Contract 189

Effects of Commingling Lake Michigan Water and Groundwater

Prepared by the Illinois State Water Survey

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Illinois Department of Transportation
Division of Water Resources

EFFECTS OF COMMINGLING
LAKE MICHIGAN WATER
AND GROUNDWATER

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Division of Water Resources

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This study was requested in a letter of October 15, 1976 from Dr. Leo Eisel to Dr. W. C. Ackermann, to be completed under a contract between the Illinois Division of Water Resources and the Illinois State Water Survey.

In its responsibility for the allocation of 3200 cubic feet per second of Lake Michigan water which Illinois is permitted to divert from the Great Lakes drainage basin, the Illinois Division of Water Resources, acting for the Illinois Department of Transportation, is proposing allocation of lake water to areas now using groundwater. The proposed allocation would reduce the dependence upon the deep sandstone aquifer in northeastern Illinois and arrest the current decline in water levels in that aquifer.

It is proposed that groundwaters in this area be used to the greatest extent possible without causing a decline in the groundwater levels in the aquifer, and that the additional water requirements be met by commingling Lake Michigan water with the groundwater.

The blending, or commingling, of two waters may result in a blend which is either scale forming or corrosive, although the original waters are stable, causing neither scale formation nor corrosion. The commingling of Lake Michigan water with groundwater has been practiced at several locations. Riverside, Illinois, experienced corrosion problems in its water system when Lake Michigan water was introduced in 1963. This was not true commingling, since the groundwater and Lake Michigan water were added to the distribution system at different points, and the commingling occurred in a limited portion of the system. In this case it was reported that severe corrosion was found in the distribution system and in household plumbing services.

Experiences of this type indicated a need for this study to determine the probable effects of commingling and protective action that might be required.

In the letter previously mentioned, Dr. Eisel requested that the commingling study be concentrated upon water supplies in the following locations:

<u>Communities</u>

Palatine
Hanover Park
Hoffman Estates
Downers Grove

Townships	Location Township-Range
42	44N H E
49	42N 10E
53	41N 09E
54	41N 10E
74	40N 10E
77	39N 10E
80	38N 10E
95	34N 13E
96	34N 14E 34N 15E

The groundwaters considered were those from community-owned wells because the most reliable and complete analyses were available for those waters. The specific wells and analyses were selected primarily on the basis of the reported rate of water production. Wells with low rates of water production, and those which are not in use, were eliminated from consideration. This method of selection was used both for the communities listed above and for the townships studied. In addition, all analyses selected were examined to be sure that complete data were available and that the data were free of any obvious errors.

The Lake Michigan analyses used in this study were those from the Chicago Central District Water Treatment Plant. Since temperature is an important factor in the calculations, three different analyses were selected, representative of the temperature range which occurs in Lake Michigan. In the remainder of this report, these analyses are designated by temperature only.

Background

There are four factors which should be considered in commingling Lake Michigan water with these groundwaters because of possible effects upon corrosion rates in the commingled waters:

1. Dissolved oxygen is essentially nonexistent in. the groundwaters, whereas the lake water is very nearly saturated with dissolved oxygen.

2. The total dissolved mineral content of the groundwaters is much higher than that of the lake water.

3. Iron is present in many of the groundwaters (concentrations up to 4.4 mg/l), whereas the lake water is practically free of iron.

4. The Saturation Index of the commingled water is an indication of its corrosive or scale-forming properties. Our work was concentrated on this criterion, and a brief definition and explanation will be given at this point:

The pH at which a water would be in equilibrium with solid calcium carbonate is known as the pH of saturation, or pH . The saturation index (SI) is equal to the actual pH minus pH_s. A positive saturation index indicates that the water may deposit calcium carbonate (scale formation) in the distribution system. A negative index indicates that the water would tend to dissolve calcium carbonate, and possibly cause some corrosion.

For satisfactory conditions, the saturation index should be zero or a slight positive value. The latter is associated with deposition and maintenance of a protective coating of calcium carbonate on the pipe walls. It is difficult to predict corrosion rates with confidence, since other variables such as dissolved oxygen, temperature, hardness, and mineralization are involved. As an estimate, -0.1 or -0.2 saturation index may be only slightly corrosive.

Calculations of Saturation Index

The groundwater and Lake Michigan analyses used for this study have been described above. Reliable pH values of the well waters are not available. We have assumed that both the treated Lake Michigan water and well waters would have a pH equal to pH_s. The Chicago plant effluent is adjusted to this pH and the groundwaters acquire this pH by prolonged contact with calcium carbonate in the aquifer.

To determine the effect of commingling upon the saturation index, calculations were made with each groundwater analysis and each of the three lake water analyses, representing lake temperatures of 5, 15, and 25°C, and varying the percentage of lake water in the mixture from 0 to 100 in steps of 10. The composition of the resulting blended water was calculated, including the temperature, calcium, alkalinity, pH, pH_s, and saturation index.

The quantity of computer output from this operation was rather large and it does not appear appropriate to include it in this report. For any who may be interested, a computer listing of all analyses used can be supplied upon request. Likewise, copies of the computer output for selected commingling calculations could be made available. The results are summarized below.

Conclusions

As predicted by the calculations of the saturation index, some increase in corrosive tendency is probable if Lake Michigan water is blended with these groundwaters, particularly with low temperature lake water and a high percentage of lake water in the blended water. A few of the groundwaters show negligible deviations in saturation index when blended with Lake Michigan water, but the majority show increasingly negative saturation indexes as the percentage of lake water in the blend increases from zero to about 80%. With proportions of lake water above 80% in the blend, the saturation indexes increase to the assumed value of zero at 100% lake water.

In addition to the negative saturation index which our calculations predict, the addition of Lake Michigan water, which is saturated with dissolved oxygen, will add dissolved oxygen as another factor in the corrosion problem. Groundwaters generally have no dissolved oxygen, whereas the commingled waters will have a concentration of dissolved oxygen which is approximately proportional to the percentage of lake water in the blend. Corrosion is much more probable in a water containing dissolved oxygen than in a water free of dissolved oxygen. Therefore it is probable that measures will be necessary to avoid corrosion in commingled waters even though the saturation index is very near zero.

For optimum results, commingling should take place in facilities designed for the purpose and not in the distribution system itself. This would permit pretreatment of the groundwater to remove iron before commingling, and adjustment of the pH of the commingled water to provide a slight positive saturation index. A corrosion inhibitor could also be applied at this point.

<u>Saturation Index Calculations for Communities Now Commingling</u>

Four communities, not in the designated areas of interest for this study, are reported to have practiced commingling of their groundwaters and Lake Michigan water. These include Riverside, mentioned above, Hickory Hills, Lyons, and Des Plaines. For comparative purposes, the saturation index calculations were also made for groundwaters from these communities. Des Plaines softened its well water and adjusted its pH to the range, 8.2 to 8.6, before commingling. Therefore the commingling calculations for the Des Plaines softened water were made assuming that the softened water was in this range rather than at pH_s, as was assumed for the other groundwaters.

The saturation index at the point of the maximum deviation from zero for all groundwaters, blended with the three Lake Michigan waters are listed in Table I. The data for the groundwaters from communities which have practiced commingling are included at the bottom of this table.

Figures 1-22 show the variation in the calculated saturation index with the percent of lake water in the blend. These figures are given as examples which illustrate the variation in the saturation index as the proportions of the blended waters are changed. Figures are also included showing the same data for the Des Plaines softened water at three assumed pH values for that water. From these curves one can see that excellent results could be obtained with this water at pH 8.6, whereas lower pH values would produce negative saturation indexes for all blends containing appreciable portions of the softened water. This optimum pH for the softened water would vary with the efficiency of the softening process, and might vary from day to day.

TABLE I

SATURATION INDEX AT MAXIMUM DEVIATION FROM ZERO FOR WATERS COMMINGLED WITH LAKE WATER AT THREE TEMPERATURES

TWP	RNG	Source	Aquifer*	Sample Date	SI at Max. Deviation from Zero for Blend with Lake Water at Indicated Temperature		
					5°C	15°C	25°C
38N	10E	Downers Grove No. 10	II	10/27/60	-.31	-.24	-.14
38N	11E	Downers Grove No. 13	II	4/01/75	-.38	-.30	-.19
39N	11E	Downers Grove No. 12	II	12/08/75	-.29	-.22	-.13
38N	11E	Downers Grove No. 13	II	2/24/72	-.40	-.32	-.21
42N	10E	Palatine No. 2	III	1/08/59	-.26	-.19	-.11
42N	10E	Palatine No. 6B	II	1/10/77	-.12	-.08	-.02
42N	10E	Palatine No. 3	II	1/10/77	-.05	-.03	+.01
42N	10E	Palatine No. 7	III	1/10/77	-.28	-.21	-.13
42N	10E	Palatine No. 9	III	1/10/77	-.20	-.14	-.07
41N	09E	Hanover Park No. 4	III	9/04/75	-.26	-.19	-.11
41N	10E	Hoffman Estates No. 2	III	5/15/58	-.31	-.23	-.15
41N	10E	Hoffman Estates No. 3	II	5/16/58	-.09	-.06	+.00
42N	10E	Hoffman Estates No. 9	III	12/05/73	-.29	-.22	-.13
44N	10E	Mundelein No. 9	III	11/18/71	-.27	-.20	-.12
44N	10E	Mundelein No. 7	I	6/27/72	-.05	-.03	+.01
44N	11E	Libertyville No. 11	III	3/30/76	-.26	-.20	-.12
44N	11E	Libertyville No. 10	II	3/30/76	-.03	-.02	-.01
41N	09E	Streamwood No. 4	I	6/16/75	-.37	-.28	-.18
41N	09E	Bartlett No. 3	I	5/24/62	-.39	-.30	-.20
40N	10E	Roselle No. 4	II	1/15/76	-.19	-.13	-.06
40N	10E	Roselle No. 3	II	1/15/76	-.31	-.24	-.14

TABLE I

(continued)

TWP	RNG	Source	Aquifer*	Sample Date	SI at Max. Deviation from Zero for Blend with Lake Water at Indicated Temperature 5°C	15°C	25°C
40N	10E	Carol Stream No. 2	II	3/31/75	-.28	-.21	-.12
40N	10E	Bloomingdale No. 2	III	10/01/68	-.27	-.20	-.12
40N	10E	Itasca No. 8	I	9/27/73	-.33	-.26	-.15
40N	10E	Glendale Hts. No. 4	II	2/23/72	-.20	-.14	-.07
39N	10E	Wheaton No. 5	II	9/26/73	-.31	-.23	-.14
39N	10E	Wheaton No. 4	II	5/27/75	-.36	-.28	-.18
39N	10E	Glen Ellyn No. 5	II	11/02/76	-.11	-.04	-.01
39N	10E	Glen Ellyn No. 6	II	7/28/75	-.24	-.17	-.09
38N	10E	Naperville No. 16	III	1/07/76	-.23	-.16	-.09
38N	10E	Naperville No. 5	II	5/17/72	-.32	-.25	-.15
38N	HE	Woodridge No. 5	II	7/19/76	-.30	-.23	-.14
38N.	10E	Woodridge No. 1	II	1/19/76	-.34	-.26	-.16
34N	13E	Park Forest So. No. 6	II	3/19/74	-.31	-.24	-.14
34N	13E	Park Forest So. No. 2	II	8/26/74	-.42	-.33	-.23
34N	13E	Park Forest So. No. 3	II	3/19/74	-.35	-.27	-.17
34N	14E	Steger No. 1	II	6/03/75	-.38	-.29	-.19
34N	14E	Steger No. 2	II	6/03/75	-.40	-.31	-.21
34N	14E	Crete No. 1	II	3/30/76	-.41	-.32	-.22
		COMMUNITIES NOW COMMINGLING					
37N	12E	Hickory Hills No. 2	III	5/25/62	-.26	-.19	-.11
39N	12E	Riverside No. 4	III	2/13/74	-.30	-.23	-.14
39N	12E	Riverside No. 3	III	3/22/76	-.30	-.23	-.14
38N	12E	Lyons No. 2	III	3/29/76	-.28	-.20	-.12

TABLE I

(continued)

TWP RNG	Source	Aquifer*	Sample Date	SI at Max. Deviation from Zero for Blend with Lake Water at Indicated Temperature 5°C	15°C	25°C
	COMMUNITIES NOW COMMINGLING					
41N 12E	Des Plaines No. 6	III	4/06/62	-.22	-.16	-.09
41N 12E	Des Plaines No. 3	III	8/04/76	-.22	-.16	-.08
41N HE	Des Plaines No. 5	III	8/04/76	-.27	-.20	-.12

*Aquifer Definitions:

I Sand and gravel deposits in the glacial drift.
II Shallow dolomite formations, mainly of Silurian Age.
III The Cambrian-Ordovician aquifer, or deep sandstone.

REFERENCE: "Water Resources Availability, Quality, and Cost in Northeastern Illinois", Richard J. Schicht, J. Rodger Adams, and John B. Stall, Illinois State Water Survey Report of Investigation 83, 1976.

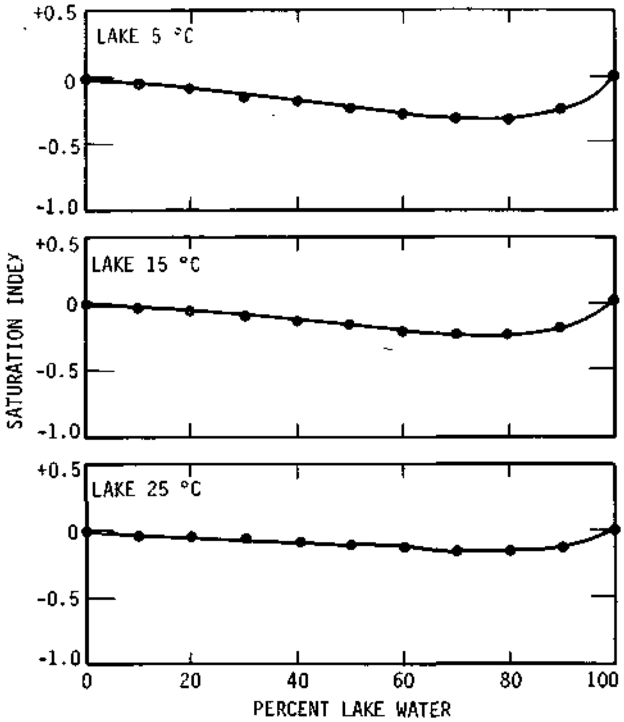

Figure 1. Downers Grove #10
October 27, 1960

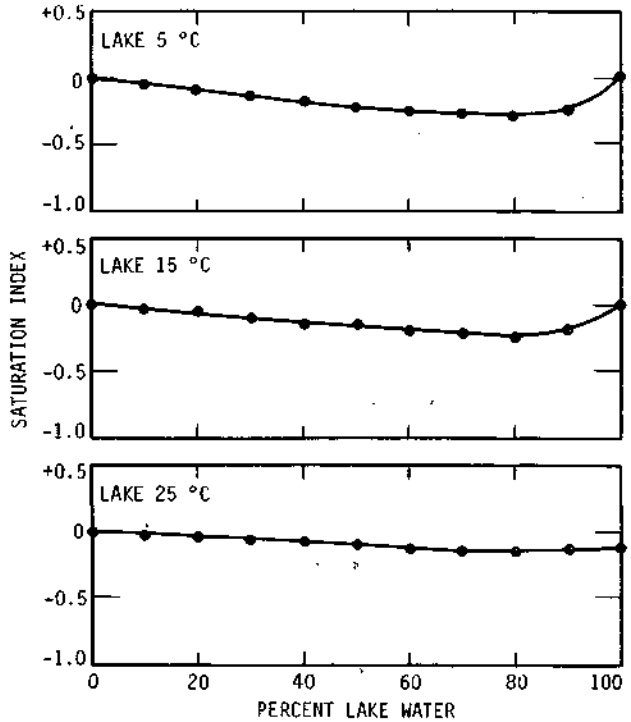

Figure 2. Downers Grove #12
February 8, 1975

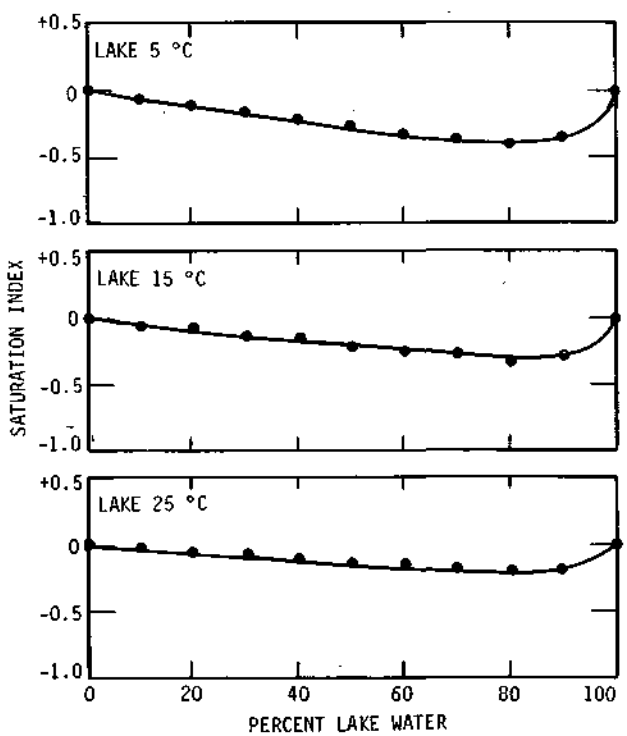

Figure 3. Downers Grove #13
February 24, 1972

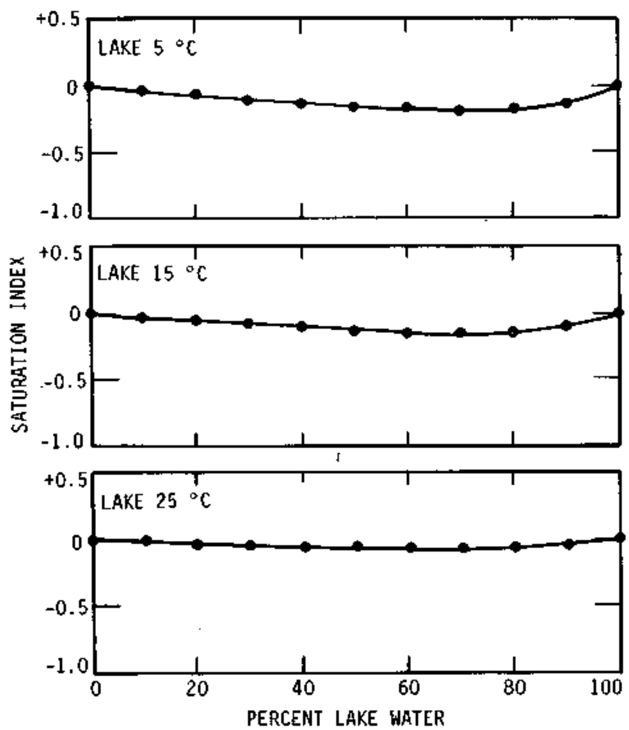

Figure 4. Palatine #9
January 10, 1977

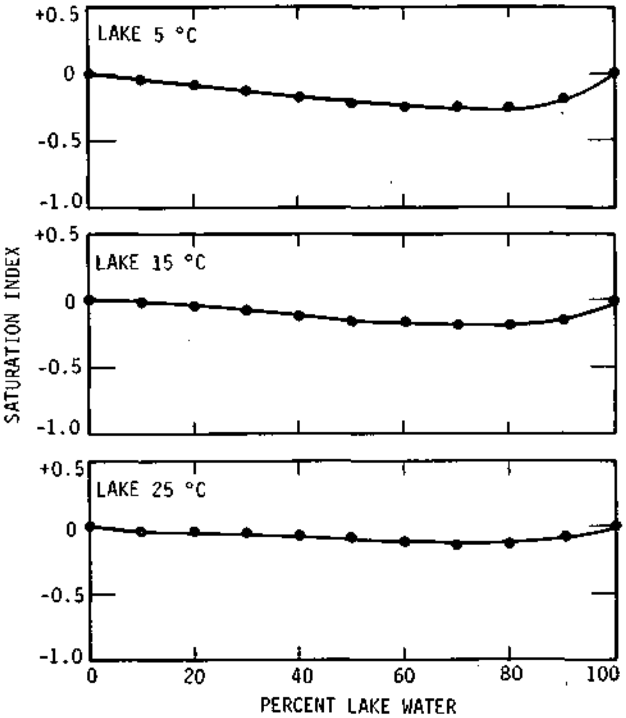

Figure 5. Palatine #2
January 8, 1959

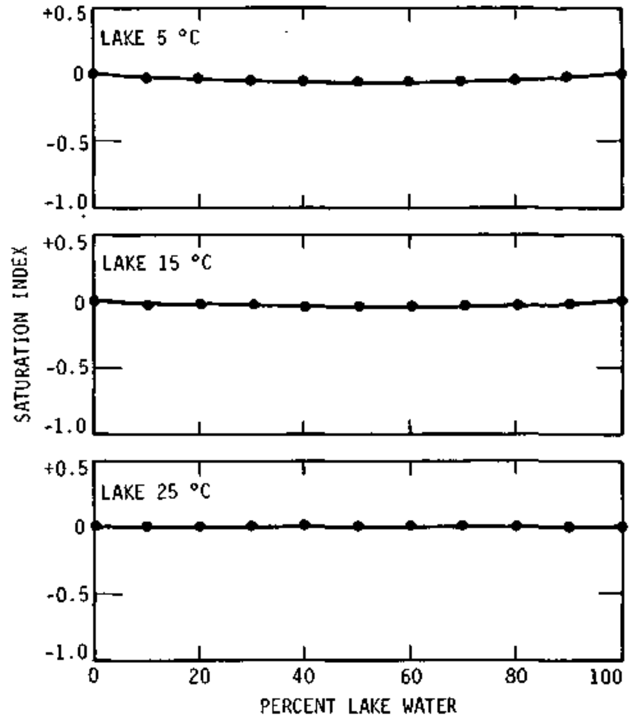

Figure 6. Palatine #3
January 10, 1977

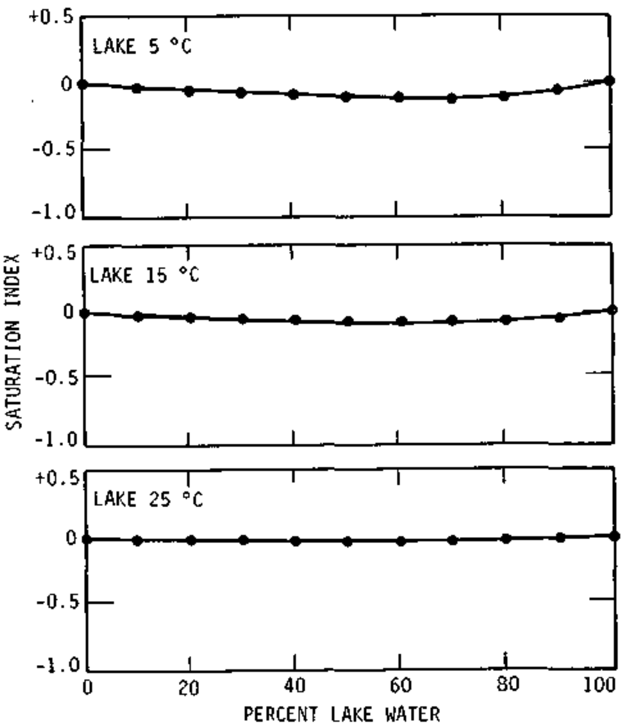

Figure 7. Palatine #6B
January 10, 1977

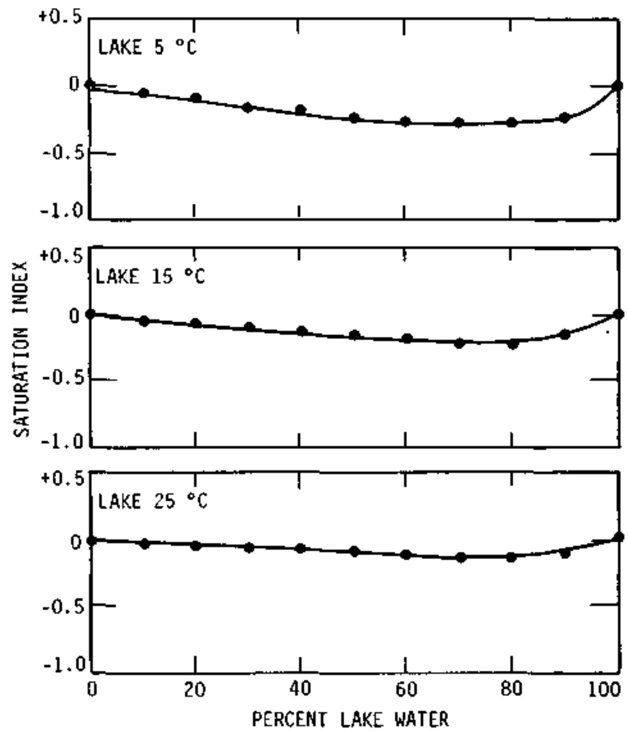

Figure 8. Palatine #7
January 10, 1977

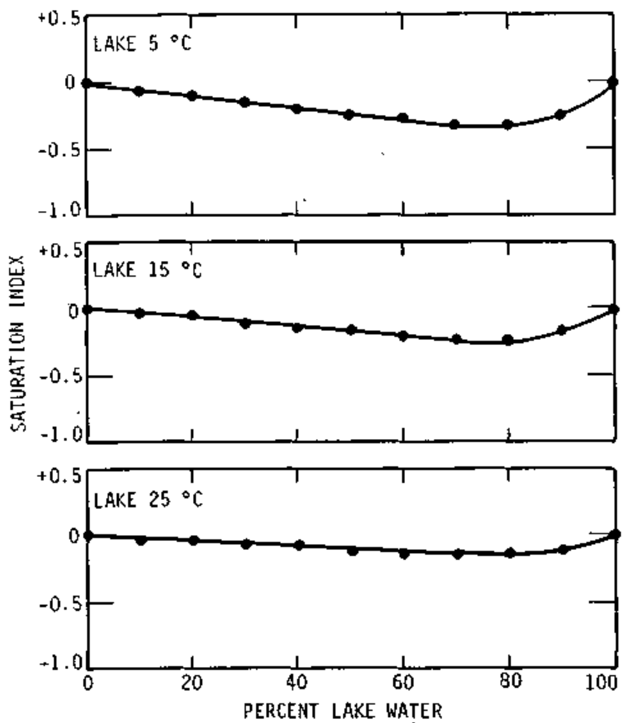

Figure 9. Hoffman Estates #2
May 15, 1958

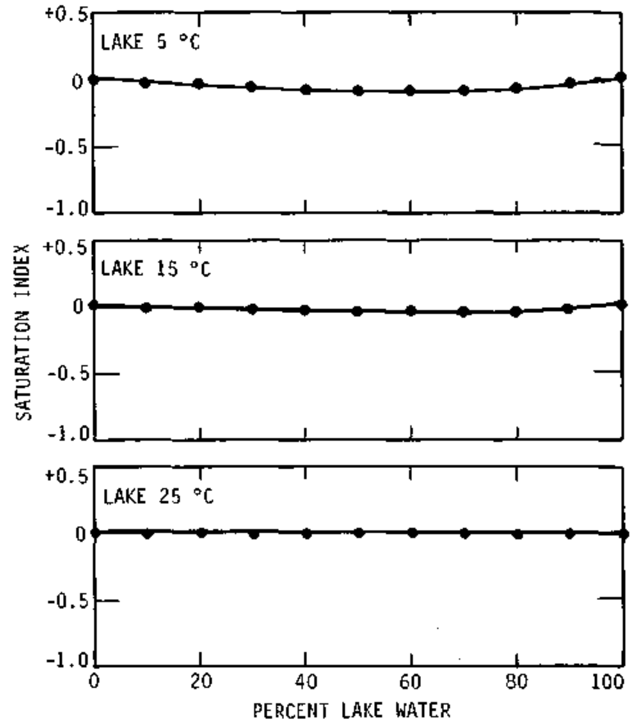

Figure 10. Hoffman Estates #3
May 16, 1973

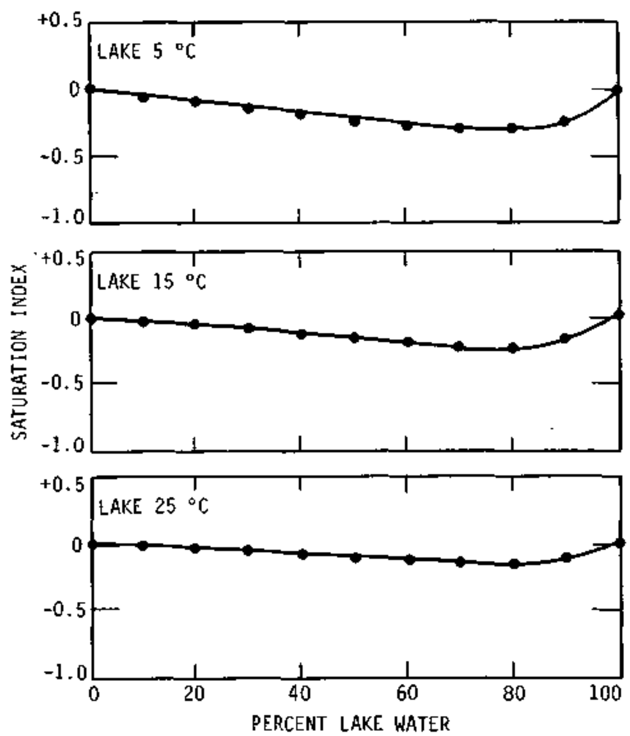

Figure 11. Hoffman Estates #9
December 5, 1973

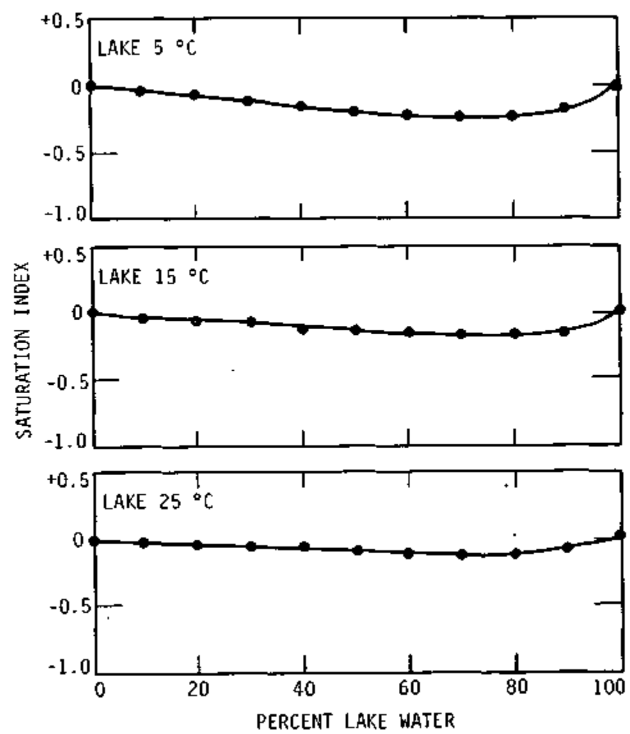

Figure 12. Hanover Park #4
September 4, 1975

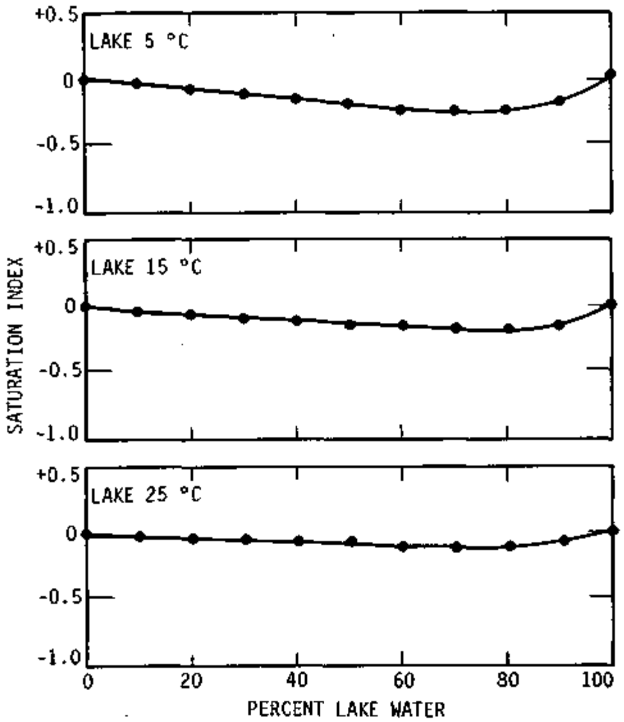

Figure 13. Hickory Hills #2
May 25, 1962

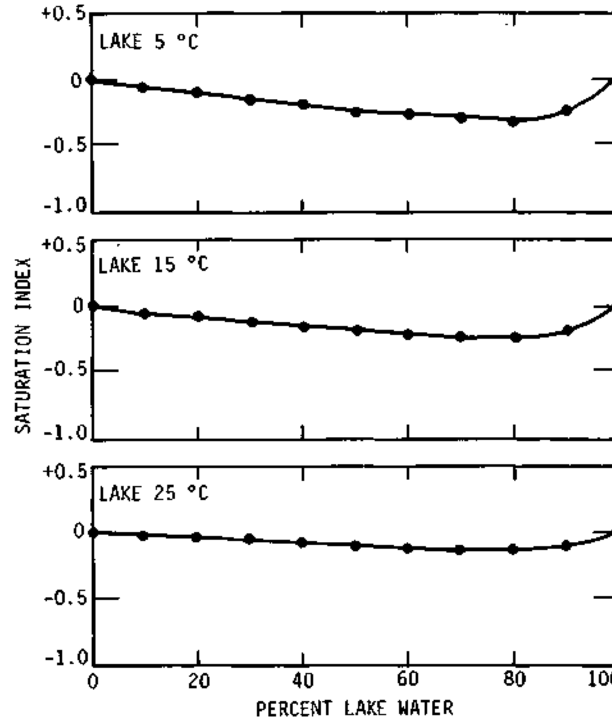

Figure 14. Riverside #4
February 13, 1974

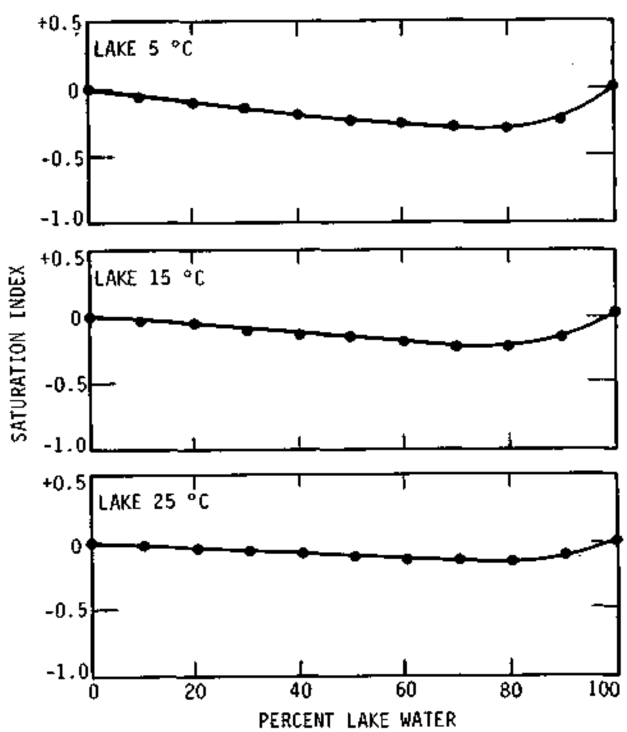

Figure 15. Riverside #3
March 22, 1976

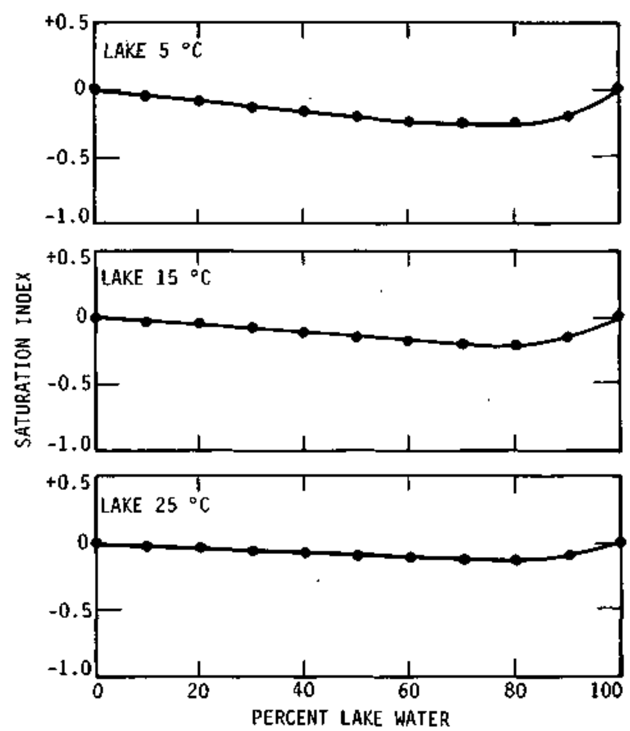

Figure 16. Lyons #2
March 29, 1976

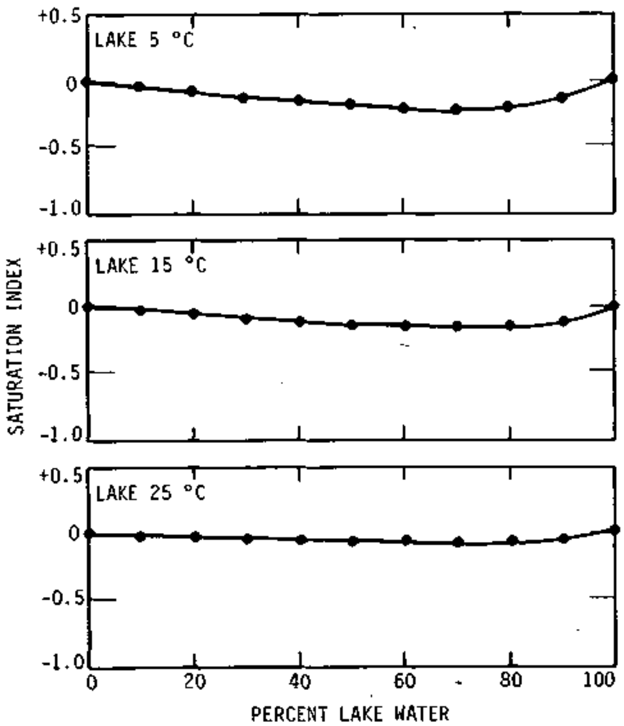

Figure 17. Des Plaines #6
April 6, 1962

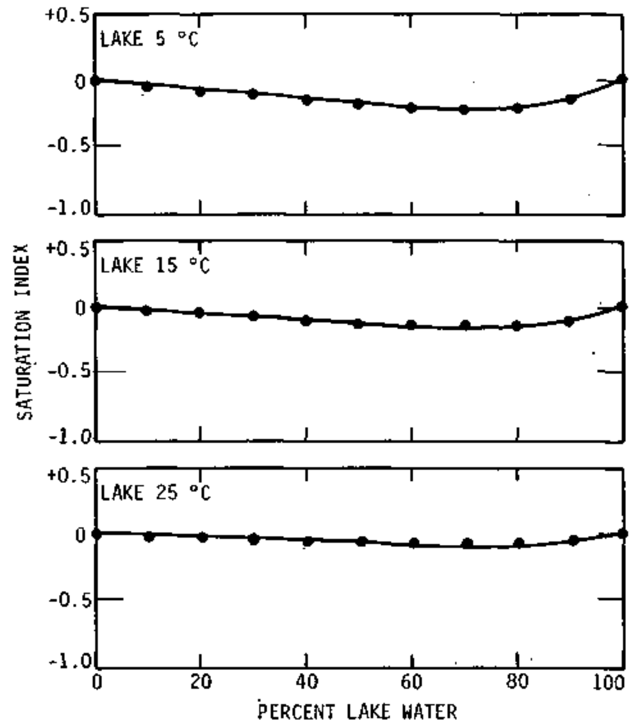

Figure 18. Des Plaines #3
August 4, 1976

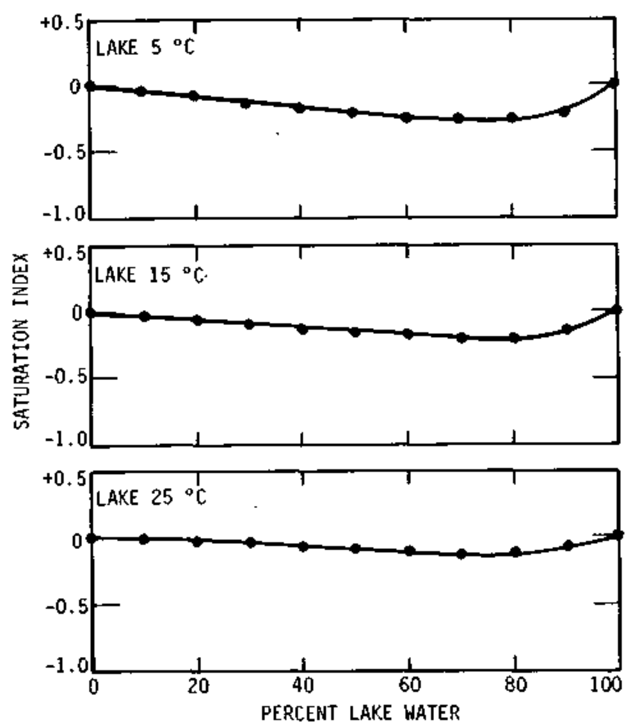

Figure 19. Des Plaines #5
August 4, 1976

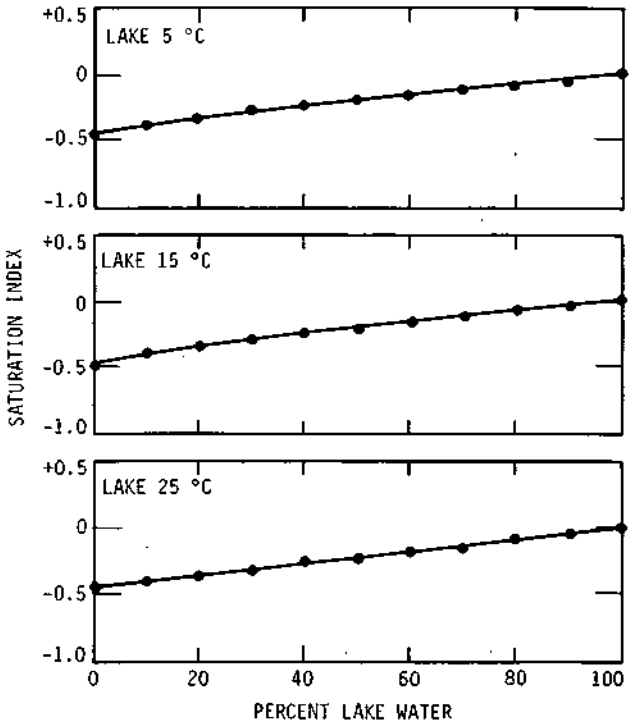

Figure 20. Des Plaines
Softened Water (pH = 8.2)
April 11, 1975

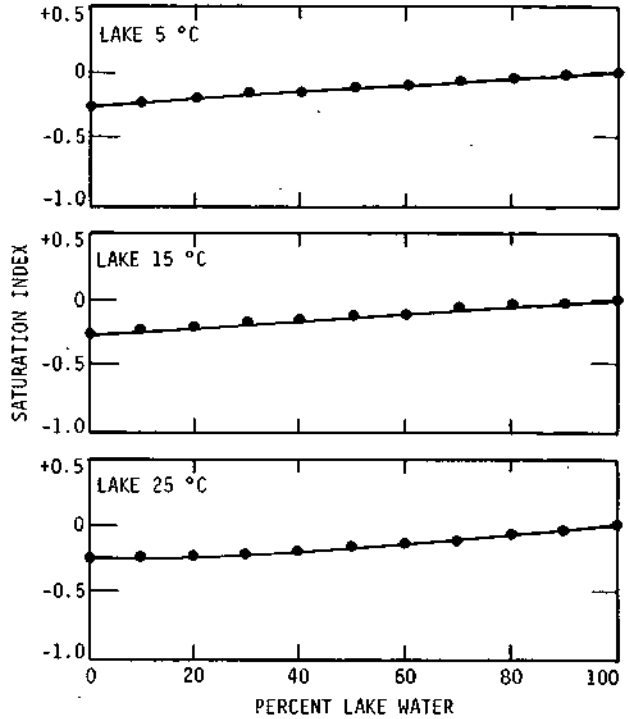

Figure 21. Des Plaines
Softened Water (pH = 8.4)
April 11, 1975

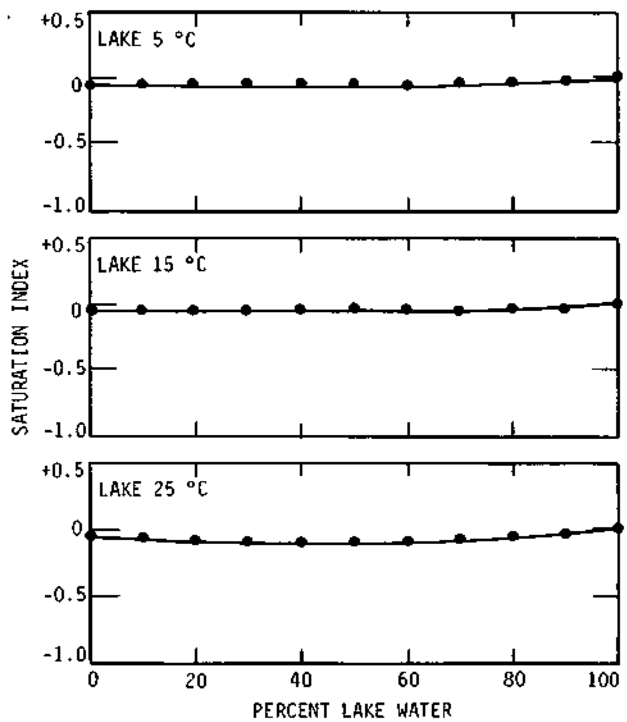

Figure 22. Des Plaines
Softened Water (pH = 8.6)
April 11, 1975