Contract 188

Effects of Proposed 1980 and 1985 Lake Water Allocations on the Deep Sandstone Aquifer in Northeastern Illinois

Prepared by the Illinois State Water Survey

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EFFECTS OF PROPOSED 1980 AND 1985 LAKE WATER ALLOCATIONS ON THE DEEP SANDSTONE AQUIFER IN NORTHEASTERN ILLINOIS

by Richard J. Schicht and J. Rodger Adams

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INTRODUCTION

In its responsibility for allocating the 3200 cubic feet per second (cfs) 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 on the deep sandstone aquifer in northeastern Illinois, and arrest the rapidly declining water levels in the aquifer.

In October 1976 the Division of Water Resources contracted with the Illinois State Water Survey to study the effects of reduced withdrawals from the deep sandstone aquifer, as a result of the proposed allocations, on water levels in the aquifer. The Division in a letter dated October 15, 1976, gave two allocation plans for study. In Plan 1, 39.49 million gallons per day (mgd) would be allocated to 6 townships in 1980, with the allocation remaining constant until 2010. In Plan 2, the 39.49 mgd would be allocated to 6 townships in 1980 as in Plan 1, with 148.38 mgd allocated to 20 townships in 1985. The 1985 allocation would be held constant until 2010. Proposed allocations are given in table 1.

Table 1. Proposed Allocations from Lake Michigan

(In millions of gallons per day)

Township	1980 Plan 1	1985 Plan 2
42		6.37
46		0.71
49	2.79	10.53
50	8.64	15.64
53		4.88
54	3.71	9.40
55	7.53	13.05
62		4.15
65		0.53
69		1.45
70		4.14
71		7.00
72		11.38
74		5.91
75	8.91	13.31
78	7.91	15.00
80		7.95
81		11.65
95		4.23
96		1.10
Totals	39.49	148.38

The State Water Survey's digital computer model of the deep sandstone aquifer was used to determine the effect of the two allocation plans on the water levels in the aquifer. The computer model of the aquifer was described in the testimony of Dr. William C. Ackermann (*Water Resources of Northeast Illinois,* 1976) regarding water resources of northeastern Illinois with respect to allocation of Lake Michigan diversion water. This testimony was entered in the record of the Division of Water Resources hearings on March 1, 1976. Chapter 7 of the testimony, Balancing Supply and Demand, describes the computer model and various pumping schemes used to predict water levels in the deep sandstone aquifer. The testimony, with a few modifications, was published by the State Water Survey as Report of Investigation 83, *Water Resources Availability} Quality, and Cost in Northeastern Illinois* (Schicht, Adams, and Stall, 1976). Subsequent references in this report will be made to Report of Investigation 83.

The deep sandstone pumpage projections used for Mining Scheme 1 (Schicht, Adams, and Stall, 1976) were revised on the basis of the allocations in table 1. Under Mining Scheme 1, groundwater would be mined until the pumping water level reaches the top of the Ironton-Galesville formation. After that time pumpage would be gradually reduced to maintain a constant pumping level. Eventually, total deep sandstone pumpage in northeastern Illinois would reach the practical sustained yield (46 mgd).

Water levels estimated from the revised pumpage were determined by the computer model. These water levels were compared with water levels determined for Mining Scheme 1.

REVISED DEEP SANDSTONE PUMPAGE

Revised deep sandstone pumpage for Allocation Plan 1 is given in table 2. Revised pumpage for Allocation Plan 2 is given in tables 3 and 4.

The revised deep sandstone pumpage for each township was determined in the following manner. In townships without estimates of projected Mt. Simon withdrawals, the township allocation was simply subtracted from the deep sandstone pumpage for Mining Scheme 1. In many of the townships the allocation would equal or exceed the deep sandstone pumpage, in which case the revised deep sandstone pumpage was assumed to be zero. For example, the allocation under Plan 2 would exceed the total deep well pumpage for all 20 townships in 1985, for 19 townships in 1990, and for 15 townships in 2010. Allocation in excess of the total deep well pumpage for Plan 2 in 2010 for each township is shown in table 4. In 2010, 26.15 mgd of the 148.38 mgd allocation would not be used to reduce deep sandstone pumpage.

Since many deep wells are also open to the Mt. Simon aquifer, it was necessary to consider its contribution to pumpage. Allocation would result in shutting down some Mt. Simon wells. The Mt. Simon contribution (given below) was estimated for 5 of the townships in this study and is included in the total deep well pumpage given in tables 2 and 3.

Township	Estimated Mt. Simon contribution *(mgd)*
49	0.4
50	1.5
55	1.5
75	1.0
78	2.8

Table 2. Revised Deep Sandstone Pumpage, Allocation Plan 1

			Pumpage (*mgd*)		
			Mining Scheme 1		
Township	Total demand (*mgd*)	Allocation (*mgd*)	Deep sandstone	Total deep well	Revised deep sandstone
Pumpage in 1980					
49	10.21	2.79	4.98	5.38	2.40
50	15.20	8.64	9.01	10.51	1.60
54	8.10	3.71	5.10	5.10	1.39
55	13.15	7.53	8.08	9.58	1.73
75	12.10	8.91	6.73	7.73	0
78	14.50	7.91	6.80	9.60	1.20
Pumpage in 1985					
49	11.35	2.79	6.00	6.40	3.34
50	15.64	8.64	9.36	10.86	1.90
54	9.40	3.71	6.30	6.30	2.59
55	13.63	7.53	8.51	10.01	2.09
75	13.31	8.91	7.94	8.94	0.03
78	15.00	7.91	7.30	10.10	1.55
Pumpage in 1990					
49	12.24	2.79	7.01	7.41	4.28
50	15.90	8.64	9.71	11.21	2.20
54	10.50	3.71	7.50	7.50	3.79
55	14.01	7.53	8.94	10.44	2.45
75	14.50	8.91	9.15	10.15	1.08
78	15.50	7.91	7.80	10.60	1.91
Pumpage in 2000					
49	12.50	2.79	7.27	7.67	4.52
50	16.50	8.64	10.31	11.81	2.72
54	13.50	3.71	10.51	10.51	6.79
55	14.11	7.53	9.04	10.54	2.54
75	16.20	8.91	10.47	11.47	2.23
78	16.00	7.91	8.30	11.10	2.26
Pumpage in 2010					
49	13.12	2.79	7.89	8.29	5.09
50	17.99	8.64	11.80	13.30	3.99
54	14.60	3.71	11.60	11.60	7.89
55	16.07	7.53	10.96	12.46	4.16
75	16.45	8.91	11.08	12.08	2.76
78	16.53	7.91	8.83	11.63	2.64

Table 3. Revised Deep Sandstone Pumpage, Allocation Plan 2

Township	Total demand (*mgd*)	Allocation (*mgd*)	Pumpage (*mgd*): Mining Scheme 1: Deep sandstone	Pumpage (*mgd*): Mining Scheme 1: Total deep well	Pumpage (*mgd*): Revised deep sandstone
Pumpage in 1990					
42	7.60	6.37	2.94	2.94	0
46	3.47	0.71	0.35	0.35	0
49	12.24	10.53	7.01	7.41	0
50	15.90	15.64	9.75	11.21	0
53	9.00	4.88	6.24	6.24	1.36
54	10.50	9.40	7.50	7.50	0
55	14.01	13.05	8.94	10.44	0
62	10.80	4.15	3.48	3.48	0
65	0*	0.53	0*	0*	0*
69	1.70	1.45	1.18	1.18	0
70	5.00	4.14	0.69	0.69	0
71	8.00	7.00	3.43	3.43	0
72	16.05	11.38	9.37	9.37	0
74	8.40	5.91	4.43	4.43	0
75	14.50	13.31	9.15	10.15	0
78	15.50	15.00	7.80	10.60	0
80	9.80	7.95	4.07	4.07	0
81	12.50	11.65	5.27	5.27	0
95	5.90	4.23	1.08	1.08	0
96	2.80	1.10	0.08	0.08	0
Pumpage in 2000					
42	9.20	6.37	4.54	4.54	0
46	4.94	0.71	0.56	0.56	0
49	12.50	10.53	7.27	7.67	0
50	16.50	15.64	10.31	11.81	0
53	10.50	4.88	7.74	7.74	2.86
54	13.50	9.40	10.50	10.50	1.10
55	14.11	13.05	9.04	10.54	0
62	10.80	4.15	3.48	3.48	0
65	0*	0.53	0*	0*	0*
69	1.80	1.45	1.18	1.18	0
70	5.00	4.14	0.69	0.69	0
71	8.30	7.00	3.73	3.73	0
72	17.16	11.38	10.48	10.48	0
74	11.00	5.91	6.63	6.63	0.72
75	16.20	13.31	10.47	11.47	0
78	16.00	15.00	8.30	11.10	0
80	10.71	7.95	4.77	4.77	0
81	14.00	11.65	6.77	6.77	0
95	8.20	4.23	3.38	3.38	0
96	3.46	1.10	0.08	0.08	0

**Groundwater demand projections estimated for Township 65 were zero (Schicht, Adams, and Stall, 1976)*

Table 4. Revised Deep Sandstone Pumpage and Excess Allocations in 2010, Allocation Plan 2

(*In million gallons per day*)

Township	Total demand	Allocation	Pumpage: Mining Scheme 1 Deep sandstone	Pumpage: Mining Scheme 1 Total deep well	Pumpage: Revised deep sandstone	Excess
42	10.60	6.37	5.91	5.91	0	0.46
46	5.10	0.71	0.74	0.74	0.03	0
49	13.12	10.53	7.89	8.29	0	2.24
50	17.99	15.64	11.80	13.30	0	2.34
53	11.20	4.88	8.44	8.44	3.56	0
54	14.60	9.40	11.60	11.60	2.20	0
55	16.07	13.05	10.96	12.46	0	0.59
62	10.80	4.15	3.48	3.48	0	0.67
65	0*	0.53	0*	0*	0*	0.53
69	1.90	1.45	1.18	1.18	0	0.27
70	5.00	4.14	0.69	0.69	0	3.45
71	8.60	7.00	4.33	4.33	0	2.67
72	17.96	11.38	11.28	11.28	0	0.10
74	11.35	5.91	7.38	7.28	1.47	0
75	16.45	13.31	11.08	12.08	0	1.23
78	16.53	15.00	8.83	11.63	0	3.37
80	10.93	7.95	5.20	5.20	0	2.75
81	14.42	11.65	7.19	7.19	0	4.46
95	10.00	4.23	5.18	5.18	0.95	0
96	4.00	1.10	0.08	0.08	0	1.02

**Groundwater demand projections estimated for Township 65 were zero (Schicht, Adams, and Stall, 1976)*

With Allocation Plan 2 the Mt. Simon contribution would not be a factor since allocation would exceed the total deep well pumpage (deep sandstone pumpage plus Mt. Simon contribution) in the five townships for each year. To determine the revised deep sandstone pumpage for townships with Mt. Simon wells in Allocation Plan 1 a part of the allocation was assigned for reduction of the Mt. Simon contribution. The amount allocated was in proportion to the ratio of the. Mt. Simon contribution to the deep sandstone pumpage.

WATER LEVEL CHANGES AND DEFICIENT TOWNSHIPS

Water levels in the deep sandstone aquifer for Allocation Plans 1 and 2 were computed with the use of the computer model and were compared with water levels determined for Mining Scheme 1. Maps were prepared showing the differences in water levels near the center of each township (figures 1 through 7). The water levels computed for Allocation Plans 1 and 2 are higher than

Table 5. Groundwater Deficiencies for Allocation Plans 1 and 2

		Year critical water levels are reached		Deficiencies (*mgd*)			
				2000		2010	
Township	Allocation (*mgd*)	Mining Scheme 1	With allocation	Mining Scheme 1	Allocation plan	Mining Scheme 1	Allocation plan
Allocation Plan 1							
22		1995	1996	7.5	5.92	12.0	10.89
31		2000	2000	3.8	2.85	9.4	8.67
49	2.79	2005				2.8	
50	8.64	2004				4.1	
53		2000	2005	1.3		5.4	3.42
54	3.71	1996	2008	6.8		10.6	2.07
55	7.53	1996		3.4		8.2	
74		1998	2006	2.9		6.1	3.22
75	8.91	1996		5.7		8.8	
77		2002	2008			4.4	2.03
78	7.91	2000		2.1		5.9	
79		2007	2009			2.4	1.68
80		2006	2010			2.1	0.39
81		2008				1.9	
88		1998	1998	2.4	2.16	6.4	5.93
			Totals	35.9	10.93	90.5	38.30
Allocation Plan 2							
22		1995	1999	7.5	3.84	12.0	7.58
31		2000	2000	3.8	1.22	9.4	6.90
88		1998	2000	2.4	0.70	6.4	4.73
			Totals	13.7	5.76	27.8	19.21

the water levels computed for Mining Scheme 1 because of the reduction in pumpage, except for townships in which critical levels are reached during the same year for both the allocation plans and Mining Scheme 1.

In figures 1 through 7 townships that would have received an allocation were marked with an 'A' in the lower left township corner. Townships in which pumping levels would have dropped to the top of the Ironton-Galesville sandstone (defined as the critical level) were marked with a 'D' in the lower left township corner. As in Schicht, Adams, and Stall (1976), pumpage in townships with critical water levels would be gradually reduced to maintain pumping levels at the top of the Ironton-Galesville. Deficiencies given in table 5 are the difference between projected deep sandstone pumpage and the reduced pumpage necessary to maintain the pumping levels at the top of the Ironton-Galesville. There is no difference between water levels determined for deficient townships that are common to Allocation Plans 1 and 2 and Mining Scheme 1 since water levels are maintained at the critical level.

The water level differences in 1985 resulting from the 1980 allocation under Plan 1 are shown in figure 1. The effect on water levels of continuing the 1980 allocation into the future is shown in figure 2 for 1990, in figure 3 for 2000, and in figure 4 for 2010. The area in which substantial differences in water levels occur would enlarge with time.

In some townships by the year 2000 the difference in water levels for Allocation Plan 1 and Mining Scheme 1 would start to narrow because deep well pumpage would continue to increase while the allocation would remain constant. Among townships receiving allocations, township 54 had a difference of 312 feet in 1990 and 305 feet in 2000. In townships not receiving allocations, townships 22, 31, and 88 had differences of 20, 6, and 2 feet, respectively, in 1990 and zero differences in 2000 as water levels reached critical levels. Since these townships are relatively far from townships receiving allocations and have large projected withdrawals, the allocation would have little effect. As shown in table 5 the year in which critical water levels are reached in townships 31 and 88 is the same for both Allocation Plan 1 and Mining Scheme 1. In township 22 the year in which critical levels are reached is delayed by 1 year.

As shown in table 5 implementing Allocation Plan 1 would reduce deficiencies from 35.9 mgd to 10.93 mgd in 2000 and from 90.5 mgd to 38.30 mgd in 2010. The number of deficient townships in 2010 would be reduced from 15 to 9. In townships 53, 54, 74, 77, 79, and 80 the number of years of delay in reaching critical water levels would be 5, 12, 8, 6, 2, and 4, respectively. Except for township 54, water levels in the other townships (49, 50, 55, 75, and 78) that received allocations would be well above critical levels.

Although Allocation Plan 1 would have little effect on the years critical water levels are reached in townships 22, 31, and 88, the deficiencies would be less, as noted in table 5.

Allocation Plan 2 in 1985 would increase the quantity of lake water from about 39 mgd to 148 mgd and allot it to 20 townships instead of 6. The water level differences from Mining Scheme 1 'resulting from the 1985 allocation are shown in figure 5 for 1990, in figure 6 for 2000, and in figure 7 for 2010. The area in which substantial water level changes occur would be much increased and the magnitude of change at the townships receiving allocation would be considerably greater than in Allocation Plan 1.

With Plan 2 the only deficient townships would be 22 by 1999 and 31 and 88 by 2000. The total deficiencies (table 5) would be about 6 mgd in 2000 and 19 mgd in 2010, considerably less than the 35.9 mgd and 90.5 mgd deficiencies under Mining Scheme 1 for the same years. Total deficiencies for the three townships would be considerably less for Allocation Plan 2 (5.76 mgd in 2000 and 19.21 in 2010) than for Mining Scheme 1 (13.7 and 27.8 mgd).

By the year 2010 in townships 53, 54, 55, 75, and 78 the difference in water levels for Allocation Plan 2 and Mining Scheme 1 would start to narrow as in Allocation Plan 1.

COST BENEFITS FROM ALLOCATION PLANS

A benefit resulting from the allocation plans would be a reduction in the cost of electrical energy for pumping water. Figure 8 illustrates the relationship between pumping lift and annual cost in 1974 dollars. For example, township 74 in 2000 has a projected deep sandstone pumpage of 6.63 mgd (table 2). The water level difference in 2000 at the center of township 74 (figure 3) between Mining Scheme 1 and Allocation Plan 1 is 262 feet. Thus, the annual cost saving would be approximately $6800.

SUMMARY AND CONCLUSIONS

Allocation Plan 1 designates 39.49 mgd in 1980 to 6 townships with predicted deficiencies under Mining Scheme 1. Except for township 54, years in which critical water levels are reached would be delayed until after 2010. Water levels in township 54 would reach critical levels in 2008. The allocation would delay years that critical water levels are reached in all but 2 of the townships with critical water levels under Mining Scheme 1.

Allocation Plan 2 designates 39.49 mgd to the 6 townships included in Allocation Plan 1 in 1980 and an additional 108.89 mgd in 1985 to 20 townships including the 6 townships in Plan 1. Allocation Plan 2 would eliminate deficiencies under Mining Scheme 1 until after 2010 in all but 3 townships, 22, 31, and 88. Deficiencies would be reduced in these townships, however.

A benefit to a large number of townships not allocated lake water would be the reduced pumping lifts resulting in reductions in the cost of electrical energy for pumping water.

The analyses made in this report indicate that it may be desirable to amend the allocation plans. For example, a different distribution of the 39.49 mgd available under Allocation Plan 1 may result in delaying critical water levels in township 54 until after 2010. With Allocation Plan 2, the total allocation exceeds total deep well pumpage through 2010. By 2010 only 5 of the 20 townships would have deep well pumpage (total of 8.21 mgd). By 2010 the total allocation in the remaining 15 townships exceeds total deep well pumpage by 26.15 mgd. Part of the 26.15 mgd could be allocated to the 5 townships to eliminate deep well pumpage. The remainder could be allocated to other townships.

REFERENCES

Schicht, Richard J., J. Rodger Adams, and John B. Stall. 1976. *Water resources availability, quality, and cost in northeastern Illinois.* Illinois State Water Survey Report of Investigation 83.

Water resources of northeast Illinois. 1976. Testimony prepared by Illinois State Water Survey for Illinois Division of Water Resources Hearings on Allocation of Lake Michigan Diversion Water.

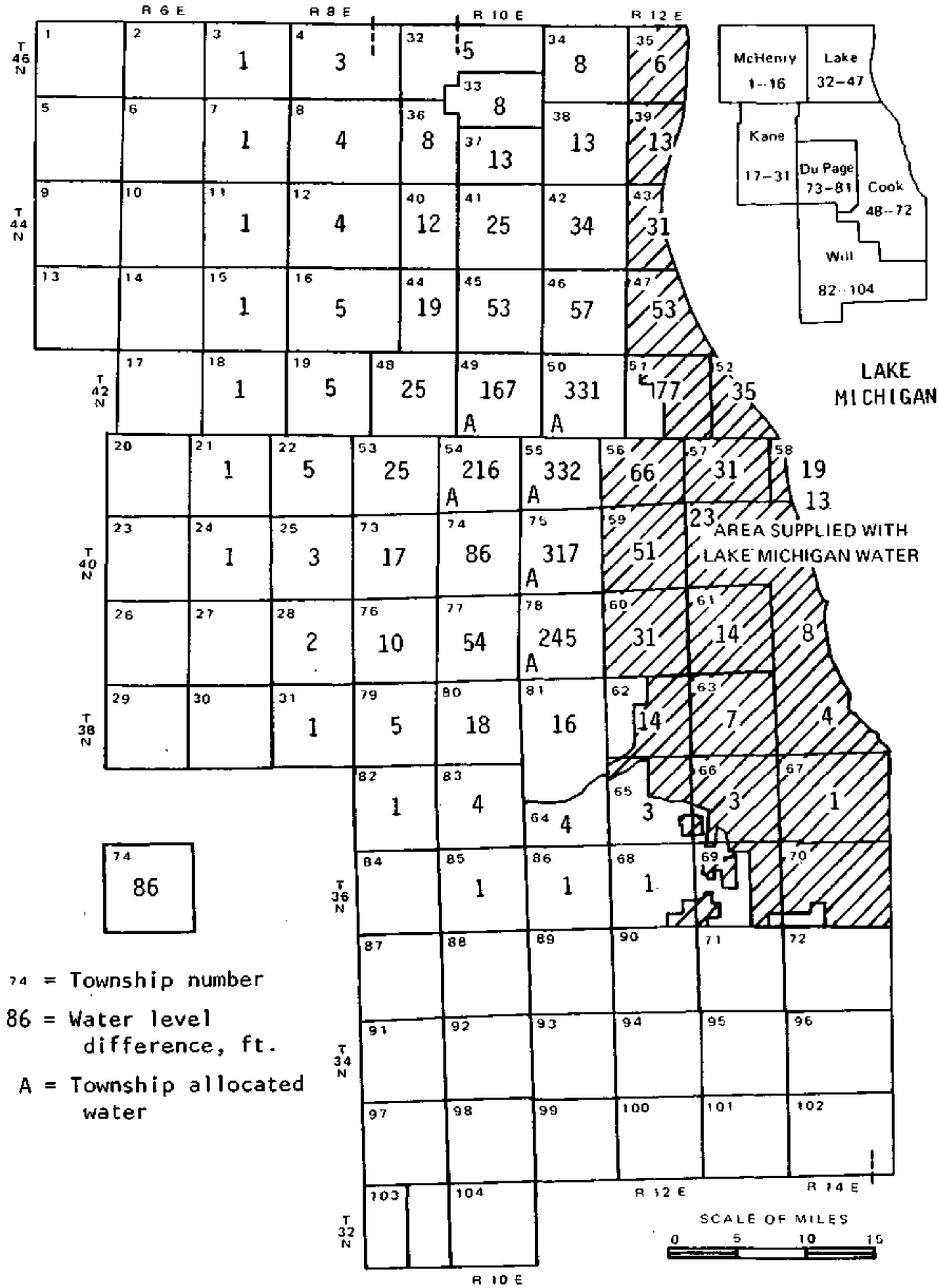

Figure 1. Water level differences for 1985, Allocation Plan 1

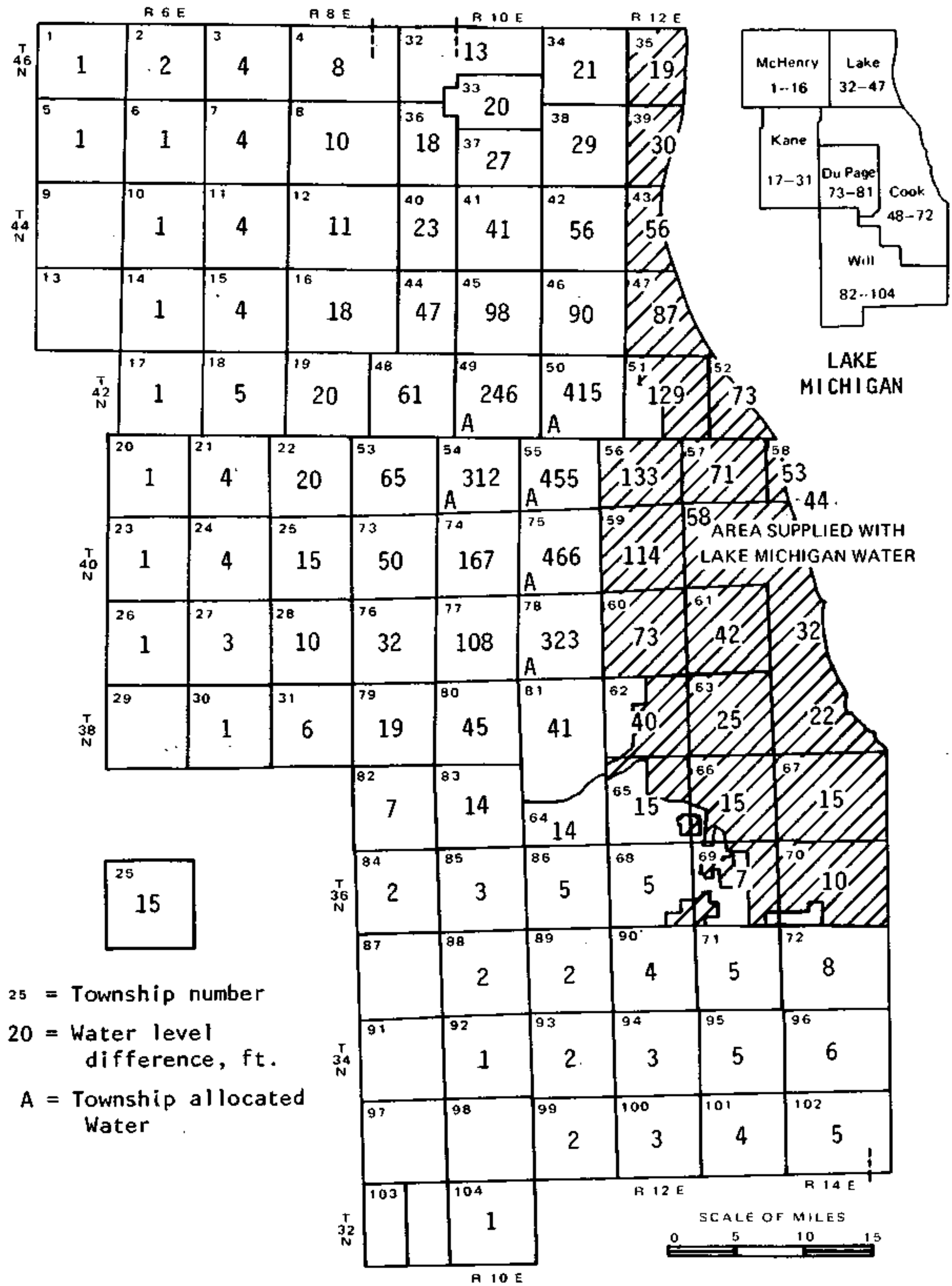

Figure 2. Water level differences for 1990, Allocation Plan 1

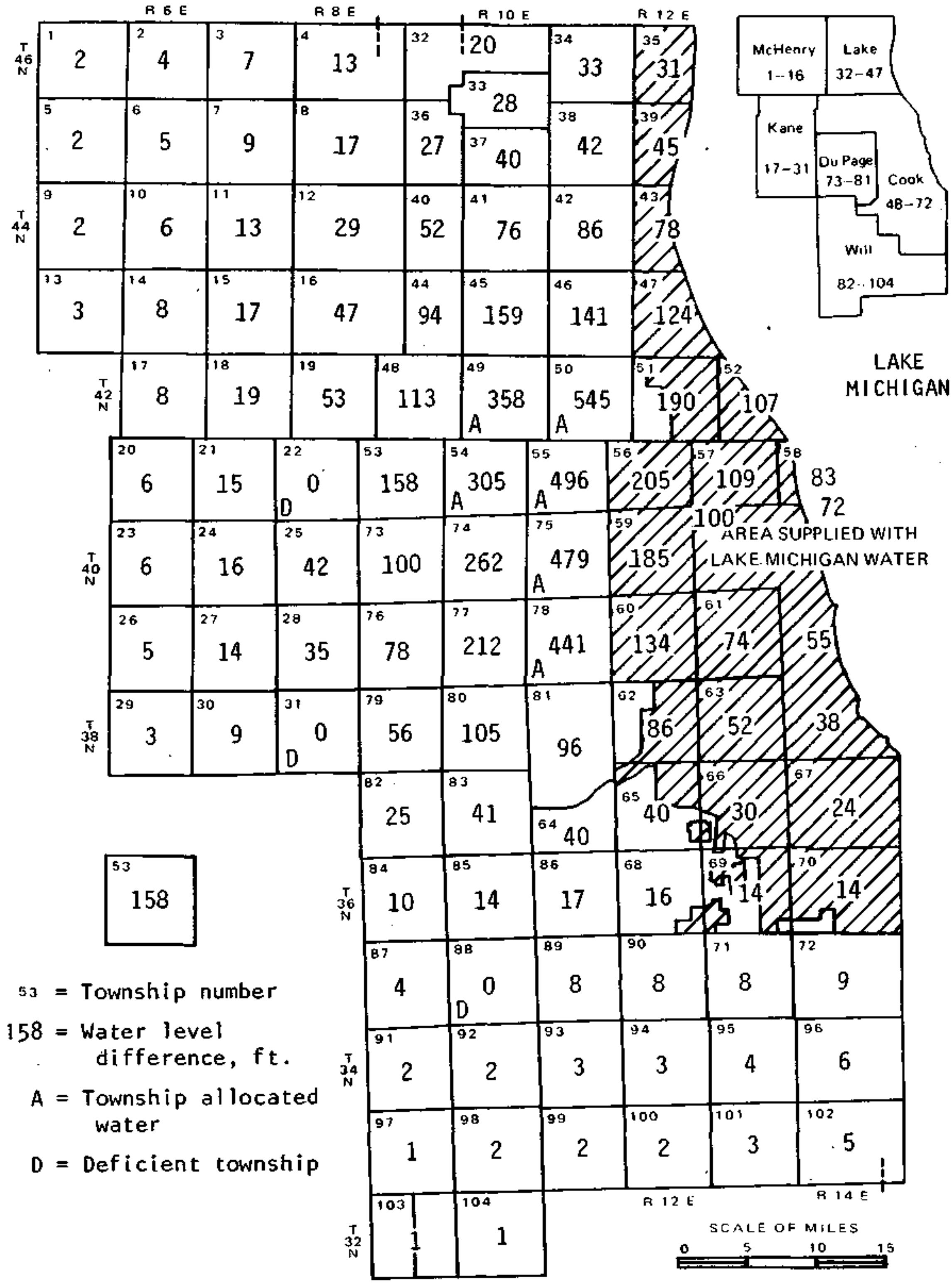

Figure 3. Water level differences for 2000, Allocation Plan 1

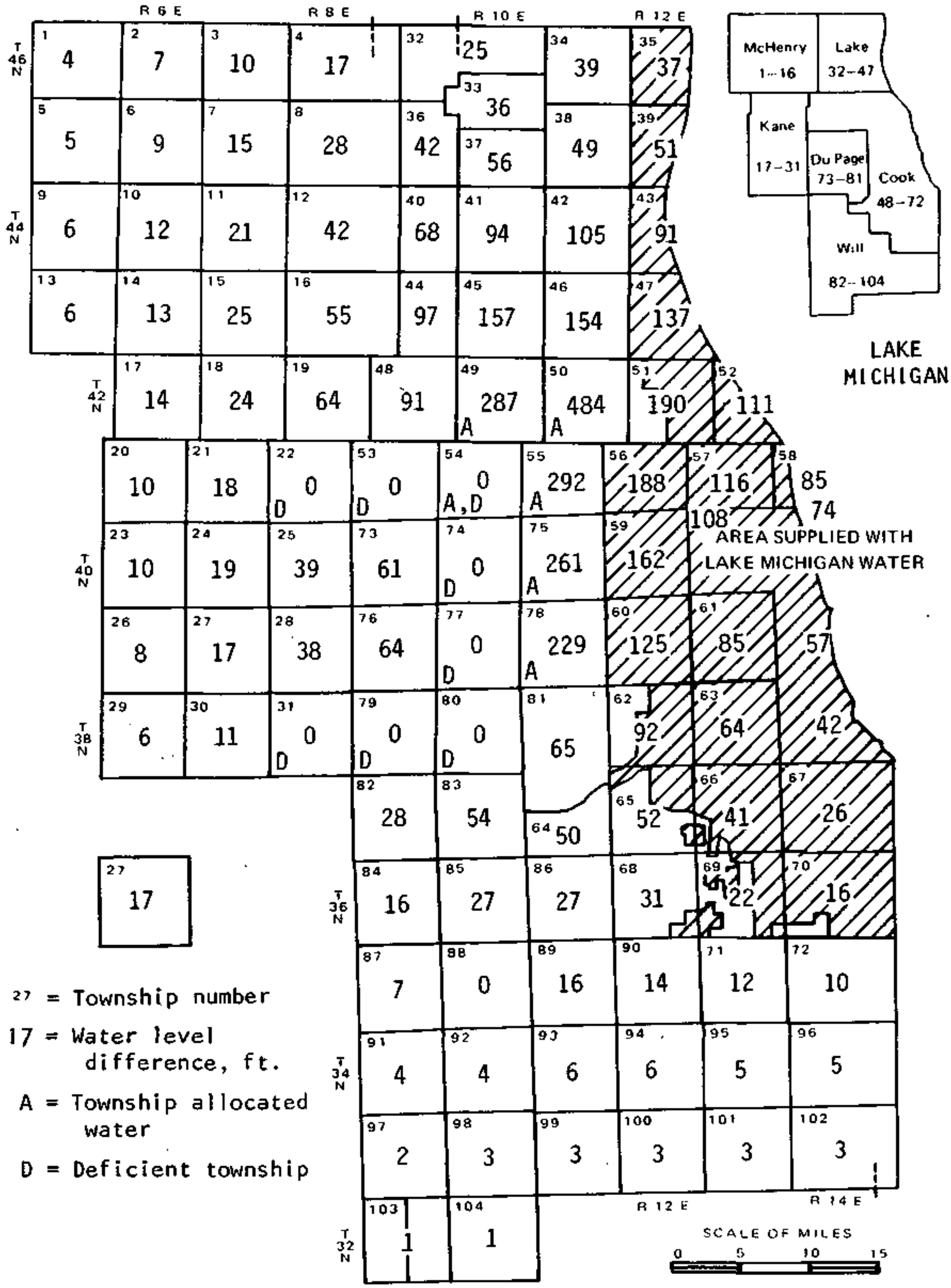

Figure 4. Water level differences for 2010, Allocation Plan 1

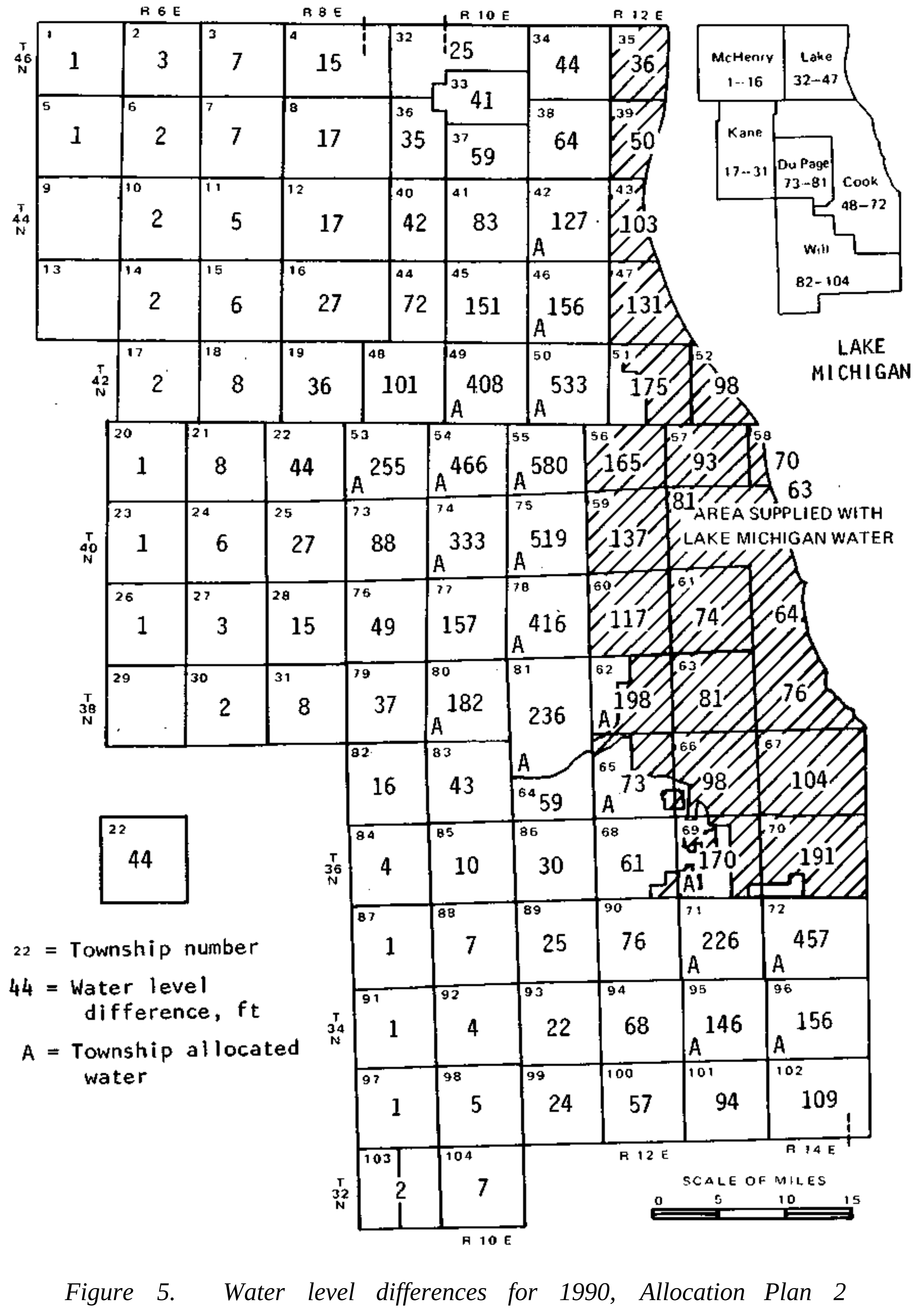

Figure 5. Water level differences for 1990, Allocation Plan 2

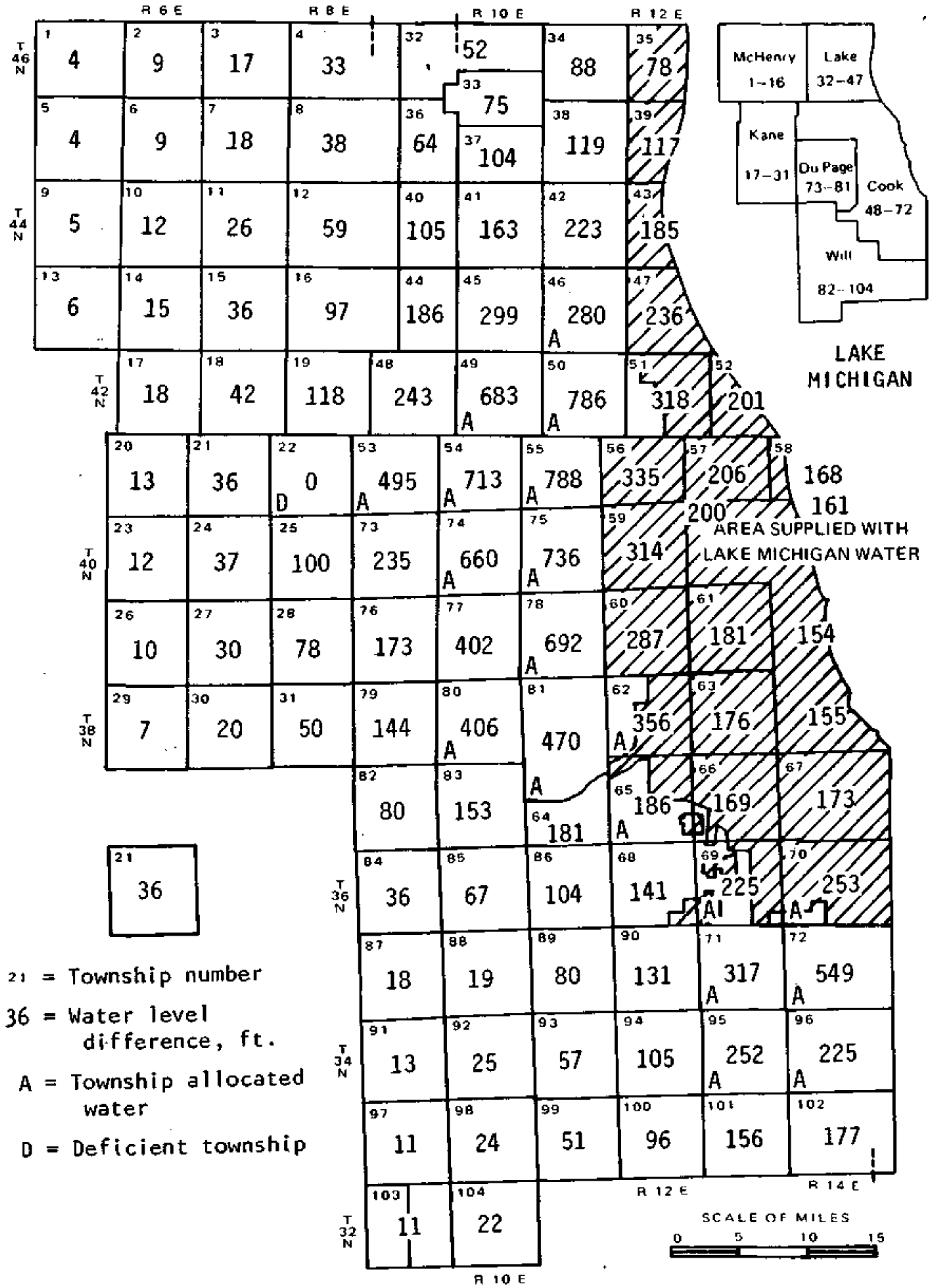

Figure 6. Water level differences for 2000, Allocation Plan 2

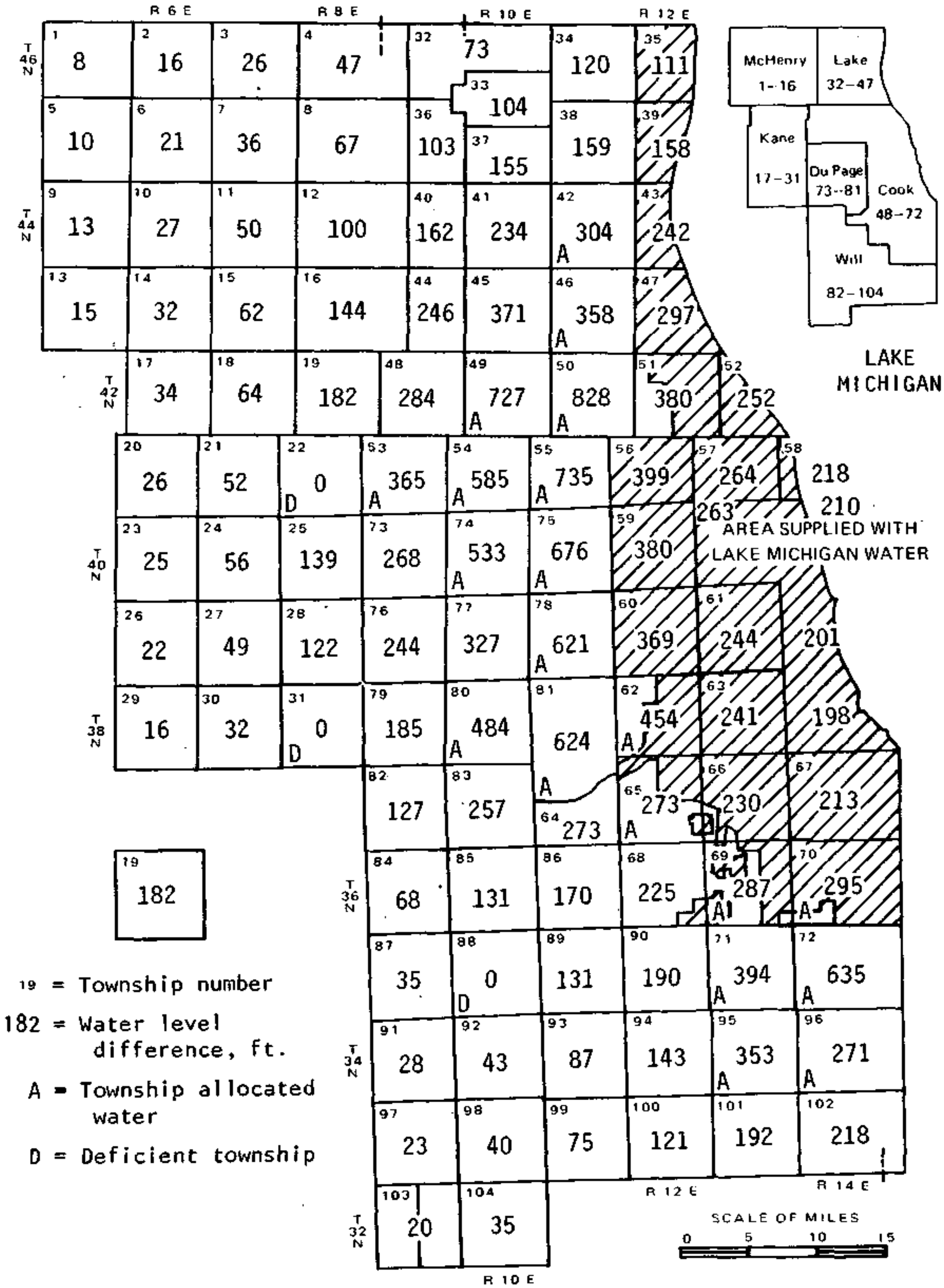

Figure 7. Water level differences for 2010, Allocation Plan 2

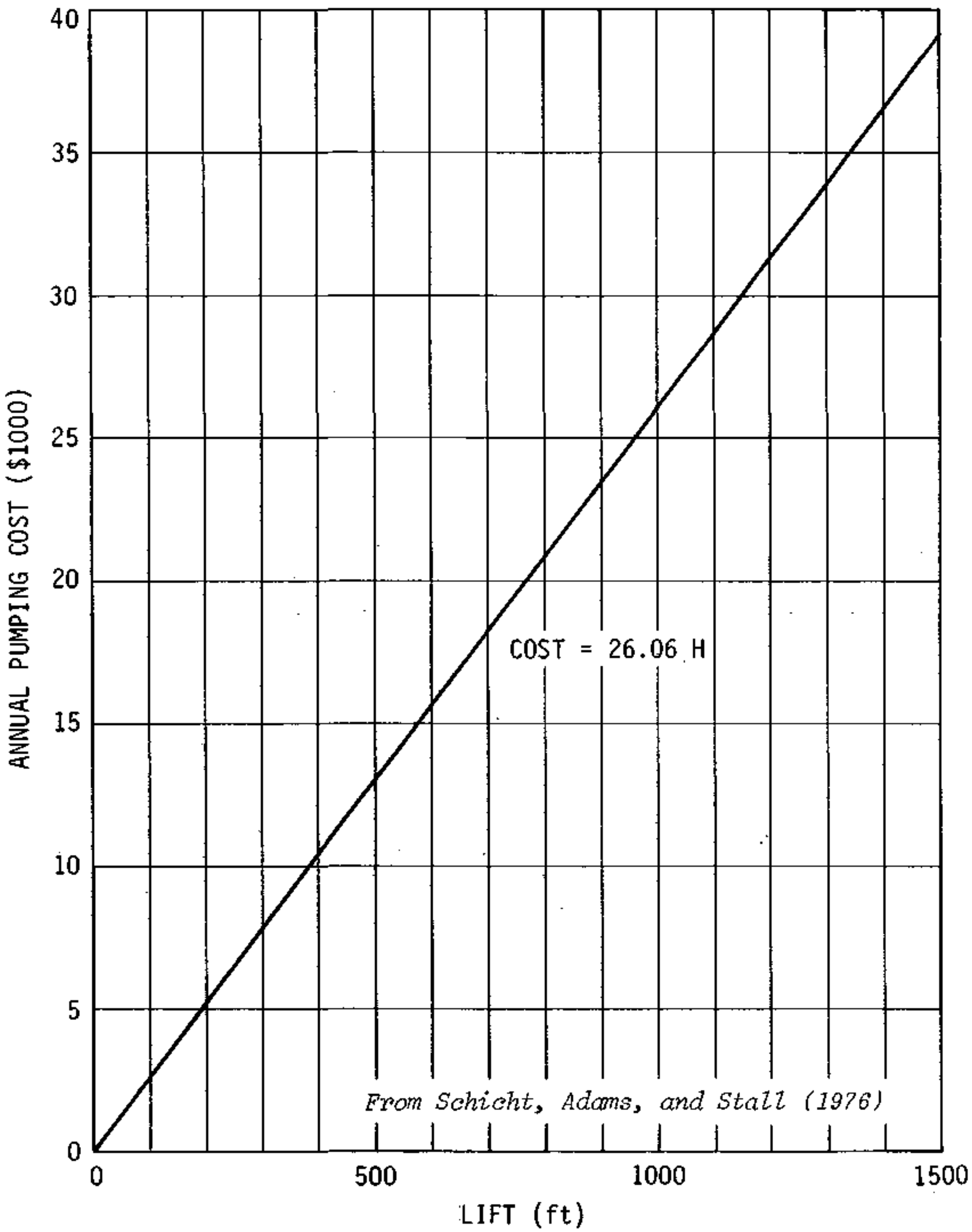

Figure 8. Annual pumping cost per million gallons per day versus lift