

TECK COMINCO LTD.
Decommissioning of Dock Facilities at Polaris Mine
Little Cornwallis Island, Nunavut

APPENDIX H

Preliminary General Blast Design

REVISION 1

Westmar

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 curtains 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 Cell Dock**

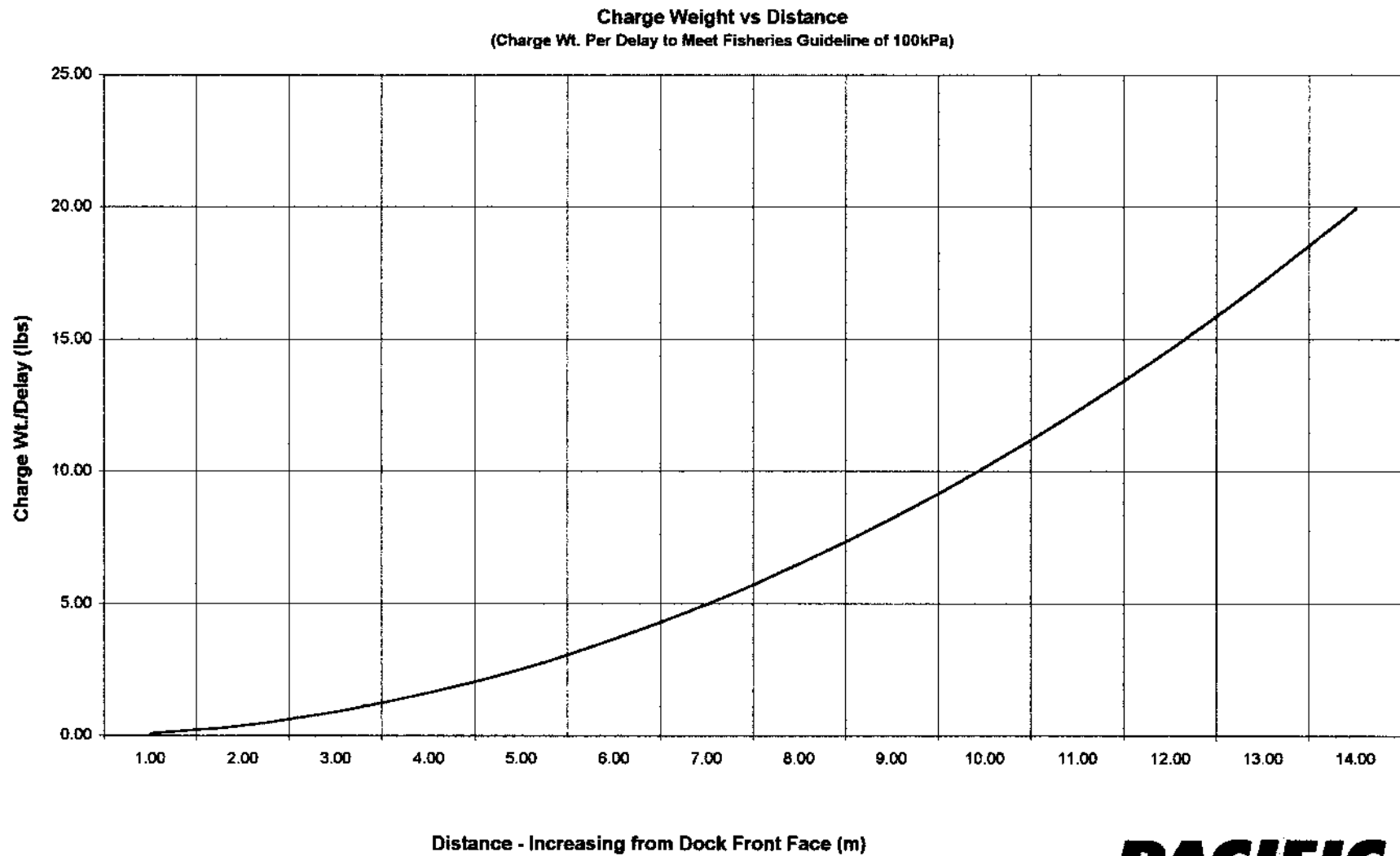
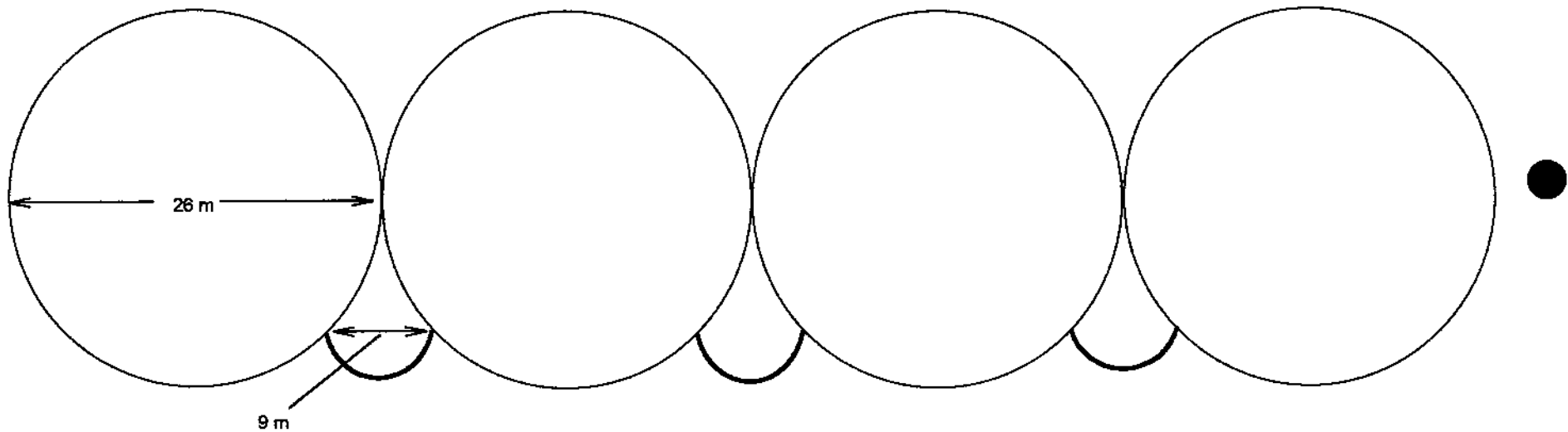


Figure 1

PACIFIC
BLASTING & DEMOLITION LTD.

Polaris Mine Decommissioning Sheet Pile Cell Dock

Cell Layout



		TOTAL	
Volume per Cell	3716.5	14866	cu.m
Volume per Tie Cell	445	1336	cu.m
TOTAL Cell Volume		16202	cu.m
Volume beyond Cells		12500	cu.m
TOTAL VOLUME		28702	cu.m
Powder Factor	1.2		kg/bcm
Explosives Required		34442	kg

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Figure 2

Polaris Mine Decommissioning Sheet Pile Dock

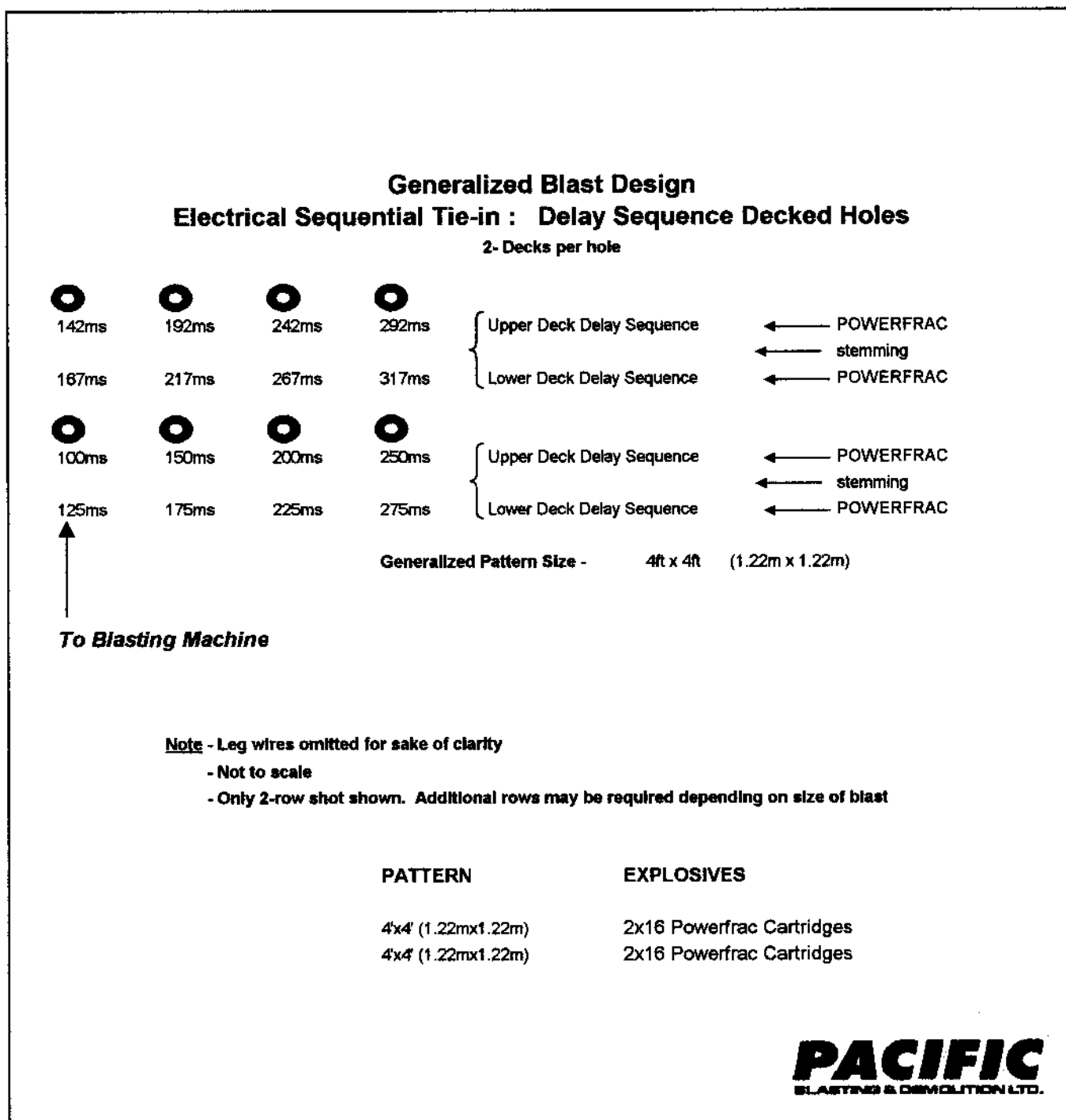


Figure 3

**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·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 2 - 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
0.06	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						
	$Zw = \frac{DwCr}{DrCr}$	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	2.60E+06 dynes - to limit Pw to 100 kPa			
	$Vr = \frac{2Pr}{DrCr}$	8.64 cm·s ⁻¹ - to limit Pw to 100kPa						
	$R = (w^5)(Vr/100)^{-0.826}$	1.0 m Minimum setback distance required to reduce overpressure to less than 100 kPa						
	$R = (w^5)(Vr/100)^{-0.826}$	3.4 m Minimum setback distance from a spawning area to maintain PPV @ 13 mm·sec ⁻¹						
	$Vr = 100(R/W^5)^{-1.8}$	9.10 cm·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						
	$Pw = \frac{2(Zw/Zr)Pr}{1+(Zw/Zr)}$	106.64 kPa	Calculated Pressure in Water at Design Criteria					

PROJECT SUMMARY	Fisheries Limit	Project Design
Pressure in Water (Pw) kPa	100.0	106.64
Peak Particle Velocity (Vr) cm·s ⁻¹	13.0	91.03

** Limit for spawning bed during period of egg incubation

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·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: Orca 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·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
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						
	$Zw = DwCr$	0.2500						
	$Zr = DrCr$							
	$Pw = \frac{2(ZwZr)Pr}{1+(ZwZr)}$							
	or							
	$Pr = \frac{Pw(1+(ZwZr))}{2(ZwZr)}$	250.0	2.50 kPa	or	2.60E+06 dynes - to limit Pw to 100 kPa			
	$Vr = \frac{2Pr}{DrCr}$	8.64 cm·s ⁻¹ - to limit Pw to 100kPa						
	$R = (w^{\frac{1}{3}})(Vr/100)^{-0.825}$	2.0 m Minimum setback distance required to reduce overpressure to less than 100 kPa						
	$R = (w^{\frac{1}{3}})(Vr/100)^{-0.825}$	6.4 m Minimum setback distance from a spawning area to maintain PPV @ 13 mm·sec ⁻¹						
	$Vr=100(R/W^{\frac{1}{3}})^{1.6}$	8.37 cm·s ⁻¹ Calculated PPV at Design Criteria						
	$Vr = \frac{2Pr}{DrCr}$							
	or							
	$Pr = (DrCrVr)/2$	2.46E+06 Dynes Calculated Pressure in Substrate at Design Criteria						
	$Pw = \frac{2(ZwZr)Pr}{1+(ZwZr)}$							
		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	83.87

** Limit for spawning bed during period of egg incubation

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·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 4 - 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
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						
	$Zw = \frac{Dw \cdot Cw}{Dr \cdot Cr}$	0.2500						
	$Pw = \frac{2(Zw \cdot Zr)Pr}{1+(Zw/Zr)}$ 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			
	$Vr = \frac{2Pr}{Dr \cdot Cr}$	8.64 cm·s ⁻¹ - to limit Pw to 100kPa						
	$R = (w^5)(Vr/100)^{-0.825}$	3.0 m Minimum setback distance required to reduce overpressure to less than 100 kPa						
	$R = (w^5)(Vr/100)^{-0.825}$	9.8 m Minimum setback distance from a spawning area to maintain PPV @ 13 mm·sec ⁻¹						
	$Vr = 100(R/W^5)^{-1.8}$	8.61 cm·s ⁻¹ Calculated PPV at Design Criteria						
	$Vr = \frac{2Pr}{Dr \cdot Cr}$ or $Pr = (Dr \cdot Cr \cdot Vr)/2$	2.62E+06 Dynes Calculated Pressure in Substrate at Design Criteria						
	$Pw = \frac{2(Zw \cdot Zr)Pr}{1+(Zw/Zr)}$	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

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", 1998
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	2.84	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 5 - 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
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						
	$Z_w = \frac{D_w C_w}{Z_r}$	0.2500						
	$P_w = \frac{2(Z_w Z_r) P_r}{1 + (Z_w Z_r)}$ or $P_r = \frac{P_w (1 + (Z_w Z_r))}{2(Z_w Z_r)}$	250.0	2.50 kPa	or	2.50E+06 dynes - to limit Pw to 100 kPa			
	$V_r = \frac{2 P_r}{D_r C_r}$	8.54 cm·s ⁻¹ - to limit Pw to 100kPa						
	$R = (w^5)(V_r/100)^{-0.625}$	4.0 m Minimum setback distance required to reduce overpressure to less than 100 kPa						
	$R = (w^5)(V_r/100)^{-0.625}$	13.0 m Minimum setback distance from a spawning area to maintain PPV @ 13 mm·sec ⁻¹						
	$V_r = 100(R/W^5)^{1.4}$	8.55 cm·s ⁻¹ Calculated PPV at Design Criteria						
	$V_r = \frac{2 P_r}{D_r C_r}$ or $P_r = (D_r C_r V_r)/2$	2.50E+06 Dynes Calculated Pressure in Substrate at Design Criteria						
	$P_w = \frac{2(Z_w Z_r) P_r}{1 + (Z_w Z_r)}$	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

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·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 6 - 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
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						
	$Z_w = \frac{D_w C_w}{D_r C_r}$	0.2500						
	$P_w = \frac{2(Z_w Z_r) P_r}{1 + (Z_w Z_r)}$ or $P_r = \frac{P_w (1 + (Z_w Z_r))}{2(Z_w Z_r)}$	250.0	2.50 kPa	or	2.50E+06 dynes - to limit Pw to 100 kPa			
	$V_r = \frac{2 P_r}{D_r C_r}$	8.54 cm·s ⁻¹ - to limit Pw to 100kPa						
	$R = (w^5)(V_r/100)^{-0.825}$	5.0 m Minimum setback distance required to reduce overpressure to less than 100 kPa						
	$R = (w^5)(V_r/100)^{-0.825}$	16.2 m Minimum setback distance from a spawning area to maintain PPV @ 13 mm·sec ⁻¹						
	$V_r = 100(R/W^5)^{-1.8}$	8.52 cm·s ⁻¹ Calculated PPV at Design Criteria						
	$V_r = \frac{2 P_r}{D_r C_r}$ or $P_r = (D_r C_r V_r)/2$	2.49E+06 Dynes Calculated Pressure in Substrate at Design Criteria						
	$P_w = \frac{2(Z_w Z_r) P_r}{1 + (Z_w Z_r)}$	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·s ⁻¹	13.0	85.15

** Limit for spawning bed during period of egg incubation

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·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: Orca 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·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
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						
	$Z_w = \frac{D_w C_w}{Z_r}$	0.2500						
	Z_r	DrCr						
	$P_w = \frac{2(Z_w Z_r) P_r}{1+(Z_w/Z_r)}$ or $P_r = \frac{P_w(1+(Z_w/Z_r))}{2(Z_w/Z_r)}$	250.0	2.50 kPa	or	2.60E+06 dynes - to limit Pw to 100 kPa			
	$V_r = \frac{2P_r}{D_r C_r}$	8.64 cm·s ⁻¹ - to limit Pw to 100kPa						
	$R = (w^6)(V_r/100)^{0.826}$	6.0 m Minimum setback distance required to reduce overpressure to less than 100 kPa						
	$R = (w^6)(V_r/100)^{0.826}$	19.4 m Minimum setback distance from a spawning area to maintain PPV @ 13 mm·sec ⁻¹						
	$V_r = 100(R/W^{0.5-1.8})$	8.53 cm·s ⁻¹ Calculated PPV at Design Criteria						
	$V_r = \frac{2P_r}{D_r C_r}$ or $P_r = (D_r C_r V_r)/2$	2.60E+06 Dynes Calculated Pressure in Substrate at Design Criteria						
	$P_w = \frac{2(Z_w Z_r) P_r}{1+(Z_w/Z_r)}$	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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Table No. 8

Charge Weight Calculations for a 7.0 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-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 8 - 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
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						
	$Z_w = \frac{D_w C_w}{D_r C_r}$	0.2500						
	$P_w = \frac{2(Z_w Z_r) P_r}{1 + (Z_w Z_r)}$ or $P_r = \frac{P_w (1 + (Z_w Z_r))}{2(Z_w Z_r)}$	250.0	2.50 kPa	or	2.50E+08 dynes	- to limit Pw to 100 kPa		
	$V_r = \frac{2 P_r}{D_r C_r}$	8.54 cm·s ⁻¹ - to limit Pw to 100kPa						
	$R = (w^5) (V_r / 100)^{-0.825}$	7.0 m Minimum setback distance required to reduce overpressure to less than 100 kPa						
	$R = (w^5) (V_r / 100)^{-0.825}$	22.7 m Minimum setback distance from a spawning area to maintain PPV @ 13 mm·sec ⁻¹						
	$V_r = 100 (R / W^5)^{-1.5}$	8.53 cm·s ⁻¹ Calculated PPV at Design Criteria						
	$V_r = \frac{2 P_r}{D_r C_r}$ or $P_r = (D_r C_r V_r) / 2$	2.50E+06 Dynes Calculated Pressure in Substrate at Design Criteria						
	$P_w = \frac{2(Z_w Z_r) P_r}{1 + (Z_w Z_r)}$	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

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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·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 9 - 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
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						
	$Z_w = \frac{D_w C_w}{D_r C_r}$	0.2500						
	$P_w = \frac{2(Z_w Z_r) P_r}{1 + (Z_w Z_r)}$ or $P_r = \frac{P_w (1 + (Z_w Z_r))}{2(Z_w Z_r)}$	250.0	2.50 kPa	or	2.50E+06 dynes - to limit Pw to 100 kPa			
	$V_r = \frac{2 P_r}{D_r C_r}$	8.54 cm·s ⁻¹ - to limit Pw to 100kPa						
	$R = (w^5)(V_r/100)^{-0.825}$	8.0 m Minimum setback distance required to reduce overpressure to less than 100 kPa						
	$R = (w^5)(V_r/100)^{-0.825}$	26.0 m Minimum setback distance from a spawning area to maintain PPV @ 13 mm·sec ⁻¹						
	$V_r = 100(R/W^{0.16})$	8.55 cm·s ⁻¹ Calculated PPV at Design Criteria						
	$V_r = \frac{2 P_r}{D_r C_r}$ or $P_r = (D_r C_r V_r)/2$	2.50E+06 Dynes Calculated Pressure in Substrate at Design Criteria						
	$P_w = \frac{2(Z_w Z_r) P_r}{1 + (Z_w Z_r)}$	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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Table No. 10
Charge Weight Calculations for a 9.0 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·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 10 - 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
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 = DwCw Zr DrCr	0.2500						
	Pw = $\frac{2(ZwZr)Pr}{1+(Zw/Zr)}$ 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·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·sec ⁻¹						
	Vr=100(R/W ⁵) ^{1.5}	8.64 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 = $\frac{2(ZwZr)Pr}{1+(Zw/Zr)}$	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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Table No. 11

Charge Weight Calculations for a 10.0 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-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 11 - 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
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						
	$Zw = \frac{DwCw}{Zr DrCr}$	0.2500						
	$Pw = \frac{2(ZwZr)Pr}{1+(Zw/Zr)}$ or $Pr = \frac{Pw(1+(Zw/Zr))}{2(Zw/Zr)}$	250.0	2.50 kPa	or	2.60E+06 dynes	- to limit Pw to 100 kPa		
	$Vr = \frac{2Pr}{DrCr}$	8.54 cm·s ⁻¹ - to limit Pw to 100kPa						
	$R = (w^{\frac{1}{3}})(Vr/100)^{-0.826}$	10.0 m Minimum setback distance required to reduce overpressure to less than 100 kPa						
	$R = (w^{\frac{1}{3}})(Vr/100)^{-0.826}$	32.4 m Minimum setback distance from a spawning area to maintain PPV @ 13 mm·sec ⁻¹						
	$Vr = 100(R/W^{\frac{1}{3}})^{-1.8}$	8.55 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						
	$Pw = \frac{2(ZwZr)Pr}{1+(Zw/Zr)}$	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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Table No. 12

Charge Weight Calculations for a 11.0 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·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 Powerpac (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·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
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						
	$Z_w = \frac{D_w C_w}{D_r C_r}$	0.2500						
	$P_w = \frac{2(Z_w/Z_r)P_r}{1+(Z_w/Z_r)}$ or $P_r = \frac{P_w(1+(Z_w/Z_r))}{2(Z_w/Z_r)}$	250.0	2.50 kPa	or	2.50E+08 dynes - to limit Pw to 100 kPa			
	$V_r = \frac{2P_r}{D_r C_r}$	8.64 cm·s ⁻¹	- to limit Pw to 100kPa					
	$R = (w^{0.5})(V_r/100)^{-0.825}$	11.0 m	Minimum setback distance required to reduce overpressure to less than 100 kPa					
	$R = (w^{0.5})(V_r/100)^{-0.825}$	38.7 m	Minimum setback distance from a spawning area to maintain PPV @ 13 mm·sec ⁻¹					
	$V_r = 100(R/W^{0.5})^{1.8}$	8.64 cm·s ⁻¹	Calculated PPV at Design Criteria					
	$V_r = \frac{2P_r}{D_r C_r}$ or $P_r = (D_r C_r V_r)/2$	2.50E+08 Dynes	Calculated Pressure in Substrate at Design Criteria					
	$P_w = \frac{2(Z_w/Z_r)P_r}{1+(Z_w/Z_r)}$	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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Table No. 13
Charge Weight Calculations for a 12.0 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·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						
	$Zr = \frac{DrCr}{DwCw}$							
	$Pw = \frac{2(ZwZr)Pr}{1+(ZwZr)}$ or $Pr = \frac{Pw(1+(ZwZr))}{2(ZwZr)}$	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						
	$Vr = 100(R/W^5)^{1.6}$	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						
	$Pw = \frac{2(ZwZr)Pr}{1+(ZwZr)}$	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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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·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: Orca 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·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
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 = DwCw Zr = DrCr	0.2500						
	Pw = $\frac{2(ZwZr)Pr}{1+(Zw/Zr)}$ or Pr = $\frac{Pw(1+(Zw/Zr))}{2(Zw/Zr)}$	250.0	2.50 kPa	or	2.50E+08 dynes - to limit Pw to 100 kPa			
	Vr = $\frac{2Pr}{DrCr}$	8.54 cm·s ⁻¹	- to limit Pw to 100kPa					
	R = $(w^5)(Vr/100)^{-0.825}$	13.0 m	Minimum setback distance required to reduce overpressure to less than 100 kPa					
	R = $(w^5)(Vr/100)^{-0.825}$	42.2 m	Minimum setback distance from a spawning area to maintain PPV @ 13 mm·sec ⁻¹					
	Vr = $100(R/W^5)^{-1.8}$	8.55 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 = $\frac{2(ZwZr)Pr}{1+(Zw/Zr)}$	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

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·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: Orca 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·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
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						
$Pw = \frac{2(ZwZr)Pr}{1+(Zw/Zr)}$ 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					
$R = (w^5)(Vr/100)^{0.825}$	14.0 m	Minimum setback distance required to reduce overpressure to less than 100 kPa					
$R = (w^5)(Vr/100)^{0.825}$	45.4 m	Minimum setback distance from a spawning area to maintain PPV @ 13 mm·sec ⁻¹					
$Vr = 100/(RW^{0.5})^{1.8}$	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					
$Pw = \frac{2(ZwZr)Pr}{1+(Zw/Zr)}$	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