Environment Canada Environnement Canada

7 March 1996

Tom Hoefer
General Manager
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Dear Mr. Hoefer:

This letter is to confirm that the Departments of Environment and Fisheries and Oceans have agreed on the following:

Interim Guidelines for On Ice Drilling in the NWT

1) All drill cuttings shall be removed from the ice surface.

2 The release of total suspended solids to the receiving environment should be in compliance with the Guidelines for Total Suspended Solids contained in the Canadian Council of Ministers of the Environment (CCME) Canadian Water Quality Guidelines, Chapter 3 - Freshwater Aquatic Life (copy attached).

3) In addition, for drilling in kimberlite deposits, toxicity testing will be done on the effluents from the drilling operation.

Thank you for undertaking to advise your membership of this new development. A copy of the complete CCME Water Quality Guidelines is available for consultation in our office.

Yours truly

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exposures are defined more rigidly. Many of the concepts included in the current guidelines were recommended earlier by the U.S. EPA (1973).

The tentative temperature guidelines recommended by EIFAC (Alabaster and Lloyd 1982) to protect European inland fisheries are divided into three seasons. During autumn and winter, an increase of 2°C above normal would be damaging to the reproduction of whitefish (*Coregonus* sp.) and burbot (*Lota lota*). A rise of 5-6°C increases the mortality of other salmonid embryos and fry; it may also stimulate early spring spawning in pike (*Esox lucius*), percids and cyprinids. During the spring, the optimum range of temperatures for spawning and embryonic development is no greater than 8°C. During the summer, the growth rate of bream (*Abramis brama*), white bream (*Blicca bjoerkna*) and rudd (*Scardinius erythrophthalmus*) (cyprinids) is reduced above 28°C. The upper permissible temperature for salmon and trout waters should be 20-21°C, although natural waters may rise above this temperature. Coregonids (except embryos) can withstand a rise of temperature of 5-6°C, but the sustained maximum should not exceed 22-23°C. It is reasonable to expect that an increase in temperature of 5°C to a maximum no greater than 23°C would destroy salmonid populations except for some species of *Coregonus*, and an increase of 8°C to a maximum no greater than 30°C would favour a preponderance of some cyprinids.

3.2.3.1.3 Rationale

The effects of temperature on aquatic organisms have been the subject of a number of comprehensive literature reviews (Brett 1956; Fry 1967; Kennedy and Mihursky 1967; Raney and Menzel 1967; Federal Water Pollution Control Administration 1968; Kinne 1970; Houston 1982) and annual reviews of the U.S. Water Pollution Control Federation.

Temperature changes in water bodies can alter the existing aquatic community. For example, algal predominance changes from diatoms to green algae and then to blue-green algae as water temperature increases (Cairns 1956), and fisheries change from cold- to warm-water fisheries as temperature becomes lethal, reduces activity, changes behaviour or limits reproduction (Brett 1960). Chronic exposure to slightly elevated temperature in organically enriched waters will generally cause an increase in productivity (Dickson 1975). Decreases in species diversity have also been observed. The upper tolerance limit for a balanced benthic population structure is usually higher than limits for fish, but benthic fauna are not able to move out of zones which reach intolerable levels (Federal Water Pollution Control Administration 1968; Dickson 1975).

Considerable data are available for temperature limits for fish, particularly upper limits (U.S. EPA 1973, 1976). The tolerance of organisms to extremes of temperature is a function of their genetic ability to adapt to thermal changes, the acclimation temperature prior to exposure and the time of exposure (Coutant 1972). Available data indicate that organisms subject to stress from toxic substances are less tolerant to temperature extremes (De Sylva 1969).

The effects of sublethal temperatures on metabolism, respiration, behaviour, distribution, migration, feeding rate, growth and reproduction have been summarized by De Sylva (1969). There are also more restrictive ranges for normal activity and normal reproduction in fish (Brett 1960). Different temperature conditions are required at different times of the year to meet the needs of different life stages of the fish. For example, the eggs and larvae of salmonids and coregonids are extremely sensitive to elevated temperatures. Natural temperature changes are necessary to induce the reproductive cycles of aquatic organisms and to regulate other factors (Mount 1969). A change in the natural temperature regime produces changes in the composition of aquatic communities and behaviour of aquatic species (Alabaster and Lloyd 1982).

The NRCC (Dickson 1975) assessment of waste heat in the Canadian aquatic environment concluded that a one-number guideline for the protection of aquatic life would not be feasible. The guideline currently recommended follows those adopted by the IJC, the U.S. EPA and Manitoba.

3.2.3.2 Total Suspended Solids

3.2.3.2.1 Guideline

Suspended solids should not exceed 10 $mg \cdot L^{-1}$ when background suspended solids concentrations are equal to or less than 100 $mg \cdot L^{-1}$. Suspended solids should not exceed 10% of background concentrations when background concentrations are greater than 100 $mg \cdot L^{-1}$.

3.2.3.2.2 Summary of Documents

The Ontario Ministry of the Environment (1984) recommended that suspended matter should not be added to surface water in concentrations that will change the natural Secchi disc reading by more than 10%. The British Columbia Ministry of Environment (Singleton 1985) recommendations for suspended solids state that induced nonfilterable residue should not exceed 10 $mg \cdot L^{-1}$ when background nonfilterable residue is equal to or less than 100 $mg \cdot L^{-1}$, nor should induced nonfilterable residue be more than 10% of background when background is greater than 100 $mg \cdot L^{-1}$.

Manitoba recommended that water should be free from materials that produce turbidity in such a degree as to be objectionable or to impair any beneficial use (Williamson 1983). Manitoba also has a maximum acceptable concentration for nonfilterable residue of 25 $mg \cdot L^{-1}$. The Great Lakes (IJC 1978b) water quality objectives combine both a general statement and the Ontario approach.

EIFAC (Alabaster and Lloyd 1982) recommended tentative water quality guidelines for finely divided solid matter to maintain freshwater fisheries (Table 3-19). In addition, EIFAC recommended that temporary high concentrations should be prevented in rivers where good fisheries are to be maintained, even though several thousand milligrams of solids per litre may not kill fish during exposures of several hours or days. The U.S. EPA (1973) relied on the EIFAC (1965) recommendations in establishing maximum concentrations of suspended solids.

Suspended solids usually restrict light penetration in the water column. This optical property of suspended solids has been used to establish guidelines. The U.S. EPA (1973) recommended that the combined effect of colour and turbidity

Embeddedness, or the degree to which the dominant particles are surrounded by fine inorganic sediments, and the presence of coarse woody debris were found to have the strongest correlations with macroinvertebrate assemblage richness and composition (Richards and Host 1994). Other subtle effects of suspended sediment (silt) deposition on streambeds include the elimination of the predation of stoneflies on benthic invertebrates, demonstrating that turbidity can override the effects of predation by predators in stream communities (Peckarsky 1985).

The macroinvertebrate community structure in streams is correlated with the average size of particles in the stream's substrate (Erman and Erman 1984). When median particle size was held constant, heterogeneity of substrate composition was not an important component structuring macroinvertebrate communities. Thus, an increase in the deposition of fines could create an imbalance of the median particle size and affect species abundance and richness.

Studies reporting the effects of suspended sediments on aquatic invertebrates are more abundant than those for aquatic plants. The information gathered suggests that invertebrates are as sensitive to high levels of suspended sediments as salmonid fishes (Newcombe and MacDonald 1991). The LC_{50}s range from 0.72 to 5.11 $mg \cdot L^{-1}$ (Newcombe and Jensen 1996).

The effects of suspended sediments on algae are associated with reduced primary productivity (Singleton 1985). Increased or excessive suspended sediments can reduce productivity by (1) inhibiting photosynthesis, due to decreased light penetration; (2) physically smothering benthic communities; (3) removing periphyton by scouring; and (4) affecting community composition (Singleton 1985). Notwithstanding these general patterns, temporary resuspension (e.g., dredging and logging) of sediments and nutrients in the water column can temporarily augment algal productivity (Bilby and Bisson 1992).

Natural or anthropogenic events leading to disturbances in aquatic systems and elevated suspended sediments affect whole ecosystems (Lloyd et al. 1987). Effects on algae are the first consequence of perturbation. For example, logging practices may produce shifts in the sources of food supply originating within the stream (autochthonous) and from the riparian landscape (allochthonous) energy inputs. These shifts have the effect of changing the amount and quality of available food resources in streams (Culp 1996). With increased suspended sediments and nutrients and less shading of streams resulting in higher temperatures and more light available for photosynthesis, algal biomass may flourish, temporarily giving rise to increased invertebrate (Behmer and Hawkins 1996) and fish abundance (Bilby and Bisson 1992). This may not be the case, however, as other factors essential to primary productivity (e.g., phosphorus) may be limiting (Shortreed and Stockner 1996). In a study where logging practices brought about changes in stream bottom particle size, it was found that green algae and flowering plants were more abundant in clear-cut streams than in reference streams where diatoms dominated. In logged areas, streams had relatively higher amounts of sand and gravel than reference streams, which had more of a pebble, cobble, and boulder bottom composition (Noel et al. 1986).

It has been shown in laboratory experiments that mineral particles (e.g., silica, kaolin, and bentonite) affect many physical and biotic processes such as algal–clay flocculation and sedimentation (Threlkeld and Soballe 1988). These in turn would have an effect on trophic interactions. 1999

Guidelines for Suspended Sediments

For suspended sediments and turbidity, in most lotic systems, background levels are to be monitored in clear flow periods. Clear flow must not be confused with low flow periods, which give a much smaller window of opportunity for sampling background levels. Clear flow periods are determined on a site-specific basis. Even though most sediment load in streams is transported during spring freshets and storm events, these high flow periods have been excluded from the determination of background levels due to the extreme variability found in relationships between suspended sediment concentrations and discharge flows (MacDonald et al. 1991). The clear and turbid flow periods for individual stream systems should be defined using data on the background concentrations of suspended sediment at the site-specific level.

During clear flow periods, anthropogenic activities should not increase suspended sediment concentrations (or nonfilterable residue levels) by more than 25 $mg \cdot L^{-1}$ over background levels during any short-term exposure period (e.g., 24-h). For longer term exposure (e.g., 30 d or more), average suspended sediment concentrations should not be increased by more than 5 $mg \cdot L^{-1}$ over background levels.

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To be expected in a base camp setting clear flow ie. lake/pond

During high flow periods, anthropogenic activities should not increase suspended sediment concentrations by more than 25 mg·L^{-1} at any time when background levels are between 25 and 250 mg·L^{-1}. When background levels exceed 250 mg·L^{-1}, suspended sediment concentrations should not be increased by more than 10% of the measured background level at any one time (Singleton 1985; CCREM 1987).

This two-pronged approach to guideline setting for suspended sediments recognizes that exposure duration plays a key role in the toxicity response. The guideline is based on the severity-of-ill-effects (SEV) concentration-duration-response curve approach (Newcombe 1994b; Newcombe and Jensen 1996). The approach is based on the change in suspended sediment concentration causing an increase of one in a SEV score for the most sensitive taxonomic group of aquatic organisms. The steepest slope representing a change in response of one SEV score was for adult salmonids (24–48 h; slope 2.08), which represents a 25 mg·L^{-1} increase in suspended sediments (Caux et al. 1997).

In clear stream systems, small induced exceedances in suspended sediment concentration above a 25 mg·L^{-1} change from background levels for short-term exposure (e.g., 24 h) are likely to cause behavioural and low sublethal effects on fish, all of which are reversible. Conditions in these systems should be rectified to prevent possible further damage of the designated water use. Small amounts of excess suspended sediment are known to cause egg mortality (40%) to rainbow trout at long durations (7 mg·L^{-1} at 48 d; 0.5–75 µm) (Slaney et al. 1977). Based on extrapolation from the SEV analysis, a long-term exposure guideline has been set at an average suspended sediment change in 5 mg·L^{-1} (e.g., for exposures lasting 30 d). According to the SEV scale this concentration-duration exposure translates to a SEV score of five (i.e., minor physiological stress, increased rates of coughing and respiration)

The guidelines have been based on a large database (Newcombe 1994a; Newcombe and Jensen 1996) that reports effects to biota, many of which are found in North America.

Guidelines for Turbidity

Although turbidity is a function of particle size per unit mass of suspended sediment, guidelines can be developed for the general case. Induced turbidity should not exceed a change of 8 NTUs for a short-term exposure (e.g., 24 h) above the background concentration in all waters during clear flows. A long-term guideline (e.g., 30 d) has been set as well, stating that mean turbidity should not exceed a change of 2 NTUs during clear flows.

During high flows and in turbid waters, the short-term guideline is adopted i.e., turbidity should not exceed 8 NTUs at any time when background turbidity is between 8 and 80 NTUs, nor should it increase more than 10% of background when background is >80 NTUs at any time (Singleton 1985; CCREM 1987).

These guidelines are extrapolated from the suspended sediment guidelines of a 25 and 5 mg·L^{-1} change from background for short-term and long-term exposures, respectively, according to the suspended sediment and the general turbidity correlation of 3 to 1. A turbidity of 8.33 NTUs has been rounded to 8 NTUs and 1.67 to 2 NTUs for practical reasons.

The turbidity guideline of an 8 NTU change from background turbidity for a short-term exposure is a recommended check in every routine field sampling program as it can be measured accurately and quickly with field nephelometers. If problem areas are found, joint measurements of turbidity and residue are recommended. The longer-term turbidity guideline of 2 NTUs, as well as the long-term guideline for nonfilterable residues, will protect against low anthropogenic suspended sediment inputs that persist over the long term. The guidelines will protect against harm to all aquatic life in freshwaters, marine, and estuarine waters.

Guidelines for Deposited Bedload Sediment

Insufficient information is currently available to develop numerical water quality guidelines for deposited bedload sediments. The effects of bedload sediment on fish and aquatic life are poorly understood, primarily due to the difficulty associated with the measurement of bedload transport in stream systems.

Streambed Substrate and Deposited Sediments

Incubation of Salmon and Trout Eggs

The results of numerous studies demonstrate that elevated levels of fine sediment in streambed substrates have the potential to compromise the survival of salmonid eggs and alevins. The survival of salmonid eggs and alevins