FLYROCK BACKGROUNDER

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WHAT IS FLYROCK?

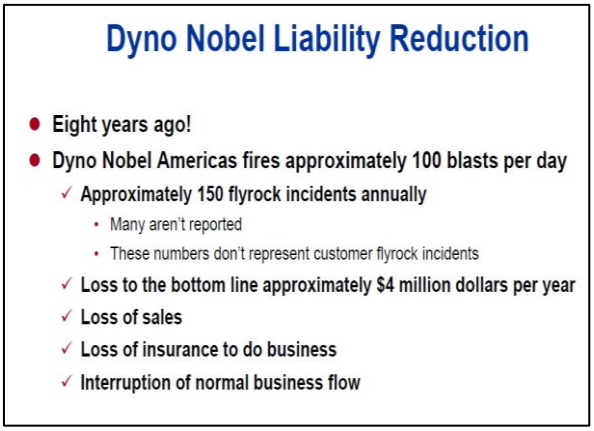
Flyrock in open pit mines such as quarries is the unintended propulsion of rocks through the air as a result of blasting. The risk to the public (as opposed to the operators) arises when their trajectory ends beyond the confines of the operating site. As determined by the Supreme Court of Canada (*Castonguay Blasting Ltd. v. Ontario (Environment*)), under the Ontario EPA, any flyrock discharge that results in adverse effects on the natural environment is regarded as discharge of a contaminant, and is forbidden by Provincial Law. There are recorded incidents of flyrock being thrown up to 1300 m but normally (reportedly 90% of the time) flyrock falls within a radius of 500 m.

Flyrock is generally caused by natural variations in the geology and particularly by imperfections such as faults, cavities, fractures, water passage opening, clay seams, etc. It can also be the consequence of human error through overloading with explosive and mistakes in blast design. Of particular concern in the Hidden Quarry case is the nature of weathering which has occurred in the top 5 to 10 m, and possibly greater depth, of the rock formation, as demonstrated in the borehole logs. This part of the rock formation can be loosely described as having a very porous and crumbly texture (like "Swiss cheese"), known technically as "karst". The characteristics of this layer of rock have been caused by weathering and leaching by surface waters percolating through the overburden. This unstable geological condition provides the natural variations and imperfections that can lead to the generation of flyrock.

Flyrock from the bench top, as opposed to the bench face—which in the case of the Hidden Quarry is proposed to be partially submerged—is the concern. Bench top flyrock occurs in two ways, cratering, which as the name implies involves an area around the bore hole being ejected at a less than vertical trajectory, and stemming, or "rifling" which is ejection upwards through the borehole.

WHAT IS THE FLYROCK RISK?

The probability of flyrock being ejected from a site is low, but it is not zero. The international blasting contractor, Dyno Nobel Americas, experiences an average of approximately 150 flyrock incidents annually which roughly translates into a probability of 0.6%, clearly a small number, although a lot higher than your chances of winning the lottery.



But **Probability** is not the only determinant of **Risk**. A working definition of Risk is **the probability of something happening x the consequences if it does**. For flyrock, this product is low probability x very large, potentially catastrophic consequences, meaning that **the risk cannot be ignored**.

A North American study of 412 lethal and non-lethal accidents in 2001 found that 27.7 per cent of these accidents were caused by flyrock outside the exclusion zone. A 2007 study reported that blasting related accidents had claimed the lives of more than a thousand people around the world since the turn of the Millennium. Most of these accidents were due to flyrock and an inadequate blast exclusion zone.

The design of the HQ incorporates a setback or buffer zone between blasting operations and five occupied buildings of approximately 150 m, and as little as 80 m from Highway 7, the main area thoroughfare carrying approximately 10,000 vehicles per day, as well as the adjacent Eramosa Sixth Line and Nassagaweya Fifth Line.

HOW CAN THE FLYROCK RISK BE MITIGATED?

The short answer to this question is, "by ensuring that there is a safe distance between the specific location of the blast and any equipment, vehicles, residences, structures and personnel that may be harmed or damaged in the event that flyrock is ejected." That is, an **Exclusion Zone** must be large enough around the blast site such that there are no structures, vehicles nor personnel and any flyrock that is ejected falls only within that exclusion zone.

Blasting contractors in Ontario are generally experienced, knowledgeable and careful. While errors can occur, as a general rule, in the mining industry it is accepted that the probability of flyrock can be reduced by careful control but not eliminated completely.

The reason for the uncertainty regarding the possibility of flyrock is the potential irregularities in the sub-surface rock formation noted above. This fact was articulated in an Ontario MOE inquiry into a 2009 flyrock incident at the Pakenham quarry near Arnprior, Ontario. Testimony provided by Explotech Engineering (the blasting impact consultant in the Hidden Quarry application) regarding this incident included the following statements:

- "Any experienced blaster would have had the same fly rock incident take place."
- "There is no technology available to identify anomalies in rock such as mud seams or voids."
- "90% of fly rock incidents are unexplainable."
- "Now that they know the risk [i.e. after the fact] . . . they will expand the guarding zone to two thousand feet from 1000 ft."

A letter from René Morin of Explotech included the statement: "We strongly recommend that the hazard zone be increased to 500 m when firing any future blasts in this quarry."[i] In this case the blasting contractor was fined and the prescribed exclusion zone was increased to 500 m.

The design of the HQ incorporates a setback or exclusion zone between blasting operations and five occupied buildings of approximately 129 m, and as little as 80 m from Highway 7, the main area thoroughfare carrying approximately 10,000 vehicles per day, as well as the adjacent Eramosa Sixth Line and Fifth Line Nassagaweya. Clearly the setback in this case does not by definition create an exclusion zone because of the existence of residences and vehicles travelling on Highway 7 within it.

WHAT IS A SAFE EXCLUSION ZONE?

The problem in Ontario is that statements such as the one quoted from Mr. Morin and enforcement action by the government are after the fact, rather than proactive. That is, if flyrock is thrown 300 m, the reaction is to say "we should have applied an exclusion zone of (say) 400 m, and will do so from now on." This "correction" is of little comfort to those individuals who were subjected to property damage or personal injury in the first place.

Legislation and Regulations in Ontario place the onus of preventing ejection of flyrock from the exclusion zone on the operator. No minimum setback from buildings, vehicles or personnel is specified. The **Aggregate Resources Policies and Procedures Manual** published by MNRF addresses neither flyrock nor exclusion zones.

The federal **Explosives Act** requires the operator to "protect people from the effects of any … explosion." **Ontario Provincial Standard Specification (OPSS.PROV 120)** regarding the use of explosives specifies the use of blasting mats (not practical in the multiple sequenced explosions used in quarries) "or other suitable means of controlling flyrock . . . to limit potential hazardous effects of the blast." Interestingly, and in contrast to the general absence of concern about the flyrock risk, the Federal Department of Fisheries and Oceans provides significant detail on how blasting contractors are to prevent excessive ground vibration from blasting to adversely affect fish habitat.

The aggregate industry association (Ontario Stone, Sand and Gravel Association) in its **Controlled Blasting at Quarries** publication, ignores the risk of flyrock, a practice commonly emulated by the companies themselves.

Clearly the responsibility for ensuring public safety in quarry blasting operations is placed on the owner/operator of the quarry. But it is a fair observation that the industry is prepared to "roll the dice" on the possibility of a serious incident occurring. Blasting impact contractors either ignore flyrock all together, or grossly underestimate the size of a safe exclusion zone.

This does not have to be the case, however. Numerous jurisdictions around the world require an exclusion zone around quarry blasting operations in the 400 to 500 m range, including some US states (e.g. Texas), Australia and New Zealand. Good practice in the aggregate industry is to calculate the distance that flyrock may be thrown using a ballistics model, similar to what is used with artillery. Two such models are commonly used, one developed by the US Bureau of Mines (USBOM)[ii] and one developed by the Australian engineering firm, Terrock[iii]. The flyrock ranges calculated by the Terrock and USBOM models are quite similar. The basic difference between the two models is that the USBOM model produces only one range of fly rock which it terms as "maximum" while the Terrock model provides one range of flyrock which may require the application of safety factors to protect structures and personnel.

EXAMPLES OF FLYROCK INCIDENTS

Flyrock incidents causing damage or injury do occur, contrary to the assertion "it never happens to us" by aggregate companies. But within British Columbia, Ontario, Yukon, and Nova Scotia there were 31 reported incidents of flyrock between 2001 and 2011.[iv] Here is a non-exhaustive list of Canadian incidents:

Ontario	Location	Incident
September 2014	Merrick Township, ON	Basketball sized flyrock was projected to within 50 to 75 m of a neighbouring residential property. The blasting contractor was fined.[v]
May 2014	North Bay, ON	Flyrock was projected outside the blasting area onto a neighbouring residential property about 25 ft. from the homeowner. The quarry owner and blasting contractor were fined.
July 2009	Pakenham, ON	Two occurrences of flyrock damaged three vehicles at a distance of about 300 m and caused a personal injury to a resident off site. The blasting contractor was fined.
August 2009	Chelmsford, ON	An inexperienced blaster detonated a blast using a single stick of dynamite that caused flyrock to project approximately 33 m onto adjacent private property.
November 2007	Marmora, ON	Flyrock penetrated the roof, damaged the eaves and sidings, and entered a kitchen of a residential home.

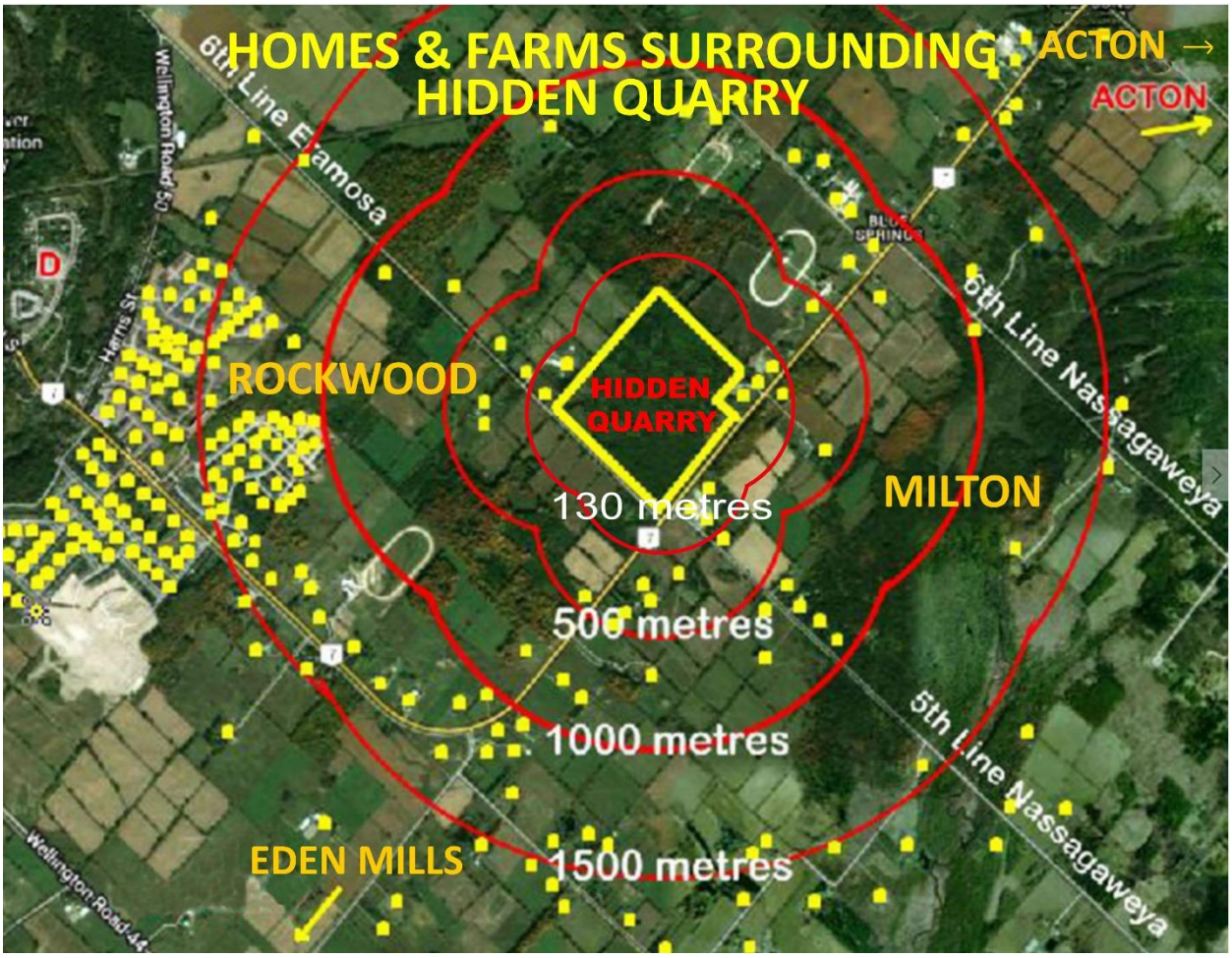
August 2007	McNab-Braeside, ON	Flyrock damaged a home and vehicle parked in the driveway.
August 2006	Bracebridge, ON	Flyrock shower sent nearby resident running for cover. Flyrock about the size of a softball landed on his lawn.
August 2004	Hamilton, ON	Flyrock showered a residential area. Rock went through the roof of a home, and damaged two vehicles.
Nova Scotia		
September 2016	Halifax, NS	Basketball sized flyrock was projected more than 300 m through the roof of an apartment building, the same building was struck by flyrock in 2005. The blasting contractor was fined.
August 2003	Halifax, NS	Flyrock ranging from pebbles to 150 kg flew from the blasting site into an occupied apartment building.
BC Incidents		
October 2009	Central Interior	Traffic control person struck 45 m from blast site.
June 2009	Central Interior	Flyrock thrown more than 100 m into surrounding homes
February 2009	Lower Mainland	Flyrock struck homes and put numerous workers at risk
September 2008	Lower Mainland	Flyrock struck nearby homes and vehicles of a blast
September 2008	Lower Mainland	During road construction, flyrock from a blast struck homes
August 2008	Lower Mainland	Flyrock flew 75 m into homes and vehicles
June 2008	Central Interior	Flyrock ejected 75 m from the blast site striking homes and a parked car
May 2008	Central Interior	Flyrock from a blast damaged several nearby homes
April 2008	Lower Mainland	Flyrock resulted from a blast that misfired
December 2007	Vancouver Island	Flyrock covered 4 cars in dust and small particles at a residential area near the blast
July 2007	Vancouver Island	Workers received minor injuries from flyrock
May 2007	Lower Mainland	Flyrock from a blast took out overhead power lines
March 2007	Lower Mainland	Flyrock struck a house across the highway from a blast site
January 2007	Vancouver Island	Numerous flyrock incidents occurred at a Sechelt jobsite. In one incident, rock went through a residential roof.
October 2006	Central Interior	Flyrock landed in the yard of a house
August 2006	Central Interior	Flyrock struck several private vehicles and a bridge pier
May 2006	Central Interior	Flyrock blast flew 150 m damaging a sundeck
May 2006	Central Interior	Flyrock damaged a home and scattered material over a public roadway
February 2005	Lower Mainland	Flyrock escaped from blast mats and travelled 60 m onto private property

February 2005	Lower Mainland	Flyrock from a blast site struck nearby homes
June 2004	Central Interior	Flyrock damaged nearby homes
January 2003	Central Interior	Flyrock damaged the roof of a covered deck off site

THE HIDDEN QUARRY – TOO CLOSE, TOO SMALL

JDCL's blasting consultant, Explotech, used the Terrock model to calculate a range of 129 metres. However, because of the considerable uncertainties in bedrock blasting, especially in the porous, fissured limestone rock known as Karst, the Terrock model applies a safety factor of two times to protect buildings and equipment, and a further two times to protect personnel. That is, a safety factor of four times should reasonably be applied in the HQ case bringing the safe setback to 526 metres. The USBOM calculation gives approximately the same result by a different method.

If setbacks of 500 metres or more were used, it would be virtually impossible to work the HQ site—it is too close to some residences and the heavily travelled Highway 7, and it is too small for a 500 metre radius exclusion zone to fit on the site itself.



CRC'S POSITION ON FLYROCK RISK MITIGATION

CRC's view is that the Ontario Government needs to require a minimum exclusion zone of 500 m for quarry blasting operations when any vulnerable structures, equipment, inhabited or travelled areas, and livestock exist within that 500 m radius of proposed operations. We believe that it is not acceptable for the aggregate industry to "roll the dice" with the health and welfare of Ontario residents.

Flyrock damage 2009 Pakenham Ontario

[i] This information is from testimony into the Pakenham quarry flyrock incident inquiry, obtained by FOI request from MOECC.

[ii] Roth, J., Management Sciences Associates. **A Model for the Determination of Flyrock Range as a Function of Shot Conditions**. US Bureau of Mines, 1979

[iii] Richards, Alan B. and Moore, Adrian J. **Flyrock Control – By Chance or Design,** Paper Presented at ISEE Conference, New Orleans, 2002. Terrock Consulting Engineers.

[iv] Loeb, Jeffrey Thomas. **Regulatory Mitigation of the Adverse Environmental Effects of Urban Blasting**. MASc Thesis, UBC, March 2012

[v] MOECP, https://news.ontario.ca/ene/en/2015/11/drilling-and-blasting-contractor-fined-60000-for-fly-rock-discharge-and-failing-to-report-incident.html

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