boats which can be launched at the site.

The number of moorings at multi-boat sites was determined by site visits and by review of marina permits. The number of moorings at individual sites was determined by a shoreline survey by boat in the period Aug. 14-17, 1997. A conservative estimate was made that 10 of the 31 parking spaces at the Narrows DNR launch site were used to place boats in North Lake Leelanau.

MULTI-BOAT SITES:	Number of Moorings			
	Public	Private	Road end	Total
DNR launch site - River St. - Leland	37			
Stander Marine		260		
Waterford Hills (Oxford Drive)		13		
Cedar Haven Resort		7		
St. Mary's Street (Lake Leelanau)			10	
DNR launch site - Narrows (assume 33% to North Lake Leelanau)	10			
Crescent Ridge		5		
East Leland Park - Alpers Rd.	5			
Bartholomew Public Beach - Pearl St.	16			
Road end - Fourth St.			1	
Road end - Horn Rd.			1	
Leland Yacht Club		18		
Sugar Bush		9		
Amy Chatfield Marina		14		
Other road ends (19)			0	
<b>Total moorings</b>	<b>68</b>	<b>326</b>	<b>12</b>	<b>406</b>
<b>Total sites</b>	<b>4</b>	<b>7</b>	<b>22</b>	<b>33</b>

	<u>Sites</u>	<u>Moorings</u>
Individual properties	505	534
Public launch sites	4	68
Private multi-boat sites	7	326
Road ends	22	12
<b>TOTALS</b>	<b>538</b>	<b>940</b>

## BOATING ACTIVITY

Date	07/06/96	08/04/96	08/31/96	08/09/97	07/14/01
Day	Saturday	Sunday	Saturday		Saturday
Time	14:30	14:40	14:30	14:00	14:00
Canoe/Kayak	1	4	1		3
Sail Boat	26	20	8	4	15
PWC	5	4	10	9	8
Pontoon Boat	6	16	14	7	16
Boat under 5 Hp	2	0	0	1	4
Boat over 5 Hp	39	56	54	69	74
<b>Motor Boats</b>	<b>50</b>	<b>76</b>	<b>78</b>	<b>85</b>	<b>98</b>
<b>Total Boats</b>	<b>79</b>	<b>100</b>	<b>87</b>	<b>90</b>	<b>120</b>

The boat counts above were made by driving a boat down the center of the lake from one end to the other at a speed of about 20 knots. Two observers aboard recorded boats in use as seen to the port and starboard sides as the boat progressed down the lake.

## CALCULATIONS FOR MATRIX FORMS

$$\begin{aligned}
 \text{Lake Shape Factor} &= \text{Shore Length} / (2 * (3.14159 * \text{lake area})^{.5}) \\
 &= 15 / (2 * (3.14159 * 4.6)^{.5}) \\
 &= 1.97
 \end{aligned}$$

$$\begin{aligned}
 \text{Percent Lake less than 5 ft. deep} &= (420/2950) * 100 \\
 &= 14
 \end{aligned}$$

$$\begin{aligned}
 \text{Flushing Rate} &= \text{Lake Volume} / \text{Water outflow} \\
 &= 5,260,000,000 / (160\text{cfs} * 3600 * 24) \\
 &= 380 \text{ days}
 \end{aligned}$$

$$\begin{aligned}
 \text{Average frontage of building sites} \\
 \text{Frontage} &= \text{Shoreline length} / \text{number properties} \\
 &= 15 * 5280 / 475 \\
 &= 167 \text{ feet}
 \end{aligned}$$

$$\begin{aligned}
 \text{Multi-boat Access Site Factor (MBASF)} \\
 \text{BMBS} &= \text{average no. boats per multi-boat site} \\
 &= 406/33 \\
 &= 12.3
 \end{aligned}$$

$$\begin{aligned}
 \text{RBE} &= \text{residential boat equivalent} \\
 &= \text{number of boats at residential sites} / \text{Number sites} \\
 &= 534/505 \\
 &= 1.06
 \end{aligned}$$

## CALCULATIONS (Continued)

$$\begin{aligned}\text{MBASF} &= \text{BMBS} - \text{RBE} \\ &= 12.3 - 1.06 \\ &= 11.2\end{aligned}$$

### Surface Area/Multi-boat Access Factor (SAMBAF)

$$\begin{aligned}\text{SAMBAF} &= \text{Multi-boat moorings per 20 acres useable surface} \\ &= 406 \times 20 / (2950 - 420) \\ &= 3.2 \text{ boats per 20 acres}\end{aligned}$$

### Riparian Boat/Non-Riparian Factor (RNRF)

$$\begin{aligned}\text{RNRF} &= \text{Riparian owned boats/non-riparian owned boats} \\ &= 534/406 \\ &= 1.32\end{aligned}$$

### Use Factor

$$\begin{aligned}\text{UF} &= \text{Number active boats (peak period)/Number moorings} \\ &= 78/940 \\ &= 0.083\end{aligned}$$

## ENVIRONMENTAL CARRYING CAPACITY MATRIX

Using data listed or calculated above along with known soil and topographical information, the attached 2 page environmental form was completed. This form indicates a minimum of 33 acres was desirable for each active motor boat.

## RECREATIONAL CARRYING CAPACITY MATRIX

The attached recreational capacity form was also completed using the above information. This form indicates a minimum of 37 useable acres was desirable for each active motor boat.

## CARRYING CAPACITY

Based on the recreational carrying capacity matrix requiring 37 acres of useable lake surface per boat and the measured useable surface area of 2530 acres, the lake has a carrying capacity of 68 boats.

Based on the measured use factor of 0.083, the lake should have a maximum of 819 (carrying capacity/use factor) boat moorings.

# ENVIRONMENTAL CARRYING CAPACITY MATRIX

Sheet 1 of 2

By: W. H. Nielsen

03/26/98

Lake Name: <b>North Lake Leelanau</b>		Score toward	Score toward
County: <b>Leelanau</b>		LESS restrictive	MORE restrictive
Township(s): <b>Leland</b>			
<b>LAKE CHARACTERISTIC</b>			
<b>LAKE SIZE (acres)</b>			
	< 50	+3	
	50 to <300	+2	
	300 to 1,000	+1	
2950	>1,000		
<b>Lake Shape Factor = Shore length/2 times sq rt(3.14159 times lake area)</b>			
	Round LSF < 1.25	-2	
	Irregular LSF 1.25 to 1.75	-1	
	LSF 1.75 to 2.5	+2	<b>2</b>
1.97	LSF > 2.5	+4	
<b>Percent lake less than 5 feet deep</b>			
	<10%	-4	
14	10 to 30%	-2	<b>2</b>
	>30%	+4	
<b>Bottom Soil Type</b>			
	Mostly muck	+1	
	Sand and muck	+1	
	Mostly sand	-1	<b>1</b>
<b>Bank Characteristics</b>			
	High bluff	+2	
	Moderate bluff	+1	
	Low bluff	-1	<b>1</b>
<b>Predominate Shoreline Soil Type</b>			
	Silts, clays and loams	+1	
	Sands and gravel	-1	<b>1</b>
<b>Option: Water Quality Protection</b>			
	Minimize WQ damage from boating	+4	<b>4</b>
<b>Flushing Rate</b>			
	Less than 2 months	-2	
	2 months to 1 year	-1	
~380 days	Over 1 year	+1	<b>1</b>

# RECREATIONAL CARRYING CAPACITY MATRIX

Sheet 1 of 1

By: W. H. Nielsen

03/26/98

Lake Name:	<b>North Lake Lelanau</b>	Score toward LESS restrictive	Score toward MORE restrictive
County:	<b>Leelanau</b>		
Township(s):	<b>Leland</b>		

LAKE CHARACTERISTIC					
LAKE SIZE (acres)					
	< 50		+4		
	50 to <300		+2		
	300 to 1,000		+1		
2950	>1,000				
Lake Shape Factor = Shore length/2 times sq rt(3.14159 times lake area)					
	Round LSF < 1.25		-2		
	Irregular LSF 1.25 to 1.75		-1		
	LSF 1.75 to 2.5		+3		<b>3</b>
1.97	LSF > 2.5		+4		
Percent lake less than 5 feet deep					
	<10%		-4		
14%	10 to 30%		-2	<b>2</b>	
	>30%		+4		
Option: Water Quality Protection					
	Minimize WQ damage from boating		+4		<b>4</b>
Surface Area/Multi-boat Access Factor (SAMBF)					
	up to 1 boat per 20 acres		-1		
3.2	over 1 boat per 20 acres		+1		<b>1</b>
Riparian Boat/Non-Riparian Factor (RNRF)					
1.32	up to 10 boats		+1		<b>1</b>
	Greater than 10		-1		
Total Score				<b>2</b>	<b>9</b>
Difference between columns					<b>7</b>
Boat acreage = 30 +/- Difference					<b>37</b>