Environment Canada   Environnement Canada

Pulp and Paper
Aquatic Environmental Effects Monitoring Requirements

ANNEX 1 TO EEM/1997/1

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Publications relating to Environmental Effects Monitoring (EEM):

Aquatic Environmental Effects Monitoring Requirements (revised EPS 1/RM/18). Environment Canada. 1997. EEM/1997/1

Pulp and Paper Aquatic Environmental Effects Monitoring Requirements. Environment Canada. 1997. Annex 1 to EEM/1997/1

Tracer Expert Working Group Report. EEM Technical Management Committee. 1997. EEM/1997/2 is also published as: Ali, N et al, 1997. Exposed or not exposed: the effectiveness of using tracers to verify exposure of fish to pulp and paper mill effluent. Canadian Technical Report of Fisheries and Aquatic Sciences 2162.

Dioxin Expert Working Group Report. EEM Technical Management Committee. 1997. EEM/1997/3

Usability Expert Working Group Report. EEM Technical Management Committee. 1997. EEM/1997/4

Toxicology Expert Working Group Report. EEM Technical Management Committee. 1997. EEM/1997/5

Fish Survey Expert Working Group Report. EEM Technical Management Committee. 1997. EEM/1997/6

Benthic Community Expert Working Group Report. EEM Technical Management Committee. 1997. EEM/1997/7

Pulp and Paper Technical Guidance for Aquatic Environmental Effects Monitoring. 1997. EEM/1997/8

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1.0 INTRODUCTION

To protect fish, fish habitat and use of the fisheries resources, the amended Pulp and Paper Effluent Regulations (PPER) of the federal *Fisheries Act* (1992) prescribe limits for discharge of biochemical oxygen demand (BOD) and total suspended solids (TSS) in effluent and acute lethality of effluent to rainbow trout, and the CEPA regulations prescribe limits for dioxins and furans. These discharge limits, based on the availability of pollution control technology, were established to be minimum national standards that would protect environmental quality. The Canadian pulp and paper industry uses a variety of manufacturing processes and discharges effluent to a wide variety of receiving environments. These uniform effluent standards alone therefore may not ensure adequate protection of receiving environments.

The adequacy of effluent regulations will be assessed by undertaking site-specific aquatic Environmental Effects Monitoring (EEM) studies at all locations where effluent is discharged to the aquatic receiving environment from a pulp and/or paper mill or an off-site treatment facility which receives mill effluent (hereafter referred to as "mills"), as regulated under the PPER. EEM will provide information to assess the need for adjustments in the national regulations and/or formulation of site-specific control measures using a weight of evidence approach to interpret the results.

Most Canadian mills have previously conducted various aspects of effects monitoring in response to government priorities, emerging environmental issues and improved process and effluent treatment technologies. To achieve national uniformity in such studies, an EEM requirement is included in the amended PPER. EEM studies will maintain standard program elements and also be site-specific, dependent upon the results of prior knowledge at the site and the decision trees for monitoring approaches outlined in this Annex. Since 1992, all Canadian mills regulated under the amended PPER have been required to conduct EEM at regular intervals in accordance with the PPER, the generic Aquatic Environmental Effects Monitoring Requirements document (Environment Canada, 1997b) referenced in the PPER and the specific requirements outlined in this Annex.

Aquatic environmental effects monitoring, as applied to mills, is a sequential series of monitoring and interpretation cycles, wherein the requirements of each cycle are dependent on the findings of the previous cycle. General steps and types of information are defined for mills regulated under the PPER, although the specific requirements within a cycle may change. The EEM program will thus be evolutionary (e.g., a joint government-industry evaluation of Cycle 1 has determined requirements for subsequent EEM cycles). The following principles will serve as a guide in its evolution. The program must continue to:

1) be scientifically defensible;

2) allow flexibility in the study design of each mill by taking into account its site specific considerations in relation to each element of the national EEM program;
3) be cost-effective;
4) be flexible so that new or improved monitoring techniques can be incorporated and correlated with the old techniques as required;
5) build on findings of relevant research programs and pilot studies;
6) be manageable with respect to its requirements and timeframes;
7) generate interpretable results with appropriate detectable effect sizes;
8) use a weight of evidence approach to interpret results with respect to effects; and
9) provide defined decision points.

2.0 OVERVIEW

The objective of the pulp and paper Environmental Effects Monitoring program is to assess the adequacy of the national regulations for protecting fish, fish habitat and the use of fisheries resources. Adequacy is assessed on the basis of:

- the magnitude of effects, if any, in receiving environments related to mills; and
- the spatial extent of effects, if any, in receiving environments related to mills.

An effect is defined as a change in the measured variable which is outside the range of the natural variation observed at reference areas, unless there is an effect size defined for that variable. Effect size is the change in a variable that is considered ecologically significant. Refer to sections 6.0 - 11.0 for specific discussion of effect sizes related to each monitoring variable. Furthermore, a weight of evidence approach, i.e., consideration of all monitoring results, will be used to determine the adequacy of the Regulations.

The EEM program has four major components:

1) Pre-design information
2) Design and approval of the EEM study
3) Field study and process effluent toxicological testing [1]
4) Interpretive report submission

2.1 PRE-DESIGN INFORMATION

Detailed pre-design information is required only once provided that the mill process, effluent

[1] This does not apply to effluent outfalls containing only cooling water.

loading or discharge location or receiving environment conditions have not changed significantly. Pre-design information should be summarized and updated as part of EEM design submissions. The pre-design requirements are listed in Table 1.

2.2 DESIGN AND APPROVAL OF THE EEM STUDY

In order to design the EEM study, it is necessary to review the elements of the EEM program (Table 2) and decide which elements must be included in the study for that specific site.

The five elements of the EEM program are:

1) Fish survey
2) Invertebrate community survey
3) Effects on the use of fisheries resources
   - Dioxins/furans
   - Tainting evaluation
4) Process effluent toxicological testing
5) Chemical tracers in fish

In order to decide which elements must be included in a mill's site-specific EEM study design, it is necessary to use the decision trees and associated tables that have been provided in this Annex. It is important to note that the decision trees where applicable include consideration of effect size and the significance of observed differences between exposed and reference areas. [2]

The study design, and updated pre-design information, including a description of and schedule for, each environmental effects monitoring study is to be submitted to the Regional Authorization Officer (RAO) at least 180 days prior to its commencement. The RAO will review and accept the proposed design for an EEM study within 180 days of submission.

2.3 FIELD STUDY AND PROCESS EFFLUENT TOXICOLOGICAL TESTING

The technical guidance documents provide the information necessary to ensure that each of the elements of EEM are carried out across the country according to standard methodologies. Toxicological testing results (sublethal tests) on the effluent are to be reported electronically and in

[2] An area, in this Annex, is qualitatively defined for sampling purposes and relates to the appropriate geographical scale encompassing one or more fundamental sampling locations called stations. A station is a fixed sampling location which can be recognized, re-sampled and defined quantitatively (e.g. latitude /longitude). Within EEM, the overall study area is sub-divided into reference and exposure areas (near-field, far-field, etc.). Also, area is defined to be relatively homogeneous with respect to major habitat class and level of exposure to mill discharge.

a paper format within 90 days of test completion. Any difficulties with the submitted data must be communicated by the RAO or designated representative to mill staff within the 90 days.

2.4 INTERPRETIVE REPORT SUBMISSION

The interpretive report and supporting data in electronic format (format provided by Environment Canada) is to be submitted to the RAO according to the dates specified in the PPER. The RAO will review and accept the interpretive report.

Table 1: Pre-design requirements for EEM information/variables

Description of Study Area (Receiving Environment) [3]
Delineation of Zone of Effluent Mixing
Habitat Inventory and Classification
Resource Inventory
Historical Receiving Environment Data (including previous EEM findings)
Effluent Quality [4]
pH
Flow
Conductivity
Biochemical Oxygen Demand (BOD)
Total Suspended Solids (TSS)
96-h Rainbow Trout Lethality
48-h *Daphnia magna* Lethality
Chlorinated Dioxin and Furan Congeners [5]
Mill History and Operations [6]

[3] To be updated and summarized prior to each EEM cycle. Delineation of the zone of effluent mixing may be required if there was a change in the location of the effluent discharge or a significant change in the effluent loading.

[4] Requirements under the Pulp and Paper Effluent Regulations (1992) except where otherwise indicated.

[5] Requirements for Regulations Respecting the Release of Polychlorinated Dibenzo-para-Dioxins and Polychlorinated Dibenzofurans from Pulp and Paper Mills (*Canadian Environmental Protection Act*).

[6] Mills are required to report on mill history and operations data as specified in the Pulp and Paper Effluent Regulations, (1992) and Regulations Respecting the Release of Polychlorinated Dibenzo-para-Dioxins and Polychlorinated Dibenzofurans from Pulp and Paper Mills. Recommendations on additional data which will assist in interpretation of EEM results are given in Table 20 and the Technical Guidance Document (Environment Canada 1997a).

3.0 EEM REQUIREMENTS

Table 1 outlines the requirements for pre-design information which must be reported prior to undertaking EEM studies. Table 2 summarizes the monitoring requirements for Cycle 1 and subsequent cycles. For Cycle 1, mills must complete all monitoring requirements. In order to confirm the results of the first cycle, all mills must apply the appropriate decision trees to design the site-specific monitoring program for subsequent cycles. In cases where alternative or refined monitoring techniques are developed to replace those used in a previous cycle, the results of the new technique(s) must be correlated with the results of the technique being replaced, where possible. Mills should be under normal operating conditions during EEM field studies, whenever possible.

3.1 NATIONAL PILOT PROJECTS

As part of the evolution of the EEM program, the EEM Management Steering Group will coordinate and approve national pilot studies. These pilot studies include the review, assessment and development of suitable alternative monitoring and assessment techniques. The mills and companies (especially those where alternatives are necessary) can participate in national pilot studies targeted at developing and assessing suitable alternative monitoring methods. This participation includes, but is not limited to, performing an actual study, reviewing other studies, sitting on an advisory panel, funding or in kind support. This will be conducted in consultation with the RAO. The RAO will keep the Management Steering Group informed.

3.2 PRE-DESIGN REQUIREMENTS

Pre-design information requirements are necessary to:

1) delineate the spatial extent of the study area, including the zone of effluent mixing and representative reference areas;
2) confirm that the samples collected are representative of these areas at the time of field sampling;
3) describe habitat type at a level of resolution sufficient to allow siting of invertebrate and fish sampling stations;
4) document any potentially confounding or influencing factors that must be considered in the study design and interpretation of results;
5) provide knowledge of the relative abundance of fish in the study area and determine the feasibility of selecting two sentinel fish species; and,
6) describe the quality and use of fisheries resources in the receiving environment to assist in the setting of statistical criteria in subsequent EEM cycles.

The detailed pre-design information will be required only once, provided that mill operations, effluent loading or discharge location or receiving environment conditions have not changed significantly. Pre-design information must be summarized and updated as part of EEM design submissions. Information and experience gained from previous cycles or related monitoring and research in the area should be included.

3.2.1 DELINEATION OF ZONE OF EFFLUENT MIXING

Delineation of the zone of effluent mixing is necessary to ensure that:

1) sampling stations are located within the zone of effluent mixing; and
2) reference areas are well beyond any potential zone of impact.

In the majority of receiving environments, the zone of effluent mixing will be delineated to a limit of resolution determined by a plume delineation study to a limit of 1.0% (100:1 dilution) effluent concentration. It is recognized that, in certain unique receiving environments, it may not be practical to undertake plume delineation studies e.g., where position of the effluent plume is highly transitory or extremely small. In such circumstances, alternative means of determining the boundaries of the study area may be acceptable. Typically, such an alternative would entail an extensive spatial characterization of the receiving environment in terms of sediment or water quality and/or toxicity or extensive mapping of benthic community structure. Additional guidance on selection of appropriate techniques, reference areas and recommended methods are provided in the Technical Guidance Document (Environment Canada, 1997a).

3.2.2 HABITAT INVENTORY AND CLASSIFICATION

Mapping and classification of the fisheries habitat that may potentially be affected by mill discharges or confounding discharges is critical to the EEM design. The area to be mapped should include:

1) areas delineated as zone of effluent mixing determined in 3.2.1;
2) areas in or proximate to this zone that are potentially affected by deposition of sediments contributed by the mill or contaminated by mill effluent; and,
3) areas within the reference area(s) with similar dominant habitat types to those identified in 3.2.2 (1) and (2) above (see the Technical Guidance Document (Environment Canada, 1997a) for guidance on selection of appropriate reference areas).

The features to be identified and mapped as part of this inventory are described in Table 3. This will assist in the identification of potentially confounding factors to be considered in the design of the study and interpretation of results such as dams, tributaries, other discharges, etc. The spatial extent of the study area to be mapped will be determined on a site-specific basis. However, since sampling areas for invertebrate surveys must be located in the dominant habitat class (as defined in Cowardin et al. 1979), all habitat areas to be mapped must be at least to the level of class.

The habitat classification studies must follow the hierarchical classification system of Cowardin et al. (1979). Additional guidance for habitat description procedures is also available in Fisheries and Oceans (1990). Additional detailed guidance on habitat classification is provided in the Technical Guidance Document (Environment Canada, 1997a).

3.2.3 RESOURCE INVENTORY

The identification of aquatic resources and resource uses which may potentially be affected by the effluent discharge is critical to the design of the EEM study and the selection of appropriate sentinel species for the fish survey. As part of the pre-design requirements for EEM, description of fisheries resources within the study area is required. This information should include the identification of fish and shellfish that are presently exploited in commercial and non-commercial fishing, that may potentially be exploited in the future, and any species recognized by federal or provincial authorities as rare, threatened or endangered, as well as any species which may be present in sufficient numbers to be considered as a monitoring species. This information can usually be obtained from district fisheries biologists in federal or provincial regulatory or museum agencies, from local conservation officials and from interviews with fishermen and members of the local community. The mills must be able to demonstrate to the RAO that a reasonable level of effort has been expended to gather this information as described in the Technical Guidance Document (Environment Canada, 1997a).

While mills are not required to undertake a preliminary field survey in order to collect fisheries resource information, they must have sufficient site-specific data to allow selection of sentinel species of fish (or shellfish) that satisfy the criteria for the fish survey (see Section 6.0). In certain instances, this may require undertaking a non-destructive preliminary fish survey to document species presence and relative abundance. Mills with knowledge of fisheries resources in the study area are generally more successful in capturing sentinel species.

The reporting requirements for resource and habitat inventory are listed in Table 3. All habitat classification is to be reported in map form, typically at a scale of 1:≤5,000 (actual scale to be reported).

3.2.4 HISTORICAL RECEIVING ENVIRONMENT DATA

The review of historical (10 year) and more recent monitoring data which has been collected for other purposes is an important component of the pre-design information requirements. This information may assist in identifying known impacts, if any, and will aid in determining selection of exposed and reference areas. This information or data may be provided as part of the pre-design stage if the data are of a sufficient quality to meet the requirements of this Annex. This review should also identify other site-specific monitoring programs, e.g., intensive dissolved oxygen monitoring programs, which should be undertaken or are being conducted on a site-specific basis.

This review should also identify past problems or concerns, such as tainting, shellfish or fisheries closures, bacterial contamination and sediment fibre mats.

3.2.5 EFFLUENT QUALITY, MILL HISTORY AND OPERATIONS

The Pulp and Paper Effluent Regulations under the *Fisheries Act* and the Regulations Respecting the Release of Polychlorinated Dibenzo-para-dioxins and Polychlorinated Dibenzofurans in Effluent from Pulp and Paper Mills under the *Canadian Environmental Protection Act* require that mills report on effluent quality and operations data. Relevant historical data governing mill history, especially processing, effluent treatment and spills should be reported, as they may affect interpretation of study design or results. This information is critical for identifying acceptability of historical data, and for selecting study areas. Recommendations on additional data are specified in the Technical Guidance Document (Environment Canada, 1997a).

3.3 DESIGN: CYCLE 1 AND SUBSEQUENT CYCLES

Cycle 1 of EEM will be used at mills to establish a baseline against which data from future cycles can be compared, to assess the need for the refinement or the need for alternative monitoring techniques, and to provide a preliminary assessment of whether effects are evident in the receiving environment. Successive cycles of EEM will allow the assessment of temporal changes in the magnitude and/or spatial extent of any mill-related effects on fish, fish habitat and the use of fisheries resources. However, where Cycle 1 or subsequent cycles techniques do not allow a suitable baseline to be established, it may be necessary to use refined or alternative techniques in subsequent cycles.

A summary of monitoring requirements for EEM cycles are specified in Table 2 of this Annex. These requirements will apply to all mills. However, as stated in the guiding principles outlined under Section 1.0, subsequent cycles may include new or alternative monitoring techniques as part of the evolutionary nature of EEM. All mills must apply the appropriate decision trees and tables to design the site-specific monitoring program for subsequent cycles.

The intent of subsequent cycles will be to compare the results to those of previous cycles and to document the magnitude and spatial extent of any observed effect. Consequently, all mills must design monitoring programs for subsequent cycles using the appropriate decision trees and criteria.

3.4 EEM FOR NEW MILLS

New mills are required to complete the relevant pre-design and Cycle 1 EEM requirements prior to commencing effluent discharge in order to establish a baseline of environmental conditions against which to assess future EEM results. This information is normally gathered during the environmental assessment process, and it is in the mill's interest to fulfill EEM requirements as well. Since no effluent will be discharged at this time, zone of effluent mixing should be estimated based on mill design and effluent discharge loading criteria using appropriate modeling techniques. A new mill is required to submit the interpretive report and supporting data on the pre-operational study no later than a day that is one year after the day on which the mill begins to discharge effluent. The next EEM cycle commences on the date which the pre-operational report is due.

Table 2: Summary of monitoring requirements for EEM cycles

VARIABLES
Effects on Fish: Fish Survey (see Section 6 for details) Sentinel species, measurements (length, weight, age, etc) **Effects on Fish Habitat:** Invertebrate Community Survey (see Section 7 for details) Community descriptors (abundance, diversity, etc) **Effects on Use of Fisheries Resources:** (see Section 9 for details) Tissue Analyses: Chlorinated dioxin and furan congeners Tainting Evaluation
Supporting Environmental Variables (seen Section 8 for details) For key and site-specific variables, see Table 20. **Process Effluent Toxicological Testing** (see Section 10 for details) Fish early life stage development test Invertebrate reproduction test Plant toxicity test **Chemical Tracers in Fish** (see Section 11 for details)

Table 3: Reporting requirements for resource and habitat inventory of the study area

Parameter	Description/Information to be Reported
Major tributaries, river mouth	locations to be shown on maps
Fish spawning grounds, nursery areas	locations of all known areas to be shown on map
Fishing grounds, aquaculture areas, significant shellfish resources	locations of all known areas to be shown on map
Water intakes, effluent discharges, stormwater discharges, sewer overflows, disposal sites, log booming and storage areas	locations of all known areas to be shown on map
Docks, wharves, ferry terminals, marinas, boat launches, and public beaches	locations of all known areas to be shown on map
Dams and other barriers to fish	locations of all known areas to be shown on map and fish movement restrictions indicated
Zones of plant growth	identify any areas in near-field plume where aquatic plant growth appears to be reduced or enhanced relative to reference areas
Bathymetry mapping	units to be reported in meters (relative to mean sea level in tidal habitats)
Gradient	gradient profile for riverine study areas, produce from topographic maps
Discharge (rivers and estuaries)	summary water discharges statistics (m^3/s), as available for each month of record (gauged watersheds) for most representative station(s); substantiated estimate of mean monthly discharge when data unavailable discharge during previous EEM cycle

4.0 QUALITY ASSURANCE/QUALITY CONTROL PRINCIPLES APPLICABLE TO EEM

Quality assurance (QA) encompasses a wide range of management and technical practices designed to ensure an end product of known quality commensurate with the intended use of the product. Quality control (QC) is an internal aspect of quality assurance. It includes the techniques used to measure and assess data quality and the remedial actions to be taken when data quality objectives are not realized. Within the context of a particular study, assurance of adequate data quality is only possible when Data Quality Objectives have been defined. Users of the data must play a lead role in defining Data Quality Objectives for a study and in ascertaining whether laboratory quality control limits are consistent with these objectives. The principles of QA/QC also apply to biological testing, both in the field and the laboratory, although the specific QA/QC activities and sources of error may be different.

External quality assurance activities include participation in inter-laboratory comparisons and audits by outside agencies. Outside audits may be a check on performance in analysis of standard reference materials, or be a general review of laboratory practice as indicated by documentation of sampling, analytical and QA/QC procedures, test results and supporting data.

A QA/QC program should stress the importance of Data Quality Objectives which encompass all components of uncertainty in data generation, and of data quality check points at all stages from project planning through sampling, analysis and data interpretation. It requires integration of these activities, with real-time quality checks and corrective actions.

Mills must ensure that a reliable method of sample tracking, logging and data recording is practiced and documented by the testing facility to establish continuity between the sample collected and the results reported. Standard operating procedures for field and laboratory activities should also be available from the testing facility, as required. Testing facilities should also document the qualifications and experience of staff conducting the tests. Procedures and records of instrument maintenance and calibration should be documented. Records of the source, care and health or condition of the test organisms should be maintained. Bench records containing original data and QA/QC for all tests must be kept on file by the testing facility for review and audit purposes for five years from the test date.

The concepts and basic elements of a good measurement system are discussed in the Technical Guidance Document (Environment Canada, 1997a). Quality assurance statements must be submitted to the RAO with each interpretive report. Documentation supporting quality control practices must be available at the request of the RAO.

5.0 SAMPLING DESIGN REQUIREMENTS

For EEM studies, there will always be at least one reference area, to which exposure areas will be compared. Refer to the relevant sections in this Annex for more specific information on sampling areas for the monitoring technique used. Reference areas should have zero mill effluent exposure, and natural habitat features similar to those in exposure areas. Reference areas are ideally located in the same water body as the mill discharge, but beyond any influence from the discharge. However, the reference area may be influenced by discharges from other sources and in some cases, it may be necessary to go to another comparable water body. A sharing of reference areas and joint-studies are encouraged. It should be noted that fish and invertebrate reference areas need not be the same.

The number of sampling units required to achieve the desired sensitivity in comparison of two areas or time periods can be statistically determined using power analysis (Green, 1989). For mills that completed Cycle 1 before 1996, such data may not have been available, so minimum numbers of sampling units for each variable were specified. In Cycle 2 and subsequent cycles, sampling units will be defined based on power analysis. Knowledge of the site-specific variation of the variables, thus specifying effect sizes and setting the statistical power will allow the determination of sample size in subsequent cycles.

6.0 EFFECTS ON FISH: FISH SURVEY

The fish survey provides an assessment of whether there are differences in fish characteristics between exposed and reference areas. It does not attempt to provide a comprehensive assessment of the health of a fish population. The study design should be based on the ability to detect a difference of 20-30% in relative gonad size between reference and exposed areas. Other variables to be measured (Table 4) will require further monitoring in order to establish effect sizes. Priority should be given to reducing variability rather than increasing sample size. A reasonable level of fishing effort, as discussed in the Technical Guidance Document (Environment Canada, 1997a) should be expended to collect the minimum number of individuals specified. Except in cases of extreme habitat degradation, it is unlikely that one cycle alone would provide sufficient data on which to judge the effects of a mill effluent on the receiving environment. Rather, it will be the results of a series of such cycles, conducted every three years, that will permit such an assessment.

6.1 CYCLE 1 FISH SURVEY

Prior to undertaking the fish survey for Cycle 1, two sentinel species should be identified and submitted in partial fulfillment of the pre-design information requirements. If no local (i.e., site-specific) fisheries resource information exists, a limited preliminary survey of resident fish species will be necessary to identify suitable species. In accordance with the definition of fish as specified in the *Fisheries Act*, sentinel species may include fish, shellfish, crustaceans, and the juvenile stages of fish, shellfish, and crustaceans. The fish survey, however, was originally designed for adult finfish which remain the preferred sentinel species.

The fish survey requires that a minimum of 20 males and 20 females from each of the two species be collected from each area sampled. However, where it can be demonstrated that this requirement is not feasible, then a re-design will be necessary, in consultation with the RAO. The main criteria for sentinel species are that they are abundant, exposed and can provide measurements for the desired characteristics (Table 4). Other characteristics of suitable sentinel species are provided in the Technical Guidance Document (Environment Canada, 1997a). For Cycle 1, only a near-field area (i.e., within the predicted zone of any sublethal effects or in the immediate vicinity of the effluent discharge) and a reference area are sampled. The fish survey need only be undertaken once during the first EEM cycle. Timing of collections should be such that fish in the near-field area are likely to have had prolonged exposure to the effluent. Consequently, sampling should be avoided during the spawning period, including immediate pre-spawning and post-spawning periods.

6.2 SUBSEQUENT CYCLES

The results of Cycle 1 should be used to site-specifically design the next cycle (Decision tree, Figure 1) based on Tables 5-11. In subsequent EEM cycles, fish survey designs will be improved based on previous results. Effects can only be determined in most cases with the minimum of two cycles of data with sufficient power. Furthermore, if effects are observed during a cycle, fish collections will be required to further determine the spatial extent of these effects in the next cycle.

Table 4: Fish survey measurements

Measurement Requirement	Expected Precision	Reporting Requirement
Length (standard, total and/or fork)	+/- 0.2cm	Individual measurements, mean, standard deviation
Total body weight (fresh)	+/- 5.0%	Individual measurements, mean, standard deviation
Age	+/- 1 year (10% to be independently confirmed)	Individual measurements, mean, standard deviation
Gonad weight	+/- 1.0%	Individual measurements, mean, standard deviation
Egg size	+/- 1.0%	Weight, minimum sub sample sizes of 100 eggs
Weight of liver or hepatopancreas	+/- 1.0%	Individual measurements, mean, standard deviation
External condition	NA	Obvious abnormalities, prevalence of lesions, tumours, parasites, etc.
Sex	NA	

Figure 1: Fish Survey Decision Tree

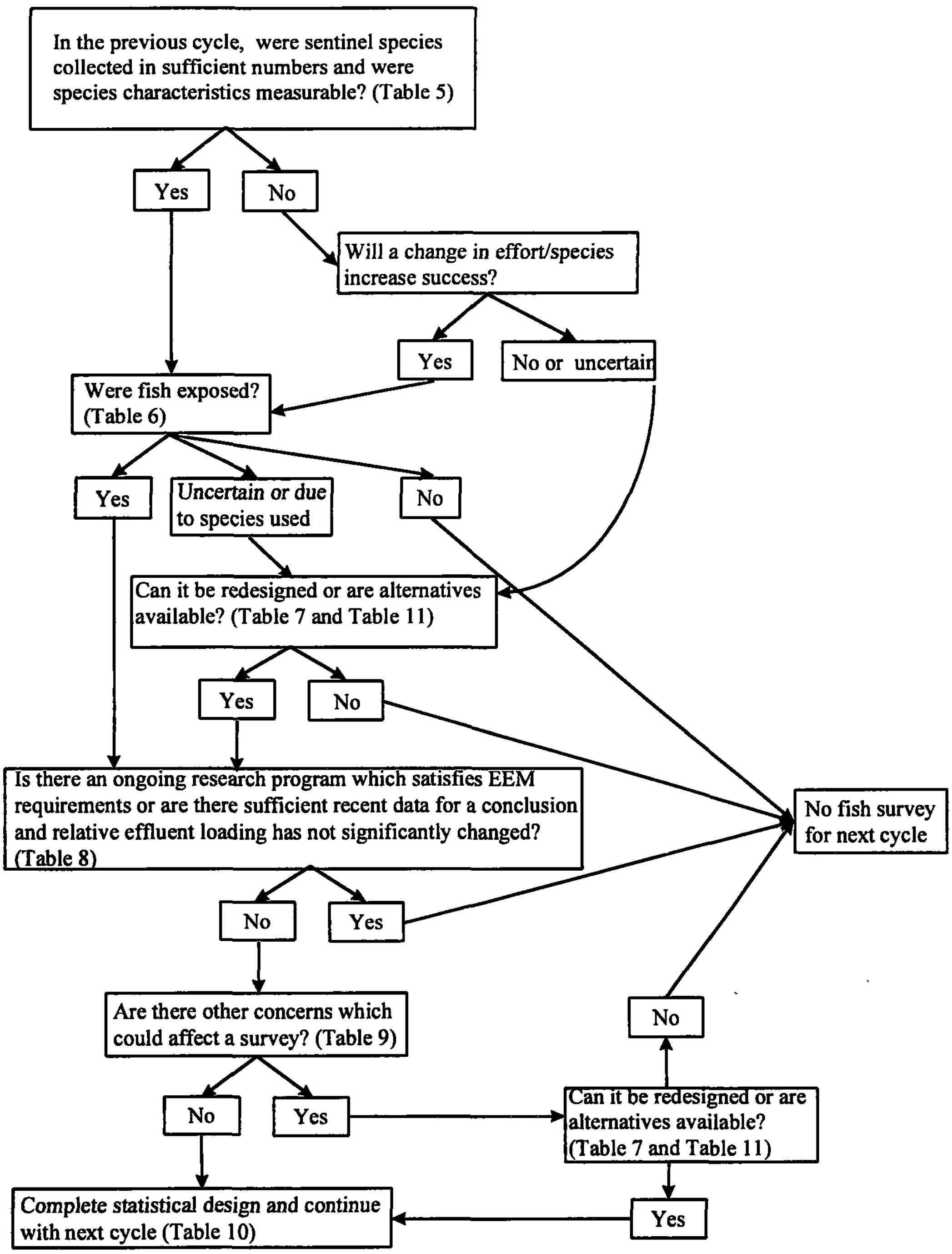

Table 5: Sentinel species characteristics and criteria for success

Criteria for defining "sufficient numbers" and "suitable characteristics" of sentinel fish species

1. were 20 fish of each sex of 2 species caught in each area? If yes, go to 2
2. was it possible to measure all fish survey parameters on the fish? If yes, go to 3
   - age
   - body weight and length
   - liver or hepatopancreas weight
   - gonad weight
   - egg size
3. were gonad weights of at least 80% of the female fish greater than 1% of the carcass weight? If yes, go to 4
4. if the sentinel species is a fractional spawner are you confident that sampling was not during the spawning period?

Some sentinel species may not meet all these criteria. Refer to the Technical Guidance Document (Environment Canada, 1997a).

Table 6: Were fish exposed?

If fish were captured in the effluent field, then exposure is obvious, although the period of residency is unknown. In situations where large, statistically significant differences are seen between exposure and reference areas, it is obvious that there has been a significant period of residency and an absence of mixing of fish between areas. Although these differences may not be the result of exposure to mill effluents, they do indicate some significant period of residency in the effluent field, and an absence of mixing between reference and exposure fish. The main concern relates to establishing the period of residency in the area of the effluent field when no obvious barriers are present and there are no differences between areas. Most chemical and biochemical tracers only provide evidence of short-term residency (days to weeks) and they were not used very successfully in the first cycle. The real value of chemical tracers is to establish that reference fish did not spend significant time in the effluent field. If there is doubt about the exposure, then redesign of the survey should be considered to utilize fish which are more likely to remain longer in the effluent field.

Surveys should not be conducted in the case of high dilution:

1. In rivers, - if effluent concentration, based on relative flows, is <0.1% after complete mixing at low flow, and if the effluent is diluted to <1% within 250 m of the discharge.
2. in marine and lake systems, if the effluent is diluted to <1% within 250 m of the discharge.

Table 7: Guidance for re-design

1. If fish exposure was uncertain a) are less mobile fish available, which would increase likelihood of exposure? If no, go to 1.b). b) if no other species are available, would changing the time of sampling increase the likelihood of exposure, using the same species as in Cycle 1? If no, go to 2. 2. Are there other factors (e.g. type of sampling gear) that would increase success? Note: the use of one species may be acceptable. If no, go to 3. 3. Sentinel fish availability is a problem. If other alternatives (See Table 11) are not appropriate, then go to 4. 4. Survey can not be redesigned, thus, no fish survey .

Table 8: Are there sufficient recent data for a conclusion?

The purpose of the EEM program is to evaluate the adequacy of the Regulations. There are three possible conclusions which can be reached: there is no effect, there is a mill-related effect, or there are confounding factors which prevent determination of the cause of an effect. 1. For determining that there are or are not changes, a minimum of two cycles, with a power and effect size that satisfies the requirements of Table 10, are required. Supplementary data could be used to replace one cycle of EEM data if it provides the required information on age, growth and reproduction, and has been collected since the last major process change. 2. Confounding factors - If there is sufficient data to demonstrate that other discharges or contaminant sources are primarily responsible for observed changes or absence of observed changes, and the survey cannot be re-designed to isolate mill effects, then there can be a conclusion that confounding factors prevent interpretation for the purposes of assessing the adequacy of the Regulations.

Table 9: Other concerns which could affect a survey

Other discharges are present and survey cannot be re-designed to isolate impact. Some examples include: 1. mill effluent is a minor component (*e.g.* less than 20%) of a combined discharge 2. the mill discharge is located within the effluent field of an adjacent discharger and/or adjacent discharge is located within the mill effluent field, and the mill discharge represents a minor component (*e.g.* less than 20%) of the discharges into the effluent field, and the survey cannot be re-designed to isolate the mill effect. Other confounding factors may exist which have not been identified. Habitat unsuitable or unsafe for sampling: *e.g.* extreme tidal fluctuations, high current velocity, etc. No suitable reference site: *e.g.* due to habitat, fish movements (reference fish exposed). Permit restrictions or concerns about protected, rare, or endangered species. Restrictions on sampling such as timing or location preventing sampling of appropriate species or correct timing.

Table 10: Power analysis

The sample sizes should be determined using the variability estimates given in Cycle 1, with a target power of 0.8.The study design should be based on the ability to detect a difference of 20-30% in relative gonad size between reference and exposed areas. Other variables to be measured (Table 4) will require further monitoring in order to establish effect sizes. If variability estimates are not available, a sample size of 30 males and 30 females from each area would be conservative. If effects were observed in Cycle 1 or subsequent cycles, monitoring must be expanded to delineate the spatial extent of the effects.

Table 11: Possible alternatives for the fish survey

No specific alternatives are recommended at this time. However, various alternatives are under review and this Table will be updated as alternatives are considered.

7.0 EFFECTS ON FISH HABITAT: INVERTEBRATE COMMUNITY SURVEY

Invertebrate community assessments will be used to delineate the extent of habitat degradation due to organic enrichment or other forms of physical and chemical contamination, and also to provide an evaluation of the aquatic food resources available for fish selected as sentinel species in the fish survey. In the majority of receiving environments, surveys of benthic invertebrate communities will be used to address this requirement. [7]

7.1 CYCLE 1 INVERTEBRATE COMMUNITY SURVEY

For Cycle 1, sampling stations are to be distributed, where feasible, throughout the zone of effluent mixing and are to include near-field and far-field areas, as well as locations within reference areas. The first EEM cycle requires that the survey be conducted with at least 15 stations, and a minimum of 2 replicate samples at each station. For coastal or lake-situated mills, a gradient or radial gradient sampling approach away from the effluent source may be used depending on site-specific circumstances. This method assumes that reference information is collected from the stations along the gradient with the least exposure to the effluent source. Also, historical data (i.e. prior to conducting the first cycle) which is determined to meet the QA/QC and protocols of current EEM practices, may be used to aid in the design as dictated by the benthic survey decision tree (Figure 2).

7.2 SUBSEQUENT CYCLES

For subsequent cycles, the decision tree must be used to aid in the design of benthic invertebrate surveys for freshwater and marine environments. The timing of the sampling should coincide with a period of high biological diversity and should be consistent from survey to survey.

The recommended sampling program designs for the freshwater and marine benthic community assessments are summarized in Table 12. These designs are based on an evolution of the approaches used in Cycle 1. Each design is aimed at estimating the magnitude and spatial extent of a potential mill effluent related effect, taking into consideration factors and possible constraints related to the availability and spatial distribution of suitable control ("reference") stations and the spatial extent and number of potential impact stations (e.g., within near field/far-field areas).

If single reference areas cannot be located (i.e., the simple Control-Impact or Linear Gradient Design is not appropriate), the Multiple Control-Impact or Radial Gradient approach should be

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[7] In site-specific cases, where benthic surveys are not feasible, it may be preferable to conduct invertebrate surveys in the intertidal zone or the water column (i.e., zooplankton). It would be necessary to demonstrate exposure of the organisms in consultation with the RAO.

used (e.g. coastal or lake-situated mills). Sampling schemes should be devised so that reference areas with minimal degradation are located in comparable habitats within the same eco-region.

7.3 OTHER CONSIDERATIONS

Only one dominant habitat type should be sampled during each EEM cycle for purposes of cost effectiveness and ease of data interpretation. For example, a decision needs to be made to sample either depositional or erosional zones in the freshwater receiving environment. In addition, decisions about sampling intertidal versus subtidal substrates in the estuarine/marine mills will depend on which is the appropriate habitat. Standard sampling devices must be consistently used to collect samples within each study and between cycles and consistent mesh sizes must be used for processing samples (i.e. 500 µm in freshwater environments and 1000µm in marine/estuarine areas). Sorting, sub-sampling and taxonomic efficiency must be standardized as much as possible and must be clearly documented for each mill. The distribution of variables from observations within exposure and reference areas must be examined for normality and equality of variance if parametric hypothesis tests are to be carried out. Further, once the data have been screened for coding or counting errors, all data should be stored in simple, accessible databases. Data transformations should only be used if they are appropriate for statistical reasons such as stabilizing of variance for parametric testing. Values for means, standard errors and simple statistical tests must be included in future reports. Organisms that cannot be identified to the desired level of taxonomic precision should be reported as a separate category in the fundamental dataset at the finest level of taxonomic resolution possible. The Technical Guidance Document (Environment Canada, 1997a) further describes in detail the variety of methods for analyzing data describing benthic invertebrate communities.

Table 12: Benthic sampling program designs

Design Type	Reference / "control" Areas	"Impact" Areas	Statistics	Considerations
Control/Impact	Single	Near field/Far-field/ as defined by effluent concentration in receiving environment	ANOVA	Is the single reference area confounded by other environmental factors?
or Linear Gradient	No or low exposure stations	Near field/Far-field/ as defined by effluent concentration in receiving environment	Regression/ Multivariate	Can suitable no / low exposure stations be found?
Multiple - Control/Impact	Multiple areas in the same or environmentally similar adjacent watersheds/coastal habitats	Near field/Far-field as defined by effluent concentration in receiving environment	Multivariate	Multiple "reference" areas
or Radial Gradient	Replicate no or low exposure stations	Near field/Far-field as defined by effluent concentration in receiving environment	Regression/ Multivariate	Can suitable no / low exposure stations be found?

Figure 2: Benthic Survey Decision Tree

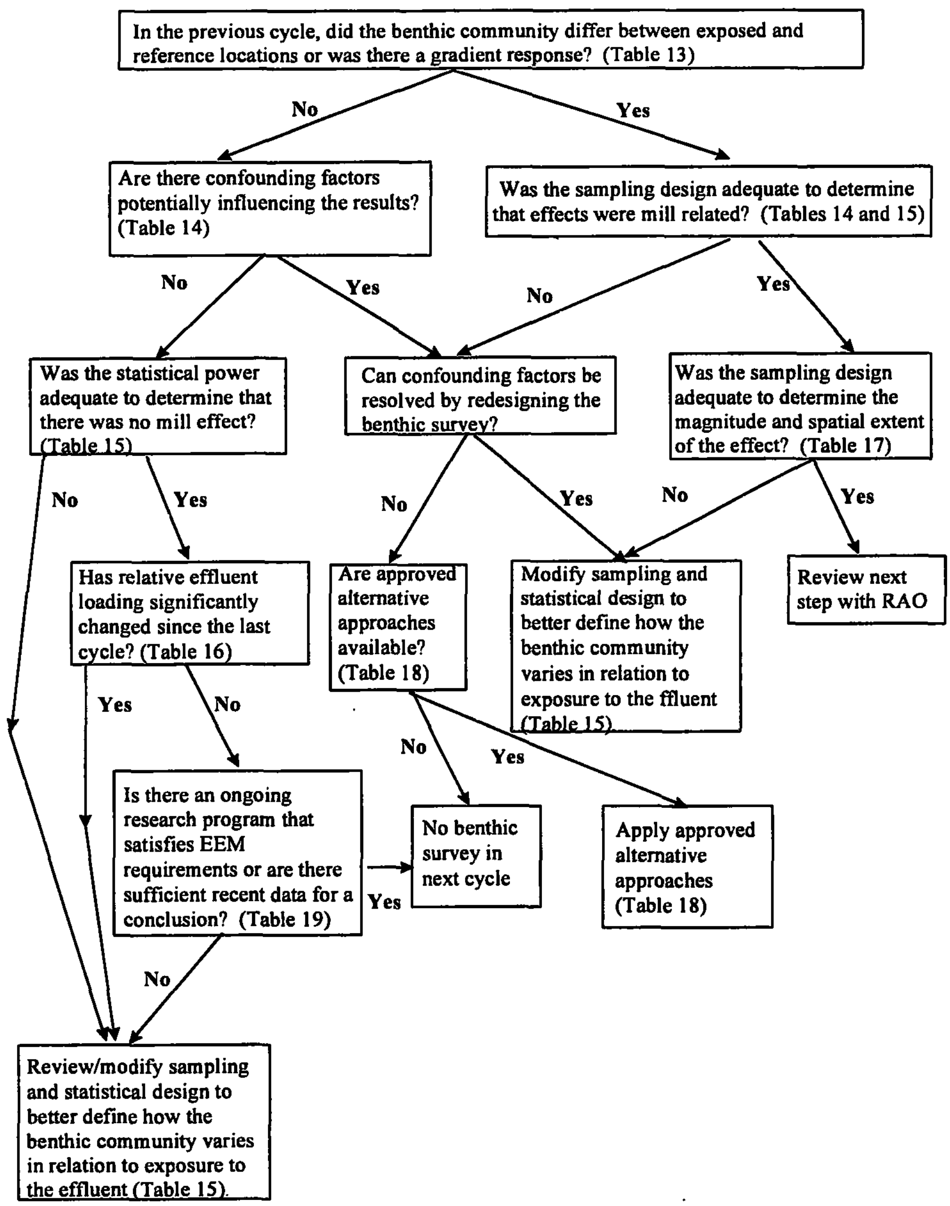

Table 13: In the previous cycle, did the benthic community differ between exposed and reference areas or was there a gradient response?

Answering this question is equivalent to comparing various descriptors of the benthic community (e.g., total abundance or biomass, taxonomic richness) among the two or more levels of exposure to the effluent. A relationship between the benthic community and the effluent may be a simple difference in a community descriptor between one or more reference areas and an exposed area, or it may be a gradient of variability in a community descriptor among stations which vary in their level of effluent exposure.
A weight-of-evidence decision must be made based on both statistical and non-statistical comparisons of stations with varying exposure levels.
Statistical comparisons are based on community descriptors calculated from each observation made at a station with a given level of exposure. An example is the average number of genera per replicate. Variation among stations with different exposure levels can be assessed with 1-way ANOVA or its non-parametric analogs. An ecologically significant effect size must be defined for each community descriptor subjected to this statistical test (Table 15).
Non-statistical comparisons are based on community descriptors calculated from the pooled observations made at a station with a given level of exposure. An example is the total number of genera found at a station. Variation among stations with different exposure levels can be assessed by inspection. If more than three levels of exposure have been sampled, the relationship between a community descriptor and exposure level can be statistically evaluated, albeit usually with weak power. Although statistical comparisons are usually not appropriate for these comparisons, an ecologically significant effect size must be defined for each community descriptor subjected to this comparison (Table 15).
A typical assessment, where several to many community descriptors are used, will result in a variety of judgments about the relationship between the benthic community and exposure to the effluent. For example, average number of genera per replicate may not be related to effluent exposure, but average total abundance per replicate is. In the case of a mixed result, the previously established response of community descriptors to mill effluent will be taken into consideration when constructing a weight-of-evidence decision. If descriptors known to be sensitive to the effluent are not correlated with exposure at a given mill, while other variables not known to be affected by mill effluent are correlated, then linking observed effects to the mill is less likely.

Table 14: Was the sampling design adequate to suggest that the effects were linked to mill effluent? Are confounding factors or sampling methods potentially influencing the results?

The interpretation of benthic community response may be influenced by confounding factors or application of incorrect sampling methods. There are four categories of such factors: 1. Environmental variables 2. Multiple discharges or historical effects 3. Time of sampling 4. Sampling methods
1. Environmental variables It is possible that environmental variables such as depth and particle size can confound the interpretation of effects. For example, if depth increases in proximity to the mill, then it may not be possible to separate the effect of the mill from depth effects. If feasible, a change in sampling design by modifying stations at macro (e.g., geographic location), meso (e.g., riffle within a river area), and micro (e.g., substrata within a riffle) spatial scales may reduce the problem. Augmenting the design to better characterize reference conditions by sampling more reference areas (e.g., moving from a gradient to a radial gradient design, or a control-impact to a multiple-control-impact design; Table 12) might reduce the problem.
2. Multiple discharges or historical effects A potential for confounding effects exists, if areas with varying levels of exposure to the mill effluent also have varying levels of exposure to other effluents or stresses, or habitat modifications from historical effects of the mill. If feasible, a change in sampling design by modifying sampling locations may reduce the problem. Core sampling may also be useful in depositional environments to resolve historical trends.
3. Time of sampling The time of year or the particular year of sampling may confound the interpretation of community response to effluent. This can be assessed by knowledge of the phenology of benthic community species (i.e. relation between climate and life history characteristics) and examination of data collected in previous years from the reference areas.
4. Sampling methods If standard methods have not been used, this may obscure any effect of the effluent on the benthic community.

Table 15: Was the statistical power adequate to determine that there was no mill effect?

If there is no relationship established between a community descriptor and the effluent, the power of the statistical tests should be assessed.

The **power** of a statistical test is the probability of detecting a given magnitude of relationship between the benthic community and the effluent, known as the effect size, when areas of varying levels of exposure to mill effluent are compared.

Effect is the magnitude of the relationship between the benthic community and the effluent that is considered ecologically significant.

Effect size of a particular community descriptor can be defined in three ways (Environment Canada, 1997a):

a) some function of ***variability*** in the community descriptor ***between observations at various exposure levels***
b) ***existing information (scientific literature)*** about the acceptable magnitude and nature of response of a community descriptor to the effluent
c) ***societal input*** into what constitutes an acceptable magnitude and direction of ecosystem change

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Once ***effect size*** is defined, the adequacy of the sampling design can be assessed. The power of detecting the effect size then must be calculated. If the power was less than 80%, even though the results show no significant difference, then the study cannot conclusively show there was no relationship between community and effluent.

Table 16: Has relative effluent loading significantly changed since the last cycle?

The absence of a relationship between community structure and effluent is based on the relationship between the loading to and the conditions of the receiving system. If either of these changes **significantly** then the assumption of no impact is no longer valid, and a sampling program should be initiated in the following cycle . The following changes in effluent or the receiving system could trigger such a sampling program depending on site specific conditions:
Relative effluent quality and quantity changes: Ecosystem response is determined by the relative loading of contaminants (e.g., nutrients, toxics) to the receiving environment (eg. dilution capacity). Contaminant loading is determined by both concentration and volume of effluent in relation to flow or volume of the receiving environment. Therefore, if either of these change and the RAO considers the changes to be significant, then a sampling program is required.

Table 17: Was the sampling design adequate to determine the magnitude and spatial extent of the effect?

If a relationship between the benthic community and the effluent has been established, but the spatial extent of the relationship is not definable from the data collected, increased sampling effort at intermediate levels of exposure is required.

Table 18: Are approved alternatives available for the invertebrate survey?

No specific alternatives are recommended at this time. However, various alternatives are under review and this Table will be updated as alternatives are considered.

Table 19: Are there sufficient recent data for a conclusion?

The purpose of the EEM program is to evaluate the adequacy of the Regulations. There are three possible conclusions which can be reached: there is no effect, there is a mill-related effect, or there are confounding factors which prevent determination of the cause of an effect.

1. For determining that there are or are not changes, a minimum of two cycles, with a power and effect size that satisfies the requirements of Table 15, are required.

2. Confounding factors - If there is sufficient data to demonstrate that other discharges or contaminant sources are primarily responsible for observed changes or absence of observed changes, and the survey cannot be re-designed to isolate mill effects, then there can be a conclusion that confounding factors prevent interpretation for the purposes of assessing the adequacy of the Regulations.

8.0 SUPPORTING ENVIRONMENTAL VARIABLES

A number of key variables must be measured to aid in the interpretation of both the benthic and fish survey data. In addition, there are site-specific variables which may be measured where applicable (Table 20). If there is a specific concern (e.g. potential eutrophication and nutrients), the approach would be to determine if the variable would be feasible to measure based on the effluent concentration and the known or predicated dilution factors in the receiving environment. Cost savings can be realized by approaching the analysis so that those samples with the likely highest concentrations are measured first, with measurements stopping when a pattern of undetectable samples is analyzed.

Table 20: Supporting variables for freshwater (F) and marine (M) habitats

KEY VARIABLES	SITE-SPECIFIC VARIABLES	HABITAT (F, M)	JUSTIFICATION
Dissolved Oxygen		F, M	Dissolved oxygen can be decreased by mill effluents due to BOD.
Water Temperature		F, M	Mill effluents may cause increases in water temperature in receiving waters.
Salinity		M	Changes in estuarine conditions may affect benthic communities.
Sediment Carbon/Nitrogen ratio		M	C/N ratio is affected by terrestrial (wood) versus aquatic plant sources of marine deposition.
Sediment Total organic carbon or Loss on ignition		F, M	Effects may be related to inputs from organic material.
Depth		F, M	Water depth has a major effect on invertebrate communities.
Bed structure - Particle size analysis: Matrix: framework ratio, degree of embeddedness, texture, colour and thickness of layers in cores		F, M	Differences in physical structure of the habitat can influence invertebrate community structure.

KEY VARIABLES	SITE-SPECIFIC VARIABLES	HABITAT (F, M)	JUSTIFICATION
pH, Conductivity, hardness	Alkalinity	F	Provides information for water quality.
Sediment Eh (redox)		M	Sediment redox provides an indication of the anoxic/oxic boundary in sediments.
Sediment total sulfides		M	Sulfides in marine sediments indicate the extent and nature of microbial response to organic enrichment.
Latitude, longitude		F, M	Provides station location information.
	Nitrate-Nitrite, Ammonia, and Total Nitrogen	F	Nitrogen is often a secondary limiting nutrient in freshwater.
	Sodium	F	Sodium may be a good tracer in freshwater.
	Dissolved Organic and Particulate Carbon	F	Carbon is a nutrient source for microbes. Mills discharge quantities of these carbon sources.
	Algal biomass as chlorophyll or ash-free dry mass	F	Algae in the water column (lakes) or on benthic substrates provides a food source for higher trophic levels.
	Colour or Turbidity	F, M	Mills may discharge effluents which are coloured. This may reduce the light available for primary production.
	Current velocity	F	Can provide information on equivalence of sampling stations.
	Bankfull channel width	F	Provides habitat structure information.
	Other chemical tracers of mill effluent (in water, fish or sediment)	F, M	Provide evidence of effluent exposure.
	Soluble Reactive or Total Dissolved Phosphorus and Total Phosphorus	F	Phosphorus is often the limiting nutrient in freshwater. Mills may discharge P which could lead to nutrient enrichment.

9.0 EFFECTS ON USE OF FISHERIES RESOURCES: TISSUE ANALYSES AND TAINTING EVALUATION

9.1 TISSUE ANALYSES: CHLORINATED DIOXIN AND FURAN CONGENERS

Mills which use or have used chlorine bleaching may be required to conduct analysis of tissue levels of chlorinated dioxin and furan congeners on edible portions of fish if dioxins and furans are an issue for the receiving environment (see Figure 3). The species selected for analyses and that portion of the fish constituting the edible portion will be decided on a site-specific basis. At sites where the levels of dioxins reported are approaching the advisory guideline and there are no other supporting data or programs, the RAO may require that dioxin analysis be included in the next cycle of EEM. Where mills are already engaged in monitoring programs to assess levels of dioxins and furans in fish tissue to conform with other federal or provincial requirements, then the existing program shall take precedence, providing it conforms with the performance requirements of this Annex and the Technical Guidance Document (Environment Canada, 1997a). Data collected for purposes other than the EEM may be substituted if they:

1) were collected after the completion of the previous cycle, and
2) meet the minimum QA/QC requirements as outlined in this Annex and the Technical Guidance Document (Environment Canada, 1997a), and
3) are equivalent to the sampling requirements (i.e., composite of 10 fish), and are reported with supporting data and information in the EEM document.

Chemical analyses for the congeners specified in Table 21 must be measured in accordance with the performance criteria provided and must be consistent with the QA/QC requirements specified in Section 4.0. Analyses will be conducted on a composite sample of 10 individuals of a single species and sex from the near-field area and reference area. Composite samples must be made up using an equal wet weight of tissue from each fish. Samples are to be homogenized and a subsample taken for dioxin and lipid analysis. Performance criteria to be achieved by a laboratory conducting analysis of chlorinated dioxins and furans on fish tissue are identified in Table 21. Further methodological and QA/QC aspects which **must be followed** are found in the Technical Guidance Document (Environment Canada, 1997a).

Figure 3: Dioxins/Furans Decision Tree

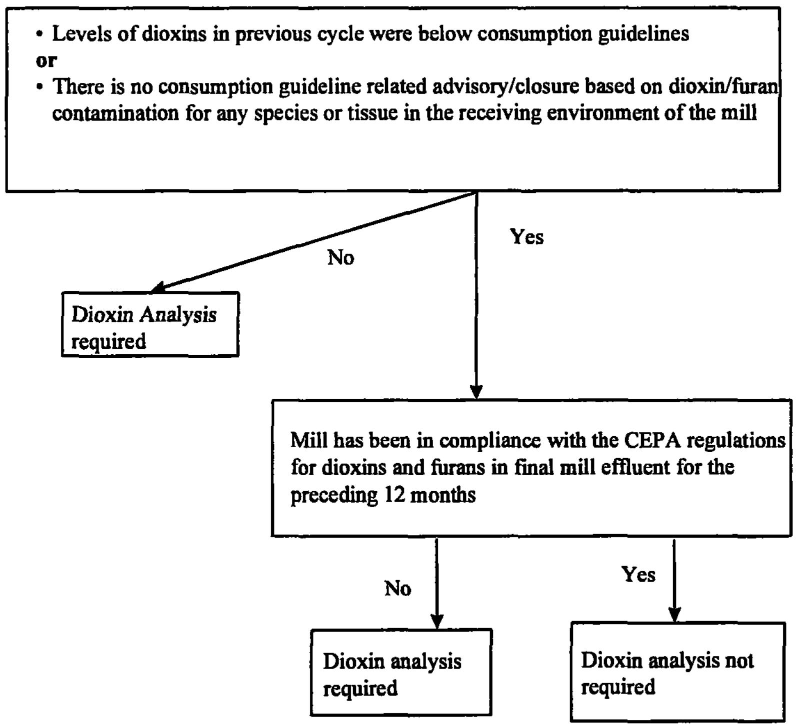

Table 21: Reporting requirements for chlorinated dioxins and furans

VARIABLE	MATRIX DETECTION LIMIT	PRECISION	ACCURACY
2,3,7,8-substituted PCDD [8]			
2,3,7,8-TCDD	1 pg/g	±20 %	40 - 120 %
1,2,3,7,8-P_5CDD	5 pg/g		
1,2,3,4,7,8-H_6CDD	5 pg/g		
1,2,3,4,6,7,8-H_7CDD	5 pg/g		
0_8CDD	20 pg/g		
Total PCDD [9]			
TCDD	1 pg/g	±20 %	40 - 120 %
P_5CDD	5 pg/g		
H_6CDD	5 pg/g		
H_7CDD	5 pg/g		
0_8CDD	20 pg/g		
2,3,7,8-substituted PCDF [10]			
2,3,7,8-TCDF	1 pg/g	±20 %	40 - 120 %
1,2,3,7,8-P_5CDF	5 pg/g		
2,3,4,6,7,8-H_6CDF	5 pg/g		
1,2,3,4,6,7,8-H_7CDF	5 pg/g		
0_8CDF	5 pg/g		
	20 pg/g		
Total PCDF [11]			
TCDF	1 pg/g	±20 %	40 - 120 %
P_5CDF	5 pg/g		
H_6CDF	5 pg/g		
H_7CDF	5 pg/g		
0_8CDF	20 pg/g		

[8] 2,3,7,8-substituted PCDD means any polychlorinated dibenzo-para-dioxin that has the molecular formula $C_{12}H_{8-n}Cl_nO_2$ in which "n" is not less than 4 and not more than 8 and chlorine atoms are located at the 2,3,7,8 positions on the molecule;

[9] Total PCDD means the sum of the concentrations of all polychlorinated dibenzo-para-dioxin congeneres that have the molecular formula $C_{12}H_{8-n}Cl_nO_2$ in which "n" is not less than 4 and not more than 8;

[10] 2,3,7,8-substituted PCDF means any polychlorinated dibenzofuran that has the molecular formula $C_{12}H_{8-n}Cl_nO$, in which "n" is not less than 4 and not more than 8 and chlorine atoms are located at the 2,3,7,8 positions on the molecule;

[11] Total PCDF means the sum of the concentrations of all polychlorinated dibenzofuran congeners that have the molecular formula $C_{12}H_{8-n}Cl_nO$, in which "n" is not less than 4 and not more than 8.

9.2 TAINTING EVALUATION

The EEM study design for each mill should include a review of all pertinent information relative to tainting and an assessment of whether a tainting[12] study is required in the current EEM Cycle using the decision tree provided (Figure 4).

Because the decision to investigate fish tainting associated with a mill is expected to occur on a mill by mill basis, the local knowledge and expertise of regional authorities is critical for ensuring that there is a sound basis for triggering tainting evaluations. The need for tainting studies should be based on a range of pertinent information including historical information, records of complaints, supporting information associated with a record of complaint, any previous tainting studies that were undertaken, and any subsequent environmental alterations or changes to mill operations that might be relevant.

A mill need not conduct a fish tainting evaluation if at least one of the following conditions is met:

1) fish contaminant analysis demonstrates that there is a potential health hazard, or
2) there is no well documented record of complaint[13] since 1992, or
3) a sensory evaluation conducted in the previous EEM Cycle has demonstrated that tainting is not an issue.

Notwithstanding the above, each mill must conduct a fish tainting evaluation if fish contaminant analysis demonstrates that there is no potential health hazard and at least one of the following conditions is met:

1) a sensory evaluation conducted in the last EEM Cycle has demonstrated that tainting is an issue, or
2) there is a new record of complaint since the last EEM sensory evaluation.

Thus it is incumbent on the local authorities, taking into account the mill's operating requirements and the interests of all stakeholders, to assess whether a tainting study should be required as part of the current EEM Cycle. In cases where the responsible parties or the mill

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[12] Tainting is defined as: fish that contain an abnormal odour or flavour (ISO 5492:1992).

[13] A well documented complaint can include (but need not be limited to) written complaints, fax or e-mail, documented telephone or verbal complaints to the mill or to government agencies.

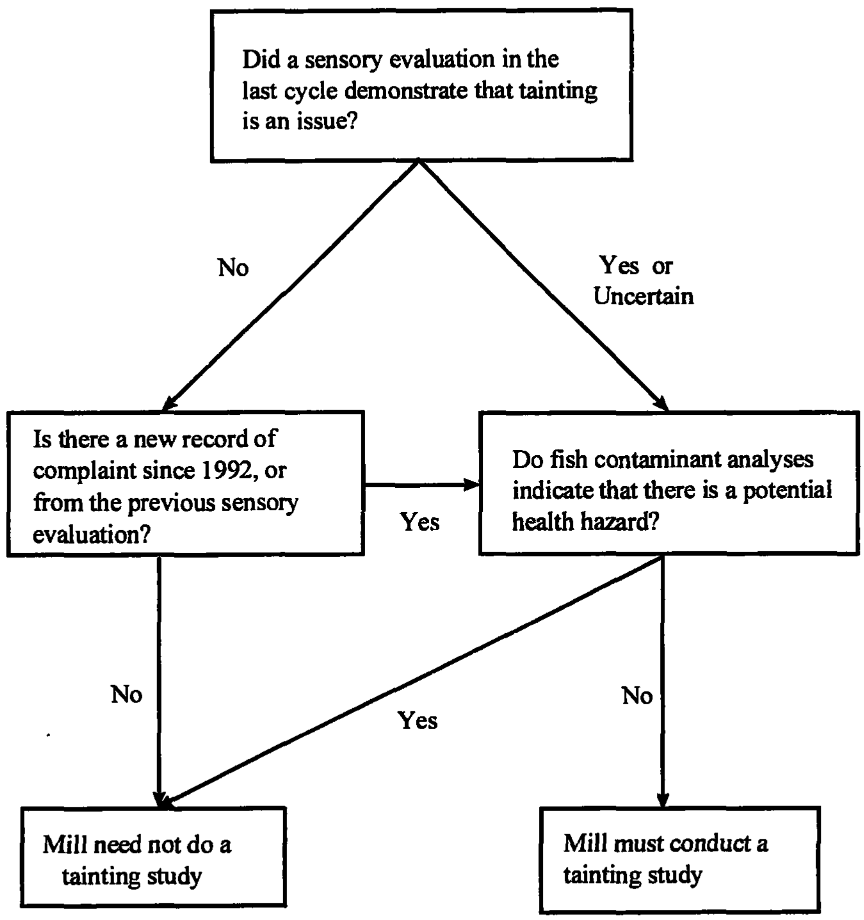
ownership do not have immediate knowledge of all prior information from which to assess whether tainting evaluations are required, some effort might be required to substantiate and/or validate existing information. In a similar manner, it might be necessary to confirm that the lack of complaints or documentation pertaining to a tainting problem is not a consequence of the abandonment of previously utilized fisheries resources by local users. A lack of utilization of fisheries resources should be due to tainting and not simply due to the perception that because a mill is in the vicinity it is not worth fishing there. At the same time, a lack of complaints should be due to a lack of tainting and not due to the fact that local users have not utilized the resource for many years because the fish were tainted at some time in the past. In most cases such situations will be readily apparent, but there might be instances where further substantiation or validation is required.

When further substantiation or validation is required, a number of considerations may be necessary. Of primary importance is whether it is possible to assume that fish tainting is attributable to the discharge of mill effluent. Therefore, the siting of the mill discharge, the location of natural and anthropogenic discharges, physical characteristics (e.g. dilution capacity) of the receiving water body, and the location and utilization of fisheries resources near the mill should all be considered. Confirmation of the location and utilization of fisheries resources may require further research. For example, local libraries often have published histories of the region which could assist with understanding the availability and utilization of fisheries resources. Regulatory agency records could also contain relevant information.

In cases where there is a history of complaints, the source and validity of such complaints should be reviewed. Creel records and/or surveys of local fishers can provide some guidance as to the basis of complaints. However, care should be taken to ensure that these records are unbiased and reproducible.

In cases where tainting evaluations have been undertaken in the past, the results and methods employed should be carefully reviewed. It has been found that fish tainting evaluation methods have often been incorrectly applied in the past and therefore the results might not be valid. Because of this, it may be necessary to repeat previous evaluations using appropriate methods and panel management procedures. Guidance is provided in the Technical Guidance Document (Environment Canada, 1997a) with respect to the appropriate evaluation procedures. In summary, the decision to initiate a taint evaluation as part of the current EEM Cycle should be based on several considerations. While most situations will be straightforward, there may be situations that require further investigation before a decision can be made. Regional authorities and the local mill's Technical Advisory Panel (TAP) are assumed to be best suited to assess whether taint evaluations are required. The sensory evaluation technique to be used for EEM is the difference-from-control-test. Details of this test which **must be followed** are found in the Technical Guidance Document (Environment Canada, 1997a).

Figure 4: Tainting Decision Tree



10.0 PROCESS EFFLUENT TOXICOLOGICAL TESTING REQUIREMENTS

The objectives for using sublethal toxicity testing in EEM are:

1) to contribute to the field program as part of the weight of evidence approach;
2) to compare process effluent quality between mill types and to measure changes in effluent quality as a result of effluent treatment and process changes; and
3) to contribute to the understanding of the relative contributions of the mill in multiple discharge situations;

The acceptable test methods and minimum reporting requirements of toxicity testing are given in Table 22. Additional guidance is provided in the Technical Guidance Document (Environment Canada, 1997a). Semi-annual testing is required one summer and one winter test period each year over the three year cycle. Winter is defined as January 1st to April 30th and summer is defined as July 1st to October 31st. New mills will begin the summer and winter testing of process effluent following commencement of discharge.

Laboratories with Canadian Association for Environmental Analytical Laboratories, Ministère de l'Environnement et de la Faune or an equivalent level of accreditation for sublethal toxicity testing should be hired by mills to conduct required testing. The following QA/QC considerations must be adhered to:

1) process effluent sublethal toxicity tests must be initiated within three days of sample collection. A new effluent sample must be collected if the toxicity test has not been initiated within the three day limit;
2) if any toxicity test method validity criterion has not been met, then testing of a new effluent sample is required;
3) reporting of "less than" values as a test endpoint (e.g.,: $IC_{25} < 10\%$) are not acceptable as this is an indication that there were insufficient test concentrations set during the test. All test endpoints must be bracketed by at least one test concentration with the exception of "greater than 100%" results;
4) reference toxicant tests must be conducted within 30 days of the effluent test and this test must be performed under the same experimental conditions as those stipulated for the effluent sample in the Environment Canada Biological Test Method Document(s).

Data from each sublethal toxicity testing period must be submitted to the RAO within 90 days of test completion (both in electronic and paper format). Any difficulties with the submitted data must be communicated by the RAO or designated representative to mill staff within the 90 days. The interpretive report should summarize the results of the toxicological tests reported to date since the last interpretive report.

Table 22: Methodologies and reporting requirements for process effluent toxicological tests

Test Description	Receiving Environment	Test Species	Frequency	Acceptable Method(s)	Reporting Requirements
Fish early life stage development test	Marine [16]	inland silverside or topsmelt	Semi-annual [14] each year of cycle	U.S. EPA 1994 and 1995	a,b
	Freshwater	Fathead minnow or salmonid spp.[15]	Semi-annual [14] each year of cycle	Environment Canada 1992a or/ Environment Canada 1997c	a,b
Invertebrate reproduction test	Marine [16]	Echinoids (sea urchins or sand dollars)	Semi-annual [14] each year of cycle	Environment Canada 1992b	b
	Freshwater	*Ceriodaphnia dubia*	Semi-annual [14] each year of cycle	Environment Canada 1992c	a,b
Plant toxicity test	Marine [16]	*Champia parvula*	Semi-annual [14] each year of cycle	U.S. EPA 1994	b
	Freshwater	*Selenastrum capricornutum*	Semi-annual [14] each year of cycle	Environment Canada 1992d	b

Reporting Requirements Code

a- Minimum reporting requirement as outlined in the test methods including LC_{50}, 95% confidence limits and indication of the quantal statistic employed.

b- Minimum reporting requirement as outlined in the test methods including IC_{25}, 95% confidence limits and indication of quantitative statistic employed and EC_{25}, 95% confidence limits and indication of quantal statistic employed (ie: EC_{25} is applicable to salmonid embryo test only).

[14] Semi-annually refers to one summer and one winter test period each year over the three year cycle. Winter is defined as January 1st to April 30th and summer is defined as July 1st to October 31st.

[15] For Canadian receiving environment locations, west of the Rocky Mountains, where fathead minnows are not an indigenous species, a salmonid species must be used according to Environment Canada (1997c).

[16] For all marine toxicity test procedures, the effluent salinity adjustment procedure recommended by Environment Canada (1997d) must be followed.

Note

Please note that there is an addition to footnotes a and b under minimum reporting requirements of Table 22 of the Annex. The footnotes should now read:

"a - Minimum reporting requirement as outlined in the test methods including LC_{50}, 95% confidence limits and indication of the quantal statistic employed. For the U.S.EPA methods, follow minimum reporting requirements of Environment Canada
b- Minimum reporting requirement as outlined in the test methods including IC_{25}, 95% confidence limits and indication of quantitative statistic employed and EC_{25}, 95% confidence limits and indication of quantal statistic employed (ie: EC_{25} is applicable to salmonid embryo test only). For the U.S.EPA methods, follow minimum reporting requirements of Environment Canada."

11.0 CHEMICAL TRACERS IN FISH

Mills are required where practical to provide confirmation at the time of field sampling that the samples collected are representative of effluent exposed and reference areas. In hydrologically dynamic receiving environments, or those receiving multiple discharges, it will likely be necessary to select a tracer which will be accumulated in fish tissue according to the decision tree (Figure 5).

The selection of a tracer will depend on the type of mill involved and the complexity of the receiving environment. Samples must be collected in accordance with the quality assurance/quality control principles identified in Section 4 and in accordance with the relevant performance criteria identified in this Annex, where applicable. Resin acids have been identified as a useful tracer in fish in some cases, but other tracers may be substituted if proven to be effective. Also, tracers in other media (e.g. sediment) may be useful as part of site-specific monitoring studies. Further guidance is provided in the Technical Guidance Document (Environment Canada, 1997a).

SAMPLE CALCULATION

To determine if the mill effluent contains sufficient concentrations of resin acid to use as a tracer in fish.

Assumptions:

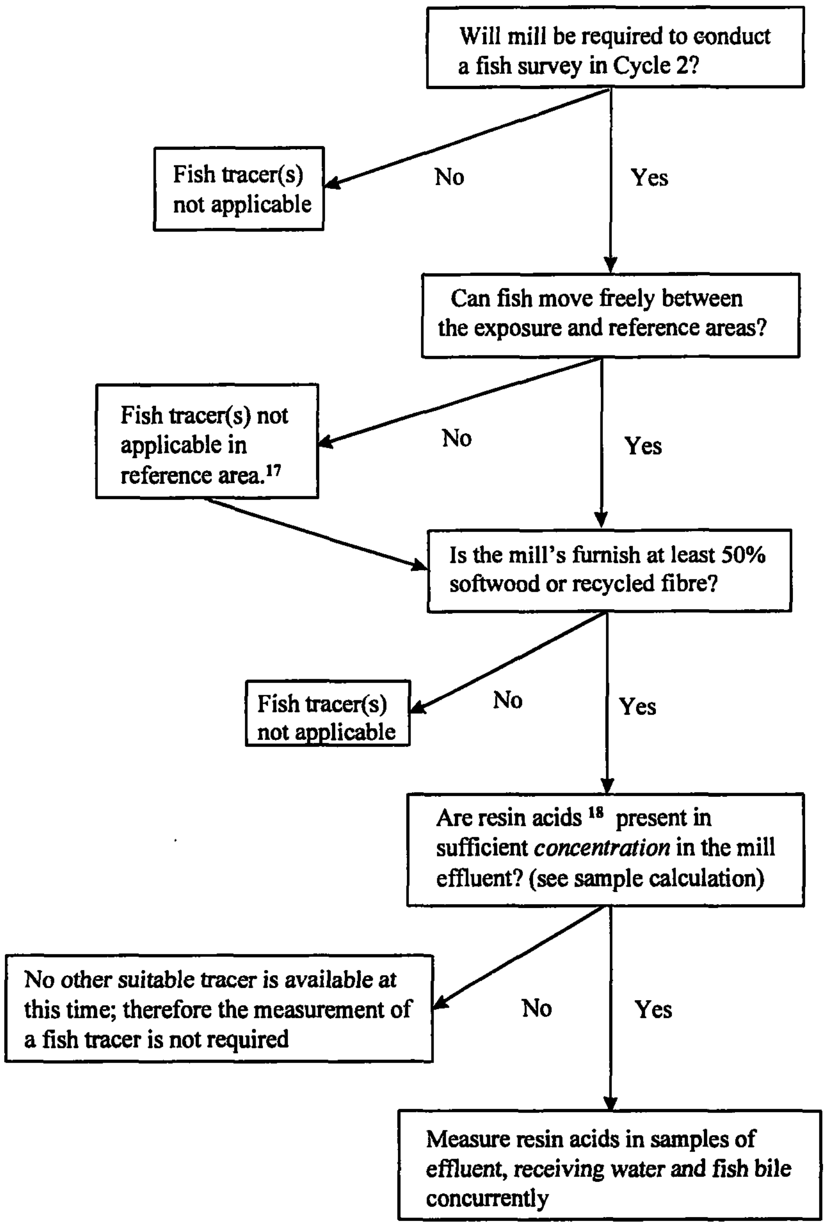
1. Detection limit for resin acids in fish bile = 0.5 μg/g
2. Detection limit for resin acid in water samples = 25 μg/L
3. Bioconcentration factor (BCF) of resin acids in fish bile = 1000
4. Exposure area fish are captured within the 1% effluent plume

Equations: Tissue concentration = water concentration X BCF
Water concentration = effluent concentration X 0.01

Therefore: Effluent concentration = tissue concentration / (0.01 X BCF)
Effluent Concentration = 0.5 μg/g / (0.01 X 1000)
= 0.05 μg/g
= 50 μg/L

Therefore if the effluent contains 50 μg/L of resin acid, then there should be detectable concentrations of resin acid in the fish bile. This is a very conservative estimate. Detection limits for resin acids in bile can be as low as 0.1 μg/g and BCF for resin acids in fish bile have been reported in the 10^4 to the 10^6 range (Stuthridge, et al. 1995).

Figure 5: Fish Tracer Decision Tree



17 Evaluate use of tracers for fish in exposure area

18 Other tracers may be substituted if proven effective

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SUPPORTING DOCUMENTATION ON AQUATIC ENVIRONMENTAL EFFECTS MONITORING PROGRAM: STAKEHOLDER ROLES AND ENVIRONMENTAL EFFECTS MONITORING SCHEDULE

1.0 Roles and Responsibilities in Environmental Effects Monitoring

1.1 Industry

Each facility will submit a study plan to the Regional Authorization Officer (RAO) for review, as described in the EEM clauses of the relevant Regulations. Each facility will conduct a study and prepare an interpretive report as outlined in the generic Aquatic Environmental Effects Monitoring Requirements document and relevant Annex, to be delivered to the RAO.[19] An electronic copy of data will also be provided in accordance with an electronic format provided by Environment Canada.

1.2 Regional Authorization Officer (RAO)

The RAO is the Regional Director of Environmental Protection, Environment Canada or a Provincial representative as prescribed in the Regulations. The responsibility of the Authorization Officer is to:

- form Technical Advisory Panel(s) (TAP), made up of representatives which will include representatives from Environment Canada and Fisheries and Oceans; representative(s) of the relevant province(s) will also be invited; the panel will be chaired by the RAO or his/her designate;
- authorize the study design, based on recommendations of the TAP;
- decide whether adverse effects are evident based on the TAP's assessment of the interpretive report submitted by the facility; and

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[19] Enough copies must be submitted to account for the number of Regional Technical Advisory Panel members and one copy for the National EEM Office. This should be discussed with the RAO.

- act on the advice of the TAP to recommend:
  - any additional work necessary to identify adverse effects in the forthcoming EEM;
  - to regulators a) the need for further regulation or control, and b) the need for specific research and development.

1.3 Technical Advisory Panel (TAP)

The responsibility of the TAP is to ensure the proper design and implementation of EEM proposed by the facilities, specifically to:

- advise the RAO in negotiation with facilities;
- make recommendations to the RAO on:
  - adequacy of pre-design information;
  - adequacy of program design (level of resolution, sampling station location, quality assurance/quality control (QA/QC) practices); and
  - adequacy of site-specific requirements.
- review the interpretive report submitted by the facilities for its acceptability and advise the RAO as to:
  - the quality of data and any required modification to QA/QC procedures;
  - the validity of conclusions presented in the report as to the adequacy of effluent;

    Regulations in protecting fish and fish habitat at that site;
  - requirements for subsequent EEM studies; and
  - requirements for remedial action or further regulatory action.

1.4 Federal Government

The information available from the EEM Program will enable the federal government to assess the adequacy of the Regulations for the protection of fish, fish habitat and the use of fisheries resources and to provide the public with information on the impacts of the current controls.

The National EEM Office within Environment Canada coordinates the assessment of the results of the EEM program on a national basis and the management of the data archive for the EEM program.

1.5 Provincial Governments

The provinces will be invited to provide a member to participate on the TAP.

2.0 Follow-Up Action

A number of possible alternatives for further actions may be identified. These will include, where appropriate:

- development of remedial action plans (voluntary or government-requested);
- regulatory action (national or site-specific);
- revision of the EEM requirements; and/or
- implementation of research and development programs (outside the regulated EEM requirements and on a national basis jointly by industry and government)

3.0 Timing and Implementation

The study design, and updated pre-design information, including a description of and schedule for, each environmental effects monitoring study is to be submitted to the RAO at least 180 days prior to its commencement. The RAO will review and accept the proposed design for an EEM study within 180 days of proposal submission.

Process effluent toxicological testing results (sublethal tests) are to be reported electronically and in a paper format within 90 days of test completion. Any difficulties with the submitted data must be communicated by the RAO or designated representative to mill staff within the 90 days.

The supporting data in electronic format (as provided by Environment Canada) and the interpretive report are to be submitted to the RAO according to the dates specified in Sections 30 and 31 of the Pulp and Paper Effluent Regulations. The RAO will review and accept the interpretive report.