APPENDIX H

Preliminary General Blast Design

Blasting Permafrost Conditions – Sheet Pile Cell Dock

Introduction

The dock facility was constructed in 1981 and is comprised of four circular sheet pile cells, each approximately 26 m in diameter. Three interconnecting arcs on the front face tied the four cells together. The wall thickness of an individual steel sheet pile is approximately 1/2-inch. The cells were constructed by driving sheet piles through the ice and backfilled with rock and overburden available locally. The face of the dock is approximately 90 m long with a depth of approximately 13 m at low water.

Blasting in or near Canadian fisheries waters has demonstrated to cause disturbance, injury and/or death to fish and marine mammals and the alteration, disruption or destruction of marine habitat. The Department of Fisheries and Oceans (DFO) has prepared guidelines to assist proponents in conservation methods to protect marine life and habitat from the destructive forces of explosives. The guidelines entitled, "Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters, 1998", forms the basis of blast design for the Polaris project

The Need for Blasting

The substrate underlying the sheet pile cell dock is comprised of overburden excavated from the barge dry dock facility that has been backfilled into the cells and compacted. The Polaris site exhibits permafrost conditions exceeding 100 m in depth and blasting will be required to sufficiently fragment the frozen fill to allow for cost effective excavation.

Type of Explosives

The "Guidelines for the Use of Explosives In or Near Canadian Fisheries Water, 1998" state: "No use of ammonium nitrate-fuel oil mixtures occurs in or near water due to the production of toxic by-products (ammonia)."

Permafrost blasting is to be performed using nitroglycerin (NG) based dynamite, such as Orica Powerfrac in cartridge form.

Linear shape charges may be used to sever the steel sheet pile at the designed depth underwater. Linear shape charges (LSC) do not normally have trade names and are commonly manufactured to meet specific project conditions. Typically, RDX explosive is used in linear shape charges.

Blast Design

Overpressure calculations, set at a peak pulse of 100kPa, were performed for the dock site and the results are presented in Figure 1. These calculations form the basis of blast design and configuration for the project area. The charge weight per delay limitations are depicted linearly in metres from the dock face towards the process barge. The use of a bubble curtain to limit blast-induced overpressure in close proximity to the dock face is mandatory.

Permafrost blasting requires approximately twice the powder factor required to break normal rock. The approximate volume of material in the dock area to blast is 28,700 cubic metres requiring approximately 34,500 kilograms of explosives in total (see Figure 2). Blasting must be performed in small discrete shots, within the overpressure guidelines, so that excavation equipment can dig out the shot material before it re-

freezes. Actual blast size will depend on the size and capability of the excavator on site. A generalized blast plan is illustrated in Figure 3, showing an 8-blasthole shot containing about 50 cubic metres of material. Maximum depth of blasting in the sheet pile cell dock area is about 7 metres.

Multi-deck loading and blasting techniques are required. Between 2 to 4 explosives decks per hole will be required to fragment the cell material in order to maintain the overpressure guidelines. The charge weight per delay will vary depending upon the proximity of the shot to the front face of dock (see Figure 1). The blasting contractor must: have a full understanding of marine blasting; be able to blast to Fisheries guidelines; have the ability to calculate the specific charge weight per delay for each blast; and be able to adjust the blast pattern or utilize a bubble curtain as the need arises. Experience in blasting permafrost conditions is also required.

Overpressure modeling was performed for the use of linear shape charges (LSC) to sever the sheet pile below water level (see Table 1). Since bubble cutains have effectively reduced the pressure pulse by a 10-fold factor, the overpressure limit for the model was set at 1,000kPa for various linear shaped charges. The results indicate that a 10-foot length of LSC may be detonated, within the Fisheries guidelines, with the proper use of a bubble curtain.

Detonation Depth

Blast depth varies throughout the project site, however, a maximum depth of 7 m is to be blasted in the sheet pile cell dock area. As noted previously, the charge weight per delay will depend on the distance of the blast from the water as illustrated on Figure 1. Detailed calculations for setback distances from 1 meter to 14 meters can be found in Tables 2-15 in the Appendix.

Method of Detonation – Electrical Sequential Blasting

The method of detonation is critical to the success of the project, both in the terms of safety and the ability to control blast-induced overpressures and limit marine life mortality.

Electric sequential blasting techniques must be employed for two reasons:

Safety: Due to the high powder factor required to blast permafrost, blasting mats must be used to contain fly rock. Nonel or shock tube type detonators are subject to damage when blasting mats are placed over the tubes, resulting in cutoffs, the blast firing out of sequence, excessive fly rock and extremely high overpressures at the water. Overpressure limitations will be exceeded if the designed delay sequence is not achieved due to damaged shock tubes. The safety of personnel and equipment are also at risk from fly rock as a result of a violent, uncontrolled blast caused by damaged shock tubes.

Accuracy: All shock tube type detonators contain +/- delay scatter time because of the inaccuracy of the pyrotechnic delay elements in the blasting caps. In order to control overpressure generated by blasting, tight control must be placed on the delay timing sequence. The multi-deck holes require accurate delay times between explosive decks and from hole-to-hole to limit the blast-induced overpressure to 100kPa. The only methods available for the accuracy required for this project are through the use of electronic detonators or electrical sequential blasting. Electronic detonators are not commonly used at present and are costly. Experienced blasting contractors commonly perform electric sequential blasting.

Polaris Mine
Decommissioning Sheet Pile Dock

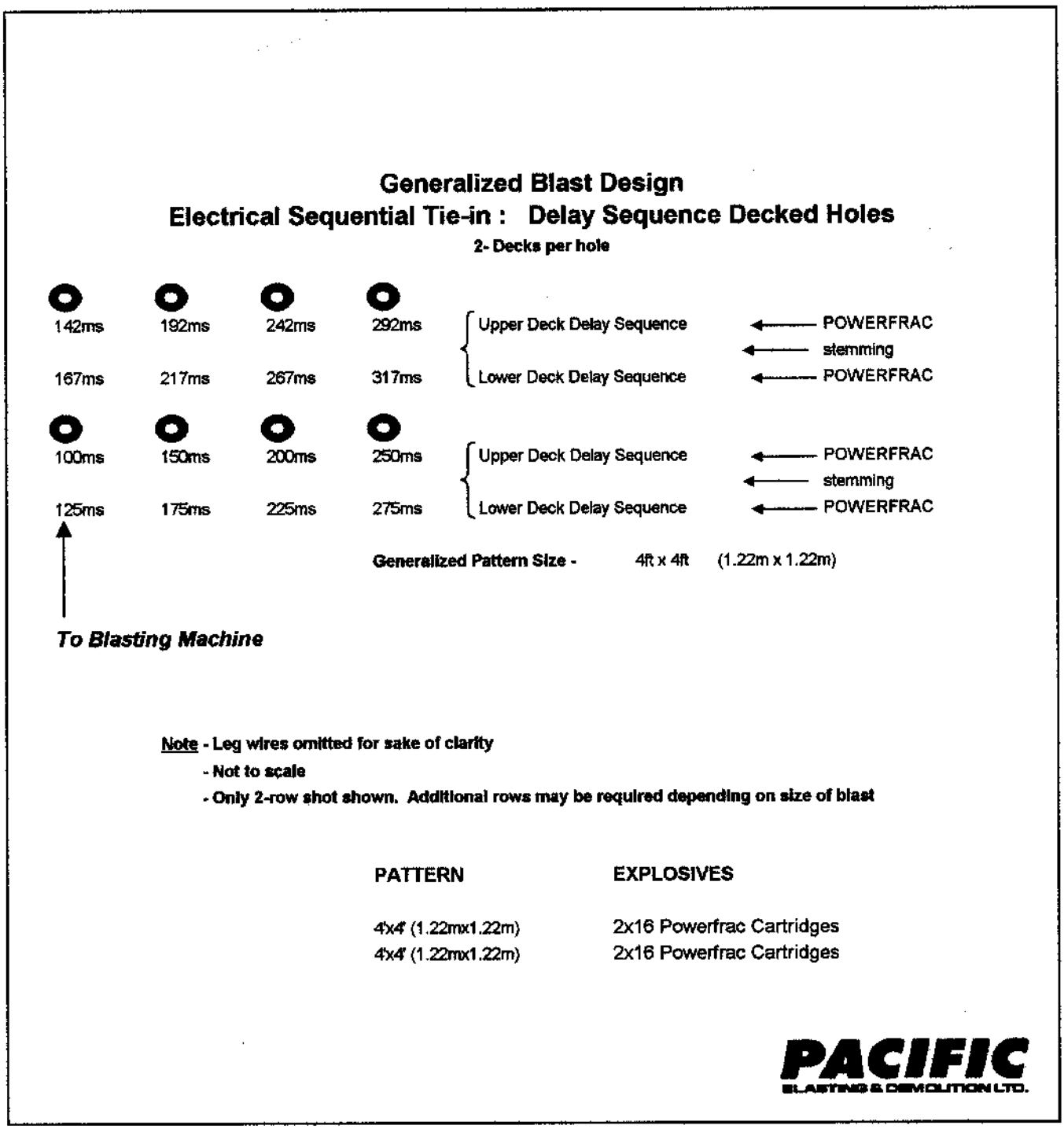

Figure 3

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SAFETY QUALITY RESPONSIBILITY PROFESSIONALISM

Design Criteria
for
Guidelines for the Use of Explosives In or
Near Canadian Fisheries Waters
Table No. 2
Charge Weight Calculations for a 1.0 m Setback

Table 1 - From " Canadian Technical Report of Fisheries and Aquatic Sciences 2107" , 1998
Titled - "Guidelines For the Use of Explosives In Or Near Canadian Fisheries Waters"

	Substrate	Dr ($g \cdot cm^{-3}$)	Cr ($cm \cdot s^{-1}$)	Cw ($cm \cdot s^{-1}$)	K	Dw ($g \cdot cm^{-3}$)	Pw (kPa)	PPV ($mm \cdot sec^{-1}$)
1	Rock	2.64	457200	146300	5.03	1.00	100.00	13.00
2	Frozen Soil	1.92	304800	146300	3.20	1.00	100.00	13.00
3	Ice	0.96	304800	146300	2.10	1.00	100.00	13.00
4	Saturated Soil	2.08	146300	146300	2.13	1.00	100.00	13.00
5	Unsaturated Soil	1.92	45700	146300	0.96	1.00	100.00	13.00

PROJECT DESIGN CRITERIA

Project Location: Polaris Mine - Little Cornwallis Island, Nunavut
Water Course: Crozier Strait
Substrate: Quarry Fill — Frozen Soil (Fisheries Substrate Classification)
Nature of Jointing/Fractures: N/A
Overburden: N/A
Hole Depth: 2 m
Explosive Type: Orica Powerfrac (Gelatin Dynamite)
Method of Detonation: Electric, blasting cap
Bubble Curtain Required: Yes

Table 2 - Calculations for : **Polaris Mine - Little Cornwallis Island, Nunavut**

	Project Substrate	Dr ($g \cdot cm^{-3}$)	Cr ($cm \cdot s^{-1}$)	Cw ($cm \cdot s^{-1}$)	K	Dw ($g \cdot cm^{-3}$)	Pw (kPa)	Vr ($mm \cdot sec^{-1}$)
2	Frozen Soil	1.92	304800	146300	3.2	1.00	100.00	13.00

0.05	Charge Weight (kg)	0.05	0.11 Lbs/delay
1	No. of Delays/Charge	1.0	
	Charge Weight/Delay	0.05	
1.0	Distance to Detonation	1.00	

$\frac{Zw}{Zr} = \frac{DwCw}{DrCr}$ = 0.2500

$Pw = \frac{2(Zw/Zr)Pr}{1+(Zw/Zr)}$

or

$Pr = \frac{Pw(1+(Zw/Zr))}{2(Zw/Zr)}$ = 250.0 — 2.50 kPa or 2.50E+06 dynes - *to limit Pw to 100 kPa*

$Vr = \frac{2Pr}{DrCr}$ = 8.54 $cm \cdot s^{-1}$ - *to limit Pw to 100kPa*

$R = (w^5)(Vr/100)^{-0.626}$ = 1.0 m *Minimum setback distance required to reduce overpressure to less than 100 kPa*

$R = (w^5)(Vr/100)^{-0.626}$ = 3.4 m *Minimum setback distance from a spawning area to maintain PPV @ 13 $mm \cdot sec^{-1}$*

$Vr = 100(R/W^{.5})^{-1.6}$ = 9.10 $cm \cdot s^{-1}$ Calculated PPV at Design Criteria

$Vr = \frac{2Pr}{DrCr}$

or

$Pr = (DrCrVr)/2$ = 2.66E+06 Dynes Calculated Pressure in Substrate at Design Criteria

$Pw = \frac{2(Zw/Zr)Pr}{1+(Zw/Zr)}$ = 106.54 kPa Calculated Pressure in Water at Design Criteria

PROJECT SUMMARY	Fisheries Limit	Project Design
Pressure in Water (Pw) kPa	100.0	106.54
**Peak Particle Velocity (Vr) cm-s-1	13.0	91.03

** Limit for spawning bed during period of egg incubation

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Design Criteria
for
Guidelines for the Use of Explosives In or
Near Canadian Fisheries Waters
Table No. 3
Charge Weight Calculations for a 2.0 m Setback

Table 1 - From " Canadian Technical Report of Fisheries and Aquatic Sciences 2107" , 1998
Titled - "Guidelines For the Use of Explosives In Or Near Canadian Fisheries Waters"

	Substrate	Dr ($g \cdot cm^{-3}$)	Cr ($cm \cdot s^{-1}$)	Cw ($cm \cdot s^{-1}$)	K	Dw ($g \cdot cm^{-3}$)	Pw (kPa)	PPV ($mm \cdot sec^{-1}$)
1	Rock	2.64	457200	146300	5.03	1.00	100.00	13.00
2	Frozen Soil	1.92	304800	146300	3.20	1.00	100.00	13.00
3	Ice	0.88	304800	146300	2.10	1.00	100.00	13.00
4	Saturated Soil	2.08	146300	146300	2.13	1.00	100.00	13.00
5	Unsaturated Soil	1.92	45700	146300	0.98	1.00	100.00	13.00

PROJECT DESIGN CRITERIA

Project Location:	Polaris Mine - Little Cornwallis Island, Nunavut
Water Course:	Crozier Strait
Substrate:	Quarry Fill — Frozen Soil (Fisheries Substrate Classification)
Nature of Jointing/Fractures:	N/A
Overburden:	N/A
Hole Depth:	2 m
Explosive Type:	Orica Powerfrac (Gelatin Dynamite)
Method of Detonation:	Electric, blasting cap
Bubble Curtain Required:	Yes

Table 3 - Calculations for : **Polaris Mine - Little Cornwallis Island, Nunavut**

	Project Substrate	Dr ($g \cdot cm^{-3}$)	Cr ($cm \cdot s^{-1}$)	Cw ($cm \cdot s^{-1}$)	K	Dw ($g \cdot cm^{-3}$)	Pw (kPa)	Vr ($mm \cdot sec^{-1}$)
2	Frozen Soil	1.92	304800	146300	3.2	1.00	100.00	13.00

0.18	Charge Weight (kg)	0.18	0.40 Lbs/delay
1	No. of Delays/Charge	1.0	
	Charge Weight/Delay	0.18	
2.0	Distance to Detonation	2.00	

$Zw = \frac{DwCw}{DrCr}$ = 0.2500

$Pw = \frac{2(Zw/Zr)Pr}{1+(Zw/Zr)}$

or

$Pr = \frac{Pw(1+(Zw/Zr))}{2(Zw/Zr)}$ = 250.0 — 2.50 kPa or 2.50E+06 dynes - *to limit Pw to 100 kPa*

$Vr = \frac{2Pr}{DrCr}$ = 8.54 $cm \cdot s^{-1}$ - *to limit Pw to 100kPa*

$R = (w^{0.5})(Vr/100)^{-0.625}$ = 2.0 m *Minimum setback distance required to reduce overpressure to less than 100 kPa*

$R = (w^{0.5})(Vr/100)^{-0.625}$ = 6.4 m *Minimum setback distance from a spawning area to maintain PPV @ 13 $mm \cdot sec^{-1}$*

$Vr = 100(R/W^{0.5})^{-1.8}$ = 8.37 $cm \cdot s^{-1}$ Calculated PPV at Design Criteria

$Vr = \frac{2Pr}{DrCr}$

or

$Pr = (DrCrVr)/2$ = 2.45E+06 Dynes Calculated Pressure in Substrate at Design Criteria

$Pw = \frac{2(Zw/Zr)Pr}{1+(Zw/Zr)}$ = 97.93 kPa Calculated Pressure in Water at Design Criteria

PROJECT SUMMARY	Fisheries Limit	Project Design
Pressure in Water (Pw) kPa	100.0	97.93
**Peak Particle Velocity (Vr) cm-s-1	13.0	83.67

** Limit for spawning bed during period of egg incubation

PACIFIC BLASTING & DEMOLITION LTD.

SAFETY QUALITY PRODUCTIVITY PERFORMANCE/RELIABILITY

Design Criteria
for
Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters
Table No. 4
Charge Weight Calculations for a 3.0 m Setback

Table 1 - From " Canadian Technical Report of Fisheries and Aquatic Sciences 2107" , 1996
Titled - "Guidelines For the Use of Explosives In Or Near Canadian Fisheries Waters"

	Substrate	Dr ($g \cdot cm^{-3}$)	Cr ($cm \cdot s^{-1}$)	Cw ($cm \cdot s^{-1}$)	K	Dw ($g \cdot cm^{-3}$)	Pw (kPa)	PPV ($mm \cdot sec^{-1}$)
1	Rock	2.64	457200	146300	5.03	1.00	100.00	13.00
2	Frozen Soil	1.92	304800	146300	3.20	1.00	100.00	13.00
3	Ice	0.98	304800	146300	2.10	1.00	100.00	13.00
4	Saturated Soil	2.08	146300	146300	2.13	1.00	100.00	13.00
5	Unsaturated Soil	1.92	45700	146300	0.88	1.00	100.00	13.00

PROJECT DESIGN CRITERIA

Project Location:	Polaris Mine - Little Cornwallis Island, Nunavut
Water Course:	Crozier Strait
Substrate:	Quarry Fill — Frozen Soil (Fisheries Substrate Classification)
Nature of Jointing/Fractures:	N/A
Overburden:	N/A
Hole Depth:	2 m
Explosive Type:	Orica Powerfrac (Gelatin Dynamite)
Method of Detonation:	Electric, blasting cap
Bubble Curtain Required:	Yes

Table 4 - Calculations for : **Polaris Mine - Little Cornwallis Island, Nunavut**

	Project Substrate	Dr ($g \cdot cm^{-3}$)	Cr ($cm \cdot s^{-1}$)	Cw ($cm \cdot s^{-1}$)	K	Dw ($g \cdot cm^{-3}$)	Pw (kPa)	Vr ($mm \cdot sec^{-1}$)
2	Frozen Soil	1.92	304800	146300	3.2	1.00	100.00	13.00

0.42	Charge Weight (kg)	0.42	0.93 Lbs/delay
1	No. of Delays/Charge	1.0	
	Charge Weight/Delay	0.42	
3.0	Distance to Detonation	3.00	

$Zw = \frac{DwCw}{DrCr}$ = 0.2500

$Pw = \frac{2(Zw/Zr)Pr}{1+(Zw/Zr)}$ or $Pr = \frac{Pw(1+(Zw/Zr))}{2(Zw/Zr)}$

250.0 — 2.50 kPa or **2.50E+06 dynes** - *to limit Pw to 100 kPa*

$Vr = \frac{2Pr}{DrCr}$ — **8.64 $cm \cdot s^{-1}$** - *to limit Pw to 100kPa*

$R = (w^{E})(Vr/100)^{-0.625}$ — **3.0 m** *Minimum setback distance required to reduce overpressure to less than 100 kPa*

$R = (w^{E})(Vr/100)^{-0.625}$ — **9.8 m** *Minimum setback distance from a spawning area to maintain PPV @ 13 $mm \cdot sec^{-1}$*

$Vr = 100(R/W^{E})^{-1.5}$ — **8.61 $cm \cdot s^{-1}$** Calculated PPV at Design Criteria

$Vr = \frac{2Pr}{DrCr}$ or $Pr = (DrCrVr)/2$ — **2.52E+06 Dynes** Calculated Pressure in Substrate at Design Criteria

$Pw = \frac{2(Zw/Zr)Pr}{1+(Zw/Zr)}$ — **100.82 kPa** Calculated Pressure in Water at Design Criteria

PROJECT SUMMARY	Fisheries Limit	Project Design
Pressure in Water (Pw) kPa	100.0	100.82
**Peak Particle Velocity (Vr) cm-s-1	13.0	86.14

** Limit for spawning bed during period of egg incubation

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SAFETY QUALITY PRODUCTIVITY PERFORMANCE/RELIABILITY

Design Criteria
for
Guidelines for the Use of Explosives In or
Near Canadian Fisheries Waters
Table No. 5
Charge Weight Calculations for a 4.0 m Setback

Table 1 - From " Canadian Technical Report of Fisheries and Aquatic Sciences 2107" , 1996
Titled - "Guidelines For the Use of Explosives In Or Near Canadian Fisheries Waters"

	Substrate	Dr ($g \cdot cm^{-3}$)	Cr ($cm \cdot s^{-1}$)	Cw ($cm \cdot s^{-1}$)	K	Dw ($g \cdot cm^{-3}$)	Pw (kPa)	PPV ($mm \cdot sec^{-1}$)
1	Rock	2.64	457200	146300	5.03	1.00	100.00	13.00
2	Frozen Soil	1.92	304800	146300	3.20	1.00	100.00	13.00
3	Ice	0.96	304800	146300	2.10	1.00	100.00	13.00
4	Saturated Soil	2.08	146300	146300	2.13	1.00	100.00	13.00
5	Unsaturated Soil	1.92	45700	146300	0.96	1.00	100.00	13.00

PROJECT DESIGN CRITERIA

Project Location:	Polaris Mine - Little Cornwallis Island, Nunavut
Water Course:	Crozier Strait
Substrate:	Quarry Fill — Frozen Soil (Fisheries Substrate Classification)
Nature of Jointing/Fractures:	N/A
Overburden:	N/A
Hole Depth:	2 m
Explosive Type:	Orica Powerfrac (Gelatin Dynamite)
Method of Detonation:	Electric, blasting cap
Bubble Curtain Required:	Yes

Table 5 - Calculations for : **Polaris Mine - Little Cornwallis Island, Nunavut**

	Project Substrate	Dr ($g \cdot cm^{-3}$)	Cr ($cm \cdot s^{-1}$)	Cw ($cm \cdot s^{-1}$)	K	Dw ($g \cdot cm^{-3}$)	Pw (kPa)	Vr ($mm \cdot sec^{-1}$)
2	Frozen Soil	1.92	304800	146300	3.2	1.00	100.00	13.00

0.74	Charge Weight (kg)	0.74	1.63 Lbs/delay
1	No. of Delays/Charge	1.0	
	Charge Weight/Delay	0.74	
4.0	Distance to Detonation	4.00	

$Zw = \frac{DwCw}{DrCr}$ = 0.2500

$Pw = \frac{2(Zw/Zr)Pr}{1+(Zw/Zr)}$

or

$Pr = \frac{Pw(1+(Zw/Zr))}{2(Zw/Zr)}$ = 250.0 — 2.50 kPa or 2.50E+06 dynes - *to limit Pw to 100 kPa*

$Vr = \frac{2Pr}{DrCr}$ = 8.54 $cm \cdot s^{-1}$ - *to limit Pw to 100kPa*

$R = (w^{5})(Vr/100)^{-0.625}$ = 4.0 m *Minimum setback distance required to reduce overpressure to less than 100 kPa*

$R = (w^{5})(Vr/100)^{-0.625}$ = 13.0 m *Minimum setback distance from a spawning area to maintain PPV @ 13 $mm \cdot sec^{-1}$*

$Vr = 100(R/W^{.5})^{-1.8}$ = 8.55 $cm \cdot s^{-1}$ Calculated PPV at Design Criteria

$Vr = \frac{2Pr}{DrCr}$

or

$Pr = (DrCrVr)/2$ = 2.50E+06 Dynes Calculated Pressure in Substrate at Design Criteria

$Pw = \frac{2(Zw/Zr)Pr}{1+(Zw/Zr)}$ = 100.10 kPa Calculated Pressure in Water at Design Criteria

PROJECT SUMMARY	Fisheries Limit	Project Design
Pressure in Water (Pw) kPa	100.0	100.10
**Peak Particle Velocity (Vr) cm-s-1	13.0	85.52

** Limit for spawning bed during period of egg incubation

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Design Criteria
for
Guidelines for the Use of Explosives In or
Near Canadian Fisheries Waters
Table No. 6
Charge Weight Calculations for a 5.0 m Setback

Table 1 - From " Canadian Technical Report of Fisheries and Aquatic Sciences 2107" , 1998
Titled - "Guidelines For the Use of Explosives In Or Near Canadian Fisheries Waters"

	Substrate	Dr ($g \cdot cm^{-3}$)	Cr ($cm \cdot s^{-1}$)	Cw ($cm \cdot s^{-1}$)	K	Dw ($g \cdot cm^{-3}$)	Pw (kPa)	PPV ($mm \cdot sec^{-1}$)
1	Rock	2.64	457200	146300	5.03	1.00	100.00	13.00
2	Frozen Soil	1.92	304800	146300	3.20	1.00	100.00	13.00
3	Ice	0.96	304800	146300	2.10	1.00	100.00	13.00
4	Saturated Soil	2.06	146300	146300	2.13	1.00	100.00	13.00
5	Unsaturated Soil	1.92	45700	146300	0.98	1.00	100.00	13.00

PROJECT DESIGN CRITERIA

Project Location: Polaris Mine - Little Cornwallis Island, Nunavut
Water Course: Crozier Strait
Substrate: Quarry Fill — Frozen Soil (Fisheries Substrate Classification)
Nature of Jointing/Fractures: N/A
Overburden: N/A
Hole Depth: 2 m
Explosive Type: Orica Powerfrac (Gelatin Dynamite)
Method of Detonation: Electric, blasting cap
Bubble Curtain Required: Yes

Table 6 - Calculations for : **Polaris Mine - Little Cornwallis Island, Nunavut**

	Project Substrate	Dr ($g \cdot cm^{-3}$)	Cr ($cm \cdot s^{-1}$)	Cw ($cm \cdot s^{-1}$)	K	Dw ($g \cdot cm^{-3}$)	Pw (kPa)	Vr ($mm \cdot sec^{-1}$)
2	Frozen Soil	1.92	304800	146300	3.2	1.00	100.00	13.00

1.15	Charge Weight (kg)	1.15	2.54 Lbs/delay
1	No. of Delays/Charge	1.0	
	Charge Weight/Delay	1.15	
5.0	Distance to Detonation	5.00	

$Zw = \frac{DwCw}{DrCr}$ = 0.2500

$Pw = \frac{2(Zw/Zr)Pr}{1+(Zw/Zr)}$

or

$Pr = \frac{Pw(1+(Zw/Zr))}{2(Zw/Zr)}$ = 250.0 — 2.50 kPa or — 2.50E+06 dynes - *to limit Pw to 100 kPa*

$Vr = \frac{2Pr}{DrCr}$ = 8.54 $cm \cdot s^{-1}$ - *to limit Pw to 100kPa*

$R = (w^5)(Vr/100)^{-0.826}$ = 5.0 m *Minimum setback distance required to reduce overpressure to less than 100 kPa*

$R = (w^5)(Vr/100)^{-0.826}$ = 16.2 m *Minimum setback distance from a spawning area to maintain PPV @ 13 $mm \cdot sec^{-1}$*

$Vr=100(R/W^{.5})^{-1.6}$ = 8.52 $cm \cdot s^{-1}$ Calculated PPV at Design Criteria

$Vr = \frac{2Pr}{DrCr}$

or

$Pr = (DrCrVr)/2$ = 2.49E+06 Dynes Calculated Pressure in Substrate at Design Criteria

$Pw = \frac{2(Zw/Zr)Pr}{1+(Zw/Zr)}$ = 99.67 kPa Calculated Pressure in Water at Design Criteria

PROJECT SUMMARY	Fisheries Limit	Project Design
Pressure in Water (Pw) kPa	100.0	99.67
**Peak Particle Velocity (Vr) $cm \cdot s^{-1}$	13.0	85.15

** Limit for spawning bed during period of egg incubation

PACIFIC BLASTING & DEMOLITION LTD.

SAFETY QUALITY PRODUCTIVITY

Design Criteria
for
Guidelines for the Use of Explosives in or
Near Canadian Fisheries Waters
Table No. 7
Charge Weight Calculations for a 6.0 m Setback

Table 1 - From " Canadian Technical Report of Fisheries and Aquatic Sciences 2107" , 1998
Titled - "Guidelines For the Use of Explosives In Or Near Canadian Fisheries Waters"

	Substrate	Dr ($g \cdot cm^{-3}$)	Cr ($cm \cdot s^{-1}$)	Cw ($cm \cdot s^{-1}$)	K	Dw ($g \cdot cm^{-3}$)	Pw (kPa)	PPV ($mm \cdot sec^{-1}$)
1	Rock	2.64	457200	146300	5.03	1.00	100.00	13.00
2	Frozen Soil	1.92	304800	146300	3.20	1.00	100.00	13.00
3	Ice	0.98	304800	146300	2.10	1.00	100.00	13.00
4	Saturated Soil	2.08	146300	146300	2.13	1.00	100.00	13.00
5	Unsaturated Soil	1.92	45700	146300	0.98	1.00	100.00	13.00

PROJECT DESIGN CRITERIA

Project Location: Polaris Mine - Little Cornwallis Island, Nunavut
Water Course: Crozier Strait
Substrate: Quarry Fill — Frozen Soil (Fisheries Substrate Classification)
Nature of Jointing/Fractures: N/A
Overburden: N/A
Hole Depth: 2 m
Explosive Type: Orica Powerfrac (Gelatin Dynamite)
Method of Detonation: Electric, blasting cap
Bubble Curtain Required: Yes

Table 7 - Calculations for : **Polaris Mine - Little Cornwallis Island, Nunavut**

	Project Substrate	Dr ($g \cdot cm^{-3}$)	Cr ($cm \cdot s^{-1}$)	Cw ($cm \cdot s^{-1}$)	K	Dw ($g \cdot cm^{-3}$)	Pw (kPa)	Vr ($mm \cdot sec^{-1}$)
2	Frozen Soil	1.92	304800	146300	3.2	1.00	100.00	13.00

1.66	Charge Weight (kg)	1.66	3.66 Lbs/delay
1	No. of Delays/Charge	1.0	
	Charge Weight/Delay	1.66	
6.0	Distance to Detonation	6.00	

$Zw = \frac{DwCw}{DrCr}$ = 0.2500
Zr

$Pw = \frac{2(Zw/Zr)Pr}{1+(Zw/Zr)}$

or

$Pr = \frac{Pw(1+(Zw/Zr))}{2(Zw/Zr)}$

250.0 — 2.50 kPa or — 2.50E+06 dynes - *to limit Pw to 100 kPa*

$Vr = \frac{2Pr}{DrCr}$ — 8.54 $cm \cdot s^{-1}$ - *to limit Pw to 100kPa*

$R = (w^5)(Vr/100)^{-0.626}$ — 6.0 m *Minimum setback distance required to reduce overpressure to less than 100 kPa*

$R = (w^5)(Vr/100)^{-0.626}$ — 19.4 m *Minimum setback distance from a spawning area to maintain PPV @ 13 $mm \cdot sec^{-1}$*

$Vr=100(R/W^{.5})^{-1.6}$ — 8.63 $cm \cdot s^{-1}$ Calculated PPV at Design Criteria

$Vr = \frac{2Pr}{DrCr}$

or

$Pr = (DrCrVr)/2$ — 2.50E+06 Dynes Calculated Pressure in Substrate at Design Criteria

$Pw = \frac{2(Zw/Zr)Pr}{1+(Zw/Zr)}$ — 99.86 kPa Calculated Pressure in Water at Design Criteria

PROJECT SUMMARY	Fisheries Limit	Project Design
Pressure in Water (Pw) kPa	100.0	99.86
**Peak Particle Velocity (Vr) cm•s-1	13.0	85.32

** Limit for spawning bed during period of egg incubation

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SAFETY QUALITY PRODUCTIVITY

Design Criteria
for
Guidelines for the Use of Explosives In or
Near Canadian Fisheries Waters
Table No. 8
Charge Weight Calculations for a 7.0 m Setback

Table 1 - From " Canadian Technical Report of Fisheries and Aquatic Sciences 2107" , 1996
Titled - "Guidelines For the Use of Explosives In Or Near Canadian Fisheries Waters"

	Substrate	Dr ($g \cdot cm^{-3}$)	Cr ($cm \cdot s^{-1}$)	Cw ($cm \cdot s^{-1}$)	K	Dw ($g \cdot cm^{-3}$)	Pw (kPa)	PPV ($mm \cdot sec^{-1}$)
1	Rock	2.64	457200	146300	5.03	1.00	100.00	13.00
2	Frozen Soil	1.92	304800	146300	3.20	1.00	100.00	13.00
3	Ice	0.98	304800	146300	2.10	1.00	100.00	13.00
4	Saturated Soil	2.08	146300	146300	2.13	1.00	100.00	13.00
5	Unsaturated Soil	1.92	45700	146300	0.98	1.00	100.00	13.00

PROJECT DESIGN CRITERIA

Project Location: Polaris Mine - Little Cornwallis Island, Nunavut
Water Course: Crozier Strait
Substrate: Quarry Fill — Frozen Soil (Fisheries Substrate Classification)
Nature of Jointing/Fractures: N/A
Overburden: N/A
Hole Depth: 2 m
Explosive Type: Orica Powerfrac (Gelatin Dynamite)
Method of Detonation: Electric, blasting cap
Bubble Curtain Required: Yes

Table 8 - Calculations for : **Polaris Mine - Little Cornwallis Island, Nunavut**

	Project Substrate	Dr ($g \cdot cm^{-3}$)	Cr ($cm \cdot s^{-1}$)	Cw ($cm \cdot s^{-1}$)	K	Dw ($g \cdot cm^{-3}$)	Pw (kPa)	Vr ($mm \cdot sec^{-1}$)
2	Frozen Soil	1.92	304800	146300	3.2	1.00	100.00	13.00

2.26	Charge Weight (kg)	2.26	4.98 Lbs/delay
1	No. of Delays/Charge	1.0	
	Charge Weight/Delay	2.26	
7.0	Distance to Detonation	7.00	

$Zw = \frac{DwCw}{DrCr}$ = 0.2500

$Pw = \frac{2(Zw/Zr)Pr}{1+(Zw/Zr)}$

or

$Pr = \frac{Pw(1+(Zw/Zr))}{2(Zw/Zr)}$ = 250.0 — 2.50 kPa or 2.50E+06 dynes - *to limit Pw to 100 kPa*

$Vr = \frac{2Pr}{DrCr}$ = 8.54 $cm \cdot s^{-1}$ - *to limit Pw to 100kPa*

$R = (w^{.5})(Vr/100)^{-0.625}$ = 7.0 m *Minimum setback distance required to reduce overpressure to less than 100 kPa*

$R = (w^{.5})(Vr/100)^{-0.625}$ = 22.7 m *Minimum setback distance from a spawning area to maintain PPV @ 13 $mm \cdot sec^{-1}$*

$Vr = 100(R/W^{.5})^{-1.8}$ = 8.53 $cm \cdot s^{-1}$ Calculated PPV at Design Criteria

$Vr = \frac{2Pr}{DrCr}$

or

$Pr = (DrCrVr)/2$ = 2.50E+06 Dynes Calculated Pressure in Substrate at Design Criteria

$Pw = \frac{2(Zw/Zr)Pr}{1+(Zw/Zr)}$ = 99.88 kPa Calculated Pressure in Water at Design Criteria

PROJECT SUMMARY	Fisheries Limit	Project Design
Pressure in Water (Pw) kPa	100.0	99.88
**Peak Particle Velocity (Vr) cm-s-1	13.0	85.34

** Limit for spawning bed during period of egg incubation

PACIFIC BLASTING & DEMOLITION LTD.

SAFETY QUALITY PRODUCTIVITY PROFESSIONALISM

Design Criteria
for
Guidelines for the Use of Explosives In or
Near Canadian Fisheries Waters
Table No. 9
Charge Weight Calculations for a 8.0 m Setback

Table 1 - From " Canadian Technical Report of Fisheries and Aquatic Sciences 2107" , 1998
Titled - "Guidelines For the Use of Explosives In Or Near Canadian Fisheries Waters"

	Substrate	Dr ($g \cdot cm^{-3}$)	Cr ($cm \cdot s^{-1}$)	Cw ($cm \cdot s^{-1}$)	K	Dw ($g \cdot cm^{-3}$)	Pw (kPa)	PPV ($mm \cdot sec^{-1}$)
1	Rock	2.64	457200	146300	5.03	1.00	100.00	13.00
2	Frozen Soil	1.92	304800	146300	3.20	1.00	100.00	13.00
3	Ice	0.98	304800	146300	2.10	1.00	100.00	13.00
4	Saturated Soil	2.08	146300	146300	2.13	1.00	100.00	13.00
5	Unsaturated Soil	1.92	45700	146300	0.98	1.00	100.00	13.00

PROJECT DESIGN CRITERIA

Project Location: Polaris Mine - Little Cornwallis Island, Nunavut
Water Course: Crozier Strait
Substrate: Quarry Fill — Frozen Soil (Fisheries Substrate Classification)
Nature of Jointing/Fractures: N/A
Overburden: N/A
Hole Depth: 2 m
Explosive Type: Orica Powerfrac (Gelatin Dynamite)
Method of Detonation: Electric, blasting cap
Bubble Curtain Required: Yes

Table 9 - Calculations for : **Polaris Mine - Little Cornwallis Island, Nunavut**

	Project Substrate	Dr ($g \cdot cm^{-3}$)	Cr ($cm \cdot s^{-1}$)	Cw ($cm \cdot s^{-1}$)	K	Dw ($g \cdot cm^{-3}$)	Pw (kPa)	Vr ($mm \cdot sec^{-1}$)
2	Frozen Soil	1.92	304800	146300	3.2	1.00	100.00	13.00

2.96	Charge Weight (kg)	2.96	6.53 Lbs/delay
1	No. of Delays/Charge	1.0	
	Charge Weight/Delay	2.96	
8.0	Distance to Detonation	8.00	

$Zw = \frac{DwCw}{DrCr}$ = 0.2500

$Pw = \frac{2(Zw/Zr)Pr}{1+(Zw/Zr)}$

or

$Pr = \frac{Pw(1+(Zw/Zr))}{2(Zw/Zr)}$ = 250.0 — 2.50 kPa or 2.50E+06 dynes - *to limit Pw to 100 kPa*

$Vr = \frac{2Pr}{DrCr}$ = 8.64 $cm \cdot s^{-1}$ - *to limit Pw to 100kPa*

$R = (w^{6})(Vr/100)^{-0.625}$ = 8.0 m *Minimum setback distance required to reduce overpressure to less than 100 kPa*

$R = (w^{6})(Vr/100)^{-0.625}$ = 26.0 m *Minimum setback distance from a spawning area to maintain PPV @ 13 $mm \cdot sec^{-1}$*

$Vr=100(R/W^{6})^{-1.6}$ = 8.58 $cm \cdot s^{-1}$ Calculated PPV at Design Criteria

$Vr = \frac{2Pr}{DrCr}$

or

$Pr = (DrCrVr)/2$ = 2.50E+06 Dynes Calculated Pressure in Substrate at Design Criteria

$Pw = \frac{2(Zw/Zr)Pr}{1+(Zw/Zr)}$ = 100.10 kPa Calculated Pressure in Water at Design Criteria

PROJECT SUMMARY	Fisheries Limit	Project Design
Pressure in Water (Pw) kPa	100.0	100.10
**Peak Particle Velocity (Vr) cm•s-1	13.0	85.52

** Limit for spawning bed during period of egg incubation

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SAFETY QUALITY PERFORMANCE PROFESSIONALISM

Design Criteria
for
Guidelines for the Use of Explosives In or
Near Canadian Fisheries Waters
Table No. 10
Charge Weight Calculations for a 9.0 m Setback

Table 1 - From " Canadian Technical Report of Fisheries and Aquatic Sciences 2107" , 1995
Titled - "Guidelines For the Use of Explosives In Or Near Canadian Fisheries Waters"

	Substrate	Dr ($g \cdot cm^{-3}$)	Cr ($cm \cdot s^{-1}$)	Cw ($cm \cdot s^{-1}$)	K	Dw ($g \cdot cm^{-3}$)	Pw (kPa)	PPV ($mm \cdot sec^{-1}$)
1	Rock	2.64	457200	146300	5.03	1.00	100.00	13.00
2	Frozen Soil	1.92	304800	146300	3.20	1.00	100.00	13.00
3	Ice	0.98	304800	146300	2.10	1.00	100.00	13.00
4	Saturated Soil	2.08	146300	146300	2.13	1.00	100.00	13.00
5	Unsaturated Soil	1.92	45700	146300	0.98	1.00	100.00	13.00

PROJECT DESIGN CRITERIA

Project Location: Polaris Mine - Little Cornwallis Island, Nunavut
Water Course: Crozier Strait
Substrate: Quarry Fill — Frozen Soil (Fisheries Substrate Classification)
Nature of Jointing/Fractures: N/A
Overburden: N/A
Hole Depth: 2 m
Explosive Type: Orica Powerfrac (Gelatin Dynamite)
Method of Detonation: Electric, blasting cap
Bubble Curtain Required: Yes

Table 10 - Calculations for : **Polaris Mine - Little Cornwallis Island, Nunavut**

	Project Substrate	Dr ($g \cdot cm^{-3}$)	Cr ($cm \cdot s^{-1}$)	Cw ($cm \cdot s^{-1}$)	K	Dw ($g \cdot cm^{-3}$)	Pw (kPa)	Vr ($mm \cdot sec^{-1}$)
2	Frozen Soil	1.92	304800	146300	3.2	1.00	100.00	13.00

3.74	Charge Weight (kg)	3.74	8.25 Lbs/delay
1	No. of Delays/Charge	1.0	
	Charge Weight/Delay	3.74	
9.0	Distance to Detonation	9.00	

$Zw = \frac{DwCw}{DrCr}$ = 0.2500

$Pw = \frac{2(Zw/Zr)Pr}{1+(Zw/Zr)}$

or

$Pr = \frac{Pw(1+(Zw/Zr))}{2(Zw/Zr)}$ = 250.0 — 2.50 kPa or 2.50E+06 dynes - *to limit Pw to 100 kPa*

$Vr = \frac{2Pr}{DrCr}$ = 8.54 $cm \cdot s^{-1}$ - *to limit Pw to 100kPa*

$R = (w^5)(Vr/100)^{-0.826}$ = 9.0 m *Minimum setback distance required to reduce overpressure to less than 100 kPa*

$R = (w^5)(Vr/100)^{-0.826}$ = 29.2 m *Minimum setback distance from a spawning area to maintain PPV @ 13 $mm \cdot sec^{-1}$*

$Vr=100(R/W^{.5})^{-1.6}$ = 8.54 $cm \cdot s^{-1}$ Calculated PPV at Design Criteria

$Vr = \frac{2Pr}{DrCr}$

or

$Pr = (DrCrVr)/2$ = 2.50E+06 Dynes Calculated Pressure in Substrate at Design Criteria

$Pw = \frac{2(Zw/Zr)Pr}{1+(Zw/Zr)}$ = 99.96 kPa Calculated Pressure in Water at Design Criteria

PROJECT SUMMARY	Fisheries Limit	Project Design
Pressure in Water (Pw) kPa	100.0	99.96
**Peak Particle Velocity (Vr) cm-s-1	13.0	85.41

** Limit for spawning bed during period of egg incubation

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SAFETY QUALITY PRODUCTIVITY PROFESSIONALISM

Design Criteria
for
Guidelines for the Use of Explosives in or
Near Canadian Fisheries Waters
Table No. 11
Charge Weight Calculations for a 10.0 m Setback

Table 1 - From " Canadian Technical Report of Fisheries and Aquatic Sciences 2107" , 1996
Titled - "Guidelines For the Use of Explosives In Or Near Canadian Fisheries Waters"

	Substrate	Dr ($g \cdot cm^{-3}$)	Cr ($cm \cdot s^{-1}$)	Cw ($cm \cdot s^{-1}$)	K	Dw ($g \cdot cm^{-3}$)	Pw (kPa)	PPV ($mm \cdot sec^{-1}$)
1	Rock	2.64	457200	146300	5.03	1.00	100.00	13.00
2	Frozen Soil	1.92	304800	146300	3.20	1.00	100.00	13.00
3	Ice	0.98	304800	146300	2.10	1.00	100.00	13.00
4	Saturated Soil	2.06	146300	146300	2.13	1.00	100.00	13.00
5	Unsaturated Soil	1.92	45700	146300	0.98	1.00	100.00	13.00

PROJECT DESIGN CRITERIA

Project Location: Polaris Mine - Little Cornwallis Island, Nunavut
Water Course: Crozier Strait
Substrate: Quarry Fill — Frozen Soil (Fisheries Substrate Classification)
Nature of Jointing/Fractures: N/A
Overburden: N/A
Hole Depth: 2 m
Explosive Type: Orica Powerfrac (Gelatin Dynamite)
Method of Detonation: Electric, blasting cap
Bubble Curtain Required: Yes

Table 11 - Calculations for : **Polaris Mine - Little Cornwallis Island, Nunavut**

	Project Substrate	Dr ($g \cdot cm^{-3}$)	Cr ($cm \cdot s^{-1}$)	Cw ($cm \cdot s^{-1}$)	K	Dw ($g \cdot cm^{-3}$)	Pw (kPa)	Vr ($mm \cdot sec^{-1}$)
2	Frozen Soil	1.92	304800	146300	3.2	1.00	100.00	13.00

4.62	Charge Weight (kg)	4.62	10.19 Lbs/delay
1	No. of Delays/Charge	1.0	
	Charge Weight/Delay	4.62	
10.0	Distance to Detonation	10.00	

$Zw = \frac{DwCw}{DrCr}$ = 0.2500

$Pw = \frac{2(Zw/Zr)Pr}{1+(Zw/Zr)}$

or

$Pr = \frac{Pw(1+(Zw/Zr))}{2(Zw/Zr)}$ = 250.0 — 2.50 kPa or 2.50E+06 dynes - *to limit Pw to 100 kPa*

$Vr = \frac{2Pr}{DrCr}$ = 8.54 $cm \cdot s^{-1}$ - *to limit Pw to 100kPa*

$R = (w^{.5})(Vr/100)^{-0.825}$ = 10.0 m *Minimum setback distance required to reduce overpressure to less than 100 kPa*

$R = (w^{.5})(Vr/100)^{-0.825}$ = 32.4 m *Minimum setback distance from a spawning area to maintain PPV @ 13 $mm \cdot sec^{-1}$*

$Vr=100(R/W^{.5})^{-1.5}$ = 8.55 $cm \cdot s^{-1}$ Calculated PPV at Design Criteria

$Vr = \frac{2Pr}{DrCr}$

or

$Pr = (DrCrVr)/2$ = 2.50E+06 Dynes Calculated Pressure in Substrate at Design Criteria

$Pw = \frac{2(Zw/Zr)Pr}{1+(Zw/Zr)}$ = 100.01 kPa Calculated Pressure in Water at Design Criteria

PROJECT SUMMARY	Fisheries Limit	Project Design
Pressure in Water (Pw) kPa	100.0	100.01
**Peak Particle Velocity (Vr) cm-s-1	13.0	85.45

** Limit for spawning bed during period of egg incubation

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Design Criteria
for
Guidelines for the Use of Explosives In or
Near Canadian Fisheries Waters
Table No. 12
Charge Weight Calculations for a 11.0 m Setback

Table 1 - From " Canadian Technical Report of Fisheries and Aquatic Sciences 2107" , 1995
Titled - "Guidelines For the Use of Explosives In Or Near Canadian Fisheries Waters"

	Substrate	Dr ($g \cdot cm^{-3}$)	Cr ($cm \cdot s^{-1}$)	Cw ($cm \cdot s^{-1}$)	K	Dw ($g \cdot cm^{-3}$)	Pw (kPa)	PPV ($mm \cdot sec^{-1}$)
1	Rock	2.64	457200	146300	5.03	1.00	100.00	13.00
2	Frozen Soil	1.92	304800	146300	3.20	1.00	100.00	13.00
3	Ice	0.98	304800	146300	2.10	1.00	100.00	13.00
4	Saturated Soil	2.08	146300	146300	2.13	1.00	100.00	13.00
5	Unsaturated Soil	1.92	45700	146300	0.98	1.00	100.00	13.00

PROJECT DESIGN CRITERIA

Project Location: Polaris Mine - Little Cornwallis Island, Nunavut
Water Course: Crozier Strait
Substrate: Quarry Fill — Frozen Soil (Fisheries Substrate Classification)
Nature of Jointing/Fractures: N/A
Overburden: N/A
Hole Depth: 2 m
Explosive Type: Orica Powerfrac (Gelatin Dynamite)
Method of Detonation: Electric, blasting cap
Bubble Curtain Required: Yes

Table 12 - Calculations for : Polaris Mine - Little Cornwallis Island, Nunavut

	Project Substrate	Dr ($g \cdot cm^{-3}$)	Cr ($cm \cdot s^{-1}$)	Cw ($cm \cdot s^{-1}$)	K	Dw ($g \cdot cm^{-3}$)	Pw (kPa)	Vr ($mm \cdot sec^{-1}$)
2	Frozen Soil	1.92	304800	146300	3.2	1.00	100.00	13.00

5.59	Charge Weight (kg)	5.59	12.32 Lbs/delay
1	No. of Delays/Charge	1.0	
	Charge Weight/Delay	5.59	
11.0	Distance to Detonation	11.00	

$Zw = \frac{DwCw}{DrCr}$ = 0.2500

$Pw = \frac{2(Zw/Zr)Pr}{1+(Zw/Zr)}$

or

$Pr = \frac{Pw(1+(Zw/Zr))}{2(Zw/Zr)}$ = 250.0 — 2.50 kPa or 2.50E+06 dynes - *to limit Pw to 100 kPa*

$Vr = \frac{2Pr}{DrCr}$ = 8.54 $cm \cdot s^{-1}$ - *to limit Pw to 100kPa*

$R = (w^5)(Vr/100)^{-0.626}$ = 11.0 m *Minimum setback distance required to reduce overpressure to less than 100 kPa*

$R = (w^5)(Vr/100)^{-0.626}$ = 36.7 m *Minimum setback distance from a spawning area to maintain PPV @ 13 $mm \cdot sec^{-1}$*

$Vr=100(R/W^5)^{-1.6}$ = 8.54 $cm \cdot s^{-1}$ Calculated PPV at Design Criteria

$Vr = \frac{2Pr}{DrCr}$

or

$Pr = (DrCrVr)/2$ = 2.50E+06 Dynes Calculated Pressure in Substrate at Design Criteria

$Pw = \frac{2(Zw/Zr)Pr}{1+(Zw/Zr)}$ = 100.01 kPa Calculated Pressure in Water at Design Criteria

PROJECT SUMMARY	Fisheries Limit	Project Design
Pressure in Water (Pw) kPa	100.0	100.01
**Peak Particle Velocity (Vr) cm•s-1	13.0	85.45

** Limit for spawning bed during period of egg incubation

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SAFETY QUALITY PRODUCTIVITY PROFESSIONALISM

Design Criteria
for
Guidelines for the Use of Explosives in or
Near Canadian Fisheries Waters
Table No. 13
Charge Weight Calculations for a 12.0 m Setback

Table 1 - From " Canadian Technical Report of Fisheries and Aquatic Sciences 2107" , 1996
Titled - "Guidelines For the Use of Explosives In Or Near Canadian Fisheries Waters"

	Substrate	Dr (g•cm^{-3})	Cr (cm•s^{-1})	Cw (cm•s^{-1})	K	Dw (g•cm^{-3})	Pw (kPa)	PPV (mm•sec^{-1})
1	Rock	2.64	457200	146300	5.03	1.00	100.00	13.00
2	Frozen Soil	1.92	304800	146300	3.20	1.00	100.00	13.00
3	Ice	0.98	304800	146300	2.10	1.00	100.00	13.00
4	Saturated Soil	2.08	146300	146300	2.13	1.00	100.00	13.00
5	Unsaturated Soil	1.92	45700	146300	0.98	1.00	100.00	13.00

PROJECT DESIGN CRITERIA

Project Location: Polaris Mine - Little Cornwallis Island, Nunavut
Water Course: Crozier Strait
Substrate: Quarry Fill — Frozen Soil (Fisheries Substrate Classification)
Nature of Jointing/Fractures: N/A
Overburden: N/A
Hole Depth: 2 m
Explosive Type: Orica Powerfrac (Gelatin Dynamite)
Method of Detonation: Electric, blasting cap
Bubble Curtain Required: Yes

Table 13 - Calculations for : **Polaris Mine - Little Cornwallis Island, Nunavut**

	Project Substrate	Dr (g•cm^{-3})	Cr (cm•s^{-1})	Cw (cm•s^{-1})	K	Dw (g•cm^{-3})	Pw (kPa)	Vr (mm•sec^{-1})
2	Frozen Soil	1.92	304800	146300	3.2	1.00	100.00	13.00

6.65	Charge Weight (kg)	6.65	14.66 Lbs/delay
1	No. of Delays/Charge	1.0	
	Charge Weight/Delay	6.65	
12.0	Distance to Detonation	12.00	

$Zw = \frac{DwCw}{DrCr}$ = 0.2500 / Zr

$Pw = \frac{2(Zw/Zr)Pr}{1+(Zw/Zr)}$ or $Pr = \frac{Pw(1+(Zw/Zr))}{2(Zw/Zr)}$ = 250.0 — 2.50 kPa or 2.50E+06 dynes - *to limit Pw to 100 kPa*

$Vr = \frac{2Pr}{DrCr}$ = 8.54 cm•s^{-1} - *to limit Pw to 100kPa*

$R = (w^5)(Vr/100)^{-0.826}$ = 12.0 m *Minimum setback distance required to reduce overpressure to less than 100 kPa*

$R = (w^5)(Vr/100)^{-0.826}$ = 38.9 m *Minimum setback distance from a spawning area to maintain PPV @ 13 mm•sec^{-1}*

$Vr=100(R/W^{.5})^{-1.5}$ = 8.54 cm•s^{-1} Calculated PPV at Design Criteria

$Vr = \frac{2Pr}{DrCr}$ or $Pr = (DrCrVr)/2$ = 2.50E+06 Dynes Calculated Pressure in Substrate at Design Criteria

$Pw = \frac{2(Zw/Zr)Pr}{1+(Zw/Zr)}$ = 99.98 kPa Calculated Pressure in Water at Design Criteria

PROJECT SUMMARY	Fisheries Limit	Project Design
Pressure in Water (Pw) kPa	100.0	99.98
**Peak Particle Velocity (Vr) cm•s-1	13.0	85.42

** Limit for spawning bed during period of egg incubation

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SAFETY QUALITY PRODUCTIVITY PROFESSIONALISM

Design Criteria
for
Guidelines for the Use of Explosives In or
Near Canadian Fisheries Waters
Table No. 14
Charge Weight Calculations for a 13.0 m Setback

Table 1 - From " Canadian Technical Report of Fisheries and Aquatic Sciences 2107" , 1998
Titled - "Guidelines For the Use of Explosives In Or Near Canadian Fisheries Waters"

	Substrate	Dr ($g \cdot cm^{-3}$)	Cr ($cm \cdot s^{-1}$)	Cw ($cm \cdot s^{-1}$)	K	Dw ($g \cdot cm^{-3}$)	Pw (kPa)	PPV ($mm \cdot sec^{-1}$)
1	Rock	2.64	457200	146300	5.03	1.00	100.00	13.00
2	Frozen Soil	1.92	304800	146300	3.20	1.00	100.00	13.00
3	Ice	0.98	304800	146300	2.10	1.00	100.00	13.00
4	Saturated Soil	2.06	146300	146300	2.13	1.00	100.00	13.00
5	Unsaturated Soil	1.92	45700	146300	0.98	1.00	100.00	13.00

PROJECT DESIGN CRITERIA

Project Location: Polaris Mine - Little Cornwallis Island, Nunavut
Water Course: Crozier Strait
Substrate: Quarry Fill — Frozen Soil (Fisheries Substrate Classification)
Nature of Jointing/Fractures: N/A
Overburden: N/A
Hole Depth: 2 m
Explosive Type: Orica Powerfrac (Gelatin Dynamite)
Method of Detonation: Electric, blasting cap
Bubble Curtain Required: Yes

Table 14 - Calculations for : **Polaris Mine - Little Cornwallis Island, Nunavut**

	Project Substrate	Dr ($g \cdot cm^{-3}$)	Cr ($cm \cdot s^{-1}$)	Cw ($cm \cdot s^{-1}$)	K	Dw ($g \cdot cm^{-3}$)	Pw (kPa)	Vr ($mm \cdot sec^{-1}$)
2	Frozen Soil	1.92	304800	146300	3.2	1.00	100.00	13.00

7.81	Charge Weight (kg)	7.81	17.22 Lbs/delay
1	No. of Delays/Charge	1.0	
	Charge Weight/Delay	7.81	
13.0	Distance to Detonation	13.00	

$Zw = \frac{DwCw}{DrCr}$ = 0.2500

$Pw = \frac{2(Zw/Zr)Pr}{1+(Zw/Zr)}$

or

$Pr = \frac{Pw(1+(Zw/Zr))}{2(Zw/Zr)}$ = 250.0 — 2.50 kPa or — 2.50E+06 dynes - *to limit Pw to 100 kPa*

$Vr = \frac{2Pr}{DrCr}$ = 8.64 $cm \cdot s^{-1}$ - *to limit Pw to 100kPa*

$R = (w^{5})(Vr/100)^{-0.625}$ = 13.0 m *Minimum setback distance required to reduce overpressure to less than 100 kPa*

$R = (w^{5})(Vr/100)^{-0.625}$ = 42.2 m *Minimum setback distance from a spawning area to maintain PPV @ 13 $mm \cdot sec^{-1}$*

$Vr = 100(R/W^{5})^{-1.8}$ = 8.55 $cm \cdot s^{-1}$ Calculated PPV at Design Criteria

$Vr = \frac{2Pr}{DrCr}$

or

$Pr = (DrCrVr)/2$ = 2.50E+06 Dynes Calculated Pressure in Substrate at Design Criteria

$Pw = \frac{2(Zw/Zr)Pr}{1+(Zw/Zr)}$ = 100.03 kPa Calculated Pressure in Water at Design Criteria

PROJECT SUMMARY	Fisheries Limit	Project Design
Pressure in Water (Pw) kPa	100.0	100.03
**Peak Particle Velocity (Vr) cm-s-1	13.0	85.47

** Limit for spawning bed during period of egg incubation

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Design Criteria
for
Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters
Table No. 15
Charge Weight Calculations for a 14.0 m Setback

Table 1 - From " Canadian Technical Report of Fisheries and Aquatic Sciences 2107" , 1998
Titled - "Guidelines For the Use of Explosives In Or Near Canadian Fisheries Waters"

	Substrate	Dr ($g \cdot cm^{-3}$)	Cr ($cm \cdot s^{-1}$)	Cw ($cm \cdot s^{-1}$)	K	Dw ($g \cdot cm^{-3}$)	Pw (kPa)	PPV ($mm \cdot sec^{-1}$)
1	Rock	2.64	457200	146300	5.03	1.00	100.00	13.00
2	Frozen Soil	1.92	304800	146300	3.20	1.00	100.00	13.00
3	Ice	0.96	304800	146300	2.10	1.00	100.00	13.00
4	Saturated Soil	2.08	146300	146300	2.13	1.00	100.00	13.00
5	Unsaturated Soil	1.92	45700	146300	0.98	1.00	100.00	13.00

PROJECT DESIGN CRITERIA

Project Location: Polaris Mine - Little Cornwallis Island, Nunavut
Water Course: Crozier Strait
Substrate: Quarry Fill — Frozen Soil (Fisheries Substrate Classification)
Nature of Jointing/Fractures: N/A
Overburden: N/A
Hole Depth: 2 m
Explosive Type: Orica Powerfrac (Gelatin Dynamite)
Method of Detonation: Electric, blasting cap
Bubble Curtain Required: Yes

Table 15 - Calculations for : **Polaris Mine - Little Cornwallis Island, Nunavut**

	Project Substrate	Dr ($g \cdot cm^{-3}$)	Cr ($cm \cdot s^{-1}$)	Cw ($cm \cdot s^{-1}$)	K	Dw ($g \cdot cm^{-3}$)	Pw (kPa)	Vr ($mm \cdot sec^{-1}$)
2	Frozen Soil	1.92	304800	146300	3.2	1.00	100.00	13.00

9.05	Charge Weight (kg)	9.05	19.95 Lbs/delay
1	No. of Delays/Charge	1.0	
	Charge Weight/Delay	9.05	
14.0	Distance to Detonation	14.00	

$Zw = \frac{DwCw}{DrCr}$ = 0.2500 / Zr

$Pw = \frac{2(Zw/Zr)Pr}{1+(Zw/Zr)}$

or

$Pr = \frac{Pw(1+(Zw/Zr))}{2(Zw/Zr)}$ = 250.0 — 2.50 kPa or 2.50E+06 dynes - *to limit Pw to 100 kPa*

$Vr = \frac{2Pr}{DrCr}$ = 8.54 $cm \cdot s^{-1}$ - *to limit Pw to 100kPa*

$R = (w^{5})(Vr/100)^{-0.625}$ = 14.0 m *Minimum setback distance required to reduce overpressure to less than 100 kPa*

$R = (w^{5})(Vr/100)^{-0.625}$ = 45.4 m *Minimum setback distance from a spawning area to maintain PPV @ 13 $mm \cdot sec^{-1}$*

$Vr = 100(R/W^{.5})^{-1.5}$ = 8.54 $cm \cdot s^{-1}$ Calculated PPV at Design Criteria

$Vr = \frac{2Pr}{DrCr}$

or

$Pr = (DrCrVr)/2$ = 2.50E+06 Dynes Calculated Pressure in Substrate at Design Criteria

$Pw = \frac{2(Zw/Zr)Pr}{1+(Zw/Zr)}$ = 99.97 kPa Calculated Pressure in Water at Design Criteria

PROJECT SUMMARY	Fisheries Limit	Project Design
Pressure in Water (Pw) kPa	100.0	99.97
**Peak Particle Velocity (Vr) cm-s-1	13.0	85.41

** Limit for spawning bed during period of egg incubation

APPENDIX I

Thermistor Data

TABLE 1: Dock Thermistor Readings – August 16, 1990 (Readings in Degrees Celsius)

Cable Location		South Cell West Edge	South Cell Centre	North Cell West Edge	North Cell North Edge
Plug No.	**Depth (m)**	**507**	**510**	**488**	**418**
1	1.5	-0.6	-1.9	+1.6	-1.6
2	2.5	-2.0	-4.0	-0.8	-3.0
3	3.5	-2.8	-5.5	-2.0	-4.3
4	4.5	-2.9	-6.7	-2.8	-5.0
5	5.5	-2.9	-7.3	-3.0	-5.4
6	6.5	-2.9	-7.6	-3.1	-5.4
7	9.25	-2.8	-5.7	-3.2	-5.5
8	12.0	-2.8	-6.9	-2.8	-4.4
9	14.75	-3.0	-5.6	-2.9	-4.3
10	17.5	-2.6	-5.0	-2.8	-3.7

TABLE 2: Dock Thermistor Readings (Thermistor Located in Centre of South Cell of the Dock Freezing Unit, not in Operation. Temperature in Degrees Celsius)

Date	Depth (m)									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
January 1985	-20.3	-15.3	-9.4	-6.1	-3.8	-2.7	-2.3	-2.1	-2.1	-2.1
June 1985	-7.5	-9.7	-10.2	-9.8	-9.2	-7.9	-4.0	-5.4	-3.4	-2.6
July 1985	-3.2	-5.7	-7.5	-7.8	-7.8	-7.3	-4.0	-5.4	-4.0	-3.4
May 1986	-17.1	-16.8	-15.3	-13.2	-11.6	-9.7	-5.1	-6.9	-5.2	-4.3
December 1986	-16.8	-12.7	-10.2	-7.5	-6.7	-5.7	-5.0	-5.0	-4.4	-4.0
June 1987	-9.5	-11.1	-11.9	-11.6	-11.0	-10.0	-5.6	-7.6	-5.6	-4.7
July 1987	-5.0	-7.1	-8.7	-9.4	-9.6	N/A	N/A	-7.4	N/A	-4.7
August 1987	-2.0	-4.5	-6.5	-7.4	-7.8	-7.8	-5.4	-6.0	-5.5	-4.6
September 1987	-1.6	-3.5	-5.0	-5.9	-6.7	-6.9	-5.2	-6.5	-5.2	-4.5
October 1987	-2.3	-3.1	-4.3	-5.0	-5.7	-6.1	-5.0	-5.8	-5.0	-4.4
November 1987	-7.5	-5.1	-4.4	-4.8	-5.2	-5.5	-4.8	-5.5	-4.9	-4.3