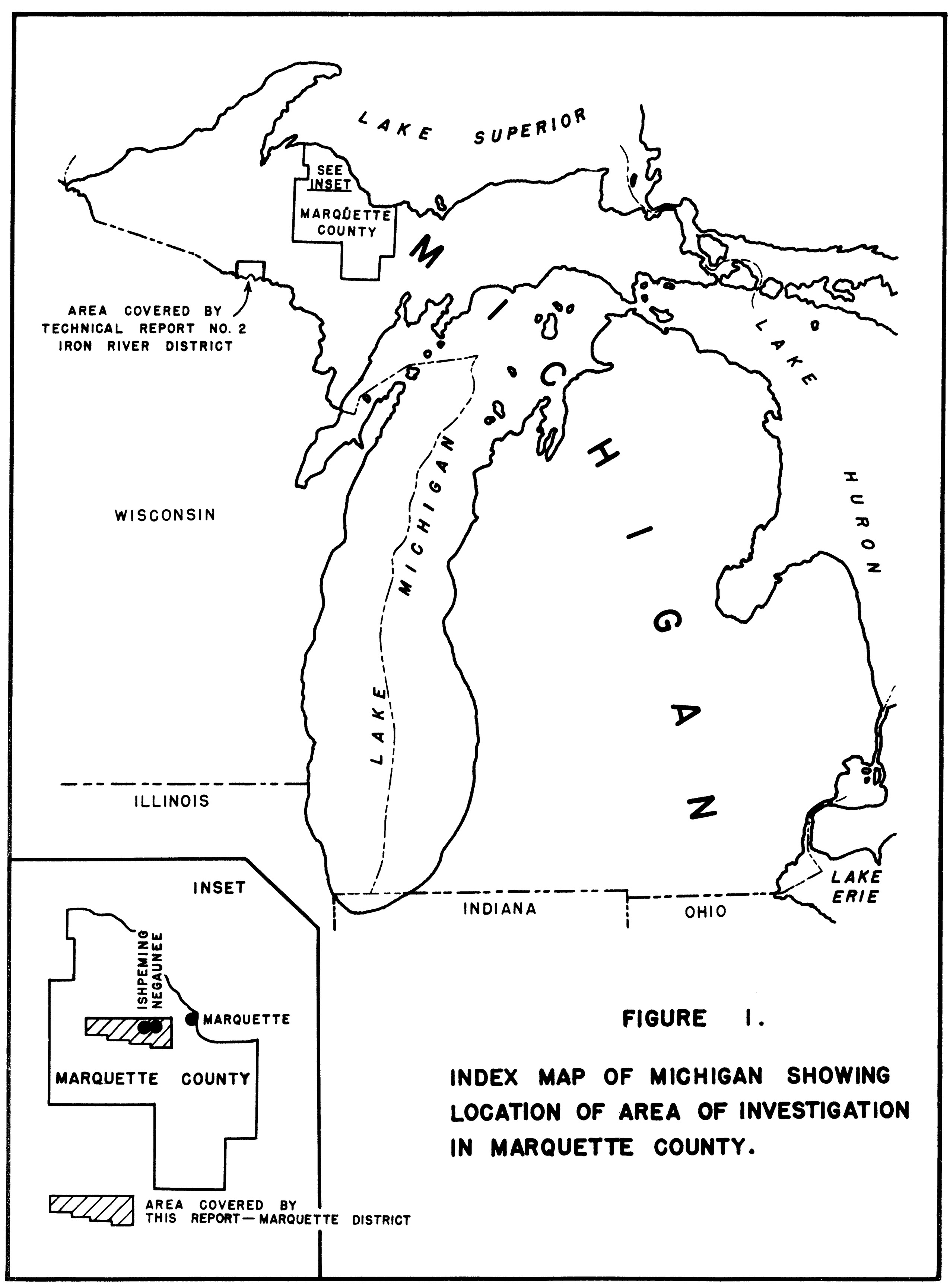


FIGURE 1.

INDEX MAP OF MICHIGAN SHOWING LOCATION OF AREA OF INVESTIGATION IN MARQUETTE COUNTY.

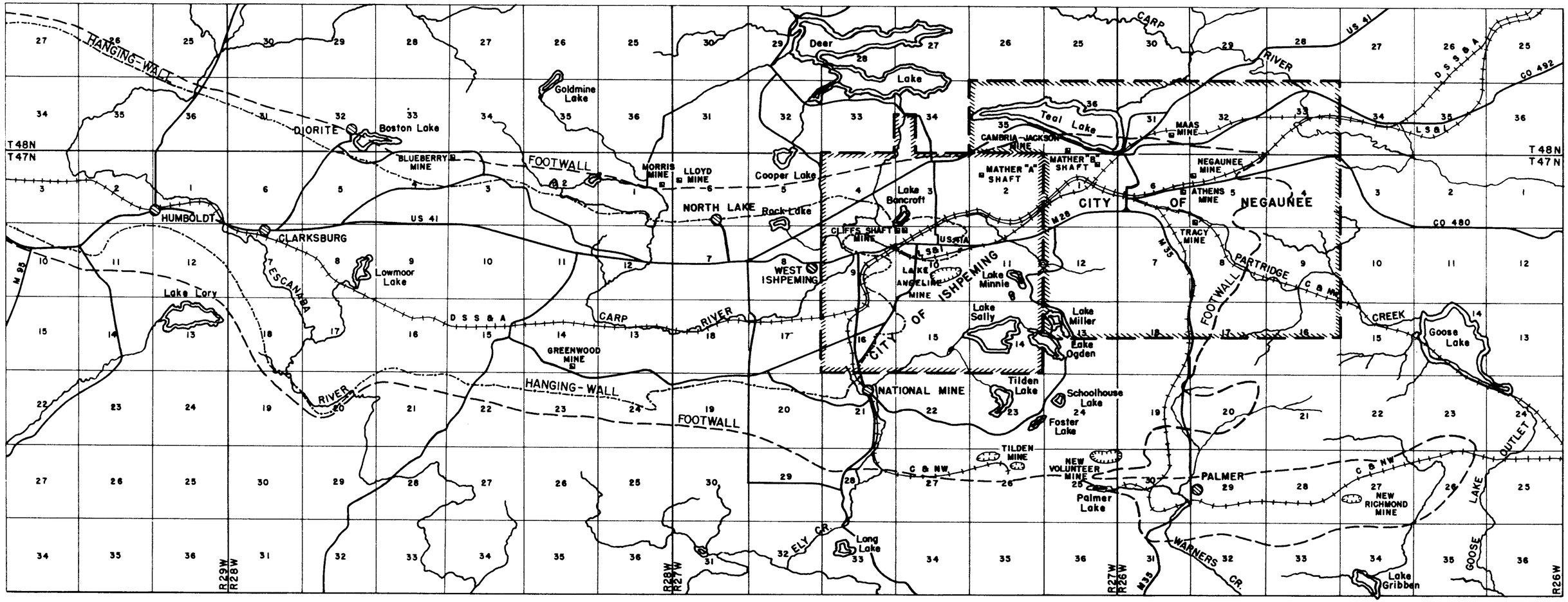


FIGURE 2. MARQUETTE DISTRICT, MICHIGAN

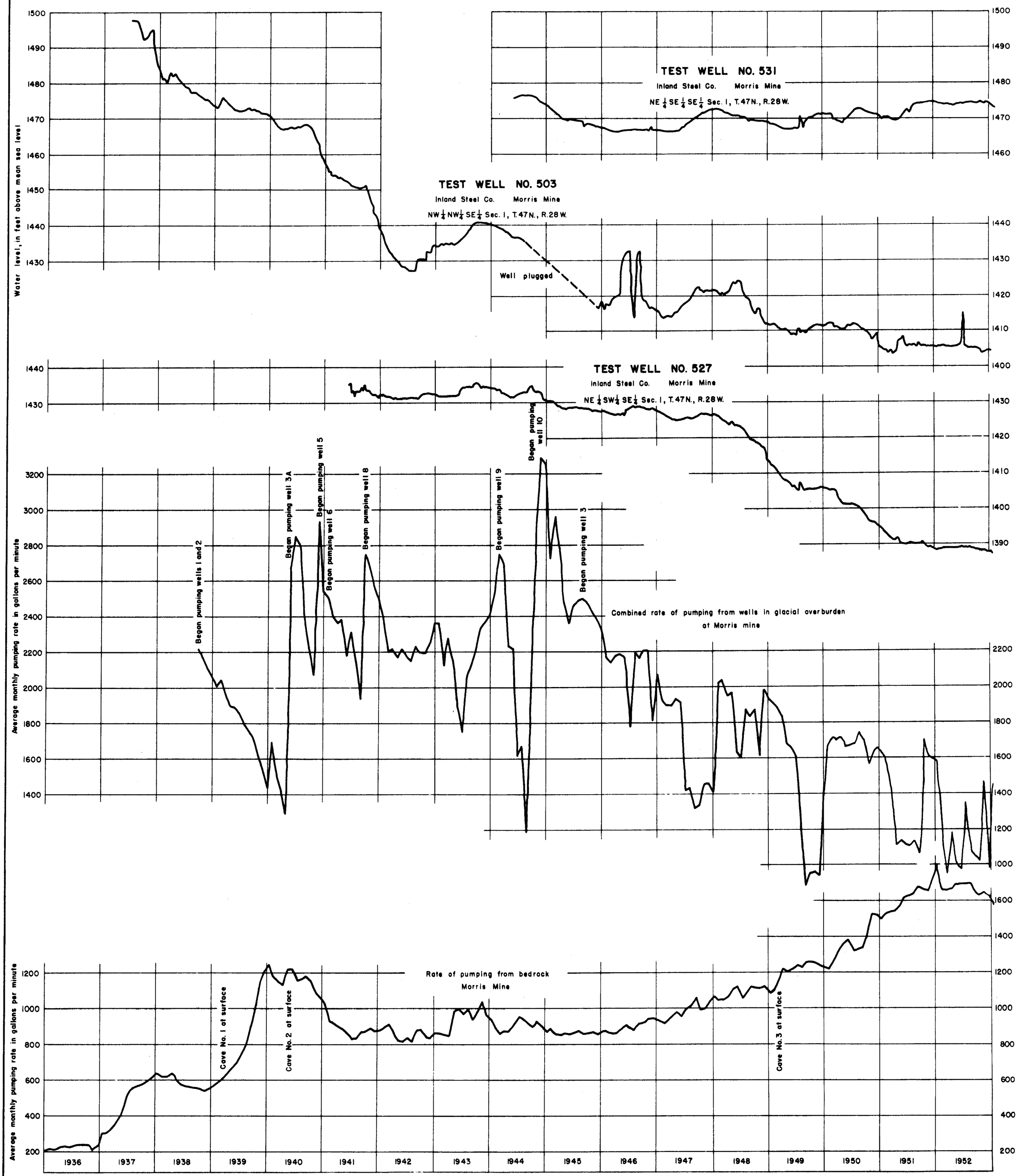


FIGURE 6. GRAPHS SHOWING FLUCTUATIONS OF WATER LEVELS AND RATES OF PUMPING IN THE VICINITY OF THE MORRIS MINE MARQUETTE DISTRICT, MICH.

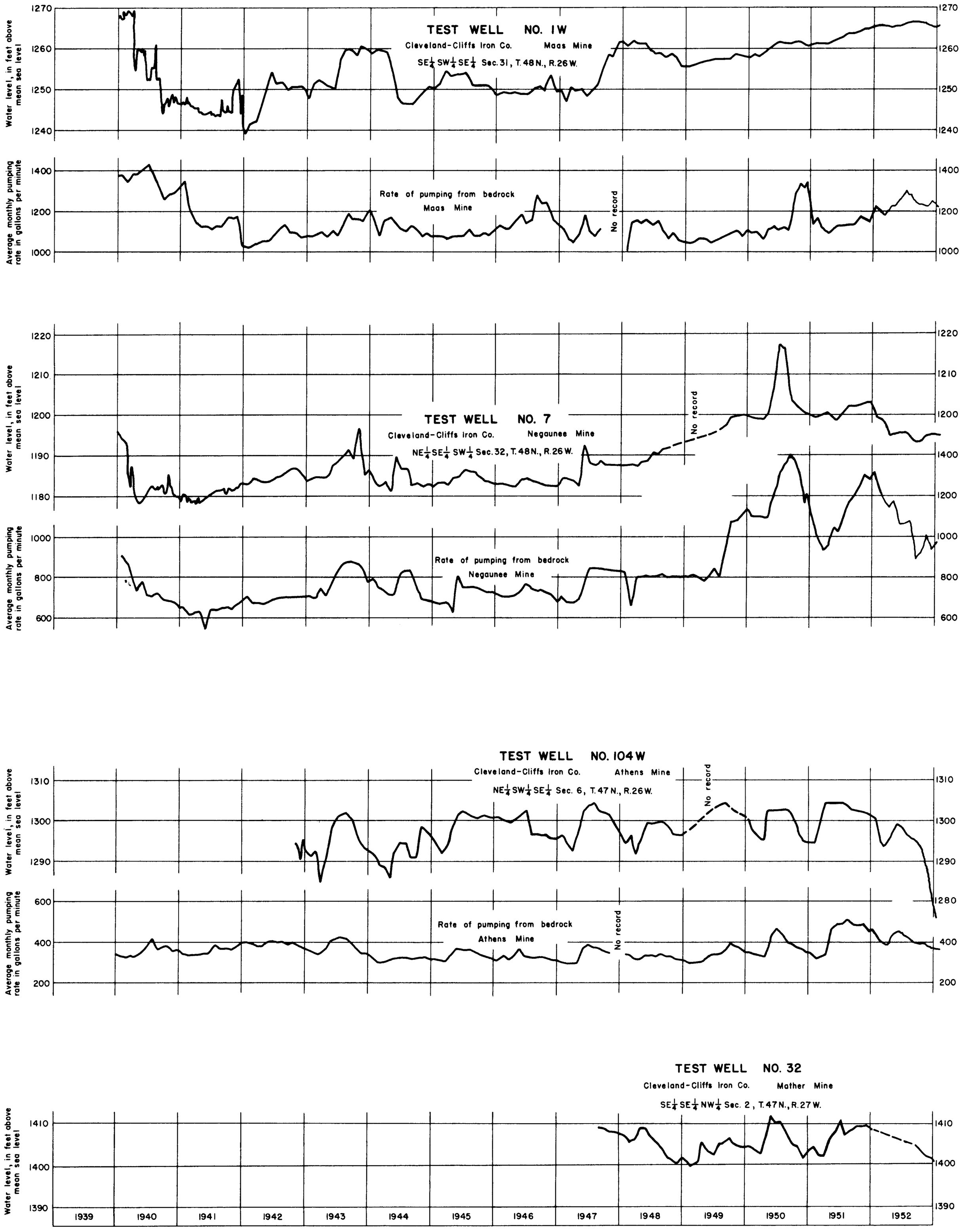
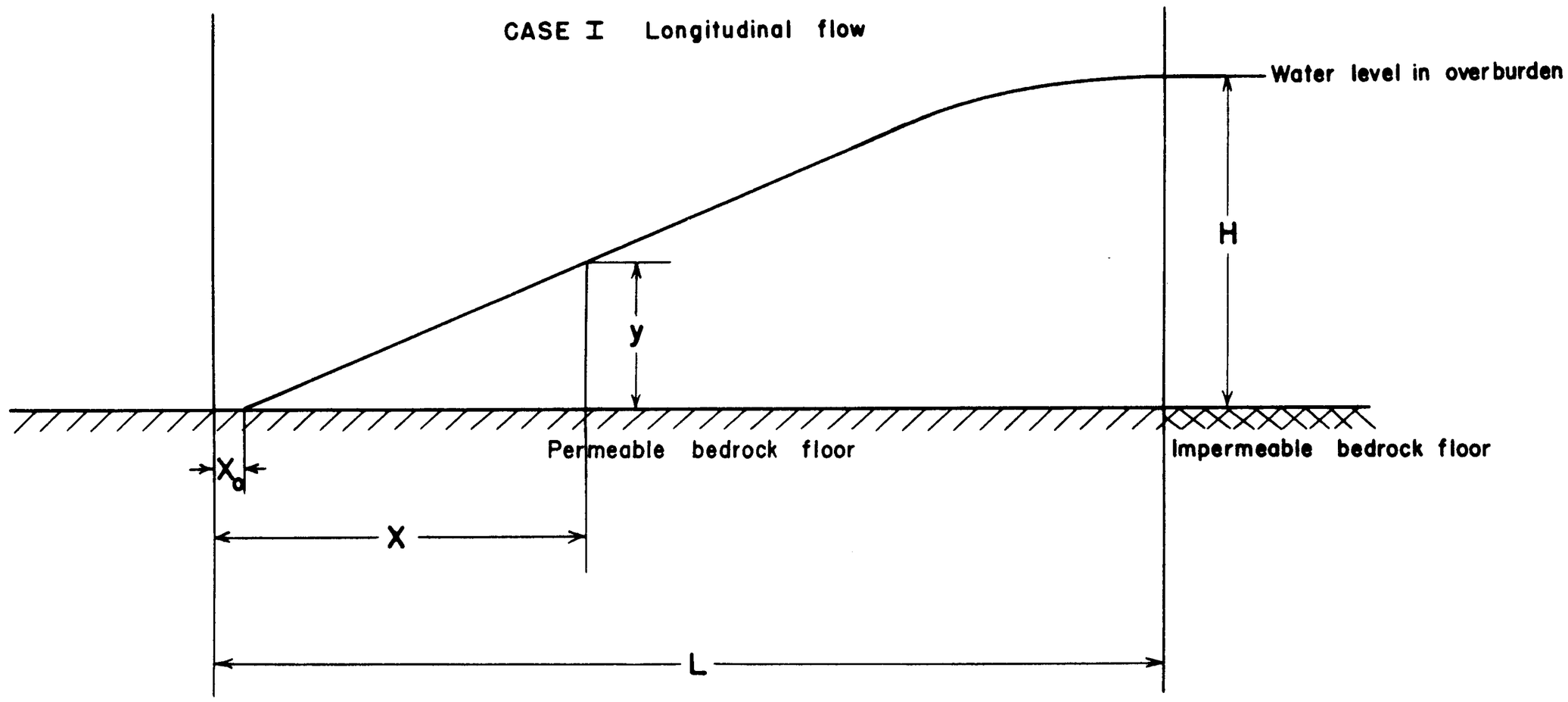


FIGURE 7. GRAPHS SHOWING TYPICAL WATER LEVEL FLUCTUATIONS AND RATES OF PUMPING AT MINES IN THE ISHPEMING-NEGAUNEE AREA, MARQUETTE DISTRICT, MICH.



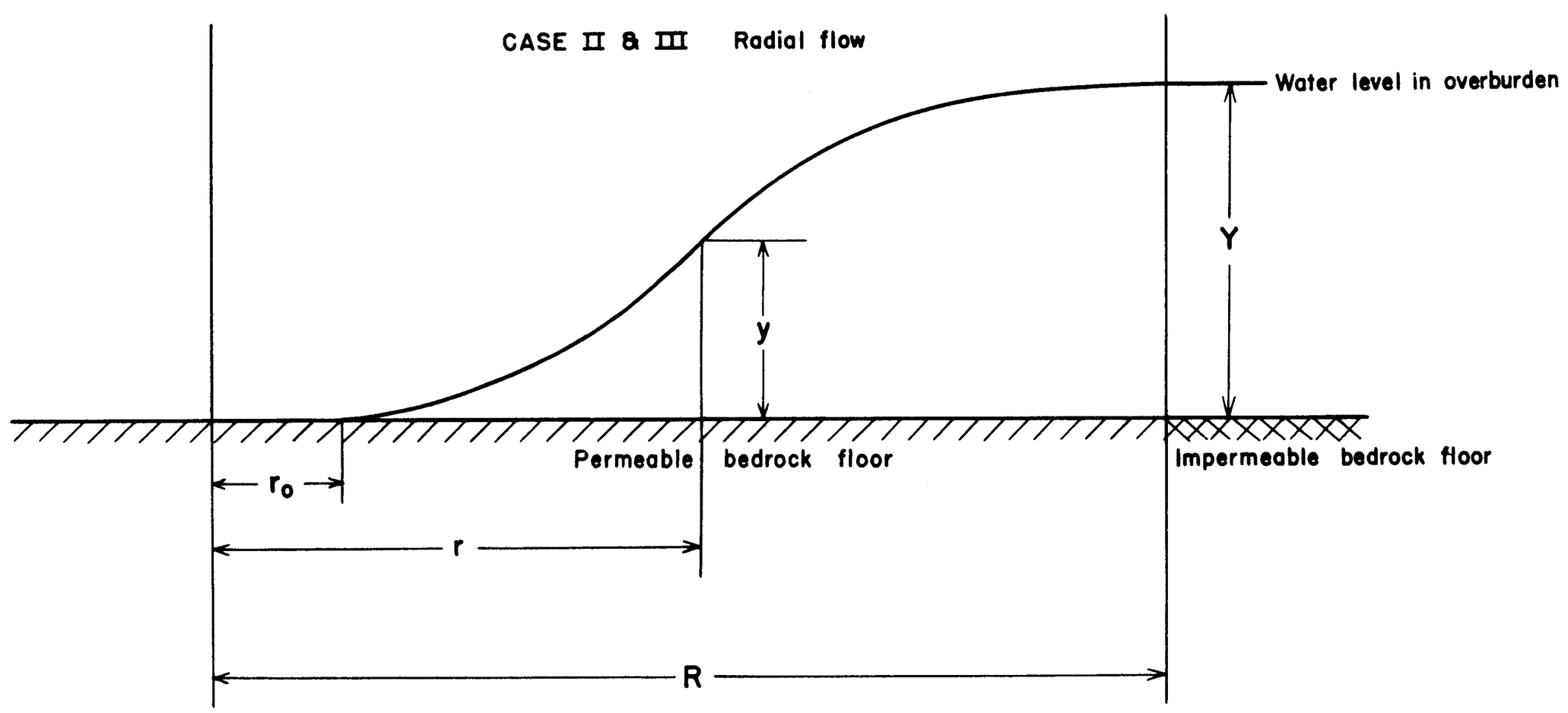


FIGURE 8. FLOW OF WATER INTO PERMEABLE BEDROCK FORMATIONS

System	Series		Formation or unit	Rock type	Thickness (feet)
Quaternary	Recent		Alluvium, swamp, and lacustrine deposits	Silt, clay, sand, gravel, muck, marl, and peat deposited in rivers, swamps, and lakes	10
	Pleistocene		Glacial drift: Till Outwash Lacustrine deposits	Unstratified to slightly stratified heterogeneous mixture of sand, gravel, clay, and boulders Sand, gravel, cobbles, and boulders Fine sand, silt, and clay	0 to 283
			Unconformity		
Pre-Cambrian	Killarney granite*		Acidic intrusives	Granite	---
	Keweenawan		Basic intrusives	Diabase and basalt ("diorite")	---
			Unconformity		
	Huronian	Upper	Michigamme slate (including Bijiki iron-formation member)	Slate and mica schist (grunerite-magnetite schist and sideritic chert)	1,000 to 2,000
			Clarksburg volcanics	Greenstone and conglomerate (cut by diabase and basalt)	Several thousand
			Greenwood iron-formation	Grunerite schist with chloritic material and quartz sand; sideritic slate containing specular hematite or masses of "specularitic schist"	About 50
			Goodrich quartzite	Quartzite and conglomerate	1,550
			Unconformity		
		Middle	Negaunee iron-formation	Sideritic slate, grunerite-magnetite schist, ferruginous slate and chert, and jaspilite	About 1,500
			Siamo slate	Slate, graywacke, and "quartzite"	About 650
			Ajibik quartzite	Quartzite (with slate, graywacke, and basal conglomerate)	700 to 900
			Unconformity		
		Lower	Wewe slate	Slate (with graywacke, conglomerate, and mica slate and schist)	1,050
			Kona dolomite	Cherty dolomite (with slate, graywacke, and quartzite)	700 to possibly 1,400
			Mesnard quartzite	Quartzite (with conglomerate, graywacke, and slate)	670
			Unconformity		
	Laurentian		Granite, syenite, and peridotite	Granite, syenite, and peridotite	---
			Palmer gneiss	Gneiss	---
	Keewatin		Kitchi schist	Basic schist	---
			Mona schist	Basic and acidic schist	---

*Stratigraphic position doubtful

Sources of data: U. S. Geol. Survey Mon. 28
U. S. Geol. Survey Mon. 52
U. S. Geol. Survey Prof. Paper 184
Michigan Geol. Survey Centennial Geological Map of the northern peninsula of Michigan

Table 20.--Chemical analysis and related physical measurements of ground water in Marquette district, Michigan

(Dissolved constituents given in parts per million)

Well No.	Location	Date of Collection	Elevation of sampling point above or below sea level (feet)	Formation or source	Temp. °F.	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Strontium (Sr)	Barium (Ba)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$	Specific conductance ($Ex10^6$ at 25° C.) (micromhos) c/	pH	Color
SAMPLES COLLECTED AT LAND SURFACE																												
Athens mine #1	T. 47 N., R. 26 W. NE¼SW¼SE¼ sec. 6	2- 5-52		Glacial drift	46	12	0.0	0.11	0.36	71	19			5.5	6.3	262	0	48	5.2	0.1	2.3	0.0	0.2	293	254	488	7.3	5
Negaunee mine #1	T. 48 N., R. 26 W. SE¼SE¼SW¼ sec. 32	2- 5-52		do.	47	11	.0	.09	.00	77	23			10	1.9	270	0	64	11	.1	7.6	.0	.2	337	286	547	7.2	5
Mather Mine No. 1	T. 47 N., R. 27 W. NE¼SE¼NW¼ sec. 2	2- 5-52		do.	44	14	.0	.07	.00	64	15			6.9	2.3	136	0	110	3.0	.1	13	.0	.3	293	222	448	7.1	2
Lake Sally	W½ sec. 14	3-20-52		Lake	36	4.1	.1	.16	.00	5.6	2.4			.8	.7	20	0	5.9	2.1	.1	.4	.0	.0	37	24	52	5.0	7
Teal Lake	T. 48 N., R. 27 W. S½ secs. 35, 36	3-20-52	1,362	Lake	34	.6	.1	.10	.00	12	3.2			.8	.7	42	0	7.0	.9	.2	.5	.0	.0	54	42	86	6.9	5
Morris Mine #1	T. 47 N., R. 28 W. SW¼SW¼NE¼ sec. 1	2- 5-52		Glacial drift	45	14.	.0	2.5	1.2	92	23			2.0	1.3	225	0	140	.8	.1	.7	.0	.0	394	323	578	7.2	3
Morris Mine #8	NE¼SE¼NW¼ sec. 1	2- 5-52		do.	44	13	.0	3.7	.44	36	9.5			1.6	1.2	132	0	29	.4	.2	.3	.0	.0	153	128	244	7.2	15
Morris Mine #10	NE¼NW¼NW¼ sec. 12	2- 5-52		do.	44½	16	.0	2.1	.45	57	18			1.6	1.5	156	0	94	1.4	.1	.1	.0	.0	270	215	408	7.1	2
Humboldt TW 6W b/	T. 47 N., R. 29 W. NW¼SW¼NW¼ sec. 2	10-20-49	1,537	Glacial drift	44			1.0		16.8	5.7							20	0						66		7.1	-
Humboldt TW 5W b/	T. 48 N., R. 29 W. NE¼NE¼SE¼ sec. 35	10-13-49	1,552	Glacial drift	44			2.5		2.8	3.2							.6	0						83		6.8	-
Humboldt TW 10W b/	NW¼NE¼SE¼ sec. 35	11- 4-49	1,550	do.	44½			1.8		24	4.0							4.9	0						76			-
Humboldt TW 12W b/	NE¼NW¼SW¼ sec. 36	11-11-49	1,553	do.	43			9.2		37	4.2							.8	0						109			-
SAMPLES COLLECTED BELOW LAND SURFACE																												
Eastern section of district																												
Maas Mine																												
Drip from roof, 20 ft. from top raise from 6th level	745S, 2,162W of SE cor. sec. 6, T. 47 N., R. 26 W.	1-24-52	- 9	Top oxidized soft-ore	54	6.4	.0	.87	1.4	588	17	.0	a/	62	11	109	0	1,430	70	.8	.0	.0	5.4	2,450	1,540	2,400	6.6	0
Drip from roof of 6700 cross cut 30 ft. from 6th level	716S, 1,926W of SE cor. sec. 6, T. 47 N., R. 26 W.	1-24-52	- 113	Bottom of oxidized soft-ore	57	9.3	.0	.15	.00	614	52	.0	a/	180	20	132	0	1,570	255	.8	1.3	.0	13	3,020	1,750	3,130	6.8	0
Drip from roof of 5th level at 5300 ft. switch	328S, 1,156W of SE cor. sec. 6, T. 47 N., R. 26 W.	2- 1-52	- 10	Siamo slate footwall	--	7.3	.0	.72	.00	400	22	.0	a/	100	19	140	0	905	209	1.0	1.4	.0	8.0	1,830	1,090	2,130	7.4	2
Middle section of Negaunee Basin																												
Cliffs Shaft mine																												
Flow from vertical drill hole 8th level raise	6,810S, 18,785W of SE cor. sec. 6, T. 47 N., R. 26 W.	1-28-52	+ 902	Overburden and bedrock	45	8.7	.0	.14	.00	48	16	-	-	7.5	2.7	156	8	49	12	.1	2.1	.0	-	229	186	385	7.6	0
Drip from roof at drift near raise on 5th level	5,810S, 20,160W of SE cor. sec. 6, T. 47 N., R. 26 W.	1-28-52	+ 950	Bottom of oxidized hard-ore	46	8.7	.0	.08	.00	52	17	.0	a/	17	8.7	203	10	47	12	.4	.8	.0	.5	267	202	453	7.7	0
Drip from roof of 6th level raise	5,110S, 17,965W of SE cor. sec. 6, T. 47 N., R. 26 W.	1-28-52	+1,000	Goodrich quartzite hanging wall	45	7.6	.0	.21	.20	32	16	.0	a/	8.5	3.1	144	0	39	8.0	.2	2.7	.0	0.2	183	147	323	7.9	2
Drip from wall of drift 50 ft. from 8th level	5,650S, 17,665W of SE cor. sec. 6, T. 47 N., R. 26 W.	1-28-52	+ 830	Unoxidized iron-formation	-	7.6	.0	.41	.00	57	28	.0	a/	12	4.4	184	0	110	16	.5	1.5	.0	.0	337	259	532	7.8	3
Mather mine A Shaft																												
Flow drill hole 89, 7200 crosscut on 7th level	2,314S, 12,975W of SE cor. sec. 6, T. 47 N., R. 26 W.	1-30-52	- 932	Bottom oxidized iron-formation	59	8.1	.0	.31	.34	264	17	-	-	52	31	61	0	757	24	.8	.0	.0	-	1,280	730	1,460	7.2	2
Drip from roof of 8½ pocket level, 30 ft. from bottom shaft	1,280S, 14,655W of SE cor. sec. 6, T. 47 N., R. 26 W.	1-31-52	-1,196	Siamo slate footwall	--	8.3	.0	.47	.30	190	35	.5	a/	340	47	85	0	813	330	.8	2.1	.0	12	1,830	620	2,560	6.8	5
Central section of district																												
Greenwood mine																												
Flow from drill hole 162 on 5th level	15,980S, 6,380W of NE cor. sec. 1, T. 47 N., R. 28 W.	3-25-52	- 183	Hanging wall quartzite	55	6.8	.0	1.2	1.9	452	155	6.0	a/	1,080	54	28	0	2.1	3,030	.4	.0	.0	11	5,050	1,770	8,380	5.4	12
Flow from drill hole 173 on 5th level	15,990S, 6,360W of NE cor. sec. 1, T. 47 N., R. 28 W.	3-25-52	- 183	Negaunee iron-formation Jasper	54	7.1	.0	1.1	1.3	408	151	5.0	a/	963	49	26	0	3.7	2,690	.4	.0	.0	10	4,470	1,640	7,560	5.9	7
Morris mine																												
Drip from roof of drift 50 ft. North of Sta. 1617 on 9th level	3,450S, 1,415W of NE cor. sec. 1, T. 47 N., R. 28 W.	3-25-52	- 326	Bottom of soft-ore Negaunee iron-formation	48	8.9	.0	.47	.50	114	6.3	1.5	a/	10	11	223	0	143	2.4	0.5	.1	.0	2.3	422	310	617	7.4	5
Drip from roof of drift 280 ft. east of St. M1245 on 8th level	3,325S, 1,290W of NE cor. sec. 1, T. 47 N., R. 28 W.	3-25-52	- 125	Siamo slate footwall	45	8.2	.0	.12	.50	101	5.6	2.0	a/	13	10	212	0	128	5.2	0.5	.0	.0	2.9	385	275	574	7.4	3

a/ Barium less than 0.5 ppm turbidity test (limit of test).
b/ Analysis furnished by Cleveland Cliffs Iron Co.
c/ In Tech. Rept. No. 2 Ground-water problems of Iron River district, this is reported as $Ex10^{-5}$