VII. UNAVOIDABLE ADVERSE IMPACTS

A. Acidic Events

In limed lakes, acid inflow with elevated aluminum concentration still constitutes a major threat to aquatic organisms (Hultberg and Andersson 1982). These episodes have been observed in lakes of varying water quality in regions sensitive to acidic deposition (Schofield et al. 1985, Gunn and Keller 1985, Kelso et al. 1986). It is generally unknown whether a limed lake experiences greater impacts from acidic events than circumneutral lakes. Individual lakes may respond differently depending on a number of hydrologic and chemical factors. The following discussion deals with impacts from acid episodes which may occur regardless of liming and would be expected to occur in many lakes with acidic tributaries.

Episodic acid events with elevated aluminum concentrations may occur during spring snowmelt or following large precipitation events, but their intensities and duration are regulated by prevailing weather conditions and intrinsic hydrological factors. The main reason for the occurrence of acid episodes in lakes is the incomplete mixing of acid inflow and lake water. Layering is dependent on the density difference between lake water and inflow water. Other physical factors like wind/wave action, stream water turbulence, convective processes, and ice-cover act as modifiers either enhancing or impeding the mixing process. Horizontal mixing currents due to wind action are by far the most effective as they generally are strong enough to establish a homogenous epilimnion. With ice-cover this dominating mixing force disappears. Therefore the distinct density dependent horizontal stratification of an inflow water plume is only counteracted by comparatively slow vertical mixing rates, unless inflow water velocity by shear stress creates turbulence at the boundary to lake water proper (Rahm 1985). Density differences, at least in small lakes, are mainly due to temperature differences. At temperatures around 4 C the water has its maximum density and both colder and warmer waters, therefore, have a lower density.

In general, two types of acid events have been observed in surface water. The first type occurs following heavy rainfall. During periods with prolonged intensive precipitation, runoff successively increases. Acidity increases almost simultaneously due to limited neutralization within surficial soil layers. The acidity may be particularly pronounced if the rain has been preceded by a long drought period (Cristophersen and Wright 1980; Braekke 1981; Hultberg and Johansson 1981). In lakes with a hydraulic retention time of ≤ 1 year smaller bays with large littoral areas may be affected. In lakes with a shorter retention time pH and alkalinity may decrease and aluminum increase, lake-wide.

The second type of event is associated with snowmelt. Accumulated acids, and other pollutants in the snow pack, are predominantly released during the early melting phase (Johannessen et al. 1980). Related to the time and sequence of melting, these acid events may be characterized as follows: (1) intermittent winter-melting with low discharge but very acidic water, or (2) a pronounced final spring-melt with an initial pulse of acidic water during increasing discharge.

Intermittent melting periods generally will result in a very thin, very acidic surficial water layer which, due to slow mixing, may influence large shallow littoral areas but very limited volumes of lake water. However, episodes that affected lake surface water to depths > 3 meters have been reported (Hultberg 1977).

The main spring snowmelt results in discharges that will be more directly correlated to the total snow accumulation. In years with large snow amounts a high discharge usually follows. However, climatological situations during the snowmelt period influence the melting significantly. Therefore, in dry weather the melting will be prolonged and the resulting acidic inflow to the lake could be of minor importance specifically concerning the water volume and bottom area affected. Heavy rains during the melting period could create a severe acid event that may substantially affect the biota in lakes and streams, even if liming countermeasures have been undertaken (Hasselrot et al. 1987).

Many organisms in both lakes and streams are sensitive to acidic water or more specifically the elevated concentrations of monomeric aluminum that generally occur coincidentally (Hagen and Langeland 1973; Leivestad et al. 1976; Cronan and Schofield 1979; Baker and Schofield 1982). In limed lakes, at least two reactions of the sensitive organisms may be beneficial for survival. The first is migration to other parts of the lake where water chemistry is more suitable. The second mechanism is to move inside the bottom sediment, where more favorable pH conditions usually exist only 0.5 cm below the sediment/water interface (Andersson 1985). However, the bottom sediments may be only a temporary refuge, as the prevailing low O_2 conditions are disastrous for many aquatic organisms (Hultberg 1985).

During the winter months crayfish <u>Astacus</u> <u>fluviatilis</u> are buried in the bottom substrate in shallow littoral areas, and may, therefore, be exposed to both stratified acidic inflow water by streams and seepage inflow. Normally, they do not move during this period and may, therefore, be affected by acidic water (Appelberg 1984). Hasselrot et al. (1987) reported that in neutralized Lake Bredvatten, Sweden, the <u>Lymnaea peregra</u> population suffered a substantial population decline in the littoral sediments as a result of an acidic event in 1977.

The liming of Bowland Lake in Ontario was found to improve the water quality for stocked lake trout survival, but did not prevent spring melt pulses of acid and aluminum in a zone nearshore under the ice (Booth et al. 1986). Lake trout spawn in nearshore shallow shoal areas, and fry would be expected to emerge from the gravel during early spring. Specific liming of these shoal areas with fine calcite gravel may be required to protect these areas from acidic episodes. Stocked trout have also been observed to emigrate down the outlet stream to avoid episodic acidification. In the Lake Acidification

Mitigation Project (Section II.C.6.b) substantial numbers of stocked trout emigrated as a result of acidic events (C. Schofield, personal *communication*).

To date, only limited knowledge of aquatic biota effects due to acidic events exists. There is a need for more thorough documentation, which by dynamic and mechanism studies will increase further the understanding of interactions between organisms and populations exposed to temporal and spatial acid stress. Moreover, the studies in limed lakes have shown that the routinely performed lake liming is no guarantee against damages to biota caused by acid episodes.

B. Increased Activity in Some Forest Preserve Areas

A number of impacts might be expected to arise from increased public use of limed waters. The severity of these would be expected to be related to the amount of public use. A certain threshold is most likely associated with when public use adversely impacts the resource. The amount of public use is also directly related to the distance of a limed waterbody from a public road. In other words, use and the potential for adverse impacts will tend to decrease as the *distance from public roads increase.*

Impacts which may result from increased activity are:

- Increased littering
- Increased use of and consequent degradation of facilities such as trails and lean-tos
- Increased soil compaction, destruction of vegetation and erosion from portions of the shoreline of limed waters
- A diminution of the sense of wilderness for some users of forest preserve areas

VIII. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

A. Commitment to Management Once Liming Initiated

The DEC realizes the importance of maintaining satisfactory water quality once a pond or lake has been limed and a viable fish population established or protected. There is therefore a commitment to management made by the DEC when a water becomes part of the liming program. This commitment requires monitoring of the water quality, *fishery assessments, stocking, and reliming when necessary.* There are therefore certain annual costs and personnel commitments which will be a necessary part of the DEC liming program. These annual commitments will be necessary until emissions of sulfur and nitrous oxides are reduced and result in a reduction of acid deposition impacts.

The reasons why a limed body of water must not be allowed to reacidify have been discussed in previous sections. In general however, as the system reacidified the acid sensitive species which became established following liming would now die. Certain metals in the ecosystem which became bound in the sediments during the period of circumneutral water chemistry, would become soluble in a reacidified system. *This could result in an environment more toxic to aquatic* life than was present before liming occurred. In order to maintain a neutralized environment suitable for brook trout, reliming will occur after the summer surface water chemistry reaches a pH of 6.0 or an ANC of 25 μeq/l. This arbitrary threshold includes a margin of safety which will insure fish survival until the following season when the actual liming will occur.

B. Availability and Use of Agricultural Limestone

The agricultural limestone used in the DEC liming program will be a consumptive use of a non-renewable resource. However, agricultural limestone is not in limited supply and in fact is available from a number of sources within the state. In addition the quantity of material used by DEC would be very small compared to the quantity used in agriculture. A total of 14 million metric tons of lime were used by U.S. farmers in 1982 (NAPAP 1987), and the DEC use has averaged less than 60 tons of aglime per year over the past five years.

IX. *GROWTH INDUCING ASPECTS OF THE PROGRAM*

A. Increase in Fishing and Other Recreational Activities

The development of a fishery on an acid impacted pond or lake leads to increased angler use. As noted under Economic Benefits (V.B.3.), angler use of limed ponds is assumed to be similar to that of non-acid impacted waters of the same size class and fish species composition. In other words, the growth in angler use realized after liming represents the regaining of lost opportunity. The levels of angler use of the various water classes within the Adirondack Zone has been reported by Pfeiffer (1979). Impacts from public use on both Wilderness and Wild Forest land classes has been described in many DEC Unit Management Plans completed to date. In most plans uses by anglers, including any increases after liming projects, has not been considered greater than any area's capacity to withstand use.

Post-liming increases in non-angling activities have also been noted. Generally, these are limited to boating and camping activities associated with increased angler use, and similarly are not considered beyond any areas capacity to withstand use.

B. *Increase in Tourism and Related Areas of the Economy*

Increased public use of ponds post liming has undoubtedly induced some growth in local and regional tourism and economy. (Using 1988 estimates of angler expenditures and use of coldwater ponds, presented earlier in Economic Benefits (V.B.3.), anglers fishing in limed ponds are expected to contribute $306,432 to local economies.) This may be of some importance on local levels, but when compared to the estimated $1 to $2 million loss in angler expenditures due to acidification in the Adirondacks (Menz 1981), the region-wide benefits seem less significant. This conclusion does not contradict the favorable pond liming cost-benefit analysis reported under Economic Benefits (V.B.3.), but instead illustrates the limited size of the current liming program when compared to the great number of waters lost or impaired due to acidification in NYS.

In recent years, DEC's Region 6 has utilized up to 20 tons of agricultural lime per year on liming projects. Lime is usually bought locally. At an average price of $35 per ton, this purchase brings approximately $700 per year into local business economies, thus impacting their growth and stability. Statewide, the growth inducing aspect of the pond liming program are insignificant.

X. EFFECTS ON USE AND CONSERVATION OF ENERGY RESOURCES

The use of energy results directly from conducting pond liming operations, and indirectly as a result of increased public use of the limed ponds. Involved is the transportation of workers to and from the site, and the energy consumed by the public traveling to and from the particular ponds.

Liming projects utilize energy involving various size vehicles and equipment, including snowmobiles, small outboard motor equipped boats, small and large trucks, and for remote projects, a helicopter or fixed wing aircraft. Overall impacts of pond liming on the use and conservation of energy are insignificant.

XI. ALTERNATIVES TO THE PROPOSED PROGRAM

A. Control Emissions

The control of acid deposition causing emissions may be considered by some to be an alternative to the proposed liming program. However, the DEC is currently pushing for effective emissions controls and will continue to do so regardless of the status of the liming program. As has been mentioned in other sections of this EIS, the only viable solution to the acid deposition problem is emissions controls, and liming is not viewed by the DEC as a viable alternative to reduced emissions. The DEC was instrumental in the passage of the State Acid Deposition Control Act of 1984 and has prepared environmental impact statements for the control of sulfur dioxide and nitrous oxides. Emissions controls are viewed as a high priority and will not be affected by the implementation of the proposed revised liming policy.

When federal legislation is finally passed to control acidic deposition by reducing emissions on a national level, the probable result is that emitters will have a number of years to actually implement the controls. As was the case with the New York State emissions reduction plan, the emitters may also be granted several phases to gradually reduce emissions. There will therefore be a lag period of possibly 5-10 years before reductions in emissions are actually required.