

REPORT

WHANGAREI DISTRICT COUNCIL

**Mine Subsidence Hazard
Kamo Area, Whangarei**

Report prepared for:
WHANGAREI DISTRICT COUNCIL

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1 Introduction

In 1999 Whangarei District Council (WDC) engaged Tonkin & Taylor Ltd (T&T) to undertake a re-assessment of the subsidence hazard resulting from the underground mining of coal in the Kamo area, Whangarei. The scope of work is set out in T&T's proposal dated 23 August 1999, and authority to proceed with the re-assessment was given by Ms Alison Geddes on 30 August 1999, and T&T reported in October 1999.

The purpose of that report was to provide Council with a basis for the preparation of an updated and revised policy on development within the areas in Kamo identified as being subject to possible mine subsidence. At the meeting of Council on 5 April 2000, Council resolved:

“That the council’s policy with respect to Section 36(2) of the Building Act and Mine zone areas be amended by the addition of the following:

1. That areas in zones one and two indicated in the Tonkin and Taylor report (figure 1 zones 1 and 2 to the west of zone 3) will require building consents be granted under 36(2) with the appropriate engineer’s report, unless the engineer can show council (subject to expert review by council’s consultant) that Section 36 is not applicable or that the hazard can be mitigated:

AND

subdivision and landuse requests associated with building development, will require an appropriate engineer’s report, subject to expert review with regard to the Tonkin and Taylor report.

2. That no building will be permitted within 20 m of a mine shaft, crown hole or mine entrance unless it can be demonstrated that the hazard can be mitigated or that building damage can be prevented.
3. That in all areas which are undermined (zones 1, 2 and 3) building design and construction must make allowances for potential subsidence.”

That report has now been revised in light of experience over the last five years, and changes to the new Building Act 2004, which took effect in its entirety on 31 March 2005.

2 Background

Following the discovery of coal in 1865, underground mining was undertaken beneath the Kamo area from 1876 until 1955. The coal was extracted by room and pillar method, and the mining history is summarised in Tonkin & Taylor Ltd (1984).

Room and pillar methods of coal extraction rely on the coal pillars being left to support the overburden. Such methods typically extract about 20% of the coal resource. However, it was common practice to further work the coal pillars after the initial extraction, leading to either collapse of the mine roof or the punching of the pillars into the mine floor. Collapse of the mine roof can lead to the development of crown hole subsidence, whereas punching failure or collapse of the pillars can lead to the development of trough subsidence, as shown on Figure 1.

In 1977 a crown-hole occurred at 14 Wakelin Street, and in 1980 a large trough subsidence occurred in the general vicinity of the intersection of Grant and Boswell Streets.

Figure 1: Types of subsidence: a) crown-hole and b) trough subsidence

(After Van Besien and Rockaway, 1988)

As a result of these incidents, and the requirements of the Town and Country Planning Act 1977, and 1979 and 1981 Amendments to the Local Government Act 1974 (refer Section 3), WDC engaged John St George (a mining engineer now with the University of Auckland, Department of Resource and Civil Engineering) to undertake an assessment of the mine subsidence hazard, and his findings are summarised in J.D. St. George (1981), 1982(a), (b), (c), (d), (e) and (f).

This work was reviewed by a U.S. expert in coal mine subsidence Professor Nolan Aughenbaugh. As a result of the work undertaken by John St George, and a DSIR geologist G.D. Mansergh (1982), the Kamo area was subdivided into three (3) zones of relative mine hazard.

In December 1982, WDC adopted a policy for building and subdivision in the mine zones, and this is set out in Appendix A. That policy put significant restrictions on development in Zone 1, and any development was generally subject to Section 641(a) of the Local Government Act (refer Section 3).

In 1983, WDC engaged T&T to undertake a review of the mine subsidence hazard, and the findings of that review are summarised in T&T report dated January 1984. In addition to Dr Laurie Wesley of T&T, the review team included Mr Richard Gray, another U.S. expert in coal mine subsidence.

As a result of the 1983 review, the mine hazard zoning was refined but the mine hazard zones in the Proposed Whangarei District Plan (1998) are essentially those developed by John St George in 1982.

In December 1995, WDC updated the policy for building in the Kamo mine zones, and this is set out in Appendix B. This update was necessary as Section 36(2) of the Building Act 1991 (BAct) had superseded Section 641(a) of the Local Government Act 1974.

In June 1999, WDC undertook a review of the virtual blanket use of Section 36(2) of the BAct in the Kamo mine zones and decided to commission T&T to revisit the study with a view to re-assessing the hazard and the WDC policy on development. The policy dated April 2000 resulted from the T&T report.

A review of natural hazards information for Whangarei District was undertaken by the Institute of Geological & Nuclear Sciences (GNS) and their findings are presented in their report dated July 2003. IGNS concluded that *"it is apparent that significant, useful and definitive work has already been carried out to determine the subsidence hazard above the old mine workings at Kamo. Old mine maps in the possession of GNS confirm the extent of the old mine workings at Kamo shown on Figures 1 and 6 of the District Scheme."*

"We have obtained copies of the Kelsey (1980), St George (1981), and Tonkin & Taylor reports on which this hazard zonation appears to be based, and we have been able to review the methodology used to assess the subsidence hazard zoning at Kamo. We are satisfied that a useful, practical and workable system is in place to allow for the potential for mine subsidence at Kamo."

" We recommend that the current status of all shafts and drives are carefully evaluated and their locations clearly marked on the planning maps. In addition a check should be carried out on the other small areas of coal mining in Whangarei District to ensure they are treated in a similar manner to Kamo."

This current review by Tonkin & Taylor Ltd specifically addresses the hazard in the context of the Resource Management Act 1991 and the Building Act 2004, with a view to updating the Council policy of April 2000.

3 Statutory responsibilities in relation to mine subsidence hazard

There are two primary pieces of legislation which define the responsibilities of WDC for the management of land hazards including subsidence. These are the Resource Management Act 1991 (RMA) and the Building Act 2004 (BA).

3.1 Resource Management Act 1991

The overall purpose of the RMA is to promote the sustainable management of natural and physical resources and WDC has responsibilities under the Act for the avoidance and mitigation of natural hazards.

The specific functions of WDC are defined under Section 31 of the RMA, and include the avoidance and mitigation of natural hazards through the control of land use and subdivision.

Section 31(b) states that every District Council has, as a function:

The control of any actual or potential effects of the use, development, or protection of land, including for the purpose of the avoidance or mitigation of natural hazards.

To carry out these functions, WDC must produce a District Plan which describes how resource management issues will be managed to achieve the sustainable management of natural and physical resources. Section 74 of the Act requires that the District Plan be consistent with the relevant Regional Plan and Regional Policy Statement, thereby ensuring the integrated management of the natural and physical resources of the region and district.

With respect to the subdivision and use of land, WDC has requirements relevant to the avoidance or mitigation of natural hazards. Section 106 (g) specifies that a consent authority shall not grant a subdivision consent for:

- “(a) Any land or any structure on that land (which) is or is likely to be subject to material damage by erosion, falling debris, subsidence, slippage, or inundation from any source; or*
- (b) any subsequent use that is likely to be made of the land (that) is likely to accelerate, worsen, or result in material damage to that land, other land, or structure, by erosion, falling debris, subsidence, slippage, or inundation from any source.”*

unless the consent authority is satisfied the effects of the proposed subdivision will be avoided, remedied or mitigated.

It is generally impractical to remedy or mitigate the hazard which undermining presents and hence one approach to address the hazard is to avoid it by preventing development. This is certainly true for the undermined areas of Kamo, and needs to be reflected in any amendments to the current (April 2000) policy.

3.2 Building Act 2004

The purpose of the BA is to provide the necessary controls over building works, use and safety. Under this Act the obligations for managing building works in relation to natural hazards are solely the responsibility of the District Council.

The BAct requires WDC to refuse the granting of a building consent for construction of a building, or major alterations to a building, if:

Section 71(1)

- (a) *the land on which the building work is to be carried out is subject or is likely to be subject to 1 or more natural hazards; or*
- (b) *the building work is likely to accelerate, worsen, or result in a natural hazards on that land or any other property.*
- Unless (2) *the building consent authority is satisfied that adequate provision has been or will be made to:*
- (a) *protect the land, building work, or other property referred to in that subsection from the natural hazard or hazards; or*
- (b) *restore any damage to that land or other property as a result of the building work.*
- (3) *In this section and sections 72 to 74, natural hazard means any of the following:*
- (a) *erosion (including coastal erosion, bank erosion, and sheet erosion)*
- (b) *falling debris (including soil, rock, snow, and ice)*
- (c) *subsidence*
- (d) *inundation (including flooding, overland flow, storm surge, tidal effects, and ponding)*
- (e) *slippage.*

72 *Building consent for building on land subject to natural hazards must be granted in certain cases*

Despite section 71, a building consent authority must grant a building consent if the building consent authority considers that:

- (a) *the building work to which an application for a building consent relates will not accelerate, worsen, or result in a natural hazard on the land on which the building work is to be carried out or any other property; and*
- (b) *the land is subject or is likely to be subject to one or more natural hazards; and*
- (c) *it is reasonable to grant a waiver or modification of the building code in respect of the natural hazard concerned.*

73 *Conditions on building consents granted under section 72*

- (1) *A building consent authority that grants a building consent under section 72 must include, as a condition of the consent, that the building consent authority will, on issuing the consent, notify the consent to:*
- (a) *in the case of an application made by, or on behalf of, the Crown, the appropriate Minister and the Surveyor-General; and*
- (b) *in the case of an application made by, or on behalf of, the owners of Maori land, the Registrar of the Maori Land Court; and*

- (c) *in any other case, the Registrar-General of Land.*
- (2) *The notification under subsection (1)(a) or (b) must be accompanied by a copy of the project information memorandum that relates to the building consent in question.*
- (3) *The notification under subsection (1)(c) must identify the natural hazard concerned.*

It is generally impractical to protect or restore the land, building work or other property against subsidence, although with appropriate design it is possible to reduce the damage to buildings arising from mine subsidence.

3.3 Community expectations

Prior to the RMAct and the BAct, subdivision and building in potentially hazardous areas was controlled by the Town and Country Planning Act 1977 and the Local Government Act 1974.

The Abbotsford landslip disaster and subsequent commission of enquiry highlighted the very much greater expectation the public has of local authorities, and the demand for councils to put more effort into their land subdivision and building permit control. Parliament, anxious to protect property owners from the considerable loss that could result if land disappeared underneath them, obliged with Sections 274 and 641 of the Local Government Amendment Act in 1979. That Act made it difficult, if not impossible, for local authorities to allow subdivision or to issue building permits on land that was likely to be subject to, amongst other hazards, subsidence.

With the advent of the Local Government Amendment Act (1979), councils found administering subdivisional and building permit applications in terms of Sections 274 and 641 a bitter pill to swallow. Local authorities were suddenly faced with refusing building permits on land where they had earlier allowed subdivision to proceed, and developers and land owners saw potential profits threatened and brought pressure to bear. The public who found themselves restricted in hazard prone areas resented the loss of land value and loss of "freedom" to do what they wanted.

Accordingly, despite the clear conclusions and recommendations of the Commission of Enquiry into the Abbotsford Landslip Disaster which reported in November 1980, less than a year later the Local Government Amendment Act was yet again amended with Section 641(a) (now Section 72 of the BAct) which allows a local authority to issue a building permit where the land is subject to erosion, subsidence, slippage or inundation and not be under any civil liability (Rogers and Taylor 1986).

No amount of controls on development can produce zero risk in the urban areas of Whangarei District, and we do not believe that the community expects that to be achieved.

What the community can rightly expect, however, is that the actual and potential hazards are properly identified, and that the potential consequences are clearly explained. We believe the proposed Whangarei District Plan as amended by Council and 1995 policy and 2000 amendment appropriately fulfill this expectation, at least for building works.

3.4 Development controls in mine subsidence hazard areas

The need to deal with the control of development in hazard-prone areas is recognised and district plans are required to identify areas at risk, to state how the land is to be used, and to set down the ground rules indicating what an owner or occupier can or cannot do with property in hazard-prone areas.

WDC recognise (Section 7.2 of the Proposed Whangarei District Plan) that "subdivision and development are closely related as subdivision generally enables further development of a particular area of land to occur. Subdivision is therefore a key factor in determining future landuse patterns and is linked to the landuse expectations of land owners". "Most people who buy a vacant site do so with an expectation to be able to build a house or other building on the site." WDC also recognise that natural hazard identification, potentially affecting site suitability for anticipated land uses, is also linked to the subdivision process.

Under Section 7.4.13 (Natural Hazards) of the Proposed Whangarei District Plan

"To avoid, subdivision and development in areas where natural hazards including erosion, falling debris, subsidence, slippage, inundation, flooding and sea level rise may occur, unless adverse effects on health, safety and property can be avoided as far as is practicable or otherwise, remedied or mitigated."

Explanation and Reasons: "Many areas within the District may be subject to natural hazard. The likelihood and extent of damage may be aggravated by human activity. Major risks include erosion, flooding and inundation from the sea. The Regional Policy Statement requires both the Northland Regional Council and the Whangarei District Council to provide information on areas which have known natural hazard related problems."

"The Regional Policy Statement for Northland also requires the Northland Regional Council to undertake monitoring of coastal hazards and area of possible flooding. The policy also reflects the requirements of Section 106 of the Resource Management Act 1991."

Mining subsidence, although clearly caused solely by people, is included under the Natural Hazards section of the Proposed Whangarei District Plan. Section 38.6 sets out activities and rules for mining subsidence.

38.6 Mining subsidence	
<p>Construction or alteration of a building or earthworks in a Mining Hazard Area is permitted if:</p> <ul style="list-style-type: none"> a) A geotechnical survey of the ground under and in the immediate vicinity of the site is undertaken, and b) A report or certificate from a soils engineer approved by the Whangarei District Council is provided to the council which indicates that: <ul style="list-style-type: none"> i) The site is suitable for the activity or structure ii) The structure is of an appropriate design and the building materials are appropriate in the circumstances; and c) The risk of subsidence is not increased by the construction, alteration or excavation. 	<p>Any activity that does not comply with a condition for a permitted activity is a restricted discretionary activity.</p> <p>Discretion is restricted to:</p> <ul style="list-style-type: none"> i. Construction standards ii. Effects on health and safety iii. The additional matters listed in Section 2.3.3.

Section 38.7 sets out Reasons for the Rules/Explanations:

Mining Subsidence

“The areas subject to possible mining subsidence are identified on the Planning Maps. A network of tunnels exists in the residential areas of Kamo and Hikurangi. The risk to properties situated above these old coal mining tunnels and to human life can be minimised by ensuring that any earthworks or structure is suitable and does not increase the likelihood of subsidence. This can be achieved by controlling the design and building materials of structures that are built in these areas.”

In the application of this rule, further urbanisation of the Kamo Mine Zones areas is occurring and significant areas have recently been subdivided. We believe that this was not the intention of the 1995 policy and 2000 amendment.

4 Mine hazard subsidence assessment

4.1 Mine subsidence hazard zones

From a review of the mine hazard work undertaken by John St George, Nolan Aughenbaugh, Graham Mansergh, Laurie Wesley and Richard Gray from 1981 to 1984, it is evident that the work was very thorough and in addition to extensive secondary data (maps, photos, plans and reports) utilised primary sources of data (particularly miners who worked in the Kamo coal mines) which are no longer available. From a review of the available data we have not identified any new information which would lead us to alter the current hazard zonations. Several new crown holes have become evident over the past five years in Zone 1, and an infilled sinkhole or shaft in Zone 2 became reactivated.

Initial concerns that the Kamo By-Pass roadworks may have resulted in increased effective stresses due to dewatering do not appear to have been realised, although further work is required to investigate this matter.

Accordingly, we consider that the zones as currently delineated on the planning maps, adequately reflect the potential hazard and should remain unchanged.

4.2 Risk

The issue of risk needs very careful consideration in its application to the Kamo mine area. The risks associated with the undermining beneath Kamo also needs to be considered in the context of other risks associated with natural hazards, in both the Kamo area and in the wider District.

All living involves risk taking and from an aspect of natural hazards, Whangarei is a relatively risky place to live. Hillslope properties are potentially subject to landslip, and low lying properties are actually or potentially subject to flooding. Erosion threatens many coastal properties.

In the Kamo area, properties are at risk of subsidence as a result of undermining (extraction of coal). The fact that the subsidence hazard in Kamo is due to coal extraction and hence not a 'natural' hazard (Act of God) is only relevant with respect to insurance considerations.

The test which WDC is required to meet in terms of its statutory obligations under both the RMA and the BAct, is whether or not subsidence is likely to occur to a particular area of land or building site.

Risk is defined as the probability of a hazard (in this case mine subsidence) occurring multiplied by the consequences (in this case damage to buildings and other property). Accordingly, the more the Kamo area is urbanised, the greater the risk will be of damage to buildings.

In Zone 1 which covers an area of 13 hectares (ha), a risk of crown-hole development clearly exists due to the close proximity of the undermined areas to the ground surface. Several isolated properties have been subject to crown-hole subsidence events, and hence the risk is not just theoretical. However, even in Zone 1 there is no evidence to suggest that any particular property is likely to be subject to subsidence, unless it has been so in the past, or is located close to shafts or drives. The number of crown-holes appears to be less than 25, and the area of land involved is probably less than 2,000 m² (0.2 ha).

In Zone 2, which covers an area of 105 ha, a risk of trough subsidence development also clearly exists, and many properties were subject to subsidence as a result of a single event in 1980. The number of trough subsidence events is unknown, but the 1980 event alone affected nearly 3ha. In Zone 2 there is no evidence to suggest that any particular property is likely to be subject to subsidence, unless it has been so in the past.

In Zone 3, which covers an area of 139 ha, trough subsidence is possible but unlikely to result in significant surface deformation. Accordingly, even in the event of subsidence occurring, this is unlikely to result in significant damage to structures on the ground surface.

Collapse of shafts and drives pose specific localised risks to nearby structures and these need to be identified and managed on a case by case basis. These areas of specific risk are already addressed under the 1995 policy (refer Appendix B).

As discussed in the Tonkin & Taylor Ltd 1984 report, the factors associated with subsidence over abandoned mines mean that the timing and location of subsidence events cannot be predicted with any reliability. Also, the area involved is relatively small and the number of events is so low that it is not possible to carry out a statistical analysis and to use this as a basis for predicting likely trends in subsidence events in the future.

Since eleven (11) properties were damaged as a result of the 1980 trough subsidence in the vicinity of Grant and Boswell Streets, no subsidence events have been recorded by WDC. What we can state, however, is that where the competent rock cover is greater than 10 times the mined coal seam thickness (Zone 2) crown hole subsidence is unlikely to occur, and where the rock cover is greater than 100 m (Zone 3), trough subsidence is unlikely to be sufficiently great to cause significant damage. In Zone 3, the differential settlements arising from trough subsidence are likely to be within the tolerance limits for most structures.

In 2003 an apparent sinkhole appeared in Zone 2. This was not a new event, however, as it had previously been infilled and the infill material had merely migrated down the same opening also. Although there was no evidence of any support, it may also have been an excavated shaft rather than a sinkhole. Several small new sinkholes have, however, appeared in Zone 1 over the last five years.

Another issue which is important is the status of the flooded mine. The current 'apparent' stability of some of the undermined areas in Kamo may in part be due to the fact that the mine is flooded. It must be appreciated that should this situation change (e.g. draining parts of the mine by pumping from groundwater bores) then the stability situation could deteriorate significantly. Accordingly, if it is to permit development over the old mine workings, Council may need to instigate controls on groundwater abstraction to ensure that mine draining does not occur. It is possible that the Kamo by-pass has led to dewatering which could have an affect on subsidence but to date this issue has not been investigated in sufficient detail to draw any definite conclusions.

4.3 Consequences of mine subsidence

As set out in Tonkin & Taylor Ltd (1984), the subsidence arising from crown-hole or trough development in the Kamo area would not normally pose any threat of personal injury or loss of life, and that overseas experience has been that cases of personal injury resulting from mining subsidence are so few as to be of almost negligible significance. Perhaps the greatest threat to people would be a crown-hole developing in the road.

Recent risk assessments undertaken for the Kamo By-Pass (Opus, International), the Fairfield By-Pass south of Dunedin (Stewart & Glassy, 1998), and the Allison No 2 mine in Huntly (Tonkin & Taylor Ltd, 1994) have emphasised the generally low probability of crown-hole and trough subsidence events in New Zealand arising from underground coal mining and the high cost for mitigation. The lithologies (rock types) overlying the Kamo coal measures are relatively strong, which should limit both the depth and extent of subsidence events. Accordingly, even if mine subsidence occurs, the subsidence at the ground surface is most likely to be relatively shallow and gradual. The most likely consequences of future mine subsidence events are therefore damage to buildings due to differential settlement.

In addition to houses and other private structures, the Kamo mine zones are partially covered by a network of public roads and services (sanitary sewer and stormwater pipes), as shown on Figure 3. These structures act as strain gauges, and sharp differential settlements arising from subsidence should be reflected in damage to kerb lines, footpaths, roads and pipelines.

Unfortunately WDC do not maintain a damage register for roads and services which may indicate subsidence. However, from discussions with WDC staff there do not appear to be any particular or persistent problems with the roads or services in the Kamo area.

Survey points have been established throughout the Kamo area since at least 1966-68. Re-surveys of these points (shown on Figures 2 & 3), in 1980 - 82 indicated up to 118 mm of settlement (at Wakelin St) had occurred over the 13 - 16 year period. However, apparent settlement of up to 68 mm of areas outside the mine zones cast considerable doubt on the accuracy of the survey data. Further survey work is recommended.

Following a walkover reconnaissance of the Kamo mine zones in 1999, nine (9) properties were shortlisted for inspection to provide some performance benchmarks. Of these, seven (7) were inspected in detail. The selection criteria included the approximate age of the building (as old as possible) and their construction (as brittle as possible), and their location with respect to drives, shafts and areas of known subsidence.

Of the seven properties inspected, four properties are in Zone 2, two are in Zone 1 and one is in Zone 3. Re-inspection of these properties in 2005 indicated no evidence to suggest ground subsidence. Most of the properties were in good conditions and exhibited no evidence of differential settlement due to ground subsidence. Where damage was evident, shrink-swell movement of the ground was the most likely cause of damage. Indeed, given the high plasticity and shrinkage potential of the soils in the Kamo area, soil shrinkage probably poses the most significant threat to building damage.

5 Discussion

From a review of the available data it is clear that the development controls imposed for the various hazard zones in 1982 and 1983 were strongly influenced by:

- The subsidence events of 1977 and (in particular) 1980
- The amendments to the Local Government Act in 1979 and 1981
- The Abbotsford Landslip disaster and subsequent Commission of Enquiry
- The cautious approach of the U.S. experts, Professor Nolan Aughenbaugh and Mr Richard Gray.

Based on our re-assessment of the hazard and the risks associated with mine subsidence in the Kamo area, we believe that the current controls on building works are appropriate.

With the possible exception of Zone 1, areas in Zone 2 exhibiting evidence of past subsidence, and areas close to shafts and drives, WDC should be able to grant consent for building in the hazard zones without resorting to Section 72 of the Building Act.

Issuing building consent under Section 72 implies that damage is likely to occur, which impacts negatively on property values. Under the Third Schedule of the Earthquake Commission Act 1993 (EQC Act), the Commission may decline a claim for natural disaster damage where the building consent is granted under Section 36(2). It is anticipated that changes to the EQC Act will include a similar reference to S72 of the B Act 2004.

We believe that WDC should adopt a cautious approach to allowing further subdivision in the area, particularly at green-field sites. There can be no doubt that the best way to reduce damage to buildings and minimise the distress to people is to prevent development on areas where a hazard has been identified. This is particularly so for the Kamo areas which have been undermined, as it is generally not practicable to mitigate the hazard. Evidence of past or incipient subsidence is also very difficult, if not impossible, to detect on a green-field site, given the relatively small amounts of deformation which would be expected in Zones 2 and 3. As a land use on undermined land, the Denby Golf Course appears to be particularly appropriate.

The more the Kamo hazard zones are urbanised, the greater the risk will be of property damage due to mine subsidence. Accordingly, we recommend that no further subdivision of land be permitted in Zone 1 and Zone 2, and a restriction be placed on the extent of land subdivision in Zone 3.

Mine subsidence is not the only hazard associated with the Kamo coal mines. Mine gas (primarily methane) and fire (due to spontaneous combustion) also pose a threat (albeit slight) to people and property in the Kamo area, and consideration should also be given to these potential hazards in determining Councils future policy on urbanisation over undermined areas.

6 Conclusions

- The hazard zonations as shown on the Proposed (Whangarei District) Plan are considered appropriate and should be retained. Appropriate information should be recorded on all property files to alert current and future land owners of the potential for mine subsidence.
- With the exception of Zone 1 and areas in Zone 2 where previous subsidence has occurred, and areas close to shafts and drives, mine subsidence on any specific property is not considered likely to occur.
- Subsidence events are expected to continue to occur and further urbanisation on the undermined areas will increase the risk of damage to private property.
- Dewatering of the flooded mine works would increase the risk of subsidence.

7 Recommendations

- WDC should maintain the current controls on building works in the area, as set out in the 1995 Policy and April 2000 amendment.
- WDC should adopt a cautious approach on subdivision of green-field sites for urban development in areas which are undermined. We recommend that no further subdivision of land in Zone 1 or Zone 2 be permitted, and that the extent of subdivision of land in Zone 3 be restricted.
- A video surveillance programme should be initiated in the Kamo mine zones to check the integrity of the sanitary sewer and stormwater lines. Should lines be ruptured due to ground subsidence, leakage could cause erosion and further undermining to occur.
- A resurvey of survey marks in the Kamo area should be undertaken to identify areas of subsidence and to provide a basis for future assessments.
- WDC should investigate options for properties to be insured against subsidence in the Kamo mine zones.
- The WDC GIS should incorporate the location of all known crown-holes, subsidence areas, drives and shafts, and the location of these features should be made available to the public.
- Dewatering of the flooded mine should not be permitted unless it can be demonstrated that such dewatering will not increase the risk of subsidence.

8 **Applicability**

This report has been prepared for the benefit of Whangarei District Council with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

TONKIN & TAYLOR LTD

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**Appendix A: Policy for Building and Subdivision
in Mining Zones adopted by Council**

1st December 1982

Appendix A

Policy for Building and Subdivision in Mining Zones Adopted by Council 1st December 1982

Reworded to clarify the intention of the policy writer.

ZONE 1

All building permits are to be issued under Section 641A of the Local Government Act and are to be issued:

- a For the repair or replacement if any buildings are damaged by accident.
- b Generally for the extension or addition to service rooms only (as defined in NZSS 1900 Chapter 4).
- c For the erection repair or extension of any out-house, garage, shed or carport (up to 50 sq.m in area).
- d For the erection repair or extension of any porch or terrace, or
- e For the erection repair or extension of any fence or garden wall, including retaining walls.

The structure is to be designed to minimise the effects of any subsidence and/or is to be relocatable.

No further subdivision is allowed in Zone 1 unless such subdivision makes specific provision for the removal of the subsidence hazard.

ZONES 2 and 3

- i. All building permits are to be granted for building using normal domestic type building construction in the normal manner with the proviso that the design and type of construction be certified by a Registered Engineer as being suitable to minimise the effects of any possible mining subsidence.
- ii. All buildings other than normal domestic buildings are the subjects of special consideration and all permits are to be issued under Section 641(a) of the Local Government Act.

**Appendix B: Building Control Policy for Building
in the Kamo Mine Zone**

December 1995

Appendix B

Building Control Policy for Building In The Kamo Mine Zones December 1995

Introduction

This policy was updated to reflect the legislation of the NZ Building Act 1991.

Background

Coal mining was a major industry in the early development of Kamo. A network of worked tunnels still exists in the depths of land covering these tunnels and varies from area to area. The areas subject to possible mining subsidence are shown on Planning Map 6.

Mining was carried out by pillaring. Although the extent of workings and approximate depths are known for recorded workings, there are additional areas of unrecorded workings. The potential for subsidence depends on a number of factors, particularly the extent of the pillaring, whether subsidence has already occurred, and the depth of the workings. Present knowledge cannot discount subsidence occurring at any area underlain by mine workings.

The map shows three zones, which indicate the different depths of cover. Zone 1 indicates the area where there is a possibility of crown-holing and major subsidence due to there being less than 10 t cover, where t = seam thickness. Zone 2 indicates (a) areas where there is up to 10 metres of cover and "medium" subsidence is possible and (b) areas where there has been 2 seam pillaring and greater than 100 metres of cover exists. Possible problems associated with this zone would be surface settlement, horizontal strains and subsidence fracturing. Zone 3 indicates areas where there is greater than 100 metres of cover. Although this is a low risk zone, it is possible for buildings to be affected by minor subsidence.

The zones indicate the best information the Council has to date. There may be land within these areas where such classification is not needed and there may be land outside these areas where special care on such factors is important or where actual problems exist. For confirmation of zone boundary positions, reference must be made to detailed maps held by the Council.

Reason For Policy

To minimise the danger to persons and damage to property due to mine subsidence.

Policy

No building work is permitted where the risk of subsidence is increased by the proposal.

All Building Consents for building work in mining zones are to be considered in terms of Section 36(2) of the Building Act.

Construction methods used are to be compatible for any possible subsidence that may occur.

RULES

Zone 1

1. Building consents are only to be issued for:
 - i) Repair of existing buildings.
 - ii) Minor extensions to existing buildings.
 - iii) Erection of single storey accessory buildings not exceeding 50m² in area (e.g. carports, garages etc).
 - iv) Erection of fences, walls and retaining walls.
 - v) Single storey housing that can be transported intact, constructed using light weight building materials with the proviso that buildings or part thereof, located within a 20 metre radius of air shafts and mine entrances are supported with a full geotechnical appraisal by a suitable qualified engineer.
2. Building Consents are to be issued only to the owner of the property, under Section 36(2) of the Building Act, with an entry on the Certificate of Title to the land that a building consent has been issued in respect of a building on land subject to subsidence.

Zones 2 and 3

1. In all cases construction methods adopted must allow for potential subsidence and may require specific design.
2. Proposed Building Works or part thereof located within a 20 metre radius of air shafts and mine entrances are to be supported with a full geotechnical appraisal by a suitably qualified engineer.
3. The Council may issue Building Consents to the owner of the property, under Section 36(2) of the Building Act, with an entry on the Certificate of Title to the land that a building consent has been issued in respect of a building on land subject to subsidence.

Please note that although the rules are the same for both Zones 2 and 3, it is useful to maintain these zones to indicate the different potential for damage to a property owner considering development of the land.

Appendix C: Policy amendment, April 2000

Appendix C

"Your report A440855 to the meeting of council on 5 April refers.

Council resolved:

That the council's policy with respect to Section 36(2) of the Building Act and Mine Zone areas be amended by the addition of the following:

- 1. That areas in zones one and two indicated in the Tonkin and Taylor report (figure 1 zones 1 and 2 to the west of zone 3) will require building consents be granted under 36(2) with the appropriate engineer's report, unless the engineer can show council (subject to expert review by council's consultant) that Section 36 is not applicable or that the hazard can be mitigated:*

AND

subdivision and landuse requests associated with building development, will require an appropriate engineer's report, subject to expert review with regard to the Tonkin and Taylor report.

- 2. That no building will be permitted within 20 m of a mine shaft, crown hole or mine entrance unless it can be demonstrated that the hazard can be mitigated or that building damage can be prevented.*
- 3. That in all areas which are undermined (zones 1, 2 and 3) building design and construction must make allowances for potential subsidence.*

Please take any action required from this resolution."

T&T job no: 17464.002
05 December 2005

Whangarei District Council
Forum North
Private Bag 9023
Whangarei

Attention: Harvey Schroyen

Dear Harvey

Review and Usage of Mine Subsidence Hazard Zones for Kamo and Hikurangi

1 Introduction

Following your request 28th November we have reviewed the Mine Subsidence Hazard Zonations for the Kamo and Hikurangi, in order to produce an Addendum to our earlier reports for of 1999¹ and 2001² and 2005³.

2 Method

The Review involved:

- Searching our archives for data relating to the creation of mine subsidence hazard zones, investigation of the necessity for/methods of defining error bars/buffers on the zones.
- Production of a summary sheet of how the zones are defined and council's building requirements for each zone.

¹ "Mine Subsidence Hazard, Kamo Area, Whangarei"; Report for Whangarei District Council, March 1999; T+T reference 17464.

² "Mine Subsidence Hazard, Hikurangi Area, Whangarei"; Report for Whangarei District Council, January 2001; T+T reference 18596.

³ "Mine Subsidence Hazard, Kamo Area, Whangarei"; Report for Whangarei District Council, March 2005; T+T reference 17464.001 (update of the October 1999 report).

- Indication of appropriate use of mine subsidence hazard zones with respect to any uncertainty/error bar in the data.

We present our summary sheet in Appendix One.

We trust that this addendum clarifies the issues that relate to appropriate application of the mine zones we defined in our earlier reports. If you have any further questions, please do not hesitate to contact us.

3 Applicability

This report has been prepared for the benefit of Whangarei District Council with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

TONKIN & TAYLOR LTD

Environmental and Engineering Consultants

Report prepared by:

Authorised for Tonkin & Taylor by:

.....

.....

Marion Irwin

Nick Rogers

Engineering Geologist

Project Co-ordinator

Appendix A: Addendum to Tonkin and Taylor Reports:

1 "Mine Subsidence Hazard, Kamo Area, Whangarei"; Report for Whangarei District Council, March 1999; T+T reference 17464.

2 "Mine Subsidence Hazard, Hikurangi Area, Whangarei"; Report for Whangarei District Council, January 2001; T+T reference 18596:

3 "Mine Subsidence Hazard, Kamo Area, Whangarei"; Report for Whangarei District Council, March 2005; T+T reference 17464.001 (update of the October 1999 report).

<u>Mine Zone</u>	<u>Definition of Mine Zone</u>	<u>WDC Policy for Building in Kamo and Hikurangi Mine Zone</u>
<u>Zone 1</u> (high risk of subsidence)	Areas where there is less than 10xt cover, where t=seam thickness. Average tends to be about 20m, based on seam thickness of 2m. Within these areas there is a potential for “crown holing”.	<p><u>Zone 1</u></p> <p style="text-align: center;"><u>A) Building Control Policy for Building In Mine Zones</u></p> <p style="text-align: center;"><u>December 1995</u></p> <ol style="list-style-type: none"> 1. Building consents are only to be issued for: <ol style="list-style-type: none"> i) Repair of existing buildings. ii) Minor extensions to existing buildings. iii) Erection of single storey accessory buildings not exceeding 50m² in area (e.g. carports, garages etc). iv) Erection of fences, walls and retaining walls. v) Single storey housing that can be transported intact, constructed using light weight building materials with the proviso that buildings or part thereof, located within a 20 metre radius of air shafts and mine entrances are supported with a full geotechnical appraised by a suitable qualified engineer. 2. Building Consents are to be issued only to the owner of the property, under Section 36(2) of the Building Act, with an entry on the Certificate of Title to the land that a building consent has been issued in respect of a building on land subject to subsidence. <p><u>B) Policy Ammendment, 2000 adds</u></p> <ol style="list-style-type: none"> 1. <i>That areas in zones one and two indicated in the Tonkin and Taylor report (figure 1 zones 1 and 2 to the west of zone 3) will require building consents be granted under 36(2) with the appropriate engineer’s report, unless the engineer can show council (subject to expert review by council’s consultant) that Section 36 is not applicable or that the hazard can be mitigated:</i> <p style="text-align: center;">AND</p> <p style="text-align: center;"><i>subdivision and landuse requests associated with building development, will require an appropriate engineer’s report, subject to expert review with regard to the Tonkin and Taylor report.</i></p> <ol style="list-style-type: none"> 2. <i>That no building will be permitted within 20 m of a mine shaft, crown hole or mine entrance unless it can be demonstrated that the hazard can be mitigated or that building damage can be prevented.</i> 3. <i>That in all areas which are undermined (zones 1, 2 and 3) building design and construction must make allowances for potential subsidence.</i>
<u>Zone 2</u> (moderate risk of subsidence)	<p>1)Areas where overburden is between 20 and 10m thick. Within these areas there is a potential for “trough subsidence”, which could result in ground surface deformation, and damage to structures and services.</p> <p>2) areas where there has been 2 seam pillaring and greater than 100m cover exists. Possible problems associated with this zone would be surface settlement, horizontal strains and</p>	<p><u>Zones 2 and 3</u></p> <p style="text-align: center;"><u>A) Building Control Policy for Building In Mine Zones</u></p> <p style="text-align: center;"><u>December 1995</u></p> <ol style="list-style-type: none"> 1. In all cases construction methods adopted must allow for potential subsidence and may require specific design. 2. Proposed Building Works or part thereof located within a 20 metre radius of air shafts and mine entrances are to be supported with a full geotechnical appraisal by a suitably qualified engineer. <p>The Council <u>may</u> issue Building Consents to the owner of the property, under Section 36(2) of the Building Act, with an entry on the Certificate of Title to the land that a building consent has been issued in respect of a building on land subject to subsidence.</p> <p><u>B) Policy Ammendment, 2000 adds</u></p> <ol style="list-style-type: none"> 4. <i>That areas in zones one and two indicated in the Tonkin and Taylor report (figure 1 zones 1 and 2 to the west of zone 3) will require building consents be granted under 36(2) with the appropriate engineer’s report, unless the engineer can show council (subject to expert review by council’s consultant) that Section 36 is not applicable or that the hazard can be mitigated:</i>

	<p>subsidence fracturing. (ref T+T 17464.001 (2005))</p>	<p>AND</p> <p><i>subdivision and landuse requests associated with building development, will require an appropriate engineer's report, subject to expert review with regard to the Tonkin and Taylor report.</i></p> <p>5. <i>That no building will be permitted within 20 m of a mine shaft, crown hole or mine entrance unless it can be demonstrated that the hazard can be mitigated or that building damage can be prevented.</i></p> <p>6. <i>That in all areas which are undermined (zones 1, 2 and 3) building design and construction must make allowances for potential subsidence.</i></p>
<p>Zone 3 (low risk of subsidence)</p>	<p>Areas where depth to the workings is greater than 100m below the surface. Minor surface deformation is possible, but is unlikely to result in significant damage to structures.</p>	<p>Zones 2 and 3</p> <p style="text-align: center;"><u>A) Building Control Policy for Building In Mine Zones</u></p> <p style="text-align: center;"><u>December 1995</u></p> <p>3. In all cases construction methods adopted must allow for potential subsidence and may require specific design.</p> <p>4. Proposed Building Works or part thereof located within a 20 metre radius of air shafts and mine entrances are to be supported with a full geotechnical appraisal by a suitably qualified engineer.</p> <p>5. The Council <u>may</u> issue Building Consents to the owner of the property, under Section 36(2) of the Building Act, with an entry on the Certificate of Title to the land that a building consent has been issued in respect of a building on land subject to subsidence.</p> <p><u>B) Policy Ammendment, 2000 adds</u></p> <p>7. <i>That areas in zones one and two indicated in the Tonkin and Taylor report (figure 1 zones 1 and 2 to the west of zone 3) will require building consents be granted under 36(2) with the appropriate engineer's report, unless the engineer can show council (subject to expert review by council's consultant) that Section 36 is not applicable or that the hazard can be mitigated:</i></p> <p>AND</p> <p><i>subdivision and landuse requests associated with building development, will require an appropriate engineer's report, subject to expert review with regard to the Tonkin and Taylor report.</i></p> <p>8. <i>That no building will be permitted within 20 m of a mine shaft, crown hole or mine entrance unless it can be demonstrated that the hazard can be mitigated or that building damage can be prevented.</i></p> <p>9. <i>That in all areas which are undermined (zones 1, 2 and 3) building design and construction must make allowances for potential subsidence.</i></p>
<p>Notes</p>	<p>(The worked areas have been projected to the surface at an angle of 60 to the horizontal (angle of draw) to allow for the increased area that would be affected should subsidence occur. This means that deeper workings will have a greater projected area of potential subsidence than shallower workings.)</p>	<p>A) The 1995 Policy also states that:</p> <p style="padding-left: 40px;">“No building work is permitted where the risk of subsidence is increased by the proposal.</p> <p>All Building Consents for building work in mining zones are to be considered in terms of Section 36(2) of the Building Act.</p> <p>Construction methods used are to be compatible for any possible subsidence that may occur.”</p> <p>B) WDC Policy is now outdated, since the new Building Act 2004 took effect in its entirety on 31 March 2005.</p> <p>The relevant parts of Section 36(2) of Building Act 1991 are now replaced by Sections 72 and 73 of the Building Act 2004.</p> <p>C) Please note that although the rules are the same for both Zones 2 and 3, it is useful to maintain these</p>

		<p>zones to indicate the different potential for damage to a property owner considering development of the land.</p> <p>D) T+T ref. 17464.001 has the additional suggestion that:</p> <p>“WDC should adopt a cautious approach on subdivision of green-field sites for urban development in areas which are undermined. We recommend that no further subdivision of land in Zone 1 or Zone 2 be permitted, and that the extent of subdivision of land in Zone 3 be restricted.”</p>
<u>T+T reference</u>	<p>Mine Subsidence Hazard, Hikurangi area, Whangarei. Report for Whangarei District Council, 2001). T+T ref. 18596</p>	<p>Mine Subsidence Hazard, Kamo area, Whangarei. Report for Whangarei District Council, 2005). T+T ref. 17464.001</p>
<u>Application of Mine Zonations</u>	<p>A) The mine zones are drawn conservatively, so that their boundary represents the outermost limit of possible subsidence. In other words, any error bar/ uncertainty buffer is included within the zone itself.</p> <p>B) The rules that apply to any proposed building work are defined by taking the highest hazard zonation that affects the proposed building and its amenities (not the whole property).</p> <p>C) For example, if only part of a property is defined as being within a mine subsidence hazard zone, then the above rules will only apply if any part of the proposed building and/or its amenities lie(s) within the zone. If the proposed building and its amenities lie entirely outside the mine hazard zone, then these rules do not apply: the proposed building works are to be treated as not being at hazard of mine subsidence.</p> <p>D) Likewise, if part of the property is defined as being within a high mine subsidence hazard, and part is defined as being of moderate hazard, the rules for high hazard will only apply if the proposed building and/or its amenities lie(s) within the high hazard zone. If the proposed building and its amenities lie entirely within the moderate mine hazard zone, then the proposed building works are to be treated as being at moderate hazard of mine subsidence.</p>	