USER'S GUIDE

Screening Methodology for Calculating ANC Change to High Elevation Lakes

USDA Forest Service • Rocky Mountain Region

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Introduction

The purpose of this screening methodology is provide a simplistic step-by-step process that can be used in New Source Review and NEPA(National Environmental Policy Act) processes to predict air pollution caused changes to the chemistry of sensitive lakes. Like other air quality related value screening methodologies this relatively conservative approach can be used to determine if a proposed source or group of sources either <u>do not</u> have the potential to impact to impact wilderness lakes or if it is appropriate to conduct a more complex but less conservative analysis.

This screening methodology uses a very simplistic set of equations to estimate how additions of sulfate and/or nitrate deposition from air pollution sources may cause a change in lake acid neutralizing capacity (ANC) from a monitored baseline. The methodology uses the following assumptions:

* The generation of acid neutralizing capacity in the watershed catchment to be analyzed is constant over time.

* All atmospheric deposition of sulfates and nitrates into the catchment enters the lake and neutralizes an equivalent amount of acid neutralizing capacity.

* The monitored baseline acid neutralizing capacity of the lake represents baseline acid neutralizing capacity of all of the water in the catchment.

These assumptions are meant to be conservative and, as such, do not incorporate aquatic ecosystem biogeochemistry. However, the methodology is appropriate to produce a relatively low cost screening level estimate of potential change in acid neutralizing capacity caused by a single pollution source or group of sources.

This approach is based on previous research papers by Fox, 1983 and Clayton, 1998, with changes suggested by Jim Clayton (personal communication) and John Turk (personal communication). In complex situations or where the screening results exceed Forest Service Limits of Acceptable Change (thresholds of concern) , a more sophisticated model such as the Model of Acidification of Groundwater in Catchments (MAGIC) should be run (Sullivan, 1995).

In order to assist in the use of this screening methodology the Forest Service will provide new source applicants or those persons conducting NEPA analysis with the following:

(1) A list of lakes for which potential change in acid neutralizing capacity should be calculated in the wilderness areas of concern, along with map coordinates for those lakes. In most cases, only one or two lakes per wilderness will be identified for analysis.

(2) Baseline lake acid neutralizing capacity as determined by monitored chemistry at the lakes of concern. Baseline acid neutralizing capacity values will usually be for the most sensitive (10% lowest) acid neutralizing capacity values from the lake so that predicted lake chemistry changes will consider sensitive (low acid neutralizing capacity) conditions that may occur on an episodic or seasonal basis.

(3) Estimates of watershed catchment size.

(4) Estimates of the average annual precipitation amounts for the catchment area.

For each analysis, the screening methodology will usually be applied twice:

* first to predict any change in acid neutralizing capacity from the proposed new source or proposed action by itself and,

* second to predict any change in acid neutralizing capacity from the cumulative total of all emissions sources that are included in the cumulative impact analysis (where applicable).

Process

Step 1: Computation of Deposition Flux from Annual N and S Emissions
The purpose of the following conversions is to produce outputs in both kg/ha/yr for reporting deposition (to evaluate aquatic and terrestrial effects) and in eq/m^2/yr to evaluate lake ANC change. Various models produce outputs in different formats. The following instructions will provide model outputs in the correct format to proceed with Step 2.

A.) **CALPUFF model output**: includes S from SO_2 and SO_4; and N from NO_2, HNO_3, and NO_3. Use the recommendations in IWAQM-Phase 2 (p 30-31) for calculation of N and S deposition in kg/ha/yr from the CALPUFF or CALPUFF-Screen modeling outputs. Ds will be the sum of all sulfur species and Dn will be the sum of all nitrogen species

OR

B) **ISCST or other approved model outputs**: some models may report all S outputs as SO_2 and all N outputs as NO_2. In this case, use the calculation below to estimate total (wet plus dry) deposition of S from SO_2 and N from NO_2.

$$Ds \text{ or } Dn = (X)(Vd)(R)(DEP)(Fc)$$

where: Ds = sulfur deposition flux (kg/ha/yr)
Dn = nitrogen deposition flux (kg/ha/yr)
X = pollutant concentration (ug/m^3)
Vd = deposition velocity of 0.005 m/sec for SO_2 or 0.05 m/sec for HNO_3 (ref. IWAQM Phase1)

R = Ratio of molecular weights of elements to convert from SO_2 to S and NO_2 to N (14/46 = .3 for NO_2; 32/64 = .5 for SO_2)
Molecular weight of H=1, N=14, O=16, S=32.
DEP = total deposition to dry deposition ratio (assume this equals 2.0 unless there is other info)
Fc = units conversion of ug/m^3 x m/sec to kg/ha/yr (315.4)

Step 2: Computation of Alkalinity Change from Annual Deposition Flux
This calculation provides an estimate of total equivalents of acid deposition over a year that either fall directly into the lake, or are deposited in the catchment that flows into the lake. This screening model assumes that all the equivalents of acidity eventually reach the lake, where they titrate the alkalinity.

Equation: % ANC change = [Hdep/ANC(o)] x 100
where:

ANC(o) = baseline ANC for entire lake catchment in eq = W x P x (1-Et) x A x (10,000m^2/ha) x (eq/10^6 ueq) x (10^3 liters/m^3)
A = baseline lake sample alkalinity in ueq/l
Hdep = acid deposition in eq = [H(s) + H(n)] x W x 10,000m^2/ha
Hs = sulfur deposition in eq/m^2/yr = Ds (kg/ha/yr) x (ha/10,000m^2) x (1000g/kg) x (eq/16g S)
Hn = nitrogen deposition in eq/m^2/yr = Dn (kg/ha/yr) x ha/10,000m^2) x (1000g/kg) x (eq/14g N)
W = watershed area in ha
P = average annual precipitation in meters
Et = fraction of the annual precipitation lost to evaporation and transpiration (assume Et = .33 unless better info available)
Ds = sulfur deposition in kg/ha/yr from all sulfur species
Dn = nitrogen deposition in kg/ha/yr from all nitrogen species

<u>Example</u>

Wilderness Name: Sangre de Cristo Wilderness
Lake Name : Lower Stout Lake
Lake Location: UTM coordinates 4,245,150 N and 422,300 E

Input Data:

A (baseline ANC)	= 165 ueq/l
Ds (sulfur deposition)	= 0.023 kg/ha/yr
Dn (nitrogen deposition)	= 0.112 kg/ha/yr
W (watershed area)	= 16 hectares
P (precipitation)	= 1.1 meters

Intermediate Values:

ANC(o)	= 19,457 eq

Hs = 0.000144 eq/m^2
Hn = 0.0008 eq/m^2
H(dep) = 151.04 eq

% ANC change = [151.04/19,457)] x 100
= 0.78% change in Lower Stout Lake ANC projected from source specific sulfur and nitrogen deposition

References

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