Best Practice Guidelines for Cadastral Surveying in Areas Affected by Ground Movement Caused by Earthquakes

Initiated by:

NZIS/ICS Working Party 2015 – Earthquake Affected Boundaries

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1. Introduction

1.1 Background

This document was initiated by the NZIS/ICS Working Party who were convened in February 2015 to respond to issues related to cadastral survey definitions in earthquake affected areas.

The Working Party was established primarily to provide expert advice and commentary to Land Information New Zealand (LINZ). The responses provided to LINZ were based on their collective expertise in undertaking cadastral definitions in Christchurch following the 2010-11 Canterbury Earthquakes.

As representatives from a range of firms of various sizes, the group was able to utilise and share their own cadastral experiences as well as canvas the wider wisdom of their professional colleagues.

The major outcome of the communications with LINZ resulted in the concept that boundaries can move when land is moved by earthquakes. This is encapsulated within proposed new legislation tabled in Parliament on 22nd October 2015 – the "Canterbury Property Boundaries and Related Matters Bill" (82-1).

1.2 Intent

The intent of this document is to provide a written resource option for both NZIS and ICS survey members to utilise in the course of their cadastral surveying work - especially when undertaking surveys within areas affected by ground movement following an earthquake(s).

Following the initial draft prepared by the Working Group, the document was disseminated to the wider NZIS Canterbury Branch membership; the Cadastral Stream of the NZIS; the ICS Executive Team; and LINZ Survey Analysts for review, comments and expansion.

The document is anticipated to be an evolving source of information that will assist all surveyors in understanding the important aspects of cadastral survey definition over and above the normally expected "good survey practice".

This document assumes that the basic cadastral survey definition processes are understood and already employed. The points included within this document therefore supplement and expand upon the historically proven and established principles of cadastral survey definition in New Zealand.

In addition, the document comments are intended to be compatible with all current legislation (including proposed legislation should the Bill be enacted) as well as complement the Rules for Cadastral Survey and any additional Guidelines that may be published by LINZ.

1.3 Feedback

In the first instance any feedback, contributions, comment or constructive criticism should be directed to the Secretary of the NZIS Canterbury Branch - canterburybranchnzis@gmail.com

2. Data Research

Thorough pre-survey data research will provide a surveyor with a broad range of spatial information relating to the area under survey. It will lead to a better understanding of the nature and extent of any ground movement.

2.1 The Need to Search Deeper

In order to recreate and reinstate a legal boundary with confidence and with certainty, it is necessary to search all available data.

If an underlying plan shows a calculation to boundary offset from a permanent structure, and the plan has a field note reference, the field note forms an important part of a surveyor's data search. Such ties can be used as evidence to reinstate a boundary based on an historical tie to a permanent structure.

Similar ties are sometimes shown to existing fence lines and form the basis of boundary to occupation offsets. Again, such ties can be used to determine the intent of the boundary being defined.

The search should also go beyond the immediate underlying survey to ensure that other witness and boundary marks are searched for when field observations begin.

Obtaining the survey report associated with the underlying survey plans can also aid the surveyor in understanding the underlying boundary definition logic.

1. Search and obtain field notes and survey reports as part of any boundary definition. Go the extra mile and examine beyond the immediate underlying survey to ensure other marks or evidential data is not missed.

2.2 Make Contact with Third Party Surveyors

If a calculation compared to an adjacent survey needs clarifying, make contact with that surveyor.

If contacted by a third party surveyor, it is in everyone's best interest that a sound definition is determined. It should not be taken as a threat.

Obtaining historical field notes that are not available in the public record may help determine the best possible solution. An example of this is historic flat plan field notes that were not lodged.

2. Sharing data that is not in the public record will help surveyors determine the best possible boundary solution.

2.3 Coordinates

These have been made available through LINZ Data Service (LDS) and can also be extracted from the Geodetic Database. (https://data.linz.govt.nz)

Comparing pre-earthquake coordinates with post-earthquake values will provide a local indicator of the direction and magnitude of horizontal (and possibly vertical) movement.

3. Treat the pre-earthquake coordinates as a tool only.

2.4 Other Data Sources

There are other sources of data available to the surveyor that were not available before the 2010-2011 Canterbury earthquake sequence. These resources should be fully utilised as part of the initial data assessment process before and during a survey – particularly within areas that have been affected by ground movement.

Government departments as well as private sector agencies have made their data available in various formats. Utilising these resources may help determine the best outcome for a survey definition in your area of interest. Some examples are:

- **LINZ Data Service – Post-Earthquake Aerial Photography**

  Orthophotography of the area affected by the Christchurch Earthquake, 22 February 2011.

  Imagery was captured by NZ Aerial Mapping Ltd to support the response to the 22 February 2011 earthquake in Canterbury and offers high resolution imagery (10cm pixel resolution). The imagery provides a good overview of any particular area including the extents of liquefaction.

- **Canterbury Geotechnical Database**

  This is an extensive database offering a wide variety of datasets. Once you have registered, the datasets can be viewed on Google Earth.
  Collated Investigation Data includes Aerial Photography, Areas of Liquefaction (from both Aerial Photography and from ground observations), Observed Crack Locations, LIDAR and Digital Elevation Models, Vertical and Horizontal Ground Movement
  There is also data detailing the Mass Movement and Surface Deformations relating to the Port Hills, along with ground motion models.

- **GNS Report on Mass Movement Areas**

  These are detailed reports that defined the areas of mass movement within the Port Hills. They are extensive reports compiled for risk assessment by the Council.

- **LINZ Ground Movement Map**

  LINZ have compiled a map that shows where ground movement from lodged datasets have shown differential ground movement.

4. Additional external data sources include:
   - https://data.linz.govt.nz/
   - www.koordinates.com
   - https://canterburygeotechnicaldatabase.projectorbit.com
   - http://www.ccc.govt.nz/environment/land/slope-stability/port-hills-gns-reports/
   - http://www.linz.govt.nz/system/files_force/media/file-attachments/Indicative%20shallow%20surface%20movement%20in%20Christchurch.pdf?download=1

With any data set, the user needs to be mindful of the data source, the methods employed to acquire such data and any updates to the data set being analysed. These are great tools to obtain a better understanding of the area of interest and are indicative of how the land has been affected by shallow movement.

3. Good Survey Practice

3.1 Pre-Field Calculations

With the advent of LandonLine and survey software it is very easy to extract a lot of mark positions and vectors to get calculations started.

Running some closes of measured (rather than calculated) vectors between traverse marks or pegs can give a good idea of the real accuracy in the underlying work. Working from the plans rather than XML data can also help identify which marks may be already destroyed and which marks need to be looked for to determine a definition. Rather than closing between 6th Order 2000 marks from LandonLine, which can contain a degree of network adjustment error, consider doing a closed traverse loop from one mark and building up a cadastral model from there.

It is useful to find nearby post-earthquake datasets to get an idea of the potential movements that have been measured between existing marks or mentioned in the accompanying survey reports.

These calculations are also useful to create point files that can be uploaded into survey controllers to assist with finding survey marks in the field. When staking out for these marks the controller will give position deltas between the measured and calculated positions. This is useful as a quick field check that you have the right mark, but it should not supersede careful analysis of the vectors between measured positions to determine what local movement has really happened.

1. Always endeavour to work with measured vectors from the source plans to build up a picture of the accuracy in the underlying cadastral work, both pre- and post-earthquake. While coordinates are compatible for our survey equipment software, it is the measured vectors that we should be analysing for our survey definitions.

3.2 Field Equipment and Methodology

A mixture of equipment types will be used when undertaking surveys in a post-quake environment. GNSS receivers will provide an orientation in terms of Geodetic Datum 2000 even when measuring between adjacent marks affected by ground movement. It is unwise to use just a total station for local orientation because this won't be able to pick up any block rotation distortion, even though you might be able to measure the same distances between three old marks.

Although a community or CORS base station data service can be very useful for quickly finding old marks or establishing an origin over a long line, it is preferable to obtain GNSS observations using a local base and rover RTK configuration. There is a need to minimise the measurement errors introduced so that the amount of ground movement involved can be accurately determined. Sometimes it is worth the effort to use a total station to accurately determine if traverse marks are still in a straight line.

In an area of ground movement measurement of vectors between adjacent old marks may differ from the original observations but the marks still end up being accepted as undisturbed. It is therefore important to take good independent check measurements to the old marks so that there is confidence in the observations when analysing the data back in the office.

If taking GNSS measurements in RTK mode it is good to be able to side-step a number of systematic errors by getting a set of check shots from a different base station at a different epoch in the day. Total station check measurements could involve starting a new station setup in the controller and a different back-sight from the first set of measurements. Using both GNSS

measurements in tandem with total station observations is the most effective tool in areas affected by ground movement.

Surveyors should be cognisant of the accuracy of the field observations and the rounding of bearings when making a comparison of the field observations to previous observations of the same vectors. Be aware of the operating environment affecting your observations e.g. high nearby vegetation affecting GNSS or nearby construction affecting total stations.

2. Use the right equipment and methodologies for the circumstances when undertaking cadastral surveys in areas affected by ground movement. It is important to have complete confidence in the accuracy of the measurements to correctly analyse the ground movement when determining a boundary definition.

3.3 Searching for Old Marks

"Search and search well. If it is there, find it. If it isn't, be able to say with certainty that it isn't there." (Unknown Surveyor)

Ground distortions can vary widely across the area so it is important to find witness and boundary marks as close as possible to the property corners being re-defined. Long range adoptions can have a significant effect on the location of local boundaries so it is important to look for evidence for the determination of boundaries as close as possible to the site.

However, more should be done than just finding three marks along the road frontage and re-defining boundaries based on that. It is important to find marks at the rear of the property or other side of the block so that it can be determined how the definition will affect the neighbouring titles. If the survey is the first to make a definition in an area such as a city block, then it is very helpful for those who follow if measurements are undertaken to the terminal marks of the block and a determination as to whether they are disturbed or not is made.

3. It is important to look for old marks close to the boundaries to minimise introducing errors from the land movement, but cast the net wide to ensure the effect the definition will have on neighbouring properties can be determined.

3.4 Placement of New Marks

Thought needs to be taken when placing new traverse marks to minimise their chances of moving differently to the surrounding ground during a future earthquake event. Marks should not always be placed in long rigid structures such as concrete kerbs because structures like these can suffer significant damage as they have no elasticity to move with the ground surrounding them. The same caution should be applied to drainage structures such as manholes, which can shift vertically when liquefaction occurs. Permanent reference marks should also not be placed near the banks of water features or on areas of uncontrolled fill. Buried marks appear to perform the best relative to the land around them during an earthquake event.

Similar care should also be taken with the placement of boundary marks as you consider their performance during an earthquake. Boundary nails or disks that are placed at height on a fence

rail or post can easily move differently to the ground around the structure. It is therefore worth taking the time to place a peg at ground level if at all possible.

4. Careful placement of traverse or boundary marks needs to be undertaken so that their positions do not shift differently to the ground around them. This will ensure that they remain the best evidence available to reinstate the associated boundaries after an earthquake event.

3.5 Plans and Supporting Documents

Thorough reporting is of course essential for LINZ plan processing and subsequent surveyors to understand the definition decisions made. Refer to Section 7 Survey Reporting below for more detailed guidance on this topic.

The relationship of occupation to boundaries on existing pre-quake plans becomes critically important when trying to reinstate boundaries in areas of ground movement. When the witness and boundary marks have moved or been destroyed in the subsequent reconstruction works, measurements to structures such as buildings, retaining walls and fences that are recorded on earlier plans can help give confidence when re-establishing the boundary. Therefore taking the time to prepare unambiguous occupation diagrams, or submitting fixes of boundary occupation on field notes or field file printouts, will prove invaluable for future surveyors.

In a post-quake environment where ground movement has occurred, it often becomes necessary to formally re-define and peg boundaries and submit a dataset to LINZ. At a minimum the system requires a SO Redefinition plan to record the marks placed, which is more than adequate if the title dimensions are not to change. Where there is conflict to be resolved however, and the title dimensions are to change, you should consider lodging a land transfer (LT Definition) plan instead. For minimal extra cost a land transfer plan allows the owner and their solicitor to deposit the plan and update the title dimensions should they so wish. The land transfer plan generates a diagram of parcels which, for example, architects can use as a base for the redesign of a building on the property.

5. Providing thorough and unambiguous documentation with a dataset, particularly regarding measurements to boundary occupation, can be valuable information when reinstating boundaries after an earthquake event. Consider lodging land transfer (LT Definition) plans to deal with boundary conflict so that the opportunity remains for the owner to raise a new title.

4. Mark Reliability

4.1 Undisturbed Original Monuments

Undisturbed original boundary monuments preside as the highest form of evidence next to natural boundaries. This has been established in common law and is a hierarchy that does not need to change. Refer to Section 5 below for a more detailed discussion on this.

These principles prevent the creation of holes and overlaps in the cadastre and are perhaps more valid now than at any time in the past.

> 1. Legal precedent has established that boundary lines of surveyed parcels of land are governed by the position of original pegs placed, even if this conflicts with records and their mathematical relationships.

4.2 'Disturbed' and 'Undisturbed' in Areas Ground Movement

In recent times 'documentary evidence' has perhaps become disproportionately weighted within the hierarchy of evidence. Mathematical disagreement between marks and records has commonly been used by surveyors as the sole basis to dismiss a mark as 'disturbed'. This is a reflection on the dependability of our recorded cadastre (ie: the generally high level of consistency between field measurements and official records).

As a result of the earthquake induced ground movement the land has moved inconsistently, and it's now common for survey mark measurements and records to disagree mathematically beyond expected survey tolerances. The approach in the paragraph above no longer suffices as a means to dismiss marks as disturbed as such we need to redefine our understanding of the difference between 'disturbed' and 'undisturbed' monuments.

To simply use a mathematical test would inevitably see many well established and reliable survey marks disregarded, only for a different surveyor (using a different sample of marks) to find mathematical reason to deem them as reliable. In the interim period (a few years after the earthquakes) this problem manifested itself and became widespread.

> 2. If an original survey mark remains firmly and vertically implanted within the immediate ground as it was originally placed, then it's unlikely to be disturbed. This remains the case even if the survey mark (and the immediate land surrounding it) has shifted due to earthquake induced movement.

4.3 Assessing Mark Reliability

Given that mathematical disagreement does not necessarily constitute a mark as disturbed, surveyors must now apply considerably more judgment in assessing mark reliability. This includes gathering and analysing all relevant evidence which could indicate if this peg has moved

differentially to the ground around it. This is no longer a simple assessment to make and requires a level of judgment from the surveyor. See section 4.4 below.

3. When assessing survey mark reliability, surveyors must use sound judgement and investigate evidence beyond the mathematical relationships of marks and their records.

4.4 Gathering Evidence of Mark Reliability

Gathering evidence has never been as critical or required as much work as it does after an earthquake. In the absence of mathematical agreement there are many additional clues as to whether a mark may be undisturbed.

- Mathematical agreement with records (usually conclusive, providing there is no other conflicting evidence).
- The age, nature and depth of mark agree with the records.
- The mark is vertical (or the building/structure to which the mark is fixed is stable and vertical).
- The mark maintains its pre-earthquake relationship to nearby physical features or occupation.

See Section 5.2 below for a discussion about old pegs 'no record'.

The following scenarios are examples of when survey marks are likely to be disturbed;

- Survey marks fraudulently moved by non-surveyors. Common examples including marks that have been:
  - repositioned to allow for a fence post
  - moved by a neighbour to falsely indicate a boundary position
  - accidently knocked out, and repositioned as a best guess.

  Clues may include numbers facing the wrong direction, marks non-vertical or standing proud, the age of the occupation post-dates the survey mark, a conflict between marks and occupation in records, or the mark being displaced by a disproportionate magnitude to similar marks in the area.

- Accidently disturbed by a heavy vehicle.
  Clues would generally be limited to the mark being non-vertical.

- Disturbed by the movement of an adjoining structure. Examples could include marks which are fixed to:
  - a kerb, bridge or manhole
  - a building

  Clues may include the relevant marks being out of position by a magnitude greater than similar marks in the area, a building or structure being damaged (ie non-vertical, cracked, or suffering severe structural damage).

While undisturbed boundary monuments have a high weighting in the hierarchy of evidence, surveyors should be mindful that they have a higher risk profile than buried marks. Given that they often sit proud and are more visible to the public, they are prone to being disturbed and should be treated with caution.

There are often pre-earthquake records which give clues about the relationships of survey marks and nearby occupation or physical features. If the post-earthquake relationship between these

measures the same or similar, this can be used as evidence to support the reliability of a survey mark.

4. To assess whether a mark is disturbed requires a determination whether a mark has moved inconsistently to the immediate ground around it. If a survey mark maintains its original relative relationship to its surrounding physical features then it is unlikely to be disturbed.

To deem a mark as disturbed a surveyor must attempt to determine whether or not a mark has been moved by an influence additional than earthquake induced ground movement.

5. Hierarchy of Evidence

Traditionally the hierarchy of evidence for boundary definition has been weighted as follows:

1. Natural Boundaries
2. Monumented lines (original marks)
3. Old occupation, long and undisputed
4. Abuttals
5. Mathematical evidence of position

While this hierarchy of evidence was not developed for the purpose of boundary definition in areas with earthquake ground movement, the principles are still very relevant.

This hierarchy list is not absolute, however it gives a good guide when there are conflicts between types of evidence.

Interestingly this hierarchy of evidence has not been set in New Zealand law. However it has been established by common law principles and court case precedents from countries such as Australia, Canada, South Africa and the United States.

5.1 Natural Boundaries

With the principle of boundaries moving with the land due to ground movement as a result of earthquakes, it follows that natural boundaries will move with the land. Therefore boundaries defined by natural features will have the highest weighting of all the evidence, provided there is no ambiguity or doubt about their original definition.

Natural boundaries that have moved as a result of the earthquake sequence will remain as the boundary feature. However, care needs to be taken to gather all evidence of the definition of the natural boundary to determine if there has been any accretion, erosion or avulsion prior to or after the earthquakes as well as any earthquake related ground movement.

1. Clearly defined natural boundaries should have the highest weighting when determining boundary positions.

5.2 Monumented Lines

Original boundary marks found undisturbed are conclusive. Undisturbed boundary marks overrule measurements and areas shown on any plan or document.

The key word is reliable and this is discussed in depth in Section 4 above.

Old boundary marks with no record need to be treated with caution. However they shouldn't be completely ignored as they may assist in confirming reliability of other types of evidence, and/or other evidence proves its position as the boundary. An old boundary mark (with no record) found in isolation with no corroborating evidence has no weight.

Secondary to boundary marks are their related PRM, witness or traverse marks. These are accessory to the boundary marks, but if found undisturbed can prove the location of a current or former boundary mark. Where boundary marks do not exist or have been disturbed, then the

accessory (PRM, witness or traverse) mark should be used to determine the position where the original mark was placed.

If a boundary mark and near/adjacent accessory mark are both found to be undisturbed, but their relationship is different from pre-quake records, then the boundary mark will define the boundary location.

Another source of accessory evidence is recorded pre-quake fixes to buildings or structures near boundaries shown on approved plans/datasets and field notes. The resulting boundary offsets to these structures (if they still remain) are generally a reliable source of evidence to confirm other evidence or define a boundary alignment. Cross lease plans and field notes should be searched and investigated as these can often contain relevant information.

A good quote:

> *"A found undisturbed original monument expressing the intent of the parties fixes a point, which between them, has no error in position. All non-original monuments set by measurements have some error in position"* (E.K. Elder)

2. Old 'reliable' boundary marks will govern the boundary location and overrule any measurements and areas shown on any plan or document. Reliable boundary marks also overrule reliable accessory marks (witness or traverse).

5.3 Old Occupation

Of all of the types of evidence, occupation is the one that is most commonly misunderstood. Occupation is <u>not</u> just any type of feature that is placed on or near the boundary to separate parcels.

Case law has shown that occupation (used for boundary definition) must be a physical feature placed prior to, or near time of the original survey, and on the line of the original surveyed boundaries.

If using occupation as boundary evidence all relevant information about the feature should be investigated and analysed to confirm its reliability.

Another source of evidence (often considered as occupation) are buildings or structures with pre-quake fixes recorded on approved plans/datasets and field notes. However if this evidence doesn't fit with the definition of occupation described above, it is probably more accurately classed as a witnessing feature and is detailed in section 5.2 above.

In situations where all of the local monuments have been destroyed, occupation along boundary lines may need to be used where it supports the title dimensions. Occupation of all ages would be used as evidence, but the old recorded occupation will hold much more weight than newly constructed or unrecorded fences. The surveyor would need to analyse occupation for multiple lots on either side of the subject lot and title dimensions overlaid to confirm the reliability of the occupation evidence.

Shortages and excesses shouldn't be apportioned by mathematical means unless it is supported by occupation.

- Where there is an excess, and no parcel is short, then the owner in possession of excess is entitled to retain it.
- Where there is a shortage and an owner is occupying no more than their title dimension, they should not be required to give up part to satisfy a neighbouring parcel who is short.

3. For occupation to be used as evidence it must have been constructed prior to or near the time of the

original survey, and constructed on the original surveyed boundary.

5.4 Abuttals

This is best explained as what the neighbouring lots are entitled to. When defining boundaries of a subject lot, the neighbouring lots boundary definition and evidence are also to be taken into account. This principle remains especially valid in areas of earthquake ground movement.

4. Neighbouring boundaries and parcels dimensions should be respected and taken into account in defining boundary locations.

5.5 Mathematical Evidence

In the absence or uncertainty of the above mentioned evidence, mathematical adoptions from other undisturbed marks are ordinarily the next best and most reliable definition. However adoptions made from remote undisturbed marks have little weight in defining boundary locations. They are problematic as undisturbed marks remote from the boundary location are likely to have moved differently and produce sizable misalignments of the boundary with occupation. This makes it unlikely that a reinstated boundary mark would be placed in the location of the original mark had it not been removed/destroyed.

Long adoptions may also be unreliable due to the accumulation of errors in the old and new surveys. In these cases old occupation may be found to be more reliable.

6. Mathematical adoptions are to be used when all other sources of evidence are exhausted. Adoptions from remote marks will be problematic and occupation may prove more reliable.

6. Permanent Structure Boundaries

6.1 Redefining after an earthquake

The approach that boundaries move with the land can also be applied to permanent structure boundaries. As these boundaries were originally defined by a permanent structure, then they continue to be defined by this structure after an earthquake.

Difficulties will arise if the structure defining the boundaries has been damaged or destroyed by the earthquake. In this case all available evidence should be looked at to determine where the boundary used to be. The primary record of this will be dimensions on a survey plan. This could also include physical evidence, if this still exists, as well as as-built plans or other records.

1. If a boundary is defined by a permanent structure then it continues to be defined by this structure even if the structure is moved or damaged by an earthquake.

6.2 Permanent structure boundaries (Cross Leases and Units)

The re-definition of cross-lease or unit boundaries after an earthquake will depend on how the boundaries were initially defined on the plan. There are many variations on the quality of the information shown on plans.

The original position of the boundaries can be determined through the following hierarchy:

1. Permanent structure boundaries: If the boundaries are described as following a permanent structure then this takes precedence. For example: external face of wall or fence.
2. Dimensions: Some plans show dimensions from a permanent structure to primary parcel boundaries. These dimensions need to be respected to ensure the boundary is valid and there is no conflict with the plan.
3. A post-earthquake topographic survey may have been undertaken prior to the buildings being demolished this could have fixed the structures the boundaries were based upon. It may also be possible to request the field book fixes from the original survey firm, if available.
4. Scaling information off plans: This can be used as a last resort if there is no other information to locate the flat boundaries.

If possible the original buildings and any other features defining cross-lease boundaries should be surveyed before they are demolished to remove any doubt about the original location. Then it can be proven that the new buildings match the original location and do not conflict with the original plan.

1. Gather all available evidence to determine the position of the permanent structure boundary.

6.3 Stratum boundaries

Stratum boundaries also move with the land as a result of earthquake related ground movement. Measurement to the vertical control including the origin of levels, the site benchmark as well as the site and boundary in question, need to be undertaken as structures may have performed differently to the surrounding land. For example a building that is piled may not have dropped to the extent that the surrounding land has.

Where differential movement has occurred, examination of the original intent of the boundary needs to be undertaken to ensure it is replicated. For example it was common for a stratum boundary to be struck in the centre of a floor slab or at an offset to the top of a roof line.

4. Examine the original intent of the stratum boundary and ensure measurement is not only taken to the structure but the site, the benchmarks and the origin of levels.

7. Survey Reporting

7.1 Completeness of Information

It is important to make clear the conditions encountered on site and how this has affected the survey. The conditions encountered will determine how the site has been affected by earthquake related movement and thus how it is reported. For example:

> *"The site has experienced significant liquefaction as evidenced by images from Canterbury maps and ground measurement evidence and has thus been determined as being affected by earthquake related ground movement".*

Details of underlying surveys and when they were completed can influence how the measurements from the area are treated. In other words, are they pre-Earthquake Sequence (ES), post-September 2010, or post-February 2011 definitions? Also consider if adoptions directly from plans that were completed pre-ES is appropriate when the new measurements show different relationships to pre-quake measurements.

1. Be clear what has been encountered on site and how it has been determined that the survey is subject to ground movement.
2. Provide details about the survey plans used, their vintage and how it has been determined that they are affected.

7.2 Bearing Adjustments

Bearing adjustments that are applied to underlying surveys will affect the location of adoption positions that may in turn affect the definition decisions of others. Some surveys may have multiple corrections based on different road alignments and only one can be shown on the plan face, hence it is important to detail this within the report. Some plans may appear to have a bearing correction on first look, but closer examination shows this not to be the case and this needs to be reported so other surveyors know why a correction has not been applied without having to critically examine the survey data.

Also consider that valid bearing adjustments need to be determined by direct comparison of previously directly observed line(s) – preferably the origin, or at least a good spread of common line pairs over the survey area.

3. Report on decisions in relation to what adjustments have, or have not, been applied and why.

7.3 Old Survey Marks

Old survey marks will form the basis of definition for boundaries affected by ground movement. It is thus a very important section of the survey report and care needs to be taken to ensure there is a detailed list of marks found, looked for and not found, and found but not considered reliable, as well as the decisions made around those old marks.

As it is not clear from the plan which marks were looked for and not found, a list will enable surveyors to quickly assess which marks were in fact looked for. The reason they were not found should also be reported. For example:

- in recent trench;
- within house platform;
- within road rebuild area.

This will enable surveyors to assess whether other marks in their vicinity are likely to be destroyed in a similar fashion.

Old marks not looked for and the reason they were not looked for should also be detailed so that surveyors following can assess whether they should look for them. For example, old marks that were under a temporary site office and could not be looked for may be able to be looked for after the site office has been removed.

From time to time there will be old marks that have moved differently for a reason other than ground movement and which will have been deemed disturbed. For example, all marks from a survey are in the ground and/or kerb and one mark is placed in a manhole lid which has been uplifted, and so it has been considered disturbed. These decisions need to be reported with their reasoning which will enable surveyors to understand why some marks have been relied upon and not others.

A diagram of old marks searched for showing those not found, found disturbed or found undisturbed can be a useful tool for future surveyors working nearby.

4. Old survey marks will form the basis of definition for boundaries affected by ground movement. Ensure the report contains a detailed list of marks found, looked for and not found and found but not considered reliable, and the decisions made around those old marks.

7.4 Boundary Definition and Conflict with Cadastre

The boundary definition needs to be explained clearly so surveyors can follow the definition decisions made during a survey. Key points include:

- What marks were held and why?
- Were any marks ignored and why?
- Which lines were recalculated and why?
- What role did occupation play in defining the boundaries and why?
- Confirm the differences between the defined boundaries and the title boundaries including orientation of the lines.
- Have any of the abutting parcels been left short of title or is there excess left? What decisions were made in allocating a shortage or excess?
- Has this meant the area is less/more than the underlying title?

5. Clearly report how each of the boundaries was defined and how that affects the title dimensions. Report how the resulting definition affects adjoining parcels or the balance of the block.

7.5 Occupation

Occupation will play an increasing role in assessing boundary definition and will be carefully examined by LINZ and future surveyors.

Provide information about the pre-earthquake relationship of the occupation to the boundary. For example this may be the case where a pre-earthquake survey was begun but not completed; or occupation from underlying plan matches occupation noted on underlying survey.

Confirm the role that occupation played in defining the boundaries from knowledge that the occupation was on the boundary pre-earthquake and held on the boundary, to occupation matched well with the defined boundaries, but had no role in defining the boundaries.

6. Clearly report what role occupation played in the definition and why.

8. Professional Courtesy

Practitioners should be aware of their legal obligations and professional responsibilities when undertaking boundary definition surveys. These obligations apply regardless of whether a survey dataset is prepared or not.

The survey professional should undertake the survey task with an impartial view so that a boundary is interpreted using the available evidence and best practice processes and is not influenced by the client's personal or business objectives.

8.1 Legacy Data

In a post-earthquake environment it is of particular benefit to leave a good survey information trail for others to follow. This links back to full, accurate and unambiguous survey reporting, as well as complete supporting documents such as field notes; calculation sheets and supporting graphics as applicable.

1. All data can be good data. A thorough and complete dataset will contribute to the integrity of the cadastral record and benefit future surveyors who have cause to follow a definition.

8.2 Communication

When commencing survey work that will result in the submission of a dataset, it is good practice to assign a Landonline survey reference in the location of the survey as early as practicable. Therefore any subsequent information search will signal to other surveyors that someone is undertaking - or are planning to undertake - a survey in that area.

When working over prior surveys that are in conflict with a definition, it is beneficial to maintain open lines of communication with the other signing surveyor. Discussing and sharing the definition decisions will provide both parties with a greater understanding of the evidence gathered, the issues addressed, and the solution(s) reached.

2. Communication amongst survey practitioners working in the same areas in a post-earthquake environment is helpful and beneficial to both parties.