SECTION III

THE EFFECTS OF ACID MINE DRAINAGE ON WATER USE

PARAMETERS OF ACID MINE DRAINAGE POLLUTION

As is true for the threshold values of all forms of pollution, the threshold values of acid mine drainage pollution are those concentrations of contaminants which are capable of causing harmful effects on previously unaffected water uses.

The generally recognized levels of contamination which define the presence of acid mine drainage are given in Table III-l compiled by the Department of the Interior and published as part of Appendix C to the ARC ' s study of Mine Drainage in Appalachia.[6]

Those parameters indicated as affecting stream life are pH, Acidity-Alkalinity, Total Iron, Manganese, Aluminum and Suspended Solids. Dissolved Solids other than metals in toxic concentrations are not shown as adversely affecting stream life.

Acidity by itself is not sufficient to cause the adverse effects associated with acid mine drainage, if sufficient buffering capacity exists to maintain at the same time 20 mg /L of alkalinity. The primary cause of the severity of acid mine drainage pollution is believed to be the hydrogen ion concentration, which is normally expressed as a pH value. The effects of increased levels of hydrogen ion concentration expressed as pH,

caused by mine drainage were summarized by Dr. Max Katz of the University of Washington and appear in Appendix F and the main summary volume of the ARC mine drainage report. Excerpts from this summary are as shown on Table III-2.

RECREATIONAL EFFECTS

Sport Fishing

As indicated in Table III-2, when pH drops below 5.5 a warm water fish population can no longer be maintained, even if restocking is practiced. Cold water fish populations are similarly affected at a pH of 5.0. Dr. Katz, in his study of the effects of pH on fish populations concluded:

> "There is no definite pH range within which a fishery is unharmed and outside which it is damaged, but rather there is a gradual deterioration as the pH values are further removed from the normal range. The pH range which is not directly lethal to fish is 5-9, however the toxicity of several common pollutants is markedly affected by pH changes within this range and increasing acidity or alkalinity (away from neutrality) may make these poisons more toxic... Below a pH value of 5.0, fish mortalities may be expected, although some species may become acclimated to values as low as 3.7. However, the productivity of the aquatic ecosystem is considerably reduced below a pH value of 5.0. "[7]

TABLE III-1
PHYSICAL AND CHEMICAL CRITERIA SIGNIFICANT IN[6]
EVALUATING MINE DRAINAGE POLLUTION OF
STREAMS IN APPALACHIA

Parameter	Range of Values of Concern	Major Water Use(s) Affected	Source(s) of Criteria	Usual Values In Unpolluted Waters In Appalachia
pH	less than 6.0	uses involving aquatic life	1, 2, 3, 4	6.0-9.0
Acidity	suff. to lower alkalinity below 20 mg/L	uses involving aquatic life	1	less than alkalinity
Alkalinity	<20 mg/L	uses involving aquatic life	1	20 mg/L
Sulfates	>250 mg/L	domestic and indus. water supply	1, 2, 3, 4	20 mg/L
Hardness	>250 mg/L	domestic and indus. water supply	1, 2, 3, 4	150 mg/L
Total Iron	>1.0 mg/L	uses involving aquatic life domes. & indus. water supply	5	0.3 mg/L
Manganese	>1.0 mg/L	uses involving aquatic life, domes. & indus. water supply	2, 4	0.05 mg/L
Aluminum	>0.5 mg/L	uses involving aquatic life	1, 4	absent
Suspended solids	>250 mg/L	uses involving aquatic life	1	100 mg/L (except during high runoff periods)
Dissolved solids	>500 mg/L	domestic and indus. water supply	1, 2, 3, 4	250 mg/L

1. U. S. Dept. of the Interior, 1967
2. Pa. Sanitary Water Board, 1967
3. U.S. Dept. of Health, Ed. & Welfare, Public Health Service, 1962
4. McKee and Wolf, 1963
5. Ellis, 1937

The exact mechanism of acid damage to fish life is only conjecture. Several researchers have investigated this phenomenon and have suggested possible explanations. It is suspected that the toxicity of hydrogen-ions to goldfish is due to the precipitation of mucus on the gill epithelium resulting in death by suffocation or by precipitation of protein within the epithelial cells. Investigators subjected goldfish to solutions of HCl and H_2SO_4 in distilled water and found that exposure to a pH of 4.0 for one hour led to a complete destruction of the gill epithelium. However, other observers have held fish for longer periods of time in water of a low pH and failed to observe any abnormal mucus production or tissue damage. Rainbow trout which had been immobilized after 24 hours in a solution of pH 3.8 recovered on transfer to water of pH 8.2.

A second constituent of acid mine drainage, dissolved iron, is also suspected of causing fish kills. One observer found that one year old carp died in a water of pH 4.3 to 4.4 containing between 1.2 and 1 0.5 ppm Fe. Investigators observed fish kills in a trout hatchery when the pH value was 6.2 to 7.0 and the water contained 1.5 to 20 ppm Fe. Further, in the presence of iron, pH values of 5.5 are dangerous for carp. Fe precipitates in large flakes upon the gills which are alkaline.[8]

Water Contact Recreation

The Appalachian Regional Commission also investigated the effects of acid mine drainage on water contact recreation activities such as swim-

ming, water skiing and boating. A study was undertaken by Robert R. Nathan Associates of Washington D. G and published as Appendix E to the mine drainage report. The basic findings of the investigation were that, "a single tolerance scale cannot be applied to the three principle water based activities (swimming, boating and fishing)because of the varying degree of body contact with the water the varying tolerance levels as between humans and aquatic life. Second, acid pollution is but one of a number of factors which limit or completely deter the use of water for recreation, indicating that a multi-aspect type of tolerance scale may' he called for. Third, human tolerance for acid polluted water, all other factors being equal, is probably higher than commonly believed."[9] It is clear, however, that in state parks, a severe case of mine acid drainage will interfere with swimming and fishing which may very well be the parks ' main activities.

ARC further states that in water impoundments where power boating and water-skiing are the main activities, pH readings can fall as low as 4.5 or even 4.0 without discouraging users unduly, provided the color of the water is not objectionable and the water level does not fall excessively. Furthermore, the literature and our experience confirms that swimming drops off to negligible numbers when the pH falls below 4. Where acidity is very high, ranging from pH 2.5 to 3.0, use for recreational purposes will be zero. [9]

TABLE III-2

BIOLOGICAL EFFECTS ON TYPICAL STREAMS WITH SELECTED RANGES OF ACID POLLUTION

pH Range	FISH LIFE		PLANTS
	Warm Water Species	Cold Water Species	
6.5-7.0	Full fish production[1]	Full fish production[1]	Normal[1] flora
6.0-6.5	Maintenance and growth	Full fish production[1]	
5.5-6.0	Maintenance but no carry-over[3]	Maintenance and growth[2]	Most aquatic plants will grow at this range if substrate, water velocity and fluctuations satisfactory
5.0-5.5	No viable fishery[4]	Maintenance but no carry-over[3]	
4.5-5.0	No viable fishery	No viable fishery[4]	Cattails common Eleocharis may be abundant
4.0-4.5	No viable fishery	No viable fishery	Little change
3.5-4.0	No viable fishery	No viable fishery	Cattails only common plant
below 4.0	No viable fishery	No viable fishery	Generally not found at this low pH; cattails occur occasionally

[1] "Viable Fishery" - capability of a stream to reproduce species.

[2] "Maintenance and growth" - prevention of reproduction but allow existing fish population which occurs by stocking or migration, to survive and grow for entire year.

[3] "Maintenance but no carry-over" - pollution level which allows fish maintenance by stocking, but no growth.

[4] "No Viable Fishery" - pollution level which pre-empts vertebrate life but allows specialized invertebrate and plant survival.

From the findings of the two cited investigations concerning the effects of pH upon fish life and the recreation use of acid mine drainage affected lakes as related to pH, we have postulated the following relationship of pH to recreation use:

pH Maintained Above	Recreation Uses
6.0	Fishing, * Swimming, Water Skiing Boating
5.5	Fishing, Swimming, Water Skiing Boating (Fish require restocking)
4. 5	Swimming, Water Skiing, Boating
4.0	Water Skiing, Boating
3.0 Boating	
Below 3.0	None

*It is assumed that fishing may be considered as a viable activity only when a substantial fish population may be maintained between stockings.

The validity of these inferred "pH standards" is suggested by Buchart Horn's 18 month sampling study of the creek and reservoir. The observed pH of Loyalhanna Reservoir fluctuated between 3.5 and 6.5. During the 1969 and 1970 recreation seasons (June through September) the measured pH was 4.0 or below on at least two monthly sampling dates each season. At the same time the use of the reservoir has been limited to boating only, because of the effects of mine drainage on the water quality. (See Plate I-2 following page 1-2.)

PROPOSED WATER QUALITY IMPROVEMENT

It is proposed that to assure the usability of Loyalhanna Reservoir as a recreation facility, the pH be maintained at 6.0 during the recreation season. This pH is proposed as sufficiently high to allow the maintenance of fish life at a viable level if no other non AMD pollution is present. Realizing the difficulty of maintaining pH at this level at all times, it is proposed that pH not be allowed to fall below 4.5 at any time. Below pH 4.5 the water contact recreational use of the reservoir is no longer attractive to all visitor s, and the viability of fish life is endangered.

It is suggested that this same standard be applied to all tributaries and reaches of Loyalhanna Creek where recreational use is contemplated.