Ministry of Environment and Climate Change Strategy

Interim Technical Guidance 11
Environmental Management Act

Development and Use of Initial Dilution Zones in Effluent Discharge Authorizations

Version 1.0

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Environmental Protection Division

TABLE OF CONTENTS

DEFINITIONS AND ACRONYMS

7Q10	Seven day duration, 1 in 10 year return period, low flow statistic
acute toxicity	A toxic effect (severe biological harm or death) produced in an organism by a substance or a physical or biological attribute of water, sediment or biota (either separately or in combination) within a short exposure period (usually 96 hours or less).
aquatic life	Any living component of the freshwater or marine aquatic ecosystem, including phytoplankton, zooplankton, benthos, macrophytes and fish.
benchmark	A point of reference against which things may be compared or assessed. Environmental or water quality benchmarks provide a range or threshold within or below which effects to designated uses are not anticipated. For the purpose of impact assessment under waste discharge permitting, these benchmarks include provincial water quality guidelines, water quality objectives or science based environmental benchmarks.
best achievable technology (BAT)	The technology which can achieve the best waste discharge standards and that has been shown to be economically feasible through commercial application.
best management practices (BMP)	A recommended technique that has been demonstrated to be an effective and practical means of preventing or limiting harmful impacts to the environment. Best management practices include any program, technology, process, siting criteria, operating method, measure, or device that controls, prevents, removes, or reduces pollution.
bioaccumulation	The process by which a substance is taken up and accumulated in the various tissues of an organism (e.g., through water and food). Bioaccumulation takes place within an organism when the rate of intake of a substance is greater than the rate of excretion or metabolic transformation of that substance.
biomagnification	The increasing concentration of a substance in the tissues of organisms at successively higher levels in a food chain.
buoyancy	As it relates to physical mixing processes, buoyancy refers to the upward force of the effluent plume in the receiving environment due to density differences.
chronic toxicity	A lethal or sub-lethal toxic effect produced in an organism by a substance or a physical or biological attribute of water, sediment or biota (either separately or in combination) over a long exposure period (the length of exposure to be identified "chronic" depends on the species of concern).
contaminant of potential concern (COPC)	Any physical, chemical, or biological substance in air, soil or water at a concentration that exceeds regulatory thresholds, or may have an adverse effect on environmental or human health receptors.
country foods	Foods that are harvested by hunting, trapping, or fishing; and produce such as that grown in vegetable gardens and orchards or collected from naturally occurring sources (e.g., wild berries).

designated water uses	Water uses that are protected at a specific location, including drinking water, aquatic life and wildlife, agriculture (irrigation and livestock watering), recreation aesthetics, and industrial water use.
dilution – chemical	Ratio of effluent concentration (end of pipe) to the effluent plume concentration at a set of selected locations downstream from the point of discharge.
dilution – volumetric	Ratio of receiving environment flow volume to effluent flow volume in the effluent plume at a set of selected locations downstream from the point of discharge.
effluent	As per the *Environmental Management Act*: A substance that is introduced into water or onto land and that: (a) injures or is capable of injuring the health or safety of a person, (b) injures or is capable of injuring property or any life form, (c) interferes with or is capable of interfering with visibility, (d) interferes with or is capable of interfering with the normal conduct of business, (e) causes or is capable of causing material physical discomfort to a person, or (f) damages or is capable of damaging the environment.
EMA	*Environmental Management Act*
groundwater	Subsurface water at or below a water table in fully saturated geological materials and formations.
initial dilution zone (IDZ)	The 3-dimensional zone around the point of discharge where mixing of the effluent and the receiving environment water occurs. At the edge of an IDZ, the effluent should not cause chronic toxicity in the receiving environment.
long-term (chronic) WQG	A scientifically-derived numerical concentration or narrative statement considered to be protective of designated uses against chronic or long-term exposure. Chronic exposure involves a stimulus that lingers for a long time - several weeks to years. An averaging period approach is used for chronic WQGs.
plume	The physical extent within the receiving environment where the effluent mixes with the receiving water and there is a distinguishable difference from the ambient water conditions.
pollution	As per the *Environmental Management Act*: "pollution means the presence in the environment of substances or contaminants that substantially alter or impair the usefulness of the environment".
Qualified Professional (QP)	An applied scientist or technologist specializing in an applied science or technology applicable to the duty or function including, if applicable, and without limiting this, agrology, biology, chemistry, engineering, geology, or hydrogeology; who is registered with the appropriate professional organization, is acting under that organization's code of ethics and is subject to disciplinary action by that organization; and, through suitable education, experience, accreditation and/or knowledge, may be reasonably relied on to provide advice within their area of expertise.

receiving environment	Air, land, water and all other external conditions or influences under which humans, animals and plants live or are developed, into which discharges occur.
receptor	Any individual organism, species, population, community, habitat, or ecosystem that may be exposed to parameters or substances of potential concern.
short-term (acute) WQG	A scientifically-derived numerical concentration or narrative statement considered to be protective of designated uses against acute or short-term exposure (e.g., <96-h exposures). Acute exposure may have a sudden onset, last a short time, or be a stimulus severe enough to induce a response rapidly.
statutory decision maker (SDM)	A representative of government making a decision, as authorized to do so by their delegated/designated powers under a statute. To exercise decision making authority under a particular enactment, a decision maker must have lawful authority to make the decision and must make it within the scope and manner prescribed by the enactment.
surface water	Surface water is any water that collects on the surface of the earth. This includes the oceans, seas, lakes, rivers, or wetlands.
water quality guideline (WQG)	WQGs are generic numerical concentrations or narrative statements recommended to protect designated water uses on a provincial basis. BC's WQGs represent safe levels of substances that protect different water uses, including: drinking water, recreation, aquatic life, wildlife and agriculture. Exceeding a WQG does not imply that unacceptable risks exists, but rather that the potential for adverse effects may be increased and additional investigation may be required.
zone of passage	Zone within a water body that allows fish or other aquatic life to pass through without being harmed.

DISCLAIMER

This document has been prepared to help proponents and regulators understand where and when initial dilution zones are appropriate and how they should be developed in the environment for authorized effluent discharges under the *Environmental Management Act* (EMA). The reader is encouraged to consult a qualified professional (QP) and the references located in this document when preparing an application for authorization to discharge effluent. This document does not supersede EMA, its regulations or other provincial or federal legislation.

Recommendations in this document are not mandatory requirements, but are recommended practice, and become legally enforceable if they are included in an authorization issued under EMA. This document is not intended to provide a legal interpretation of EMA, its regulations and/or codes of practice. This is a guidance document that describes procedures, practices and results that are consistent with legislated requirements.

Where specifics are not provided, flexibility in the application of guidance recommendations may be required to adequately achieve environmental protection. A recommended practice may be modified when an alternative could provide better results. For information on the process of applying for a discharge permit please visit the Ministry of Environment & Climate Change Strategy – Waste Management website:

www2.gov.bc.ca/gov/content/environment/waste-management/waste-discharge-authorization

1.0 INTRODUCTION AND BACKGROUND

When authorizing effluent discharges to surface waters (receiving environment) under the *Environmental Management Act* (EMA), the ability of the receiving waters to dilute the effluent is an important consideration. The extent of the receiving waters affected by a discharge depends on the effluent characteristics and the rate of mixing in the receiving environment. Proponents should ensure that best management practices (BMPs) to minimize waste and prevent or limit harmful impacts and best achievable technologies (BAT) for waste treatment have been applied prior to considering an initial dilution zone (IDZ). Authorization processes must also consider the physical mixing processes expected to occur to determine the extent of the receiving environment influenced by a discharge.

This document is intended to provide guidance to applicants applying for or amending a permit or approval for effluent discharges. It describes the requirements for assessing a proposed IDZ, as well as when an IDZ may be used or restricted from use in an authorization. This document is not a detailed manual, and should be used in conjunction with other applicable ministry guidance and policy.

Individual projects may have specific considerations that may not be addressed by the general level of information provided in this guidance. The decision to approve the use of an IDZ rests solely with a director, or their delegated statutory decision maker (SDM), and may be determined on a case-by-case basis, depending on project specific conditions. There may also be parameters or contaminants that might not be suitable for the application of an IDZ.

Discharges authorized by specific regulation may have specific requirements relating to IDZs (e.g., Municipal Wastewater Regulation) in which case the requirements of the regulation must be followed. While discharges of effluent to ground may be authorized under EMA, IDZs as described in this document are not intended to apply to discharges to ground. This document does not apply to spills or environmental emergencies, as IDZs are applicable only to authorized effluent discharges.

1.1 Legislation

Sections 6 (2) and (3) of EMA prohibit the introduction of waste into the environment in the course of conducting a prescribed industry, trade or business, or the introduction of waste produced by a prescribed activity or operation into the environment.

Despite Sections 6 (2) and (3), Section 14 (1) and 15 (1) of EMA give a director the authority to issue a permit or approval authorizing the introduction of wastes into the environment subject to requirements for the protection of the environment that the director considers advisable. When evaluating an application for a permit or approval, the director may consider the application relevant policy and guidelines, such as this document. If a permit or approval is issued, the director may impose requirements ensuring that BMPs and BAT are applied.

1.2 Definition of an IDZ

The IDZ is the 3-dimensional zone around a point of discharge where mixing of the effluent and the receiving environment water occurs. An IDZ does not encompass the entire extent where all mixing occurs, since the effluent plume may extend beyond the edge of an IDZ before the plume is fully mixed with the receiving environment. At the edge of an IDZ, the effluent should not cause chronic toxicity in the receiving environment. Defining the allowable extent of an IDZ depends on the sensitivity and values of the receiving environment downstream from the discharge.

1.3 Purpose of an IDZ

An IDZ is a regulatory construct that at the discretion of a director under EMA, or their delegated SDM, can allow proponents to discharge effluent in a way that limits the effects from chronic exposure to a specified extent in the receiving environment before effluent fully mixes with receiving water. An IDZ allows for somewhat elevated concentrations of contaminants of potential concern (COPCs) to occur within relatively small areas of a receiving water body, without significantly affecting the integrity of the water body as a whole. The mixing that occurs in an IDZ allows for some reliance on dilution to achieve the long term water quality benchmarks that ensure protection of the most sensitive species and life stages against toxicity effects for indefinite exposures.

2.0 CONDITIONS FOR USE OF AN IDZ

The Ministry of Environment and Climate Change Strategy (ENV) considers an IDZ only for authorized point source discharges to surface water and only if the following conditions are met:

a) Best management practices (BMPs) for preventing or limiting harmful impacts to the environment should be applied;
b) Best Achievable Technology (BAT) has been considered in the proposed discharge plan. An IDZ should not be used as an alternative to reasonable and practical treatment of effluent or effluent stream. BAT Factsheet www2.gov.bc.ca/assets/gov/environment/waste-management/industrial-waste/industrial-waste/pulp-paper-wood/best_achievable_control_tech.pdf;
c) Effluent discharge and water quality within the IDZ should not be acutely toxic to aquatic life;
d) COPCs should not bioaccumulate to levels harmful to receptors as a result of conditions within an IDZ;
e) COPCs should not accumulate to acutely toxic levels in the water or sediments of the IDZ;
f) Conditions within an IDZ should not attract aquatic life or wildlife, causing increased exposure to COPCs;
g) Negative aesthetic qualities or other nuisance conditions in the receiving waters (e.g., odour, colour, scum, oil, floating debris) should not occur as a result of the discharge and/or IDZ;
h) Dominance of a nuisance species[1] should not occur as a result of conditions within the IDZ that are due to the discharge; and,
i) Use of an IDZ should not impair the integrity of the water body as a whole.

3.0 CONSIDERATIONS FOR IDZs AND SITING A DISCHARGE

In addition to the conditions outlined above in Section 2.0, the following will also be considered when reviewing proposed IDZs:

a) An IDZ should be as small as possible to minimize the extent of the receiving environment potentially exposed to chronic toxicity levels;

[1] As per the USEPA, "Aquatic nuisance species are organisms that disrupt the ecological stability of infested inland (e.g., rivers and lakes), estuarine or marine waters. Beyond doing ecological damage, the infestation may impair the recreational, commercial and agricultural uses of the water body" (https://www.epa.gov/vessels-marinas-and-ports/aquatic-nuisance-species-ans).

b) An IDZ should not adversely affect sensitive aquatic habitats. These include, but are not limited to:
   - Spawning, hatching, or rearing areas for fish, overwintering habitats for fish or migratory waterfowl, ecosystems ranked as at risk as per the BC Conservation Data Centre and ecosystems of regional, provincial or national importance (e.g., unique to the region, province); and,
   - Aquaculture and marine protected areas;

c) An IDZ should maintain adequate zones of passage for migrating fish that do not deter the fish from passing through, do not affect their sense of orientation, and do not pose health risks to migrating species;

d) An IDZ should not result in an adverse effect at the edge of the IDZ on designated water uses in the area:
   - Designated uses include aquatic life, wildlife, agriculture (e.g., livestock watering and irrigation), and drinking water and recreation.
   - An IDZ should not be sited near drinking water intakes or food harvesting areas (e.g., shellfish beds or Indigenous Peoples traditional harvesting locations);

e) An IDZ should consider setbacks from sensitive areas;

f) An IDZ should avoid highly-frequented recreational water use areas (e.g., public beach);

g) At the edge of the IDZ, water quality should not result in short-term or long-term effects to aquatic life;

h) IDZs for adjacent authorized effluent discharges should not overlap with each other;

i) The effluent plume within the IDZ should not contact the shoreline of a water body in any manner that would prevent effective mixing and/or result in accumulation of COPCs in the sediments; and,

j) Diffusers used to discharge effluent into an IDZ should be designed to maximize mixing effectiveness.

4.0 PROCESS FOR DEVELOPING AN IDZ

The process for developing an IDZ includes assessing characteristics of both the effluent to be discharged and the receiving environment into which the discharge will occur. A conceptual site model should be developed for the discharge to help identify key assessment needs especially for more complex scenarios (ref: Use of Conceptual Site Models to Support EMA Effluent Permit Applications, March 2018, MECCS). Assessment of background water quality, designated water uses, sensitivity of receptors, and physical characteristics affecting mixing in the receiving environment should be undertaken. Options for discharging should be assessed, including assessing quality and discharge rate alternatives. Seasonal variation of the discharge may be considered to address seasonal variations in flow or water body conditions, seasonal presence of receptors, seasonal variation in water uses, and/or seasonal variation in background water quality.

The following are key considerations in the process for establishing an IDZ:

a) Timing and rate of discharge to minimize the amount during low dilution periods may be required;

b) Location, depth, type of diffusers and their influence on mixing should be evaluated;

c) IDZ mixing analyses should consider the range of expected-, best- and worst-case conditions for effluent discharge and mixing in order to demonstrate that applicable water quality benchmarks will be met at the edge of the IDZ under all potential effluent quality/quantity conditions, as well as seasonal flows/currents/conditions within the receiving water;

d) An IDZ proposal should consider the effects to aquatic life, including effect level and life stage, as well as the concentrations and nature of parameters that may interfere with the aquatic life uses of the water body, including but not limited to:

   - Chronic toxicity risks
   - Composition of aquatic community
   - Critical aquatic habitat
   - Zone of passage
   - Spawning
   - Species of special concern
   - Bioaccumulation

e) The IDZ proposal should consider the effects on aquatic and riparian mammals and birds/waterfowl, including life cycle, migration and forage;
f) The IDZ proposal should consider the effects on human health (directly and through consumption of country foods);
g) A monitoring plan should be designed to assess changes in the receiving environment within the IDZ and/or at the edge of the IDZ relative to baseline conditions and to validate modeling used in deriving the IDZ. Such a plan can be included as part of an existing or proposed monitoring plan to measure effects from discharges into the environment; and,
h) If some elements of site conditions are unknown or are uncertain at the time of application, an IDZ may still be considered depending on an assessment of risk. In this case a trigger and response plan to ensure timely and appropriate actions are taken in response to findings from monitoring, and an adaptive management plan to address residual uncertainties would be required to appropriately manage the discharge (refer to Appendix B – Trigger Response and Adaptive Management Plans for more information).

Dimensions allocated to an IDZ will vary on a case-by-case basis depending on site-specific factors. The extent of an IDZ requires justification based on the environmental impact assessment and dispersion modeling. The following IDZ extent targets are intended as guidance:

a) Width - not greater than 25% of stream width (for flowing water)
b) In marine waters and lakes, the initial dilution zone should not extend closer to shore than mean low water and should be located outside of the shallow water zone in which surf will form along the shore
c) Flow – not greater than 25% of stream flow volume at low flow receiving environment (i.e., 7Q10) (for flowing water)
d) Lakes (non-flowing) – not greater than 5% of surface area
e) Typically may extend up to a maximum of 100 metres from the point of discharge.

5.0 RECEPTOR CONSIDERATIONS

An IDZ should not result in an impairment of the usefulness of the receiving environment, harm designated water uses, or cause pollution. Determining whether usefulness of the receiving environment may be impaired can be complex, as a water body may have many designated uses. The following section provides some detail on what to consider for designated uses when developing a proposal for an IDZ. Note that this section may not cover all designated uses or all considerations for the designated uses. A qualified professional (QP) should consider site-specific attributes when developing a proposal for an IDZ.

In order to delineate areas that may be suitable for an IDZ and may not result in the impairment of designated water uses (e.g., aquatic life, wildlife, agriculture, drinking water and recreational) such uses need to be identified in the vicinity and downstream of the discharge. In addition, uses by Indigenous Peoples (e.g., hunting, fishing, gathering for sustenance, medicinal or spiritual uses) need to be determined.

5.1 Aquatic Life

Permit applications that include IDZs should be assessed on a site specific basis to ensure potential effects on aquatic life are acceptable and to ensure a zone of passage remains for aquatic life. The following should be considered in developing permit applications that include an IDZ:

a) What species are present in the aquatic ecosystem, particularly any ecologically, culturally or economically important species, or species at risk;
b) Seasonal changes that may occur – both physical changes to the water body and ecological changes such as migration of species in or out of the area, or times where ecological sensitivity is increased (e.g., spawning, presence of vulnerable life stages);
c) Physical impacts on aquatic habitat from the discharge;
d) Potential for avoidance of the area by aquatic life due to elevated parameter concentrations or other characteristics resulting from the discharge; and
e) Length of time and frequency that the aquatic ecosystem will be exposed to elevated concentrations or other potentially harmful water quality characteristics resulting from the discharge.

To assess potential effects on the environment, determine nearby areas where potentially exposed species are likely to spend significant time, particularly during periods when species congregate, periods when effluent concentrations or receiving environment concentrations are predicted to be highest, or periods of high species sensitivity (e.g., spawning). A survey of aquatic life (e.g., fish species, aquatic mammals, birds and waterfowl, marine mammals, rare plants) as well as a habitat suitability determination will provide information on existing and potential aquatic receptors, including life-stages and potential periods of use.

While the integrity of the water body receiving an effluent must be protected, IDZs may allow elevated concentrations of COPCs to occur within a relatively small area of a receiving water body. Within an IDZ there may be some potential to cause chronic effects to aquatic life through exposure to elevated concentrations of water chemistry parameters, through negative impacts to habitat, or through changes in oxygen concentrations, sediment chemistry concentrations, temperature, or turbidity. Lethality and sub-lethal toxicity are a function of both parameter concentration and duration and frequency of exposure, and can be modified by local conditions. Site specific toxicity testing on locally present sensitive species may, therefore, be necessary.

5.1.1 Habitat

An IDZ should be placed away from critical habitat areas, such as overwintering, spawning, or rearing habitat. Physical alteration of habitat due to the discharge and changes in water quality that may result in chronic toxicity within the IDZ should not occur in areas where fish species, marine mammals, or entire populations of endangered, vulnerable, threatened species or species at risk spend significant amounts of time. Endangered, vulnerable, threatened species and species at risk information can be found at:

a) BC Conservation Data Centre (www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/conservation-data-centre/explore-cdc-data/red-blue-yellow-lists); and
b) Canada Species at Risk Pubic Registry (www.registrelep-sararegistry.gc.ca/sar/index/default_e.cfm)

Bioaccumulation potential is particularly important in locations where fish, shellfish, and/or marine mammals spend considerable time, including spawning areas and main feeding grounds for aquatic or terrestrial species. Biomagnification should also be considered.

It is important to identify receiving water hydrographs and flow needs for aquatic life to determine best time periods and locations for effluent discharges.

5.1.2 Zone of Passage

Migrating routes for aquatic species in the area need to be identified to ensure that an IDZ does not obstruct migration passages or result in adverse effects on migrating species (e.g., salmon, steelhead, sturgeon).

5.2 Wildlife

Potential use by wildlife in the vicinity of the discharge needs to be determined. Habitat suitability and various methods to determine wildlife species use, as well as information on general wildlife distribution, provide useful tools in identifying potential wildlife receptors.

The following questions are important:

a) Which species frequent the area? Are these species sensitive to substances in the discharge?
b) Where are the main watering sites and feeding grounds? Could wildlife be in contact with water inside the IDZ?
c) What potential exists for wildlife toxicity (acute or chronic) due to drinking or wading into the water?
d) What potential exists for wildlife toxicity (acute or chronic) due to food-web contamination (e.g., directly through consumption of aquatic plants or animals, or indirectly via consumption of irrigated terrestrial plants)?

IDZs should be placed away from areas highly frequented by wildlife (e.g., main watering sites or feeding grounds, or preferred locations for water body crossings on popular wildlife trails).

5.3 Human Water Uses

When evaluating a potential IDZ, the impacts on human health due to the discharge should be considered. Depending on the designated uses of the water body, various human health-based water quality guidelines may be appropriate for evaluating and regulating the IDZ. Potential impacts can be evaluated through water quality guidelines associated with ingestion of water (domestic water supply uses, drinking water), contact recreational use, indirect consumption through agricultural products (irrigated crops, edible products from livestock consuming the water or irrigated crops), or consumption of fish, other aquatic life or wildlife. Particularly, consumption of water or fish, shellfish, wildlife and wild plants should be considered in areas where collection by Indigenous Peoples for sustenance or other traditional uses occurs. In addition, agriculture can be affected where the water is used for irrigation and/or livestock watering. In determining which human health-based or agricultural criteria should be considered, the designated uses of the water body in question should be known.

To reduce potential for effects on human water uses, an IDZ should not overlap with any water intakes or specific locations regularly used by Indigenous Peoples to fish or collect aquatic life for sustenance. Locations of licensed domestic and agricultural (e.g., irrigation, livestock watering) water licences can be determined from the following BC Government websites:

a) iMapBC: http://maps.gov.bc.ca/ess/sv/imapbc/; and
b) Water Licences Query Page: www.env.gov.bc.ca/wsd/wrs/query/licences/help/all.htm.

5.3.1 Drinking Water

The location of an IDZ should not result in water quality parameters exceeding maximum acceptable concentrations indicated in drinking water guidelines at water intakes. The location of licensed intakes can be found at the links above.

Besides licensed drinking water intakes, un-licensed water intakes exist in BC. As per Section 6 (3) of the *Water Sustainability Act*, a person is not prohibited from diverting surface water, in accordance with any applicable regulations, and beneficially using unrecorded water from a stream for domestic purposes. This means a water license search may not capture all existing domestic water intakes. If private land exists near the proposed IDZ, private land owners should be contacted to determine if, when and where diversion of unrecorded water is occurring. In addition, Indigenous Peoples should be contacted to determine where drinking water is collected, proximity to cultural camps, and locations used for camps when engaged in hunting, fishing, gathering, or other traditional activities.

5.3.2 Recreation

Areas of recreational use should be mapped, such as: beaches, boat launches, popular boating routes, and hiking trails. Tourist information material (e.g., maps, guides, and websites) as well as local tourist centers and information from local residents can be used to determine sites frequently used for recreation.

An IDZ should not overlap a frequently used recreational site (e.g., swimming beach) and should not result in water quality parameter conditions exceeding water quality guidelines for contact recreation at nearby recreational sites due to the discharge.

5.3.3 Indirect Human Consumption

An IDZ should be located to ensure adverse health effects do not occur through indirect consumption and the IDZ should not overlap with popular fishing or harvesting areas. Awareness of important Indigenous Peoples hunting, fishing and plant collection areas in the vicinity is important in order to avoid adverse effects on human health and Indigenous Peoples traditional uses. In addition, popular fishing or aquatic life harvesting areas (e.g., shellfish beds or crab trapping) areas in the vicinity or downstream of the discharge should be identified. Be aware that Indigenous Peoples consumption rates and target species may differ from other populations, so a site specific human health risk assessment may be necessary.

5.4 Agricultural Uses

5.4.1 Irrigation

Diversion points for irrigation in the vicinity or downstream of a discharge need to be mapped in a similar way as for domestic water intakes. If irrigation occurs in the vicinity, water intake locations, intake volumes, timing and irrigation purposes should be identified.

An IDZ should be placed away from an irrigation intake and an assessment should be provided to show that the discharge and IDZ do not cause an adverse effect on agricultural use and indirect human consumption of irrigated crops, meat, eggs, or milk from livestock feeding on irrigated crops.

5.4.2 Livestock Watering

Diversion points for livestock watering and potential livestock access to waterbodies in the vicinity and downstream of a discharge need to be identified. Effects of the discharge on livestock from water ingestion or from water contact from wading into the water need to be evaluated.

An IDZ should be placed away from livestock watering diversion points. The delineation of an IDZ and a discharge should not result in adverse effects to livestock from consuming or wading into water downstream of a discharge and should not lead to human health effects from indirect consumption of meat, milk, or other products.

5.4.3 Aquaculture

When evaluating a potential IDZ, the impacts on any nearby aquaculture sites should be considered. The proximity of the discharge to the aquaculture site(s) needs to be mapped, and the expected effluent concentrations in the immediate vicinity of the site should be estimated under a representative range of conditions of receiving water flows and other water properties (e.g., temperature, salinity, vertical stratification).

An assessment may be necessary to show that the IDZ is placed sufficiently far away from aquaculture sites and the discharge will not cause a negative impact from the specific substances released in the discharge. This assessment would include consideration of the potential linkages between the estimated concentrations of the specific substances at the aquaculture site in relation to the uptake by, and biological effects on, the particular type of finfish or shellfish being farmed and/or on the workers at the site.

6.0 PHYSICAL MIXING PROCESSES

The development of an IDZ requires the prediction of how effluent physically behaves once discharged into the receiving environment, which is governed by physical mixing processes.

Physical mixing processes can be generally divided into two different regions: near- and far-field. The near-field region is the first stage of mixing, where mixing is predominantly defined by the characteristics of the effluent discharge itself, such as the velocity and density of the discharged effluent and outfall design (e.g., diffuser). The far-field region is where the plume travels further away from the discharge location, and mixing is largely controlled by the receiving environment (ambient) characteristics, such as ambient velocity and density distribution. The distinction between the near-field and far-field regions is based on physical mixing processes, and is not on a prescribed regulatory basis.

The simulation of physical mixing processes, often called hydrodynamic analysis, relies on the use of models and/or field dilution studies. The primary goal of hydrodynamic analyses is the derivation of the dilution (volumetric) that can be achieved within the effluent plume and/or at the edge of IDZ in the receiving environment. The hydrodynamic analyses should be conducted by a QP with expertise in the area of hydrodynamic mixing processes. Refer to Appendix C for more detailed information on dilution and water quality predictions at the edge of IDZ.

6.1 Freshwater Environments

This section focuses on considerations for freshwater, whereas specific considerations for the marine environment are discussed in Section 6.2 and Appendix D.

6.1.1 Modelling Overview

Models are important tools for evaluating the mixing behavior and plume dynamics of a point source discharge. Models can also be used in an iterative process in order to optimize the engineering design and operational plans for a discharge in order to minimize the size of the IDZ. Available modeling methods range from analytical calculations (e.g., simple mass balance equations using dilution factors) to complex numerical models (e.g., computer simulations using specific mathematical models). It is recommended that proponents discuss the approach to modelling with ENV prior to conducting the work.

Numerical models are computer software systems used to simulate the physical mixing processes of an effluent discharge within the receiving environment. A variety of modelling software is available for estimating near- and/or far-field mixing processes. Examples of near-field models include CORMIX and Visual Plumes, which are widely used for computing dilution of the effluent plume. More than one modelling software package may be necessary to evaluate the mixing and dilution for a given IDZ, and it is important that the QP conducting the modelling understand the strengths and limitations of the numerical model(s) selected for analyses. Regardless of the modelling software selected, the reliability of model predictions depends on the accuracy of the model input information to characterize site conditions. In general, the minimum site-specific information requirements are:

- Receiving environment:
  - Flow rate or velocity
  - Density/temperature – uniform or stratified (profile at depth)
  - Geometry – bounded (river/stream) or unbounded (lake/reservoir)
  - Channel roughness (Manning's n)
- Effluent:
  - Flow rate or velocity
  - Density/temperature
  - Discharge concentration of representative water quality parameter
  - Particulates concentrations and size distributions (if present)
- Outfall/diffuser design information

Using the above site-specific information, the modelling should include scenarios to simulate a range of expected case, best-case, and worst-case conditions for the effluent discharge and receiving environment. For flowing waters, the most commonly used low flow index (worst-case) to characterize the receiving environment is 7Q10, defined as the annual 7-day low flow with a 10-year return period.

Model results should include, at a minimum:

- Figure(s) to illustrate the model extents, with any other relative discharges within close proximity, public access points, known spawning locations, drinking water intakes, and diversions;
- Predicted dilution within the effluent plume and/or edge of IDZ under a range of flow scenarios;
- Description and figures to illustrate the physical extents of the effluent plume (downstream, cross-stream); and,
- Description of effluent plume mixing characteristics within model extents.

6.1.2 Model Calibration and Verification

Models should undergo calibration and verification, including comparison with independent field data, before predictions can be relied on for decision-making. In some cases, a sensitivity analysis may be required to determine limitations on input parameters.

Model calibrations are achieved by operating the model for a specific case of receiving water conditions where actual field data is available, along with selected simulated effluent discharges. The results of the comparison between the model and the independent field observations, combined with analytical and possibly tracer measurements, are then used to adjust the model parameters to improve the agreement between the model and the field observations.

Model verification can be achieved by applying the calibrated model to one or more historical events with different ambient and effluent discharge conditions. A reasonably high level of agreement between the model results with the field observations provides a quantitative verification score to support the validity of the modelling approach used. A discussion should be provided on the frequency of occurrence of the particular ambient and effluent conditions being considered.

6.1.3 Field Dilution Studies

The physical mixing of effluent within the receiving environment can also be estimated by conducting field dilution studies using a tracer that is either naturally present in the effluent (e.g., conductivity) or is added (e.g., Rhodamine WT dye). The purpose of this type of field study is to provide discrete direct measurements of the dilution achieved from the discharge structure, whether the structure (e.g., discharge pipe or channel) is a preliminary version used for site testing purposes or a more sophisticated engineering structure (e.g., diffuser). The direct measurements require that the effluent tracer be readily detected in the receiving environment, and may involve using boat-based sampling instruments.

Field observations are also generally required to provide calibration and verification of modelling results, as discussed above, and as part of a monitoring plan (Section 7.0).

At a minimum, field studies should correspond to the critical worst-case conditions, such as a low ambient flow (i.e., 7Q10) and maximum effluent discharge. Preliminary calculations or modelling may be required prior to conducting field dilution measurements to estimate the adequate volume or mass of dye/tracer in order to detect concentrations at selected sampling locations.

6.2 Marine Environments

In many areas, the marine waters of British Columbia are highly energetic, with strong seasonal wind forcing, and large tidal flows. Combined with freshwater inputs from several major rivers, this renders marine water conditions highly variable (Appendix D). The receiving waters for the IDZ in the marine environment, in particular the stratification, are more variable than for rivers, lakes and freshwater. In estuarine areas, large variations occur in the marine stratification over tidal cycles.

The higher density of the saline marine receiving waters imparts a positive buoyancy to the more commonly lower density effluent, resulting in a rising initial mixing region with enhanced dilution. Strong stratification of the receiving water, as under estuarine conditions, modifies the rise of the mixing region, determining if and where the diluted effluent first surfaces. Ocean waves can also have an effect on mixing and dilution in the water column, especially in shallower waters. Buoyancy-driven ocean currents with time scales longer than tidal currents and large spatial scales can be present, often along the coastlines of the marine water body.

Developing an IDZ in the marine environment starts from an assessment of the effluent discharge and the marine environment receiving the discharge. The relevant attributes of the marine environment and modeling in the marine environment are further discussed in Appendix D.

6.2.1 Modelling Overview

Mixing of the effluent with the receiving waters occurs in the near-field, where exit kinetic energy dominates, and in the far-field where more passive diffusion or ambient mixing occurs. Models for analysing the behaviour of effluent discharges under various marine scenarios are discussed in Appendix D.

The major variables needed to quantify plume extent in marine receiving waters include:

a) Velocities and currents of the receiving waters in relation to the tidal ranges;
b) Wind conditions;
c) Temperature/salinity (as well as other potential marine factors discussed in Appendix D);
d) Velocities of the effluent discharges;
e) Densities of the entire receiving water column and effluent waters; and
f) Geometry of the receiving body of water and of the effluent discharge structure.

Physical oceanographic processes need to be fully represented in modelling of estuaries, coastal waters and seas. Proponents are referred to Appendix D for more details of the model input.

The expected "worst-case" scenario design and case studies need to consider seasonal variability in temperature, salinity, flows and concentrations of water quality parameters, wind speeds, and river discharges (estuarine environment). Statistical analyses should be applied rather than assuming simultaneous occurrence of individual worst case conditions, which will in fact rarely occur together (Bleninger et al 2011).

6.2.2 Field Dilution Studies

Field dilution measurements may be required to inform and validate the analytical and modelling derived computation of the IDZ extents, especially if the effluent discharges are large and/or the effluent poses a significant chronic toxicity risk. Field studies are necessary to address the following requirements including:

a) Ensure sufficient and up-to-date baseline marine data for the development area;
b) Provide data for the purpose of calibration and verification of analytical and numerical models used to characterize the near-field and far-field conditions (Appendix D.3); and,
c) Establish monitoring of the marine environment once the project is completed to ensure water quality is not acutely toxic within the IDZ and not chronically toxic at the edge of the IDZ (as described below and in Section 7.0).

More information on the conditions under which field dilution measurements are needed is provided in Appendix D.

Monitoring programs are described in some detail in Section 7.0 and also in Appendix D. The design of the monitoring program for the marine environment needs to consider the temporal and spatial scales of the near- field mixing region as well as the adjoining far-field region. The design of the field studies and monitoring programs should involve qualified professionals and the monitoring programs should be conducted according to best practices for oceanographic measurement programs (JCOMM, 2018 and Appendix D).

6.3 Groundwater and IDZs

Discharges of effluent to ground must be authorized under EMA, as this is considered as introduction of waste into the environment. However, IDZs as described in this document are not applicable to discharges to ground. However, there may be circumstances where a discharge to ground is located close to a surface water body such that insufficiently diluted effluent (less than 1:10 dilution) is entering the water body and the water quality of the adjacent water body is impacted. In such cases an IDZ in the adjacent water body may need to be established. Proponents are encouraged to discuss with ENV prior to applying for an IDZ that involves a discharge to ground.

7.0 MONITORING

A monitoring program is a key component in developing an IDZ, to ensure water quality does not result in chronic effects to aquatic life at the edge of the IDZ for an authorized discharge. A proposed monitoring program should be included as part of the request to use an IDZ. The monitoring program should be developed prior to discharge commencing, and based on a conceptual site model for the discharge. A monitoring program should include details about sampling design, sampling methods, frequency, sample handling, analytical methods, data reporting and quality assurance/quality control. Monitoring programs are used to assess any changes in the physical, chemical and biological characteristics of the receiving environment within and at the edge of the IDZ relative to baseline conditions. Monitoring programs can also be used as a means to validate and calibrate model predictions. A monitoring program should be initiated prior to project construction in order to collect baseline data and to establish natural variability at the discharge and un-impacted reference locations.

The IDZ monitoring program should consider the following:

a) Effluent – continuous flow monitoring, discrete water quality sampling at an appropriate frequency for water chemistry, and toxicity testing (acute and chronic);
b) Receiving environment including:
    - Physical monitoring – river/stream cross-sections, ambient velocity, lake/marine water column stratification, and water depth data near outfall (when possible);
    - Water quality - monitoring locations representative of ambient conditions as well as within and at edge of proposed IDZ and at any sensitive receptors or areas;
    - Biological monitoring - benthic macroinvertebrates or fish;
    - Lake or marine environment – around and about the discharge point (i.e. throughout the water column), monitoring locations should be set at several points along the edge of the IDZ (usually the circumference, both at surface and at depth), ideally where the plume crosses the authorized IDZ boundary;
    - River/stream – monitoring locations set at downstream edge of IDZ and at a distance across width of river, ideally where the plume crosses the authorized IDZ boundary;
    - If effluent plume is predicted to float upwards (in case of bottom discharge) or sink towards bottom (surface discharge), monitoring at one or more depths to ensure maximum concentrations are captured at edge of IDZ in samples;
    - If effluent discharge contains bioaccumulative or other substances that accumulate in the sediment (e.g., selenium), important to monitor sediments in vicinity of IDZ; and,
    - If suspended sediment is a pollutant of concern – turbidity monitoring, upstream and downstream of discharge.
c) Typically water quality monitoring frequency should be at minimum monthly intervals to verify seasonal conditions; should include 5 weekly samples in 30 days for relevant COPCs at appropriate times throughout the year; and flow monitoring frequency should be sufficient to characterize seasonal flows;
d) Analysis and reporting of monitoring data should occur on an annual basis;
e) Calibration and/or validation of model predictions as a result of comparison to monitoring data; and,
f) Outfall/diffuser monitoring – recommended to inspect condition of outfall/diffuser structure (at least once every 5 years). If outfall has substantial differences in physical condition than originally planned, then re-evaluation of IDZ may be required.

8.0 INFORMATION TO BE PROVIDED BY PROPONENTS

Proponents are expected to provide all information necessary to support the proposed IDZ based on best professional judgement. Information should be submitted to ENV in a concise report format and include, at a minimum, the following:

- Description of why an IDZ is necessary;
- Proposed dimensions of IDZ;
- Conceptual Site Model;
- Receiving water characteristics:
  - Type of water body;
  - Volume of receiving water available for dilution;
  - Seasonal water temperature/density ranges or vertical temperature/density profile information for deeper lakes or marine environments;
  - Background receiving water quality;
  - Assessment of critical habitat, sensitive receptors and designated water uses, and;
  - Applicable WQGs and/or or site-specific water quality benchmarks for the receiving environment, if applicable.
- Effluent discharge characteristics:
  - Effluent flow rate;
  - Seasonal effluent water temperature/density ranges;
  - Expected buoyancy of effluent relative to receiving water;
  - Concentration of substances in effluent;
  - Comparison of predicted or actual substance concentrations in effluent to water quality guidelines or site specific benchmarks for the protection of the designated uses in this area and/or acute or chronic effluent toxicity test results;
  - Evidence that discharge design and discharge plan has been optimized to minimize the extents of the IDZ within practical limits;
  - Description of potential for substances to bioaccumulate;
  - Design and expected performance of outfall, diffuser type during best-case, worst-case and expected case conditions;
  - Clear identification of where end of pipe is located; and,
  - Results from toxicity testing of effluent.
- Physical and aquatic life receptors of effluent discharge to receiving waters;
- Environmental impact assessment of effluent discharge to receiving environment;
- Method for physical mixing analyses;
- Results of physical mixing analyses; and
- Proposed monitoring program.

A checklist summarizing details of the information required for an IDZ proposal is available in Appendix A. The checklist should be reviewed with ENV prior to beginning the application process to ensure that all parties understand what information should be included in an IDZ proposal.

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10.0 APPENDIX A – INFORMATION CHECKLIST FOR AN IDZ PROPOSAL

INFORMATION	REQUIREMENTS	COMMENTS	Location in Final Application
1. IDZ DESCRIPTION AND OVERVIEW			
1.1. Description of why an IDZ is necessary	Required ☐		
1.2. Proposed dimensions of IDZ - percentage of stream flow and stream width encompassed by the proposed IDZ or percentage of the lake surface area or marine environment encompassed by the proposed IDZ	Required ☐		
1.3. Conceptual model for effluent discharge and IDZ	Required ☐		
2. RECEIVING WATER CHARACTERISTICS			
2.1. Type of water body – lake, marine environment or river/stream	Required ☐		
2.2. Volume of receiving water available for dilution – seasonal, low flows	Required ☐		
2.3. Seasonal water temperature/density ranges or vertical temperature/density profile information for deeper lakes or marine environments	Required ☐		
2.4. Background receiving water quality	Required ☐		
2.5. Assessment of critical habitat, sensitive receptors and designated water uses (e.g., use by Indigenous Peoples, drinking water, domestic use, recreation, irrigation, livestock watering, wildlife, and/or aquatic life)	Required ☐		
2.6. Applicable WQGs and/or site-specific water quality benchmarks for the receiving environment (e.g., Water Quality Objectives (WQOs), Science-Based Environmental Benchmarks (SBEBs), Site Performance Objectives (SPOs)).	Required ☐		
3. EFFLUENT DISCHARGE CHARACTERISTICS			
3.1. Effluent flow rate and description of whether discharge will occur on a continuous, temporary or seasonal basis	Required ☐		

INFORMATION	REQUIREMENTS	COMMENTS	Location in Final Application
3.2. Seasonal effluent water temperature/density ranges	Required ☐		
3.3. Expected buoyancy of effluent relative to receiving water	Required ☐		
3.4. Concentration of substances in effluent	Required ☐		
3.5. Comparison of predicted or actual substance concentrations in effluent to water quality guidelines or site specific benchmarks for the protection of the designated uses in the area and/or acute or chronic effluent toxicity test results	Required ☐		
3.6. Evidence that discharge design and discharge plan has been optimized to minimize the size of the IDZ within practical limits.	Required ☐		
3.7. Description of potential for substances to bioaccumulate	Required ☐		
3.8. Design and expected performance of outfall, diffuser type during best- case, worst-case and expected-case conditions	Required ☐		
3.9. Clear identification of where end of pipe is located	Required ☐		
3.10. Results from toxicity testing of effluent	Required ☐		
4. RECEPTORS, MIXING, AND MONITORING			
4.1. Physical and aquatic life receptors effluent discharge to receiving waters	Required ☐		
4.2. Environmental impact assessment of effluent discharge to receiving environment that explains how proposed IDZ will not adversely affect the identified receptors and designated water uses	Required ☐		
4.3. Methodology for physical mixing analyses – mixing model software and/or field dilution studies, and list of model inputs including a description of the source data for each input and a description of the data suitability and/or limitations	Required ☐		

INFORMATION	REQUIREMENTS	COMMENTS	Location in Final Application
4.4. Results of physical mixing analyses: dilution achieved within the receiving environment under a range of flow scenarios and plume mixing characteristics with supporting rationale	Required ☐		
4.5. Proposed monitoring program	Required ☐		

Additional information may also be requested by a director:

11.0 APPENDIX B – TRIGGER RESPONSE AND ADAPTIVE MANAGEMENT PLANS

Introduction - Managing uncertainty and risk in waste discharge permitting

Environmental permitting decisions involve elements of uncertainty and risk management. Despite the use of best science to predict outcomes and the implementation of monitoring to verify performance, efforts may be required to actively manage uncertainty and risk when dealing with environmental systems and impacts to them. As each project is unique, the details of how risk and uncertainty are addressed will differ. However, a consistent approach is desirable for implementing requirements for waste discharge permits (i.e., similar structure in permit clauses).

Risk and uncertainty are two linked yet distinct concepts, and it is important to understand both the differences and the linkages in order to construct management systems and regulatory requirements to address them. Standard approaches need to be applied for effluent permitting to ensure a consistent regulatory regime, and to ensure a coordinated and cohesive approach is used in authorizations for waste discharges where risk and uncertainty are regulated and managed.

Risk management in waste discharge permitting decisions means setting permit requirements to control risks that are posed by hazards resulting from the introduction of waste into the environment. The hazard can be described through the potential exposure to contaminants of potential concern contained in the waste. Various models can be developed to describe the potential risk to valued components, receptors or uses of environmental resources. Requirements may attempt to limit risk through treatment, operational procedures, or limits to the rate, quality, duration or frequency of the authorized discharge.

Uncertainty in waste discharge permitting means the unknown or unpredictable elements involved in understanding the hazard, predicting responses to exposure, and effectiveness of mitigations planned to address the risk posed by contaminants of potential concern in the waste. During a permit application process the information available may be insufficient to completely characterize all risk to the environment, or there may be unknown risks that cannot be characterized. While there may be sufficient information to proceed with permitting, the precautionary approach is to address any remaining uncertainty with an adaptive management plan to validate the mitigations in place, and the permit requirements.

DEFINITIONS

Adaptive Management Plans – describe and address the outstanding key uncertainties through a process of designing assessments to learn and understand the factors influencing the potential effects from a specific discharge. The adaptive management process follows a cycle of assessment, design of management actions, implementation, monitoring results, evaluation of effectiveness, and provisions of feedback to adjust strategies and plans.

Discharge Standards - specify the quality, quantity, frequency and duration requirements of the waste discharge including the maximum and/or mean limits for contaminants of potential concern, and specifies the period over which the standards are measured.

Site Performance Objectives - are permit standards set for a location in the receiving environment to ensure the performance of treatment works and management of a waste discharge to protect the environment. Site performance objectives may be standards that must be met, conditions that must be true for a discharge to occur, or triggers for implementation of contingency measures.

Trigger-Response Plans - ensure the implementation of planned contingency measures in the event that identified environmental conditions (triggers) occur. They are not considered adaptive management.

Setting discharge requirements

Discharge permit requirements are intended to mitigate the risk posed by the introduction of waste into the environment. Requirements in permits may include waste discharge quality limits, quantity limits, duration and frequency limits and by specifying the location where waste may be introduced. Operational requirements, general requirements, and the authorized works required to store, treat or otherwise manage a waste may be specified. Operational or general requirements may specify operational procedures or practises that must be implemented or require the development of specific operational plans needed to control the waste discharge.

A site performance objective (SPO) is a permit standard set for a specific location in the receiving environment to ensure protection of the environment. An SPO may be set to limit the discharge to times when a certain environmental condition is met or to impose an additional requirement to take steps necessary to achieve the SPO. An SPO may also be used to trigger contingency mitigations, further investigations or additional monitoring that are required when specified environmental conditions arise.

Permit requirements may impose an immediate responsibility on the permittee to implement a required action. Contingency mitigations, triggered by specified thresholds, are requirements that must be implemented if a specified operational or environmental condition occurs. Requirements for implementing contingency mitigations may be contained in a response plan that outlines a permittee's planned actions should a specified trigger occur.

Discharge standards

Permits issued under EMA will prescribe discharge standards that specify the authorized rate or quantity of discharge, the frequency (timing) of discharge, the duration of discharge, and the quality of the waste being discharged. The standards specifying the quality requirements of the waste sets the maximum and/or mean limits for contaminants of potential concern, and specifies the period over which the standards are measured. The period over which the standard is measured may be an instantaneous maximum determined in a grab sample, the result of a composite sample comprised of subsamples taken over a specified time period at specified intervals, or an average of a given number of samples taken over a period of time.

Discharge standards are usually measured against samples that are taken at a specified sampling point identified as the last point of control beyond which the waste is being released into the environment. In some instances, the location may be a point within the facilities, called in-plant, where a specified quality must be met. Examples of where an in-plant limit is set is where there is no practical way to sample at the last point of control or where the introduction of waste is from a diffuse area rather than a single point. A discharge standard applies to a waste source, and is set to ensure adequate treatment meeting the ministry's expectations for implementing best achievable technology.

Key elements of Discharge Standards are:

1. Clear and precise limits and point of compliance;
2. Clear frequency and duration of the discharge; and,

3. Clear metrics for determining if a discharge standard has been reached.

Site performance objectives and their relation to benchmarks

Site performance objectives are permit standards set in the receiving environment to ensure the performance of treatment works and the management of a waste to protect the environment. Site performance objectives are set at a defined point and for a specified discharge, as authorized in a permit. Site performance objectives compliment discharge standards by ensuring that the facility is meeting expectations in regards to receiving environment quality. Site performance objectives should only be established for contaminants of concern, and not generically for all parameters (i.e. do not set SPOs for all WQG in general).

Site performance objectives are implemented in one of three ways:

- As triggers to ensure implementation of contingency mitigations in a timely manner in response to impacts from the discharge or from cumulative effects.
- As limitations to the authorized discharge, such that the discharge may only occur if specified environmental conditions occur or do not occur as the case may be.
- As a compliance target in the receiving environment that must be achieved by a specified time.

Site performance objectives are set in consideration of environmental benchmarks applicable to the particular site and circumstances of the proposed project being reviewed. The benchmarks considered may be water quality guidelines (WQGs) or site specific water quality objectives (SSWQO) that pre-exist for the receiving waters. Alternatively the application of benchmarks to reflect the unique nature of a given project at a specific environmental location may apply. This is where Science Based Environmental Benchmarks may be developed through the permitting process to inform the permit impact assessment and also to inform a site performance objective if applicable.

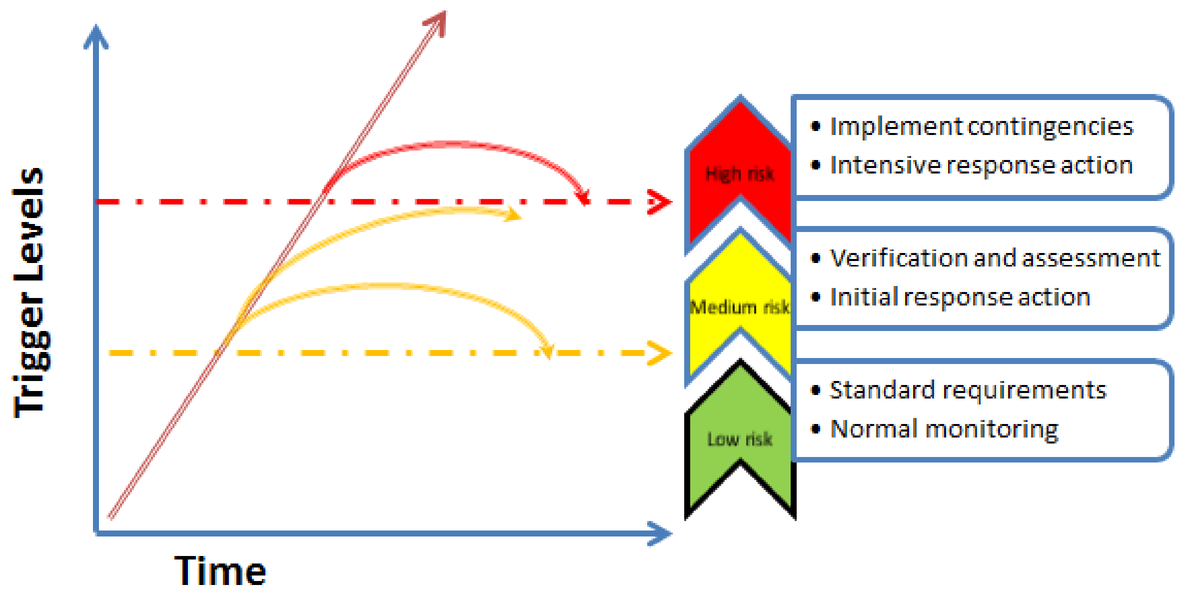
Key elements of Site Performance Objectives are:

1. Clear identification and assessment of the benchmark being used to inform the Site Performance Objective;
2. Clear and precise definition of how the SPO applies to regulate the discharge; and
3. Clear and precise parameters, limits and point of compliance.

Trigger-response plans

Trigger-Response Plans are developed to plan appropriate actions used in response to observed changes in environmental conditions that are approaching or exceeding management objectives. Waste discharges should be managed to avoid the need to implement Trigger-Response Plans, and such plans should be considered a means to deal with lower probability conditions that require more intense management than the expected case. The actions outlined in a response plan may include contingencies developed to address unwanted impacts, either by avoiding or limiting further effects on the environment.

As illustrated in the following graphic the relationship of triggers to levels of appropriate action depend on the degree of risk or potential effects. The appropriate action should reflect risk level associated with a trigger level that is reached. If lower triggers are reached (indicated by the yellow arrows) initial responses would include a confirmation of observed levels and/or assessment of actual impacts. At higher trigger levels (red arrows) which reflecting greater risk, contingency measures such as provision of treatment would be implemented as a more intensive response. If no trigger levels are exceeded then the standard permit requirements and normal monitoring are considered sufficient.



Triggers need to be established relative to a site performance objective. A trigger may be set equal to a site performance objective or there may be different trigger levels above and/or below a site performance objective for different degrees of response. The combination of triggers and responses, and their relationship to the site performance objective will depend on the site specific circumstances and proposed responses. The details of setting the specific trigger levels will be determined by the SDM; however, a consistent approach to laying out the requirements in the permit clause must be followed.

The key elements of a trigger-response plan are:

- Definition of trigger – location, water quality characteristic or biological measure, concentration or level, frequency and duration, etc.;
- Description of clear and time bound actions to be taken in response to a trigger being reached;
- Clear process for determining and confirming if a trigger has been reached, and a process for reporting the trigger exceedance; and
- An enforceable action plan that is approved by an SDM, and that once approved must be implemented. The use of figures and/or decision trees to illustrate the steps to follow in applying the Trigger-Response Plan will assist in communicating how the plan will be implemented.

An alternative to having a plan approved separately from a permit is to prescribe the triggers and responses directly in a permit. Where this is done the permit must be clear in establishing the trigger (addressing the key elements above) and prescribing the expected responses that must be implemented. Triggers can be set at varying levels so that the most appropriate response is applied depending on the trigger level reached.

When a trigger-response plan has multiple levels, the responses to each level will escalate to ensure an appropriate response. Initial responses upon reaching any trigger may include further investigation to confirm findings. Responses to a level 1 trigger exceedance may include further characterization of potential effects, identification of causes for reaching the trigger, and determination if additional contingency measures require implementation. Additional data collection, beyond routine monitoring may be required. An escalated response will be necessary upon reaching higher trigger levels, such as changes to management actions or upgrading of works. Trigger-response plans are not considered adaptive management. Trigger-response plans are a means to ensure the implementation of contingency measures in the event that prescribed environmental conditions occur.

Adaptive management plans – how they relate to risk and uncertainty, and how are they different from trigger-response plans

An adaptive management plan addresses the key uncertainties through a process of designing assessments to provide a better understanding of the factors influencing potential effects in the environment. The results of these assessments are then used to determine refinements to modelling assumptions and to adapt management strategies, actions and methods so that attainment of environmental objectives is ensured.

Results from adaptive management plans may potentially include revisions to discharge standards, management plans, operations, site performance objectives and trigger-response plans. A permit requirement to establish an adaptive management plan should include a definition of scope or requirement to develop a terms of reference for approval. Requirements to ensure implementation of the plan, evaluation of results, and a means to revise management practices, including other permit requirements must also be included.

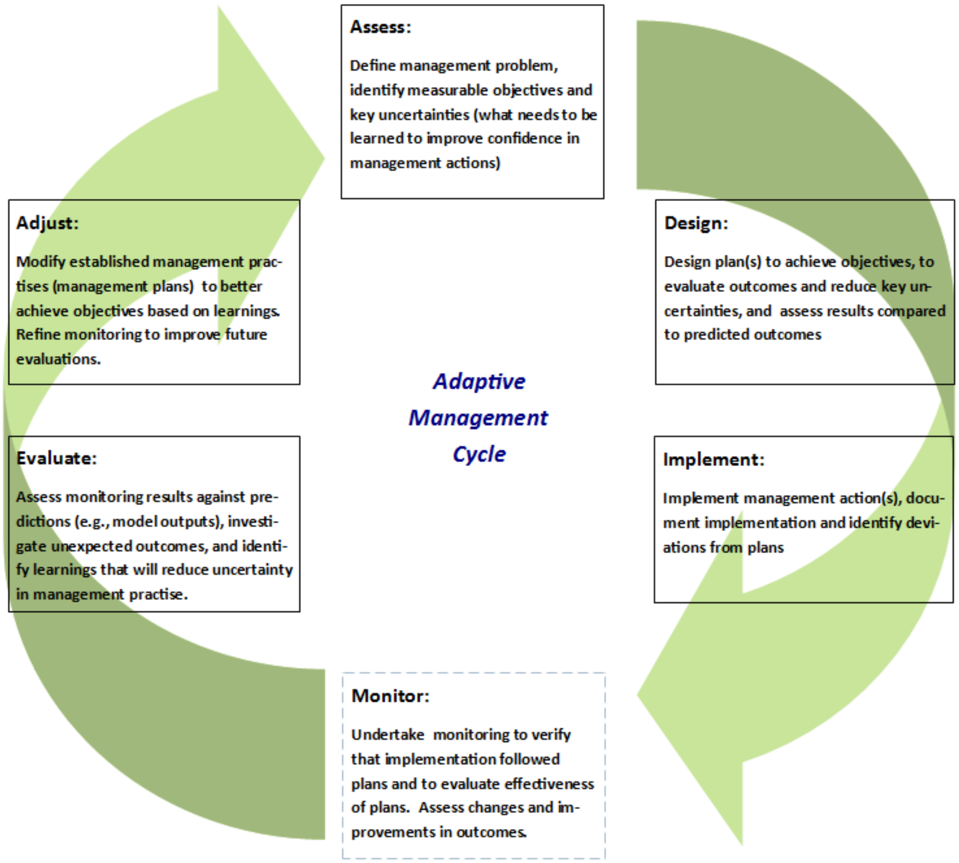
Adaptive management plans are not the same as trigger-response plans in that they are intended to address and reduce uncertainty, and lead to refined permit requirements and discharge management practices. Adaptive management plans are not intended to address the need for contingency measures in the manner that trigger-response plans do.

As the uncertainty and complexity levels increase on a given project, the importance of requiring an Adaptive management plan increases. Adaptive management plans can be used for permits where there is increased uncertainty and complexity to clarify the uncertainties and provide feedback to inform deliberations about future amendments and improvement to management and regulation of the risks associated with a waste discharge.

Key elements of Adaptive Management Plans are:

1. Clear and precise statement of the question/uncertainty(s) that the adaptive management plan is to address;
2. Process and timeline to design the adaptive management assessments;
3. Process and timeline to use the knowledge gained to improve on past decisions and current management practises; and,
4. Timeframe for the plan to be executed and reported out on.

The six stages of the adaptive management cycle



Monitoring – links to site performance objectives, trigger-response plans and Adaptive Management

The monitoring and reporting requirements of a permit provide an indication of compliance with permit requirements, and an assessment of ongoing effects from a discharge. Where a permit establishes site performance objectives, the monitoring and reporting requirements must also support the determination of attainment of site performance objectives. Monitoring and reporting requirements must also support the implementation of a trigger-response plan where one is in effect.

Adaptive management plans may require additional monitoring to support the planned assessments. However, the additional monitoring should be included in proposed study designs developed as part of the adaptive management plan, since it cannot be determined in advance of the adaptive management plan development and would not be included in the routine monitoring requirements of a permit.

Implementation and Compliance

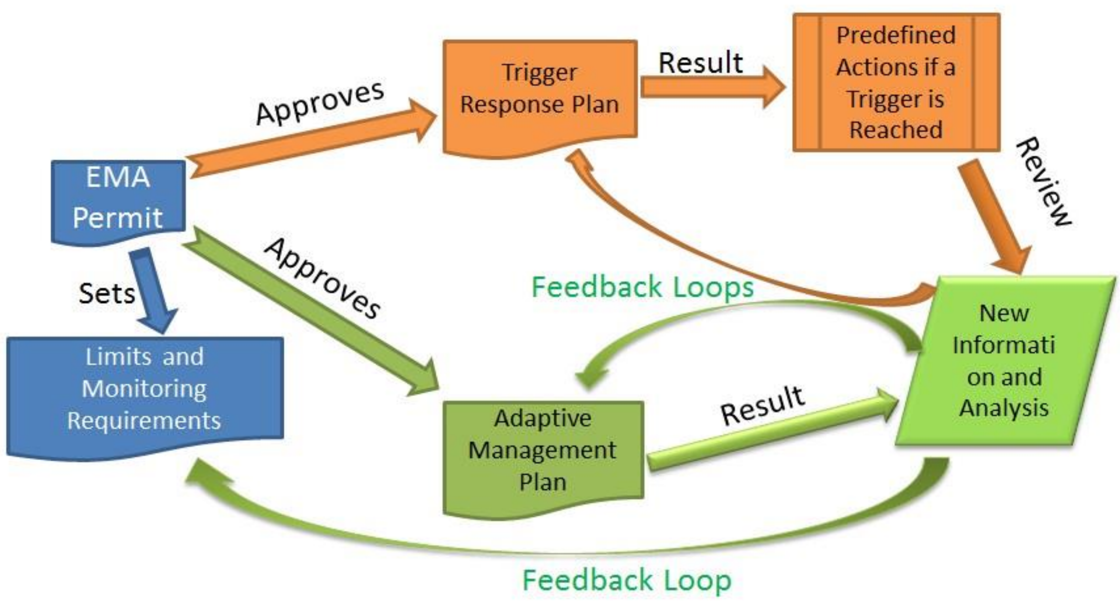
The preferred approach to develop permit requirements for a trigger response plan is to set the triggers in the permit. The details of the contingencies and procedures for responding to a trigger exceedance can be in a trigger-response plan approved by a director, or their delegated statutory decision maker. Relying on submission of plans in permits provides some flexibility, but the wording of the clause must ensure that implementing the plan is a requirement, and the approval letter must clearly identify any specific requirements for implementation using enforceable language. This can be achieved through the setting of clear actions and timelines in the plans. Decision trees can also clearly illustrate the path of thresholds and responses.

Permit clauses for adaptive management plans need to lay out a clear process, time table and deliverables for approval. However, the detailed content of the adaptive management plan can be flexible to meet the needs of specific situations. An iterative and deliberative process will likely be needed for adaptive management, as will involvement of Indigenous Peoples and other agencies with overlapping interests.

Summary

Trigger-Response plans and Adaptive Management Plans can be required in effluent permits either independently or together as a means to address residual risk and uncertainty. These tools can be used with monitoring to ensure continuous improvement in managing effluent discharges. Where there is further investigation of uncertainties through adaptive management processes, permit amendments may be needed to address findings. Similarly, trigger response plans use site performance objective based criteria to escalate the implementation of changes in management actions or implementation of contingency plans and actions where there is confirmation of degrading environmental conditions. The following diagram illustrates this Operational Model:

Operational Model – Permit Limits, Trigger-Response Plan, Adaptive Management Plan



12.0 APPENDIX C – DILUTION AND WATER QUALITY PREDICTIONS

Dilution is a measure of the amount of mixing of the effluent and receiving environment, and can be defined in two ways: volumetric dilution and chemical dilution. One of the key results of a physical mixing analysis (hydrodynamic modelling and/or field dilution study) is the determination of volumetric dilution.

The volumetric dilution, S, for a given location downstream of the point of discharge can be expressed using the following equation:

$$S = \frac{Q_{ambient} * P + Q_{effluent}}{Q_{effluent}} \qquad (1.1)$$

Where:

S [unitless] = dilution (volumetric)

$Q_{ambient}$[m^3/s] = ambient flow rate in receiving environment, upstream of effluent discharge

$Q_{effluent}$[m^3/s] = flow rate of effluent discharge

P [%] = proportion of ambient flow within effluent plume for a given location

Using the mass balance approach, the concentration of a water quality parameter in the receiving environment can be calculated using the continuity equation, as follows:

$$C = \frac{(C_{ambient} * Q_{ambient}) + (C_{effluent} * Q_{effluent})}{(Q_{ambient} + Q_{effluent})} \qquad (1.2)$$

Where:

C [mg/L] = concentration in receiving environment, at a given point downstream of effluent discharge

$C_{ambient}$[mg/L] = concentration in receiving environment (background), upstream of effluent discharge

$Q_{ambient}$[m^3/s] = ambient flow rate in receiving environment, upstream of effluent discharge

$C_{effluent}$[mg/L] = concentration in effluent discharge

$Q_{effluent}$[m^3/s] = flow rate of effluent discharge

Equation 1.2 as presented assumes instantaneous and complete mixing of the effluent discharge with the entire ambient flow volume in the receiving environment. This assumption is generally not valid within an IDZ, where only partial mixing of the effluent and receiving environment occurs. Therefore, the development of an IDZ needs to consider the proportion (P, %) of the ambient flow volume that mixes with the effluent, based on a physical mixing analysis. Once the volumetric dilution has been determined for a range of flow scenarios, equation 1.1 can be rearranged to solve for the proportion of ambient flow (P) within the effluent plume. The proportion of ambient flow (P) can then be plugged into the following equation 1.3 to calculate the water quality concentration for a given parameter at the edge of IDZ.

Water quality concentrations for a given parameter at the edge of IDZ can be calculated using the following equation:

$$C_{IDZ} = \frac{(C_{ambient} * Q_{ambient} * P) + (C_{effluent} * Q_{effluent})}{(Q_{ambient} * P + Q_{effluent})} \qquad (1.3)$$

Where:

C_{IDZ} [mg/L] = concentration at edge of IDZ

P (%) = proportion of ambient flow at edge of IDZ within effluent plume

$C_{ambient}$[mg/L] = concentration in receiving environment (background), upstream of effluent discharge

$Q_{ambient}$[m^3/s] = ambient flow rate in receiving environment, upstream of effluent discharge

$C_{effluent}$[mg/L] = concentration in effluent discharge

$Q_{effluent}$[m^3/s] = flow rate of effluent discharge

13.0 APPENDIX D – DETAILED CONSIDERATIONS FOR INITIAL DILUTION ZONES APPLICABLE TO THE MARINE ENVIRONMENT

D.1 Mixing Processes in the Marine Environment – Near-Field and Far-Field

The IDZs for the marine environment are generally more complex than those for rivers and lakes, especially in the very large and highly variable areas of the British Columbia (BC) marine environment. Here, the marine areas cover the northeast Pacific Ocean continental margin, spanning water depths as large as 1800 m on its western side, with a myriad of deep inlets or fjords extending to the east into the Coastal mountain range (Thomson, 1981). These marine waters are highly energetic under the forcing of seasonally large winds (fall and winter), large tides – especially in the northern BC waters, and major fresh water discharges, including the Fraser, Skeena and Nass Rivers which result in a high degree of density stratification of the water column.

The complex nature of the receiving waters, with strong temporal and spatial variability, impacts not only the physical characteristics of the initial mixing processes, but complicates the identification of a "worst case" scenario for satisfying the designated pollution criteria.

The near-field is the region where mixing is mainly dominated by the discharge exit conditions, such as the flow rate relative to the receiving water, the size and design of the exit structure, and the density of the discharged effluent relative to the ambient receiving water. In the far-field region, mixing is dominated by the ambient ocean conditions, lateral and vertical spreading of the plume trajectory and dilution through entrainment of the plume with the receiving waters. Typical time and distance scales for the two regimes are of the order of tens of metres and minutes for the near field and kilometres and hours for the far field shown in Figure 1 (Bleninger et al., 2011).

In the marine environment, the ocean density and stratification play a role in both near-field and far-field regimes, as these dictate the vertical rise characteristics of the mixing plume; determining if and where the diluted effluent first surfaces. Shear between the exit flow and the slower moving receiving water dominates dilution in the near field. The rate of dilution can be enhanced by the use of multiple port systems, subdividing the discharge into a number of higher speed discharges. With positively buoyant discharges, the potential energy of the buoyancy further contributes to the mixing and dilution of the rising plume.

For negatively buoyant discharges, the initial dilution is solely driven by the kinetic energy of the exit jet. If the diluted dense plume contacts the sea bed, bottom friction retards the motion, while the density difference tends to suppress mixing over the upper surface of the plume. Gravity now plays a forcing role in plume advection, with the eventual fate of the diluted mixture controlled by the bottom topography. Examples of negatively buoyant discharges found in the literature are mostly associated with de-salination plants, such as those found on the California coast (Jenkins, 2016). Although these particular discharges are unlikely to occur in BC waters, some industrial processes may have similar effluents.

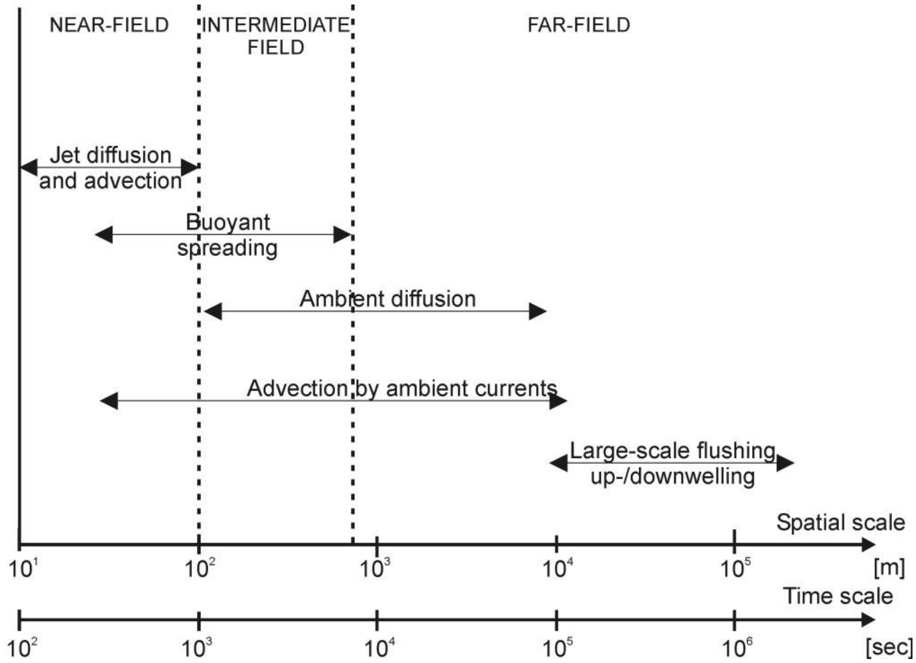


Figure 1: Typical temporal and spatial scales for transport and mixing processes related to coastal discharges (Bleninger et al., 2011)

In the far-field, where ambient conditions control plume trajectory and dilution, mixing is dominated by the background ocean diffusion and advection by the time dependent velocity field. In estuarine regions where fresh river water intrudes over the ocean water, the resulting stable density stratification can prevent the effluent from surfacing, in which case the far-field mixing is controlled by subsurface currents and properties.

D.2 Models

D.2.1 Approaches to Modelling

The chosen model(s) should be determined by the questions raised by a proposed development. It is recommended that the proponent use a qualified professional (QP) to design and conduct the modelling work, and should discuss the approach to modelling with ENV prior to conducting the work.

There are a wide variety of analytical (e.g., simple mass balance equations using dilution factors) and numerical models (computer simulations using specific mathematical models) available for the marine environment, including those that are specifically developed for modelling the IDZ for effluent discharges. No single model is suitable for all discharge situations, and multiple models, in particular a near-field model for the IDZ coupled to a far-field model may be appropriate for the particular effluent discharge system.

Table 1 provides a preliminary guide to choosing applicable models for the marine environment. This table provides a small selection of commercially available models to serve as examples. It does not reflect the latest developments or modifications, nor include purpose built in-house models.

Table 1: Selection of Models for analysing the behaviour of effluent discharges under various marine scenarios (adapted from Environment Canada, 2003).

Typical Scenario Information	**Examples of Model Selection**
Simple cases for discharges to inland rivers, freshwater and saline-dominated parts of estuaries, and coastal waters.	Simple mass balance equations using dilution factors, Monte-Carlo simulations of initial dilution, and other analytic methods.
Plume is highly transitory or there is rapid plume dilution in the initial dilution zone to within target level.	Numerical models such as CORMIX and Visual Plumes for the initial dilution assessment only.
Effluent is discharged into turbulent, narrow stream; complete mixing is achieved rapidly over a short distance. The water is well mixed laterally and vertically.	1-D numerical models, normally down the middle section of a river channel or estuary.
Effluent is discharged into uniform, wide body of water. No stratification is observed. The water body is well mixed vertically but not laterally.	2-D horizontal models, such as CORMIX for initial plume dilution; 2-D far field numerical models, such as MIKE 21, TELEMAC 2D, for subsequent dilution simulations
Effluent is discharged into non-uniform, wide body of water. Stratification is observed as result of thermal or salinity differences in the receiving water or between the effluent and the receiving water. Stratification may be non-uniform and dynamic.	Numerical models such as CORMIX and Visual Plumes for initial dilution assessments, only. 3-D numerical models, such as MIKE 3, TELEMAC 3D, Delft3D and FVCOM for far field simulations.
The water body is well mixed laterally but not vertically	2-D vertical models, and/or 3-D models.

The approach to modelling in marine environments should be conducted to estimate the maximum areal extent, average conditions, and minimum dilution of the affected area. If the 'worst-case' model results indicate a potential problem, further work involving a more complex approach is recommended. The model can be run for a variety of conditions (e.g., seasonal variations of water movements and wind patterns), thereby overcoming the limitations of the particular conditions recorded in a single field study (EC, 2003). The approach to "worst-case" conditions in the marine environment should be considered carefully. For example, the strongest stratification realized during a limited measurement campaign, or through a modelling analysis, is unlikely to be the historical maximum. Instead, it is better to use a statistical measure such as the 10th percentile level of stratification (EPA, 2014) based on analysis of all historical data available. Another consideration is the selection of the currents of the receiving waters for the modelling studies. In steady state analysis, attention should be directed to low-flow conditions to realize the higher values of effluent concentrations for such cases (Bleninger, 2011). Dynamic models can be run to include temporal variation of the effluent discharges, along with variable velocities and stratification of the receiving water. These dynamic model results can be discussed, through analysis of the historical record, as being representative of various probabilistic conditions.

D.2.2 Input Data to Models

Models require site specific oceanographic data for the effluent discharge and the receiving waters, as described in more detail below. As the complexity of the model increases, more extensive data inputs (CIS-WFD, 2010) are generally required (e.g., detailed bathymetry, tidal characteristics and details of river flow, interactions with tributaries etc.). The variation of salinity and temperature in space and time is also required to derive the density input to the model.

The model domain selection is important to ensure that the influences of the boundary conditions are negligible within the active area of the model having non-negligible effluent concentrations. The areal extent of the model domain and the horizontal and vertical grid size resolution have consequences for the necessary computer time and costs as the modeling complexity increases.

Table 2: Typical Required Data Inputs for Modelling in the Marine Environment

Relating to the receiving water environment	Bathymetry
	Flows and tidal heights at model boundaries
	Temperature, salinity, and density/stratification
Non-physical model parameters	Roughness coefficient
	Eddy viscosity coefficient
	Grid resolution and choice of modelling grid (e.g., rectilinear versus curvilinear grid)
	Size of modelling domain
	Time step
Parameters related to the discharge	Water intake: location, volume of water abstracted
	Water outlet: location, volume, velocities, temperature and pollutant content of water discharged
	How results from initial dilution zone modelling are represented as inputs
Parameters relating to model scenarios	Seasonal variability in temperature, salinity, flows and concentrations of water quality parameters, ambient temperatures and wind speeds
	Tidal variations including spring-neap tides and semi-annual tides (solstice vs. equinox)
	Receiving water: temperature and salinity (i.e. density) by seasonal and year-to-year time scales

	Meteorological conditions (wind speed and direction, ambient air temperature)
Others	River discharges, ocean waves, or sea-ice if applicable
	Other discharge sources, and the effects of ship movements (e.g., for harbour)

D.2.3 Model Calibration and Verification

Models must undergo calibration and verification, including the comparison with independent field data, before predictions can be relied on for decision-making, as discussed in Section 6.2. Model calibrations are achieved by operating the model for a specific case of receiving water conditions where actual field data is available, along with selected simulated effluent discharges. The results of the comparison between the model and the independent field observations, combined with analytical and possibly tracer measurements, are then used to adjust the model parameters to improve the agreement between the model and the field observations. By applying the calibrated model to one or more historical events, and demonstrating a reasonably high level of agreement of the model with observations, the modelling approach is verified. A discussion should be provided on the frequency of occurrence of the particular environmental conditions being considered (EC, 2003).

For the near-field effluent discharge results, it is often difficult to obtain meaningful field measurements for low to moderate effluent discharges, given the short time and spatial scales of the near-field mixing processes (Figure 1). Unless the effluent discharges are large and/or the chronic toxicity values of the effluent are high in terms of risks to the receiving environment, the near-field model results can be compared with expected values based on analytical representations or well accepted rules that have been extensively validated for similar effluent discharge scenarios. In those cases involving large effluent discharges combined with the potential for higher environmental risks, a field-based tracer measurement program, as discussed below, may be required.

As a minimum, the model calibration, verification and sensitivity runs should demonstrate their capability to accurately reproduce the hydrodynamic process of the study area, including a physically reasonable realization of the effluent plume resulting from the discharge (EC, 2003). Other typical boundary conditions for far-field models are the fresh water input on the upstream end and the water level on the downstream end. In tidal waters, where the shore line near the discharge changes from high to low tide, the model should be able to reproduce wetting and drying of tidal flats (EC, 2003).

D.2.4 Model Outputs

Model runs will be retained as a part of the administrative record for a permit.

A discussion on the confidence limits of the results should be provided. The minimum requirements for the model outputs are provided in Section 6, above.

A more detailed checklist of recommended model outputs, as adapted from (EC, 2003), follows:

- Summary of information collected to aid in developing the conceptual model of effluent plume behaviour, including:
    - description of characteristics of the effluent;
    - description of the effluent discharge configuration and performance;

    - description of the receiving environment in terms of flows and currents, physical and chemical water quality (e.g., thermal and salinity variation horizontally and vertically), climatic conditions, and any other relevant site-specific parameters used to develop the conceptual model of plume behavior; and
    - confounding conditions, such as atypical climatic conditions;
- A conceptualized model of plume behavior and/or documentation of any tracer study conducted;
- A description of the near-field and far-field models used in the study, including the computational and underlying physics on which the model operates, the model domain and grid sizes (and vertical layers, if applicable);
- The results of the model calibration, verification and sensitivity runs including sufficient detail to present the model set-up and situation for each case run, the input data sets, the model outputs and the comparisons of the model results with analytical principles and with independent field data;
- The numerical model results depicting predicted plume envelopes for:
    - maximum extent; and
    - long-term average conditions

  (based on the effluent concentrations at the chronic toxicity value, and separately at a value reduced by a factor of 2 to 10)

Computer animation is a useful option for depicting effluent plume behavior in more complex receiving environments, such as estuaries and coastal locations. (EC 2003).

D.3 Field Studies

The need for field studies for effluent discharges into the marine environment will depend on the particulars of the proposed development, including the nature of the effluent and its rate of discharge, and the knowledge of the marine receiving environment. All field studies should be conducted using widely accepted best practices for oceanographic measurement programs (JCOMM, 2018) including the design and conduct of the field program and the instruments used in data collection. It is recommended that qualified professionals (QP) be involved in the design of the field studies and oversee the field work as well as data processing and analysis of the field data.

For the early stages of the IDZ development process, field studies may be required if the existing historical marine data on the receiving waterway is very limited. In this situation, additional field data may be required for data inputs to characterize the initial dilution zone (described in Appendix A). These include measurements such as bathymetry, ambient flow speeds and tidal heights, seasonal variability in temperature, salinity and other water properties, and if applicable, data on discharges from nearby rivers, ocean waves and marine ice cover.

The next stage in the IDZ development process involving field dilution studies arises in regards to model calibration and verification studies, as described above. In some cases, there may be a requirement for a passive tracer study to provide quantitative measurements of the dilution from the effluent release (EC, 2003). The need for this type of field study is predicated on large effluent discharges combined with major potential risks to the environment arising from the model-derived dilution zone characteristics. The purpose of this type of field study is to provide direct measurements of the dilution achieved from the discharge structure.

Finally, a field study may be required as part of a monitoring plan (Section 9). The purpose of this type of field study is to confirm that the anticipated initial dilution zone and other aspects of the distribution of the discharged effluent in space and in time conform to the quantitative characterizations presented as to permitted levels and the validity of the model predictions.

The model and field related studies outlined above should be carried out and analysed by appropriately qualified and experienced personnel, and as a consequence, are time consuming and expensive. Near-field measurements involve relatively small temporal and special scales, of the order of 10 minutes and 100 m as indicated in Figure 1. Studies at these small scales require considerable care to yield reliable results, particularly under variable conditions, as the transverse scales are an order of magnitude smaller, i.e., 10 m. Far-field studies involve standard oceanographic instrumentation and techniques, and pose fewer measurement challenges.