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Powell River Environmental Effects Monitoring (EEM) Cycle Five Interpretive Report

Final

March 2010

Prepared for:

Catalyst Paper Corporation
Powell River Division
Powell River, British Columbia

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POWELL RIVER

ENVIRONMENTAL EFFECTS MONITORING (EEM) CYCLE FIVE INTERPRETIVE REPORT

FINAL

Prepared for:

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LIST OF ACRONYMS

ADt	air-dried tonnes
AOX	adsorbable organic halides
BOD	biochemical oxygen demand
C	Celsius
cm	centimetre
CTMP	chemi-thermomechanical pulp
d	day
EEM	Environmental Effects Monitoring
EPA	Environmental Protection Agency
g	gram
IC25	effluent concentration causing 25% inhibition of a biological function
kg	kilogram
km	kilometre
L	litre
LC50	effluent concentration causing 50% mortality of test organisms
m	metre
µg	microgram
mg	milligram
pg	picogram
ppb	parts per billion
PPER	Pulp and Paper Effluent Regulations
ppm	parts per million
s	second
t	tonne
TMP	thermomechanical pulp
TSS	total suspended solids
v/v	volume/volume
yr	year

ACKNOWLEDGEMENTS

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- Ms. Janice Boyd of Environment Canada;
- Ms. Liz Freyman of BC Ministry of Environment; and
- Ms. Sarah Barkowski of Catalyst Paper Corporation.

Contributors to this EEM program at Hatfield included Mr. Martin Davies, Ms. Danika Affleck, Mr. John Wilcockson, Ms. Jackie Porteous, and Ms. Susan Stanley.

EXECUTIVE SUMMARY

Pulpmills in Canada are required by the *Pulp and Paper Effluent Regulations* (PPER) under the federal *Fisheries* Act to conduct Environmental Effects Monitoring (EEM) studies on a regular basis. Four EEM cycles were completed between 1992, when the PPER were originally released, and 2007. This report presents results from the EEM Cycle Five program, covering the period 2007 to 2010, for the Catalyst Paper Powell River pulpmill.

The Powell River pulpmill releases effluent to Malaspina Strait through a submerged diffuser. Because effluent is diluted to 1% concentrations within 50 m of the outfall, the mill was exempt from fish population and benthic invertebrate surveys in Cycle Five, as per the PPER. The mill was also exempt from a fish tissue survey due to low or non-detectable concentrations of dioxin/furan previously measured in fish tissue and mill effluent, respectively. Thus, the EEM Cycle Five program for the Powell River pulpmill was comprised of sublethal toxicity testing of effluent, conducted twice per year.

Sublethal toxicity testing indicated that effluent did not affect fish early life stage growth or survival. Algal reproduction was affected at a mean effluent concentration of 16.0%, while invertebrate fertilization was affected at a mean effluent concentration of 77.4%. These effluent concentrations would not be expected to occur in the receiving environment around Powell River beyond the initial effluent mixing zone, immediately above the effluent diffuser.

The addition of Powell River pulpmill effluent to the marine environment should not have resulted in any observable toxicity during Cycle Five given the extremely small zone of sublethal effect near the diffuser. Potential sublethal toxicity effects are expected to be seen to a maximum extent of 3.1 m from the effluent diffuser.

Given the expected continued rapid dilution of effluent from the Powell River pulpmill (i.e., 1% effluent zone is defined as 50 m from the diffuser), no fish survey or benthic invertebrate survey will be required for EEM Cycle Six.

DISTRIBUTION LIST

The following individuals/firms have received this document:

Name	Firm	Hardcopies	CDs	PDF
Sarah Barkowski	Catalyst Paper Corporation, Powell River Division	3		√
Janice Boyd	Environment Canada	3		√
Liz Freyman	B.C. Ministry of Environment	1		
Laura Roddan	Sliammon Treaty Society	1		

1.0 INTRODUCTION

1.1 ENVIRONMENTAL EFFECTS MONITORING PROGRAM

Pulpmills in Canada are required by the *Pulp and Paper Effluent Regulations* (PPER) under the federal *Fisheries Act* to conduct Environmental Effects Monitoring (EEM) studies on a regular basis. EEM studies are typically conducted in three-year cycles, each of which includes a study design phase, study implementation, data analysis, and reporting. The required components of an EEM study usually include:

- Sublethal toxicity testing of effluent, to examine the effect of chemicals or chemical mixtures on the reproduction and growth of representative aquatic organisms;

- A biological monitoring program, to assess the potential effects of effluent on fish populations, benthic invertebrate communities, and fish tissue in the receiving environment; and

- Water and sediment quality measurements, to support interpretation of biological monitoring results.

Effluent sublethal toxicity testing is conducted twice per year for mills that discharge effluent over a period of more than 120 days. The fish population and benthic invertebrate surveys and supporting environmental measurements are conducted once per cycle, or once every two cycles (i.e., once every six years) if no effects in these components have been observed in the two most recent EEM cycles. In addition, a mill is exempt from a fish survey and a benthic invertebrate community survey if the concentration of effluent in the exposure area is 1% or less within 250 m or 100 m, respectively, of the effluent outfall. An assessment of dioxin/furan concentrations in the tissue of fish captured from the exposure area is required if the effluent contains measurable concentrations of these chemicals, or if concentrations in fish tissue reported in the most recent interpretive report exceeded Health Canada consumption guidelines (Government of Canada 2008).

Five EEM cycles have been completed since the release of the original PPER in 1992: Cycle One, from 1993 to 1996; Cycle Two, from 1997 to 2000; Cycle Three, from 2001 to 2004; Cycle Four, from 2004 to 2007; and Cycle Five, from 2007 to 2010. All components of the Powell River pulpmill EEM programs have been conducted in accordance with applicable regulatory requirements, with implementation guided by applicable technical guidance documents produced by Environment Canada.

1.2 POWELL RIVER EEM CYCLE FIVE DESIGN AND UPDATE

The Powell River pulpmill EEM Cycle Five program was designed in accordance with the 2008 amendments to the PPER (Government of Canada 2008), with guidance from the pulp and paper technical guidance document (Environment Canada 2005). The study design is described in Hatfield (2009).

A plume delineation study conducted by Hay & Company Consultants (Hayco) in 2007 (Hayco 2007) indicated that the Powell River mill's effluent diluted to less than 1% concentration within 50 m of the effluent outfall (Section 2.4). Thus, the mill requested and received an exemption from both a fish population survey and a benthic invertebrate survey in Cycle Five. In addition, no fish tissue survey was required due to undetectable concentrations of dioxin/furan in the effluent samples most recently tested for these chemicals, and concentrations below Health Canada guidelines in fish tissue from the exposure area (Hatfield 2009).

Sublethal toxicity testing was conducted on mill effluent six times during Cycle Five (twice per year). The Cycle Five Design report (Hatfield 2009) indicated that three tests (fish early life stage, echinoderm fertilization, and plant reproduction) would be conducted in each of the six test periods; however, the fish early life stage test was discontinued after August 2008, due to the 2008 PPER amendments that eliminated the requirement for this test. No other changes to the study design were made.

2.0 SITE CHARACTERIZATION

2.1 STUDY AREA

The Catalyst Paper Powell River pulpmill is located at the north end of Malaspina Strait in the northern Strait of Georgia, British Columbia, Canada (Figure 2.1). Malaspina Strait is a deep (>300 m), steep-sided channel separated from the Strait of Georgia by Texada Island. Water temperatures in the area are relatively constant (about 7°C) at depths below approximately 50 m. A thermocline generally develops in summer between about 25 m and 45 m depth, but largely breaks down in winter when surface waters cool (Hatfield 1994). Tides at Powell River are mainly diurnal, with a mean range of 3.35 m; flood tides move north up the strait while ebb tides flow south (Hatfield 1994).

The marine environment in the vicinity of Powell River supports numerous species of aquatic organisms, including fish and benthic invertebrates. The eastern portion of the Strait of Georgia between Texada Island and Desolation Sound and Malaspina Strait are important migratory routes for juvenile salmon. Several areas within the region are important for salmon and herring rearing, as well as Pacific hake, walleye pollock, herring, and Pacific cod spawning. Near-shore marine waters support numerous species of invertebrates, including oysters, shrimp, and clams (Hatfield 1994).

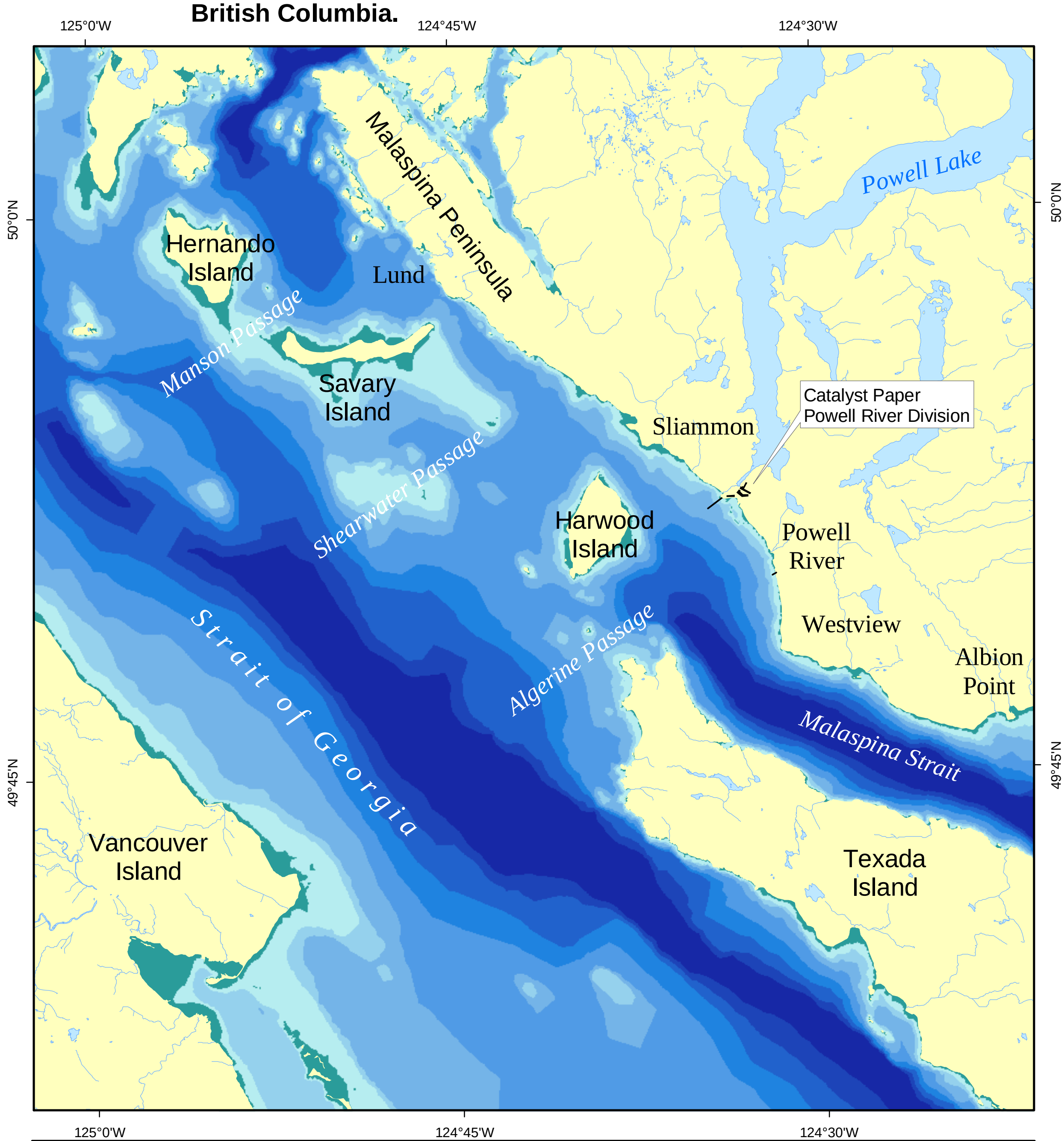
No new large-scale human influences or significant natural changes in the Powell River study area have occurred since the beginning of the EEM program in 1993.

2.2 MILL OPERATIONS

When operations began in 1912, the Powell River mill was the first newsprint mill in western Canada (Catalyst Paper 2009), and used groundwood and sulphite pulping processes. The sulphite mill closed in 1969, and was replaced by a kraft mill that began production in 1967. A refiner mechanical pulp mill was started in 1969, and used surplus refiners from the sulphite mill; this mill continued operation until 1982. Thermomechanical pulp (TMP) production began in 1975, and was converted to chemi-thermomechanical pulp (CTMP) production over the period 1982 to 1985 by means of sodium sulphite treatment of wood chips (Hatfield 1994). Further details on the operational history of the Powell River pulpmill are available in the pre-design report (Hatfield 1994).

In 1991, elemental chlorine use in the kraft mill bleach plant was substantially replaced by a chlorine dioxide system; this resulted in the bleaching sequence DE_OD. Use of elemental chlorine during bleaching was completely eliminated in October 1996. In 2000, the bleaching sequence changed again with the inclusion of peroxide in the alkali extraction process, resulting in the bleaching sequence $DE_{OP}D$ (P=peroxide) (Hatfield 2001). Elimination of elemental chlorine bleaching led to the virtual elimination of dioxins and furans in mill effluent (Hatfield 1994) and greatly reduced effluent adsorbable organic halide (AOX) concentrations (Figure 2.2) (Hatfield 2001).

Figure 2.1 Location of Catalyst Paper, Powell River Division, in Powell River, British Columbia.



LEGEND

Lakes / Ponds

Streams / Rivers

Pulpmill

Depth (metres)

- Intertidal
- 0 - 20
- 20 - 50
- 50 - 100
- 100 - 150
- 150 - 200
- 200 - 250
- 250 - 300
- 300 +

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Data Source:
a) Bathymetric data from Canadian Hydrographic Service.
b) Lakes / Ponds and Streams / Rivers from 1:50,000 NTSB.

0 2.5 5 10 Km

1:320,000

Projection: Albers Equal Area - NAD83

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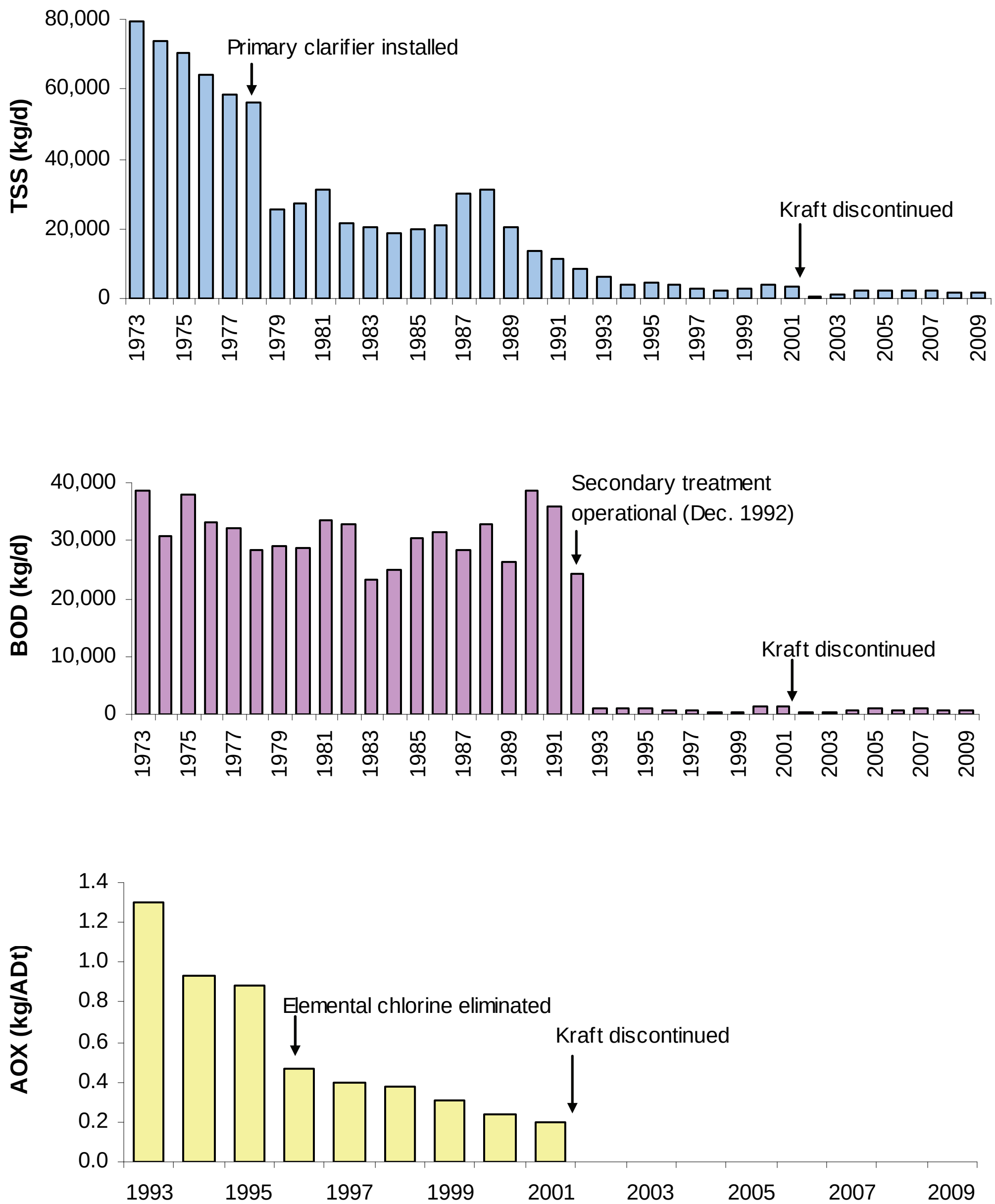
The Powell River pulpmill currently uses an aerobic activated-sludge secondary treatment system, installed in December 1992. This system consists of a three-train bioreactor, three 65.5 m diameter secondary clarifiers, and the submerged effluent diffuser. Installation of the secondary treatment system resulted in a large reduction in effluent BOD (Figure 2.2).

Effluent from the mechanical pulping, woodroom, hog fuel boilers, and paper machines was historically collected in a series of pump stations and transported to a 91 m diameter primary clarifier, installed in 1978, where solids settled out of the effluent and were removed as primary sludge. Effluent TSS concentrations decreased following installation of this primary clarifier (Figure 2.2). During EEM Cycle Four (2004 to 2007), the mill bypassed this existing oversized primary clarifier and converted a much smaller, swing clarifier into a permanent primary clarifier. This modification helped to reduce odour problems related to septicity in the old primary clarifier. In August 1997, liquid ammonia nitrogen (liquid fertilizer) replaced anhydrous ammonia (gas) as the source of nitrogen added to the secondary treatment system (Hatfield 2001). Additional details on the mill's secondary treatment system can be found in the pre-design report (Hatfield 1994).

Since 1993, the combined, treated effluent from all Powell River mill operations has entered the receiving environment through a submarine outfall (Hatfield 1994). This outfall, operational since 1980 (Gillie and Daniel 1981), extends approximately 820 m into Malaspina Strait. Thirty-six diffuser ports, equally spaced along the length of the outfall starting at the 345 m point, discharge effluent at depths between 57.3 and 72.5 m below low water. Before completion of the outfall in 1980, mill effluent was discharged through a surface tailrace at the mill site. Effluent from the CTMP and groundwood mills, papermill, and woodroom were discharged from this site (after primary treatment) until fall 1992, when the secondary treatment system became operational (Hatfield 1994).

Additional discharges from the Powell River pulpmill include cooling and storm waters from the TMP and woodroom areas (Outfall #2, surface discharge to Malaspina Strait); cooling waters from the steam plant and paper machines, and stormwater (Outfall #4, surface discharge to Malaspina Strait); and block flume transport water from Powell Lake, discharged to the Powell River estuary (Outfall #3) (Hatfield 2001).

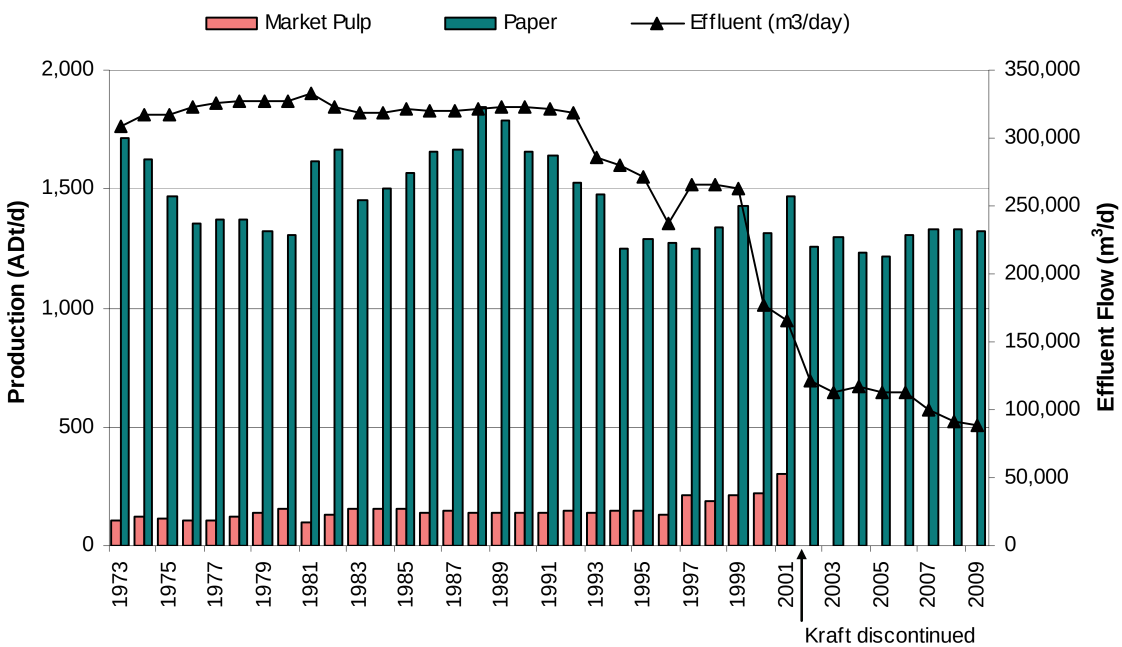
Figure 2.2 Average annual total suspended solids, biochemical oxygen demand, and adsorbable organic halides (AOX) in Powell River pulpmill effluent.



During summer 2001, all paper machines were converted to neutral papermaking processes. In late 2001, the groundwood pulpmill, wood mill operations, and kraft mill operations were discontinued. These changes resulted in a significant reduction in effluent flow (Figure 2.3) and changes in effluent characteristics.

Currently, Powell River pulp and paper operations include a thermomechanical pulpmill, three repulpers for purchased deinked pulp and kraft pulp, and three paper machines. All pulp produced is used for the production of newsprint and groundwood specialties paper. The mill currently produces 33,000 tonnes of newsprint and 435,000 tonnes of specialty papers per year for clients throughout the world (Catalyst Paper 2009). In 2009, average paper production at the Powell River mill was 1,322 ADt/d.

Figure 2.3 Average annual paper and market pulp production and effluent flow, Powell River pulpmill, 1973 to 2009.



The Powell River mill has been owned by several different companies, including MacMillan Bloedel Ltd. and Pacifica Papers. Pacifica Papers and Norske Skog merged in August 2001 to create NorskeCanada. In 2005, NorskeCanada changed its name to Catalyst Paper Corporation. Catalyst Paper Corporation is currently the largest producer of specialty printing papers and newsprint in western North America (Catalyst Paper 2009).

2.3 EFFLUENT QUALITY

Effluent quality is measured routinely in accordance with provincial permits and federal PPER requirements.

Average effluent flow from the mill has decreased from 318,522 m^3/d in 1992 to 88,688 m^3/d in 2009, a decrease of over 70% (Figure 2.3). Reductions in effluent flow, as well as improvements in effluent quality, have resulted from changes to the Powell River pulpmill facility and operations over this period. Installation of the primary clarifier in 1978 led to a substantial decrease in total suspended solids, while implementation of secondary effluent treatment in 1992 led to a decrease in BOD of approximately 96% (Figure 2.2). With the closure of the kraft mill in November 2001, dioxin/furan and AOX monitoring is no longer required.

Given that no major changes to the pulpmill facility or processes occurred during Cycle Five, effluent quality variables measured during Cycle Five were generally similar to those reported in Cycle Four, although effluent TSS and BOD concentrations in 2008 and 2009 were lower than in Cycle Four (Table 2.1). Acute toxicity values were greater than 100% effluent in Cycle Five, indicating that effluent was not lethal to fish and invertebrates tested.

2.4 EFFLUENT DISPERSION

Since 1993, the combined, treated effluent from all Powell River mill operations has entered Malaspina Strait through the submarine outfall (Hatfield 1994). Given numerous process changes since 1992, average effluent discharge rates from the Powell River pulpmill have decreased from 318,522 m^3/day in 1992 to 88,688 m^3/day in 2009 (Figure 2.3), a decrease of over 70%. These lower volumes of effluent continue to be released to the receiving environment via the mill's diffuser, resulting in much more rapid dilution of effluent than occurred previously, when higher flows of effluent were released.

Dispersion of kraft mill effluent from the Powell River pulpmill prior to 1992 was examined through dye dispersion, oceanographic modeling, and water quality studies. These studies indicated that the 1% effluent zone could be delineated as a circle extending 1 km in radius from the outfall diffuser (Hatfield 1994). Effluent flows from the outfall increased in late 1992, when mill effluent flows were combined and released through the submarine outfall rather than the surface tailrace (Section 2.2). The various effluent dispersion studies indicated that while patterns of effluent dispersion were expected to remain similar, the effluent 1% zone should be expanded to a circle extending 3 km in radius from the outfall diffuser (Hatfield 1994). Oceanographic modeling suggested that effluent would disperse along two main paths: south along Malaspina Strait to Jervis Inlet, or north to Savary Island and into the Strait of Georgia (Hatfield 1994). Additional information on these early effluent dispersion studies can be found in the pre-design reference document (Hatfield 1994).

Table 2.1 Annual average values for process effluent quality variables, Powell River pulpmill, 2000 to 2009.

Parameter	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Production (ADt/d) - Paper	1,314	1,468	1260	1296	1,235	1,215	1,305	1,328	1,330	1,322
- Market Pulp	223	305*	0	0	0	0	0	0	0	0
Flow (m^3/d)	176,860	166,320	121,310	112,670	116,600	113,440	113,134	99,758	91,388	88,688
TSS (t/d)	4.2	3.4	0.4	0.9	2.1	2.4	2.5	2.2	1.5	1.5
BOD (t/d)	1.2	1.2	0.18	0.3	0.70	1.0	0.78	0.86	0.55	0.65
Conductivity (µS/cm)	1,050	980	680	790	820	854	920	937	834	881
AOX (kg/ADt)	0.24	0.20	NA	NA	NA	NA	NA	NA	NA	NA
2,3,7,8 TCDD +(0.1[2,3,7,8 TCDF]) (pg/L)	ND	ND	NA	NA	NA	NA	NA	NA	NA	NA
Rainbow trout 96-hr LC50	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100
Daphnia 48-hr LC50	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100
Fibre losses (t/d)										
Net to Clarifier	65	68	50	69	60	66	75	38	39	55
Out of Clarifier	6	6.8	5.4	5.5	5.5	3.7	3.5	3.8	3.5	3.9
% Solids Removal	94	92	88	93	76	95	95	94	95	93

* Note that the Kraft mill was permanently closed in November 2001.

ND = non-detectable.

Effluent dispersion from the Powell River pulpmill has been investigated more recently by Hay and Company (i.e., Hayco 2002, Hayco 2007). A numerical model, the U.S. EPA PLUMES (UM) model, was used to evaluate the expected dispersion of effluent under current conditions and flows in the immediate vicinity of the diffuser (Hayco 2007). Detailed results of this modeling are included in Appendix A1 of the Cycle Five design document (Hatfield 2009), and are summarized below.

Modeled scenarios included effluent flows of 113,000 m^3/day and 120,000 m^3/day, and a range of ambient current velocities (data collected by the Canadian Hydrographic Service at a nearby meter). The U.S. EPA PLUMES (UM) model was used to ensure consistency with historical modeling of effluent dispersion. Modeling was conducted at the most shoreward (shallowest) port (#36), as dilution at this port was generally poorest (Hayco 2007) and provided the most conservative approach.

Modeling results indicated that except for short periods of time when ambient currents drop below 3 cm/s, pulpmill effluent is diluted to over 100:1 (i.e., less than 1% of release) immediately above the diffuser (port #36), with the depth of maximum rise estimated to be approximately 30 m. At lower ambient current velocities (at or below 3 cm/s), lower dilution ratios of approximately 87:1 to 98:1 were predicted to occur through vertical rise only. Through mixing upwards to the point of maximum rise, the effluent plume is predicted to spread horizontally to a diameter of approximately 9 to 11 m. Additional dilution associated with horizontal mixing at this final trapping depth would result in dilutions above 100:1 (i.e., concentrations below 1% of release) within 50 m from the diffuser. Consequently, the 50 m value was assigned as the 1% zone of effluent dilution.

2.5 SUMMARY OF PREVIOUS BIOLOGICAL MONITORING

This section briefly summarizes the findings of previous biological monitoring studies conducted in the vicinity of the Powell River pulpmill. Further details on these studies and their results are available in the Powell River pre-design document (Hatfield 1994) and the Cycle One, Two, Three, and Four interpretive reports (Hatfield 1997, 2000, 2004, 2007, respectively).

A summary of a recent study examining bivalve tissue in traditional Sliammon First Nations territories (Tiley and Bocking 2009) is also included.

2.5.1 Fish Surveys

Various methods have been used for fish population surveys at Powell River given the marine waters and lack of barriers to fish movement. Insufficient numbers of finfish were collected during Cycle One for the adult fish survey; oysters were also collected and analyzed. In Cycle Two, a wild oyster survey was conducted as an alternative to the adult fish survey, given that oysters are sedentary and available along the coastline of Malaspina Strait (Hatfield 2000).

Oysters collected in near-field and far-field areas exhibited very similar values for condition and shell density, while reference area oysters exhibited significantly higher condition and lower shell density. However, the effect of pulpmill effluent on oysters was inconclusive, given the very low levels of resin acids measured in oyster tissue (Hatfield 2000).

In Cycle Three, an extended sublethal toxicity test (28-day topsmelt) indicated that effluent effects were not likely in the receiving environment; toxicity testing conducted in Cycle Four indicated that effluent had no effect on topsmelt survival and growth. No fish survey was conducted during Cycle Four due to an exemption based on the limited 1% effluent zone (i.e., <50 from diffuser). Given the lack of a finfish sentinel species and viable alternative methods for trapped effluent, EEM fish surveys have been inconclusive.

No fish tissue surveys were required at Powell River for Cycle Three or Cycle Four, as concentrations of dioxins/furans in fish tissue were below Health Canada consumption guidelines (30 pg/g in liver/hepatopancreas tissues) in previous EEM cycles (1998 TEQ levels ranged from 2.9 pg/g TEQ in grey cod liver to 13.0 pg/g TEQ in English sole liver). Fishing closures and consumption advisories related to dioxins and furans were also lifted. The mill no longer produces Kraft pulp and does not use chlorine in any form for bleaching.

2.5.2 Benthic Invertebrate Community Surveys

Benthic invertebrate community surveys were conducted for Cycles Two and Three as gradient designs. Potential effects on benthic invertebrate communities were examined using density and richness endpoints (required EEM endpoints for these Cycles), using a statistical significance level of $p<0.05$ ($\alpha=0.05$, $\beta=0.80$). Potential effects were also evaluated using evenness and the Bray-Curtis index in Cycle Three. Cycle Two and Three benthic invertebrate community surveys indicated no effects at Powell River, based on correlation of density and richness with distance from the outfall (Hatfield 2004). No benthic invertebrate community surveys were conducted in Cycle Four, as the 1% effluent zone was less than 100 m from the outfall.

2.5.3 Sliammon First Nations Bivalve Tissue Study

The concentration and spatial variability of bioaccumulative contaminants in intertidal bivalves important for Sliammon First Nations domestic and commercial harvesting were recently assessed in a reconnaissance-level investigation in the Powell River region (Tiley and Bocking 2009). This investigation was undertaken primarily to determine the distribution of bivalve populations containing concentrations of contaminants that could pose a risk to human health.

In the Tiley and Bocking (2009) study, various bivalve species, including littleneck clams (*Protothaca staminea*), manila clams (*Venerupis philippinarum*), Nuttall's cockles (*Clinocardium nuttalli*), butter clams (*Saxidomus giganteus*), and

Pacific oysters were collected from eleven beaches within Sliammon traditional territory in July 2008. These beaches included Scuttle Bay, Okeover Inlet, and Harwood Island beaches, Waterfront Beach, and Theodosia Inlet beaches (reference site). Bivalve samples were analyzed for a suite of metals. Concentrations of arsenic III, arsenic V, dioxins, furans, PCBs, and organochlorines were also analyzed in five samples.

Potential risks to human health associated with consumption of local shellfish were expressed as the number of shellfish that could safely be consumed per day or week, based on observed contaminant concentrations and Health Canada consumption guidelines. Concentrations of four metals—cadmium, zinc, aluminum, and iron—were sufficiently high that potential health risks could occur in the absence of consumption guidelines (Tiley and Bocking 2009). Based on study results, the estimated number of oysters that could be consumed by an adult of average weight (79.19 kg) to restrict cadmium consumption to guideline levels was 0.5 oysters per day, or 3.4 oysters per week (Tiley and Bocking 2009). Health Canada has also recommended a consumption guideline of 460 g oyster tissue per month (16.4 g/day) for adults and 60 g oyster tissue per month for children to limit cadmium intake (Tiley and Bocking 2009).

Dioxin and/or furan congeners were detected at trace concentrations in all clam samples (consisting of 10 to 25 manila and littleneck clams), including those from the reference site at Theodosia Inlet. Total TEQ levels ranged from 0.00093 pg/g TEQ to 0.067 pg/g TEQ at Scuttle Bay Site 3 and Site 2, respectively (assuming concentrations of non-detectable congeners were zero), or 0.225 pg/g TEQ to 0.279 pg/g TEQ at Scuttle Bay Sites 3 and 2, respectively, assuming concentrations of non-detectable congeners were equal to the analytical detection limit in TEQ calculations. These concentrations are well below the Health Canada consumption guideline of 30 pg/g TEQ. Arsenic III, arsenic V, PCBs, and organochlorine pesticides were not detected in any of the clam samples analyzed for these substances.

The study concluded that to fully address health concerns related to the intake of contaminants, intake associated with other food sources must also be considered, and advice from a health expert should be sought to determine how best to monitor the health effects of contaminants derived from seafood. The study recommended that the Health Canada consumption guideline for Pacific oysters should be communicated to the Sliammon community. Additional research needs identified included periodic monitoring for dioxins/furans, PCBs, and organochlorines; assessment of concentrations of these analytes at other beaches and in other bivalve species; and to assess the seasonal, temporal, and spatial variability of metals in both bivalve and plankton communities (Tiley and Bocking 2009).

2.6 SPILLS TO THE RECEIVING ENVIRONMENT

Spills of untreated effluent to the receiving environment occurred on August 13, 2007 and August 25, 2007; details of these spills are reported in the Cycle Five design report (Hatfield 2009).

On January 28, 2010, untreated effluent was released from outfall #2, located at the southeast end of the tailrace, due to a failure at pump station H between 10:22 and 10:36 am (Barkowski 2010). Approximately 210 m^3 of untreated effluent was released at a rate of about 250 L/s. The untreated effluent bypassed the primary clarifier, bioreactor, and secondary clarifier, and combined with cooling water before release. The spill was reported to authorities at 14:03, and the problem at pump station H was subsequently investigated by a professional electrical engineer. Data from online water quality meters indicated that the flow from outfall #2 reached a maximum temperature of 27°C and a maximum pH of 8.1, both below permit limits.

3.0 SUBLETHAL TOXICITY OF EFFLUENT

Summary of Sublethal Toxicity Testing (Winter 2007 through Summer 2009) for Catalyst Paper, Powell River Division:

- No effect of effluent was observed on survival (LC50) or growth (IC25) of topsmelt (*Atherinops affins*) larvae;
- Echinoderm fertilization was affected at a mean effluent concentration of 77.41% (IC25); and
- Algal reproduction was affected at a mean effluent concentration of 16.1% (IC25).

Environment Canada's predictive model suggests maximum potential zones of sublethal effect from the effluent discharge point of <0.50 m for fish survival and growth, 0.65 m for invertebrate fertilization, and 3.12 m for algal growth.

Federal and provincial government regulations require pulp and paper mills to undertake toxicity testing as part of their EEM programs to determine any potential lethality or inhibitory effects of their effluent on fish populations and fish habitat. Current EEM regulations require the use of sublethal toxicity tests to help meet the following objectives (Environment Canada 2005):

- Contribute to the field program as part of a weight-of-evidence approach;
- Compare process effluent quality between mill types and measure changes in effluent quality as a result of effluent treatment and process changes; and
- Contribute to the understanding of relative contributions of the mill to multiple discharge situations.

For the Catalyst Paper Powell River pulpmill, which discharges to a marine receiving environment, Cycle Five sublethal toxicological testing included the following tests, as stipulated in the EEM Technical Guidance Document (Environment Canada 2005):

- Fish early-life-stage survival and growth test, using topsmelt (Atherinops affinis). This test was excluded from the EEM testing requirements in August 2008 as stated in amendments to the *Pulp and Paper Effluent Regulations* (Government of Canada 2008);
- Invertebrate fertilization test using an echinoderm (either the sand dollar *Dendraster excentricus*, or the purple sea urchin *Strongylocentrotus purpuratus*); and
- Algal reproduction test, using the marine red alga *Champia parvula*.

Sublethal toxicity testing of topsmelt and echinoderms for Powell River was undertaken by Cantest Inc. (formerly Vizon SciTech, Vancouver, BC). *Champia* tests were subcontracted to the Saskatchewan Research Council (Saskatoon, SK) or AquaTox Testing & Consulting Inc (Guelph, ON). A summary of reported endpoints is included with this Cycle Five interpretive report (Appendix A1).

3.1 SUBLETHAL TOXICITY TEST METHODS

3.1.1 General Methods and Definitions

During Cycle One, quarterly tests were required for the year in which field studies were conducted. Since Cycle Two, the *Pulp and Paper EEM Guidance Document* (Environment Canada 2005) stipulates sublethal toxicological testing of process effluent during both winter and summer seasons each year. Testing for Cycle Five began in winter 2007 and continued until summer 2009.

In Cycle Five, test seasons assigned were not necessarily representative of the date the test was conducted. The first test period of each year (the "winter" test period) was usually carried out in April. The second test period of each year (the "summer" test period) was usually carried out between September and December. The apparent discrepancy in naming of the test seasons was due to delays that occurred in Cycle Four, resulting from retesting combined with the restrictions associated with test organism availability. Figures presented in this section provide both the test season name and actual test date to prevent any confusion. This naming discrepancy has not been corrected because it has no effect on the validity of toxicity results, and because correcting the naming would require that two sequential test periods be conducted too close to each other. The intent of having two test periods per year is to have them approximately six months apart.

On each test date, a grab sample of effluent was collected by mill personnel according to the methodology described in the *Pulp and Paper EEM Guidance Document* (Environment Canada 2005) and shipped to Cantest Ltd. for testing. Sublethal toxicity testing involved exposure of organisms to a series of effluent dilutions. All sublethal toxicity tests were conducted with controls to assess the background response of test organisms and determine the acceptability of the test using predefined criteria. In addition, in-house cultures were tested with a reference toxicant to monitor the health and sensitivity of the culture.

Sublethal toxicity tests report LC50 or IC25 endpoints. Tests of fish larvae growth, algal reproduction and invertebrate fertilization provide an IC25 endpoint, which is an estimate of the concentration of effluent that causes 25% inhibition of a quantitative biological function, such as reproduction or growth. The fish larvae test also yields an LC50 endpoint, which is the effluent concentration that is lethal to 50% or more of the test organisms. Confidence limits are given for each endpoint where possible.

3.1.2 Sublethal Toxicity Test Methods

General procedures for conducting the topsmelt tests are based on *Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to West Coast Marine and Estuarine Organism* (U.S. EPA 1995). This seven day static renewal test uses nine to 15-day-old topsmelt (*Atherinops affinis*) larvae to assess the toxicity of a sample by comparing the growth and survival of exposed organisms to that observed in control organisms. The endpoints include effluent concentrations that result in 50% survival over seven days (LC50), and effluent concentrations causing 25% inhibition of growth measured as dry weight (IC25) relative to control weights.

General procedures for the echinoderm fertilization tests are based on the methodology document *Biological Test Method: Fertilization Assay Using Echinoids (Sea Urchins and Sand Dollars)* (Environment Canada 1997). The test assesses the fertilization success of an echinoderm using the sand dollar *Dendraster excentricus* or the purple sea urchin *Strongylocentrotus purpuratus*. Male and female gametes are exposed to the test effluent for 20 minutes. The percentage of eggs fertilized is compared between the controls and the sample concentrations to determine if any significant inhibition of fertilization is observed. The test result for fertilization (IC25) represents the percent effluent concentration at which fertilization is reduced by 25% from control rates.

Procedures for conducting the marine algae (*Champia parvula)* tests are based on *Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Water to Marine and Estuarine Organisms* (U.S. EPA 2002). The *Champia* test is a static, non-renewal, marine algal reproduction test where male and female plants are exposed to a test sample for a 48-hour period, followed by a six- to eight-day recovery period. The inhibition of cystocarp reproduction by 25% at the end of the recovery period is the effluent concentration endpoint (reproduction IC25) used to assess toxicity.

3.1.3 Zones of Effluent Concentration

A zone of effluent mixing was determined through modeling completed in March 2007 based on current effluent discharge rates (Hayco 2007). This study determined the maximum extent of effluent concentration of 1% (i.e., 100:1 dilution) or greater, potentially present in the receiving water environment. For the Powell River EEM study, the maximum extent of 1% effluent was defined as a radial distance of approximately 0.05 km (50 m) from the pulpmill diffusers (Section 2.4).

A maximum potential zone of sublethal effect was calculated for each test species from the geometric mean of the IC25 or LC50 results and the extent of the 1% effluent concentration zone, as per Environment Canada (2005). The potential zone of sublethal effect is the maximum distance from the effluent discharge where a specified effect may be expressed for a test species, and describes the area where the effluent concentration exceeds the geometric mean of the endpoints. This maximum potential zone of sublethal effect was calculated as follows:

$$\text{Zone (m)} = \frac{\text{Extent of 1\% effluent zone (m)}}{\text{Geometric mean of IC25 or LC50 results}}$$

This model assumes simple, linear dilution of effluent, which is not realistic for this situation, since the Powell River pulpmill effluent is discharged through a multi-port diffuser that rapidly dilutes effluent into the marine environment upon release.

3.2 RESULTS AND DISCUSSION

The Powell River mill conducted six sublethal toxicity tests for Cycle Five, from winter 2007 through summer 2009. A summary of Cycle Five sublethal toxicity test results, including dose-response curves for all tests conducted, is included in Appendix A1.

3.2.1 Topsmelt (*Atherinops affinis*) Growth and Survival Test

Topsmelt growth and survival tests were completed for the winter 2007 through winter 2008 test periods. Consistent with amendments to the *Pulp and Paper Effluent Regulations* (Government of Canada 2008), this test was no longer required after winter 2008.

For Powell River effluent, topsmelt survival (LC50) and growth (IC25) results were >100% (i.e., the highest concentration of effluent tested resulted in no observed effect), indicating no toxicity during the Cycle Five testing period (Figure 3.1, Figure 3.2). These results are consistent with those observed in all previous cycles (Figure 3.5) (prior to Cycle Four, the highest concentration of effluent tested for topsmelt growth and survival was 67%).

Figure 3.1 Effect of exposure to Powell River pulpmill effluent on topsmelt survival, expressed as LC50 ±95% confidence limits, EEM Cycle Five.

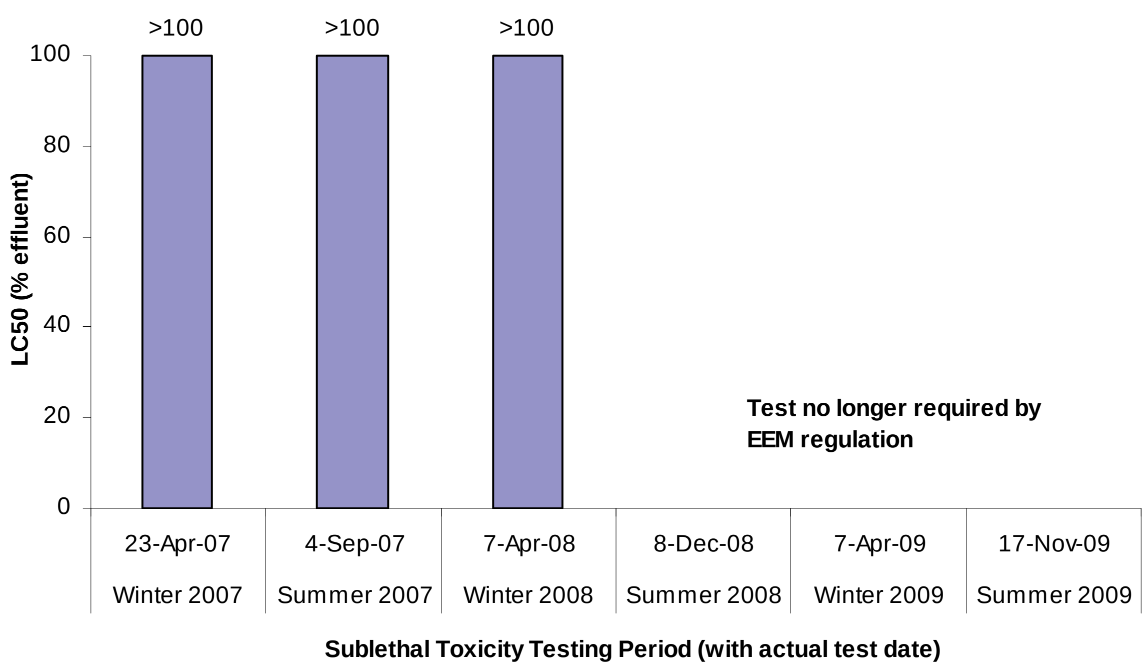
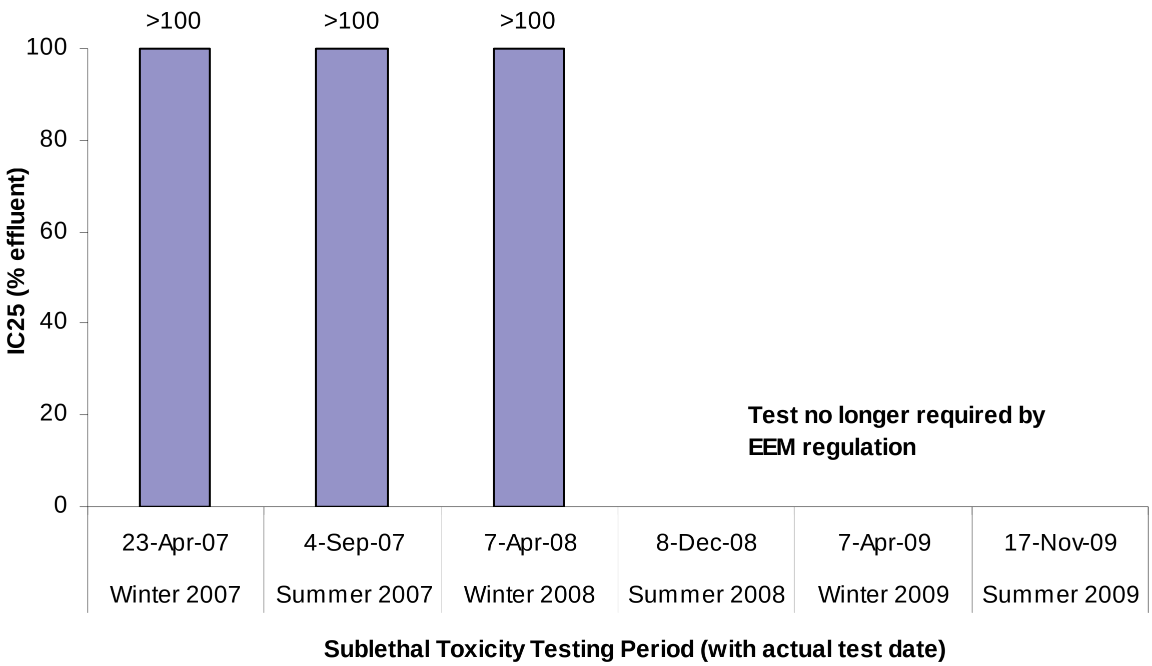


Figure 3.2 Effect of exposure to Powell River pulpmill effluent on topsmelt growth, expressed as IC25 ±95% confidence limits, EEM Cycle Five.

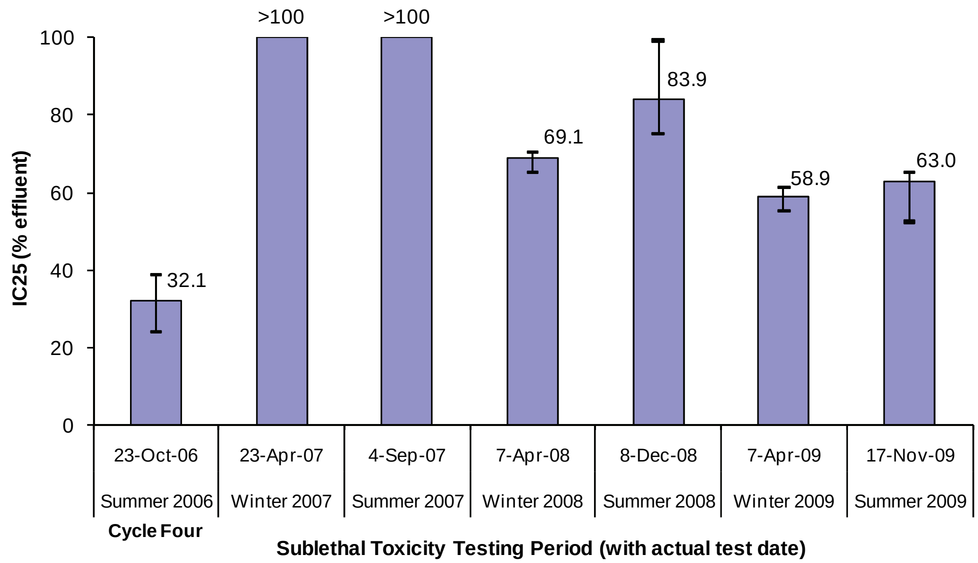


3.2.2 Echinoderm Fertilization Test

Echinoderm fertilization results for the summer 2006 test period (Cycle Four) are included in this report (Figure 3.3). These results were excluded from the Cycle Four report because control organisms failed to meet minimum survival criteria, and retest results were unavailable at the time the Cycle Four report was finalized. The echinoderm fertilization IC25 for the summer 2006 retest was 32.1% v/v effluent.

Fertilization (IC25) results for Cycle Five echinoderms using sand dollars (*Dendraster excentricus*) or purple sea urchins (*Strongylocentrotus purpuratus*) are summarized in Figure 3.3. Results ranged from 58.9% to >100% v/v effluent, with a geometric mean of 77.4%. In the first two test periods of Cycle Five, echinoderm fertilization was not affected by effluent exposure. During the remaining four test periods, effects on echinoderm fertilization were variable and indicate somewhat higher effluent toxicity. However, overall results in Cycle Five suggest improved effluent quality compared to all other test cycles (Figure 3.5).

Figure 3.3 Effect of exposure to Powell River pulpmill effluent on echinoderm fertilization, expressed as IC25 ±95% confidence limits, EEM Cycle Five.

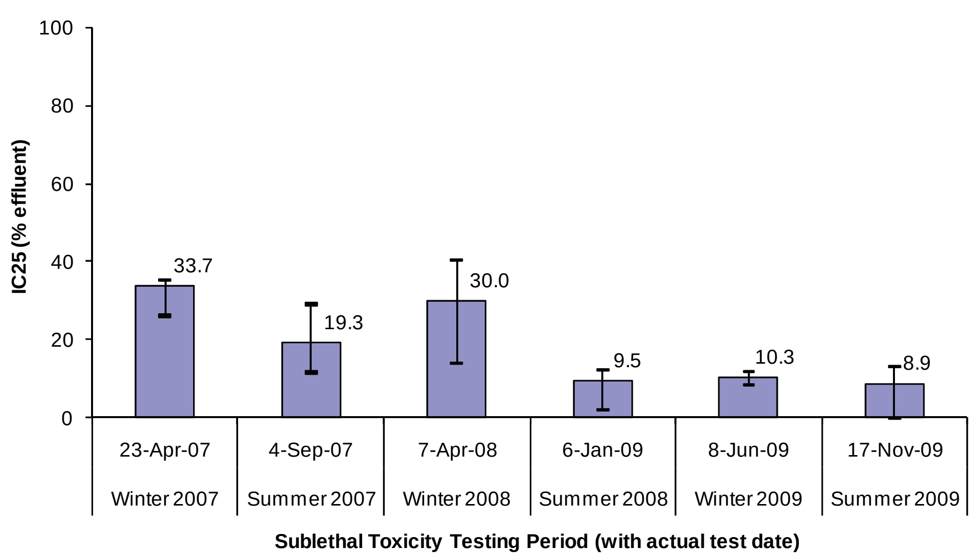


3.2.3 *Champia parvula* Algal Reproduction Test

Champia parvula IC25 reproduction results for Cycle Five are summarized in Figure 3.4.

Algal reproduction was affected by effluent at concentrations ranging from 8.9% to 33.7% v/v effluent with a geometric mean concentration of 16.0%. Effects were variable, with higher effluent toxicity observed during the later Cycle Five test periods. However, overall results in Cycle Five suggest improved effluent quality compared to all other test cycles (Figure 3.5).

Figure 3.4 Effect of exposure to Powell River pulpmill effluent on algal reproduction, expressed as IC25 ±95% confidence limits, EEM Cycle Five.



3.2.4 Potential Zone of Sublethal Effect

In Cycles One through Three, the 1% effluent zone for the Powell River pulpmill was defined as 3,000 m. However, with the closure of the Kraft mill and other changes in the mill that led to large reductions in effluent volume, this distance was dramatically reduced. The 1% effluent zone for Powell River was defined conservatively in Cycle Four as extending a distance of approximately 50 m in radius from the effluent diffusers (Hayco 2007). This 1% effluent zone of 50 m was also used in Cycle Five.

Zones of sublethal effect for Cycles One through Five are shown in Table 3.1. Calculations of geometric means and potential zones of sublethal effect are found in Appendix A1.

Table 3.1 Potential Zone of Sublethal Effect, Powell River pulpmill, EEM Cycle One through Cycle Five.

Sublethal Toxicity Test Species	IC25 or LC50 Geometric Mean (% v/v)					
	Cycle One	Cycle Two	Cycle Three[1] Kraft+TMP	Cycle Three[1] TMP	Cycle Four	Cycle Five
Topsmelt[2] Early Life Stage Growth IC25	>65%	>67%	>67%	>91%	>100%	>100%
Topsmelt[2] Early Life Stage Survival LC50	>65%	>67%	>67%	>91%	>100%	>100%
Echinoderm Fertilization IC25	26.5%	24.5%	23.9%	45.1%	47.8%	77.4%
Algal Reproduction IC25	14.0%	21.4%	7.4%	32.3%	12.1%	16.0%
	Maximum Potential Zone of Sublethal Effect[3] (m)					
Topsmelt[2] Early Life Stage Growth IC25	<46 m	<44 m	<45 m	<33 m	<0.5 m	<0.5 m
Topsmelt[2] Early Life Stage Survival LC50	<46 m	<44 m	<45 m	<33 m	<0.5 m	<0.5 m
Echinoderm Fertilization IC25	113 m	122 m	126 m	67 m	1.1 m[4]	0.7 m
Algal Reproduction IC25	214 m	140 m	407 m	93 m	4.1 m	3.1 m

1 Pulping process changed in November 2001 from Kraft and TMP to TMP only.

2 *Menidia beryllina* was used as the fish test organism in Cycle One. Cycle Five geomeans and Potential Zones of Sublethal Effect for topsmelt growth and survival are based on three test periods, as testing for this species was no longer required after winter 2008.

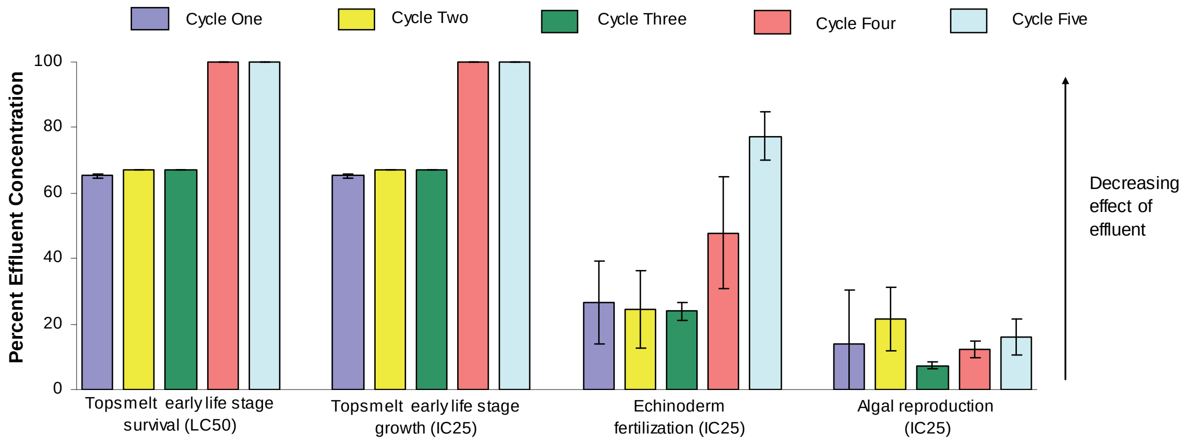
3 Based on a 1% effluent zone of 3,000 m for Cycles One, Two, and Three, and a 1% effluent zone of 50 m for Cycles Four and Five.

4 Echinoderm fertilization test results for the summer 2006 test period were excluded from this calculation in the Cycle Four Interpretive Report because retest results were unavailable at the time the report was finalized. Values for Cycle Four presented here have been updated to include these results.

The potential zone of sublethal effect for topsmelt cannot be calculated with any accuracy, as the IC25 and LC50 concentrations were always greater than the highest concentration tested. Consequently, the zone is shown as being less than the distance calculated (e.g., <0.50 m for Cycle Five) assuming that the IC25 was equal to the highest concentration tested. Consistent with Cycle Two through Cycle Four, there were no observable effects of pulpmill effluent on topsmelt growth or reproduction in Cycle Five (Figure 3.5).

The zone of sublethal effect decreased for both echinoderms (from 1.1 m to 0.7 m) and algae (from 4.1 m to 3.1 m) in Cycle Five compared to Cycle Four, indicating an improvement in effluent quality (Figure 3.5, Table 3.1).

Figure 3.5 Geometric means of IC25 and LC50 results from sublethal toxicity tests of Powell River pulpmill effluent for EEM Cycle One through Cycle Five.



3.3 CONCLUSIONS

The quality of effluent discharged from the Powell River pulpmill, as measured by sublethal toxicity results, was similar to or better than effluent quality observed in previous EEM cycles (Table 3.1, Figure 3.5). Effluent did not affect fish early life stage growth or survival. Algal reproduction was affected at a mean effluent concentration of 16.0%, while invertebrate fertilization was affected at a mean effluent concentration of 77.4%. These effluent concentrations would not be expected to occur in the receiving environment around Powell River beyond the initial effluent mixing zone, immediately above the effluent diffuser.

The addition of Powell River pulpmill effluent to the marine environment should not have resulted in any observable toxicity during Cycle Five given the extremely small zone of sublethal effect near the diffuser. Potential effects are expected to be seen to a maximum extent of 3.1 m from the effluent diffuser.

4.0 CONCLUSIONS AND RECOMMENDATIONS

Despite increases in production since Cycle Four, effluent flow from the Powell River pulpmill has continued to decrease. As indicated by effluent chemistry, acute toxicity, and sublethal toxicity testing, Cycle Five effluent from the Powell River pulpmill was generally similar to or better than in previous Cycles. Effluent did not affect fish early life stage growth or survival. Algal reproduction was affected at a mean effluent concentration of 16.0%, while invertebrate fertilization was affected at a mean effluent concentration of 77.4%. These effluent concentrations would not be expected to occur in the receiving environment around Powell River beyond the initial effluent mixing zone, immediately above the effluent diffuser.

The addition of Powell River pulpmill effluent to the marine environment should not have resulted in any observable toxicity during Cycle Five given the extremely small zone of sublethal effect near the diffuser. Potential sublethal toxicity effects are expected to be seen to a maximum extent of 3.1 m from the effluent diffuser.

Given the expected continued rapid dilution of effluent from the Powell River pulpmill (i.e., 1% effluent zone is defined as 50 m from the diffuser), no fish survey or benthic invertebrate survey will be required for EEM Cycle Six.

5.0 REFERENCES

Barkowski, S. 2010. Personal communication (letter to Director, Environmental Protection, Environment Canada Pacific and Yukon Region, regarding January 28, 2010 untreated effluent release [#902835]). Catalyst Paper Powell River Division, Powell River, BC. 2 pp + attachments. February 19, 2010.

Catalyst Paper Corporation. 2009. Catalyst Paper Corporation website. Accessed at: http://www.catalystpaper.com/default.pasp on September 17, 2009.

Dwernychuk, L.W., L.U. Young, J.A. Allan, and M. Davies. 1997. Dioxin/furan trend monitoring program, 1997 (sediment/crab/fish). Prepared for MB Paper, Powell River Division, by Hatfield Consultants Ltd., September 1997.

Environment Canada. 1997. Biological Test Method: Fertilization Assay Using Echinoids (Sea Urchins and Sand Dollars). Report EPS 1/RM/27 (December 1992, and November 1997 amendments).

Environment Canada. 2005. Pulp and Paper Technical Guidance for Aquatic Environmental Effects Monitoring. Environment Canada. July 2005.

Government of Canada. 2004. Regulations amending the Pulp and Paper Effluent Regulations. Canada Gazette Part II, Vol. 138, No. 10. SOR/2004-109. May 2004. p. 598-658.

Government of Canada. 2008. Regulations Amending the Pulp and Paper Effluent Regulations. Registered July 28, 2008. Canada Gazette Part II, Vol. 142, No. 16 SOR/DORS/2008-239 published August 6, 2008.

Hatfield (Hatfield Consultants). 1994. Powell River environmental effects monitoring (EEM) pre-design reference document. Prepared for MacMillan Bloedel Limited, Powell River Division, by Hatfield Consultants Ltd., June 1994.

Hatfield. 1997. Powell River environmental effects monitoring (EEM) Cycle One interpretive report. Prepared for MacMillan Bloedel Limited, Powell River Division, by Hatfield Consultants Ltd., April 1997.

Hatfield. 2000. Pacifica Papers Inc., Powell River Operations, Environmental Effects Monitoring (EEM) Cycle Two Interpretive Report, 1997 to 2000. 2 Volumes. Prepared for Pacifica Papers Inc., Powell River Operations, by Hatfield Consultants Ltd., March 2000.

Hatfield. 2004. Powell River environmental effects monitoring (EEM) Cycle Three interpretive report. Prepared for NorskeCanda, Powell River Division, by Hatfield Consultants Ltd., March 2004.

Hatfield. 2007. Powell River environmental effects monitoring (EEM) Cycle Four interpretive report. Prepared for Catalyst Paper Corporation, Powell River Division, by Hatfield Consultants, March 2007.

Hatfield . 2009. Powell river Environmental Effects Monitoring (EEM) Cycle Five Design. Prepared for Catalyst Paper Ltd., Powell River Division, Powell River, BC. Prepared by Hatfield Consultants, North Vancouver, BC. October 2009.

Hay & Company Consultants (Hayco). 2002. Powell River Pulp Mill Effluent Outfall Plume Modelling. Prepared for Norske Canada, Powell River Division, by Hay & Company Consultants, Vancouver, BC.

Hayco. 2007. Diffuser Performance at the Catalyst Paper Powell River Outfall. Hay & Company Consultants, Vancouver, BC. March 2007.

Tiley, M.H. and R.C. Bocking. 2009. Contaminant levels in marine bivalves collected from Sliammon First Nations traditional territory beaches and recommended consumption limits. Prepared by LGL Limited, Sidney, BC for the Tla'amin Community Health Services, Powell River, BC. March 2009.

U.S. EPA (United States Environmental Protection Agency). 1995. Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to West Coast Marine and Estuarine Organisms, First Edition. EPA/600/R-95/136. August 1995.

U.S. EPA. 2002. Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Water to Marine and Estuarine Organisms, Third Edition. EPA-821/R/02-014. October 2002.

6.0 GLOSSARY

Acute	With reference to toxicity tests with fish, usually means an effect that happens within four to seven days, or an exposure of that duration. An acute effect could be mild or sublethal, if it were rapid.
BOD	Biochemical oxygen demand. The test measures the oxygen utilized during a specified incubation period for the biochemical degradation of organic material and the oxygen used to oxidize inorganic material such as sulfides and ferrous iron. Usually conducted as a 5-day test (i.e., BOD_5).
CL	Confidence limits. A set of possible values within which the true value will lie with a specified level of probability.
Colour	True colour of water is the colour of a filtered water sample (and thus with turbidity removed), and results from materials which are dissolved in the water. These materials include natural mineral components such as iron and calcium carbonate, as well as dissolved organic matter such as humic acids, tannin, and lignin. Organic and inorganic compounds from industrial or agricultural uses may also add colour to water. As with turbidity, colour hinders the transmission of light through water, and thus "regulates" biological processes within the body of water.

Concentration Units

Concentration Units	Abbreviation	Units
Parts per million	ppm	mg/kg or µg/g or mg/L
Parts per billion	ppb	µg/kg or ng/g or µg/L
Parts per trillion	ppt	ng/kg or pg/g or ng/L
Parts per quadrillion	ppq	pg/kg or fg/g or pg/L

Conductivity	A numerical expression of the ability of an aqueous solution to carry an electric current. This ability depends on the presence of ions, their total concentration, mobility, valence and relative concentrations, and on the temperature of measurement.
Dioxins/Furans	Polychlorinated dibenzo-para-dioxins (PCDDs) and dibenzofurans (PCDFs) are often simply called dioxins, although they are two separate groups of substances with similar effects. There are 210 different compounds, of which 17 are the most toxic.

EC*p*	A point estimate of the concentration of test material that causes a specified percentage effective toxicity (sublethal or lethal). In most instances, the EC*p* is statistically derived by analysis of an observed biological response (e.g., incidence of nonviable embryos or reduced hatching success) for various test concentrations after a fixed period of exposure. EC25 is used for the rainbow trout sublethal toxicity test.
IC*p*	A point estimate of the concentration of test material that causes a specified percentage impairment in a quantitative biological test which measures a change in rate, such as reproduction, growth, or respiration.
Intertidal	The area of the marine shoreline that is only covered with water a portion of the time. Three intertidal zones typically are identified: upper (which is out of water most of the time); mid (which is in or out of water roughly equal amounts of time); and lower (which is underwater most of the time). Each zone supports a unique assemblage of biological communities.
LC_{50}	Median lethal concentration. The concentration of a substance that is estimated to kill half of a group of organisms. The duration of exposure must be specified (e.g., 96-hour LC_{50}).
Macroinvertebrates	Those invertebrate (without backbone) animals that are visible to the eye and retained by a sieve with 500 µm mesh openings for freshwater, or 1,000 µm mesh openings for marine surveys (EEM methods).
Plume	The main pathway for dispersal of effluent within the receiving waters, prior to its complete mixing.
Reference Toxicant	A chemical of quantified toxicity to test organisms, used to gauge the fitness, health, and sensitivity of a batch of test organisms.
SD	Standard deviation.
SE	Standard error.
Secondary Treatment	A stage of purification of a liquid waste in which micro-organisms decompose organic substances in the waste. In the process, the micro-organisms use oxygen. Oxygen usually is supplied by mechanical aeration and/or large surface area of treatment ponds (lagoons). Most secondary treatment also reduces toxicity.
Sublethal	A concentration or level that would not cause death. An effect that is not directly lethal.
T_4CDD	2,3,7,8-tetrachlorodibenzo-para-dioxin, the most toxic dioxin.

TEQ	Toxic Equivalents.
TSS	Total suspended solids (TSS) is a measurement of the oven dry weight of particles of matter suspended in the water which can be filtered through a standard filter paper with pore size of 0.45 micrometres.
v/v	volume/volume - used to define dilution ratios for two liquids.

7.0 CLOSURE

We trust the above information meets your requirements. If you have any questions or comments, please contact the undersigned.

HATFIELD CONSULTANTS:

Approved by:	Danika Affleck Project Manager	March 18, 2010 Date
Approved by:	Martin Davies Project Director	March 18, 2010 Date

APPENDICES

Appendix A1

Sublethal Toxicity Testing Results and Calculations

Table A1.1 Catalyst Paper, Powell River Division, Sublethal Effluent Toxicity Test Results, Cycle Five.

Testing Period	Project Number	Effluent Description (final, cooling, etc.)	Collection Date yyyymmdd	Consultant/Laboratory	Species Tested	Test type S=Survival, G=Growth, R=Reproduction	Flag LC50% > for greater than 100%	LC50%	LC50 Lower 95% cl	LC50 Upper 95% cl	Flag EC25 or IC25% > for greater than 100%	EC25 or IC25 %	EC25 or IC25 Lower 95% cl	EC25 or IC25 Upper 95% cl	Comments
Summer 2006	pp1053	final	20061023	Cantest Ltd.	Strongylocentrotus purpuratus	R						32.1	24.1	38.9	Re-test results (original test failed to meet minimum criteria for control survival)
Winter 2007	pp1053	final	20070423	Cantest Ltd.	Atherinops affinis	S	>	100							
Winter 2007	pp1053	final	20070423	Cantest Ltd.	Atherinops affinis	G					>	100			
Winter 2007	pp1053	final	20070423	Cantest Ltd.	Strongylocentrotus purpuratus	R					>	100			
Winter 2007	pp1053	final	20070423	Saskatchewan Research Council	Champia parvula	R						33.74	26.17	35.41	
Summer 2007	pp1053	final	20070904	Cantest Ltd.	Atherinops affinis	S	>	100							
Summer 2007	pp1053	final	20070904	Cantest Ltd.	Atherinops affinis	G					>	100			
Summer 2007	pp1053	final	20070904	Cantest Ltd.	Dendraster excentricus	R					>	100			
Summer 2007	pp1053	final	20070904	Saskatchewan Research Council	Champia parvula	R						19.25	11.68	29.12	
Winter 2008	pp1053	final	20080407	Cantest Ltd.	Atherinops affinis	S	>	100							
Winter 2008	pp1053	final	20080407	Cantest Ltd.	Atherinops affinis	G					>	100			
Winter 2008	pp1053	final	20080407	Cantest Ltd.	Strongylocentrotus purpuratus	R						69.09	65.18	70.47	
Winter 2008	pp1053	final	20080407	Saskatchewan Research Council	Champia parvula	R						30.01	14.13	40.51	
Summer 2008	pp1053	final	20081208	Cantest Ltd.	Strongylocentrotus purpuratus	R						83.9	75.2	99.2	
Summer 2008	pp1053	final	20090106	Aquatox Testing and Consulting Inc.	Champia parvula	R						9.5	2	12.4	
Winter 2009	pp1053	final	20090407	Cantest Ltd.	Strongylocentrotus purpuratus	R						58.9	55.3	61.4	
Winter 2009	pp1053	final	20090608	Cantest Ltd.	Champia parvula	R						10.3	8.59	11.8	
Summer 2009	pp1053	final	20091117	Cantest Ltd.	Strongylocentrotus purpuratus	R						63	52.5	65.1	
Summer 2009	pp1053	final	20091117	Saskatchewan Research Council	Champia parvula	R						8.86	0	13.29	

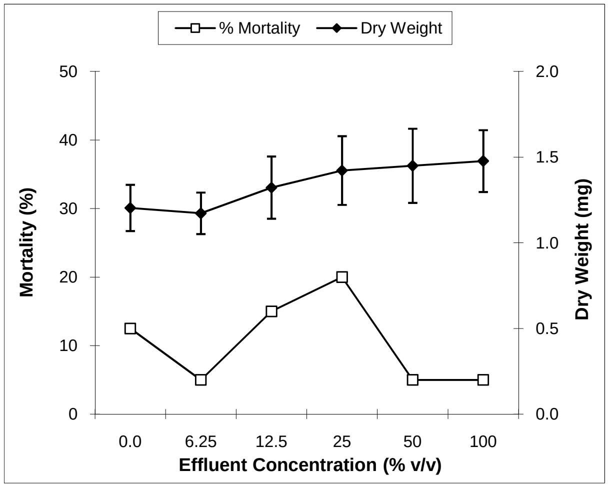
(shaded) = Cycle 4 results

Table A1.2 Catalyst Paper, Powell River Division - Calculation of geomeans and potential zones of sublethal effect.

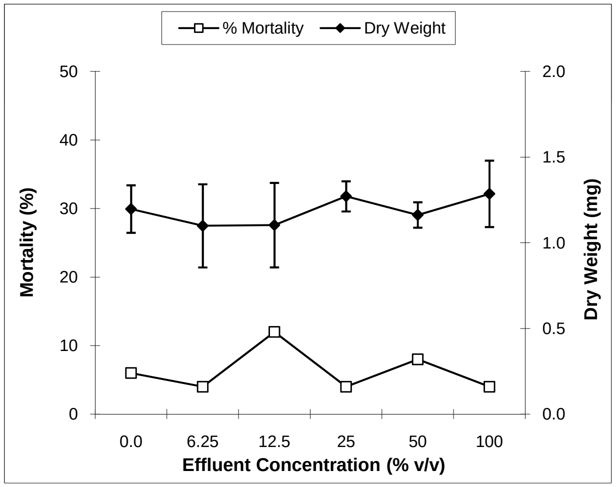
	Fish										Invertebrate					Algae				
	Survival					*Growth*					*Fertilization*					*Reproduction*				
	Cycle 1 LC50	Cycle 2 LC50	Cycle 3 LC50	Cycle 4 LC50	Cycle 5 LC50	Cycle 1 IC25	Cycle 2 IC25	Cycle 3 IC25	Cycle 4 IC25	Cycle 5 IC25	Cycle 1 IC25	Cycle 2 IC25	Cycle 3 IC25	Cycle 4 IC25	Cycle 5 IC25	Cycle 1 IC25	Cycle 2 IC25	Cycle 3 IC25	Cycle 4 IC25	Cycle 5 IC25
	63.8	67	67	100	100	63.8	67	67	100	100	62.5	67	31.07	67	100	60.9	61.09	12.09	11.39	33.74
	67.1	67	67	100	100	67.1	67	67	100	100	48.1	32.33	31.5	23.29	100	2.7	38.4	6.66	7	19.25
	65.8	67	67	100	100	65.8	67	67	100	100	10.4	62.16	18.95	100	69.09	4	14.98	5.52	19.42	30.01
	64.6	67	67	100		64.6	67	67	100		15.7	2.25	17.53	35.57	83.9	58.7	25.3	6.62	12.12	9.5
		67		100			67		100			29.37		67	58.9		5.07		9.96	10.3
				100					100					32.1	63				16.89	8.86
Geomean	65.31	67.00	67.00	100.00	100.00	65.31	67.00	67.00	100.00	100.00	26.47	24.54	23.88	47.81	77.41	14.0	21.4	7.4	12.1	16.0
SE	0.7	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	12.6	11.8	3.8	11.9	7.4	16.3	9.7	1.5	1.9	4.5
1% effluent zone (m)	3,000	3,000	3,000	50	50	3,000	3,000	3,000	50	50	3,000	3,000	3,000	50	50	3,000	3,000	3,000	50	50
Zone of potential effect (m)	45.9	44.8	44.8	0.50	0.50	45.9	44.8	44.8	0.50	0.50	113.3	122.3	125.6	1.05	0.65	214.0	140.1	407.3	4.13	3.12

Figure A1.1 **Mean (± SD) percent mortality and average dry weight of topsmelt *(Atherinops affinis)* exposed to final effluent and control water, Catalyst Paper - Powell River Division, EEM Cycle Five.**

April 23, 2007 (Winter 2007)



September 4, 2007 (Summer 2007)



April 7, 2008 (Winter 2008)

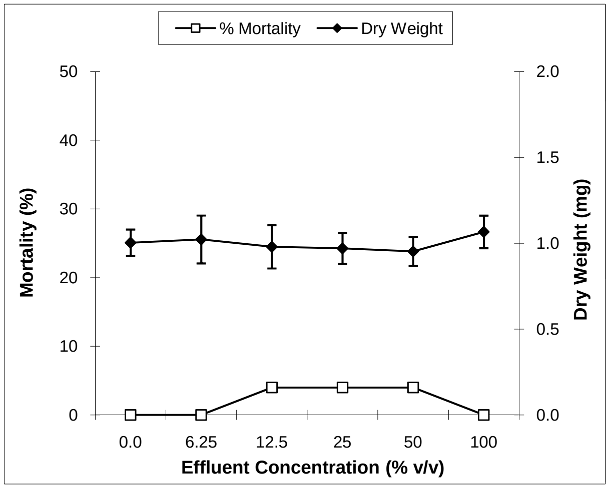
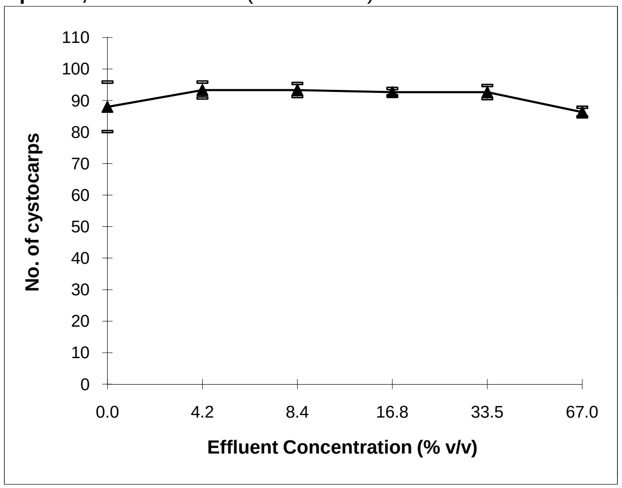
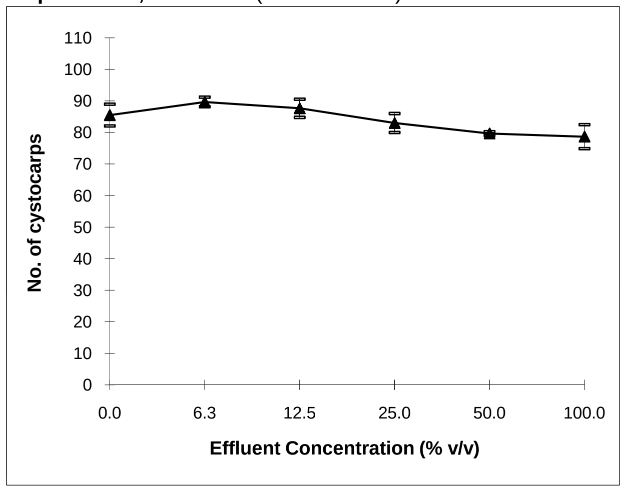


FIgure A1.2 **Mean (± SD) number of echinoderm eggs fertilized when exposed to final effluent and control water, Catalyst Paper, Powell River Division, EEM Cycle Five.**

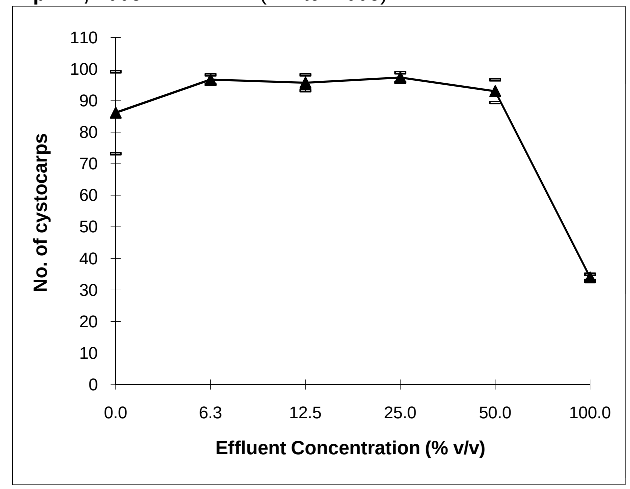
April 23, 2007 (Winter 2008)



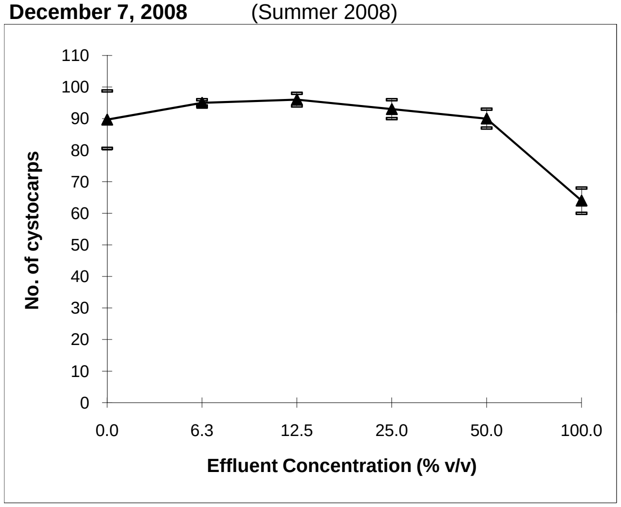
September 4, 2007 (Summer 2007)



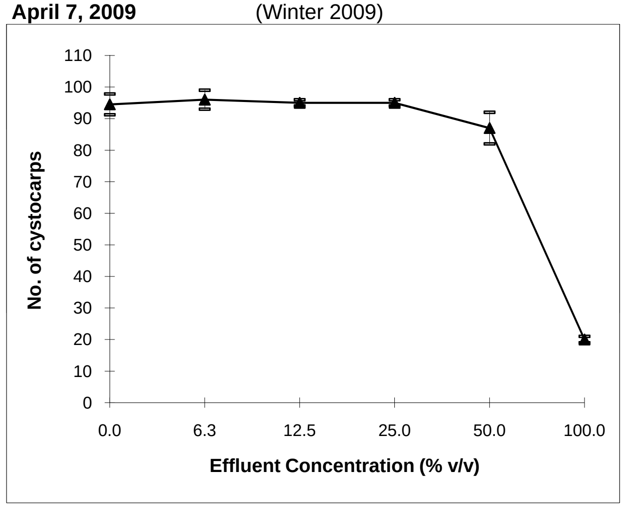
April 7, 2008 (Winter 2008)



December 7, 2008 (Summer 2008)



April 7, 2009 (Winter 2009)



November 17, 2009 (Summer 2009)

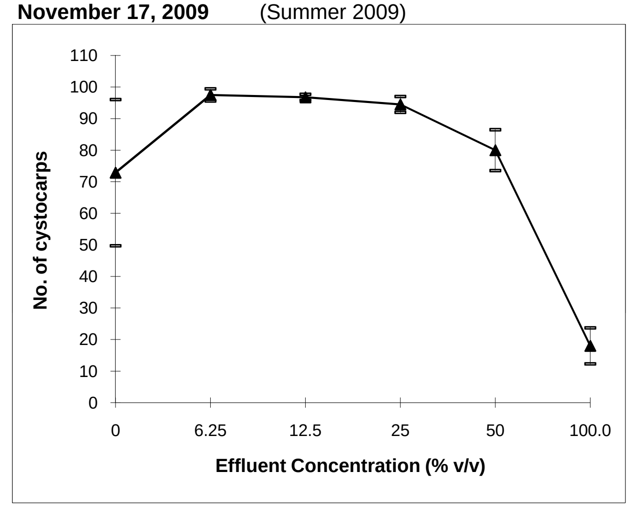
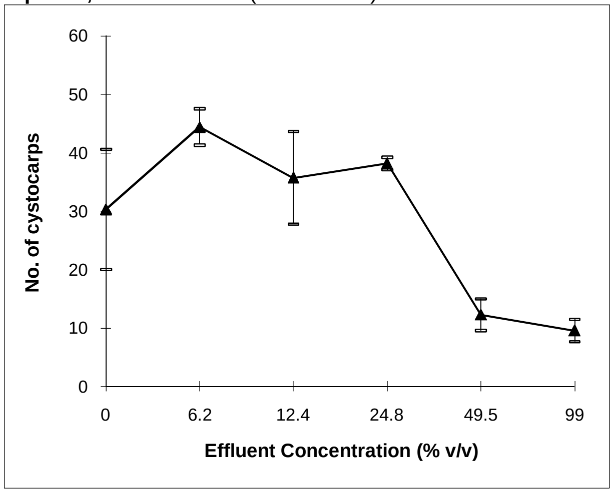
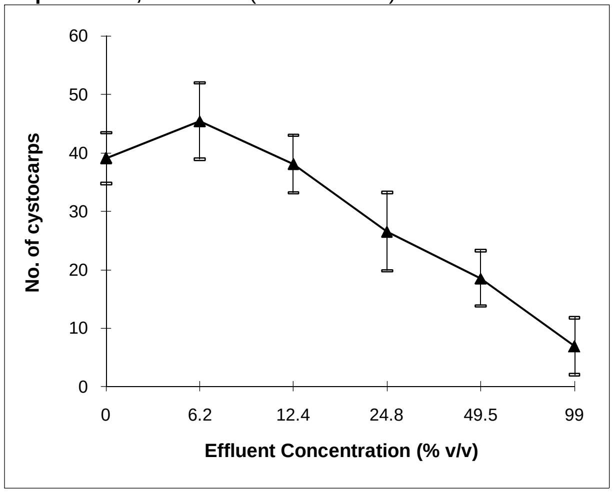


Figure A1.3 **Mean (± SD) number of cystocarps produced by an alga (*Champia parvula*) exposed to final effluent and control water, Catalyst Paper, Powell River Division, EEM Cycle Five.**

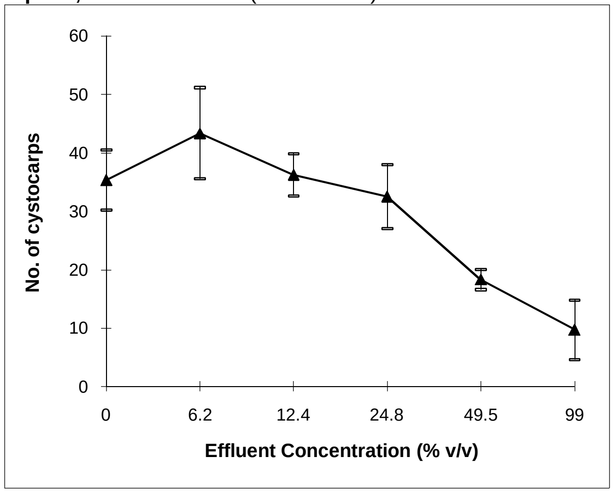
April 23, 2007 (Winter 2007)



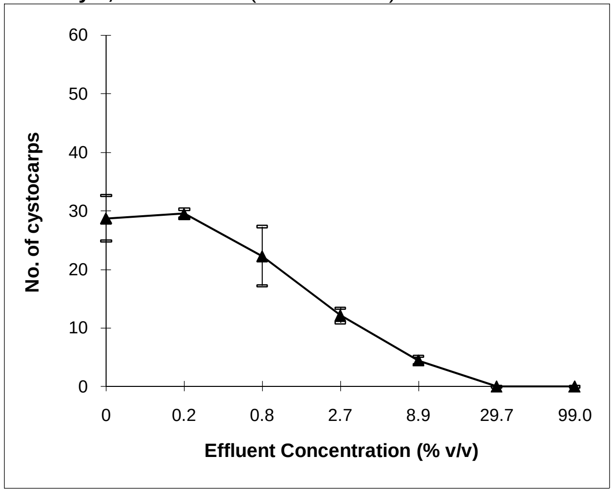
September 4, 2007 (Summer 2007)



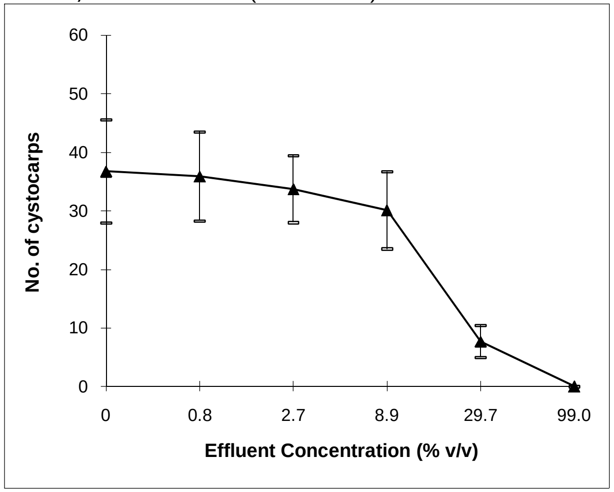
April 7, 2008 (Winter 2008)



January 6, 2009 (Summer 2008)



June 8, 2009 (Winter 2009)



October 23, 2006 (Summer 2006)