Scientific Excellence • Resource Protection & Conservation • Benefits for Canadians
Excellence scientifique • Protection et conservation des ressources • Bénéfices aux Canadiens

Guidelines for the Protection of Fish and Fish Habitat During Bridge Maintenance Operations in British Columbia

S.C. Samis, M.D. Nassichuk and B.J. Reid

Water Quality Unit
Habitat Management Division
Fisheries Branch
Department of Fisheries and Oceans
555 West Hastings Street
Vancouver, B.C. V6B 5G3

January 1991

Canadian Technical Report of
Fisheries and Aquatic Sciences
No. 1692

Fisheries and Oceans / Pêches et Océans

Canada

Canadian Technical Report of
Fisheries and Aquatic Sciences 1692

January 1991

GUIDELINES FOR THE PROTECTION OF FISH AND FISH HABITAT DURING BRIDGE MAINTENANCE OPERATIONS IN BRITISH COLUMBIA

by

S.C. Samis, M.D. Nassichuk and B.J. Reid

Water Quality Unit
Habitat Management Division
Fisheries Branch
Department of Fisheries and Oceans
555 West Hastings Street
Vancouver, B. C. V6B 5G3

Cat. No. Fs 97-6/1692 ISSN 0706-6457

Correct citation for this publication:

Samis, S.C., M.D. Nassichuk and B.J. Reid. 1990. Guidelines for the protection of fish and fish habitat during bridge maintenance operations in British Columbia. Can. Tech. Rept. Fish. Aquat. Sci. 1692 : vii + 64 p.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

ABSTRACT

Samis, S. C., M. D. Nassichuk and B. J. Reid. 1990. Guidelines for the protection of fish and fish habitat during bridge maintenance operations in British Columbia. Can. Tech. Rept. Fish. Aquat. Sci. 1692: vii + 64 p.

This report examines the potential impacts on fish and fish habitat from bridge cleaning and painting operations in British Columbia. Guidelines in the report are designed to ensure the protection of aquatic life during routine bridge maintenance operations. Included are abatement techniques that minimize losses of paints and abrasives into fish habitat. Toxicity of bridge maintenance products are reviewed and bioassay test procedures are recommended. A referral procedure is outlined to facilitate review of bridge maintenance proposals near fish habitat.

RÉSUMÉ

Samis, S. C., M. D. Nassichuk and B. J. Reid. 1990. Guidelines for the protection of fish and fish habitat during bridge maintenance operations in British Columbia. Can. Tech. Rept. Fish. Aquat. Sci. 1692: vii + 64 p.

Ce rapport traite des conséquences que le nettoyage et la peinture des ponts en Colombie-Britannique pourralent avoir sur les poissons et leur habitat. Les principes directeurs enoncés dans ce rapport visent à assurer la protection da la vie aquatique pendant les travaux d'entretien courant des ponts. Le rapport présente des techniques de réduction des pertes en peinture et abrasifs dans l'habitat des poissons. On y examine la toxicité des produits d'entretien des ponts et on recommande des modalités dans l'exécution des tests biologiques. On y ébauche une methode de mise en rapport pour faciliter l'examen des projets d'entretien des ponts situés près d'habitats de poissons.

PREFACE

These Guidelines have been prepared with the knowledge that the paints and abrasives described herein can legally be used in Canada. Reference to specific paint or abrasive product brand names is not intended to economically jeopardize manufacturers, suppliers or distributors of these products. The Department of Fisheries and Oceans, under the authority of the Fisheries Act, can request the provision of plans and specifications for proposals, such as bridge maintenance operations, which can negatively impact fish habitat. The Department of Fisheries and Oceans will not be liable for prosecution through the use of these guidelines related to paint and abrasive products listed herein.

During the preparation of these Guidelines, the Federal Court of Canada, in a decision respecting a dam proposal in Alberta, provided a judicial interpretation of the federal Environmental Assessment and Review Process (EARP) Guidelines Order (1984). The EARP Guidelines Order requires federal departments to assess all projects which have a potential for environmental impact on an area of federal responsibility. This includes proposals and activities in those areas of Eastern B.C. that do not support Pacific salmon. In addition, new federal assessment legislation (Bill C-78, Environmental Assessment Bill) was introduced and when enacted, will replace the EARP Guidelines Order. As a result, the next (second) edition of these Guidelines will reflect any new federal responsibilities to review bridge maintenance proposals in Eastern B.C. and will identify any new or modified review procedures and requirements.

OBJECTIVES

These Guidelines are designed to ensure that bridge maintenance operations carried out near fish habitat do not harmfully alter such areas, or cause deleterious conditions in waters frequented by fish. They provide information and guidance to those individuals involved with developing or reviewing bridge cleaning and painting proposals in British Columbia and those parties responsible for conducting or managing bridge maintenance operations.

This document provides:

(1) The information necessary to prepare and submit a proposal to carry out bridge maintenance operations;

(2) A description of the proposal review process;

(3) Schedules of products used in bridge cleaning and painting operations listed according to potential risk to fish and fishery waters and;

(4) Conditions and restrictions applicable to bridge maintenance activities necessary to protect fish and fish habitat.

The appendices provide information on bridge cleaning and painting technology and methods to minimize impacts on aquatic resources from such operations. In addition, information is provided on the metals content of paints removed from bridges, concentrations of lead leached from flaked paint samples, and standardized fish toxicity testing procedures. Lists of agency offices are provided for contact purposes.

BACKGROUND

Legislation

The specific sections of the Fisheries Act relevant to bridge maintenance operations are detailed in Appendix 1. The Fisheries Act provides authority to the federal government to manage fish and fish habitat. Section 35 of the Act prohibits the harmful alteration or destruction of fish habitat. Fish habitat is defined in section 34 (1) of the Fisheries Act as, "...spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life processes".

Section 36 (3) of the Fisheries Act prohibits the deposit of deleterious substances in waters frequented by fish. Further, under section 37 (1) of the Fisheries Act, the authority exists to require the provision of plans and specifications for proposals which can negatively impact fish habitat. Although a procedure for bridge maintenance proposal review is established herein, if necessary, the authority under the Fisheries Act to obtain plans and specifications for such works can be exercised.

Fishery Resources of B.C. - An Overview

Aquatic systems in B.C. support diverse stocks of socially and commercially important fish, including anadromous species (fish which migrate from saltwater to freshwater) and resident freshwater and marine fish. Of principal importance are the five species of Pacific salmon that sustain significant native, recreational and commercial fisheries. Salmon and anadromous trout (i.e. steelhead and sea-run cutthroat) annually migrate from marine waters to spawning grounds in their natal streams and lakes. The extent of Pacific salmon freshwater migration in British Columbia is coincident with DFO's habitat and fisheries management district boundaries as illustrated in Figure 1.

Figure 2 depicts the stages of Pacific salmon development. Figure 3 depicts the presence of the various life stages of Pacific salmon in freshwater. Adult salmon migrate upstream to spawning grounds during summer to early winter. On the spawning grounds, gravels are excavated by spawning fish and eggs are deposited in "redds" or nests. Eggs incubate for several weeks in the gravels prior to hatching. Newly hatched salmon called "alevins" spend several weeks in gravels occupying interstitial spaces until the yolk sac is absorbed. Following yolk absorption the juvenile salmon spend from a few weeks to more than two years rearing in freshwater, depending on the species. The downstream migration of juveniles to marine waters occurs during spring and early summer. Migration timing is influenced by fish species, stream temperature and flow. Some species of salmon (e.g. chinook, coho) rely heavily on estuarine environments and marine foreshore areas for extended periods prior to migration to the ocean.

In addition to Pacific salmon, anadromous steelhead and cutthroat trout, and non-anadromous salmonids such as resident rainbow and cutthroat trout also support major recreational and native fisheries. Resident rainbow and cutthroat trout generally spawn in spring, with incubation of eggs occurring in streams and lakes in early summer. These species have life cycles similar to those of their sea going counterparts, except that migration to the ocean does not occur. Adult steelhead and sea-run cutthroat trout migrate into freshwater to spawn. Juveniles rear in freshwater for a period of one to three years and then migrate to the ocean. Trout may spawn annually for a number of years, whereas Pacific salmon spawn once and die.

Sensitivity of Salmonids to Pollutants

Pacific salmon and other salmonids are highly sensitive to contaminants and habitat degradation (Birtwell et al. 1981). Physical disturbance and/or cementing of gravels during spawning and incubation can kill eggs and juveniles. Water quality degradation can impact all life stages directly, or indirectly by reducing numbers of fish food organisms. Exposure to toxic contaminants such as heavy metals and organic compounds can either kill fish rapidly, or lead to chronic impacts (e.g. reduced stamina, growth and reproductive rate; increased metabolic rate). In addition, exposure to persistent compounds that are bioconcentrated can cause increased tissue levels of contaminants potentially reducing fish health and/or marketability. Because some species of salmon inhabit estuarine and nearshore marine areas for long periods, such stocks may be highly vulnerable to estuarine habitat disruption and water quality degradation.

Sensitive fishery waters for the purposes of these Guidelines include, but are not restricted to salmon streams, riparian (streamside) zones and marine foreshore areas. Of particular importance are spawning and rearing areas, downstream migration routes and food production areas.

Bridge Maintenance Technology

For the information of persons unfamiliar with the bridge maintenance industry, operations typically involve the following steps.

1. Bridge preparation:
   - Installation of safety nets, tarpaulins, drapes or other enclosures (see Figures 5-10); and possibly
   - Deployment of barges under bridges for debris collection and to trap paint chips.
2. Old paint removal:
   - Use of hydroblasting to remove road dirt, soluble salts, loose paint and rust;
   - Removal of old coatings using abrasive blasting, high pressure hydroblasting or manual methods; and
   - Application of rust inhibiting chemicals, if required.
3. New paint application:
   - The application of new paints can include use of:
     - Primers (zinc, aluminum or lead-based);
     - Midcoats (epoxy, vinyl or lead-based coatings); and
     - Topcoats (epoxy, polyurethane, vinyl or lead-based coatings).

A more detailed overview of current bridge maintenance technology including methodologies to contain waste materials during paint removal and application operations is provided in Appendices 2, 3 and 4.

Possible Impacts of Bridge Maintenance Operations on Fish and Fish Habitat

Bridge cleaning and painting operations conducted without adequate mitigative measures may result in negative impacts on fish, fish habitat and water quality. In summary, the major concerns associated with bridge maintenance are:

1. <u>Toxicity of Products to Fish</u>. Liquid paints, primers, solvents, degreasers and rust inhibitors may be acutely toxic or lethal to fish. Acute effects are typically measured in the laboratory using bioassay tests in which fish are exposed to these products under controlled conditions for relatively short durations, usually 96 hours, which allows standardized interpretation and reporting. Toxicity test results developed over a 96-hour test period are referred to as 96-h LC50 values. LC50 is an abbreviation for median lethal concentration or the concentration of a substance or effluent that kills one-half of the test fish in a 96-hour bioassay test. LC50 values are derived by exposing the test fish to a range of concentrations of the pollutant in water and documenting the mortality over 96 hours. The final LC50 value is calculated by graphing fish mortality against contaminant concentration and selecting the median fish death as the point that determines the LC50.

   The LT50 is the time elapsed until the death of the median test fish exposed to a single concentration of a pollutant in water. The LT50 test, although easier to conduct than the LC50, provides incomplete data for an evaluation of risks to fish from abrasives and paints.

   Fish sublethal effects can also occur during or following exposure to toxicants. Although difficult to measure, such effects may, in the long term, be more damaging to fish populations than short term or acute impacts. Sublethal effects may include impaired swimming ability, reduced growth rate and reproductive failure.

   Table 1 provides acute toxicity data for liquid paints, primers and rust inhibitors. Table 2 indicates the acute toxicity of abrasives and abrasive/paint chip mixtures to salmonid fish. Data have not yet been developed for inclusion in the Guidelines on the toxicity of detergents used to degrease bridge surfaces prior to paint removal.

   Because laboratory acute toxicity tests with abrasives and abrasive/paint chip mixtures for these Guidelines did not involve resuspension or recirculation of particulate material, the tests may underestimate impacts on fish from deposition of such debris in streams where such material might be inhaled or ingested by fish. Further research-oriented tests are recognized as necessary by DFO to fully examine the potential for physical impacts (e.g. gill damage) of the abrasives on salmonid fish.

2. Product Leachability. Paint flakes, abrasive grits and abrasive/paint flake mixtures may leach toxic heavy metals into receiving waters. Such metals can accumulate in aquatic organisms, affecting their survival and possibly restricting man's use of fish. For these reasons, pollutants that are persistent or which bioaccumulate should not be released into the aquatic environment. Table 3 lists the concentrations of heavy metals in samples of paints removed from bridges. Table 4 documents the results of laboratory leaching studies conducted by the Department of Fisheries and Oceans using bridge paint flakes. The latter study demonstrated that lead leached from paint flakes into water continuously over a 12-day period causing elevated dissolved lead levels (see Table 4). Appendices 1 and 5 provide a review of lead-based paint removal and its implications to the aquatic environment.

3. Ingestion of Paint Fragments by Fish. Paint flakes and abrasives deposited in watercourses may be ingested by juvenile salmonids (see Table 5) (B.C. Research 1988). Paint flakes so ingested could dissolve and release metals in the acidic conditions of the fish gut. Paint fragments and abrasives suspended in the water column may also clog and abrade fish gills, leading to bleeding, infection and impaired respiratory function.

4. Deposition of Debris into Fish Habitat. The deposition of sand, grit and paint chips into fish habitat can inundate gravels smothering eggs and fish food organisms, and can bury aquatic plants. This alteration or destruction of fish habitat may negatively affect fish stocks. Langer (1980) reported that a 55% decrease in salmon egg survival resulted from a 12% increase in suspended solids in the Coquitlam River. This finding is particularly important because, under good natural conditions, only 9 to 30% of salmon eggs survive to emergence (Lill et al. 1983). Deposition of sandblasting materials on marine foreshore areas may also smother intertidal benthic fauna and flora.

To assist proponents and agencies preparing or reviewing bridge maintenance proposals, bridge cleaning and painting materials have been placed in Schedules 1 or 2 (Appendix 5), based on fish toxicity data and environmental persistence. Schedule 1 includes materials which could pose moderate to high risks to fish if deposited in fishery waters. Schedule 2 includes materials of low to moderate risk to fish and fish habitat. Specific guidance on the use of Schedule 1 or 2 materials is provided within sections on mitigative strategies for paint removal and paint application operations.

PREPARATION AND REVIEW OF BRIDGE MAINTENANCE PROPOSALS

Pre-Proposal Planning

Consultations between proponents (e.g. B.C. Ministry of Transportation and Highways, Public Works Canada, railway companies) and resource and regulatory agencies (e.g. Department of Fisheries and Oceans and B.C. Ministry of Environment) should be conducted during the early planning stages. The purpose of these consultations is to review timing and to identify requirements for mitigating impacts (e.g. alternative methods of bridge shrouding) prior to preparing formal proposals and receiving bids. Figure 4 is a guide to the proposal review process.

The pre-proposal consultation (e.g. meeting) should take place at least 60 days prior to submission of a formal proposal as discussed in the following section. Proponents should be prepared to provide and discuss the following information at this meeting:

(1) Geographic location of the bridge and the adjacent waterbodies. Maps should be provided describing the exact location of the bridge;

(2) Proposed timing and duration of the project;

(3) Bridge cleaning techniques to be employed, including a list of degreasers, rust inhibitors and abrasives proposed for use;

(4) A description of the types or names of the paints to be removed;

(5) Possible paints that may be used, including the brand name and product name (lot number if available);

(6) Measures to be employed to protect fishery waters and fish habitat from bridge maintenance products and an estimate of losses of liquid paint overspray, abrasives and paint chips;

(7) Name, address and telephone number of a senior project contact.

The Submission of a Proposal

Contractors, B.C. Ministry of Transportation and Highways, Public Works Canada and railway operators planning to carry out maintenance operations on bridges that cross fish sensitive streams, riparian zones or nearshore marine areas in B.C. should be aware of their responsibility to prepare a written proposal outlining the work for review by the Department of the Environment (Environmental Protection, EP) and the Department of Fisheries and

Oceans (DFO). Such proposals should include information specific to each bridge including detailed information requested for the pre-proposal meetings.

The bridge maintenance proposal should be submitted for review to:

Coordinator Referrals and Liaison
Environment Canada,
224 West Esplanade,
North Vancouver, B.C. V7M 3H7

Where possible, formal proposals should be received by Environmental Protection at least 45 days prior to the proposed starting date of maintenance operations to allow for adequate review. EP will forward the referral to DFO and other relevant agencies for review. Provincial positions (e.g. Ministry of Environment) on proposals will be solicited by EP, where appropriate.

The Proposal Review Process[a]

Factors that will be considered during the review of proposals for bridge maintenance activities include:

(1) Fishery resources in waterbodies;

(2) Timing of bridge maintenance projects with regard to fish presence;

(3) Size, flow and current characteristics of the waterbodies;

(4) Proposed procedures and technology to mitigate impacts to fish and fish habitat;

(5) Contingency plans in the event of a spill of bridge maintenance products/wastes into fish habitat;

(6) Paint removal strategies;

(7) Toxicity data for abrasives, rust inhibitors, degreasers and paints, including any catalysts, promoters and thinners which may be used; and

---

[a]Proposed bridge maintenance activities will be screened by DFO and EP under the Environmental Assessment and Review Process Guidelines Order (1984). Details of this review process or the new process to be implemented pursuant to the promulgation of new federal environmental assessment legislation (i.e. the enactment of Bill C-78) will be included in the next (second) edition of these Guidelines.

(8) Data on leaching characteristics of paints to be removed.

When the proposal review is completed, a government response will inform the proponent whether the project should proceed as planned and may outline specific recommendations to minimize impacts on fish and fish habitat. For locations where fisheries resource information is not available, proponents will be informed of their responsibility to collect the required information. Further, proponents will be responsible for the provision of acute fish toxicity and chemical leaching data which are not otherwise available. There may be situations where, because of timing, presence of certain fish life stages, inability to satisfactorily mitigate potential impacts or other concerns, that bridge maintenance projects are postponed or rejected.

MITIGATIVE STRATEGIES APPLICABLE TO BRIDGE MAINTENANCE OPERATIONS FOR THE PROTECTION OF FISH AND FISH HABITAT

Suspension of Works

If all EP/DFO conditions are not met via project review, EP and DFO reserve the right under the Fisheries Act to immediately suspend, restrict or request modification to bridge cleaning and painting operations proposed, or in progress, in order to protect fish and fish habitat.

Timing

Bridge maintenance operations should be scheduled to avoid times of salmon egg incubation, juvenile fish rearing and downstream migration (see Figure 3). It is recognized, however, that some species of salmon (e.g. coho and sockeye) may be present in streams and lakes year round. In general, bridge maintenance operations should be planned to avoid periods of fish presence or to coincide with periods when fish are least vulnerable due to life cycle factors. Due to the stream-specific timing of salmon life cycles, more detailed timing guidance will be provided to operators by EP/DFO during pre-proposal meetings and upon review of individual proposals.

Swing Span Gear Degreasing

Degreasing of moving bridge parts is conducted on a routine basis and not always in conjunction with painting operations. Excess grease should be manually removed and collected for disposal without any deposition into waterbodies.

Surface Degreasing

Flushing of the bridge surface is conducted to remove grease film prior to painting. Where possible, water without additives should be used; any cleaning agents which may be required should be specified in the project proposal. Toxicity testing of the agents will be required if existing fish toxicity data are not available. Removal of water from watercourses for flushing of the bridge surface should be carried out in accordance with the DFO Fish Screening Directive (Appendix 9).

Paint Removal Operations

Several techniques are commonly used to mitigate paint and abrasive losses to watercourses during bridge cleaning. The following is a summary of those techniques. More detail is provided in Appendices 2 and 3.

Ground covers such as sheets of plastic or air-permeable cloth (e.g. burlap or canvas) can be spread horizontally to capture falling debris. These may be supplemented by vertical drapes to improve containment performance. Lined nets or tarpaulins are commonly suspended beneath bridge sections to capture debris where wind conditions are suitable for their use. Blast enclosures comprising custom-fabricated structures to encase sections of a bridge can be erected before abrasive blasting. Vacuum-shrouded power tools are also used to collect debris as it is generated, however, they are ineffective on complex structures since a vacuum cannot be maintained. Floating booms and barges can be deployed in watercourses to trap floating debris, such as paint flakes and dust from being carried downstream or laterally into the margins of the watercourse. Material trapped by such booms must be removed immediately to prevent debris from settling to the bottom. Prior approval for deployment of booms and barges must be obtained from EP/DFO.

When selecting an appropriate technique for removing paint the following points should be considered:

(1) Pressurized water blasting without additives should be used wherever possible rather than blasting using sand or grit for paint removal in order to avoid the deposition of abrasives into fish spawning and rearing areas and consequent impacts on fish habitat. However, when leachable lead-based paint is to be removed from a bridge, hydroblasting should only be used where it is possible to capture the paint chips for subsequent disposal (see Appendix 2, Item 6).

(2) Hydroblasting which employs chemical agents (e.g. rust inhibitors) may necessitate toxicity testing of additives and/or final mixtures prior to use. All chemical additives and any fish toxicity data should be specified in the bridge maintenance proposal submitted for review.

(3) If paint flakes and abrasive/paint flake mixtures are "leachable" wastes (Special Waste Regulations, B.C. Waste Management Act) due to their soluble metals content, entry of such materials into waterbodies should be prevented to protect fish. Paint chips and abrasives should be contained for disposal using plastic or cloth shielding, drapes or tarpaulins. Barges and floating booms should be used to trap particulate material when shrouding is not adequate, to prevent losses into sensitive fishery zones, such as spawning areas or rearing habitats. When wind conditions preclude effective capture of paint/abrasive material over sensitive fishery areas, bridge paint removal should not proceed.

(4) Removal of water from watercourses for hydroblasting should be carried out in accordance with the DFO Fish Screening Directive (Appendix 9).

Bridge cleaning materials appearing in Schedule 1 (Appendix 5) should be used only if their entry into sensitive fishery areas can be well controlled by enclosing (e.g. shrouding or diapering) the bridge sections to be cleaned to prevent or minimize losses to receiving waters. This requirement is especially important where the paint to be removed has "leachable" characteristics according to the B.C. Special Waste Regulations (i.e. spent abrasive and paint flakes that are found to leach 5 ppm or more of dissolved lead using the provincial Leachate Extraction Procedure). Use of hand-operated power tools for paint removal may offer the best control of particulate wastes in highly sensitive fishery areas. However, this method of paint removal may result in more frequent repainting. If leachable lead paints are to be removed, capture of the paint chips and abrasive is required.
Losses of Schedule 2 (Appendix 5) bridge cleaning materials into fish frequented waters is of less concern than those in Schedule 1. Timing the work to avoid fish presence will generally satisfy fish and fish habitat protection requirements. No deposition of Schedule 1 or 2 paint or abrasive debris should occur in small streams, riparian areas or marine foreshore zones. Specific requirements for necessary mitigation would be identified during pre-proposal planning. Where riparian and foreshore protection is necessary on large rivers, lakes and marine areas, measures should be taken to capture paint and abrasive debris.

It is the responsibility of the proponent to ensure that only those abrasives approved by regulatory agencies during the proposal review are used during the bridge maintenance operation.

Paint Application Operations

Similar to the techniques outlined previously for the capture of bridge cleaning wastes, shrouding or wrapping of bridge sections may assist in mitigating paint spray drift, where wind conditions permit the deployment of such measures. More detailed mitigative measures are outlined in Appendix 4.

Paint is most commonly sprayed on bridges with air-pressured or airless systems. Electrostatic techniques may also be used for application of paint on clean steel surfaces, however, their use is infrequent due to poor performance in confined areas. There is no spray drift associated with brush and roller applied paint, however, this method of paint application may create an increased risk for accidental spills.

When selecting the type of paint to apply and method of application, the following points must be addressed:

(1) Bridge painting over sensitive fish habitats can impact fish and fish habitat unless adequate measures are taken to contain wet paint spray drift (see (2) and (3) below). Site-specific requirements to optimize protection of fishery areas from spray drift will be developed by EP/DFO during pre-proposal planning. The final proposal should include steps that the contractor believes can be taken to prevent drift of paint spray.

(2) Coating materials appearing in Schedule 1 (Appendix 5) should only be used if it is possible to reasonably control losses into areas identified as sensitive (e.g. small salmon streams, riparian zones and marine foreshore areas), through draping of the structure or other measures.

(3) The entry of Schedule 2 (Appendix 5) paints into sensitive fishery areas is of less concern than those of Schedule 1. Draping of the bridge during application of Schedule 2 paints generally will not be required if the work is timed to avoid periods less sensitive to fish. Of particular concern, however, are very low bridges over small streams that are sprayed during periods of fish presence. Overspray with Schedule 2 paint in such cases should be controlled with draping unless it can be shown that the solvent in the wet paint droplets (a primary toxicant in most paints) will evaporate before the overspray lands on the water. Plastic sheets and tarpaulins of absorbent material should be used in such cases to minimize overspray losses. Fast drying paints, those with a high solids content, and paints which do not require solvent addition (i.e. paints that have been thinned by the manufacturer) should be used to reduce toxic risks to fish. Paint application equipment should be properly adjusted to minimize spray drift at all times.

(4) Coatings chosen should have the greatest life expectancy, provided that toxicity or other factors do not preclude their use.

General Mitigative Strategies

(1) Waste materials collected during cleaning and painting operations (e.g. blasting abrasives, paint particles, rust and grease), if they are not special/hazardous wastes, should be retained for disposal at a municipal landfill. <u>Waste materials must not be deposited into watercourses, riparian zones or marine foreshore</u>

areas. Heavy metals in paint chips/abrasives, and organic compounds in solvents and paints may preclude their disposal at municipal landfills. As stated above, the B.C. Special Waste Regulations (Waste Management Act) should be consulted regarding the classification and the appropriate disposal of special/hazardous wastes. For information on the disposal of wastes, representatives of the B.C. Waste Management Branch should be contacted (see Appendix 11).

(2) Storage, mixing and transfers of paints and solvents should be carried out on land and not on the bridge so that spill potential has been minimized. Materials left unattended at work sites should be secured in a locked enclosure to minimize vandalism. Operators should carry minimum quantities of paints and solvents in the work area. Contracting firms should ensure that staff are adequately trained in spill response and reporting procedures.

(3) Painting equipment must never be cleaned in watercourses; contaminated water flowing from onshore cleaning operations must not be permitted to enter watercourses.

(4) All work must be carried out in a manner which prevents damage to riparian vegetation and marine foreshore areas.

(5) Operators should be familiar with the spill response procedures, including containment methods outlined in Appendix 10, in case of an environmental emergency such as losses of paint, solvent or debris (e.g. abrasives or paint chips) into a waterbody or riparian/foreshore zone. Spill cleanup equipment should be on-site.

ACKNOWLEDGMENTS

The authors would like to thank R. Watts and his staff at the Environmental Protection Aquatic Toxicity Laboratory who offered valuable assistance in the design and development of the bioassay program reported herein and bioassay test results for a number of paint products. Abrasives toxicity data were provided by S. Yee, EP.

Constructive comments from DFO Divisional Habitat Management staff were most useful in ensuring that these Guidelines address current industrial practices in bridge maintenance and specific habitat management concerns.

Individuals of the bridge cleaning, and the painting and coatings industries offered valuable technical input which facilitated the development of these Guidelines and provided paint and abrasives products for bioassay testing and data for inclusion in the Guidelines.

R. Raine of the B.C. Ministry of Transportation and Highways was instrumental in ensuring the Guidelines reflect the practices of his ministry. Helpful comments from the B.C. Ministry of Environment, Public Works Canada and Environment Canada also contributed to the development of these Guidelines.

P. Futer prepared initial drafts of this manuscript. S. Gramchuk of XY3 Graphics prepared the figures.

REFERENCES

Banov, A. 1978. Paints and coatings handbook for contractors, architects, builders and engineers. 2nd edition. Farmington, Mich.: Structures Pub. Co. 432 p.

Batton, M. and F.R. Leech. 1988. Protecting the environment during coating rehabilitation in Ontario. In: Appleman et al. (Ed.) pp: 148-174. Proceedings of the Steel Structures Painting Council Symposium on Lead Paint Removal from Steel Structures. Feb. 29-Mar. 1, 1988. Arlington, Va.

B.C. Research. 1988. New Westminister Railway Bridge, spread span painting environmental assessment. Report prepared for Dept. of Public Works, Vancouver, B.C. 17 p.

Birtwell, I.K., J.C. Davis, M. Hobbs, M.D. Nassichuk, M. Waldichuk and J.A. Servizi. 1981. Brief presented to the British Columbia Pollution Control Board inquiry pertaining to the Annacis Island Sewage Treatment Plant and municipal waste discharges into the lower Fraser River. Can. Ind. Rep. Fish. Aquat. Sci. 126: xi + 40 p.

Hower, H. 1988. The dilemma of removing lead-based paint. Journal of Protective Coatings and Linings. January 1988: 30-37.

Langer, O.E. 1980. Effects of sedimentation on salmonid stream life. Paper presented at the Technical Workshop on Suspended Solids and the Aquatic Environment. June 17/18, 1980. Whitehorse, Yukon Territory. 20 p.

Lill, A.F., A. Tautz, B.G. Shepherd, J.R. Wild, D.E. Marshall, W. Schouwenburg and B. Tutty. 1983. Opportunities for salmonid enhancement projects in B.C. and the Yukon. Report of the Enhancement Opportunities Committee, Salmonid Enhancement Program, DFO. Vancouver, B.C. 160 p.

Lunardini, J. 1988. Current blasting technologies. In: Appleman et al. (Ed.) pp: 93-108. Proceedings of the Steel Structures Painting General Symposium on Lead Paint Removal from Steel Structures. Feb. 29-Mar. 1, 1988. Arlington, Va.

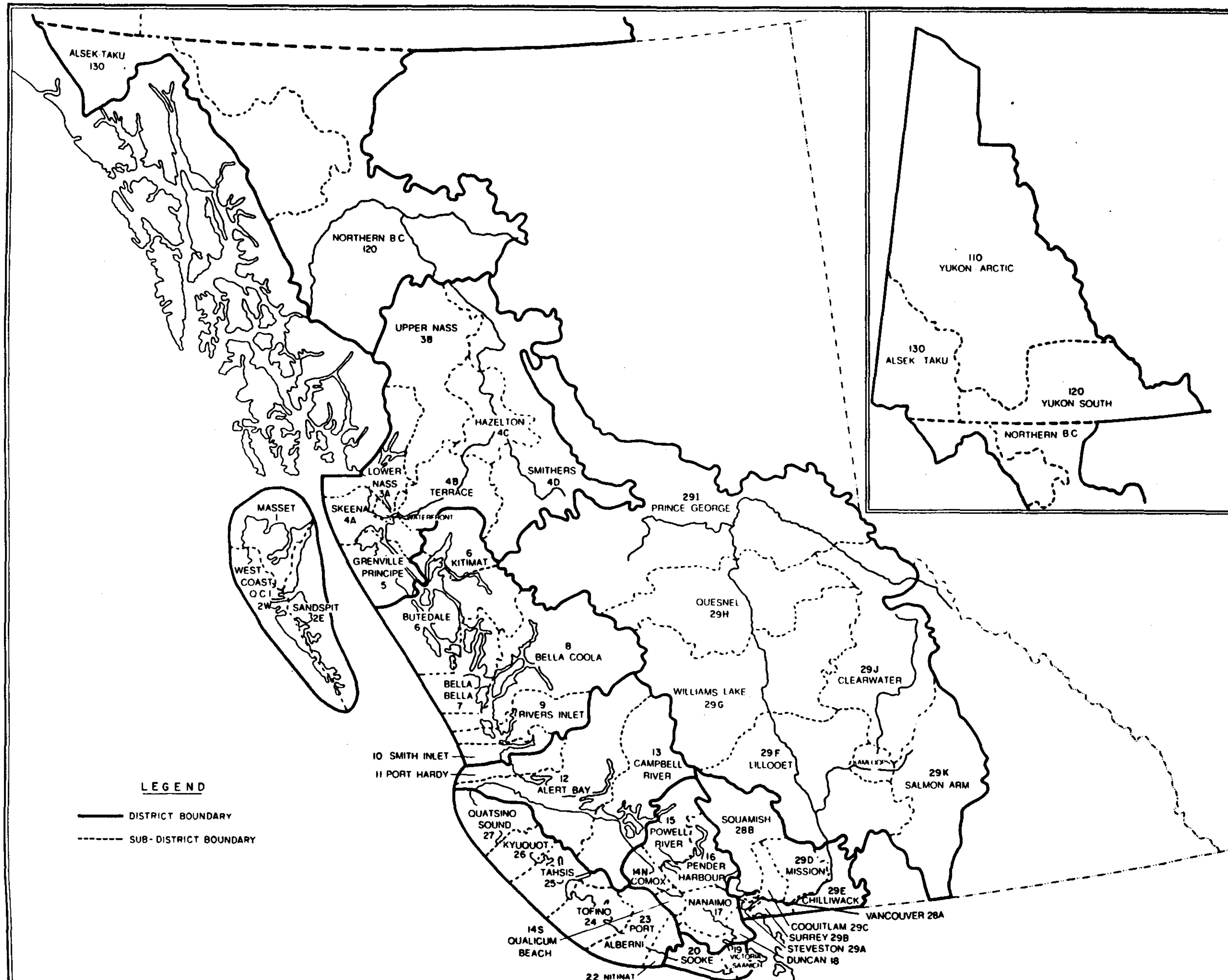
Morgans, W.M. 1982. Outlines of paint technology. Volume 2. Finished Products. Charles Griffin, London.

Parks, D.M. and G.R. Winters. 1982. Long term environmental evaluation of paint residue and blast cleaning abrasives from the Middle River Bridge repainting project. California Department of Transportation, Division of Construction, Office of Transportation Laboratory. Interim Research Project Report. FHWA/CA/TL-82/09. 28 p.

Snyder, M.K. and D. Bendersky. 1983. Removal of lead-based bridge paints. National Cooperative Highway Research Program Report 265. 73 p.

Trimber, K. 1988. The Coating Consultant. Issue 2. KTA-Tator Inc. Pittsburgh, Pa. 4 p.

Trimber, K. and Solomon, S. 1988. Analysis of leachable lead on bridges of the Port Authority of New York and New Jersey. In: Appleman et al. (Ed.) pp: 133-147. Proceedings of the Steel Structures Painting Council Symposium on Lead Paint Removal from Steel Structures. Feb. 29-Mar. 1, 1988. Arlington, Va.



DISTRICT #1 — KAMLOOPS
Subdist 29F - Lillooet
Subdist 29G - Williams Lake
Subdist 29H - Quesnel
Subdist 29I - Prince George
Subdist 29J - Clearwater
Subdist 29K - Salmon Arm

DISTRICT #2 — NEW WESTMINSTER
Subdist 28A - Vancouver
Subdist 28B - Squamish
Subdist 29A - Steveston
Subdist 29B - Surrey
Subdist 29C - Coquitlam
Subdist 29D - Mission
Subdist 29E - Chilliwack

DISTRICT #3 — NANAIMO
Subdist 14S - Qualicum Beach
Subdist 14N - Comox
Subdist 15 - Powell River
Subdist 16 - Pender Harbour
Subdist 17 - Nanaimo/Ladysmith
Subdist 18 - Duncan

DISTRICT #4 — PORT ALBERNI
Subdist 22 - Nitinat
Subdist 23 - Port Alberni
Subdist 24 - Tofino
Subdist 25 - Tahsis
Subdist 26 - Kyuquot
Subdist 27 - Quatsino Sound

DISTRICT #5 — CAMPBELL RIVER
Subdist 11 - Port Hardy
Subdist 12 - Alert Bay
Subdist 13 - Campbell River

DISTRICT #6 — VICTORIA
Subdist 19 - Victoria/Saanich
Subdist 20 - Sooke

DISTRICT #7 — CENTRAL COAST
Subdist 6 - Kitimat/Butedale
Subdist 7 - Bella Bella
Subdist 8 - Bella Coola
Subdist 9 - Rivers Inlet
Subdist 10 - Smith Inlet

DISTRICT #8 — PRINCE RUPERT
Subdist 3A - Lower Nass
Subdist 3B - Upper Nass
Subdist 4A - Lower Skeena
Subdist 4B - Terrace
Subdist 4C - Hazelton
Subdist 4D - Smithers
Subdist 5 - Grenville Principe

DISTRICT #9 — QUEEN CHARLOTTE ISLANDS
Subdist 1 - Masset
Subdist 2W - West Coast Q.C.I.
Subdist 2E - Sandspit

DISTRICT #10 — WHITEHORSE
Subdist 110 - Yukon Arctic
Subdist 120 - Yukon — North B.C.
Subdist 130 - Alsek — Taku

Figure 1 DFO Pacific Region Subdistricts and Districts

Department of Fisheries and Oceans Habitat Management, District and Subdistrict Offices.

1. FRASER RIVER, NORTHERN B.C. AND YUKON DIVISION

	Phone
<u>Habitat Management</u>	666-0315
<u>New Westminster District</u>	666-2618
Vancouver Subdistrict	666-0814
Coquitlam Subdistrict	666-8590
Surrey Subdistrict	666-6742
Chilliwack Subdistrict	792-1995
Mission Subdistrict	826-3664
Squamish Subdistrict	892-3230
Steveston Subdistrict	274-7217
<u>Kamloops District</u>	374-4322
Clearwater Subdistrict	674-2633
Lillooet Subdistrict	256-4525
Prince George Subdistrict	561-5366
Quesnel Subdistrict	992-2434
Salmon Arm Subdistrict	832-8037
Williams Lake Subdistrict	398-6544
<u>Whitehorse District</u>	667-2235
Alsek-Taku Subdistrict	634-2235
Yukon-Arctic Subdistrict	667-2235
Yukon-South & Northern B.C. Subdistrict	667-2235

2. SOUTH COAST DIVISION

	Phone
<u>Habitat Management</u>	756-7284
<u>Nanaimo District</u>	754-0235
Nanaimo Subdistrict	754-0230
Duncan Subdistrict	746-6221
Comox Subdistrict	339-2031
Qualicum Subdistrict	752-9712
Pender Harbour Subdistrict	883-2312
Powell River Subdistrict	485-7963
<u>Port Alberni District</u>	724-0195
Port Alberni Subdistrict	724-0195
Tofino Subdistrict	725-3468
Tahsis Subdistrict	934-6606
Kyuquot Subdistrict	934-6606
Nitinat Subdistrict	724-0195
<u>Campbell River District</u>	287-2102
Campbell River Subdistrict	287-2102
Alert Bay Subdistrict	974-5216
Quatsino Sound Subdistrict	949-6731
Seymour Inlet Subdistrict	949-6731
<u>Victoria District</u>	388-3252
Victoria/Saanich Subdistrict	388-3252
Sooke Subdistrict	642-5322

3. NORTH COAST DIVISION

	Phone
<u>Habitat Management</u>	624-0453
<u>Prince Rupert District</u>	624-9137
Grenville Principe Subdistrict	624-0405
Waterfront Subdistrict	624-0401
Hazelton Subdistrict	842-6327
Lower Nass Subdistrict	624-0406
Smithers Subdistrict	847-2312
Terrace Subdistrict	635-2206
Upper Nass Subdistrict	633-2408
Skeena Subdistrict	624-0404
<u>Central Coast District</u>	624-0423
Bella Bella Subdistrict	957-2363
Bella Coola Subdistrict	799-5345
Rivers Inlet-Smith Inlet Subdistrict Campbell R. Radio	N688739
Butedale Subdistrict	624-0424
Kitimat Subdistrict	632-4884
<u>Queen Charlotte Islands (Q.C.I.) District</u>	559-4413
West-Coast Q.C.I. Subdistrict	559-4413
Masset Subdistrict	626-3316
Sandspit Subdistrict	637-5340

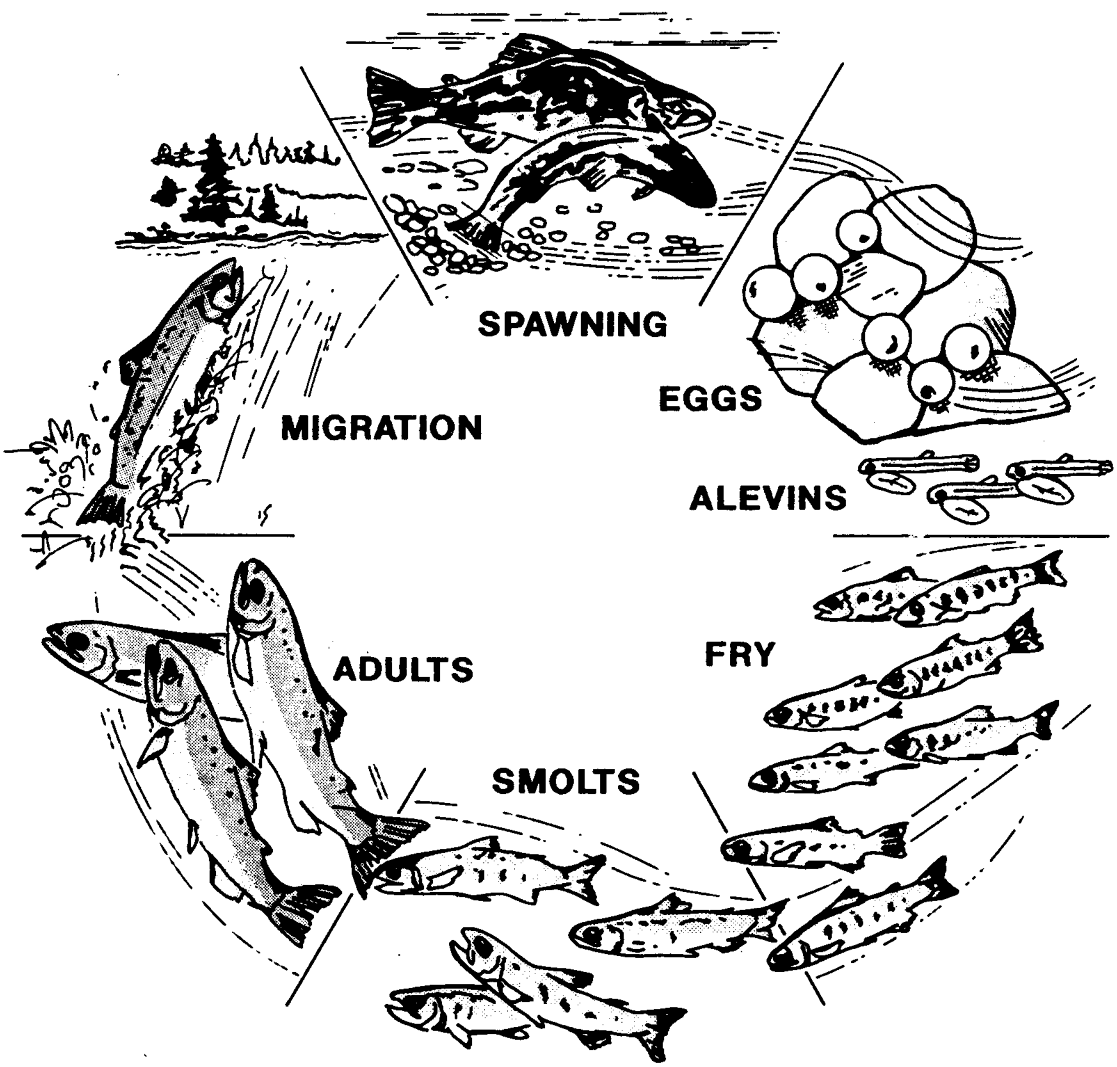


Figure 2 The generalized life cycle of Pacific salmon

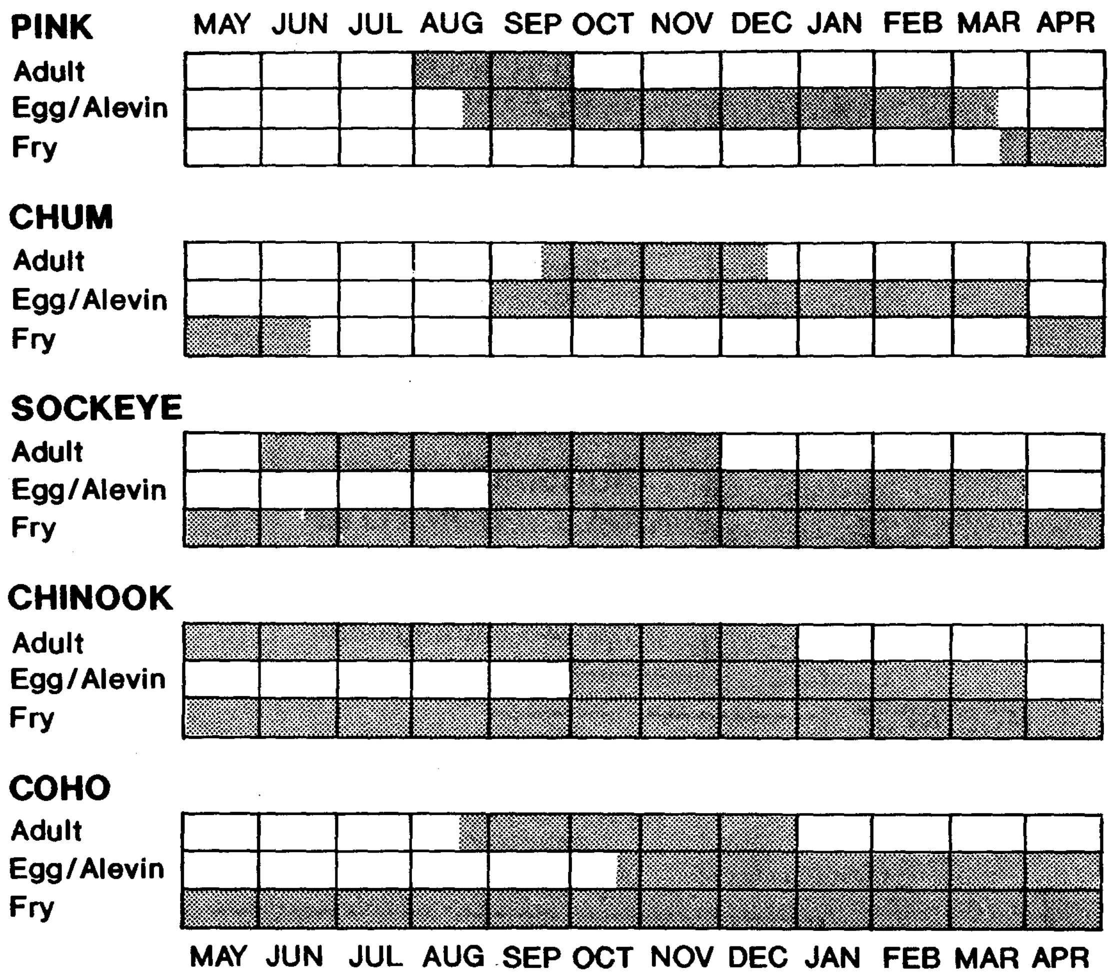
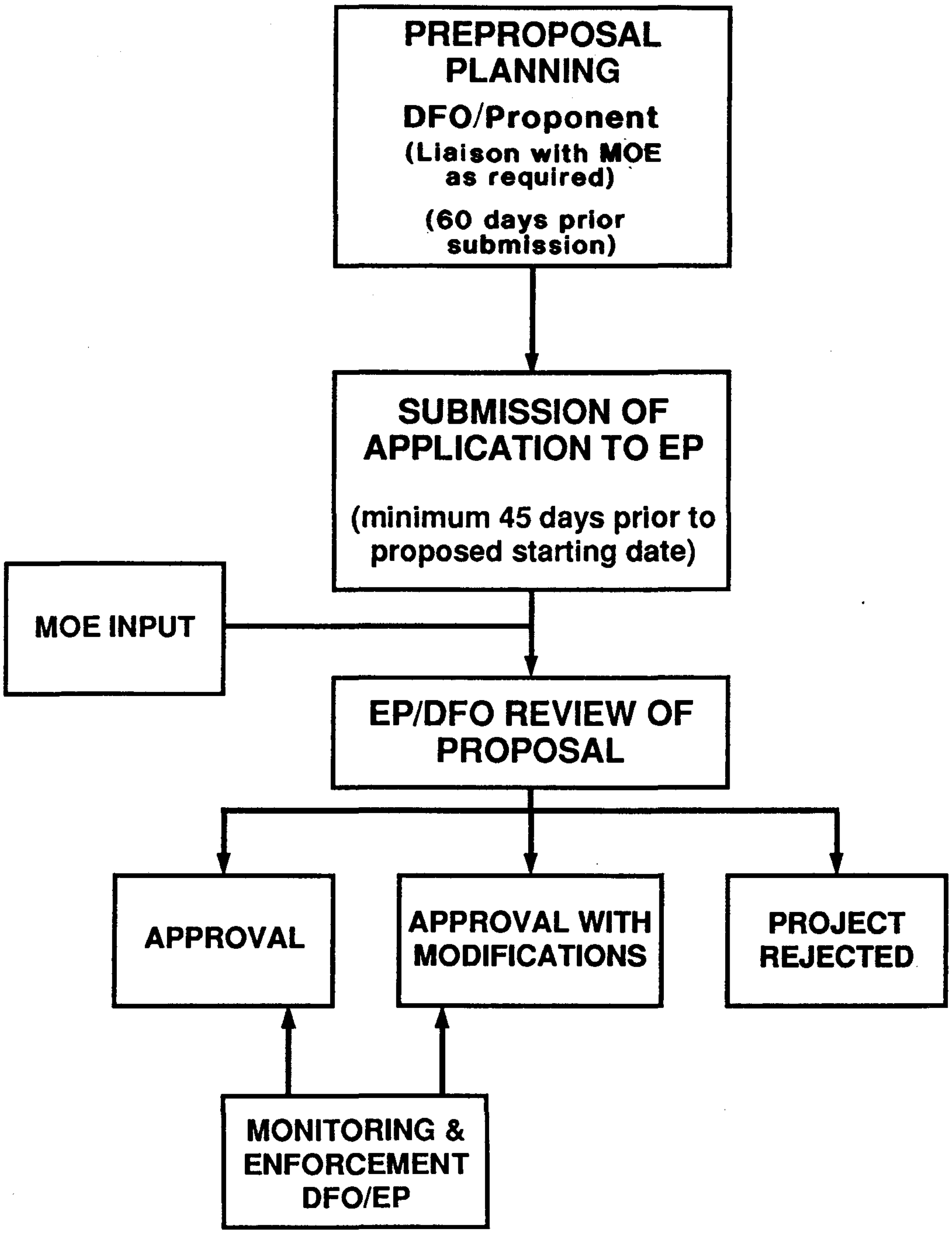


Figure 3 The presence of the various life stages of Pacific salmon in freshwater

Figure 4 Bridge maintenance proposal review flow diagram



Figures 5-10. Bridge maintenance techniques used to minimize deposition of solid wastes and paint spray drift into waterbodies during maintenance operations

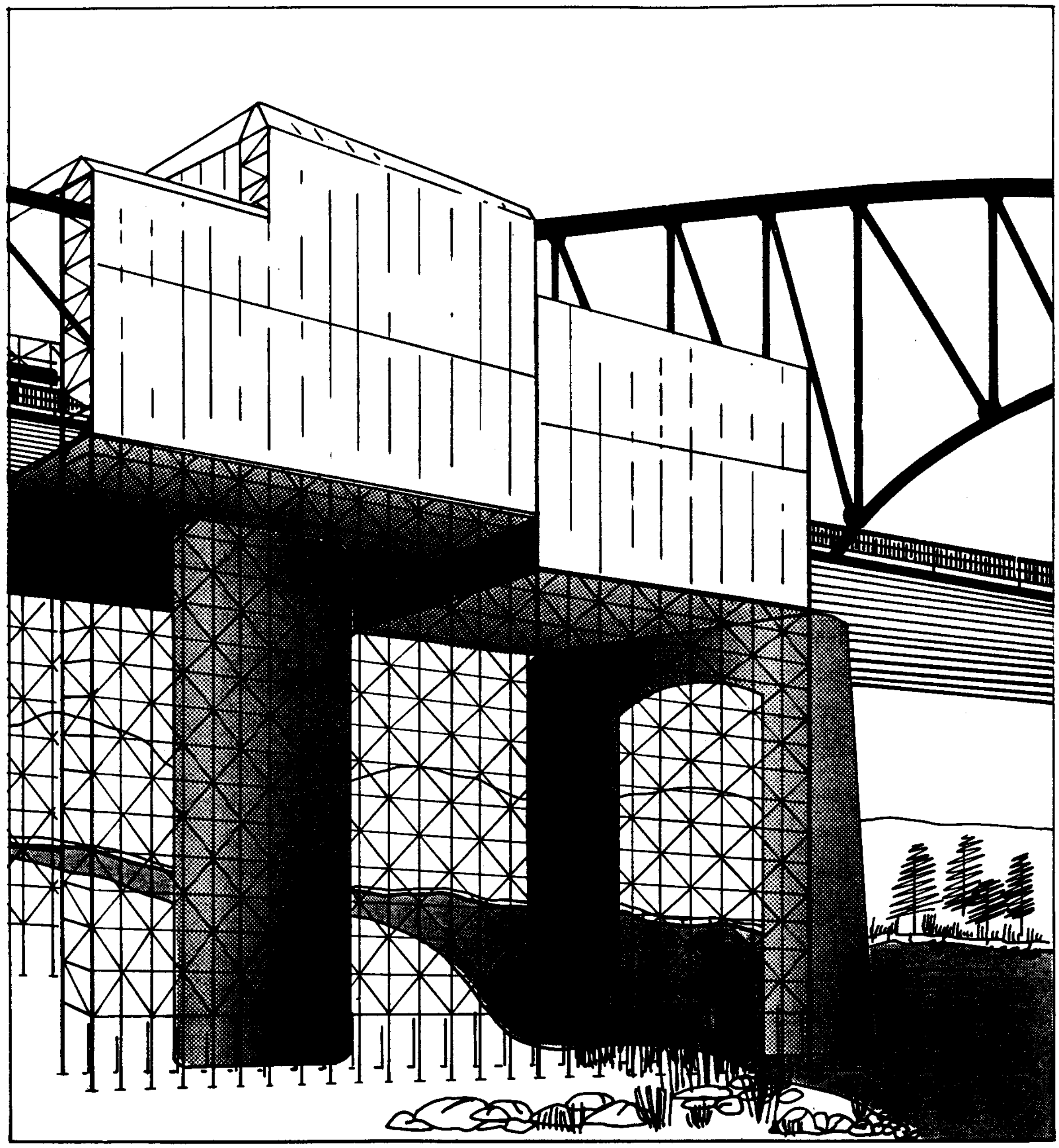


Figure 5 Scaffolding, lumber, polyethylene sheet/canvas tarpaulins completely encase sections of a bridge to confine blasting debris and paint overspray (Adapted from Lunardini 1988)

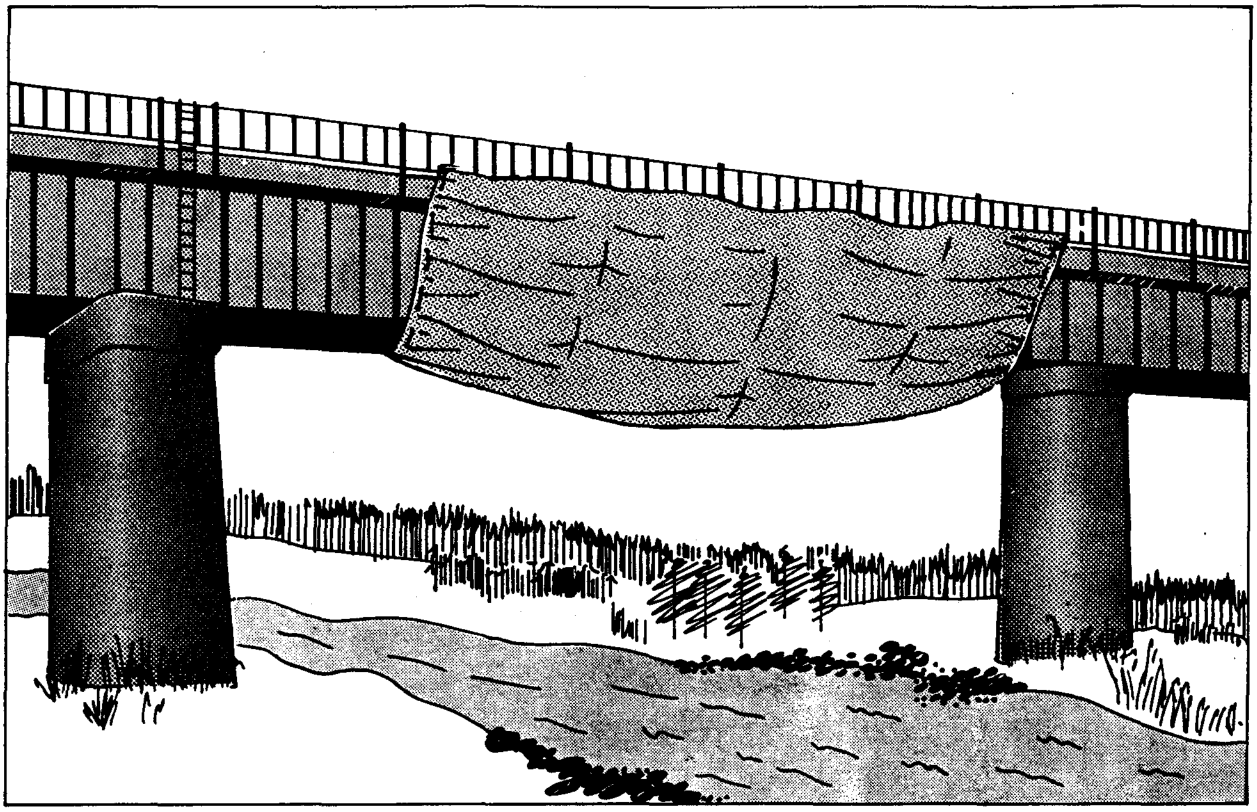


Figure 6 Lined nets suspended under bridge sections capture debris and paint particles.

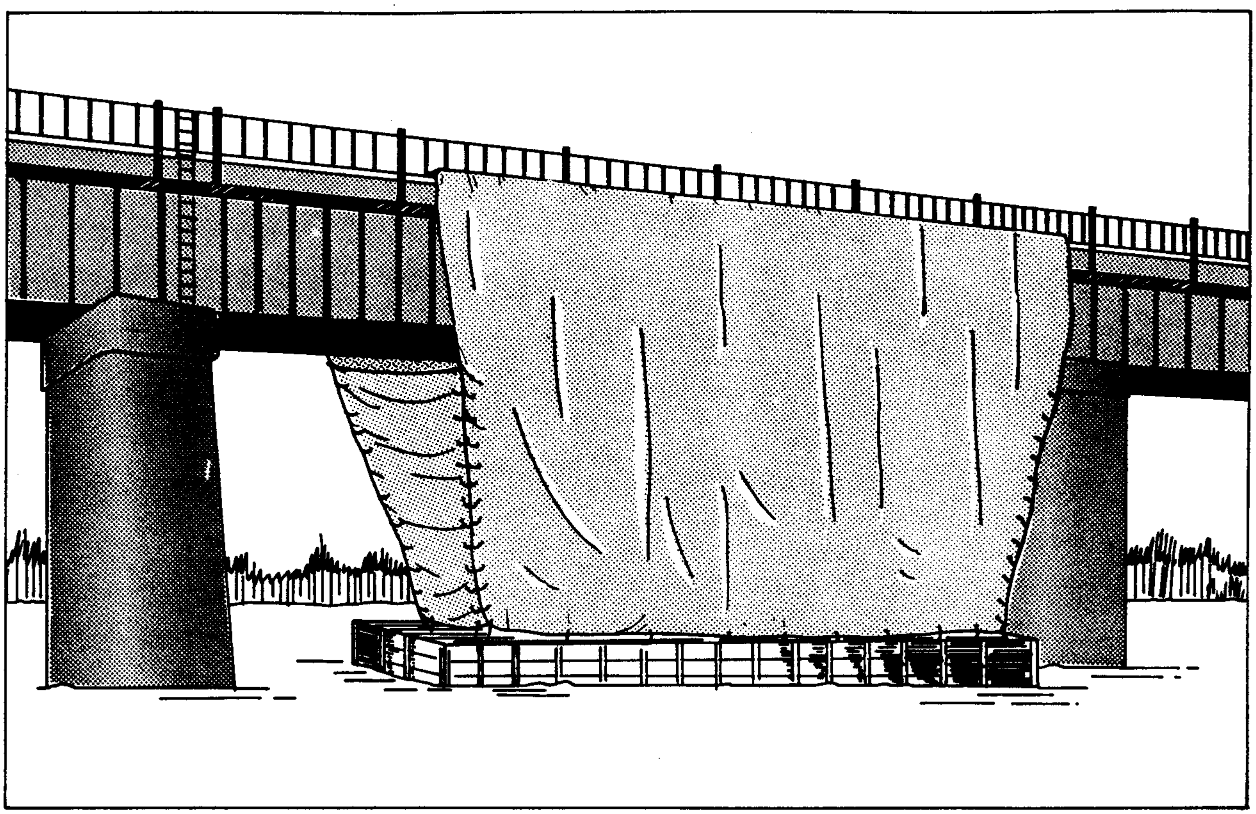


Figure 7 Hanging tarpaulins attached to a floating barge under a bridge confine debris and paint.

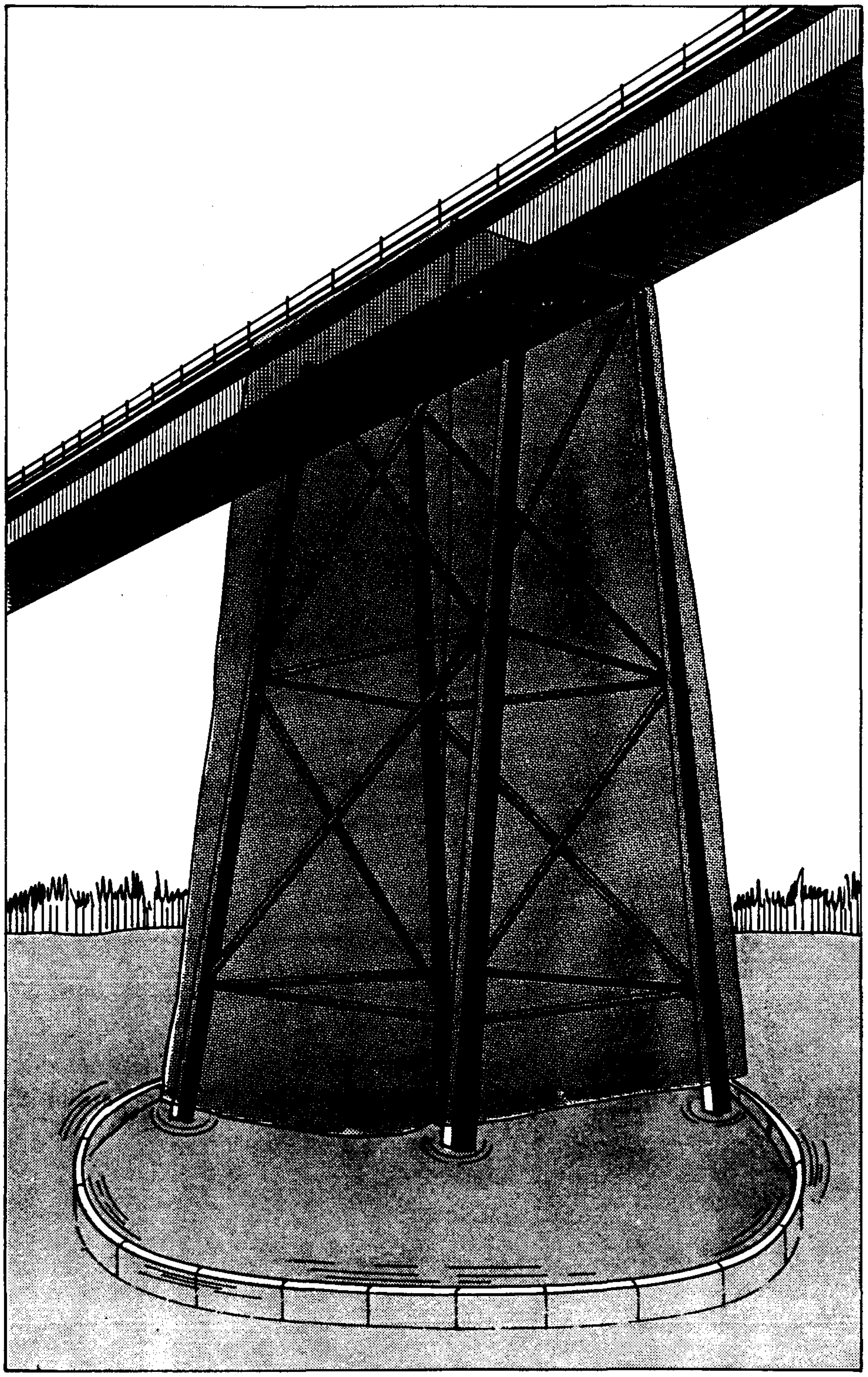


Figure 8 Hanging tarpaulins enclose a vertical bridge support.
A foam filled curtain boom contains floating debris for manual recovery.
(Adapted from Lunardini 1988)

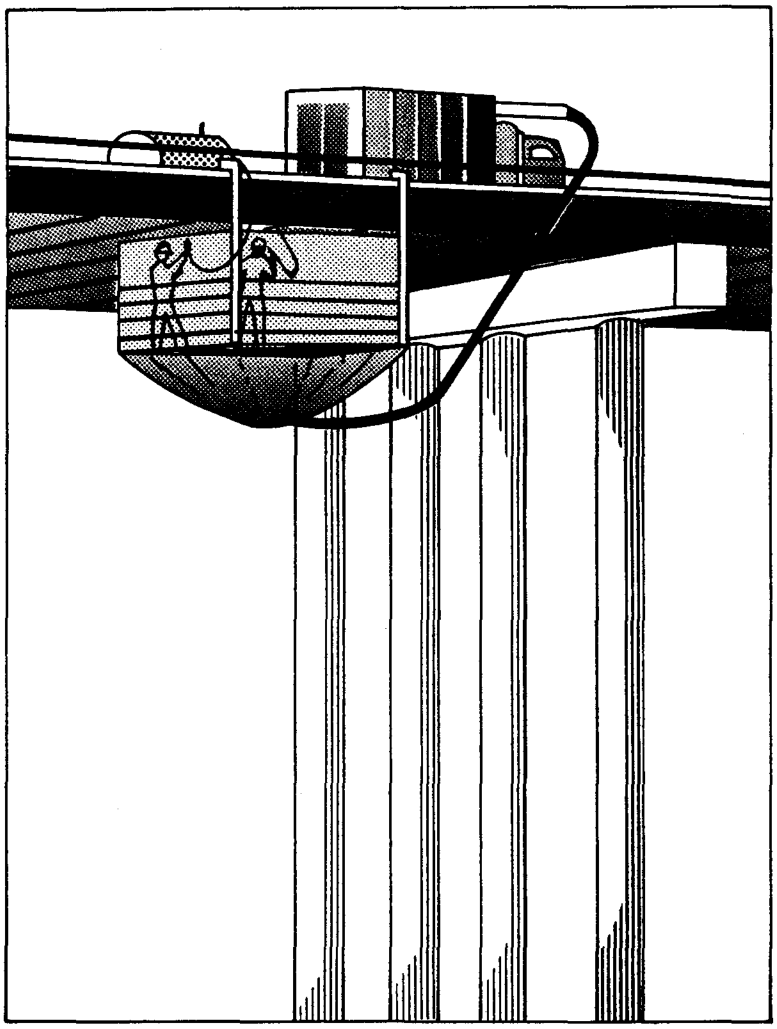


Figure 9. A fully enclosed work platform provides worker ventilation and paint and debris confinement. A truck-mounted vacuum pump captures waste materials.
(Adapted from Snyder and Bendersky 1983).

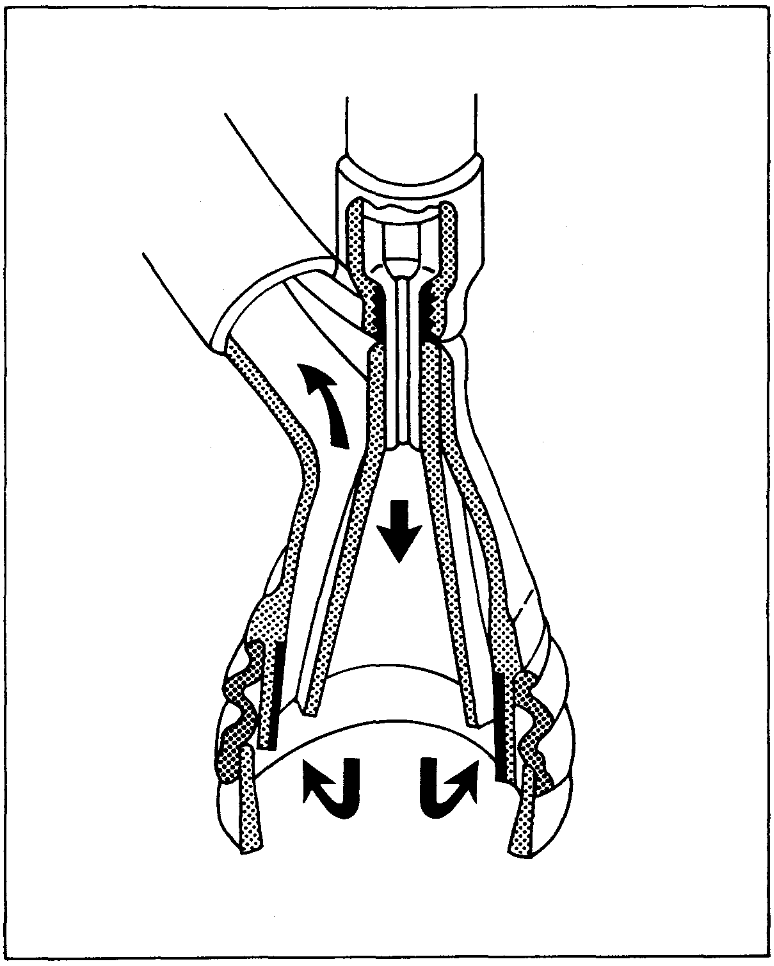


Figure 10 A vacuum/blast head captures debris as it is generated on smooth bridge surfaces. (Adapted from Snyder and Bendersky 1983)

Table 1. Fish toxicity data for bridge paints and rust inhibitors. (Juvenile rainbow trout were used as the species of test fish. Appendix 6 describes a procedure for bioassay testing of paints.)

Supplier/ Product	Date Tested	96-h LC50[a] ($mg \cdot L^{-1}$)	Comments
<u>Bapco</u>			
Al DOH C-3	21/08/78	750	topcoat
<u>Chesterton</u>			
Rust Transformer	25/09/81	150	pH unaltered
Rust Transformer	25/09/81	700	pH neutralized
<u>Corrosion</u>			
Carbomastic 15	30/11/81	50 $uL \cdot L^{-1}$	thinned with xylene
Carboline 134	17/03/88	148/148[b]	polyurethane
Carboline D801	24/03/88	559/520[b]	epoxy
Carboline D893	11/05/88	49	epoxy with 5% thinner #2
Carboline D893	24/06/88	126	epoxy with no thinners added
Carboline 658	23/06/88	77/58[b]	organic zinc primer
Carboline 658	11/05/88	4.2	same with 5% thinner #15
Carbozinc 12	11/05/88	2.0	inorganic zinc primer with 5% thinner #21
Zinc powder	22/06/88	<0.68	ingredient of zinc primers
Subox 2703	10/04/90	1000	with 10% Carboline Thinner #45
<u>Devoe</u>			
Devran 229	02/07/86	210	acrylic epoxy
Devran 229	08/03/88	318/318[b]	acrylic epoxy
Bar Rust 235	02/07/86	678	epoxy
Bar Rust 235	15/03/88	494/419[b]	epoxy
Bar Rust 235HS	23/03/88	559/318[b]	high solids epoxy
Devthane 239	02/02/87	68	polyurethane
Code X	02/02/87	148	vinyl
Columbia	24/06/88	825/792[b]	urethane aluminum primer

Footnotes to Table 1.

[a] 96-h LC50 concentrations are reported on a weight/volume basis [i.e. milligrams per litre ($mg \cdot L^{-1}$), equivalent to parts per million (ppm)] unless otherwise specified.

[b] Bioassay test was duplicated.

Table 1. (cont'd) Fish toxicity data for bridge paints and rust inhibitors. (Juvenile rainbow trout were used as the species of test fish. Appendix 6 describes a procedure for bioassay testing of paints.)

Supplier/ Product	Date Tested	96-h LC50[a] ($mg \cdot L^{-1}$)	Comments
General			
Red lead	08/08/78	27	alkyd oil
Amerlock 400	25/03/88	791/559[b]	epoxy
Amercoat 450GL	28/03/88	148/128[b]	polyurethane
International			
Intergard FP	06/04/88	748	epoxy with summer catalyst
Intergard FP	06/04/88	78	epoxy with winter catalyst
Interthane PE	06/04/88	114 $uL \cdot L^{-1}$	polyurethane
Interzinc 22	17/04/88	3.0	inorganic zinc primer
Interzinc 52	28/06/88	0.39	organic zinc primer
Interplus 56	11/04/90	599	epoxy with 5% thinner GTA 830
Sigma			
Rust-Gone 11 Finish (5612-5299)	01/09/89	141	acrylic emulsion topcoat
Colturiet-TCP	28/09/89	240	high solids epoxy
Colturiet-TCP/CSF	02/10/89	13	high solids epoxy
(Supplier unidentified)			
Sodium nitrite	07/08/81	2.2	rust inhibitor
Isopropanol	13/11/81	>5000	rust inhibitor

Footnotes to Table 1.

[a] 96-h LC50 concentrations are reported on a weight/volume basis [i.e. milligrams per litre ($mg \cdot L^{-1}$), equivalent to parts per million (ppm)] unless otherwise specified.

[b] Bioassay test was duplicated.

Table 2. Fish toxicity data for abrasives and abrasive/paint chip mixtures. (Juvenile rainbow trout were used as the test species of fish unless otherwise indicated. Appendix 7 describes a procedure for bioassay testing of abrasive and abrasive/paint chip mixtures.)

Supplier/ Product	Date Tested	Test Lab	Results	Comments[a,b,c,d]
Target				
Green diamond grit	12/04/89	EP	no mortalities	@ 6.6% by wt. over 96 h
Tuf-kut medium	12/04/89	EP	>6-<24 h	96-h LT50 @ 7.3% by wt.
Tuf-kut fine	12/04/89	EP	>6-<24 h	96-h LT50 @ 7.3% by wt.
Tuf-kut fine	04/05/89	EP	0.2%	96-h LC50 by wt.
Black Beauty	31/05/89	EP	no mortalities	@ 7% by wt. over 96 h [e]
Garnet	08/06/89	EP	no mortalities	@ 7% by wt. over 96 h [e]
OCL				
Tru-grit	11/09/86	EP	no mortalities	@ 22% by wt. over 96 h
Tru-grit	11/09/86	EP	12%	96-h LC50 by wt. (used grit)
Tru-grit	10/04/88	BCR	no mortalities	@ 10% by wt. over 96 h (used grit)
Tru-grit	12/04/88	BCR	7.1%	96-h LC50 by wt. (pink salmon exposed to used grit)
Tru-grit 16-30	12/04/88	BCR	30% mortality	@ 10% by wt. over 96 h (pink salmon exposed to used grit)
Tru-grit	27/07/89	EP	1.4%	96-h LC50 by wt.
Kleen Blast	30/08/89	EP	4.7%	96-h LC50 by wt.
Custom LM16-TG 16/30	20/11/89	EP	2.2%	96-h LC50 by wt.
LM 20/30	20/11/89	EP	no mortalities	@ 7% by wt over 96 h [e]
KB/GL 50/50	05/01/90	EP	no mortalities	@ 7% by wt over 96 h [e]
TG/GL 50/50	05/01/90	EP	no mortalities	@ 7% by wt over 96 h [e]
TG/GL 25/50	05/01/90	EP	no mortalities	@ 7% by wt over 96 h [e]

(EP=Environmental Protection; BCR=B.C. Research; EVS = EVS Consultants)

Footnotes to Table 2.

[a] 96-h LC50 is the concentration of unused or used abrasive that kills 50% of the test fish over a 96-hour exposure period.

[b] 96-h LT50 is the time required to kill 50% of the test fish exposed to a single concentration of unused or used abrasive over a 96-hour exposure period.

[c] Abrasives and abrasive/paint chip mixtures were weighed prior to the tests, as was the dilution water, providing the above weight to weight ratios as percentages.

[d] Unused sand or grit refers to sandblasting material that has not been used for removing bridge paint. Used sand or grit refers to sand blasting material that has been used for paint removal and contains paint flakes. The tested materials were unused sand or grit unless otherwise specified.

[e] 96-h LC50 tests were conducted on abrasives to a maximum concentration of 7% by weight of abrasive to diluent water.

Table 2. (cont'd) Fish toxicity data for abrasives and abrasive/paint chip mixtures. (Juvenile rainbow trout were used as the test species of fish unless otherwise indicated. Appendix 7 describes a procedure for bioassay testing of abrasive and abrasive/paint chip mixtures.)

Supplier/ Product	Date Tested	Test Lab	Results	Comments[a,b,c,d]
Aimcor				
Olivine	28/07/89	EP	no mortalities	@ 7% by wt. over 96 h [e]
Ram Products				
Sup-R-Cut 28	28/06/89	EVS	no mortalities	@ 22% by wt over 96 h
Sup-R-Cut 28	12/09/89	EP	no mortalities	@ 7% by wt over 96 h [e]
Cardium				
Frac Blast 16/40	12/09/89	EP	no mortalities	@ 7% by wt over 96 h [e]
Gen Blast 11/50	18/09/89	EP	no mortalities	@ 7% by wt. over 96 h [e]
(Supplier unidentified)				
Anyox slag	08/07/85	EP	>24-<48 h	96-h LT50 @ 6% by wt. (fish separated from test material)
Anyox slag	08/07/85	EP	>24-<48 h	96-h LT50 @ 6% by wt. (fish in contact with test material)
Fine sand	30/09/85	EP	no mortalities	@ 16.7% by wt. over 11 days

(EP=Environmental Protection; BCR=B.C. Research; EVS = EVS Consultants)

Footnotes to Table 2.

[a] 96-h LC50 is the concentration of unused or used abrasive that kills 50% of the test fish over a 96-hour exposure period.

[b] 96-h LT50 is the time required to kill 50% of the test fish exposed to a single concentration of unused or used abrasive over a 96-hour exposure period.

[c] Abrasives and abrasive/paint chip mixtures were weighed prior to the tests, as was the dilution water, providing the above weight to weight ratios as percentages.

[d] Unused sand or grit refers to sandblasting material that has not been used for removing bridge paint. Used sand or grit refers to sand blasting material that has been used for paint removal and contains paint flakes. The tested materials were unused sand or grit unless otherwise specified.

[e] 96-h LC50 tests were conducted on abrasives to a maximum concentration of 7% by weight of abrasive to diluent water.

Table 3. Results of metals analyses conducted on old paint sampled from two Lower Mainland bridges.

Total metals	Symbol	Total metal concentration ($ug \cdot g^{-1}$)[a] Camp Slough bridge paint	Coquitlam River bridge paint
Arsenic	As	< 30	< 30
Boron	B	9.7	< 1.0
Beryllium	Be	< 0.1	< 0.1
Bismuth	Bi	< 20	< 20
Cadmium	Cd	< 0.3	< 0.3
Cobalt	Co	52	34
Copper	Cu	16	166
Mercury	Hg	< 10	50
Molybdenum	Mo	< 3	9
Nickel	Ni	188	86.5
Lead	Pb	798	42800
Antimony	Sb	< 10	50
Selenium	Se	< 10	< 10
Thorium	Th	< 5	< 5
Uranium	U	< 30	< 30
Zinc	Zn	954	1064

Footnotes to Table 3.

[a] Micrograms per gram, equivalent to parts per million (ppm)

Table 4. Results of 12-day leaching trials using bridge paint chips in North Vancouver municipal water and Fraser River water.

Treatment	Days Tested	Dissolved Metal Concentration ($ug \cdot L^{-1}$)[a] Cd	Cr	Cu	Fe	Pb	Hg	Ni	Zn
Control A									
North Van.	0	0.4	<0.2	1.9	22.7	<2.0	<5.0	<0.5	5.5
municipal	1	<0.2	<0.2	1.3	23.1	<2.0	<5.0	<0.5	7.2
water	6	0.3	2.0	2.2	29.6	3.0	<5.0	1.2	6.1
	12	0.4	<0.2	2.6	20.1	4.0	<5.0	<0.5	6.9
Treatment A1[b]									
Camp Slough	1	<0.2	<0.2	<0.5	14.5	3.0	<5.0	<0.5	19.1
bridge paint	6	0.5	0.9	13.7	37.3	<2.0	6.0	5.8	<2.0
@ 50 $g \cdot L^{-1}$	12	0.3	0.7	5.1	7.3	13.0	<5.0	1.7	24.6
Treatment A2[b]									
Coquitlam R.	1	<0.2	<0.2	7.0	62.4	149	<5.0	0.7	35.8
bridge paint	6	<0.2	2.9	12.2	44.4	662	6.0	5.7	134
@ 50 $g \cdot L^{-1}$	12	0.7	0.7	16.9	29.4	883	<5.0	7.8	214
Treatment A3[b]									
Coquitlam R.	1	<0.2	0.4	14.1	73.8	285	<5.0	2.5	89.7
bridge paint	6	0.8	1.4	16.4	174	661	<5.0	8.0	183
@ 100 $g \cdot L^{-1}$	12	0.4	0.3	17.8	1800	480	<5.0	11.5	163
Control B									
Fraser River	0	0.2	<0.2	2.7	20.8	<2.0	<5.0	0.8	5.0
water	1	0.6	<0.2	9.5	25.1	<2.0	<5.0	1.0	7.6
	6	0.4	<0.2	9.0	12.2	6.0	<5.0	0.9	5.8
	12	<0.2	<0.2	8.8	5.5	<2.0	<5.0	<0.5	2.2
Treatment B1[c]									
Coquitlam R.	1	<0.2	<0.2	13.8	34.1	63	<5.0	1.7	19.9
bridge paint	6	0.3	0.4	16.8	2400	372	8.0	4.4	28.1
@ 50 $g \cdot L^{-1}$	12	<0.2	<0.2	14.5	1650	193	<5.0	<5.0	13.8

Footnotes to Table 4.

[a] Micrograms per litre, equivalent to parts per billion (ppb).

[b] Treatments A1, A2 and A3: Bridge paint flakes were added to North Vancouver municipal water and held for the test duration with moderate periodic agitation of the mixtures.

[c] Treatment B1: Bridge paint flakes were added to Fraser River water and held for the test duration with moderate periodic agitation of the mixture.

Nothing was added to the control water samples, which were also periodically agitated. The pH of control and treatments was not adjusted (pH range 5.9 to 7.0). Test temperature was 15±1°C.

Table 5. Results of chum and pink salmon fry feeding experiments with used abrasive containing lead-based paint chips (B.C. Research 1988).

		Total Metal Concentration of Whole Fish (ug• g⁻¹)[a]			
Total metals	Symbols	CHUM Starved[b]	CHUM Fed[c]	PINK Starved[b]	PINK Fed[c]
Aluminum	Al	42	83	210	220
Antimony	Sb	LD	LD	LD	LD
Arsenic	As	LD	LD	LD	2
Barium	Ba	4.4	6.3	LD	LD
Beryllium	Be	LD	LD	LD	LD
Boron	B	LD	LD	10	LD
Cadmium	Cd	LD	LD	LD	LD
Calcium	Ca	17300	15700	10900	10400
Chromium	Cr	0.8	3.0	4.1	4.3
Cobalt	Co	LD	LD	LD	LD
Copper	Cu	4.7	5.8	7.1	5.1
Iron	Fe	62.8	80.5	108	108
Lead	**Pb**	**LD**	**45.0**	**4.0**	**20**
Magnesium	Mg	1430	1440	1300	1590
Mercury	Hg	LD	LD	LD	LD
Molybdenum	Mo	LD	LD	LD	LD
Nickle	Ni	LD	LD	LD	LD
Phosphorus	P	18900	18300	13000	15900
Potassium	K	21900	22100	19400	24300
Selenium	Se	LD	9.0	10	10
Silicon	Si	LD	LD	220	260
Sodium	Na	6060	6310	6790	7500
Strontium	Sr	29.5	27.4	19	18
Thorium	Th	LD	LD	LD	LD
Titanium	Ti	3.4	7.0	3	4
Vanadium	V	LD	0.7	LD	0.3
Zinc	Zn	80.3	96.5	85.3	84.1

Footnotes to Table 5.

[a] micrograms per gram, equivalent to parts per million (ppm).
[b] Chum or pink salmon fry held in control aquaria without abrasives and without feeding for 96 hours.
[c] Chum or pink salmon fry held in aquaria for 96 hours and fed used Tru-grit abrasive daily. Used abrasive obtained from 1988 maintenance operation on New Westminster rail bridge.

Note all fish survived the 96-hour feeding experiments
LD = less than detection limit

Appendix 1. Sections of the Fisheries Act Applicable to Bridge Maintenance Operations.

30.(1) to 30.(4):

Operators of water intakes in Canadian fishery waters may be required to provide fish guards or screens (see Appendix 9).

34.(1): Definitions

For the purposes of sections 35 to 43, "deleterious substance" means

(a) any substance that, if added to any water, would degrade or alter or form part of a process of degradation or alteration of the quality of that water so that it is rendered or is likely to be rendered deleterious to fish or fish habitat or to the use by man of fish that frequent that water, or

(b) any water that contains a substance in such quantity or concentration, or that has been so treated, processed or changed, by heat or other means, from a natural state that it would, if added to any other water, degrade or alter or form part of a process of degradation or alteration of the quality of that water so that it is rendered or is likely to be rendered deleterious to fish or fish habitat or to the use by man of fish that frequent that water.

"Deposit" means any discharging, spraying, releasing, spilling, leaking, seeping, pouring, emitting, emptying, throwing, dumping or placing.

"Fish habitat" means spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life processes.

"Water frequented by fish" means Canadian fishery waters.

35.(1): Harmful alteration, etc., of fish habitat

No person shall carry on any work or undertaking that results in the harmful alteration, disruption or destruction of fish habitat.

36.(3): Deposit of deleterious substance prohibited

Subject to subsection (4), no person shall deposit or permit the deposit of a deleterious substance of any type in water frequented by fish or in any place under any conditions where the deleterious substance or any other deleterious substance that results from the deposit of the deleterious substance may enter any such water.

36.(4): Deposits authorized by regulation

No person contravenes subsection (3) by depositing or permitting the deposit in any water or place of

(a) waste or pollutant of a type, in a quantity and under conditions authorized by regulations applicable to that water or place made by the Governor in Council under any Act other than this Act; or

(b) a deleterious substance of a class, in a quantity or concentration and under conditions authorized by or pursuant to regulations applicable to that water or place or to any work or undertaking or class thereof, made by the Governor in Council under subsection (5).

37. (1) Where a person carries on or proposes to carry on any work or undertaking that results or is likely to result in the alteration, disruption or destruction of fish habitat, or in the deposit of a deleterious substance in water frequented by fish or in any place under any conditions where that deleterious substance or any other deleterious substance that results from the deposit of that deleterious substance may enter any such waters, the person shall, on the request of the Minister or without request in the manner and circumstances prescribed by regulations made under paragraph (3)(a), provide the Minister with such plans, specifications, studies, procedures, schedules, analyses, samples or other information relating to the work or undertaking and with such analyses, samples, evaluations, studies or other information relating to the water, place or fish habitat that is or is likely to be affected by the work or undertaking as will enable the Minister to determine

(a) whether the work or undertaking results or is likely to result in any alteration, disruption or destruction of fish habitat that constitutes or would constitute an offence under subsection 40(1) and what measures, if any, would prevent that result or mitigate the effects thereof; or

(b) whether there is or is likely to be a deposit of a deleterious substance by reason of the work or undertaking that constitutes or would constitute an offence under subsection 40(2) and what measures, if any, would prevent that deposit or mitigate the effects thereof.

40.(1) to 40.(5): Offences and Punishment

These sections describe specific offences and penalties.

Appendix 2. An Overview of Current Bridge Cleaning and Painting Technologies.

PAINT REMOVAL

Preparation of steel bridge surfaces prior to painting is a multi-stage process with the objective of obtaining a thoroughly cleaned area to permit long term paint adhesion.

Initial surface cleaning typically involves low pressure hydroblasting with equipment that delivers water at less than 69 x 10^3 kilo Pascals (10,000 pounds per square inch, psi) for removal of flaking paint, rust and salts (K. Poon, Sigprocan Enterprises Ltd., personal communication). This process may entail addition of detergents to the washwater to remove the oily film that is often encountered on bridges. Detergents can be acutely toxic to fish.

The second stage is the removal of rust and paint to ensure adhesion of new coatings. This step is conducted using abrasive blasting, high-pressure hydroblasting, hydroblasting with abrasives or manual cleaning. Specific techniques are detailed below:

(1) Abrasive blasting: Abrasive blasting is the most commonly used method for preparing bridge surfaces for painting in British Columbia. Silica sand, commercial grit preparations and mine slag have been used. These materials are blasted at the bridge using a compressor, hose and handheld nozzle. The blasting is intended to provide a surface partially or completely cleaned of old coatings and rust.

(2) High pressure hydroblasting: Hydroblasting at high pressure involves using a jet of water at greater than 69 x 10^3 kilo Pascals (10,000 psi) generated by a pump and delivered by a hose and handheld nozzle. High pressure hydroblasting is used less often than abrasive blasting because of the high cost and low equipment availability. In order to deter rust formation following hydroblasting, rust inhibitors (e.g. borax, diammonium phosphate, isopropanol, sodium bichromate, sodium nitrate or sodium nitrite) are sometimes added to the water. Depending on the concentration tested such additives can be acutely toxic to fish.

(3) Hydroblasting with abrasives: Abrasives are sometimes added to water blasted at bridge surfaces to increase paint removal effectiveness.

(4) Manual cleaning: In cases where a small area is to be cleaned for painting, or in cases where protection of the aquatic environment requires special measures, wire brushes and handheld power tools can be used in surface preparation.

With specific reference to lead-based paint removal, Trimber (1988) lists the following ten techniques for bridge cleaning used currently in the U.S.

(1) Blast clean - total enclosure with negative pressure - abrasive recycled: This procedure requires total enclosure of the section of bridge to be cleaned. Using a filtering system and negative pressure, 85-90% of the paint and abrasive is contained. Using a steel abrasive, the author notes that weather-proofing is necessary to keep the abrasive dry.

(2) Blast clean - total enclosure with negative pressure - abrasive is not recycled: Similar to (1), above, except that more debris is generated.

(3) Blast clean - total enclosure without negative pressure - abrasive recycled: A containment structure is erected, but without negative pressure. Because of dustier working conditions, worker efficiency may be reduced. Containment efficiency is reported to be 50-70%.

(4) Blast clean - total enclosure without negative pressure - abrasive is not recycled: Similar to (3), above, except that the abrasive is not recycled.

(5) Vacuum blast: A vacuum is created a few centimetres in diameter around the blast nozzle while the cleaning is underway. Debris is contained on a filter for disposal. Efficiency can be as high as 90% with this system on flat surfaces only. Vacuum blasting may be ineffective on complex surfaces due to the difficulty in maintaining a vacuum.

(6) Ultra high pressure water: At a pressure of 241-275 x 10^3 kilo Pascals (35,000-40,000 psi), water (with or without abrasive injection) is blasted at the bridge. A containment device is necessary to collect the water, which is subsequently filtered. If re-used repeatedly, Trimber (1988) reports that the water could become a hazardous waste (U.S. Resource Conservation and Recovery Act), because of dissolved metal content.

(7) High pressure water with abrasive injection: Water at a pressure of 103-138 x 10^3 kilo Pascals (15,000-20,000 psi) and abrasive are blasted at the bridge. More abrasive is required than with ultra high pressure water blasting (Item (6), above). Containment structures are required and the abrasive and paint flakes collected may require disposal as hazardous waste.

(8) Power tool cleaning without enclosure: This technique is used to remove corroded metal not paint, thus containment may not be required.

(9) Total enclosure with power tool cleaning: Little debris is generated in this labour-intensive method of removing paint.

(10) Total enclosure with power tool removal of coating followed by blast cleaning: This method accomplishes the majority of the paint removal with power tools, which generates a minimum amount of hazardous waste. The second step, blast cleaning with abrasive, is used only to remove scale because little paint would remain.

PAINT APPLICATION

Paint coating is necessary on steel bridges to retard rust formation. Factors considered in choosing a paint include durability, cost, ease of application and hazard to the environment and worker.

Paints have three major components (Morgans 1982):

(1) Pigment: to provide colour, opacity, enhanced durability and to suppress corrosion;

(2) Binder: to bind pigment particles into a coherent film and cause adhesion to bridge surfaces (paints are commonly designated by their binder component, e.g. vinyl, epoxy); and

(3) Solvent or thinner: to render the pigment/binder mixture sufficiently flowable for uniform application. During and after application, the solvent evaporates completely.

In addition to these major components, paints may also contain small quantities of special additives such as driers, anti-shining compounds, anti-settling compounds, fungicides and bacteriocides. The viscosity of a paint may be reduced by adding thinner. Paints with more thinners may or may not be less viscous than another formulation with less thinners.

Viscosities of paints and the accessibility of the area to be painted may determine the most suitable method of paint application. The four principal methods of paint application currently used are as follows (Morgans 1982):

(1) Air spray: Compressed air is used to force paint through a hose and spray nozzle, where atomization of the paint occurs.

(2) Airless spray: Paint is delivered under pressure and applied through a hose connected to a spray nozzle. Hydraulic pressure causes atomization of the paint as it exits the nozzle. Airless spray systems are more costly and difficult to adjust than air spray systems.

(3) Electrostatic spray: An electrostatic charge is imparted to the particles of paint delivered by a system similar to the airless spray system in (2), above. Paint particles are attracted to metal bridge components and the paint "wraps around" to coat all conductive surfaces. For use on clean metal surfaces only.

(4) Manual application: Paint is applied to the bridge by brush or roller.

An airless spray system has advantages to applicators when compared to an air spray system due to increased application speed and enhanced safety (i.e. reduced fire hazard and fogging), and reduced overspray and "bounceback", leading to better coverage. Airless spray systems are more economical because less paint and less thinning solution are needed. The equipment is compact and relatively easy to use. However, airless spray equipment may be prone to clogging and explosion due to high internal pressure.

Although an electrostatic spray system has advantages over other methods, it requires comparatively costly equipment and is only usable with certain paint formulations. In addition, electrostatic spraying is generally slower than airless spraying, can only be used on completely cleaned metal surfaces and is relatively ineffective in corner areas (Banov 1978).

There are two principal types of painting systems currently used in British Columbia, as follows:

(1) One component paint systems: One component paints are those in which the pigment (or base) and binder (or catalyst) are pre-mixed into a single formulation by the paint manufacturer.

(a) Lead-based paints

One component lead-based paints were, until recently, the only type of paints used on bridges locally. Accordingly, lead-based paint will be present on most bridges painted prior to 1985 (R. Raine, B.C. Ministry of Transportation and Highways, personal communication). Painting a steel bridge using a one component lead-based paint involves application of a "red lead" primer in one or more coats to a cleaned steel surface, followed by application of several top coats of a lead-based enamel. Painting is usually conducted with air spray equipment.

Lead-based paints are considered hazardous to operators because of toxicity and the tendency for bioaccumation of lead in animal tissues. With respect to aquatic life, bioassay results using rainbow trout indicate that lead-based paints are acutely toxic to fish at relatively low concentrations (i.e. 96-h LC50 <50 $mg \cdot L^{-1}$). Lead-based paint flakes may leach lead into receiving waters and cause accumulation of lead in the aquatic environment. Recently, concern for human health and the development of less costly, more durable coatings have resulted in substantial reduction in the use of lead-based bridge paints in B.C. (R. Raine, personal communication).

(b) Moisture Cured Urethanes

One component (i.e. no additives are required) moisture cured urethane aluminum based primers have recently been used to a limited extent in B.C. These paints do not require the addition of thinners before application. Limited fish toxicity data indicate that such products are one to two orders of magnitude less toxic than zinc-based primers (see section 2a, below). However, moisture cured urethane primers may not provide predictable durability (R. Raine, personal communication).

(c) Vinyl system midcoats and topcoats: With a vinyl system, up to three different coats may be used. A primer, typically zinc-based (see below) is first applied, followed by a midcoat consisting of a single component vinyl formulation. The midcoat is typically covered with a topcoat of single component acrylic vinyl. Information on the toxicity of vinyl paints to fish is presently very limited. A single toxicity test included in these Guidelines with vinyl paint and rainbow trout resulted in a 96-h LC50 value of 148 $mg \cdot L^{-1}$. Vinyl systems are less durable than multicomponent epoxies and are used where overspray damage to cars or buildings is a concern. (Vinyl paint spray drift dries quickly, thus there is little risk of damage to structures.)

(2) Multicomponent paints: Multicomponent paints require blending (of a base and a catalyst) by the operator on site. In B.C., the multicomponent paint systems most commonly used are epoxies. Epoxy paint systems rely on the use of a primer, typically zinc-based (see below), and a two component epoxy midcoat and/or topcoat. Epoxy systems are more frequently used than vinyls due to their durability.

(a) Zinc primers: Zinc primers are used on completely cleaned surfaces as a "last line of defense" against rust. Zinc primers may be applied as an organic or inorganic paint, or "metallized" using zinc powder or wire.

Zinc metallizing involves the heating of zinc powder or wire until it "melts" onto a clean metal surface. This method of applying zinc is best conducted in a shop prior to placing the structure in the field, however, some field applications have been successful.

Inorganic zinc primers consist of two components: a base and granular zinc. Organic zinc epoxy primers consist of three components: a base, a catalyst and granular zinc. Thinners may be added to both organic and inorganic zinc paints immediately prior to application to reduce viscosity and assist in application. Zinc primers have exhibited the greatest toxicity to fish in the test results included in these Guidelines (i.e. 96-h LC50 = 0.39 to 5 mg$\cdot$ L^{-1}). The cause of the high toxicity of zinc paint to fish is probably associated with both the elemental zinc content and the solvents used. More data on the respective toxicity of the various zinc primers are necessary.

(b) Epoxy system midcoats and topcoats: With an epoxy system, the midcoat usually consists of a high solids (i.e. "high performance"), two component (base and catalyst) epoxy paint. The topcoat consists of either a two component (base and catalyst) acrylic epoxy or aliphatic polyurethane paint. Although polyurethane paints are comparatively durable, they are generally more acutely toxic to fish (e.g. 96-h LC50 = 68 to 148 mg$\cdot$ L^{-1}) than epoxy paints (e.g. 96-h LC50 = 210 to 748 mg$\cdot$ L^{-1}).

(c) Catalysts: Depending on the ambient temperature at the time of painting, different catalysts can be added to the paint immediately prior to application. Bioassay test results included in these Guidelines on one specific epoxy paint using two different catalyst formulations showed a marked difference in toxicity to fish exists. The winter catalyst increased the toxicity of the paint by a factor of nine compared with the summer catalyst formulation.

THINNER/SOLVENT ADDITION

For most bridge paints used in B.C., solvents are added to thin the paint and thus achieve a prescribed coating thickness. Manufacturers' product sheets provide guidance on the maximum amount of thinner to be added, while Ministry of Transportation and Highways painting specifications state that bridge paints can only be thinned to a maximum of 10% solvent with 90% paint. However, similar to catalyst addition, the final responsibility for thinner addition is that of the painting contractor. The addition of thinners at the work site introduces an unknown element of increased toxicity to all paints. In the United States, because of human health concerns, the incidental inhalation of solvent vapours and state regulations to control the release of volatile organic compounds (VOCs) into the atmosphere, pre-mixed paints which meet strict VOC standards are widely used (K. Poon, personal communication). Pre-mixed paints are expected to be available in Canada eventually.

Fish toxicity data should include a description of any solvents added to paints. Testing should be carried out on the final formulation, including catalysts, promoters and thinners to be used.

RUST CONTROL

Application of a rust inhibitor or rust transformer is an additional treatment which can be carried out in conjunction with hydroblasting. Rust inhibitors are applied subsequent to hydroblasting to prevent rust "bloom" formation on bare metal surfaces.

Appendix 3. A Review of the Techniques Used to Contain Wastes Generated During Paint Removal.

Abrasive blasting of steel bridges results in the production of particulate waste material consisting of paint chips and abrasive residues which can harmfully alter fish habitat. A number of techniques have been employed in Canada and the U.S. to contain such debris, as outlined below (see also Snyder and Bendersky (1983) and Trimber (1988)):

(1) Ground and waterbody covers: Sheets of plastic or cloth can be spread on the ground as well as suspended below bridges using a safety net as support to catch debris. Vertical drapes of air-permeable cloth improve containment performance. Debris is manually collected from covers for periodic disposal (see section 2, below).

(2) Vertical drapes: Air-permeable material (e.g. burlap) is hung vertically from the bridge to divert debris down to barges or horizontal lined nets suspended beneath the bridge. Vertical drapes that are not closed at the ends or otherwise incompletely seal the structure do not function effectively. For example, Parks and Winters (1982) in a California study estimated that only 50-75% of the waste generated during the cleaning and painting of a bridge was contained by vertical draping under "calm" conditions.

(3) Blast enclosures: Custom-fabricated enclosures completely encasing sections of a bridge can be erected before abrasive blasting. A funnel system below the floor of the enclosure directs debris to trucks for collection and removal. A suction system, wet scrubber or mesh filter can be employed to remove airborne dust. Such enclosures are effective in retaining debris and are costly to employ.

(4) Vacuum-shrouded handtools: Power tools equipped with vacuum shrouds are designed to collect debris as it is generated.

(5) Booms: Floating booms can be used in watercourses to trap debris such as dust and paint chips on the water surface. (Prior approval for deployment of such equipment must be obtained from EP or DFO.) Floating booms in small streams function to control only surface debris and do not trap settlable solids including abrasive and metal debris. These more dense wastes should be trapped using shrouding, lined nets or barges, where required.

(6) Vacuum blasters: Abrasive blasting equipment can include a vacuum system to collect spent abrasive and paint particles. Vacuum blasters are slower to use than other systems and may not be effective on complex structures.

(7) Water curtains: Water can be sprayed down from the sides of a bridge to form a "curtain" to wash airborne debris to the ground for diversion via troughs to tanker trucks for collection and disposal.

(8) Centrifugal blasters: Abrasive material can be propelled against steel bridge surfaces using high speed rotating blades. The abrasive is recycled during use. Centrifugal blasters are relatively labour intensive and ineffective on complex structures.

Techniques (1) - (4), above are recommended in these Guidelines to provide optimal protection for fish and fish habitat. More specific requirements may be made by EP/DFO during review of proposals to reflect factors such as project location, timing and duration.

Appendix 4. A Review of the Techniques Used to Control Spray Drift During Bridge Painting.

Air spray, airless spray and electrostatic spray paint application systems can generate aerosol spray drift during usage which may harm fish habitat as well as damage cars and buildings. Manual use of brushes and rollers can result in dripping and spillage of paint and loss of equipment into watercourses.

The following techniques have been used in both Canada and the United States to contain paint spray drift, spilled paint and loss of equipment during coating application:

(1) Drip Tarps: Sheets of plastic or cloth can be suspended below the bridge to capture paint or equipment which falls during manual painting operations. Such tarps, used in conjuction with vertical drapes (see section 2 below), can also assist in containing paint spray drift.

(2) Vertical Drapes: Air permeable material (e.g. burlap, fine mesh or netting) is hung vertically from the bridge and used in conjunction with a suspended horizontal tarp to contain spray drift and minimize paint deposition into watercourses or damage to personal property.

(3) Full Enclosures: Custom fabricated enclosures which completely encase the section of bridge to be painted can be erected in areas where no coating materials should escape. Such enclosures may be effective, but costly to employ.

(4) Floating Booms: Floating booms can be used in suitable watercourses to trap paint spray drift that lands on the water surface. (Prior approval for deployment of such equipment must be obtained from EP/DFO).

(5) Vinyl Paints: Vinyl-based paints are often used in areas where damage to vehicle/boat traffic and private property is a concern. The spray drift from vinyl paint does not generally adhere to non-target surfaces due to rapid evaporation of its solvent.

Appendix 5. Schedules of Paints and Abrasives According to Potential Risk to Aquatic Life.

Allocation of bridge cleaning and painting materials have been made to Schedules 1 and 2, below based on the following factors:

(1) Toxicity data from standard tests using rainbow trout in freshwater (i.e. 96-h LC50 bioassay tests) and;

(2) Environmental persistence and bioaccumulation potential of paint constituents and blasting materials.

Schedule 1 includes materials which could pose moderate to high risks to fish, if deposited in fishery waters.

Schedule 2 includes materials of low to moderate risk to fish and fish habitat.

Restrictions applicable to the use of materials in Schedules 1 and 2 are outlined in the following section. Materials which do not appear in Schedules 1 and 2 have not been assessed. Products will be assumed to be in Schedule 1 until adequate information is available. Schedules will be updated by EP/DFO as data on toxicity are developed. It is the responsibility of proponents and manufacturers to provide appropriate toxicity data. Bioassay testing procedures should conform to those outlined in Appendices 6 and 7.

While the placement of specific abrasives on Schedules 1 and 2 is based on the risks to fish due to toxicity, environmental persistence, and bioaccumulation potential; it should be recognized that all abrasives have the potential to inundate stream gravels impacting fish spawning success, invertebrate production and organic productivity. Further, manufactured abrasives, because of the sharpness of the particles may seriously damage gills if inhaled from the water column by fish.

Any questions regarding fish toxicity testing procedures for paints and abrasives should be directed to:

Head, Bioassay Laboratory
Environmental Protection
1801 Welch Street
North Vancouver, B.C. V7P 1B7
Telephone: (604) 666-6104.

SCHEDULE 1. List of materials with moderate to high toxicity to fish (i.e. the 96-h LC50 is $\leq$100 mg$\cdot$L^{-1}) or which are persistent or are likely to accumulate in animal tissues, such as those of fish.

1. Rust inhibitors

(a) Sodium nitrite

2. Primers

(a) Carboline 658 (without thinner)
(b) Carboline 658 (with 5% thinner #15)
(c) Carbozinc 12 (with 5% thinner #21)
(d) Interzinc 22
(e) Interzinc 52

3. Midcoats and topcoats

(a) Red lead alkyd oil
(b) Carbomastic 15 (with xylene thinner)
(c) Carboline D893 (with 5% thinner #2)
(d) Devthane 239
(e) Intergard FP (with winter catalyst)
(f) Coulturiet - TCP/CSF

4. Abrasives[a]

(a) Anyox mine slag
(b) Tru-grit
(c) Tru-grit 16-30
(d) Tuf-kut fine
(e) Kleen Blast
(f) Custom LM16 - T6 16/30

Note: See Tables 1 and 2 for specific acute toxicity data.

[a]Manufactured abrasives, because of the sharpness of the particles, can seriously damage gills if inhaled from the water column by fish. Heavy metal content (e.g. copper) of grits may lead to toxicity to fish.

SCHEDULE 2. List of materials with moderate to low toxicity to fish (i.e. the 96-h LC50 is $\geq$100 $mg \cdot L^{-1}$) or which are not known to be persistent and are not likely to accumulate in animal tissues.

1. Rust Inhibitors

(a) Chesterton Rust Transformer
(b) Isopropanol

2. Primers

(a) Columbia 07-440-PP (aluminum primer)

3. Midcoats and topcoats

(a) Amerlock 400
(b) Amercoat 450 GL
(c) Bapco Al DOH C-3
(d) Carboline 134
(e) Carboline D801
(f) Carboline D893 (without thinner)
(g) Devran 229
(h) Bar Rust 235
(i) Bar Rust 235 HS
(j) Devoe Code X vinyl
(k) Intergard FP (with summer catalyst)
(l) Interplus 56 (with 5% thinner GTA 830)
(m) Interthane PE
(n) Rust Gone II Finish (5612-5299)
(o) Coulturiet - TCP
(p) Subox 2703 (with 10% Carboline Thinner #45)

4. Abrasives

(a) Fine silica sand
(b) Green Diamond grit
(c) Garnet
(d) Olivine
(e) Black Beauty
(f) Sup-R-Cut 28
(g) Frac Blast 16/40
(h) General Blast 11/50
(i) LM 20/30
(j) KB/GL 50/50
(k) TG/GL 50/50
(l) TG/GL 25/75

Note: See Tables 1 and 2 for specific acute toxicity data.

Appendix 6. A Review of Losses of Lead-Based Paints and Implications to the Aquatic Environment.

The type of bridge paint removal operation that has the potential for the most impact on fish habitat is abrasive or water blasting of lead-based paints. According to Snyder and Bendersky (1983), 50% of small particles (i.e. those <50 m in diameter) produced with abrasive blasting operations are deposited beyond 200 metres from the site under calm conditions. These authors also reported that losses of lead paint blasted off bridges typically resulted in high levels of lead in surface soils adjacent to bridges. In water with low turbulence, much of the debris reportedly sunk immediately. Floating particles of paint were subsequently deposited in shoreline areas.

Batton and Leech (1988) conducted a leachate extraction test on samples of spent abrasive (i.e. abrasive/paint flake mixtures) from 14 bridges in Ontario to determine if mitigative measures were necessary for bridge cleaning operations. Of the 14 samples tested by these authors, two exhibited leachable lead concentrations of >5 mg• L^{-1} dissolved lead, a level (according to the Ontario Environmental Protection Act) that constitutes a special/hazardous waste with associated disposal requirements. The average dissolved lead concentration in water from leaching tests reported by these authors using 14 spent abrasive/paint chip samples was 1.86 mg• L^{-1}. It should be noted that the samples tested by Batton and Leech (1988) contained lead-based paint mixed with abrasive. Therefore, the final lead content of the overall sample was less than that of the paint fragments alone.

Trimber and Solomon (1988) conducted The U.S. Environmental Protection Agency's extraction procedure leachability test on samples of bridge paint flakes and abrasive in water maintained at pH 5.0 $\pm$ 0.2 over 28 hours. Leachable lead in the paint flakes (tested in the absence of any abrasive material) ranged from 94 to 236 mg• $^{-1}$ lead. Dissolved lead concentrations leached from abrasive/paint chip mixtures generated during bridge cleaning were reported to range from 5.2 to 15.0 mg• L^{-1}. (No dissolved lead was detected from a control sample of unused abrasive.) If the leachable lead concentration of a sample is greater than 5 mg• L^{-1} in the dissolved form, the material is considered to be a special/hazardous waste under the U.S. Resource Conservation and Recovery Act. Containment of paint chips, followed by appropriate disposal is required for leachable paint debris in the U.S. (Hower 1988).

Trimber (1988) outlined ten technologies (most incorporated total enclosure of the bridge) applicable to removing lead-based paint in the U.S. and protecting the aquatic environment (see Appendix 2).

Laboratory leaching studies conducted by DFO in 1988 using paint chips from Lower Mainland bridges in municipal water/Fraser River water, showed continuous leaching of lead over a 12-day period. A maximum dissolved lead concentration of 0.883 mg• L^{-1} was documented. It is anticipated that under conditions of continuous agitation and pH adjustment to 5, (requirements of the B.C. Special Waste Regulations Leachate Test), substantially greater leaching of lead from the paint particles would have occurred.

In 1986, samples of used and unused abrasive from a bridge maintenance operation over the Skeena River were collected by DFO for acute toxicity testing using salmonids. The unused abrasive mixed in water exhibited no acute toxicity to rainbow trout after 96 hours, whereas the used abrasive/lead-based paint mixture tested was acutely toxic to fish (see Table 2). Similarly, toxicity tests conducted in 1988 on an abrasive/lead-based paint mixture from a blasting operation at the New Westminster railway bridge caused acute toxicity to juvenile pink salmon after 96 hours (B.C. Research 1988). In addition, juvenile pink and chum salmon fed used abrasive from the New Westminster railway bridge maintenance operation exhibited lead levels 20 to 40 times greater than control fish in a 96-hour test (B.C. Research 1988).

Because lead is toxic to fish and may bioaccumulate in animal tissues, lead-based paint debris should not be deposited into fish habitat or where it could leach into such areas.

Appendix 7. Bioassay Procedure for Testing the Toxicity of Bridge Paints to Salmonid Fish.

GENERAL CRITERIA

Test species:	Juvenile rainbow trout.
Test type:	96-h LC50, static.
Dilution water:	Dechlorinated city tap water.
Loading density:	≤ 0.5 g• L^{-1}
Temperature:	15 $\pm$ 1°C, measured at the start and the end of the test.

pH: Unadjusted after adding the toxicant, measured at the start and the end of the test.
Dissolved oxygen: Measured at the start and the end of the test and in the controls; gentle aeration through Pasteur pipettes at a flow rate of 7.5 mL• min^{-1}• L^{-1}.
Replication: One replicate test to be conducted.
Test chamber: 35-L glass aquarium equipped with a polyethylene liner.

BIOASSAY PROCEDURE

1. Add the dilution water to test aquaria fitted with disposable polyethelene liners. Allow the dilution water to attain the appropriate test temperature. (Dilution water can be measured on a weight basis or volume basis). Gently aerate the water with air passed through a Pasteur pipette at a flow rate of 7.5 mL• min^{-1}• L^{-1}.

2. Add 10 fish to each aquarium and allow the fish to acclimate for 30 minutes, prior to adding the toxicant (i.e. paint sample).

3. Prepare the final bridge paint formulation according to the manufacturer's specifications. With multicomponent paints, ensure that the proportions are accurately measured (i.e. according to label directions) and ensure that the product is allowed to react for the recommended period of time before testing. Thinners should only be added if they will be used in actual practice. When thinners are to be used, ensure that a second "control" tank is prepared and dosed with the maximum concentration of thinner to be used.

4. Due to the high viscosity of some paints, quantities are measured for bioassay by weight (not by volume) into disposable plastic beakers. After the weighing operation is completed, pour the paint evenly onto the surface of the water in the aquarium containing acclimated fish. A disposable plastic spatula can be used to scrape residual paint from the beaker. To ensure no loss of paint, both the beaker and the spatula must be placed in each test aquarium. A clean beaker and spatula are placed in the control tanks.

5. Observe and record fish mortalities and any sublethal responses (e.g. erratic swimming behaviour, coughing, loss of equilibrium) in each test concentration at 24, 48, 72 and 96

hours. Optional mortality checks are recommended for the following times: 5, 10, 20, 40, 80, 160 and 320 minutes.

6. Record initial and final pH, dissolved oxygen, and temperature for each concentration. Final measurements are taken at 96 hours, or after all fish have died in a test concentration, whichever occurs first.

REPORTING

A report should be prepared which references this procedural document and any deviations from the protocol. The report should include the method of calculating the 96-h LC50 values; whether the data have been "pooled"; the coating/abrasive tested; the type of product (e.g. primer, epoxy, polyurethane); any catalyst used (i.e. winter or summer), the amount of thinner added; and the paint lot number.

Appendix 8. Bioassay Procedure for Testing the Toxicity of Abrasives and Paint Chips to Salmonid Fish.

The following fish bioassay procedure is intended for the testing of unused abrasives (i.e. sands and grits) proposed for surface preparation of bridges, and used or spent abrasives which contain paint flakes. It is noted that this procedure is not intended to document potential effects on fish gills from sharp abrasive particles.

GENERAL CRITERIA

Test species:	Juvenile rainbow trout.
Test type:	96-h LC50.
Dilution water:	Dechlorinated city tap water.
Loading density:	$\leq$0.5 g• L^{-1}
Temperature:	15±°C, measured at the start and the end of the test.

pH: Unadjusted after addition of the blasting material, measured at the start and the end of the test.
Dissolved oxygen: Measured at the start and the end of the test and in the controls; gentle aeration through air stones inserted into a filter stem at a flow rate of 15 mL• min^{-1}• L^{-1}.
Minimum number of test concentrations: Four (4), plus a control.
Replication: No replicate test necessary.
Test chamber: 35-L glass aquarium with a plastic undergravel filter on the bottom and two filter stems. A mesh basket for holding the fish may be used if the material restricts visibility.

BIOASSAY PROCEDURE

1. Add the dilution water to the aquaria and allow it to attain the appropriate test temperature. The quantity of dilution water can be measured on a weight or volume basis. Gently aerate the water with air passed through air stones inserted into filler stems on the undergravel filter at a flow rate of 15 mL• min^{-1}• L^{-1}.

2. Select water volume to satisfy loading density requirements (i.e. $\leq$0.5 fish • L^{-1}).

3. Following selection of water volume, accurately weigh portions of blasting material for the test. Ensure the sample is homogeneous and dry (i.e. air dried). The proportion of abrasive to dilution water should include four concentrations selected from a logarithmic table to a maximum of >20% by weight (e.g. 1%, 4.4%, 10% and 22%).

4. Add the blasting material to the dilution water to obtain an even distribution on the top of the undergravel filter. After adding the test material to each aquarium, immediately add 10 fish to the test tanks or into the mesh baskets suspended in the test tanks.

5. Observe and record fish mortalities and sublethal responses in each test concentration at 24, 48, 72, and 96 hours. Optional mortality checks are recommended at the following times: 5, 10, 20, 40, 80, 160 and 320 minutes.

6. Record initial and final pH, dissolved oxygen and temperature for each concentration. Final measurements are taken at 96 hours, or after all fish have died in a test concentration, whichever occurs first.

REPORTING

A report should be prepared which references this procedural document and any deviations from the protocol. The report should include a description of test observations; test results; whether the data have been pooled; the method of calculating the 96-h LC50 values; the name of the abrasive product; the type of abrasive (i.e. silica sand, mining slag grit, steel grit); and where sand-grit mixtures are used, the proportion of each in the mix.

Appendix 9. DFO Fish Screening Directive.

FISH SCREENING DIRECTIVE

Government of Canada
Department of Fisheries and Oceans

WATER INTAKE FISH PROTECTION FACILITIES

The Department of Fisheries and Oceans has prepared this document as a guide to assist in the design and installation of water intakes and fish screening in British Columbia and the Yukon Territory to avoid conflicts with anadromous fish. Additional precautions must be taken at marine intake locations where entrainment of fish larvae, such as eulachon and herring larvae, is a possibility. The screening criteria constitute the Department's policy regarding the design and construction requirements pursuant to Section 30 of the Fisheries Act.

PROVISIONS OF THE FISHERIES ACT - SECTION 30

Every water intake, ditch, channel or canal in Canada constructed or adapted for conducting water from any Canadian fisheries waters for irrigating, manufacturing, power generation, domestic or other purposes, shall, if the Minister deems it necessary in the public interest, be provided at its entrance or intake with a fish guard or a screen, covering or netting, so fixed as to prevent the passage of fish from any Canadian fisheries waters into such water intake, ditch, channel or canal.

PROCEDURES FOR INSPECTION AND APPROVAL OF INTAKE STRUCTURES

Diversions less than 0.0283 cubic metre per second (cms) (one cubic foot per second, cfs): The intake structure shall be constructed in accordance with specifications indicated herein. Upon completion of construction and prior to operation the owner shall contact a local representative of the Department of Fisheries and Oceans to arrange for on-site inspection and approval of the installation. Permanently submerged screens must be inspected prior to installation.

Diversions greater than 0.0283 cms (one cubic foot per second): The owner shall submit to the Department of Fisheries and Oceans 2 sets of detailed plans of the proposed installation for review and approval prior to fabrication. Design drawings are required whenever the diversion quantity exceeds 0.0283 cms (1.0 cfs) or 817,200 L per day (180,000 Igpd) for industrial diversions (calculated on the basis of 8 hours per day) or 123,350 cmy

(100 ac.-ft. per year) for irrigation diversions (calculated on the basis of 100 days per year and 12 hours per day). The plans shall contain the following information:

1. Intake structure location and dimensions.
2. Maximum discharge capacity of diversion.
3. Screen dimensions.
4. Mesh size.
5. Screen material.
6. Fabrication details.
7. Minimum and maximum water levels at the intake site.
8. Provision for bypassing fish.

The intake structure shall then be constructed in accordance with the approved plans. Upon completion of construction and prior to operation, the owner shall contact the local representative of the Department of Fisheries and Oceans to arrange for on-site inspection and approval of the installation. Permanently submerged screens must be inspected prior to installation.

SPECIFICATIONS FOR INTAKE STRUCTURES WITHOUT PROVISION FOR AUTOMATIC CLEANING

1. Screen Material: The screen material shall be either stainless steel, galvanized steel, aluminum, brass, bronze, or monel metal. Stainless steel is preferred since corrosion is greatly reduced.

2. Screen Mesh Size: Clear openings of the screen (the space between strands) shall not exceed 2.54 mm (0.10 inch). The open screen area shall not be less than 50% of the total screen area. The following square-mesh wire cloth screens are recommended:

   - 7 mesh, 1.025 mm (0.041 inch) wire, 51% open, 2.54 mm (0.10 inch) openings; or
   - 8 mesh, 0.875 mm (0.035 inch) wire, 52% open, 2.25 mm (0.09 inch) openings; or
   - 9 mesh, 0.700 mm (0.028 inch) wire, 60% open, 2.54 mm (0.10 inch) openings.

3. Screen Area: A minimum unobstructed screen area (gross area) of 0.93 square metre (10 square feet) shall be provided for each 0.0283 cms (1.0 cfs) of water entering the intake. The required screen area shall be installed below minimum water level. Screen area lost by framing shall not be included as part of the unobstructed screen area.

4. Screen Support: The screen shall be adequately supported with stiffeners or back-up material to prevent excessive sagging.

5. Screen Protection: The intake structure shall, where necessary, be equipped with a trash rack or similar device to prevent damage to the screen from floating debris, ice, etc.

6. Screen Accessibility: The screen shall be readily accessible for cleaning and inspection. Screen panels or screen assemblies must be removable for cleaning, inspection and repairs.

7. Allowable Openings: The portion of the intake structure which is submerged at maximum water level shall be designed and assembled such that no openings exceed 2.54 mm (0.10 inch) in width.

8. Design and Location: The design and location of the intake structure shall be such that a uniform flow distribution is maintained through the total screen area.

9. Fish Bypass: The intake shall be designed to provide a transverse velocity (the component of the velocity parallel and adjacent to the screen face) to lead fish to a bypass or past the screens before they become fatigued. In no case should the transverse velocity be less than double the velocity through the screen.

SPECIFICATIONS FOR INTAKE STRUCTURES WITH PROVISIONS FOR AUTOMATIC CLEANING

The specifications are identical to those for intake structures without provisions for automatic cleaning except that the minimum unobstructed screen area (gross area) of 0.23 square metre (2.5 square feet) need only be provided for each 0.0283 cms (1.0 cfs) of water entering the intake. However, a regular cleaning and maintenance schedule is required to ensure seals and screen panels remain in good repair preventing impingement and entrainment of fish and debris.

For these self-cleaning intake structures, the location, design and juvenile fish avoidance system all affect operating characteristics. The final design, therefore, may incorporate modifications reflecting the best current technology available for minimizing adverse impact upon the fisheries resource.

ALTERNATE FISH PROTECTION FACILITIES

Enquiries concerning the Department's requirements for indirect intakes, such as infiltration galleries and wells, for salt water ocean intakes, and for new methods or devices for screening intake structures should be directed to the Department of Fisheries and Oceans, Senior Habitat Management Biologist (see listing in following section).

= = = = = = = = = = = = = = = = = =

Revised March 1, 1989

Conversion Factors:

1 cubic foot per second (cfs)	=449 U.S. gallons per minute (U.S. gpm).
	=374 Imperial gallons per minute (Igpm).
	=1.98 acre-feet per day (Ac.-Ft. per day).
	=28.3 litres per second (L per sec.).
	=0.0283 cubic metres per second (cms).

0.10 inch =3/32" (approx.) =2.54 millimetres

Addresses for Correspondence and Approvals

1. Senior Habitat Management Biologist
Fraser River, Northern B.C. and Yukon Division
Department of Fisheries and Oceans
Room 330, 80 - 6th Street
New Westminster, B.C. V3L 5B3 Phone: 666-0315

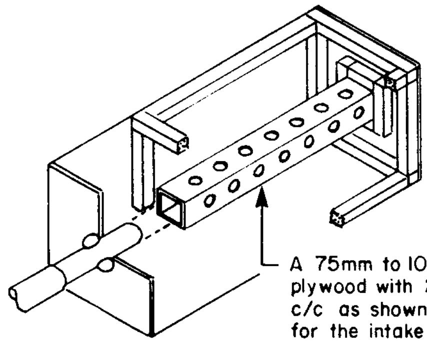
2. Senior Habitat Management Biologist
South Coast Division
Department of Fisheries and Oceans
3225 Stephenson Point Road
Nanaimo, B.C. V9T 1K3 Phone: 756-7284

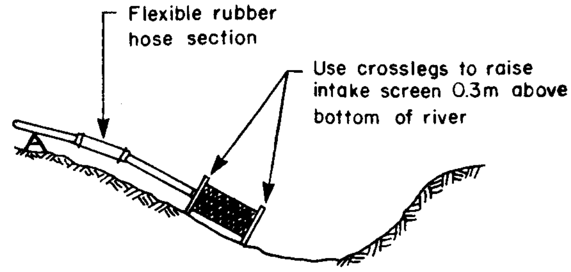
3. Senior Habitat Management Biologist
North Coast Division
Department of Fisheries and Oceans
716 Fraser Street
Prince Rupert, B.C. V6J 1G8 Phone: 624-0453

Other Federal and Provincial agencies having jurisdiction in water withdrawals and construction pertaining to watercourses in British Columbia include:

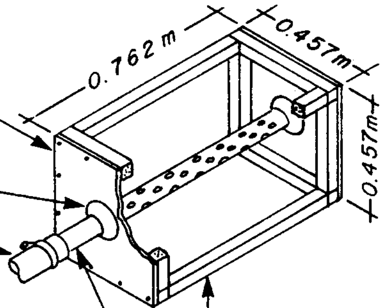
1. Transport Canada
Canadian Coast Guard.
2. B.C. Ministry of Environment
Recreational Fisheries Branch.
3. B.C. Ministry of Environment
Water Management Branch.
4. B.C. Ministry of Agriculture and Fisheries.
5. B.C. Ministry of Lands.
6. B.C. Ministry of Parks.

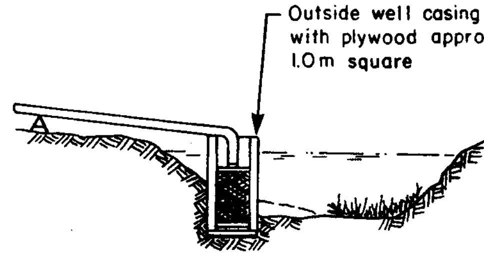
It may be necessary that several or all these agencies also be solicited for approvals prior to the installation of a water intake.





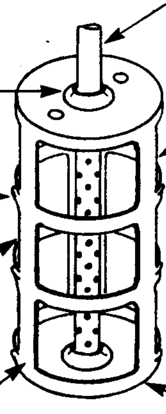
STANDARD INSTALLATION

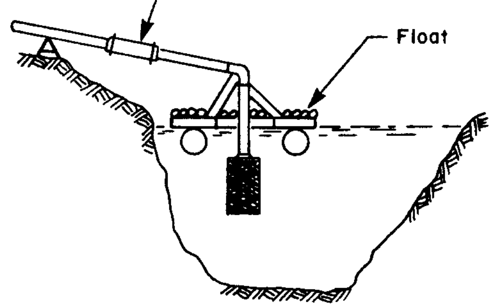




INSTALLATION IN SHALLOW WATER

MUDDY OVERGROWN BOTTOM





INSTALLATION IN DEEP WATER

NOTE:

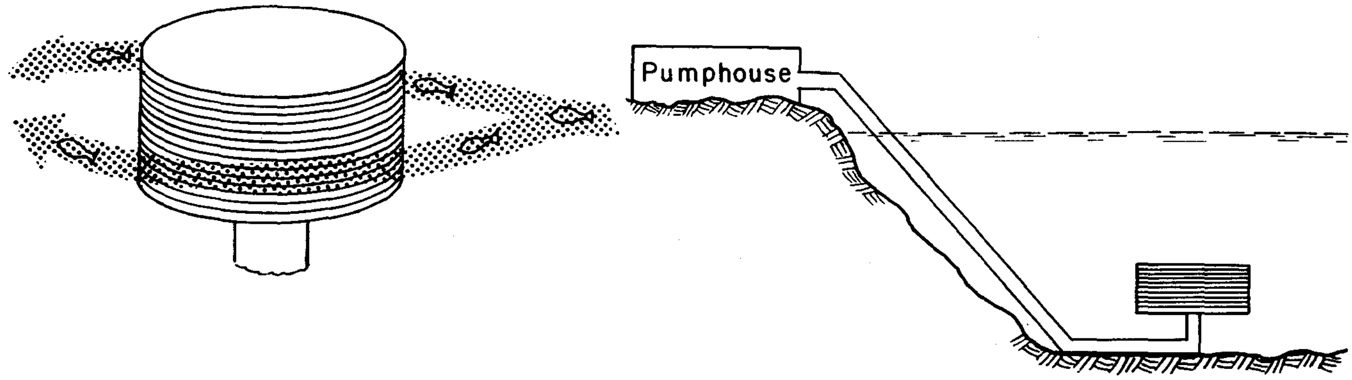
1. Oil drum shall be thoroughly washed out or steam cleaned before cutting openings.
2. All loose rust shall be removed and the drum coated with metal primer. Two coats of machinery enamel or expoxy paint shall be applied before covering with wire cloth.

NOTE:

All screens shall be installed below minimum water level, shall be easily accessible for cleaning, and shall be cleared of debris at regular intervals.

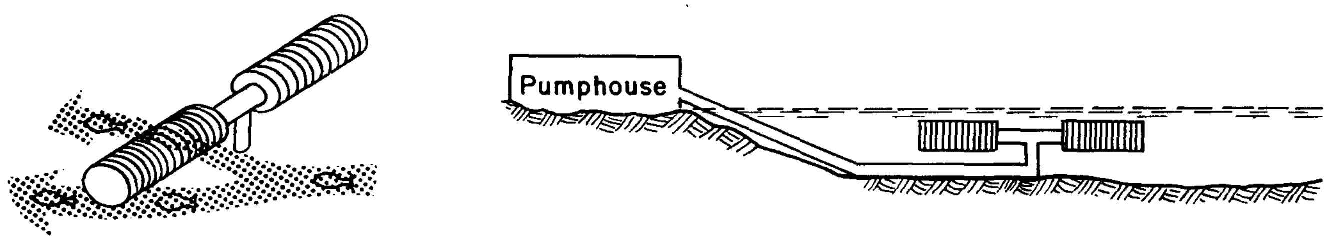
SMALL STATIONARY WATER INTAKE SCREENS

(For pumps of a capacity less than 28.3 L/sec [1 cfs, 449 U.S. or 374 Igpm])



DEEP WATER WELL SCREEN

May be installed in lakes and the ocean.



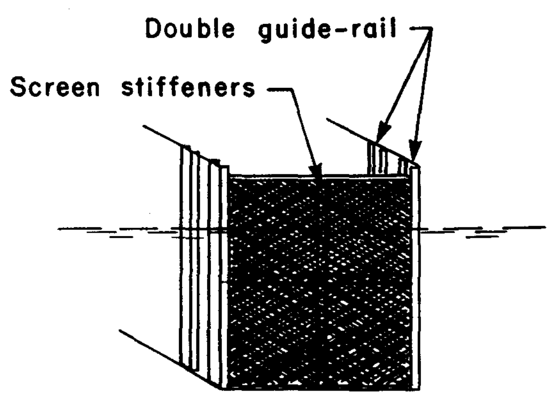
SHALLOW WATER WELL SCREEN

May be installed in lakes, pools, and stable areas in rivers.

Totally submerged cylindrical shaped stainless steel well screens provide for high intake capacity and large percentage of open area permitting water to enter at low velocities. Slot opening shall not exceed 2.54 mm (0.10 inch).

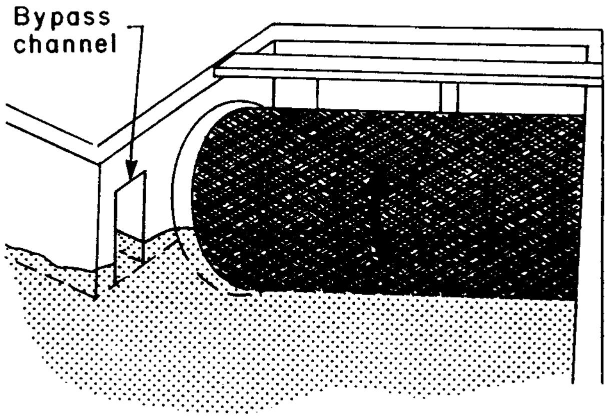
VERTICAL PANEL SCREENS

May be installed in rivers, lakes and the ocean. Generally, requires coarse trashracks, a sluice gate in river installations, double sets of guide-rails, and standby screen panels to allow for cleaning and repairs.



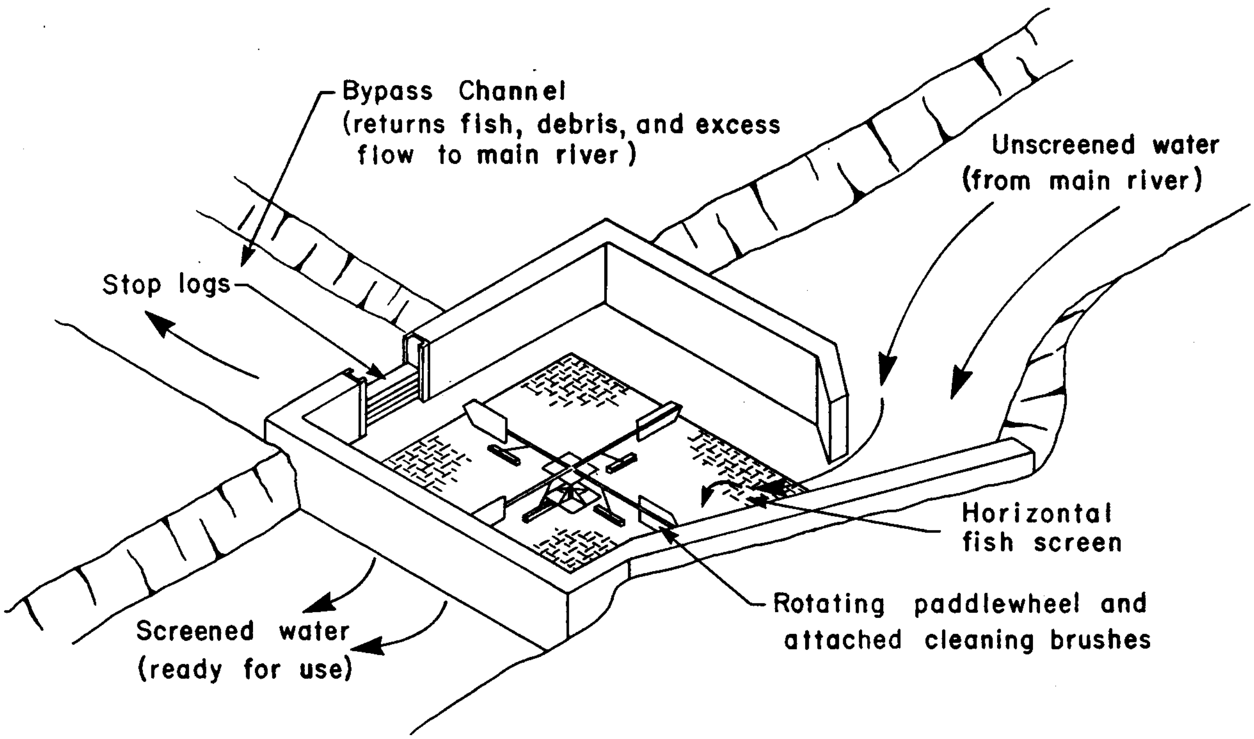
LARGE STATIONARY WATER INTAKE SCREENS

(For pumps of a capacity more than 28.3 L/sec [1 cfs, 449 U.S. or 374 Igpm])



REVOLVING DRUM SCREEN, HORIZONTAL AXIS

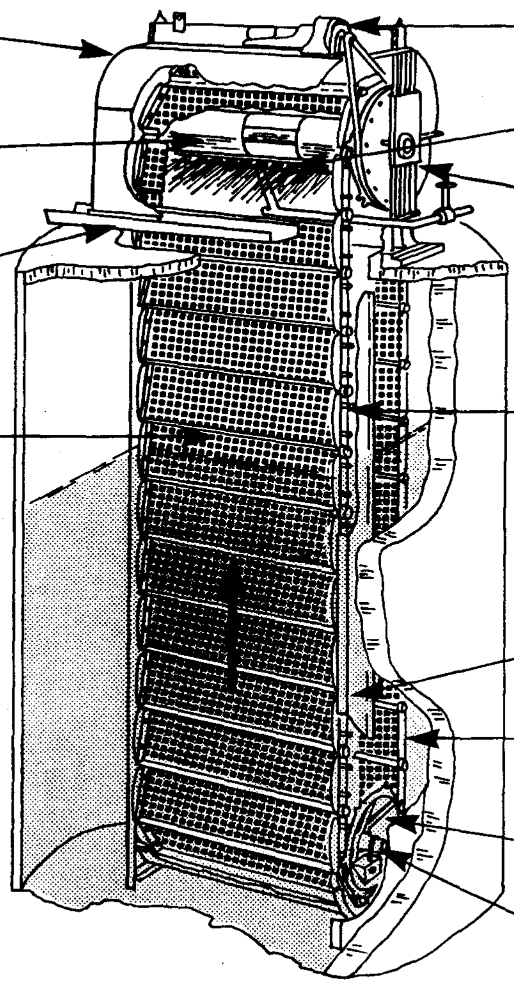
Generally, installed to divert fish from irrigation canals. Can be driven by a small motor or by a paddle wheel. To avoid juvenile fish impingement, a bypass channel is required near the front of the screen. Rubber seals are necessary along the base and sides.



FINNIGAN SCREEN

The horizontal, self-cleaning Finnigan Screen is another concept, generally installed to divert fish from irrigation or enhancement projects. The stationary horizontal screen is kept clean by a set of brushes attached to a revolving paddle wheel powered by the water current entering the structure. A portion of the flow, the suspended debris, and fish are directed to the bypass channel. The remainder of the flow passes through and below the screen for use as required.

IRRIGATION INTAKE SCREENS



CONVENTIONAL VERTICAL TRAVELLING SCREEN

May be installed in rivers, lakes and the ocean. A common screening method utilized by industry, these self-cleaning mechanical screens with modifications can prevent impact upon fish. Mounted flush to the stream bank (shoreline) or as pier intakes within streams and provided with an opening on the downstream end between the intake screens and trashracks, juvenile fish can generally escape entrapment. Rubber panel, side, and boot seals are required to prevent juvenile fish from gaining entry into the pumpwell. A safe bypass system is essential to return juvenile fish with debris back to the watercourse. Automatic controls are also necessary to ensure operation at a specific minimum head differential.

LARGE INDUSTRIAL AND DOMESTIC WATER INTAKE SCREEN

Appendix 10. Actions Required of Operators in the Event of an Environmental Emergency During a Bridge Maintenance Operation

Spills of deleterious substances into water frequented by fish are to be reported. The contacts listed below should be used to report spills. In addition, a list of DFO District and Subdistrict offices is included with Figure 1.

Spill control equipment, such as that detailed below, should be available on site to contain unforeseen losses of paints, solvents or paint chips into waterbodies.

In the event of a spill into a waterbody, streamside zone or marine foreshore area, the following actions should immediately be undertaken:

(1) Solvents spilled on land should be contained with absorbent materials specifically developed to retain flowing liquids, such as "sorbent pads". Peat moss can also be used to control liquid spills on water or land.

(2) Liquid paint spills to streams should, where possible, immediately be contained using hay bales to stop the flow of floating material. If the spill occurs on land, any storm catch basins should be blocked with plastic sheets and sand.

After the above measures are taken to contain the spilled material, the following emergency response instructions should be followed:

TO REPORT AN ENVIRONMENTAL EMERGENCY CALL EITHER OF THE FOLLOWING 24-HOUR TELEPHONE NUMBERS:

Department of Environment, Environmental Protection, Emergency Operations: **(604) 666-6100**.

Province of B.C. Provincial Emergency Program (PEP) Operations Centre: **1-800-663-3456**.

Be prepared to provide the following information:

- Location of the spill;
- Type and volume of material spilled;
- Time of the spill;
- Availability of clean-up equipment and personnel; and
- Actions taken to contain/clean up spilled material.

Appendix 11. British Columbia Ministry of Environment Regional and Sub-Regional Offices

Region 1 - Vancouver Island
2569 Kenworth Road
Nanaimo, B.C.
V9T 4P7
Phone: 758-3951

Region 2 - Lower Mainland
15326 - 103A Avenue
Surrey, B.C.
V3R 7A2
Phone: 584-8822

Region 3 - Southern Interior
1259 Dalhousie Drive
Kamloops, B.C.
V2C 5Z5
Phone: 374-9717

Sub-Regional Office - Penticton
3547 Skaha Lake Road
Penticton, B.C.
V2A 7K2
Phone: 493-8261

Sub-Region Office - Williams Lake
540 Borland Street
Williams Lake, B.C.
V2G 1R8
(Waste Management) Phone: 398-4543
(Habitat Protection) Phone: 398-4562

Region 4 - Kootenay
310 Ward Street
Nelson, B.C.
V1L 5S4
(Waste Management) Phone: 354-6355
(Habitat Protection) Phone: 354-6344

Sub-Region Office - Cranbrook
106 - 5th Avenue South
Cranbrook, B.C.
V1C 2G2
Phone: 426-1450

Region 5 - Northern Interior
3rd Floor, Plaza 40
1011 Fourth Avenue
Prince George, B.C.
V2L 3H9
(Waste Management) Phone: 565-6443
(Habitat Protection) Phone: 565-6422

Sub-Region Office - Ft. St. John
3726 Alfred St.
Bag 5000
Fort Saint John, B.C.
V0J 2H0
(Habitat Protection) Phone: 787-3288

Region 6 - Skeena Region
3726 Alfred Street
Bag 5000
Smithers, B.C.
V0J 2N0
(Waste Management) Phone: 847-7250
(Habitat Protection) Phone: 847-7288

Sub-Regional Office - Q.C.I.
Box 370
Queen Charlotte City, B.C.
V0T 1S0
Phone: 559-8431