SUBMISSION

from Dr Kelvin W Duncan, PhD

On the Roydon Quarry joint resource consent application made by Fulton Hogan Limited

Coded as: CRC192408 to CRC192414 and RC185627

Introduction

My object to today is to assist the hearing by giving a brief review of modern knowledge about the emissions from siliceous quarries since there seems to be a general ignorance of these important matters in the industry, the expert witnesses and ECAN employees.

My background

My name is Kelvin Duncan. I have a PhD. I have researched and worked on environmental problems. My major projects were: saving Lake Mahinerangi, the Waipori River and the Waihola/Wapori Lakes system, from destructive action by authorities. I helped stop the drainage of the Tuakitoto Wetlands by authorities. I defended a salmon farm against the plans of a unitary authority to construct a sewage plant right next door to the salmon farm. I convinced the authorities to take the health problems of residents of an Otago lake seriously and to change their weed control methods. In another case my evidence was crucial in preventing a major oil company from exposing Canterbury aquifers to risk of serious contamination. And there were a number smaller cases where I was used successfully as an expert witness.

I taught environmental science and helped set up and manage the joint environmental science programme at the University of Canterbury and Lincoln Universities.

However, it should be realised that I am a research scientist, and therefore use the methods appropriate in scientific research. These often differ significantly from those methods that local authorities would use. Of particular importance is that I measure. I do not use models as evidence and I do not use unsubstantiated opinion. Measurement is King in Science.

I have received no financial inducements or rewards from any person or organisation.

Topics to be covered:

Respirable crystalline silica (RCS)
Water
Radon

Respirable Crystalline Silica (RCS)

(Slide 2)

Before I took an interest in the emissions from local quarries, consent hearings for quarry permits had been assured by “experts” that silica was a very common component of rocks and that dust containing silica emitted from quarrying activities was harmless and a “less than minor” nuisance to nearby residents.

One expert said on 6 November 2015: *It is important to note that most rock contains silica, compromising either inert amorphous or crystalline silica. Certain types of rock have higher levels of crystalline silica, such as quartz, but Grey Wacke* (sic) *(the rock that forms the majority of the gravels on the Canterbury Plains) does not contain especially high levels to my knowledge. Notwithstanding this, emissions of crystalline silica can be minimised through the normal suite of dust control measures, meaning that off-site exposure to inhalable levels of crystalline silica should be low. Furthermore, in my experience, this is a consideration that arises regularly as part of the air discharge permit process that the Regional Council has responsibility for.*

This, of course, is nonsense that a few minutes searching the web using Google would have revealed.

On another occasion he admitted he did not know the silica composition of greywacke rock, even though it had been known to science for decades. It is in fact about 60%, which is a far greater concentration than he implied. Furthermore, subsequent analyses of the abundant quarry suffered by neighbours contained around 30% RCS. Obviously, the “normal dust controls” relied on by the expert as quoted above has not mitigated the serious health risk to residents.

A search of the web would have revealed that all other advanced countries, and many third world countries, have regulations to protect nearby residents against the highly deleterious effects of Respirable Crystalline Silica (RCS) which cause many chronic disease following prolonged exposure. But NZ does not h ave specific regulations to protect residents. The Yaldhurst Road residents show disturbing signs of health problems that may well be due to the amount of RCS that they have had to endure for a number of years.

The question could be asked why haven't those who are paid by the ratepayers and taxpayers of the country kept up-to-date with the international science and other countries’ regulations about RCS?

One answer may be that ECAN is not well equipped to deal with dust or RCS issues since Mr Tim Mallett, Senior Scientist for ECAN, wrote in an email on 22 August 2017; “*We’re not particularly experienced dealing with dust from quarries, or RCS, as our ambient monitoring tends to be dominated by woodsmoke* (sic).*”*

I would take issue with the later claim, that they have expertise in dealing with wood smoke, since ECAN does not seem to measure nitrogenous compounds and volatile organic compounds (VOCs) when monitoring wood smoke. Yet these compounds are measured by overseas authorities, as well as PM 100, and PM10, PM 5 or PM 2.5. The reason for this is because the nitrogen compounds and VOCs are dangerous emissions that are highly deleterious to both human and animal health. It is made worse because these emissions are not visible.

In an attempt to reduce visible emissions in smoke a regulatory authority that does not measure these invisibles is likely to make the terrible error of making users replace older log burners with models that appear to give off less smoke but which may give off dangerous levels of N and VOCs, due to an ignition temperature being allowed that does not burn up the products of combustion to CO2 and N2. These invisible compounds of incomplete ignition are very deleterious to health.

But back to RCS rather than hammering ECAN for its incompetence.

With respect to the dust being emitted by quarries we should ask the following questions:

1. *What is the composition of the rock being quarried?*
2. *What quarrying activities generate RCS?*
3. *Is RCS dangerous?*
4. *How far does RCS travel?*
5. *What size are the local RCS crystals?*
6. *What is its concentration in the dust emitted by the quarries?*

Any answers to these questions must be based on sound and appropriate measurements if they are to be considered to to be sound scientific facts. The use of smoke models, such as AusPlume, and reliance on opinion should be completely discounted no matter how distinguished the experts hold themselves out to be.

1. What is the composition of the rock being quarried and the dust being emitted?

(Slide 3) Torlesse greywacke contains up to 60% silica dioxide (quartz). The quartz is visible to the naked eye as large veins, small veins and dots of white crystalline matter that all occur where de-watering has taken place.

This table gives an early analysis of greywacke rock.

	Greywacke, Gorge Hill (%)	**Greywacke, Otira Tunnel (%)**
Silica	65.77	70.90
Alumina	15 03	14.33

Feric oxide	2.27	0.23
Ferrous oxide	2 23	2.55

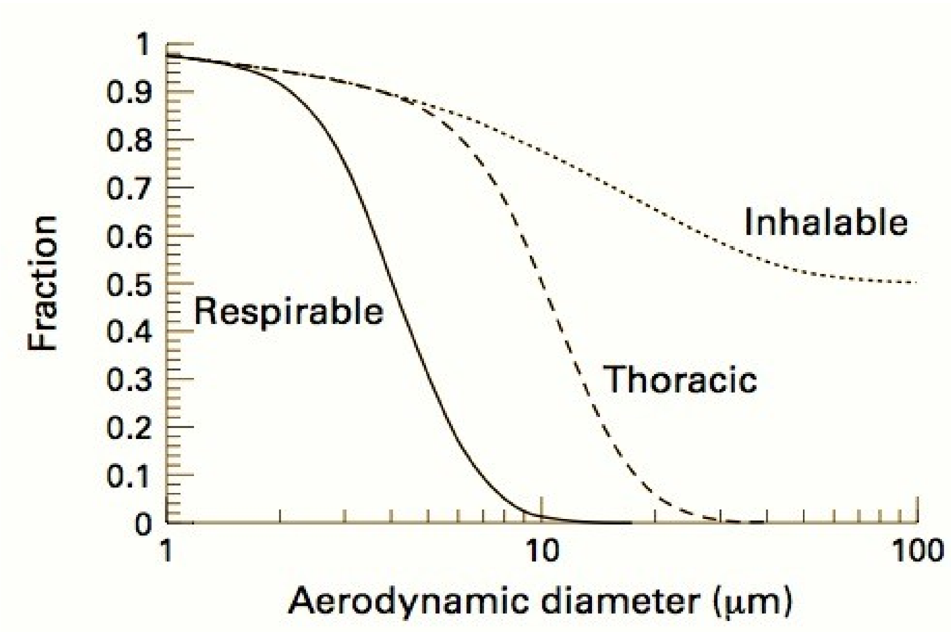
Source: The Geology of View Hill and Neighbourhood. By R Speight in Trans. And Proc. Roy Soc NZ., 58 (1928)

The presence of significant amounts of iron increases the toxicity of RCS.

2. What quarrying activities generate RCS and what is it? (Slide 4)

During quarrying the small crystals of RCS are formed during blasting, excavation, transport, crushing, and delivery. Blasting is not necessary in Canterbury quarries.

The size of the dust particles emitted are shown in this figure.



This graph taken from OSHA (USA) shows there are three major components of breathable dust: Inhalable which enters the nose and larger air passages, but which is deposited in regions where it can be easily removed by the body; Thoracic which penetrates further but is still easily removed; and Respirable which penetrates to the narrowest and deepest air passages. From here it cannot be easily removed and it can cause damage to the air/blood interface.

NOTE: the respirable fraction is comprised of particles that have a size less than about 16 micrometres, which explains why the investigators and experts employed by ECAN thought that Canterbury RCS is low. They used the PM2.5 or PM5 fractions. RCS in Canterbruy has a size of at least 5 micrometres.

3. Is RCS dangerous?

(Slide 6) RCS is invisible. It consists of flat, regular plates with sharp vertices and edges. Being fairly laminar they fly long distances from the point of release because of their aerodynamic shape. Fugitive dust occurs where dust that has settled on the ground but is thrown back up into the air stream by trucks or strong winds. So RCS can travel considerable distances, transported by a direct air flow or by hopping repeatedly as they are thrown up in the air by surface movements. Its behaviour is very difficult to model, so most experts rely on direct measurements rather than models. In some jurisdictions actual measurements, with samples taken centrally, at the boundary and along transects, are a requirement for consent.

Torlesse RCS crystals seem to be 4 µm to 6 µm long, so PM2.5 measurements miss most RCS particles.

(Slide 7) RCS is invisible, it penetrates right down into the narrowest lung airways, it is difficult to remove by normal body processes. On prolonged exposure (10 years?) it can cause a variety of chronic diseases that are difficult to diagnose in the early stages and mostly impossible to cure in the latter stages.

Medical effects

(Slide 8) Cumulative exposure to RCS causes a range of diseases, including silicosis, lung cancer, renal disease, chronic obstructive disease, scleroderma, rheumatoid arthritis, polyarthritis, mixed connective tissue disease, systemic lupus erythematosus, Sjogren’s syndrome, polymyositis, fibrositis, cor pulmonale, lymphatic cancers (leukemia, lymphonas), stomach and/or gastrointestinal malignancies, dermatomyosistis, and glomerulonephritis (Bridges, I. Crystalline *Silica: A review of the dose response relationship and environmental risk.* Air Quality and Climate Change 2009 vol 43 [1] pp 17-23.)

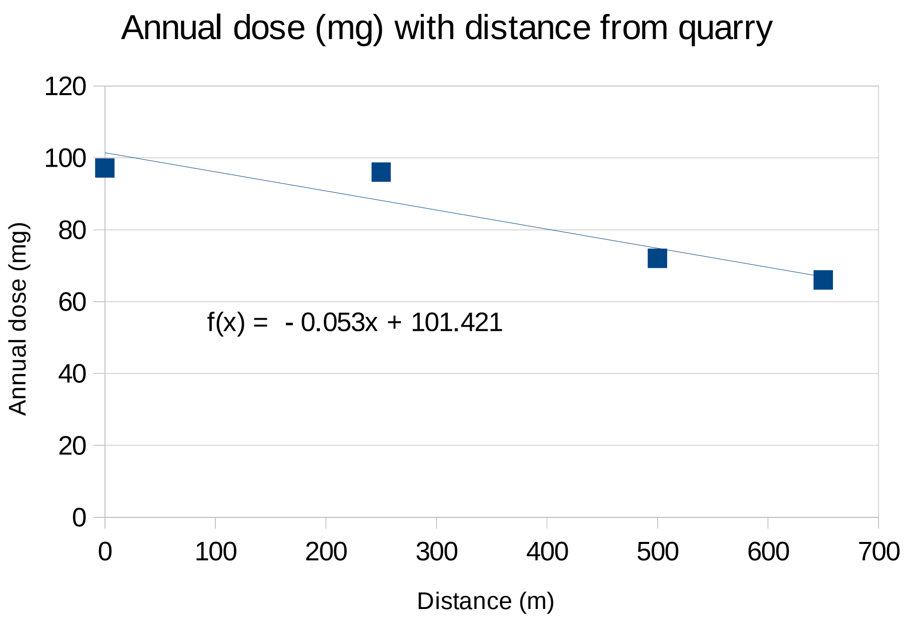
(Slide 9) The outlook for people who have contracted RCS induced diseases is not good.

(Slide 10) The toxicity of RCS is related to the age of the particles. Freshly cleaved crystals are the most dangerous, but as they age their edges become worn, and their silica based radicals on the fracture planes and their hydroxyl radicals in aqueous media diminish in potency. If iron is present, as it often is in greywacke, there is enhanced generation of free radicals which causes increased damage to the alveolar air-blood barrier. However, activity diminishes as the crystals age.

It can take many years before these diseases manifest themselves, and, unfortunately, when they are diagnosable, they often cannot be cured.

How far does RCS travel

(Slide 11) Only one study (other than mine) has been made to determine how far RCS s travels from a Canterbury quarry. The results are shown below.



This is data from MOTE's report. It is of measurements taken on a transect line at distances from the quarry. I calculated the cumulative annual dose data from these measurements using linear methods.

The usual acceptable level for an annual RCS cumulative dose is 3 mg per annum. This "safe" level would not be reached until the distance from the source is 2 km.

We can conclude that the dust carries for a considerable distance.

Previous studies

(Slide 12) There have been three studies commissioned by ECA. All suffer from being:

of too short a duration,

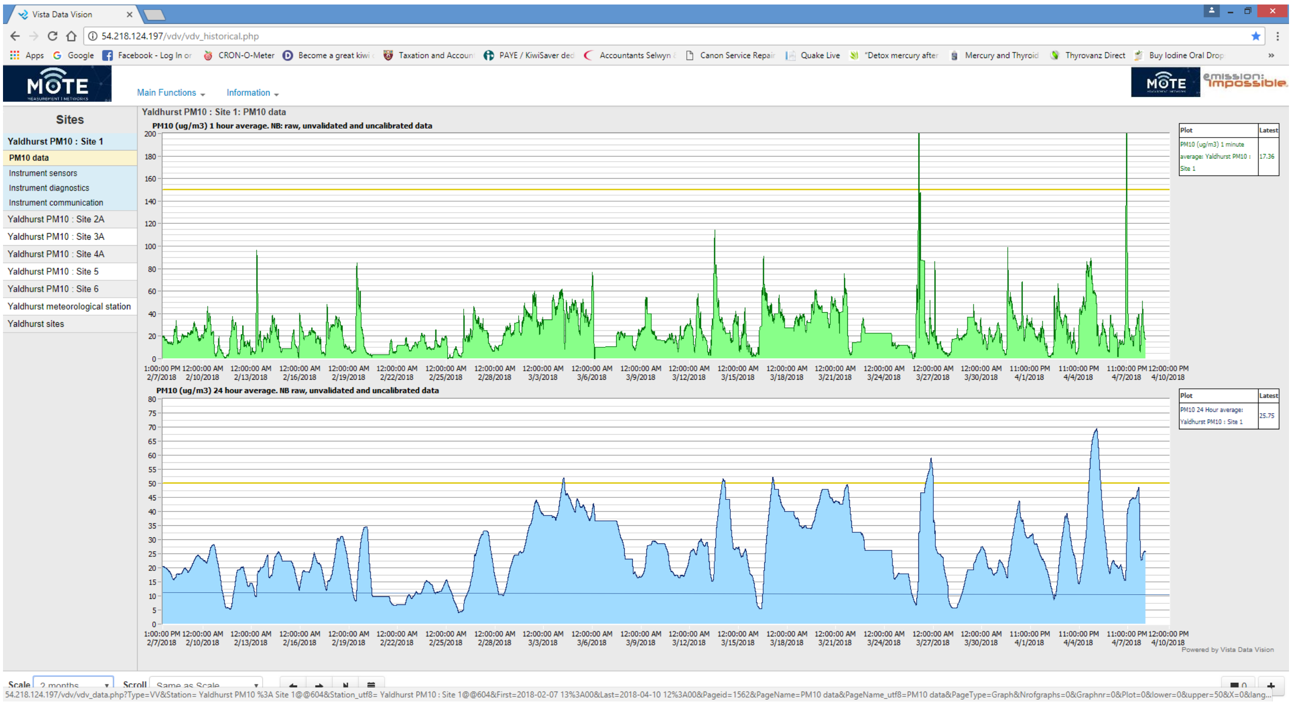
not realising that the respirable fraction does not equate to the PM 2.5 fraction,

and a lack of appropriate protocols. To measure the effect on residents you must use cumulative measures, not hourly ones. It is the cumulative dose that is importance, not hourly exceedances.

And geometric means are more appropriate for dose-response situations.

What is its concentration?

(Slide 13) The graph below shows a typical result from the monitoring commissioned by ECAN. It was taken over a period that included the Christmas break when the quarries were not working and over a time of year when winds were minimal. Even so it shows a number of exceedances of the limits for workers (50µg/m3 – the yellow line). If you accept the limits given in other countries for residents of 3 µg/m3 (10 µg/m3 is shown as a blue line) then there are numerous exceedances.

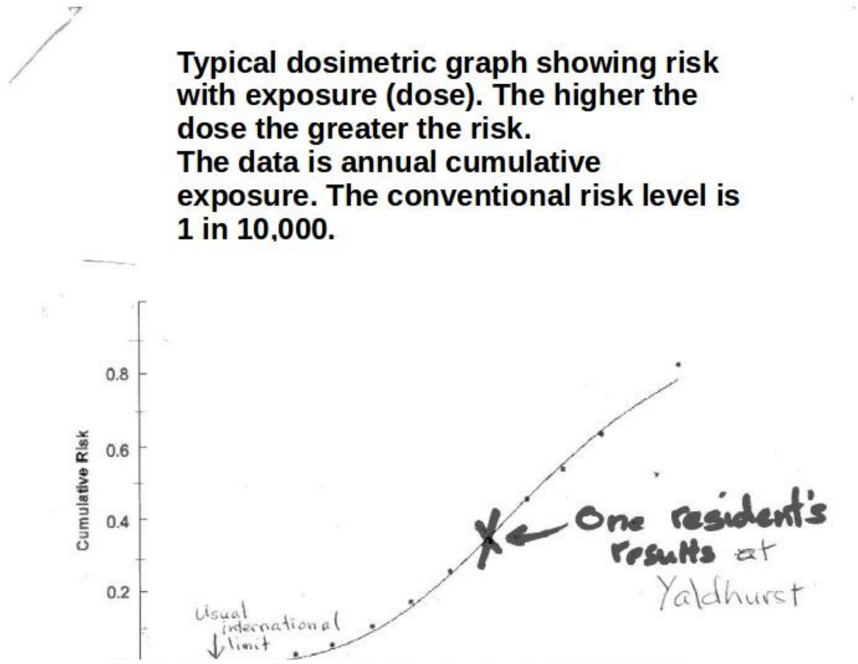


But this form of monitoring is fine for Health and Safety at Work purposes where workers are usually fit and healthy and are exposed to dust for only 2,000 hours per year. But it is not acceptable for assessing risk to nearby residents who are exposed continuously, for 24/7/365 hours each year, and who may be far more susceptible to dust than workers, being older or younger and with possible conditions that make them much more susceptible. Furthermore, it is widely accepted that it is the cumulative dose that is important, and not the acute, hourly dose as shown in this figure.

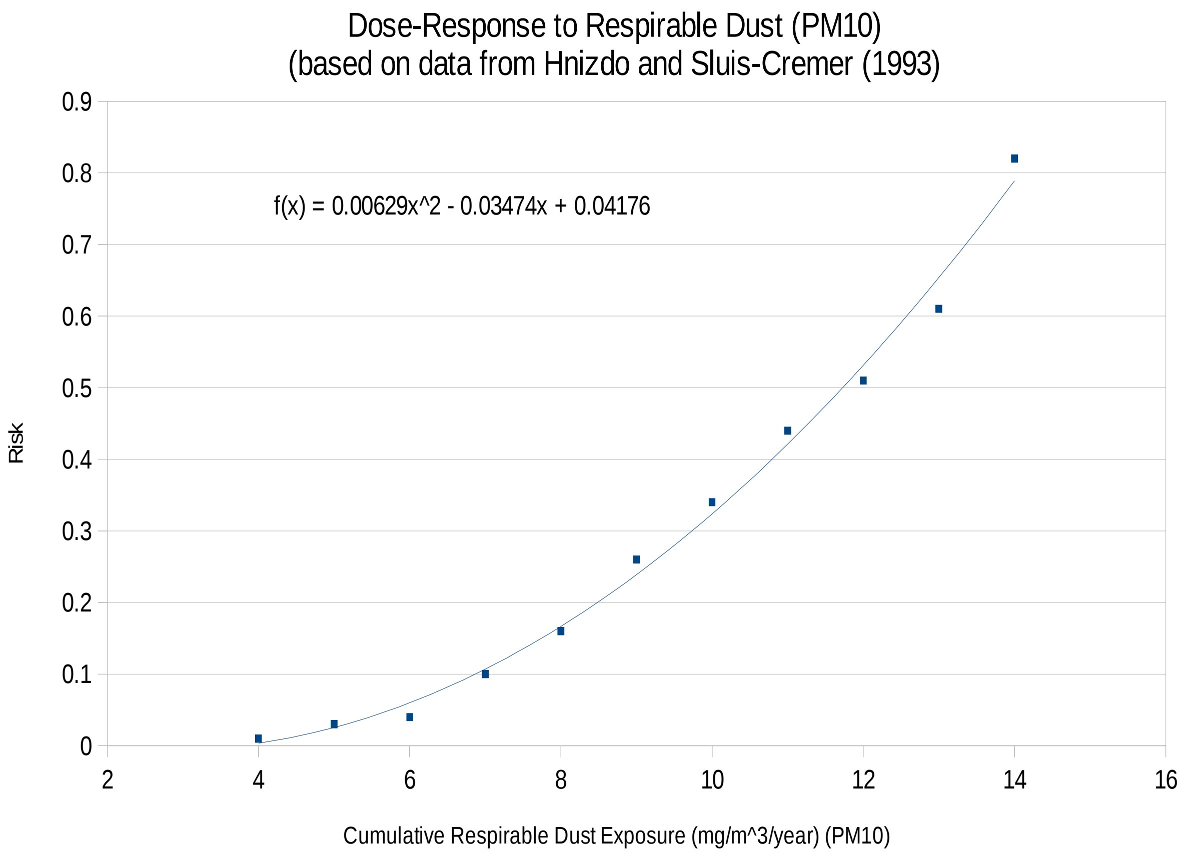
Monitoring should record cumulative dust or RCS concentrations over at least one year. This study was conducted using BAM Monitors rather than deposition monitors. BAMs are banned in some countries. No check on possible interferences was made (e.g., high natural radiation diminishing the recordings), and covers were sometimes used over the monitors that would have reduced the dust carried by the sampled air. The study was conducted for a very short period of time.

(Slide 14)

(Slide 15) To make the data in the report more meaningful I converted the results to annual dosages as shown in the figure below. The station data I converted showed the nearby resident had 5 times the acceptable exposure dose.



Slide 16



(Slide 17) Residents at Yaldhurst were given personal monitors to wear. Here are the results.

PERSONAL MONITORS – RESULTS

SUBJECT	Inhalable Dust (µg.m-3)	Respirable Dust (µg.m-3)	Crystalline Silica Dust (µg.m-3)
1	270 ± 5	<21*	20 ± 3 **
2	263 ± 5	<21	<3
3	822 ± 5	622 ± 21	9 ± 3 *
4	381 ± 5	36 ± 21	21 **
5	207 ± 5	<21	20 ± 3 **
6	213 ± 5	<21	<3 ns
7	325 ± 5	26 ± 21	<3 ns
8	302 ± 5	<21	<3 ns

The red asterisks indicate readings that are above the international limits.

Other effects

(Slide 18) The literature mentions damage to livestock, pets and crops. Livestock and pets have the same responses as humans; plants may have their stomata blocked, resulting in reduced photosynthesis and reduced yields. Micro-organisms may be affected which can result in reduced plant growth and greater incidence of plant diseases.

(Slide 20) Gravel supply areas

Quarries naturally want to be sited as close to their customers as possible. They have said that requiring a more distant location would increase cost substantially. However, at present product price is the same no matter how distant the quarry from the city so there is some doubt as to the validity of this argument.

In any case, the Waimakariri River bed would provide an inexhaustible supply of gravel, and it would be an excellent thing to do to lower the level of the bed in order to reduce the risk of the almost inevitable devastating flooding.

Water

(Slide 21) In 2005 ECAN produced a provisional plan that said that industry should not be allowed in the recharge zones owing to the thin and porous soils in those zones. This was based on sound hydrological and pedagogical knowledge. Is it not too much of a risk to allow such great amount of deep excavations given this knowledge? Some residents have had water analyses that show far too high levels of E.coli and other pollutants. ECAN put these results down to animal faeces contamination, a conclusion that is completely unjustified given that there are no stock animals in this zone.

In my opinion the community should ask itself if it wants pure water or industry. My answer is that the industry can be conducted elsewhere or by means that are advantageous to the environment and not posing a serious risk.

The quarries have advanced the argument that placing quarries far away would greatly increase costs, but this argument has been exposed as false since the price of gravel does not vary with distance of the supplying quarry from Christchurch.

There is another argument advanced by the quarry companies against extracting Waimakariri River gravel and thus helping to prevent the almost inevitable future flooding events that threaten Christchurch and surrounding areas. They claim that river gravel does not have the amount of fines required for certain uses. But this ignores the fact that the gravel they currently quarry has been laid down by the Waimakariri River. They are quarrying recent Waimak river bed deposits. And casual inspection shows that there are massive deposits in the Waimakariri River bed and flood plain that contain any amount of fines.

Lowering the Waimakariri River bed would be an excellent thing to do. It would be necessary to protect endangered bird nesting sites (such as those of the wry bill) but other river bed inhabitants are well used to the massive bed disruption that occurs during every flush or flood, so moderate quarrying is most unlikely to affect them. Toe Biters (*Archichauliodes diversus)* for instance, are to be found hundreds of metres beyond the river during floods, burrowing deep in the gravel and far away from the disturbances caused by flooding.

Radon

(Slide 22) Radon is a naturally occurring radioactive gas. It has no smell, colour or taste. Radon is produced from the natural radioactive decay of uranium, which is found in all rocks and soil. Radon can also be found in water.

Radon escapes easily from the ground into the air, where it decays and produces further radioactive particles. As we breathe, the particles are deposited on the cells lining the airways, where they can damage DNA and potentially cause lung cancer.

Outdoors, radon quickly dilutes to very low concentrations and is generally not a problem. The average outdoor radon level (1) varies between 5–15 Bq/m3. However, indoors, radon concentrations are higher, with highest levels found in places like mines, caves and water treatment facilities. In buildings such as homes, schools, and offices, radon levels in the range of 10 Bq/m3 to more than 10 000 Bq/m3 have been found.

Health effects of radon

Radon is the most important cause of lung cancer after smoking. It is estimated that radon causes between 3–14% of all lung cancers in a country, depending on the average radon level and the smoking prevalence in a country.

An increased rate of lung cancer was first seen in uranium miners exposed to high concentrations of radon. In addition, studies in Europe, North America and China have confirmed that even low concentrations of radon – such as those found in homes – also confer health risks and contribute significantly to the occurrence of lung cancers worldwide.

The risk of lung cancer increases by 16% per 100 Bq/m3 increase in long time average radon concentration. The dose-response relation is linear – for example, the risk of lung cancer increases proportionally with increasing radon exposure.Radon is an invisible, radioactive gas that emits alpha radiation. This is a dangerous form of radiation but it has low penetrating power. It has to come into intimate contact with susceptible tissues, such as lung tissues. But if it does then it can be very damaging in causing lung cancer. It comes from the radioactive decay of Uranium and Thorium, both quite common in small amounts in natural materials, such as greywacke rock.

Radon permeates into and accumulates in homes and buildings unless preventative building techniques have been used. It has a short half life (4 days) and decays quite rapidly to radioactive “daughter” products.

Greywacke is the predominant rock type through the east coast regions of both islands, so it is not just a regional concern. Greywacke emits Radon. Radon is the second, or perhaps now the first cause of lung cancer. The worry is that although smoking rates have dropped to one-third of what they were few decades ago, lung cancer rates are still increasing. What is causing this increase? Is it because Radon is being emitted from concrete made from greywacke and from greywacke rubble (used for 'rubble' foundations in NZ) instead of pile foundations that was common years ago.

The rock that is being quarried around Christchurch is greywacke. When the rubble is used for roading there is unlikely to be a problem, but when used for rubble foundations or concrete there may be a very serious problem. We just don’t know for certain.

(Slide 23) Most countries have regulations regarding building codes in order to minimise the radon content in homes and buildings. Here are some examples. Other countries use 80 Bq/m3 as their reference level. Many states in the US aim at having indoor Radon levels at the same level as outdoors – between 15 and 30 Bq/m3. We have no such standards.

(Slide 24) The WHO suggested “establishing a national annual average concentration reference level of 100 Bq/m3.”

Immediate evacuation of the dwelling and the installation of Radon lowering treatments are recommended if the Radon level exceeds 300 Bq/m3. In North America the goal is to have the interior of houses at the same Radon activity level as outside. Houses in some regions must have a Radon safety certificate before they can be occupied. If they fail to meet the standard (80 to 100 units) then remedial action is mandatory. Pumps to draw the air out of rubble or concrete foundations are often employed. In many states of the USA and in Canada houses have to have a Radon certificate to show they are safe.

The 1986 survey

(Slide 25) There has been only one survey of Radon emissions in New Zealand, but it is fairly old having been conducted in 1986 by M K Robertson, M W Randle, and L J Tucker of IRL for the then Health Department. They reported that he natrual dose rate in New Zealand is low. " But if you use modern WHO, EU, or North American standards we may have a problem.

The New Zealand survey done in 1986 recorded many houses above these limits particularly if they were in Canterbury or had concrete floors of walls.

(Slide 25) Selection of local data from the 1986 Radon survey

Region	**Mean**	**Max**
Avon	44.8	153.5
Sydenham	32.8	139.5
Lyttelton	23.6	102.5
General Christchurch and surroundings	59.6	152.8
Building materials		
Wood floor	*43.6*	*273.8*
Concrete floor	*60.1*	*242.1*
Concrete exterior wall	*51.8*	*273.8*

Even worse, they recorded anomalous results when the recording units were posted back. They hypothesized that our concrete emits considerable amounts of Radon, but because we didn't then use concrete for dwellings anything like as much as we do now they considered there was not a problem even though the recordings were very high.

Reasons why the situation may be worse now than in 1986

(Slide 26) The situation regarding the likelihood of there being a problem has changed since 1986 owing to the following factors:

1. We use much more concrete in housing today.

2. Pile foundations are not used as much as they used to be (piles allowed Radon to escape before entering the house).

3. We now favour greywacke rubble foundations (which emit Radon). We do this because they are cheap.

4. We make our houses far more airtight than we did earlier. Indeed, the government may be compounding the danger by requiring more insulation.

5. We use concrete far more than we used to.

- Radon is a naturally occurring radioactive gas which may be found in indoor environments such as homes, schools, and workplaces.
- Radon is the most important cause of lung cancer after smoking.
- Radon is estimated to cause between 3–14% of all lung cancers in a country, depending on the national average radon level and smoking prevalence.
- The lower the radon concentration in a home, the lower the risk of lung cancer as there is no known threshold below which radon exposure carries no risk.
- Well-tested, durable and cost-efficient methods exist for preventing radon in new houses and reducing radon in existing dwellings.

Radon is much more likely to cause lung cancer in people who smoke. In fact, smokers are estimated to be 25 times more at risk from radon than non-smokers. To date, no other cancer risks have been established.

Radon in homes

For most people, the greatest exposure to radon occurs in the home. The concentration of radon in a home depends on:

- the amount of uranium in the underlying rocks and soils;
- the routes available for the passage of radon from the soil into the home; and
- the rate of exchange between indoor and outdoor air, which depends on the construction of the house, the ventilation habits of the inhabitants, and the air-tightness of the building.

Radon enters homes through cracks in the floors or at floor-wall junctions, gaps around pipes or cables, small pores in hollow-block walls, or sumps or drains. Radon levels are usually higher in basements, cellars or living spaces in contact with soil.

Radon concentrations vary between adjacent homes, and can vary within a home from day today and from hour to hour. Residential radon levels can be measured in an inexpensive and simple manner. Because of these fluctuations, it is preferable to estimate the annual mean concentration of radon in indoor air by measurements for at least 3 months. However, measurements need to be based on national protocols to ensure consistency as well as reliability for decision-making.

Reducing radon in homes

Slide 27) Well-tested, durable and cost-efficient methods exist for preventing radon in new houses and reducing radon in existing dwellings. Radon prevention should be considered when new houses are built, particularly in radon prone areas. In many countries of Europe and in the United States of America, the inclusion of protective measures in new buildings has become a routine measure. In some countries it has become a mandatory procedure.

Radon levels in existing homes can be reduced by:

- increasing under-floor ventilation;
- installing a radon sump system in the basement or under a solid floor;
- avoiding the passage of radon from the basement into living rooms;
- sealing floors and walls; and
- improving the ventilation of the house.
- Deprecating rubble foundations.
- Requiring houses to have Radon safety certificates.

Passive systems of mitigation have been shown to be capable of reducing indoor radon levels by more than 50%. When radon ventilation fans are added radon levels can even be reduced further.

Radon in drinking water

In many countries, drinking water is obtained from groundwater sources such as springs, wells and boreholes. These sources of water normally have higher concentrations of radon than surface water from reservoirs, rivers or lakes.

To date, epidemiological studies have not found an association between consumption of drinking-water containing radon and an increased risk of stomach cancer. Radon dissolved in drinking-water can be released into indoor air. Normally, a higher radon dose is received from inhaling radon compared with ingestion.

The "WHO guidelines for drinking water quality" (2011) recommend that screening levels for radon in drinking-water be set on the basis of the national reference level for radon in air. In circumstances where high radon concentrations might be expected in drinking-water, it is prudent to measure radon concentrations. Straightforward and effective techniques exist to reduce the concentration of radon in drinking-water supplies by aeration or using granular activated carbon filters.

- WHO Guidelines for drinking-water quality

WHO response

In 2009, WHO published the "WHO handbook on indoor radon: A public health perspective", which provides policy options for reducing health risks from residential radon exposure through:

- providing information on levels of radon indoors and the associated health risks;
- implementing a national radon programme aimed at reducing both the overall population risk and the individual risk for people living with high radon concentrations;

- establishing a national annual average concentration reference level of 100 Bq/m3, but if this level cannot be reached under the prevailing country-specific conditions, the reference level should not exceed 300 Bq/m3;
- implementing radon prevention in building codes to reduce radon levels in homes under construction, and radon programmes to ensure that the levels are below national reference levels; and
- developing radon measurement protocols to help ensure quality and consistency in radon testing.

In other countries a householder can buy Radon measuring equipment for a relatively low cost at hardware stores. These countries have standards that are enforced and they employ Radon inspectors. New Zealand has no Radon regulations and, even worse, no reliable modern information about our Radon emission rates.

All Radon is harmful - there isn't a safe dose. But the best anyone can do is to reduce emission rates inside the house to the same as that occurring naturally outside the house. The aim in many States in the USA is to have Radon levels inside homes at the same level as outside the homes.

I must emphasize that I do not have modern measurements of Radon levels in NZ, but judging by the 1986 study, we may have a very serious problem that affects about half of New Zealand.

Does the Precautionary Principle apply?

Is an applicant required to show their proposed activities are safe and will not offend the RMA with respect to the issues involving dust, water and Radon that I have raised?

The Minister assures me the Precautionary Principle does apply in New Zealand law.

Surely, the obvious answer is that we do not know enough to make a lawful judgement.

I conclude that more investigation is needed.