Riparian Boundaries: The State of the Uncertain Realm

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ABSTRACT

The location of natural riparian boundaries is determined by the whim of nature. As a consequence, they are naturally ambulatory. However, mankind places restraints on how the natural boundaries are translated to property boundaries. Some people who deal with land often view riparian boundaries with a degree of certainty and consistency, bordering on static, as to their position. Even a catastrophic change in the physical location of the boundary still might not change that static view. Many surveyors, despite knowing that riparian boundaries are ambulatory, also show a similar certainty and consistency when deriving the riparian boundary position for cadastral cataloguing. With examination of survey derivation techniques, definition dictates and the natural fundamentals of an ambulatory boundary, it is not difficult to discover that the results are far from certain. This paper brings together various components that create such an uncertain realm. In adjusting for the future, consideration must also be given to adjusting the way in which riparian boundaries are dealt with, otherwise the result will be greater uncertainty and loss of integrity in the surrounding cadastre.

KEYWORDS: *Riparian boundaries, uncertainties, cadastre, integrity*.

1 INTRODUCTION

Riparian boundaries are, in the natural order of existence, ambulatory. The physical edge of a river or shoreline of the coast is where it is. The location can change over time, the where and when determined by the forces of nature. Land parcels often use these natural features to provide a boundary to the extent of ownership. These cadastral riparian boundaries differ from the natural boundaries in that artificial restraints are placed on them so that the ambulation is controlled not necessarily by nature but by rules and regulations that have been put in place, possibly to give some certainty to an ever-evolving situation.

You as a surveyor have been asked to conduct a survey of an extensive tract of land, parts of which contain riparian boundaries beside both tidal and non-tidal waters. You are certain of what needs to be done and how the riparian boundaries are to be conducted, but exercising due diligence you consult the Surveying and Spatial Information Regulation 2017, which, at this time, should provide you with the surety of your understanding.

Examining the legislation closely, conducting several readings to make certain you understand what is written, rather than what you previously thought was the case, you come away uncertain as what should be and what to do. You have found that from the definitions what you thought was a boundary is instead a different entity and there is no identifier for what you considered was one of the boundaries. What you thought was the other boundary has no identifier and from inference could be called something else. As part of the survey is over Crown Land, you also consult the current Crown Lands Act to see if it brings any clarity. Instead what you find creates

further uncertainty as there is conflict between the two legislations that would leave you stuck in the middle with nowhere to go.

There is a lot of importance resting on this survey and it must be absolutely correct, so that nothing can be brought into question or challenged. Continuing to exercise due diligence, and despite the legislative uncertainties, you dig deeper into the mechanics of surveying the location of what industry considers to be the boundaries. Rather than feeling more assured your feeling of uncertainty has gone up a few levels. You have found that some boundaries are virtually impossible to locate with a degree of certainty no greater than a guess and others with a fundamental inaccuracy that could leave the location in a high degree of lateral variability. The surveying standards for this survey expect at the worst centimetre-positioning, not plus or minus a few metres. You even find one section of the river that defies any legislation as to what it should be or how to position the boundary.

What you thought was a large but relatively straight forward survey has shifted into a realm of uncertainties as to what things are and how things should be done. You investigate further to see if there is any clearer path to providing an outcome. In your many readings of legislation and any other instructional publications you find that just about at every step of the way some form of approval must be gained for many components of the survey and the plan. You find that if you can gain agreement to and thus approval from the various parties for whatever you produce, then the uncertainties can be circumvented and the survey completed to some form of acceptance.

Does this read like an implausible story? Think again. It is not. This is the current uncertain state of the realm that exists around riparian boundaries. As surveyors adjust for the future with new technologies and techniques to improve the certainty and accuracy of positioning where we are in the world, the dealings of riparian boundaries have been left behind. Past errors, discrepancies and inconsistencies have not been resolved but instead compounded upon. Outcomes are riddled with poor judgement and erroneous assessments, leaving the cadastre prone to integrity loss (Songberg, 2019), rippling out from inappropriately determined riparian boundaries.

Surveyors have adjusted in the past to provide riparian boundaries that meet with industry expectations. To do so, surveyors have adopted methodologies that are not in strict accordance with legislative requirements (Songberg, 2020). If someone disagreed with the surveyor's choice of riparian boundary location, it would not be too difficult to prove that as the letter of the law has not been adhered to the surveyor cannot be correct. Such a scenario would leave the surveyor with an even greater level of uncertainty as to the future.

So where has it all gone haywire? What are the uncertainties that left our poor surveyor wondering if there was any meaningful way forward other than to conduct a boundary by agreement (Songberg, 2020)? Is there any way in which riparian boundaries can adjust for the future and perhaps return to some degree of certainty? This paper outlines various components that have created the state of the uncertain realm for riparian boundaries.

2 RIPARIAN BOUNDARY LEGISLATION

Riparian boundaries are split into two basic categories, tidal and non-tidal. Other riparian boundaries such as landward reserve or road boundaries have different characteristics, but their fundamental derivation still stems from the two basic categories. Legislation governing the delineation of riparian boundaries is, however, not spelt out in such simple terms. The legislative wording can be quite convoluted with some things left to uncertain interpretation.

2.1 Tidal Boundaries

For tidal waters, the industry-accepted land boundary, and identified in practice, is the Mean High Water Mark (MHWM). But legislation describes another entity as MHWM, which is not the land boundary (Songberg, 2020). There are, and have been, other land boundary identifiers used with tidal waters on previous plans, e.g. boundaries such as high water mark or even low water mark. Legislation would have these other identifiers forced to conform to the same uniformity of MHWM, but MHWM is another entity that is not the land boundary. Then to cap the already cyclic uncertainty, the legislation has an almost fine print foot note saying that this condition should be used unless there is a contrary intention. So, if the naming of another identifier is not a contrary intention, then the legislation becomes meaningless and uncertain as to its intent. It also leaves us with the situation that the land boundary against tidal waters is not MHWM and under the strict wording of the legislation cannot be named as such. For want of a better name, this paper will call it the mark or line of mean high water (MHW) (against the foreshore).

2.1.1 Mean High Water Mark

The definition for MHWM can be found in the Surveying and Spatial Information Regulation 2017 (NSW Legislation, 2017):

> "***mean high-water mark*** means the line of mean high tide between the ordinary high-water spring and ordinary high-water neap tides"

The intent was to describe the line that a certain tide height made upon the foreshore, which is the property boundary that should be determined by surveyors. But that is not what was written. The resulting line of this definition is a tidal plane (Figure 1).

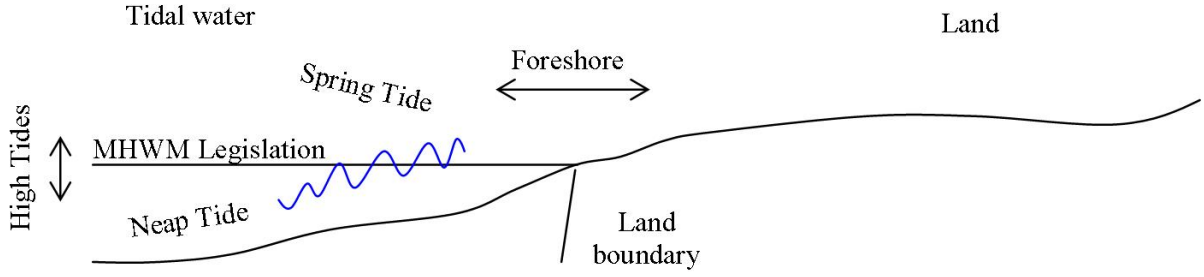

Figure 1: MHWM legislation compared to land boundary.

To add further uncertainty, there is no definitive definition of what a spring or neap tide is. Any search will result in several options (Songberg, 2015). Add in the word 'ordinary' and the degree of uncertainty increases manyfold. There is just no definitive answer for what an ordinary high-water spring tide or ordinary high-water neap tide is. Then there is the uncertainty of which tides the surveyor needs to observe to calculate the mean. The definition requires all

high tides "between" ordinary spring and neap high tides. So, the ordinary spring and neap must be excluded from the calculation because the word 'between' does not mean including. But what of the non-ordinary spring and neap high tides, are they to be included or excluded? Which are the non-ordinary spring and neap high tides? Because there is only one spring and one neap tide in each tidal set, does that mean that these are the ordinary tides? Or does the height of the spring or neap tide make the distinction between ordinary or non-ordinary. If so, does that mean that some tide cycles cannot be used because the spring and neap tides are of the non-ordinary type? There are just no answers to these questions. If there are no answers to resolve the uncertainties, then how can there be a definitive result for the boundary marked as MHWM on cadastral plans?

Examination of how the MHWM came into existence must also be given due consideration. This definition was brought to the surveying industry in 1854 with the English court case *Attorney General v. Chambers.* This case was not about how boundaries were determined on the surface or what the surface conditions were like but rather the extent to which coal miners could extend underground out into the sea. The Attorney General took the stance that the interest of the Crown extended to the high water mark or the extent of the spring (highest) tides. The miners, however, took the view that the Crown's interest did not extend beyond the neap (lowest) tides (Blume, 1995).

The judges, in their deliberation, considered that the land over which only the spring tides extended was for the most part "dry and maniorable". Even though the land would not always be covered in salt water, it supposedly could be used for some things. Cattle might browse through the salt grass marshes and mangroves, but vegetables or other crops would not likely be grown. In essence, the farming land might have only extended to the high water line, but the miners wanted to go further because there were valuable resources to be gained. The result was a compromise between the two opponents, a point mid-way. The boundary given to the coal miners is also not ambulatory. Coal was dug out of the mine to the limit of what was determined as the line of MHW at that time, and there it remains. Should the line of MHW progress inland, the mine company was not about to fill in the mine or give back the coal. The boundary remained static.

2.1.2 Other Tidal Boundary Entities

The legislation for tidal boundaries supposedly tries to make some degree of conformity as to which entity should be regarded as the land boundary. At clause 51 of the Surveying and Spatial Information Regulation 2017, it says:

> For the purposes of preparing a survey, in any previous survey plan or other description of land:
> (a) a reference to high-water mark is taken to be a reference to mean high-water mark, and
> (b) a reference to, or description of, a boundary that abuts tidal waters is taken to be a reference to, or description of, a boundary that abuts mean high-water mark

And at the end of the clause in almost a foot note:

> unless a contrary intention appears.

It may have been the intent of this legislative clause to bring some certainty as to what entity constitutes a tidal boundary, but it does the opposite. This clause calls for any other identifier or description to call the boundary MHWM. And if you want to know what the MHWM is, then refer back to the definition and you will find that it is an entity that is not a boundary line (see Figure 1). This is a curious circular exercise into uncertainty.

The clause also does not change the physical situation where there are tidal boundaries that are not the mark of MHW. The legislation might want the surveyor to call them MHWM but that does not change the fact that they are not. The tidal limit is an example which is determined by the highest tides, or loosely, the mark of high water. The extent either the high water or MHW reach up an estuary will depend on the gradient of the upper reaches. The distance between the MHW limit and the tidal limit will vary, but the land that abuts this area is still abutting tidal waters. The boundary of such land is thus the mark of high water, not the mark of MHW as clause 51(b) would have you determine it (Figure 2).

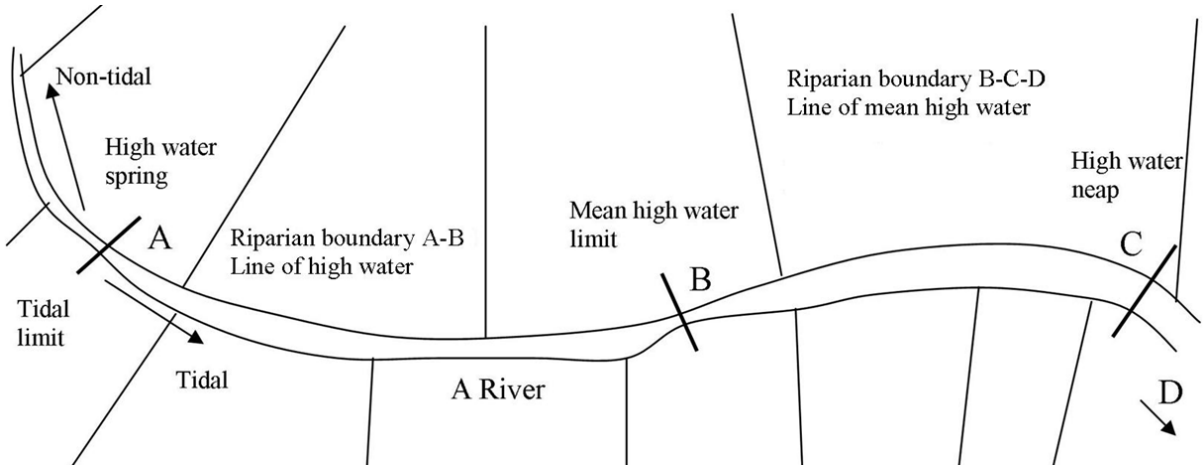

Figure 2: Tidal limit Mean High Water uncertainty.

This brings up the situation with plans that label the tidal boundary high water mark. The legislation would have the surveyor determine the boundary at the MHWM, but the question still remains: Does the land extend that far into the tidal estuary? Without doubt there is a difference in water levels between high water and MHW. Where the two entities intersect the shore, there will be a distance separating the two lines. High water will reach further up the shore than MHW. Whether this legislation has the effect of changing the boundary location and consequently the extent and area of the land, or even if it is legal to do so, is uncertain. Because the change took place suddenly by a purposeful act upon the passing of the legislation, the application of the doctrine of accretion and erosion would prevent such a change being adopted. There is also the uncertainty as to whether the *Attorney General v. Chambers* decision of 1854 is retrospective. It may well be that titles issued to high water prior to the ruling could retain the high water limit.

If the meanings of words in the English language are also to be adhered to, then land that has a description “abutting” tidal water should have no part of the tidal reach within the bounds of the land. Abutting means beside and there is no presumption that there is any partial inclusion of that which is beside or abutting. The boundary should thus be the mark of high water and not the mark of MHW. Use of MHW would result in part of the tidal regime being included in the title and the land would no longer be abutting tidal water.

Attorney General v. Chambers may have limited the English Royal prerogative of the seashore to the line of MHW against that shore but legislation, title descriptions and some practices have not caught up with this. The change to MHW may not have resulted in the change in location of some land boundaries that were previously abutting or extending only to the mark of high water. The application of clause 51 of the Regulation does attempt to affect a location change in many instances, but at the same time it contradicts itself by saying unless a contradictory intention appears. Is not the use of the identifier high water mark or the fact that only high water could occur in some sections of the tidal reach a contrary intention? It is all very uncertain.

2.2 Non-Tidal Boundaries

The legislative dictates that govern the derivation of non-tidal riparian boundaries possibly contain greater uncertainties than those surrounding tidal boundaries. It could even be concluded that derivation of non-tidal boundaries has no degree of certainty of position and that there is conflict as to what that boundary should be identified as.

2.2.1 The Bank

The legislative definition of a non-tidal boundary initially comes from the Crown Lands Act following the 1931 amendment to the Crown Lands Consolidation Act 1913 adding section 235A (section 13.3 in the current Crown Lands Management Act 2016). This amendment brought into being in New South Wales the definition of the bank, being the identified non-tidal riparian boundary for Crown Grants. Unfortunately, the definition wording is both convoluted and contains unanswerable uncertainties:

> *Bank* means the limit of the bed of a lake or river.
> *Bed* means the whole of the soil of a lake or river including that portion:
> (a) which is alternately covered and left bare with an increase or diminution in the supply of water, and
> (b) which is adequate to contain the lake or river at its average or mean stage without reference to extraordinary freshets in time of flood or to extreme drought.
> *Lake* includes a permanent or temporary lagoon or similar collection of water not contained in an artificial work.
> *River* includes any stream of water, whether perennial or intermittent, flowing in a natural channel, and any affluent, confluent, branch or other stream into or from which the river flows.

Most of the wording is quite straight forward but there is no qualification as to what is an "extraordinary freshet" or an "extreme drought". These terms are left to the contemplation of the practitioner. The stage to which the river or lake must rise to become an extraordinary freshet is not determinable. The conditions of extreme drought are even more uncertain. Although during times of drought, lake levels and river flows diminish, the situation could occur where a river flowing through a region in drought has its origins in a region having good rainfall and is not in drought. The river might well be flowing through the drought region with good vigour. The conditions of drought might not necessarily correlate to river or lake stage, leaving an uncertainty as to what the term actually refers to or what the measure of the stage is. Thus there is a degree of uncertainty as to what stages of a river or lake over or under an undetermined amount must be excluded so as to determine the mean stage.

2.2.2 Not The Bank

If the Crown Lands definition was not enough of an issue, the legislative writers had to have another go at providing a non-tidal boundary definition by inclusion of a similar narrative in the Surveying and Spatial Information Regulation 2017. Unfortunately, they did not do a straight copy from the Crown Lands definition but had to change things so that surveyors can be left with conflicting and uncertain directions:

> (*Bank*: The term 'bank' was excluded as part of the definition.)
> *Bed* in relation to a lake or stream, includes any portion of the lake or stream:
> (a) that is alternately covered and left bare with an increase or diminution in the supply of water, and
> (b) that is adequate to contain the lake or stream at its average or mean stage without reference to extraordinary freshets in time of flood or to extreme drought.
> *Lake* includes a permanent or temporary lagoon or similar collection of water not contained in an artificial work but does not include tidal waters.
> *Stream* includes any non-tidal waters that are not a lake.

To add to the uncertainty of what is an extraordinary freshet or an extreme drought, there is no identifier for what the non-tidal boundary should be called. The wording also changes what is considered a stream. In the Crown Lands version, the stream must have a natural channel. However, in the Regulation version, any channel not a lake can be included which would suggest that an artificial drainage line could be considered a stream and thus form a riparian boundary.

If a survey is to be conducted for Crown Land involving a non-tidal riparian boundary, then the boundary should be called "the bank". However, to satisfy the Surveying and Spatial Information Regulation, that tag must be removed, leaving the surveyor in an uncertain state of nowhere.

2.2.3 Other Non-Tidal Boundaries

In non-tidal riparian boundaries, the bank is not the only entity to be used as the boundary. A centre line is sometimes considered, but this involves determining the extent of the stream and taking the middle line so that is essentially little different from the property boundary on a single side. The surveyor just has to locate both sides before the middle can be determined. Other identities such as the extreme margin, the high bank and the low bank have also been used. Much older surveys or descriptions of land parcels did not always give any indicator as to what the riparian boundary was. The boundary was simply given as the stream or abutting the stream.

Use of a defined bank as boundary only came into existence in 1931. It is unclear what the non-tidal riparian boundary was prior to that date. The NSW Regulations for Licensed Surveyors 1914 describe the boundary to be a fair limit of the channel, of the watercourse, excluding also shingle beds from the land with pegs set back from an unstable bank and a distance given to the channel limit. What is the channel or what is the limit is not stated, so it was left up to the surveyor to make a guess. The NSW Regulations for the Guidance of Licensed Surveyors 1886 and 1864 were even less informative. Thus the non-tidal riparian boundary prior to 1931 could be anything or be described as anything and located anywhere within or abutting the river environment. A highly uncertain state indeed.

The Surveying and Spatial Information Regulation 2017 in clause 51 tries a similar renaming of the boundary entity as with tidal waters. It is also within this clause that a possible name of the non-tidal boundary can be inferred:

> For the purposes of preparing a survey, in any previous survey plan or other description of land:
> (c) a reference to a bank of a lake or stream is taken to be a reference to the limit of the bed of the lake or stream, and
> (d) a reference to, or description of, a boundary that abuts a lake or stream is taken to be a reference to, or description of, a boundary that abuts the limit of the bed of the lake or stream.

And the footnote:

> Unless a contrary intention appears.

It is uncertain as to what name the non-tidal boundary should be given as the legislation clause does not give one. Instead, by inference from sub clauses (c) and (d), the name that could be used is the descriptor of how to find the boundary, which is "the limit of the bed".

Changing the name of the boundary from previous plans from what is shown on those plans can give an uncertain outcome. The extreme margin is just that, the greatest extent to which the stream reaches across its width, causing the land to abut the stream (i.e. it does not include any part of the stream). The bank, for want of a better name, in cadastral purposes is much lower down within the stream environment (Songberg, 2002, 2012). For a land parcel with a riparian boundary identifier such as extreme margin or an identifier that causes the land to abut the non-tidal stream, by insistence of clause 51(d) the boundary should be identified as the cadastral bank and not the identified boundary. Calling the boundary by another name does not change the fact that the two locations are different and there could be substantial land in between (Songberg, 2020). The owner of such land might have issues with any boundary change of this nature.

The use of any other identifiers that are somewhere else in the stream environment, such as the back of the shingle bed, may have been used in the past to give a clearer location for the boundary. These other identifiers are not mentioned in clause 51 other than the possibility of them being considered as contrary intentions. By rights then, it should be possible to retain these other boundary identifiers as the boundary which would also include the extreme margin or the top of the high bank. The contrary intentions part of clause 51 may have a slightly different effect on non-tidal boundaries compared to the effect on tidal boundaries, but it still creates some uncertainty.

2.2.4 Other Ad Medium Filum Aquae

The simple explanation of Ad Medium Filum is that the title of land that runs to a non-tidal stream is likely to enjoy the presumption of title to the middle thread of that stream unless otherwise stated. However, that condition will only occur if the grant was prior to the reservation of all beds of streams from 3 May 1918 in the eastern and central divisions of the state and from 31 May 1935 in the western division.

This sounds simple, but there are a number of uncertainties that exist that will make location of the possible centre thread alignment an uncertain probability. Only in the western division and only after 1931 was the riparian boundary determined to be the bank. Prior to 1931 in the western and prior to the reservation in the eastern and central divisions the land boundary is uncertain and could have any entity. The Surveying and Spatial Information Regulation 2017 in clause 51(d) would have the boundary called and located at "not the bank" but that does not necessarily make it so, nor would it have been at the time of grant. If the land boundaries on the other side of the stream were different entities, then what would constitute the centre thread? Would it be the mid-point between the two different entities, or would the two entities need to be the same, otherwise there could be an unequal distribution of the stream? Determining the centre using one entity from one side and another entity from the opposite side could even result in an overlap. Whatever the outcome, determining the position of the centre thread line is likely to be an uncertain task.

2.3 Lake or Not a Lake, Stream or Not a Stream

It has already been shown how legislation conflicts can result in uncertainties as to what should be the appropriate terminology in identifying a riparian boundary. Legislation conflicts can go further, and in this instance an uncertainty is created when it comes to identifying the body of water associated with a riparian boundary. In NSW, just south of Newcastle on the Central Coast, is a large body of water known as Lake Macquarie (Figure 3). The Geographical Names Board of NSW identifies the body of water as Lake Macquarie and gives it a designation of a lake. The Crown Lands Management Act 2016 agrees that this body of water is a lake. In section 13.3(9) it states that "lake includes a permanent or temporary lagoon or similar collection of water not contained in an artificial work".

Figure 3: Lake Macquarie.

The Surveying and Spatial Information Regulation 2017, because it was not a straight copy but instead changed, disagrees that this body of water is a lake. In clause 44, it states that a "lake includes any permanent or temporary lagoon or similar collection of water not contained in an artificial work, but does not include tidal waters". Considering that Lake Macquarie is considered tidal and the riparian boundaries along the foreshore are generally the MHWM, it is uncertain why the Regulation would not designate it as a lake. It could be that the lake does not have its own individual tidal regime like the sea. The ebb and flow of the tide originates from the sea as the water within the lake rises or falls as the tide flows in or out of the entry channel. The lake in this respect is an inlet of the sea and thus possibly not a lake.

The same applies to streams. In the Crown Lands realm, a stream (or river), perennial or intermittent, occurs in any natural channel. With perennial meaning lasting, enduring or continually reoccurring, this would include the tidal stretches of such streams. In the Regulation realm, the stream cannot be within tidal waters. Like the lake, tidal river systems are really an inlet of the sea so that under the Regulation they are not a stream (or river).

Where does that leave the surveyor if not in an uncertain state? Non-tidal riparian boundaries can be called a bank in one legislation but not another, and now a tidal body of water can be identified as a lake or stream in one legislation but not in the other. It is all a bit uncertain, but then what is in a name?

3 FINDING THE RIPARIAN LINE

Legislation has not provided the practitioner with any degree of certainty as to what a riparian boundary is, where it is, or what its designation is. Surveying practices in determining riparian boundaries have instead evolved over time to where the processes are comfortably understood, followed and accepted by most. Those practices, however, do not comply with the dictates of the legislation (Songberg, 2020). With the legislation so full of uncertainties, it is uncertain that surveyors could adhere to the letter of the law. It is much easier to follow the well-established practices.

Adopting such a protocol, however, does not guarantee certainty in the determination. Slightly different techniques will produce different results with sometimes surprising variations. Consistency, even in a single protocol, will still produce variances in results so the determination can become inaccurate and uncertain (Songberg, 2005, 2015). There are also the variances in nature, which are not easy to follow or measure, causing a determination of the riparian boundary to become very uncertain. Then there are the artificial constraints that fix a boundary in time. The landward reserve boundary is such an example and locating one may require an extraordinary time-travel style investigation (Songberg, 2007).

3.1 Mean High Water Mark

Despite the vagrancies of the legislation in naming the tidal boundary line and instead giving the name MHWM to the tidal plane, the boundary line that is expected by industry must still be determined. If a surveyor is to determine the line along the foreshore that is intersected by the MHW, then the MHW level must first be ascertained. There are several ways to achieve this. Certainty and accuracy of the outcome is to be expected, however, the search for the right method leaves its own uncertain results.

3.1.1 Time Dependence

In attempting to follow the dictates of the legislative definition, a 7-day period of observation of high tides is required to determine the mean (Songberg, 2020). This is also the observation extent envisaged by the judges in *Attorney General v. Chambers*. A quarter of a lunar revolution and 3 days out of 7 being just a couple of the supportive phrases used to support the decision in the court case (Blume, 1995).

Because the tides vary considerably throughout the year, the short observation period will produce considerable variations in the value of MHW between periods (Figure 4). In any 12-month period, the variation in level of MHW could be as much as 0.35 m. Such a difference could result in quite a discrepancy in the lateral position of the land boundary in two adjacent surveys. Neither is wrong, but there would be questions asked as to why the difference. There would also be a level of uncertainty as to the validity of such determinations. Figure 4 also shows that there could even be a variation in level of 0.25 m from one week to the next. Such a level of uncertainty would not be acceptable to anyone, but it is what legislation and legal precedence have thrust upon us.

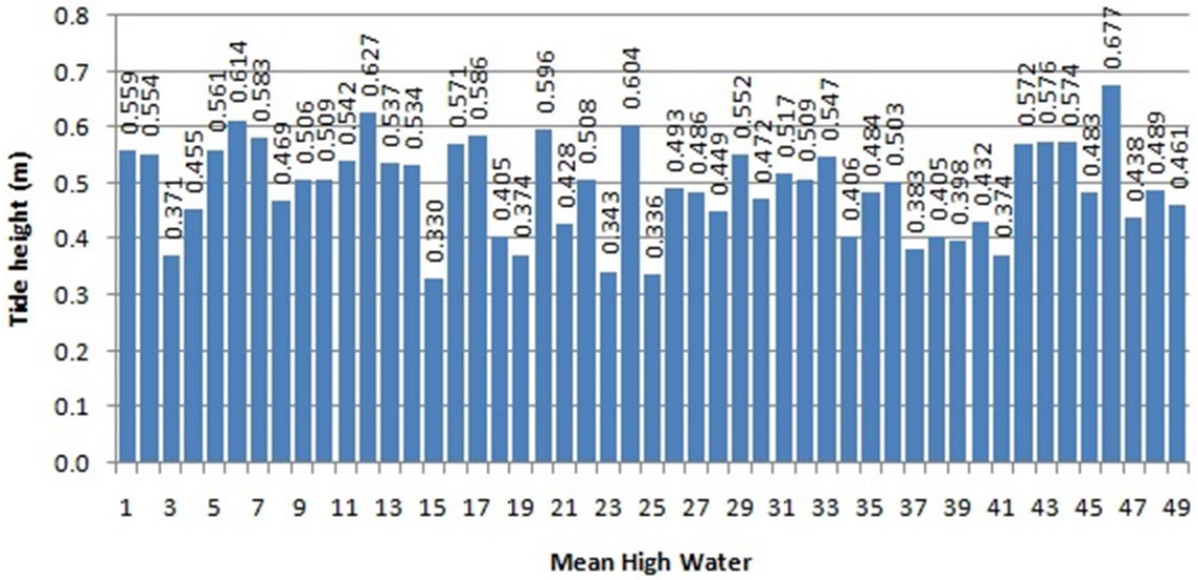

Figure 4: Legislation length observation sets for Mean High Water over a 12-month period (quarter lunation, i.e. 7.38 days).

Such an observation set has likely never been undertaken as guiding practice documents, e.g. NSW Regulations for Licensed Surveyors 1914 and the Manual for the NSW Integrated Survey Grid (Lands, 1976), suggest a period of a month (1 lunation), or even better a year, to obtain an accurate result for MHW. No matter which observation period is used to obtain a mean, an accurate determination is uncertain as each method will produce variances between one observation period to the next (Songberg, 2005, 2015). The uncertainties do not come from the observation techniques but instead from the vagrancies of the tide.

The variations across longer periods of observations do diminish considerably. Applying a lunation length period (29.53 days), the difference over a year is reduced to only 0.15 m (Figure 5), based the same dataset as used for Figure 4. However, the result could differ between datasets. It is quite possible that such a difference could result in two surveys side-by-side but one month apart arriving at two entirely different positions of the line of MHW on the common

boundary. Again, neither is wrong but the results create a climate of uncertainty in a situation where consistency would be expected.

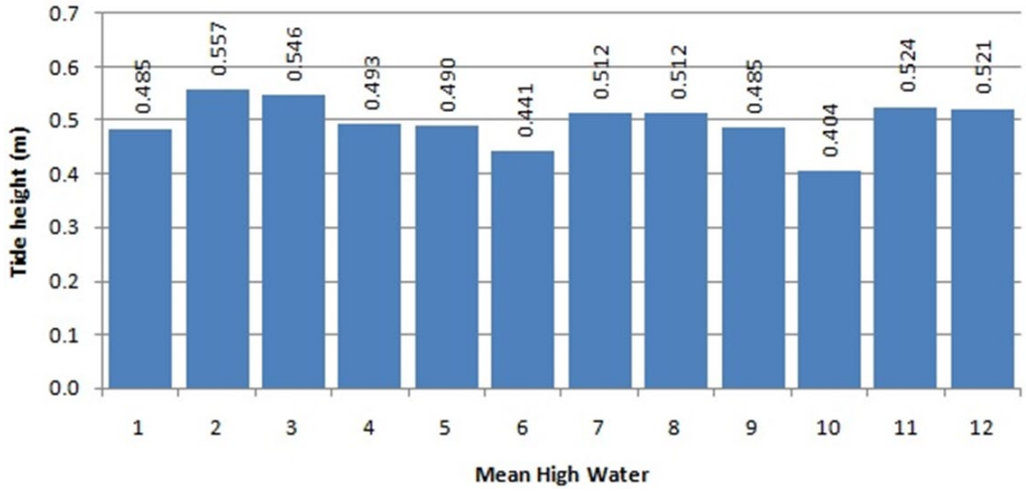

Figure 5: Lunation length (29.53 days) observation sets for Mean High Water over a 12-month period.

Lengthening the period of observation out to one year does not remove the probable variations from one year to the next (Figure 6). The greatest difference across the 20-year period is still 0.12 m, and there could still be a noticeable difference between successive observation sets. Extending the observation period out beyond a year does not remove the variances, nor will doing so significantly reduce the probable difference from one period to the next. Neither does extending the observation period provide any advantage as other factors such as sea level rise start to take effect and influence the outcome (Songberg, 2015, 2016).

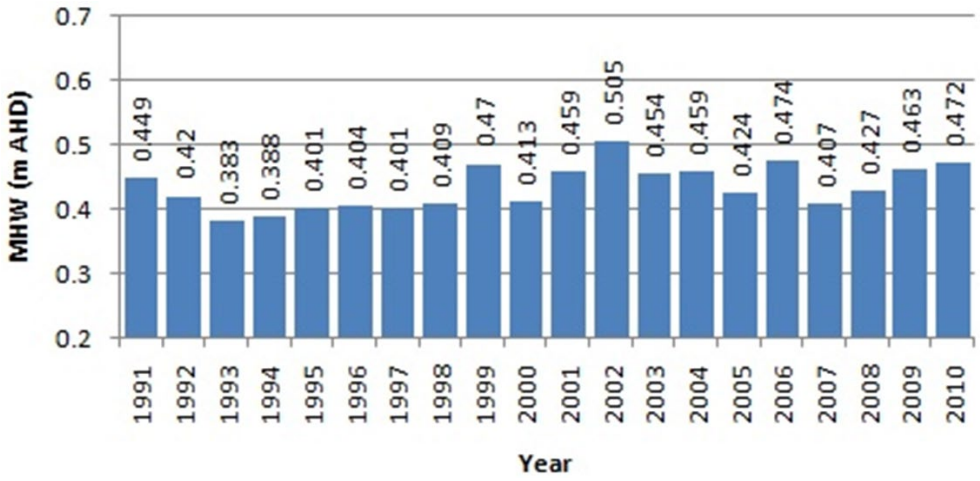

Figure 6: 1-year long observation sets for Mean High Water over a 20-year period (Port Macquarie).

A 19-year moving average (18.6-year lunar nodal cycle) is used at times to determine various tidal information sets (Couriel et al., 2012; ICSM, 2017). Such a period may be valid or essential for some purposes, but for cadastral surveying the inconsistencies become evident when examining the changing sea level trend. Sea level change is evident within the period and holding the mean beyond the period creates greater uncertainty when compared to the extrapolated sea level change (Figure 7) (Songberg, 2015, 2016). As the surveyor would always use the mean after the period, the value of MHW use would always be too low. The longer the time for the survey is after the period, the greater the discrepancy.

The effects caused by changes in sea level become even more apparent when data is viewed over a longer period. Figure 8 shows that sea level change is an ongoing process that cannot be ignored if accurate MHW levels are to be obtained for cadastral purposes. Even though a linear trend is shown, it may not be appropriate as there may be different rhythms that may have to be considered. Taking smaller segments, such as 19 or 20 years, still produces variations from one period to the next with the expected variation in results being similar to the other time periods.

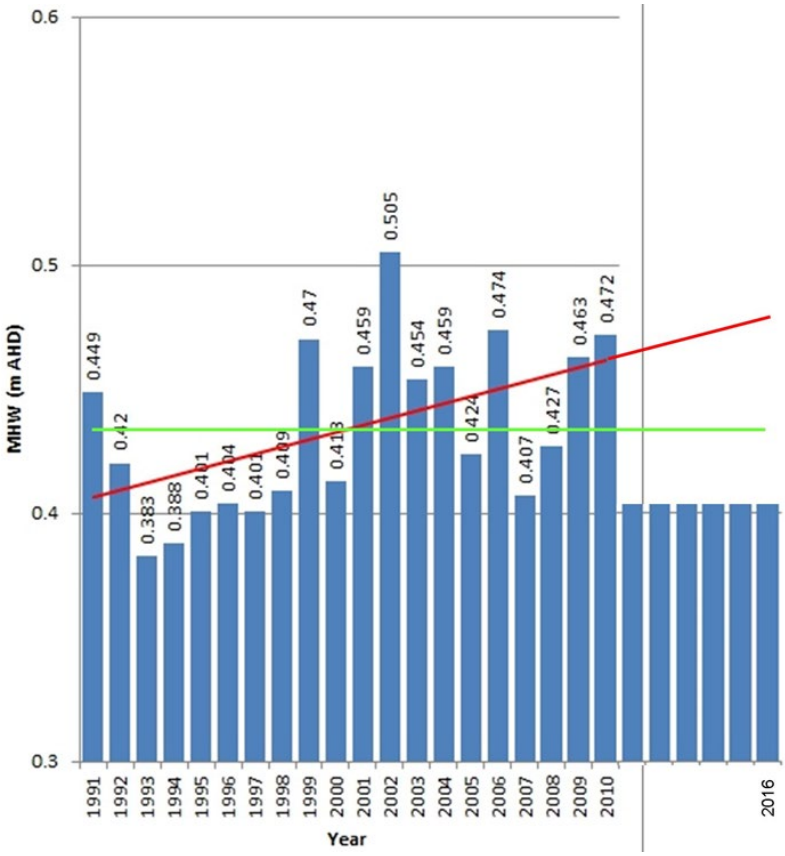

Figure 7: The effects of sea level change on long-term means (Port Macquarie) (Songberg, 2016).

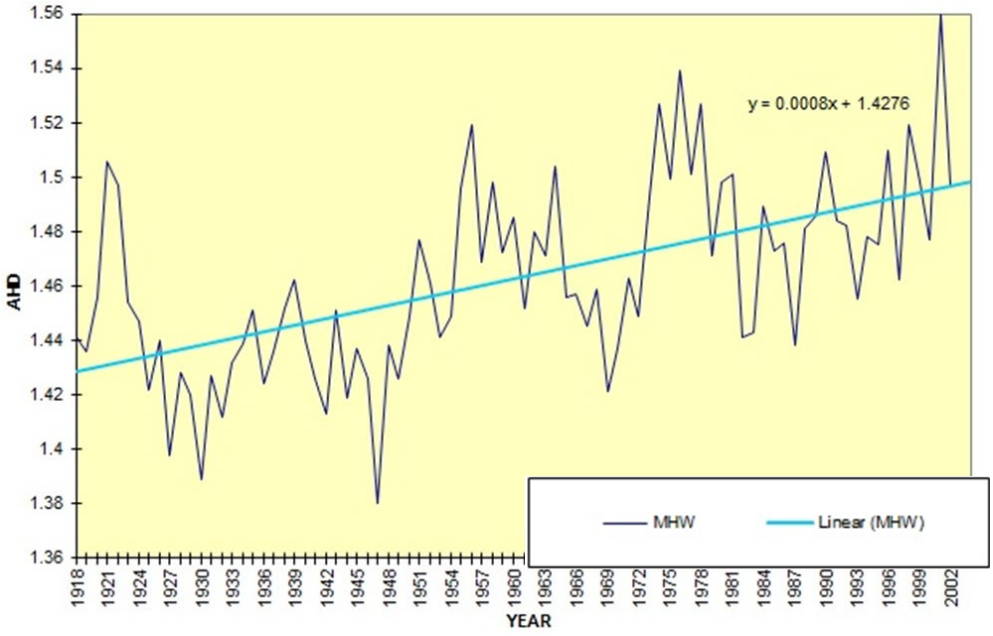

Figure 8: Trend in sea level change at Fort Denison, Sydney (Songberg, 2015).

Where this leaves the surveyor in the search for certainty is anywhere but certain. No matter which time period of observation is considered, the results remain uncertain. There is no repeatability, and although the outcomes are technically correct within themselves, there is an apparent disagreement between each determination which could result in conflict. There is also no consistency between the different time period observation sets as each will produce a different result. The simple outcome is different data equals different results, and the resulting uncertainty is not in what the surveyor has done but within the tides themselves.

3.1.2 AHD Levelling

By far the most common method used to determine the MHW surface level at any survey site is to relate it to the tide gauge network, which is in turn related to the Australian Height Datum (AHD). Given the AHD level of MHW, even though it is one not compliant with the terms of the legislative definition (Songberg, 2020), and knowing the tidal plane characteristics, it is presumably a simple matter of running a levelling traverse along the foreshore to determine the appropriate line. This sounds good, but is the outcome certain? Combine the characteristics of the AHD network with tidal plane idiosyncrasies and the answer is no.

Across Lake (or not Lake) Macquarie in Figure 3, it is approximately 7.5 km as the crow flies from Swansea on the east to Wangi Wangi on the west. Whichever way around, the road distance is approximately 40 km. Although widely used, the AHD network is not recommended for projects greater than 10 km in length and water might not flow in the direction suggested by AHD levels (Brown, 2019). The AHD levelling network is made up of a combination of 1st, 2nd and 3rd order levelling runs (with network adjustments). So, for the 40 km length of the AHD traverse around the lake, the allowable misclose is ±25 mm (1st order or $4\sqrt{k}$), ±51 mm (2nd order or $8\sqrt{k}$) or ±76 mm (3rd order or $12\sqrt{k}$). Theoretically, the slope of the water surface across the lake from west to east could be either uphill or downhill by at least 25 mm. However, the vagrancies of the tides themselves may produce a different result.

As with the vagrancies of finding the MHW level, the tidal gradients exhibit similar characteristics. Figure 9 shows the changes in the tidal gradient across Lake Macquarie over time. The AHD variance is small compared to the variances in the tidal gradient. Similar changes over time occur along a tidal stream such as the Hunter River (Figure 10).

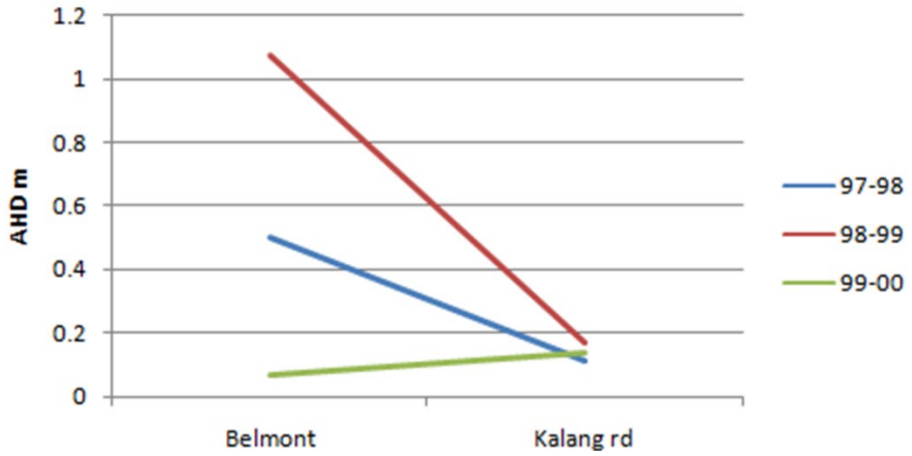

Figure 9: East-west tidal gradient across Lake Macquarie (1997-2000).

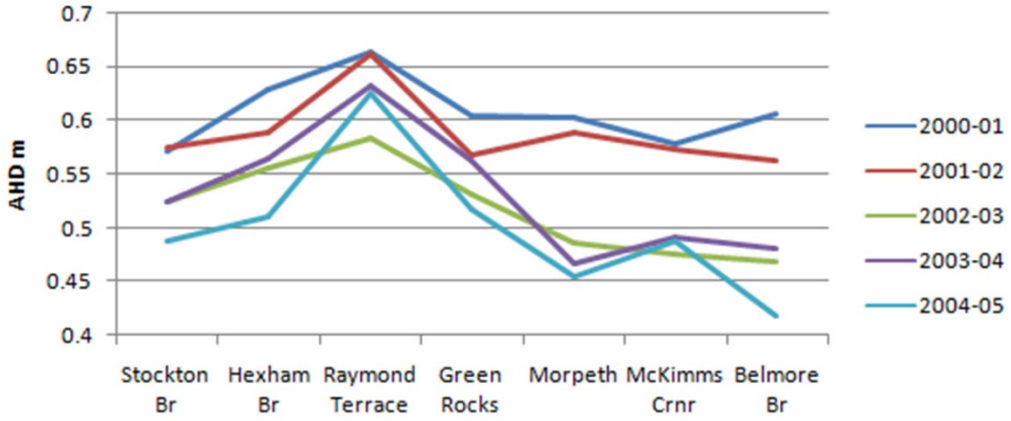

Figure 10: Tidal gradient along the Hunter River (2000-2005).

The distance between the Stockton Bridge and the Belmore Bridge at Maitland is 28 km as the crow flies. It is 32 km by road, the distance the AHD levelling would have had to run, and 56 km by river. As these distances are far in excess of the recommended limit for use of AHD in determining which way water will flow, it reduces the certainty of AHD to provide reliable relationships along the tidal gradient. When combining the uncertainty of establishing a consistent level of MHW with the distance uncertainty of AHD and possible local anomalies within the AHD network (McCubbine et al., 2019; ICSM, 2021), there would need to be some consideration as to whether or not the tidal surface flows downhill towards the river entrance to the sea. Is the rise in the river surface at Raymond Terrace (see Figure 10) a consequence of the flow characteristics of the river (the Williams River meets the Hunter at this point) or is there some anomaly in the AHD network creating the hump? Can the determination of MHW anywhere along the course of the river be certain or is any determination restrained to a localised phenomenon? Unless the AHD-determined components of riparian boundary surveying can be pulled along into adjusting for the future by proposed new techniques in advanced Global Navigation Satellite System (GNSS) levelling (Brown, 2019; McCubbine et al., 2019), then there are possibly no answers. The AHD levels of the tide gauge network need to be verified or updated to get more certainty.

3.1.3 Other Methods

Other methods of determining the location of the tidal boundary, such as relating to mangrove positioning, the tops of cobbler's pegs or the oyster ring on a post, or taking an instantaneous observational assessment, probably do not need mentioning as to the certainty of these methods. The results are of course just as uncertain as is the accuracy.

3.2 The Bank and Not The Bank

Legislation has left the surveyor in an uncertain position as to what to call the non-tidal riparian boundary. It is either the bank, if under the Crown Lands Act, or possibly the limit of the bed if the Surveying and Spatial Information Regulation is to be adhered to. Either way, the determination of this uncertain named entity must be carried out in the same manner. The average or mean stage must be determined, setting aside the uncertainties in establishing the stages associated with non-ordinary freshets and extreme droughts.

Determining the mean stage requires measurements of stream flow over an extended period of time, preferably decades. With adequate data at hand and the application of some mathematics, it is possible to determine the mean stage (Songberg, 2002, 2012). Australian river and stream

flows change with the vagrancies of nature. There is no discernible regular cycle (Figure 11), so it takes an extended set of measurements to determine the mean. A short period of measurement, using similar time scales as to those used in tidal determinations, will only obtain a heavily biased result. The observation duration of Figure 11 is only 30 years and possibly is only barely long enough to get a meaningful result. However, surveyors do not have 30 years or more to observe, or the resources to set up a stream gauging station.

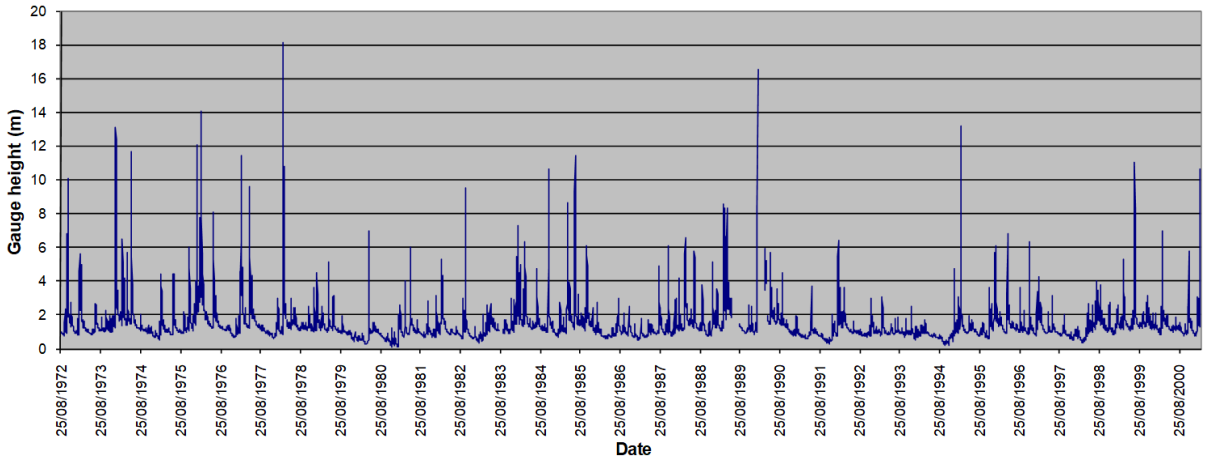

Figure 11: Typical Australian non-tidal stream characteristics, showing the maximum daily gauge height of the Manning River at Killawarra (Songberg, 2012).

It would be possible to utilise data from an established gauge (Songberg, 2002, 2012), but they are few and far between and likely nowhere near or even on the same stream as the survey. The surveyor is left with only one alternative, i.e. walk down to the stream on the day of the survey and have a guess, educated or not (Songberg, 2020). The result is highly uncertain and not likely to be the actual bank as required by the legislation. Having a guess has no basis in surveying and guessing at what the mean stage is on a river profile is impossible. It is not until some form of statistical analysis is undertaken that there can be an appreciation of where the correct stage is located across the stream profile (Songberg, 2012) (Figure 12).

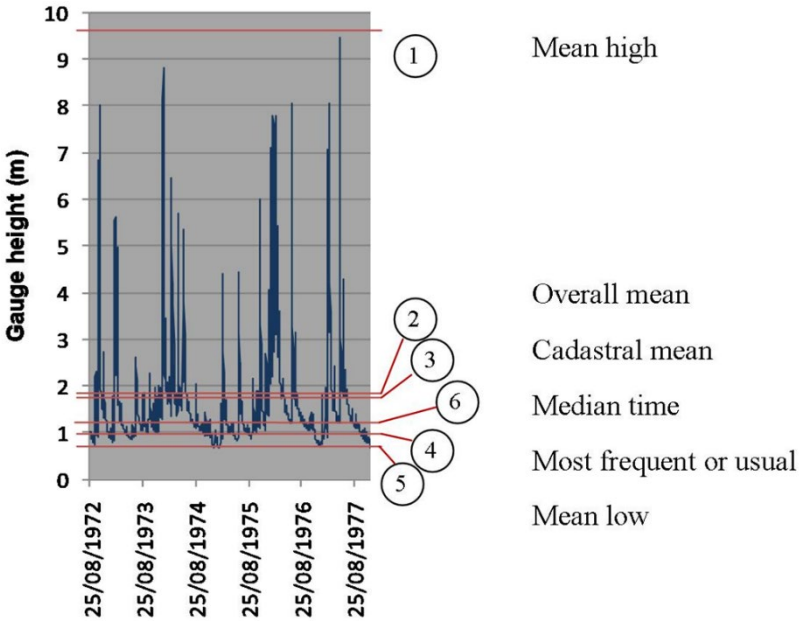

Figure 12: Typical non-tidal stream stages, showing the Manning River at Killawarra (Songberg, 2012).

Any other result is an uncertain one. With guess work being the most likely method utilised in the past throughout the State to establish non-tidal riparian boundaries, the extent of properties along non-tidal streams has been moved from a state of certainty to one of uncertainty.

Determining the mean stage of non-tidal lakes is just as uncertain as streams. Gauges only exist on some lakes, so without one, and one with long-term data, there is no way of determining the mean stage. Unlike many streams, there is often a distinctive change in the landscape that will give a natural appearance to the edge of the lake. Inland lakes might have a natural limit determined by an overflow channel. Intermittently Closed and Open Lakes and Lagoons (ICOLL) extents may be more influenced by the tidal reach during times of being open to the sea than water levels during times the bar is closed. These perceived natural extents are likely to have no relevance to the cadastral requirement of the limit of the bed but are more likely the choice of surveyors.

Inland lakes could be dry for extended periods and only fill to capacity after substantial rains. ICOLL water levels can also be as low as bare sand at low tide if the lake is open to the sea. But the upper extent is more likely to be determined by an artificial limit and manual opening when the water is deemed to be too high. Applying the definition requirements to such a stage regime may produce unintended results. The extent of non-tidal lakes is thus likely to be determined by any other visible factors observed at the time of survey rather than the dictates of the definitions.

3.2.1 Artificial Lakes

It should be stressed that determining the extent of an artificial lake, if such a thing exists in the cadastral realm, does not follow the same rule as natural lakes and does not have the uncertainties associated with natural lakes. The limit of an artificial lake is determined by the height of the constructed overflow channel or dam wall, whichever creates the 100% full lake level. The various stages have no relevance on determining the limit of the lake, see *Yeomans v. Peters (1895)* 16 NSWR (Eq) 197 (Ticehurst, 2000).

But is the body of water a lake or not a lake, as far as riparian boundaries are concerned? Both the Surveying and Spatial Information Regulation and the Crown Lands Act agree that a lake is a body of water “not contained in an artificial work”. The Yeomans court case determined how the boundaries of an artificial lake were to be found. If considered within the exact wording of the law and the outcome of the court case, then a dam across the stream would result in a lake contained “by” an artificial work and not one “in” an artificial work. Such a lake would constitute an artificial lake and have a riparian boundary. If, on the other hand, the artificial work surrounded the body of water, then it would not be a lake and could not have a riparian boundary. Is such a consideration certain? Unfortunately, the answer is uncertain.

4 CHANGES TO RIPARIAN BOUNDARIES

Riparian boundaries by the natural order of things move. They ambulate over time. The rate at which these boundaries move is dictated by the forces of nature. In the cadastral realm, however, artificial dictates and rules go against the natural order, creating disparities between the cadastre and nature. Those rules create uncertainties and situations can occur where the location of the cadastral boundary becomes indeterminate despite the natural boundary being highly visible. Unless the changes are evaluated and dealt with consistently, the results can

produce uncertainties within the cadastre (Songberg, 2004, 2007) and even loss of integrity (Songberg, 2019), so what is shown as a boundary might not be one.

The most obvious aberration against ambulatory change is within non-tidal lakes. The boundaries of these do not change. From the Crown Lands Management Act 2016, section 13.3(3), "the doctrine of accretion does not apply, and never has applied, to a non-tidal lake". The only uncertainty with this is if the lake were excised from freehold lands. As this rule was introduced under the Crown Lands Act for the alienation of Crown Lands, it is uncertain if the same condition would apply in a freehold situation unless a similar stipulation was to be made. The Surveying and Spatial Information Regulation 2017, however, seems to side with the opinion that the rule does apply as in clause 49(1): "If, since the date of a previous survey, there has been a change in the position of the bank of a lake forming a boundary of land to be surveyed, then, in any subsequent survey, the position of the bank, as it was before the change, must be adopted." This clause, however, only relates to old existing boundaries, not new ones, so the uncertainty still hangs.

Elsewhere in the riparian realm, the changes to the cadastral riparian boundaries are determined by application of the doctrine of accretion or erosion. The doctrine asserts that should the change be natural gradual and imperceptible, then the change should be adopted. It does not matter if the change creates an addition to the land (accretion) or subtraction from the land (erosion), the doctrine applies equally. The converse is that if the change is not natural or gradual, then the riparian boundary does not change, even though the physical boundary has substantially shifted. The riparian side of the boundary must also be given equal consideration as there will be some owner, be it the Crown or a private landowner.

Determining whether the change is gradual or not can be an exercise in uncertainty. In tidal waters, the ebb and flow of the tide is one changing force that is always there and could be expected to be the instrument of change. But when confronted with downstream-facing land spits (Songberg, 2007), or when no changes occur without water level rises occurring above tidal flow (Songberg, 2004), then consideration would have to be given to the major change factor being floods arising from high rainfall events upstream. This situation could be the case in the greater reach of the tidal stream, and it is only down in the lower reaches where it seems that there is a continual build-up of sand clogging the channels that gradual change occurs. Even the gradual sand build-up is not the whole story as it is from time to time pushed back out to sea when there is a major flood event within the stream.

To add further complexity, in 2002 the Coastal Protection Act 1979 was amended with the addition of section 55N with the modified doctrine of accretion and erosion. The impact of this was that within the coastal zone the area of adjacent land could not increase if the accretion is not likely to be indefinitely sustained by natural means, or public access to the waterfront will or is likely to be restricted. This could leave many riparian boundaries left in the undecided pile uncertain of how or if they can be resolved.

Rising sea levels have been well documented and are even evident in 20-year tidal records (Songberg, 2015, 2016). To say that an increase in land due to gradual accretion was indefinitely sustainable would be impossible, given that one day the rising sea will eventually cover at least the lower parts of the land, unless of course the trend reverses or the land also rises.

Gradual change must also follow the criteria that the change cannot be noticed from day to day, week to week or month to month. A change might be noticeable over a longer period, say a

year, but it cannot be considered as gradual unless it can be proven that the process had been ongoing throughout that time and not observable during the shorter time spans. An event that causes change on a yearly basis is not considered gradual as a consequence of several court cases (Ticehurst, 2000). With higher than normal flow events being the dominant factor in changes to river banks and much of the upper tidal estuaries, the frequency of when those flows occur has a telling factor on whether or not they form part of the gradual change. Statistical review of stream flow data indicates that these flows only occur on average 1-year to 1.5-year intervals (Songberg, 2002, 2012). Rainfall events that are sufficient to create such a rise do not conform to the statistical timetable (see Figure 11) and in reality occur at random intervals as so do the higher stream flows. Such rises could occur a month apart or 10 years apart. What this means is that such events, either the statistical average or the random occurrence, places the cause of change outside the gradual acceptability. It also pushes the concept of gradual change in much of our river systems to a very uncertain possibility.

One cause of change process that is certainly gradual is the steady rise in sea level. With the process evident over a 20-year recording span (see Figure 7) and undeniable over longer records (see Figure 8), the seashore will gradually encroach into the land. Whatever ownership is attributed to the wet land encompassed by tidal waters, that ownership has the same rights of gradual increase as does the dry land counterpart. So, by rights the tidal riparian boundary should gradually move into the land and the land area diminish. Some agree with this (Corkill, 2013) and some do not (Barham, 2016), resulting in the ambulatory nature of the cadastral tidal riparian boundary possibly limited and in a state of uncertainty.

The limitation and uncertainty revolves around the artificially defined right-line boundaries such as those bounding a regular shaped land parcel or the landward boundary of a foreshore reserve. Corkill (2013), based upon court decisions such as *Environmental Protection Authority (EPA) of New South Wales v. Saunders (1994)*, cites justice Bannon who deemed that the allotments, being below water, could not be occupied and had been effectively extinguished. The opposing view considers the right-line boundary do be inextinguishable so that the ambulatory riparian boundary could not pass across one, with the decision in *McGrath v. Williams (1912)* being given as reason. The decision in *McGrath v. Williams* determined where the landward boundary of the foreshore reserve should be located, offset to the position of MHW at the time of creation (granting of the land). It is held that, as a consequence of that case, the landward boundary, being a defined boundary, is not a riparian boundary and is not subject to the doctrine of accretion and erosion (Ticehurst, 2000). This would imply that the riparian boundary could not pass beyond the right-line boundary even though it physically does.

So, who is right and who is wrong? Did *McGrath v. Williams* really determine that the ambulatory boundary could not migrate across the right-line landward reserve boundary, or did the decision only determine where the reserve should be located, at a particular point in time? The reserve does not migrate parallel with the ambulatory boundary; it gets eaten away. But what happens to the right-line boundary? Does it stay or does it also get eaten away with the rising sea, just as the next right-line bounded land parcel? Do the rights of the owner of the sea get curtailed by an artificial line? There does not seem to be a definitive answer to the situation, so a resolution remains uncertain.

The effects of a rising sea can also be very noticeable when storm-driven waves and tidal surges eat away the dune behind the beach, sometimes toppling homes into the ocean. In this instance, under the doctrine of accretion and erosion, the riparian boundary does not change even though the sea marches inland and the land is physically lost to the sea.

The situation in non-tidal lakes is a complete contrast. From the Crown Lands Acts, it is deemed that the doctrine of accretion and erosion does not and never did apply to non-tidal lakes. So, wherever the riparian boundary was determined that is where it remains, no matter if the physical line changes for whatever reason. The position of the riparian boundary, however, comes down to the choice of the surveyor at the time. That choice would have been a subjective guess and not based on any stage measurements or a MHW determination in an ICOLL. The choice of different surveyors might not necessarily be the same, with the result being that non-tidal lake boundaries are not related to the average or mean stage and might not be consistently positioned around the shoreline. These boundaries thus remain in the uncertain realm.

Determining whether or not the riparian boundary, tidal or non-tidal, changes is never an easy or straight-forward exercise. Outcomes might have inconsistent consequences on both the riparian and land zones. A movement on a cadastral perspective might be completely different to the physical perspective. As Figure 13 illustrates, the physical stream and the cadastral stream might be some distance apart (Songberg, 2016). As the sea swallows the land, artificial boundary lines might cause a disparity between the cadastral and physical properties (Figure 14). Could a boater travel across someone's backyard if one principle applies or not if another is upheld?

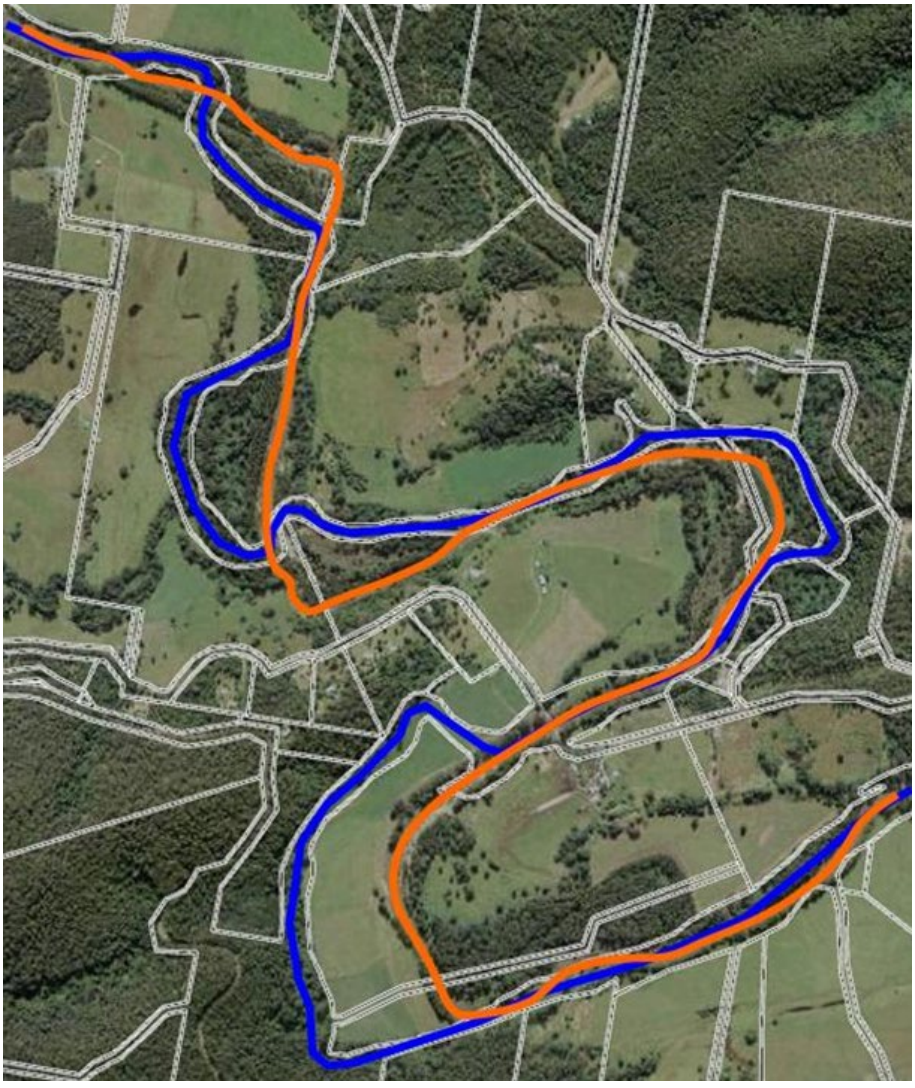

Figure 13: Cadastral stream (blue) vs. physical stream (orange).

Figure 14: The march of the sea vs. right-line boundaries.

The outcome in riparian boundary cadastral change is not always certain and differing results could change the movement regime on either side of the river. The right-line boundary dilemma might also be a factor, with the result of the uncertainties being that a cadastral river might actually disappear and cadastral land properties potentially overlap (Figure 15) (Songberg, 2004).

Figure 15: The potential for rivers to disappear in a cadastral sense.

Riparian boundary change can also be mismanaged in both assessment and recording so that once again the cadastral and physical rivers do not match (Figure 16), also creating potential for a corrupt cadastre (Songberg, 2019). The only certain thing of riparian boundary change is that it is uncertain.

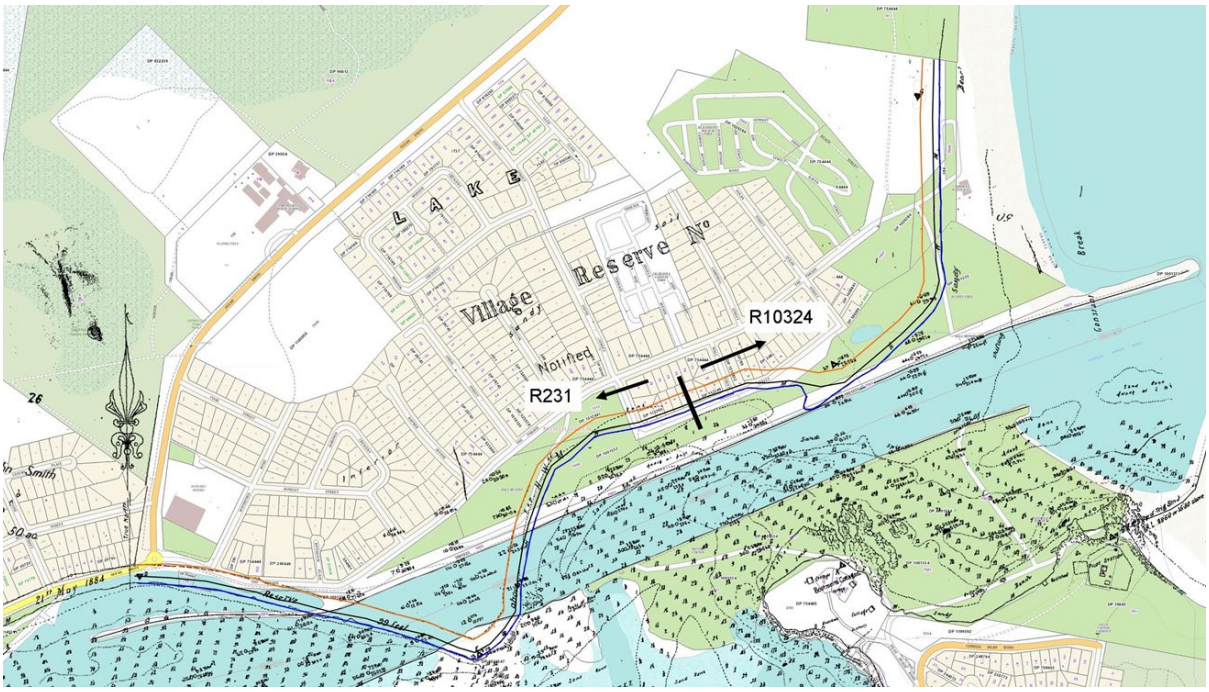

Figure 16: Corrupted cadastre, resulting from change mismanagement (the overlay to the cadastre is the correct riparian boundary alignment).

5 CONCLUDING REMARKS

This paper has outlined various components that have created the state of the uncertain realm for riparian boundaries. As the surveying community is adjusting for the future with new and evolving techniques and technologies to better position us, the way we view and conduct riparian boundary determinations must also change. Otherwise these important components of the cadastre will remain stuck in an uncertain realm.

Legislation that governs riparian boundary determination is poorly worded, inconsistent, conflicting, incomplete in meanings and at times misdirecting. Crown Lands and surveying legislations do not agree with each other so that the label for a non-tidal boundary in one is not the label in the other. Working with the two will leave a surveyor in the middle of nowhere. The label for a tidal boundary is actually a different entity, leaving the industry-expected boundary without an identifier. Both legislations have unexplained or undefined terms such as ordinary, extreme and extraordinary. Practitioners have to exercise their own interpretation, which is not always consistent. The surveying legislation would have boundaries identified by different but similar features and called by a different name grouped under one label, which could physically shift the boundary without regard for the doctrine of accretion and erosion or land ownership. The same legislation gives the surveyor an option to disregard the group label if another intention applies but at the same time ignores circumstances where another label is another intention.

Survey practice has evolved over time so that industry is comfortable with the outcomes. That is despite those practices not complying with the legislation, if the legislation could be complied with in the first instance. Those practices, however, can produce inconsistent results that are not reflective of the actual boundary. Non-tidal boundaries are a guess and not based on measurement as are some tidal boundaries. Tidal regimes, if followed, would cause

discontinuities in the physical boundary, creating disparities between adjoining surveys, because they were conducted at different times.

With riparian boundary determinations being non-compliant with legislation, it would be easy to conduct a successful legal challenge to any result if it were disagreed with. It is no wonder that our perplexed surveyor at the start adopted the unacknowledged boundary by agreement practice that has somehow evolved. The riparian boundary realm is in desperate need of reform. Calls have already been made advocating such a reform (Songberg, 2016), but since then the situation has noticeably deteriorated. The Surveying and Spatial Information Regulation is again due for update in 2022. So, as surveyors are adjusting towards the future, consideration should be given now as to how and what needs to be done to remove the uncertainties and adjust the riparian boundary realm so it can be consistent with future positioning expectations.

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