HAWK RUN ACID MINE DRAINAGE

The three acid mine drainage sources in the Hawk Run area that have been selected for treatment are Mine Hole #1, Mine Hole #3 and the (Red) Moshannon River which is contaminated by drainage from a number of mines in the area. The prime AMD water source is Mine Hole #1 which is located on the site of the treatment plant. The secondary source, Mine Hole #3, is situated about 6000 ft north of the plant, and the third source, the Red Moshannon River, flows adjacent to the southerly boundary of the plant. The mine holes are concentrated sources of acidic pollution and the river is relatively weak because of the dilution from surface runoff.

The overflow rate at the two mine sources, Hole #1 and Hole #3, have been measured by the Pennsylvania Department of Mines and Mineral Industries. The measurements show that either source has produced about 3-5 times the necessary feed. The volume rates were determined by damming the outfall of each source with a V-notched weir and measuring the overflow levels. The average outflows for April to May 1969 were:

Hole No. 1	4.4 million gpd
Hole No. 3	3.0 million gpd

The flow of the Red Moshannon was not determined at this time. Visually estimating the river flow, it appeared to be several times that of either mine source.

The chemical and physical composition of the three AMD sources has been monitored weekly since December 1968 and the results show the very high sulfates, iron and hardness. There is the expected chemical similarity among sources although the individual concentration levels and total dissolved solids vary considerably. For example, the total anion content, mostly sulfate, is 761 ppm for Hole #1, 1031 for Hole #3 and 321 ppm for the River. From December 1968 to May 30, 1969 twenty-two samples were taken from each source and were analyzed for 14 chemical and physical species. The analyses were done by the Pennsylvania Department of Health in Harrisburg. At first some difficulty was experienced

with the sampling procedure and modifications had to be made. Several of the early samples showed inconsistency in sulfate, iron, pH and turbidity with observations made by the engineers at Hawk Run site. After discussion with the analytical department it was concluded that the two to three day time lag between sampling and analyzing was too long and that it allowed the samples to oxidize and change composition while still in the bottle. The delay was reduced to one day and the subsequent results showed improved consistency and correlation was achieved within the rather broad limits expected for mine drainage samples.

The included summary sheet compares the mean values of the chemical and physical species of actual mine drainage with the water analyses estimated during the initial phase of the process design. The sulfate and the heavy metal (Fe, Mn and Al) concentrations are the critical items because the former sets the depth of the ion exchange resin bed and the latter sets the length of the aeration and settling period necessary for complete oxidation.

The sulfate concentration of 745 mg/l as CaC03 from Hole #l is well within the originally estimated design value of 1000 ppm. The variations in mineral content were analyzed statistically and it appears that the possibility of the sulfate content from Hole #l exceeding the design is remote, i.e., within confidence limits 96.6%. See Figure I. The ion exchange units therefore can be expected to be only three-quarters exhausted at the end of a 12-hour cycle treating this water. The mean sulfate content of 1018 mg/l for Hole #3 is exactly at the design value and therefore the chances of occasional daily excursions beyond the design level may be expected. See Figure 2. This situation will not result in sulfate leakage during the first two or three years of operation because the resin capacity has been derated 20 to 60% by the manufacturer and the resin bed can absorb this excess without leakage. The mean sulfate content of the Red Moshannon is only one-third of the design value and cannot logically approach the design value so long as there is flow in the river. See Figure 3.

Statistical plots, as Histograms of Sulfate Content vs Frequency of Occurrence, are shown for the three sources in Figures 1, 2, and 3. The design and the mean values are indicated in relation to the standard deviation.

The mean iron values show the same pattern as the sulfates but the mean values approach closer to the design value of 140 mg/l. Since Hole #1 has a mean value of 122 and a standard deviation of 20, the chances of excursions beyond the 140 mg/l are low. See Figure 4. Therefore, since the design value falls at the extreme of the standard deviations it is felt that the design value is conservative.

The mean iron value of 137 mg/l for Hole #3, the secondary source
is essentially that used in the design. See Figure 5. Since the standard deviation is 25 mg/l the possibilities of overrunning the design value 28% of the time might be expected. That is, in 28 of 100 days of operation the ferrous iron value may be so high that the time allocated to oxidize and separate the iron may be insufficient. In such an event, however, the iron oxidation would be completed in the softener in which more alkaline conditions exist in order to force the oxidization and precipitation of manganese besides softening.

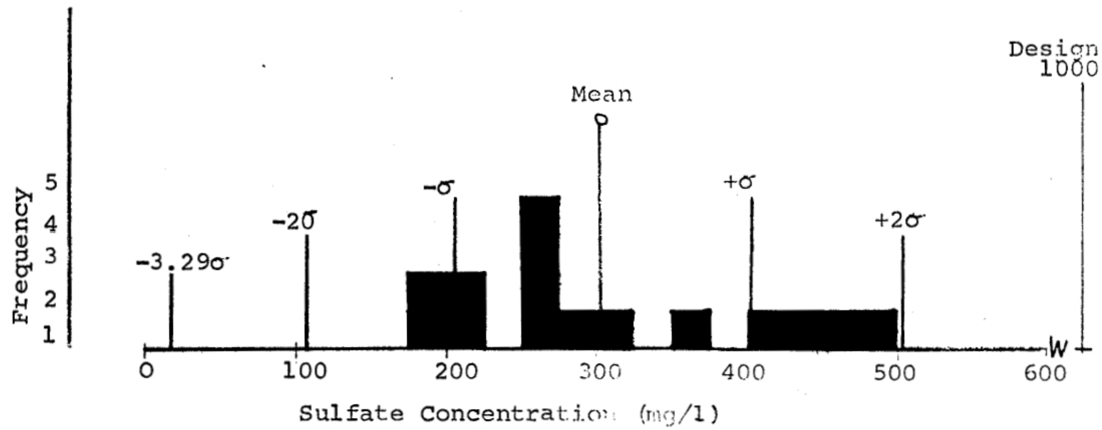
The iron content of the river is well below the design limit. See Figure 6. The only possibility of difficulty is that in the open channel flow the ferrous ion will oxidize to ferric and tend to precipitate onto the resin beads. This precipitation and plugging tendency is the reason for using upflow in the ion exchange units. The expanded bed of resin allows the precipitate to pass through and the free movement and collisions of the individual beads will tend to abrade the precipitated iron.

FREQUENCY HISTOGRAM

Sulfate Content, AMD Confluence

Sampling Period: Jan. 30 to May 14, 1969

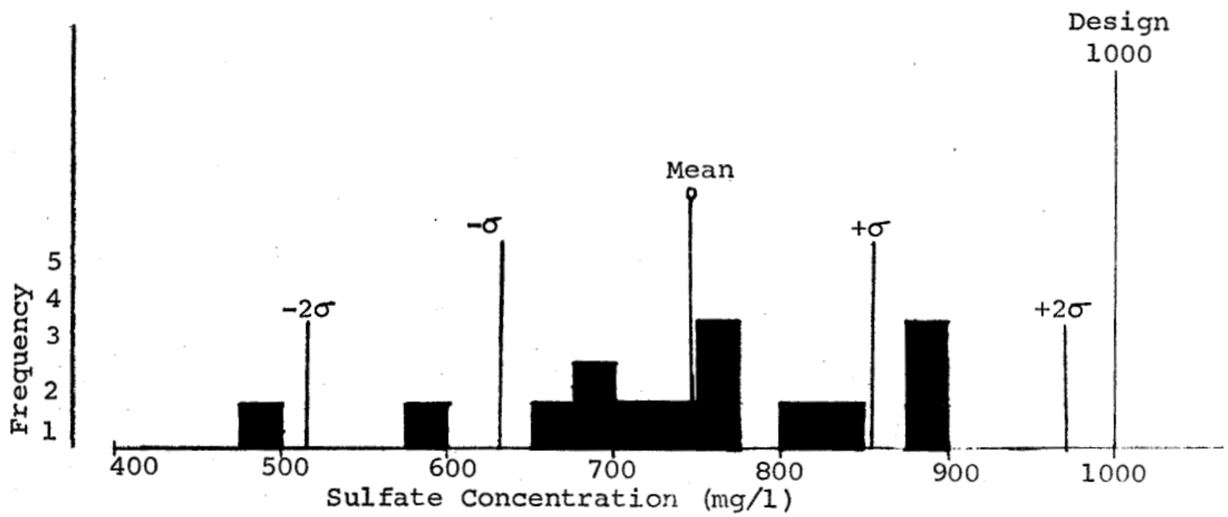
Mean value,	$\bar{x}$	=	308
Std. deviation,	σ	=	100
	2σ	=	200
	3.29σ	=	329
Confidence limits,	99.9%	=	308 $\pm$ 329
	97.8%	=	308 $\pm$ 200
	74.2%	=	308 $\pm$ 100



<u>FREQUENCY HISTOGRAM</u> Sulfate Content, AMD Hole #1

Sampling Period: Jan. 30 to May 7, 1969

Mean value,	$\bar{x}$	= 745
Std. deviation,	σ	= 114
	2σ	= 228
	3.29σ	= 375
Confidence limits,	99.4%	= 745 $\pm$ 375
	96.6%	= 745 $\pm$ 228
	71.2%	= 745 $\pm$ 114

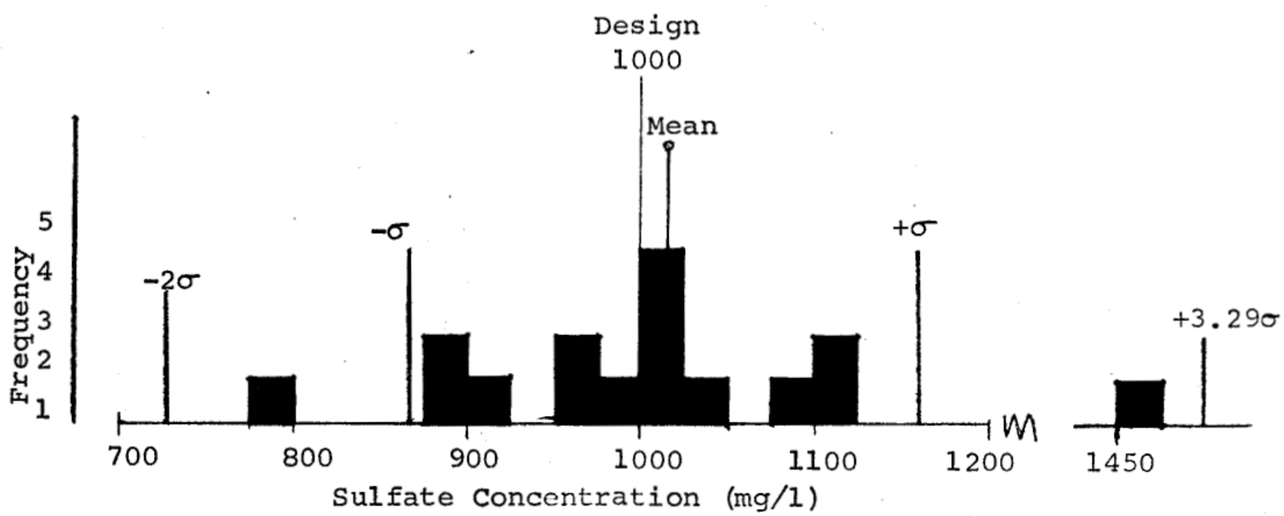


FREQUENCY HISTOGRAM

Sulfate Content, AMD Hole #3

Sampling Period: Jan. 30 to May 14, 1969

Mean value,	$\bar{x}$	= 1018
Std. deviation,	σ	= 146
	2σ	= 292
	3.29σ	= 480
Confidence limits,	99.9%	= 1018 $\pm$ 480
	94.6%	= 1018 $\pm$ 292
	72%	= 1018 $\pm$ 146

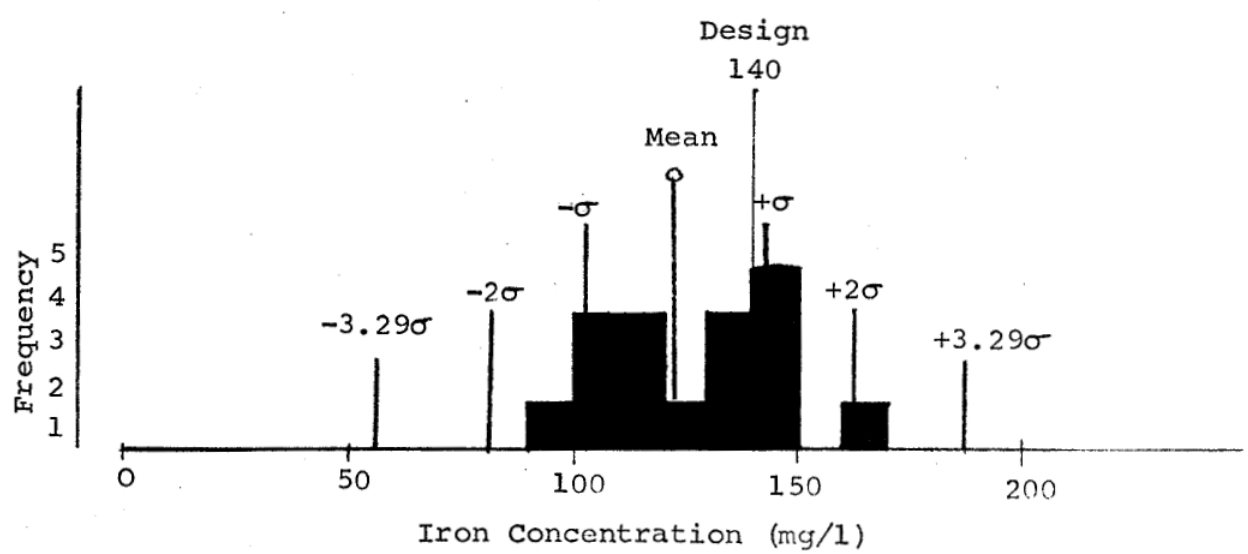


FREQUENCY HISTOGRAM

Total Iron as FeO AMD Hole #1

Sampling Period: Jan. 30 to May 14, 1969

Mean value, $\bar{x}$	=	122
Std. deviation, σ	=	20
2σ	=	40
3.29σ	=	65
Confidence Limits, 99.4%	=	122 ± 65
96.6%	=	122 ± 40
71.2%	=	122 ± 20

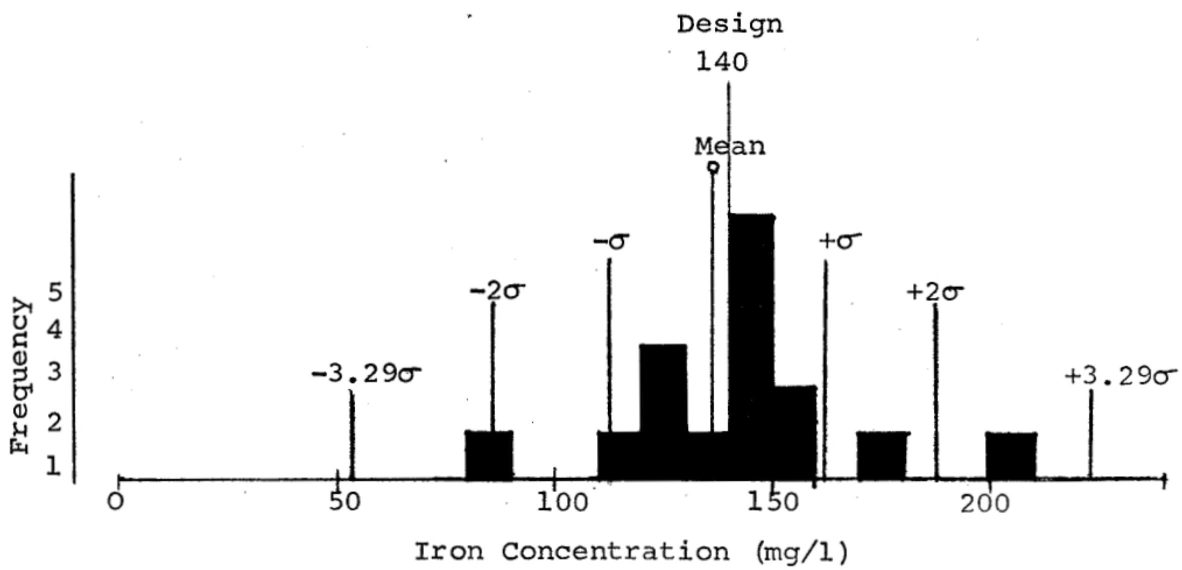


FREQUENCY HISTOGRAM

Total Iron as Fe^{o}, AMD Hole #3

Sampling Period: Jan. 30 to May 14, 1969

Mean valve,	$\bar{x}$	=	137
Std. deviation,	σ	=	26
	2σ	=	52
	3.29σ	=	84
Confidence limits,	99.9%	=	137 ± 84
	94.6%	=	137 ± 52
	72%	=	137 ± 26



FREQUENCY HISTOGRAM

Total Iron as Fe°, AMD Confluence

Sampling Period: Jan. 30 to May 14, 1969

Mean value,	$\bar{x}$	=	21
Std. deviation,	σ	=	7
	2σ	=	13
	3.29σ	=	22
Confidence limits,	99.9%	=	21 $\pm$ 22
	97.8%	=	21 $\pm$ 13
	74.2%	=	21 $\pm$ 7

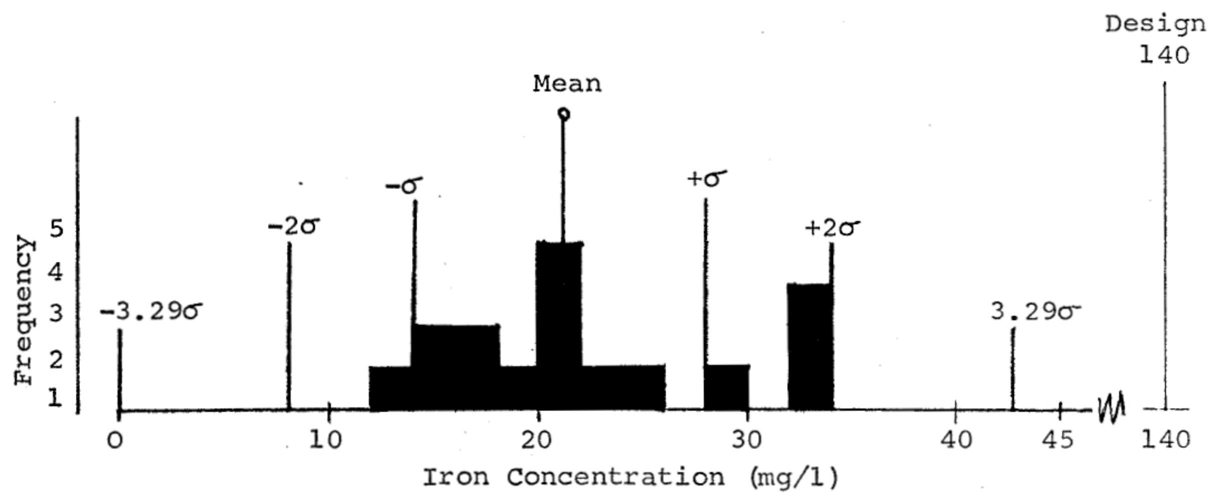


TABLE 2

HAWK RUN WATER ANALYSES SUMMARY

Material	Hole #1	Hole #3	Moshannon River at Hawk Run	Design
Calcium - Ca^{++}	280 mg/1 as $CaCO_3$	306 mg/1 as $CaCO_3$	112 mg/1 as $CaCO_3$	300 mg/1 as $CaCO_3$
Magnesium - Mg^{++}	288 "	359 "	105 "	250 "
Total Iron - Fe^{+2}	119 "	137 "	21 "	250 "
Manganese - Mn^{++}	18 "	28 "	12 "	30 "
Aluminum - Al^{+++}	76 "	244 "	58 "	100 "
Total Cations	1244 "	1777 "	456 "	1010 "
Chlorides - Cl^-	10 "	14 "	14 "	10 "
Sulfates - $SO_4^=$	745 "	1018 "	308 "	1000 "
Total Anions	761 "	1031 "	321 "	1010 "
Specific Cond.	1204 "	1600 "	676 "	-
Dissolved Solids	1402 "	1815 "	525 "	-
pH	3.6 as pH values	3.1 as pH values	3.4 as pH values	-
Acidity	350 mg/1 as $CaCO_2$	538 mg/1 as $CaCO_3$	112 mg/1 as $CaCO_2$	-
Turbidity	29 JTU	54 JTU	20 JTU	-