Appendix 8

Water Quality Monitoring Program Sea To Sky Highway Improvement Project

Water Quality Monitoring Program
Sea-to-Sky Highway Improvement Project

The Sea-to-Sky Highway Improvement Project ("the Project") water quality monitoring program consists of three separate components:

1. Water quality audit and performance monitoring
2. Water quality sampling and analysis of runoff from PAG/ML rock cuts
3. Water quality suspended sediment monitoring

The purpose of this document is to explain these three programs.

1. Water quality audit and performance monitoring – MoT Responsibility

The purpose of this sampling program is to audit the Project in the area of water quality protection and performance objectives. A description of this program is provided in Volume 3, Section D – Water Quality of the Application. Phase 1 of the program is complete and included the sampling and analysis of baseline corridor-wide water quality information, as presented in the Application. The remaining program phases will be implemented on a work-package basis.

- Phase 2 sampling and analysis will immediately precede construction start-up of a work-package to determine immediate preconstruction water chemistry. This will include sampling of surface waters, groundwater wells and domestic water supply sources. Where construction is conducted on limited sections, only those streams, water bodies, wells (registered and unregistered), or source sites within the active construction section(s) will be tested during this period. This sampling phase will establish the immediate pre-construction water chemistry and will allow for comparison with Phase 1 data and future results after the initiation of construction.
- Phase 3 sampling will take place midway through construction during the summer months. Groundwater wells, domestic water supplies and surface waters will be randomly sampled during this phase. Should any complaints, be filed by residents, then water quality analyses will take place immediately. Shallow, dug, groundwater wells will be given priority in the sampling order as they are likely to be the first affected by any water quality changes.
- Phase 4 sampling will take place approximately 6 months after construction is completed within each work-package. Post construction sampling will involve a water quality assessment of all surface waters, groundwater wells and domestic water supplies within the boundaries of the completed construction section.

The following parameters will be included in each phase of the sampling program.

1. *General Water Quality (Conventional Parameters)*

field measured pH	dissolved chloride
conductivity	dissolved nitrate
true color	nitrite
turbidity	dissolved sulphate
hardness	total BOD

total dissolved solids (TDS)	ammonia nitrogen
total suspended solids (TSS)	total Kjeldahl nitrogen
bicarbonate alkalinity	tannin and lignin
carbonate alkalinity	cation-anion balance
hydroxide alkalinity	total coliform (confirmed)
dissolved fluoride	fecal coliform

2. *Total Metals – BCWQG – Aquatic Life Standards*

Antimony	Copper	Silver
Arsenic	Lead	Strontium
Barium	Mercury	Tin
Beryllium	Molybdenum	Titanium
Boron	Nickel	Uranium
Cadmium	Phosphorous	Vanadium
Chromium	Selenium	Zinc
Cobalt	Silicon	

3. *Geochemical Indicators – Aquatic Life Standards*

Aluminum	Magnesium	Sodium
Calcium	Manganese	
Iron	Potasium	

4. *Estimated Flows*

Hydrocarbon testing, as well as oil and grease, will be conducted on samples taken as part of phase 2, 3 and 4 sampling. If samples taken during Stage 2 do not indicate the presence of hydrocarbons in the surface waters, then random sampling will be implemented for Stages 3 and 4.

2. Water quality sampling and analysis of runoff from PAG/ML rock cuts – Contractor Responsibility

This water quality program will be implemented whenever cuts are into potentially acid generating or metal leaching rock material. Samples will be obtained prior to construction to establish baseline conditions, then periodically during construction, and again following construction, to evaluate the assumptions and findings outlined in the environmental assessment and to adapt mitigation measures as required.

Water sampling and analysis will be conducted as follows:

- Pre-construction (Baseline). The first set of samples will be obtained during or immediately following a rainfall event and prior to any rock work to characterize baseline conditions. The data obtained will supplement data previously obtained for the purpose of the environmental assessment.
- During Construction. A set of samples will be obtained approximately 3 months and 6 months after the rock cut is completed.

- Post-Construction. A final set of samples will be obtained approximately 12 months following the completion of the rock cut to confirm there are no adverse effects.

During each phase of the program water samples will be submitted to a certified laboratory for analysis of pH, alkalinity / acidity, sulphate and total and dissolved aluminum, chromium, copper, iron and zinc. These parameters provide an indication of whether acid rock drainage (elevated pH detected) / metal leaching (metals) are occurring. The metals selected for laboratory analysis are those that are considered most likely to leach given the nature of the parent material and other site-specific considerations. If low pH (<5.75) or elevated metals (above background and aquatic life criteria) are measured, mitigative strategies will be implemented and additional sampling conducted. Temperature, pH, conductivity and turbidity will also be measured using hand-held portable instruments at the time the samples are taken for laboratory analysis (see Cartoon 3).

3. Water quality field sampling protocol – Contractor Responsibility

The following water quality field sampling protocol has been developed to provide guidance to construction field staff with respect to the timing, scheduling, location and conditions when developing a sampling program. The intent of this protocol is to ensure consistency in water quality sampling throughout the Sea-to-Sky construction corridor. The program will be implemented on a work package basis and is routinely conducted by the environmental monitor.

This protocol focuses on sampling and laboratory analysis for Total Suspended Solids (TSS), as this is a primary concern with respect to the impacts of construction on fish and fish habitat. Along with TSS, pH and conductivity shall be measured during works involving concrete until pH in wastewater is the same as the receiving waters. Water quality samples shall also be taken after blasting and analyzed for dissolved nitrate to determine if blasting techniques or runoff control measures need to be modified.

Short duration high levels of TSS or chronic (long duration) levels of suspended sediments in a stream can smother and kill incubating eggs, adversely affect fish feeding and cause abrasion and/or clogging of fish gill membranes. TSS is measured and reported in milligrams per liter (mg/l) which is equivalent to parts per million (ppm).

Sampling Rationale

Routine and event-related sampling is used to monitor suspended sediments in the creek that occur both naturally (ambient) and resulting from erosion off the construction site. It is also intended to provide the Ministry with a snapshot in time of contractor environmental performance, success or failure of approved Sediment and Drainage Management Plans and due diligence. In rare cases, these samples may be used as evidence in legal proceedings if charges under Section 35.1 [Harmful Alteration, Disruption or Destruction (HADD) of fish habitat] of the *Fisheries Act* are laid.

Chronic turbidity can lead to impacts on fish and fish habitat including accretion (infilling of gravel voids with fine sediments) rendering spawning beds unusable to fish.

Water Quality Criteria

Total suspended sediment is a weight measurement (expressed in mg/l = parts per million), determined by evaporating off all water in a laboratory and weighing the residual material. Turbidity is the measure of water clarity due to suspended silt and other sediments and is expressed in NTU (Nephelometric Turbidity Unit) or FTU (Formazine Turbidity Unit) where 1 FTU ≈ 1 NTU.

The *British Columbia Approved Water Quality Guidelines (Criteria) 1998 Edition, Updated August 24, 2001* provides acceptable threshold levels of suspended sediment in watercourses for drinking water, aquatic and terrestrial life. Allowable induced (contributed) turbidity or suspended sediments relate to ambient (background) levels occurring naturally in the watercourse. These allowable levels are as follows:

Water Use	**Maximum Induced Turbidity – NTU or % of background**	**Maximum Induced Suspended Sediments – mg/l or % of background**
Drinking Water – Raw untreated	1 NTU when background is less than or equal to 5	No Guideline
Drinking Water – Raw treated	5 NTU when background is less than or equal to 50; 10% when background is greater than 50	No Guideline
Recreational and Aesthetics	Maximum 50 NTU	No Guideline
Aquatic Life: fresh, marine and estuarine	8 NTU in 24 hours when background is less than or equal to 8; mean of 2 NTU in 30 days when background is less than or equal to 8	25 mg/L in 24 hours when background is less than or equal to 25; mean of 5 mg/L in 30 days when background is less than or equal to 25
Aquatic Life: fresh, marine and estuarine	8 NTU when background is between 8 and 80; 10% when background is greater than or equal to 80	25 mg/L when background is between 25 and 250; 10% when background is greater than or equal to 250
Terrestrial Life: wildlife livestock water, irrigation, industrial	10 NTU when background is less than or equal to 50; 20% when background is greater than or equal to 50	20 mg/L when background is less than or equal to 100; 20% when background is greater than or equal to 100

Sampling Equipment, Method and Handling

Water samples for laboratory analysis should be collected in clean 1 liter (minimum) plastic sample bottles. Normally, these bottles can be obtained (free of charge) from the analytical laboratory. Glass bottles are not to be used. Allow for approximately 5 working days to receive the results of laboratory analysis.

Other field equipment is available for taking and field analyzing samples. This includes the turbidimeter and "turbidity wedge". Turbidity is the measure of water clarity due to suspended silt and other sediments.

Use of this equipment is not discussed in this protocol. However, the turbidimeter can be used to provide immediate results without the waiting period common when using an analytical laboratory. A turbidity wedge provides a coarse visual measure of turbidity and may be used to determine the requirement for further laboratory analysis.

If a turbidity wedge is used for coarse day-to-day turbidity measurements, it must be calibrated using a turbidimeter to the watercourses being measured.

Where possible, samples should be taken midstream at approximately mid-water column. Sampling care must be exercised such a manner that the sampler avoids agitating settled sediment and contaminating the sample. In theory, sampling should start at the uppermost site with subsequent samples collected in consecutive order downstream. This is so the "same" volume of water is sampled to allow for accurate determination of changes in water quality as it passes the various sampling stations.

Samples collected must be kept cool (refrigerated or in a cooler) until which time they are shipped via couriered to the analytical lab. Suspended constituents in the sample can degrade over time. As such, if refrigeration is not available, it is imperative that samples are shipped to the lab on the day of collection.

All samples taken must be provided with a unique identifier. In some instances, it may be appropriate that the laboratory technicians are not informed of the sample specifics to eliminate laboratory bias. In these instances, each sample can be identified with a letter or number identifier (not associated with the sample specifics) that is cross-referenced to the sampling specifics. However, in most cases, samples can be identified with the following information either (legibly) written directly on the bottle using an indelible marker or using adhesive labels:

1) Date and time of sample
2) Specific sampling location (e.g. Creek X 100m upstream of centerline)
3) Samplers name
4) Project identifier (e.g. Sea to Sky Section XXXX)
5) Sampling parameters to be tested (e.g. TSS, turbidity etc.)

This information must also be retained as backup by the sample collector in the event samples are lost or misidentified.

If samples are taken for legal purposes, sample caps must be sealed using tape or other method and initialed by the sampler to avoid tampering. Samples must be kept in a secure location (under lock and key) until they are shipped to the lab or handed over to enforcement personnel.

Instream Sampling Requirements

1) Routine Sampling During Construction

   Routine sampling is conducted on a regular basis but may not necessarily be associated with an erosion or precipitation event. Consequently, this sampling may not capture fluctuations in water quality that is either weather or event related (see Opportunistic Sampling, below). It is recommended that sampling should be conducted at minimum weekly on the same day and time (in active construction areas or areas where drainage could potentially impact stream water quality). This sampling regime will ensure adequate tracking of ambient and project runoff water quality for the duration of the project.

   Regardless of the apparent visual clarity of the water upstream, at, and downstream of the construction site, it is important to ensure sampling consistency. In this regard, at every watercourse sampled, upstream, at and downstream sample sites are to be sampled (see Cartoon 4).

   - Upstream (Control) Site: The upstream site should be sufficiently far upstream to be completely isolated from any construction related impacts. Consequently, location of this site must consider all stages of construction and the associated changes in the lateral limits of construction. Typically on highway construction sites, 30-50m upstream of the centerline is appropriate.

   - At Right-of-Way Site: This site is typically at or near the centerline of the project. However, the site may vary slightly as conditions change (e.g. culvert is installed, watercourse is realigned etc.). It may be appropriate that this site be situated at the downstream limit of all drainage discharges off the construction site.

   - Downstream Site: This site should be located at a distance downstream of all construction discharges such that adequate mixing of ambient and runoff within the watercourse has occurred (typically 50-100m). In some instances, construction runoff water and ambient stream water will not mix for some distance downstream of the discharge as discharge will generally be confined along the stream banks. In these instances,

sampling the fringe or midstream areas may not provide an accurate record of the effects of dilution.

2) Event-Related Sampling

This sampling is conducted during an event that impacts, or has the potential to impact water quality. Two most common instances are precipitation or erosion from the construction site (that may or may not be related to precipitation).

Location of upstream and downstream controls are as defined above.

- Point Source Discharge Site. This site is situated at the point the silt-laden runoff water enters the watercourse. It is normally the sample that will have the highest TSS level.

To monitor the effects, levels, persistence and flushing of TSS in and through the stream, timed sampling is required. Sampling intervals (e.g. every 15 minutes) and overall duration may change depending on site conditions and the severity of the impact. Sampling is normally terminated once the impacts have subsided and ambient or near-ambient water quality is restored.

Time tracking also measures the success of remedial works that might be implemented to control the discharge.

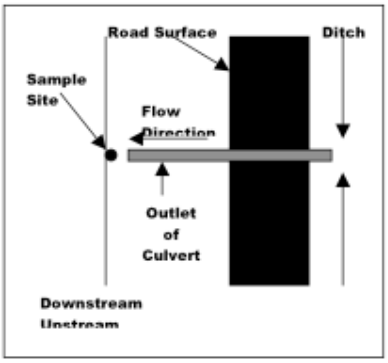
3) Opportunistic Sampling

Opportunistic sampling is random (not related to routine or event-related sampling) or coincides with a precipitation event. This could include an extreme precipitation runoff event that has not caused a construction-related incident but causes a natural increase in runoff and degraded ambient water quality. Recording these events is important to provide documentation of natural changes in ambient water quality.

Ditch Sampling Requirements

Sampling of water quality in ditches is also required should there be source of contamination entering the ditch and a water feature downstream. The protocol for instream sampling will be followed (see Cartoon 2 for sampling locations).

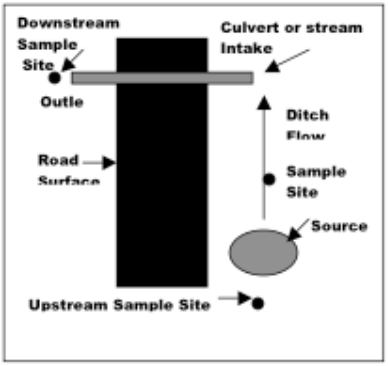
CARTOONS SHOWING SAMPLING LOCATIONS FOR WATER QUALITY TESTING



CARTOON 1 - Sampling For Stages 1 – 4
Water quality audit and performance monitoring – MoT Responsibility

Water sampling sites for Phase 2, 3 and 4 as presribed in May, 2003 report by MOT.

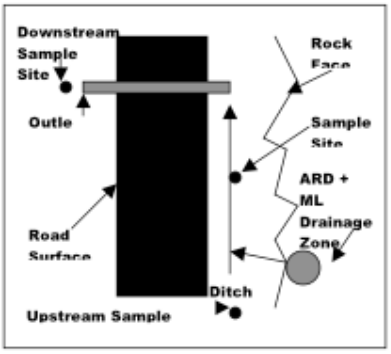
Samples taken at outlet of every collecting culvert or bridge crossing.



CARTOON 2 - Day to Day Sampling During Construction Water quality field sampling protocol – Contractor Responsibility

Water sampling sites for construction spill scenario or day-to-day sampling.

Sample site is within 15 metres - downstream of source of contamination. Upstream and downstream samples used for reference.

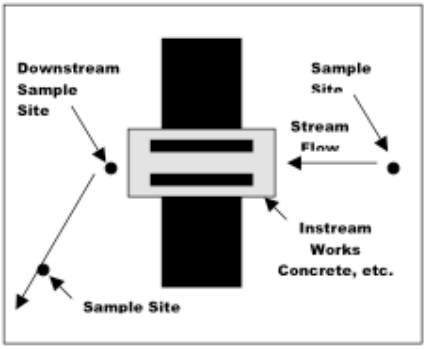


CARTOON 3 - ARD Sampling Locations
Water quality sampling and analysis of runoff from PAG/ML rock cuts – Contractor Responsibility

Water sampling sites for ARD+ML downstream from acid generating rock faces.

Sampling will be done immediately downstream of the acid generating rock mass, within the ditch line and upstream of the ditch flow entering into a culvert or stream flow channel.

CARTOONS SHOWING SAMPLING LOCATIONS FOR WATER QUALITY TESTING



CARTOON 4 - Instream Works Sampling

Water quality field sampling protocol –
Contractor Responsibility

Water sampling sites during instream works (concrete, culvert installation, etc.

Sample sites; one upstream, one at outlet area and one downstream