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Production of Aggregates in New Zealand - The Trends.

By

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PRODUCTION OF AGGREGATES IN NEW ZEALAND - THE TRENDS.

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ABSTRACT

Compared with elsewhere in the world, New Zealand quarries have tended to be mostly small. The reasons for this are a combination of the relatively high transport costs, low population density and a pioneering, self-employed attitude.

The small size of the operations is reflected in low productivity, a tendency to repair and rebuild equipment rather than replace it, designed flexibility in the processing plant, minimal reserves investigation or development planning and a versatile and innovative work force who are generally not professionally trained.

The Resource Management Act and the Health, Safety and Employment Act as well as a customer driven demand for higher quality and consistent products will have even greater influence upon future direction of the Industry. The trend will be towards fewer quarries operated by companies and professional managers that can adapt to the new demands.

PRODUCTION AND OWNERSHIP

An aggregates production of 20 million tonnes, with a value of NZ$168million, accounted for some 50% of the value of national mineral production (excluding fuels) for New Zealand in 1991. In the last 15 years it has varied between about 20 million and 27 million tonnes, in a remarkably regular five-year cycle.

The 1991 figures are the latest available, but since that time the industry has shown signs of a gradual improvement.

Figures 1 & 2 show the relationship betrween the size of quarry to the market share and the proportions of quarries of various sizes in 1989. Approximately 64% of the country's aggregates came from operations producing in the range of 50,000-500,000 tonnes/year, representing only 20% of the total number of sites. Quarries with production capacities greater than 500,000 tonnes/year accounted for less than 10% of total production.

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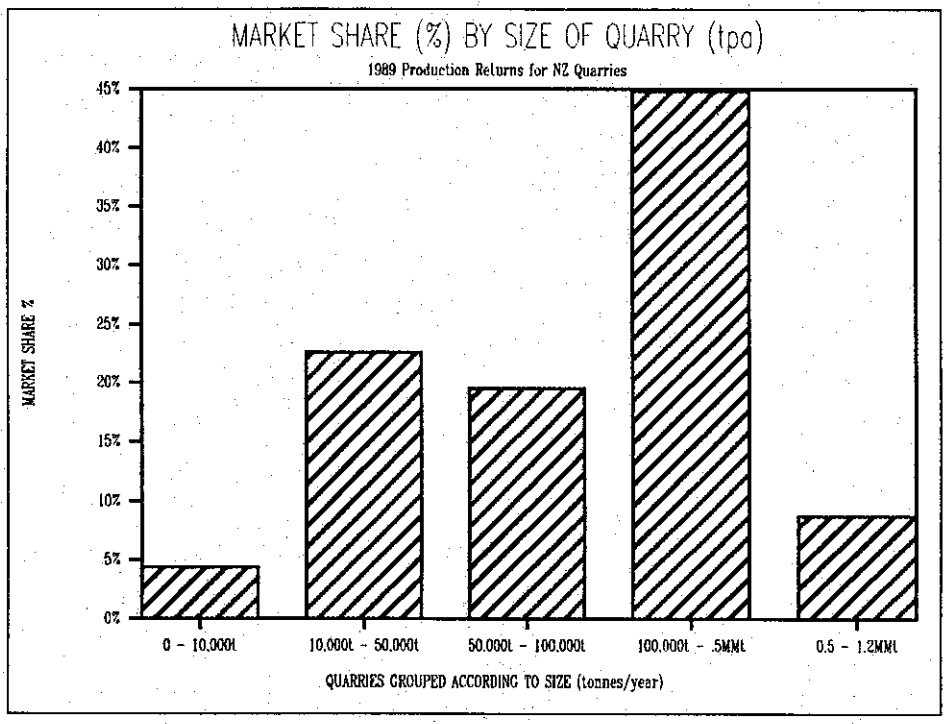

Figure 1 Market Share (%) by size of operation (tonnes/year) (1989 production)

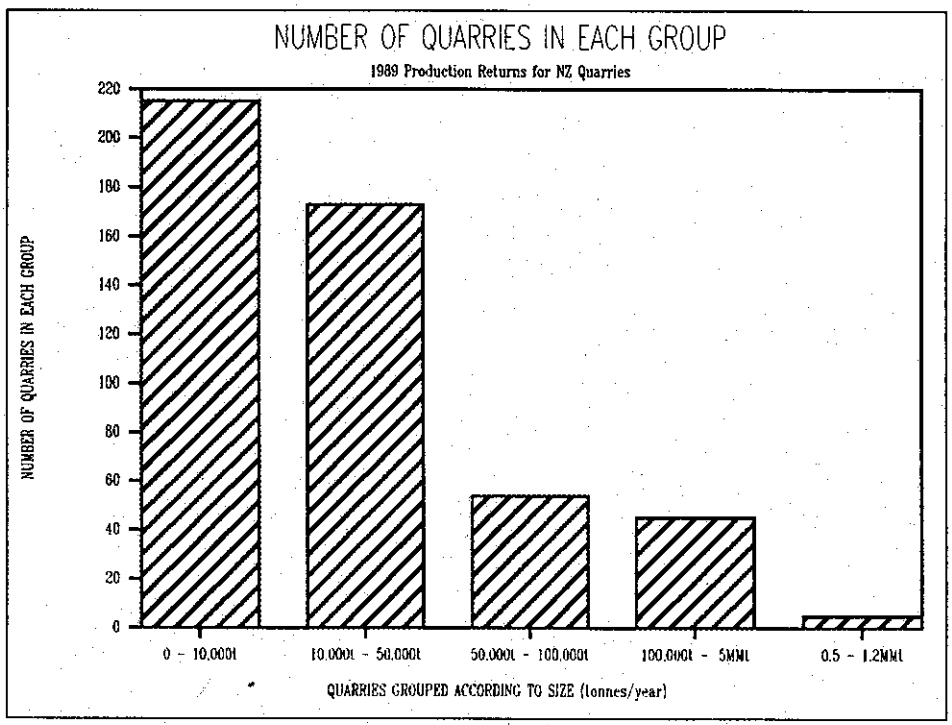

Figure 2 Number of quarries (%) by size of operation (tonnes/year) (1989 production)

While the quarries with outputs of about 100,000 tonnes/year have comprised the backbone of the industry, some of the numerous small quarries and pits that service the smaller provincial areas were equally important. Commonly a company has owned a number of small quarries, strategically distributed throughout a region, operating them intermittently with portable plant when there is local demand.

Generally, aggregate producers in New Zealand entered the industry because of a need to secure supplies for their own local or regional contracting and manufacturing activities. Only recently have several of the larger companies expanded their activities more or less nationwide. Those companies and ones with a strong capital, management and technical base can be expected to strengthen their position either through acquisition or joint venture participation.

There are two major aggregate producers in the North Island and one in the South Island. In the North Island, Winstone Aggregates Ltd, with 20 hard rock, sand, gravel and scoria operations, accounts for four million tonnes/year. The largest, Lunn Avenue basalt quarry at Mount Wellington in Auckland, produces 1.2 million tonnes/year, supplying some 50% of the requirements of the city. However, like most of the inner Auckland basalt quarries, Lunn Avenue Quarry is nearing the end of its life.

The other major producers in the North Island are W. Stevenson and Sons Ltd, servicing the Auckland and Waikato areas, and producing about one million tonnes/year from six operations, comprising basalt and greywacke hard rock quarries, and sand and gravel operations.

In the South Island, Fulton Hogan Ltd is the major producer with some 800,000 tonnes/year supplied by static and mobile plants from various locations in rivers, gold dredge tailings, older terrace gravel pits and one hard rock quarry. In contrast, Isaac Construction produces approximately 400,000 tonnes/year from their single gravel quarry at Harewood on the outskirts of Christchurch.

Throughout the country, most local authorities own one or more quarries, although they generally purchase additional aggregates from the private sector.

There have been few new quarries opened in the last 20 years. A significant exception to this is Milburn New Zealand Ltd's proposed 1 million tonne/year green field basalt quarry at Bombay, South Auckland, for which has obtained statutory consents and is proceeding.

PRODUCTS

Roads represent the largest consumer of aggregates in New Zealand, taking a range of sub-bases, basecourses, sealing chips and asphaltic materials. Low population density has resulted in the development of techniques to make a little money go a long way. A gentle climate and low traffic densities allow thin foundations (particularly using lime or cement stabilisation) and thin surface layers. Thin bitumen sealing or asphaltic concrete over a basecourse is the norm, with the more expensive asphaltic concrete necessary only where traffic loadings are high. Concrete is rarely used in road construction.

The ready-mixed concrete, pre-cast concrete and concrete masonry industries also use a range of coarse and fine aggregates.

New Zealand quarries tend to produce a wider range of products than their counterparts elsewhere; for example, Lunn Avenue basalt quarry sells 32 products.

The small quarries and pits operating in New Zealand lack the economies of scale, with resultant lower profitability and difficulty in justifying capital expenditure for plant upgrading and replacement. Nevertheless, product quality standards are comparatively high.

Conversion to selling aggregates by weight has lagged behind other countries until quite recently.

RESOURCE TYPES

Greywacke, basalt, andesite and gravels are quantitatively the most important resource types. Whereas in the North Island the bulk of coarse aggregate production is from hard rock quarries, the South Island is supplied mainly from alluvial gravels.

Generally each region has a range of resource types sufficient to supply all its needs: two substantial exceptions are the Taranaki and Gisborne areas where high-grade materials are unavailable.

In New Zealand the term "greywacke" is used to describe indurated sandstones, siltstones and mudstones which form the basement ranges of the North Island and parts of the South Island. Argillites and deleterious zeolites are contaminants, generally only tolerated in small amounts. Also greywacke characteristically has a deep weathering profile, so that much of it is unsaleable. Upgrading to remove argillities, zeolites and weathering products is achieved by selective quarrying and scalping. Despite the fact that it is a difficult material to work, greywacke is the most common hard rock aggregate, except where basalts, andesites or gravel with little overburden are available. Provided specifications can be met, greywacke operations are likely to remain dominant.

Basaltic rocks are a major source of aggregates, usually being preferred to greywacke. Vesicular material cannot be used for premium products because of its lower strength and higher porosity. Unweathered basalts are abundant in Auckland and parts of Northland, many deposits being only 10,000 to 800 years old, while elsewhere throughout the country basalts are scattered, being generally older and more weathered. Unfortunately many of the existing basalt quarries in the inner Auckland region are nearing the end of their life and much of the remaining resource is sterilised by encroaching development or restrictive zoning.

Scoria is used extensively for drainage work in the Auckland area. It is generally dug and loaded by hydraulic excavators and does not require blasting. The greater proportion is lightly crushed and screened and the remainder is sold ex-quarry.

Andesites are in common use for all grades of aggregate production, although some are suitable only for low grade products because of the presence of deleterious clay, clay-like minerals or glass.

Significant amounts of crystalline, shelly and relatively soft muddy limestones are used for unsealed road construction and maintenance. Hard, recrystallized limestones have not been accepted as suitable for sealing chip or as a concrete aggregate. Recent testing suggests that some limestones would be suitable for use in the manufacture of concrete, at least up to strengths of 40MPa.

Although not quantitatively significant today, a number of conglomerates of Tertiary age have been used. Winstone Aggregates Ltd is currently researching methods of 'disaggregating' a large deposit of conglomerate at Wainui Hills, north of Auckland, to develop an economically viable process for the removal of the deleterious clay component, to supply concrete aggregate to the Auckland market.

Gravels from rivers, their flood plains and, occasionally, beach deposits are widely used, particularly in the South Island. River extraction is now limited to the estimated renewable quantity (active bedload) and in many areas is under pressure from the environmental lobby. New Zealand rivers are relatively short and drain areas of variable rock types. This can result in contamination with soft or other unsuitable rock type such as young mudstones or sandstones or schist; processing may improve quality to an acceptable standard. There has been no significant marine gravel production.

Sand in the South Island and lower North Island is obtained from rivers and a few beach deposits, sometimes supplemented with dune sands. In areas such as Otago and Canterbury, gravely quartz sands of Cretaceous to Tertiary age are washed and screened to yield various grades suitable for ready-mixed concrete and masonry.

Where gravels are not available in the North Island, the ready-mixed concrete industry uses an all-passing 5mm or 7mm crushed aggregate, blended with river, inshore marine or dune sand for fine aggregate. This 7mm/5mm down material is usually sourced from the tertiary stage of the processing plant as a by-product of chip production, any deleterious materials having been removed by earlier crushing and screening.

The Auckland concrete market is supplied with sand dredged from the sea, and from the Waikato river to the south of the city. The sea sand is extracted from a depth of approximately 10m by suction dredge mounted on a barge and is then screened to remove shell. Salt is not washed out. Again the sustainability measure dictates the rate of production.

Both ancient and recent deposits of the Waikato river are worked in the South Auckland and central North Island regions. River sand is lifted by suction dredge and pumped or barged ashore for processing. On-shore deposits are excavated by means of rubber-tyred loaders. The material is gravely sand comprising pumice, rock fragments and single mineral grains of quartz, feldspar, dark silicates and magnetite. Separation using jigs, Humphrey spirals, Wright trays and screens yields concrete sand (free of pumice), masonry and drainage sands and fine gravel and various grades of pumice for horticultural and light-weight aggregate use. Until recently most of the premium pumice was used in gypsum wallboard manufacture.

While some of the dune sands of the east coast of the North Island are used in concrete blends, those of the west coast are considered to be too fine for the 'all-passing' blend and the dark colour and high density also make them unsuitable. Dune sands are, however, widely used for drainage and site preparation.

RESERVE ESTIMATION AND DEFINITION

Few quarries have been explored in detail. Most began in rock exposures without exploration but have subsequently been investigated to some extent by drilling and occasionally by geophysical methods.

Except in the larger quarries, survey control is generally poor or absent. Lower cost photogrammetry and computerised survey and map production will enable even the smaller operations to afford proper map coverage and survey control.

Recently established or expanded quarries have been more fully investigated, partly because of the need to prove, or at least indicate, a reserve prior to investing capital in plant and development, and partly to satisfy increasing demands for information from consenting authorities or agencies. The need to provide comprehensive Management Plans as part of the consent application process, will encourage applicants to define their resources and their development strategy.

Commonly, particularly in smaller quarries, because of cheapness (up to NZ$20/m) the only investigation carried out has been with rotary-percussion holes which yield poor sample reliability. Regrettably this has invariably been without survey control or professional supervision. Recently there has been a growing preference for reverse-circulation drilling because of the lack of sample contamination and the still modest cost (NZ$50/m).

Refinement of geophysical methods over the last five to ten years has resulted in promising applications of seismic refraction and resistivity analyses to identify structural complexities and to indicate where drill holes are needed.

Face mapping is a cost effective tool that if carried out over a number of years on controlled plans can be used to augment drilling information and provide reliable definition of resources. face mapping of the geology and the source of products will become more common as more aggregates, even the lower grades, become "Specified" as customers, particularly Transit New Zealand demand greater quality control under the umbrella of ISO 9000.

Computerised orebody modelling and mine planning tools are gradually becoming accepted in the Industry, enabling reliable and cost effective resource estimation and development planning.

QUARRYING METHODS

Soil and any overburden is generally removed and transported using motor-scrapers and/or bulldozers equipped with rippers. In more confined or smaller sites, an excavator and dump truck combination is often used.

With the exception of fresh basalts and gravels, below the strip bench there will usually be a 10-20m thickness of moderately to highly weathered rock used for GAP (general all-passing) products for low-quality roadworks and site preparation. The viability of a quarry depends to a large extent on the market for these materials.

The slightly weathered to fresh faces below the GAP faces comprise the premium stone of the quarry, used for concrete aggregates, surface chip and high-quality basecourse materials. Hydraulic excavators have almost entirely taken over from rope machines and wheel loaders at the face because of their versatility and suitability for the selective removal of deleterious materials or spalls. The versatility of excavators also makes them the choice for small operations where only one or two machines can be justified. Some small quarries and pits use wheel loaders in a load-and-carry operation from the face to the plant, eliminating the need for dump trucks.

Faces were commonly up to 30m high but there is now a trend towards reducing face height to 15m, commonly with a minimum bench width of one-half of the face height, as specified in the Quarries Regulations. Geotechnical investigation can often demonstrate the potential or need to vary from this requirement.

Few quarries drill and blast their overburden, but most drill the GAP and premium rock faces. In the Wellington region, however, where the greywackes are normally intensely fractured, all rock is commonly removed without drilling and blasting by ripping and blading with a bulldozer or by digging with a hydraulic excavator of about 40 tonnes.

ANFO is generally considered to be the most cost-effective explosive, with packaged explosives used only for wet conditions or for the base charge. Because of the relatively small volumes used, geographic isolation and the small hole sizes (76-100mm) bulk explosives have rarely been used in quarry blasting. Trials of bulk emulsions are being carried out and appear promising for the larger operations located near main centres.

Electric delays have been widely used, but are being phased out as supplies become restricted. Some operations still use safety-cord initiation. Delay blasting and in particular, sequential non-electric initiation have become widely used in response to environmental pressure and are contributing to better fragmentation and lower costs.

Mobile equipment is usually repaired and rebuilt to last much longer in New Zealand than overseas. The last 10-20 years have seen a change to the common use of hired equipment.

PROCESSING

Processing plants in New Zealand show similar variability, in relation to the nature of the raw material and the required product mix, to other parts of the world. Some generalisations can, however, be made:

1. The numerous small plant operators tend to be very innovative, designing and manufacturing a large proportion of their processing plant themselves.

2. Smaller plant sizes result in small primary crushers and the need for substantial secondary breakage at the face: drop-balls and explosives have largely been replaced by hydraulic breakers for this work in the larger operations.
3. Plants are required to be flexible, to allow for changes, to produce a wider range of products and to give a longer life.
4. Stone shaping has always been necessary in chip production, but concrete manufacturers now demand better shape to achieve a lower cement demand and improved workability, where naturally rounded gravel deposits are not available. Barmac vertical-shaft impactors, developed in New Zealand are affordable to purchase and run, and have largely replaced other shaping machines.
5. Wear factors are generally low in New Zealand: basalts are comparatively soft and greywackes are only moderately abrasive.
6. Greywacke quarries, with their need for the removal of deleterious materials, usually have high water usage, large ponding areas and pond-sediment disposal problems. There is a sensible trend towards closed circuit settling, thus avoiding discharge to natural water.
7. Track-mounted self-propelled crushing plants are not yet in use in New Zealand and the high capital cost of the machines and associated conveyor systems will probably limit their use to green field operations.

A typical plant has a capacity of 100,000-200,000 tonnes/year is fixed, located near an urban area, and consisting of a 914mmx610mm jaw primary followed by a 1,220mm secondary cone and a Barmac vertical-shaft impactor tertiary. Screens are almost invariably small at 2,438mm x 1,220mm, with final sizing being achieved by a 6,096mm x 1,220mm horizontal washing screen, supplying multiple products to short stacking conveyors or small drive-under bins.

Screens in closed circuit are inclined, seldom larger than 3,048mm x 1220mm , but final sizing is frequently carried out on one or two horizontal screens with heavy water-sprays for washing.

Alluvial plants either supply road aggregates with railway ballast or road and concrete aggregates. In the former case, the smaller sizes will be scalped to waste and only the larger stones crushed, in order to achieve sufficient broken faces in the product. The popular choice of primary crusher in gravel plants is a Kue Ken double-toggle jaw crusher, sized to suit the feed.

There is a strong trend towards modular, semi-mobile processing plants that can operate at the face. There is also a strong trend towards processing to upgrade or add value to products. Plant has to conform to tougher occupational safety and health requirements as well as being versatile and more efficient..

GOVERNMENT REGULATION

After a period of more than three years, involving unprecedented public participation, all natural resource legislation has been reviewed and, as a result, on 1 October 1991 the Resource Management Act and Crown Minerals Act became operative, replacing more than 60 previous Acts. The Resource Management Act deals with all matters concerning natural resources except for management (allocation) of the Crown's mineral resources (minerals

underlying Crown land and all petroleum, gold, silver and uranium) which are the subject of the Crown Minerals Act. The Resource Management Act is having a fundamental influence on the Aggregates Industry as it is on Mining in New Zealand.

Sustainability is the cornerstone of the Resource Management Act. The concept is intended to reflect substantial public concern to prevent further serious environmental degradation. Sustainable development is development which can be maintained in the long term, without destroying or undermining the resource base on which it rests. Minerals are excluded from the sustainability test, although the effects or impacts associated with the extraction process are not.

The Act moves away from the prescriptive controlled uses of the numerous previous statutes to the control of the effects of activities, i.e. unrestricted but with acceptable outcomes in terms of impact on resources. National standards are to be defined, with the intention that these will be the 'bottom line' on effects, such as minimum flows or water quality of streams, beyond which unacceptable environmental degradation might occur.

Resource users are currently participating in the formulation of government policy statements and regional, district and coastal plans which will provide the framework for future development activities.

Despite the intention of streamlining procedures, the Act contains a potential for even greater delays than currently occur, particularly during the settling-in period. Its success will depend to some extent on goodwill and a desire to make it work on the part of the participants.

Decades of case law have been affected, to an extent which has yet to be determined. There is great concern in the industry that provisions requiring developers to pay investigation, reporting and other costs lack clear guidelines and upper limits and, along with unrestricted public participation in the process, could result in much higher costs.

In formulating regional and district plans, and in making applications for resource consents, the principles of the Treaty of Waitangi must now be taken into account. This apparently means consultation and having regard for the relationship of the Maori people and their culture and traditions with their ancestral lands, water sites, sacred sites etc. Few people, however, profess to know how this will operate in practice.

Many quarries and pits have not been subject to specific statutory requirements to produce plans for management, rehabilitation or end use, but with the new legislation all operations will, after a transition period, be subject to management plans and controls. This in turn will encourage operators to define their stone reserves and plan their operations to a far greater degree than in the past. The security of an operator's investment in a quarry operation will to a great extent depend upon obtaining and maintaining the necessary consents.

Regional and district councils have not generally planned for protection of mineral resources: the urban development of Auckland, covering extensive basalt deposits, clearly illustrates this. Nor has district planning provided buffer zones around existing quarries and pits. It had been hoped that the new legislation would substantially improve this situation but the indications are not promising. As reserves are depleted and the resource development options become more limited the consumer will pay more for the product. It is worth noting that the current

consumption of aggregates in New Zealand is approximately 7 tonnes per person worth approximately $60 per person.

Another piece of legislation, the Health Safety and Employment Act 1992 will have a significant influence on the management of safety and health issues in quarries.

ENVIRONMENTAL MEASURES

New provisions significantly increase the exposure of companies, directors and managers to environmental liability and stiff penalties, including imprisonment. This has already resulted in companies looking more carefully at their environmental responsibilities to set up improved management and monitoring systems.

Examples of the mitigation of environmental effects are becoming more apparent. However, improvements take time at the longer established sites. Many of the improvements are best achieved by progressive improvement to the operating and management procedures that are employed day to day.

Many sites now have some bunding, usually planted, to attenuate noise and soften visual impacts. Apart from this bunding and some enclosures around noisy plant in more sensitive areas, there are generally no specific measures taken such as rubber liners and screens to suppress noise. A few of the larger quarry companies carry out regular blast-vibration monitoring but most do not. Most operators suppress dust on haulage, stockpiling and working areas using water-bowser trucks and, in the plant, by the application of water-sprays.

Regional Councils actively ensure compliance with water and soil legislation. Water Management plans are being required. The key to such plans is the reduction in the areas disturbed at any one time, the use of revegetation and the control of storm-water run-off from working areas through settling ponds. Compliance with new Standards may require the use of flocculants to facilitate removal of solids to an acceptable level typically of about 50ppm.

Care must be taken with the disposal or storage of overburden that cannot be sold or disposed off off-site. The technique of end-tipping of overburden is being replaced by controlled placement or bunding of particularly weak materials.

A number of New Zealand operations have been rehabilitated in the late stages, mostly to recreation reserves, industrial estates or pasture. Clean-fill is often used and more planning and ongoing rehabilitation will be necessary in future.

Where backfilling with refuse or sanitary fill has been done, until recently it has generally been without any lining materials or leachate and gas control systems. Environmental impacts have generally not been severe because of the small volumes involved.

In the last few years a large proportion of Auckland's refuse has been disposed of in the Greenmount Quarry, owned by W. Stevenson Ltd, as each stage of the quarry became worked out. Waste Management are currently commissioning a sanitary landfill site in conjunction with the Redvale Lime Quarry.

Because of the small size of many quarries, secondary uses like grazing and forestry, during the life of the quarry, have generally not been viable on a stand-alone basis but, with the benefits of screening, noxious weed control, storm-water run-off control and other environmental enhancements effects, they are worthwhile and commonly practised. Limitation of the extent of the actual quarry operation to say 30% of the property area may be required under certain district plans, currently under preparation. This coupled with the increasing need for buffer zones to protect the visual amenity or control noise vibration and dust levels at the property boundary will encourage secondary uses.

Isaac's Gravel Quarry near Christchurch has been progressively developed into a park and salmon farm, based on a high flow of cool, clean groundwater encountered in the pit and is an example to the industry.

EDUCATION AND PROFESSIONALISM

With the exception of a few larger companies, quarry managers and staff rarely have university or polytechnic degrees. Versatility is considered to be a virtue, particularly in the smaller operations.

In the past the Quarries Inspectors have provided valuable professional and technical input. However, with the likely transfer of the Inspectorate to the Department of Labour this input is likely to diminish.

Managers of small operations, who do not have specialist staff, can engage consultants with suitable skills but frequently this does not happen. The results are seen too often in poor productivity, lack of quality control and unacceptable environmental impacts.

The Institute of Quarrying education programme is now having a very beneficial effect in improving the technical knowledge of staff. These courses are constantly under review to raise standards but are threatened by underfunding and low enrolment. The courses may not teach all of the specialist knowledge required in quarry management, but they give a sound basic understanding and an appreciation of when to seek specialist assistance.

The Aggregates Association of New Zealand represents the commercial interests, while private individuals' professional interests are catered for by the Institute of Quarrying.

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