CHAPTER IX

THE DEEP MINE POOL COMPLEX

SUMMARY OF DEEP POOL STUDY OBSERVATIONS

The results obtained in this study have established the following important facts:

1. The high acid flow from Lancashire No. 15 pool is the major pollutant source in the West Branch headwater area which is presently producing 40,000 to 250,000 ppd acidity. This flow must be fully controlled perpetually if the Curwensville Reservoir and the lower West Branch are to be protected against future contamination such as occurred in 1970.

2. The cost of controlling this flow under present operating conditions is about $900,000 per year.

3. This study has shown that there is a potential for cutting this treatment cost by 50% by:

    a. improving operating techniques a the Duman plant.

    b. instituting a responsible engineering management program for operating the Lancashire pool under optimum conditions which will (1) reduce water influx to a minimum, (2) improve pool water quality, and (3) permit the diversion of as great a volume as possible into the Moss Creek Mine complex for natural neutralization.

4. The general validity of these conclusions can be established within a relatively short period of time by immediately increasing Lancashire No. 15 pool level to 1480 feet and monitoring all essential elements in a well designed sampling and flow measurement program.

5. The ultimate overall major benefit to be derived from efficient engineering management of underground water flow and the Duman treatment plant is a reduction in annual pollution treatment costs of $450,000 per year.

6. An important side benefit is the possible diversion of a large flow of good alkaline water into the Moss Creek watershed to permit low cost development of a much needed recreational waterway in the upper West Branch region.

This study has shown that the greatest pollution abatement need in the headwaters area is maximum positive control of water flow in the Lancashire No. 15 pool complex to produce the lowest volume of acid water for treatment at the Duman Plant. Effective programs for attaining this control are presented in Quick Start Projects No. 1 and No. 2 (see Chapter X). It is strongly recommended that these projects be given immediate consideration.

DEEP MINE POOL COMPLEX

Extensive abandoned workings in both B and D seams have lead to the formation of several deep mine pools in the study area. Some, because of the area and location of the mine workings and geologic structures involved are completely independent. Others, especially those in the same coal seam, are connected hydraulically to some degree. The extent to which there is an interchange of flows under varying pool level conditions has been the subject of much speculation. At the time this study was undertaken, a highly controversial matter was the magnitude of interflows or diversions of water from the Moss Creek mines complex pool (in D-seam) and the Sterling Mines complex pool (in B-seam) into Lancashire No. 15 pool.

Since the control of acid mine water flow from Lancashire No. 15 is the major pollution problem for the upper West Branch, it was one of the principle assignments of this survey to study pool levels and pool flows as completely as possible in order to obtain a full understanding of deep pool interrelationships and methods by which costs of pool level control might be reduced.

GENERAL DESCRIPTION

The size and relative positions of these pools can be determined from examination of the following exhibits:

Plate No. 3	B-seam Deep Mines (in rear cover pocket)
Plate No. 4	D-Seam Deep Mines
Plate No. 5	Overlays of B-seam and D-seam Deep Mines
Plate No. 6	B-seam Deep Mines, structure contours and outcrop
Plate No. 7	Deep Mining Area Cross Sections

A reduced version of Plate No. 6 showing actual pool areas in blue is presented in Figure IX-1, and a block schematic depicting pool interflows is shown in Figure IX-7.

The deep mine pools are collecting basins for drainage from the deep mined areas west of the axis of the Laurel Hill anticline through the Barnesboro syncline to the axis of the Nolo anticline. The major part of Barnes & Tucker's Lancashire #14 and #15 workings are in the Barnesboro syncline basin while most of Sterling's workings in the applicable area are on the west limb of the Laurel Hill anticline. The Moss Creek mines pool complex in the D-seam lies almost directly above the Lancashire No. 15 pool. The deep mine workings east of the Laurel Hill anticline axis, consisting of parts of Sterling #6 and Colver mine and Barnes & Tucker #20 mine, have very little or no bearing on the Barnes & Tucker #15 discharge complex. The water pools in the eastern end of Colver and Sterling #6 mines are generally below the axis of the anticline.

In January 1971, there appeared to be no significant flow through the barriers between the mines except at the designated cut-throughs between Sterling and Barnes & Tucker. This is evident via the various pool elevations of the mines in the area:

Colver Pool	1668’
Sterling Pool	1582’
Lancashire No. 15 Pool	1500 to 1530’
Reilly Pool	1435’*

*(Measured when shaft was sealed; no measurement or breakout since.)

The four cut-throughs as indicated on the various maps range in elevation from approximately 1540' to 1560'. At low pool levels in Lancashire No. 15 a flow from Sterling into the lower pool of 0.5 MGD might be expected at these cut-throughs.

According to expert testimony, there is no reported significant flow between Barnes & Tucker No. 24B and No. 24D operating mines and the No. 15 complex (see Plate No. 7 for locations).

1971 OPERATING HISTORY OF LANCASHIRE NO. 15 POOL

During the year 1971, the operating level in Lancashire No. 15 underwent several changes (see Figure IX-2). From January to early March, the Duman plant was pumping at a rate of 8 to 10 MGD, at which the pool level dropped from 1518 feet (above break-out level) to about 1480 feet (break-out flow ceased). The pool level was held between 1480 and 1485 until early July by maintaining a pumping rate of 4 to 6 MGD. Pumping rate was then increased to 8 to 10 MGD, whereupon the pool level gradually dropped to about the 1440 foot level. It was found that at this operating level, it was necessary to pump 8 to 10 MGD in order to maintain it, thus indicating an increase of flow into the pool at the lower water level elevation. Pumping records for this period are presented in Appendix C.

This variation in pool operating level with the long period of time between changes provided an excellent data background against which other pool phenomena could be correlated.

POOL LEVEL STUDY

In an effort to determine the degree of interdependency of the water levels in the adjacent Lancashire No. 15 and Sterling complex pools, daily measurements of pool levels in both pools were taken over the period April 8 through August 31, 1971. Weekly readings were taken before and after that period. These individual measurements are tabulated on the Records of Pumping Forms in Appendix C. The data are compiled in graphical form in Figure IX-2.

The plots very clearly show that no correlation exists between the levels of the two pools. If there is any flow from the high pool (Sterling) into the lower pool (Lancashire No. 15), it is probably comparatively small. Estimates by some experts have ranged from 200,000 to 500,000 GPD.

POOL FLOW STUDY

Deep mine discharge data was next analyzed to determine whether any correlation existed between the change in operating level in Lancashire No. 15 pool and the flows from Sterling No. 7 and Pardee No. 61 (Moss Creek complex). Flow data for Sterling No. 7 are on Weir No. 33 data sheet in Appendix A, and for Pardee No. 61 are compiled in Figure IX-6. The combined data are plotted on Figure IX-3.

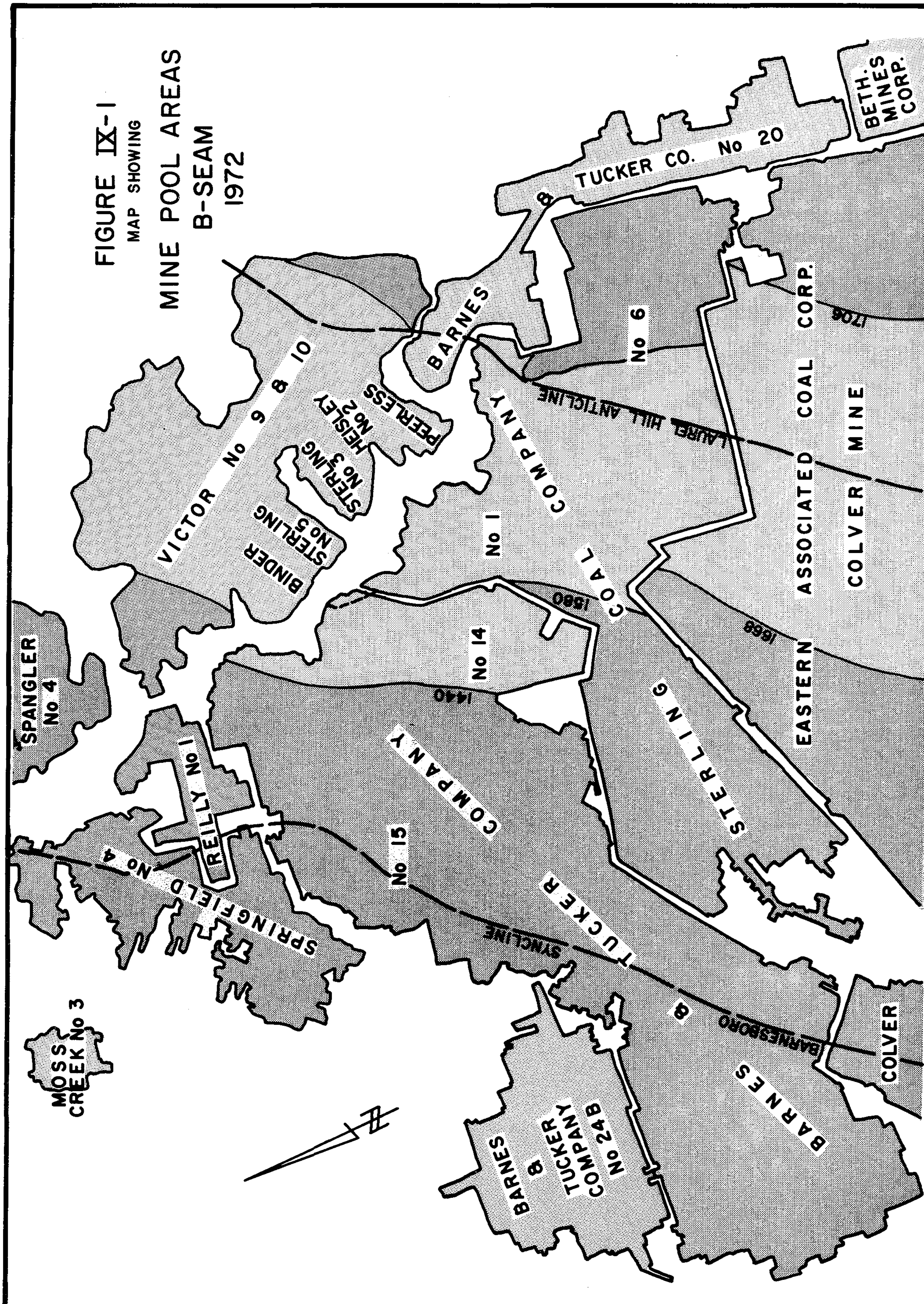
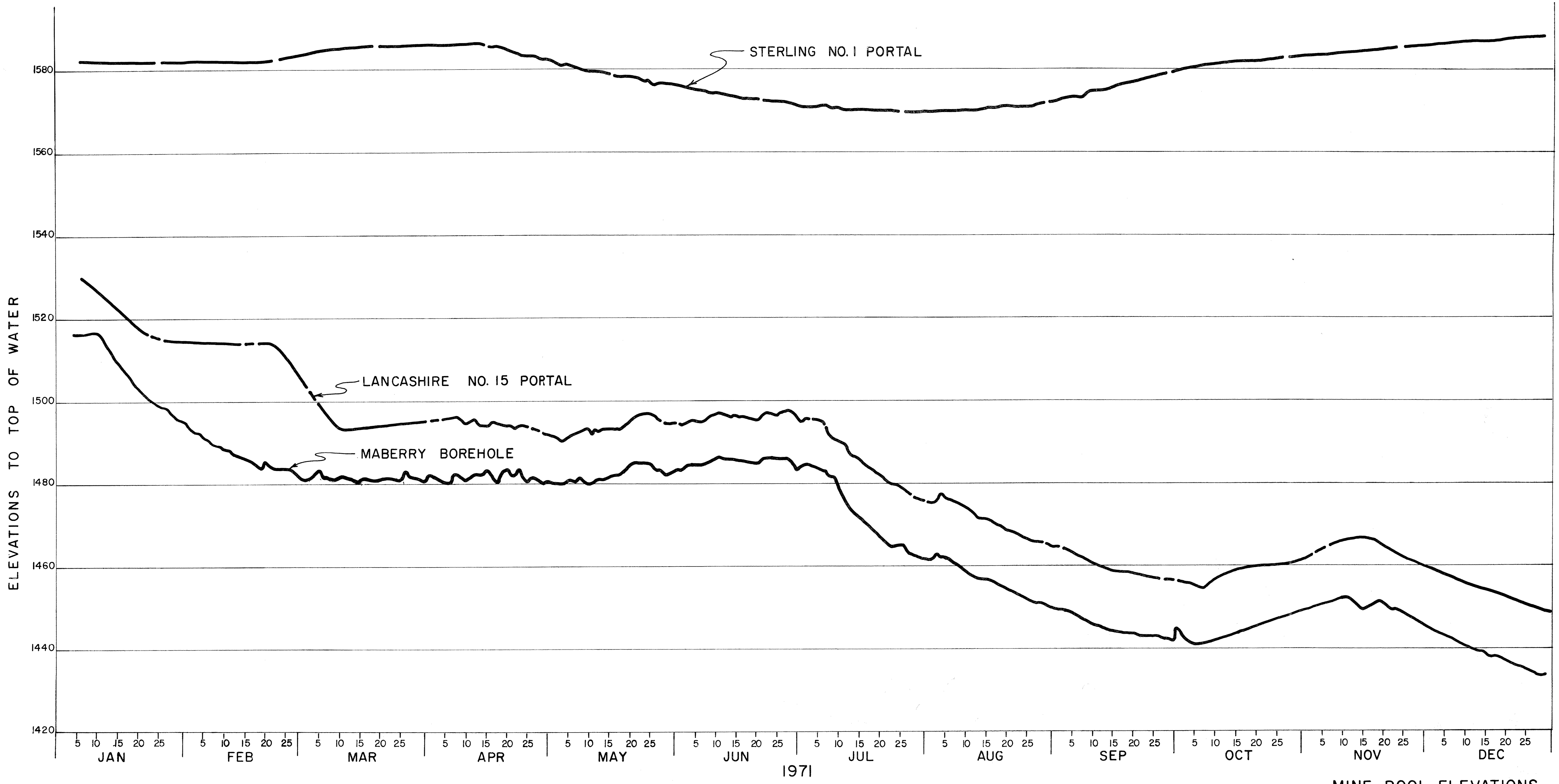


FIGURE IX-1
MAP SHOWING
MINE POOL AREAS
B-SEAM
1972



MINE POOL ELEVATIONS

FIGURE IX-2

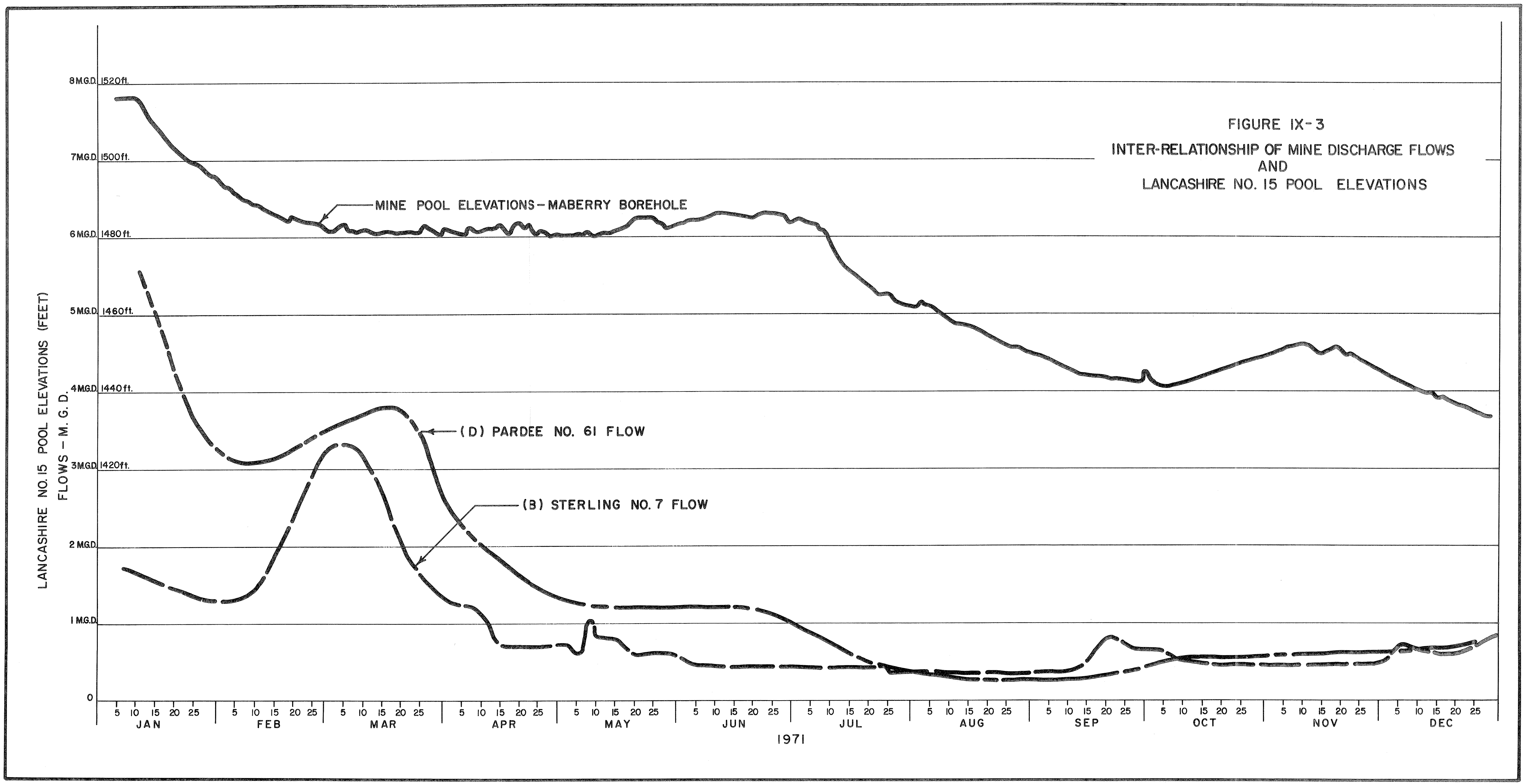


FIGURE IX-3
INTER-RELATIONSHIP OF MINE DISCHARGE FLOWS
AND
LANCASHIRE NO. 15 POOL ELEVATIONS
LANCASHIRE NO. 15 POOL ELEVATIONS (FEET)
FLOWS – M. G. D.
8 M.G.D. 1520 ft.
7 M.G.D. 1500 ft.
6 M.G.D. 1480 ft.
5 M.G.D. 1460 ft.
4 M.G.D. 1440 ft.
3 M.G.D. 1420 ft.
2 M.G.D.
1 M.G.D.
0
MINE POOL ELEVATIONS – MABERRY BOREHOLE
(D) PARDEE NO. 61 FLOW
(B) STERLING NO. 7 FLOW
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1971

This plot shows some very important relationships. While the Lancashire pool level remained at 1480 ft., the flows from the neighboring pools varied independently and maintained a fairly constant differential which would reflect the influence of ground water charge on two different areas. However, when Lancashire No. 15 level dropped to 1440 feet; Sterling No. 7 flow remained essentially constant, but Pardee No. 61 decreased by about 0.5 MGD and seemed to follow the general trend of Lancashire No. 15 thereafter. This is strong confirming evidence that there is little change in flow between the Sterling and Lancashire pools, but an appreciable flow diversion seems to occur from Pardee No. 61 to Lancashire No. 15.

REQUIRED PUMPING RATE vs. LANCASHIRE NO. 15 POOL LEVEL

Fortunately, the complete pumping records available from the Duman pumping operation permitted a check on the flows into Lancashire No. 15 by an entirely independent set of data. Pumping rates necessary to maintain Lancashire No. 15 pool level at fixed elevations were plotted against pool working level to determine average water production rates (see Figures IX-4 and IX-5). Although an appreciable spread exists in the data, there is an unmistakeable trend indicating an increase in water production rate of about 0.8 MGD as the pool level dropped from 1480 to 1440. This correlates very well with the figure of 0.5 MGD diversion from Pardee No. 61 during the same period. The difference could easily be due to additional mine "make" water at the lower elevation, or possibly a small diversion from the Sterling pool.

Lancashire Pool Complex Flow – December, 1971

On the basis of the flow data and pool level measurements obtained during 1971, it is possible to construct a qualitive water balance and flow sheet for the underground waters moving through Lancashire No. 15 as it is presently being controlled. These water flows are shown schematically in Figure IX-7. This sketch is drawn to give a general picture of the relative elevations of the pools and hydrological conditions involved when Lancashire No. 15 pool level is at 1440 feet. Several important observations can be made from a study of this flow sheet and the related data in Figures IX-2 through 6:

1. under present operating conditions the required pumping rate from Lancashire No. 15 cannot be reduced below the 8 to 10 MGD rate, which is necessary to maintain a constant level at 1440 feet.

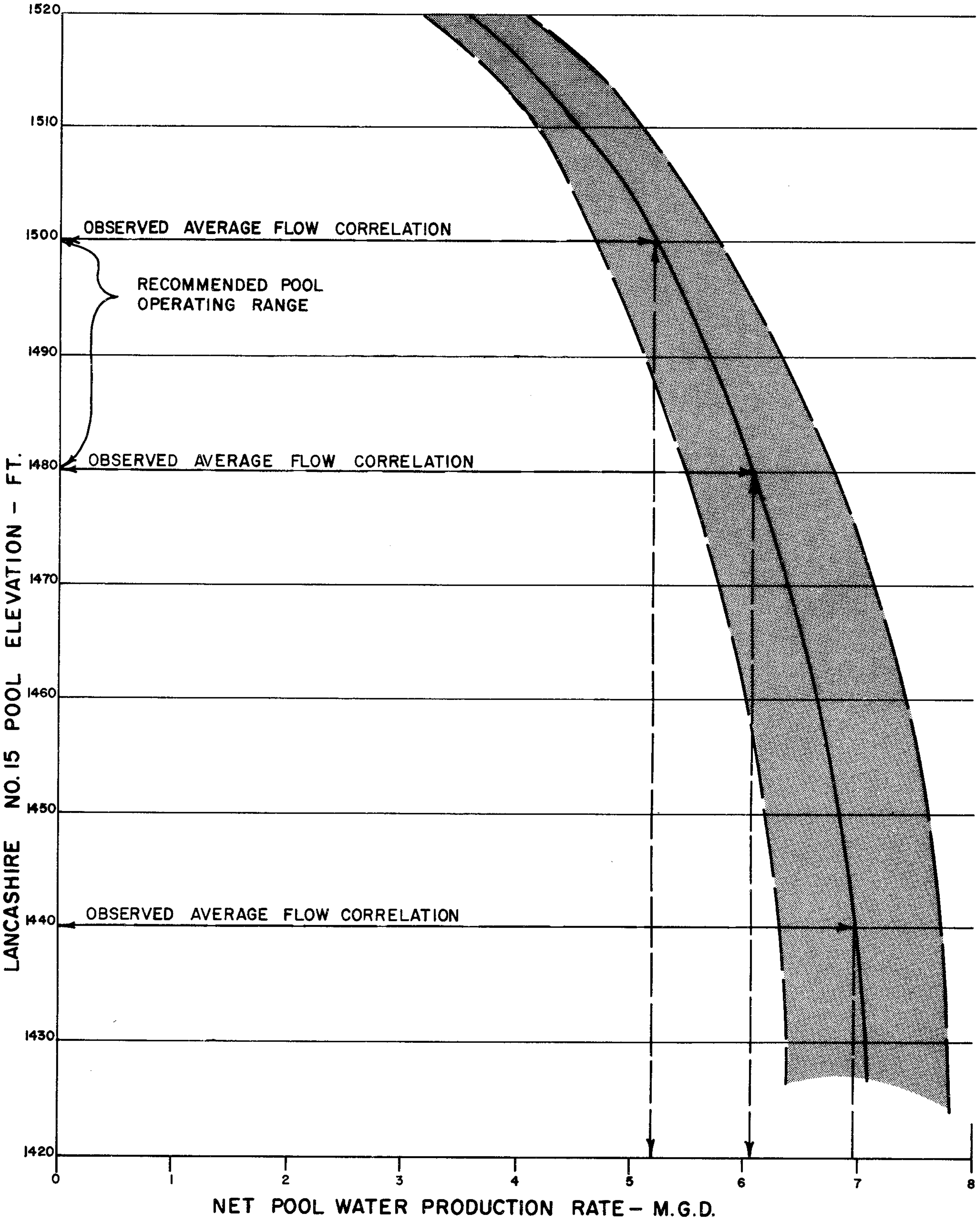
FIGURE IX-4

COMPILATION OF LANCASHIRE NO. 15 POOL WATER PRODUCTION RATE VERSUS POOL LEVEL ELEVATION
(FOR PERIOD NOVEMBER, 1970 TO DECEMBER, 1971)

	PUMPING PERIOD	POOL LEVEL CHANGE FT.	PUMPING DAYS	TOTAL AND PUMPED MG	TOTAL SLUDGE RETURN MG	NET DISCHARGE MG	EQUIV. POOL GENERATION RATE MGD
1.	11/07-11/27	1517-1517	21	87	8	80	3.76
2.	11/25-01/11	1516-1516	48	229	35	194	4.04
3.	01/11-03/10	1516-1480	59	572	115	458	7.76
4.	03/10-04/06	1480-1480	28	250	56	194	6.95
5.	04/06-05/12	1480-1480	37	321	74	247	6.68
6.	05/12-07/08	1480-1480	58	421	113	307	5.30
7.	07/08-07/29	1480-1462	22	217	44	173	7.87
8.	07/29-08/05	1462-1462	8	65	13	52	6.51
9.	08/05-10/04	1462-1441	61	602	120	482	7.90
10.	10/04-12/09	1441-1441	67	547	125	422	6.30
11.	12/09-02/20	1441-1441	74	702	148	554	7.49

AVERAGE FLOW AT 1480 FT. LEVEL (ITEMS 4, 5 & 6) $= \frac{749.17}{123} = 6.09$ MGD

AVERAGE FLOW AT 1440 FT. LEVEL (ITEMS 10 & 11) $= \frac{976.53}{141} = 6.93$ MGD



* NET FLOW IS TOTAL VOLUME PUMPED MINUS VOLUME OF SLUDGE RETURNED UNDERGROUND

FIGURE IX-5
DUMAN PUMPS NET FLOW
VS.
LANCASHIRE No. 15 POOL LEVEL

2. of the 8 to 10 MGD being pumped, 2 MGD (20%-25%) is Duman plant recycle water which must be neutralized and is merely a vehicle for a very dilute sludge. Cost of recycling this volume of water is about $180,000 per year.

3. after 1.5 years of operational experience, the data shows that the deeper the No. 15 pool operating level is maintained the more water flows into the pool. By changing level from 1480 to 1440, flow increased about 1 MGD with 0.5 MGD being diverted by gravity flow from the Moss Creek complex.

4. when the No. 15 pool level was held at 1480 feet, hydraulic flow equilibrium apparently developed between No. 15 and the Moss Creek complex. Required pumping rate at that level was 5.5 to 7 MGD.

5. there is an indication from the discharge flow for Pardee No. 61 in January 1971 (6 MGD when No. 15 pool level was at 1518 feet) that it may be possible to divert flow from No. 15 into the Moss Creek complex by maintaining the No. 15 level somewhere between 1480 and 1500 feet, just below breakout elevation. This optimum level would have to be determined experimentally in a well controlled engineering study (see Quick Start Project No. 2 in Chapter X).

6. the Pardee No. 61 discharge data for January, 1971 also shows that during periods of possible diversion from No. 15 to the Moss Creek complex, the diverted water was completely neutralized. Discharge from Weir No. 78 (Pardee No. 61 drainage ditch January 1971) had an alkalinity of 50 ppm and a pH of 7.

7. based upon the previous observations, there are promising indications that a minimum of 0.5 MGD and a possible maximum of 3 MGD might be diverted from No. 15 to the Moss Creek complex for natural neutralization under carefully controlled No. 15 pool operating conditions. Confirmation of this can only be obtained through additional study.

8. a diversion of 0.5 to 3 MGD into Moss Creek complex could result in a decrease of Duman treatment plant influent of 1 to 3.5 MGD, thus permitting a treatment cost saving of from $180,000 to $315,000 per year.

FIGURE IX-6

MOSS CREEK (PARDEE #61 - D SEAM) MINE WATER DISCHARGE AT BARNESBORO SYNCLINE OUTCROP

SAMPLING DATE (1971)	FLOW AT SAMPLING POINTS - GPM			TOTAL FLOW GPM	POOL ELEVATIONS-FT.	
	#78	#82	#83		MABERRY BOREHOLE	LANCASHIRE NO. 15 SHAFT
Jan. 12	3924	82	174	4180	1508	1525
Feb. 5	1928	70	70	2068	1501	1515
Mar. 9	2338	50	174	2562	1481	1495
Apr. 7	1351	34	94	1479	1482	1496
May 5	739	6	70	815	1480	1492
June 3	739	12	70	821	1484	1495
July 13	404	6	12	422	1474	1488
Aug. 4	200	9	2	211	1462	1477
Sept. 7	144	2	2	148	1447	1462
Oct. 6	332	2	34	368	1440	1455
Nov. 17	404	6	12	422	1450	1466
Dec. 3	404	12	34	450	1445	1459

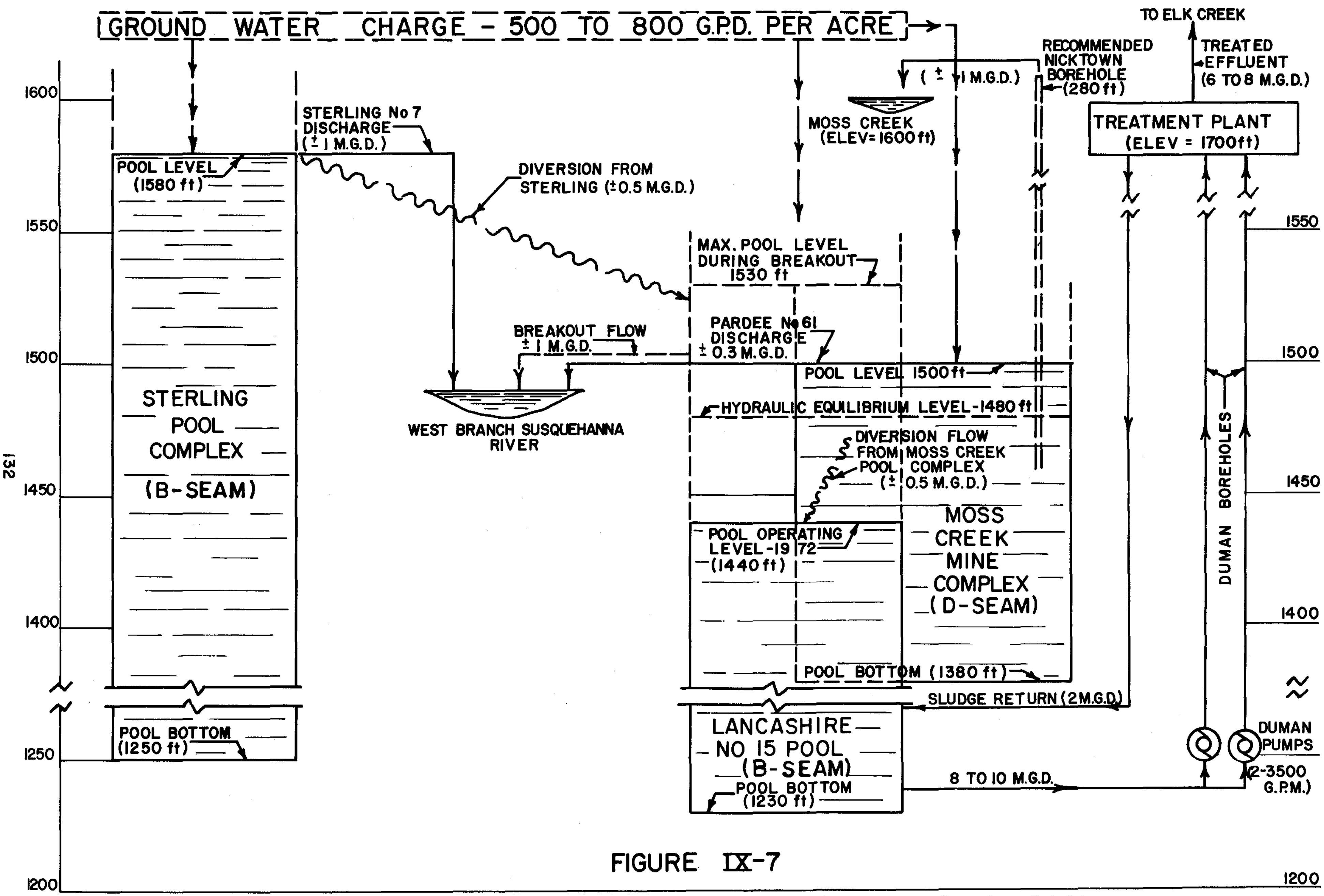


FIGURE IX-7

WATER FLOWS RELATED TO LANCASHIRE NO. 15 DEEP MINE POOL

9. improvements in sludge handling at the Duman plant could reduce the sludge return flow by 1.5 MGD. This would in turn reduce the plant influent flow by an equal volume, resulting in an additional treatment saving of $135,000 per year (see details in Chapter VIII).

10. No. 15 flows diverted into Moss Creek complex and naturally neutralized, can ultimately be discharged on the surface in two ways:

    (1) by gravity flow through Pardee No. 61 drainage ditch to the West Branch at Spangler, or

    (2) by borehole pumping at a strategic location to deliver this good alkaline water to Moss Creek watershed for recreational use (see Quick Start Project No. 2 in Chapter X).

11. sufficient data for water quality in Lancashire No. 15 are not available for the high level conditions to permit a valid correlation of pool level with water quality. There are good qualitative signs, however, that acidity loadings might be appreciably lower at high level operation. A better quality pool water would permit additional savings at the Duman treatment plant.

12. the wide diversion in acid concentrations in various portions of the No. 15 pool (500 to 5000 ppm) indicates an influx of various water qualities of unknown volume for which interceptor techniques might be developed as a result of future study.

OBSERVATIONS AND CONCLUSIONS

A review of the technical evidence indicates that a good potential exists for decreasing the flow of acid water to the Duman plant by optimum engineering control of the underground pool interflows. The most logical starting point to establish the validity of pool flow control is to raise the operating level of Lancashire No. 15 pool immediately to an elevation in the range of 1480 to 1500 feet. Information from various reports indicates that water at this level would not interfere with the operations of Lancashire No. 24B, 24D, and 25D mines of the Barnes and Tucker Company.

Any pool level operation investigation should be a well designed engineering program for monitoring all relevant factors involved on a continuous basis over a period of at least one year so that seasonal flow variation effects can be determined. A program of this nature is presented as Quick Start Project No. 2 in Chapter X.

Risk Factors Involved In High Level Operations

The foregoing recommendation for operating Lancashire No. 15 pool at levels near the breakout elevation immediately raises questions as to the margin of safety involved in preventing future breakouts. The greatest danger would arise from a failure of the pumps at the Duman plant. Therefore, a maximum pool operating level would be selected which would permit at least a 4 to 5 day surge capacity in the event both pumps failed. Figure IX-8 indicates the best present estimates of pool storage capacity at various pool level intervals based upon an analysis of Duman pumping rates and corresponding changes in No. 15 pool levels.

In the event that a short term breakout would occur, the acid loading could be neutralized by lime added upstream at the old Lancashire No. 20 treatment plant. Obviously, planning would include maintaining this plant in stand-by condition so that emergency treatment could be instituted immediately if required.

FIGURE IX-8

LANCASHIRE NO. 15 POOL STORAGE CAPACITY

POOL LEVEL INTERVAL ELEVATIONS	INTERVAL DEPTH-FT.	CALCULATED HOLDING MG	CAPACITY MG/FT.
1441-1462	21	71.7	3.41
1462-1480	18	34.6	1.92
1480-1516	36	103.9	2.89
1441-1516	75	210.2	2.80