8 February 2024

File Ref: OIAPR1274023063-25267

[redacted]
By email: [redacted]

Tēnā koe [redacted]

Request for information 2023-311

I refer to your request for information dated 26 December 2023, which was received by Greater Wellington Regional Council (Greater Wellington) on 26 December 2023. You have requested the following:

1. *"At what date, post the 2001 cut, did the Waikanae River first breach the trigger points, as set as monitoring points for intervention... and how far south from that trigger point has the river now proceeded?*

2. *Why has GWRC not used the consent granted and cut the Waikanae River mouth?*

3. *How much does it cost GWRC to cut the Waikanae River mouth?*

4. *I note an 'informal' approach was made by KCDC to GWRC in 2018 and they were told GWRC were 'monitoring the situation'. What monitoring has been done and what are the findings?*

5. *According to a recent OIA request from KCDC, the last aerial photo they have was taken in 2021. Does GWRC have aerial photographs from 2022 and 2023 and could they supply them?*

6. *Does GWRC consider it has a responsibility to cut the river so as to protect residents' properties on adjacent land accreted due to historical river management?*

7. *Have local iwi expressed that they do not want the river cut? If so, has this influenced GWRC's actions, and what was their objection?"*

Greater Wellington's response follows:

1. At what date, post the 2001 cut, did the Waikanae River first breach the trigger points, as set as monitoring points for intervention... and how far south from that trigger point has the river now proceeded?

We do not have a record of the specific date when the mouth migrated south of the trigger point following the December 2001 mouth cut. We are therefore refusing this part of your request under section 17(g) of the Local Government Official Information and Meetings Act 1987 (the Act) on the basis that the information requested is not held by Greater Wellington and there are no grounds for believing that the information is either –

(i) Held by another local authority or a department or Minister of the Crown or organisation; or

(ii) Connected more closely with the functions of another local authority, or a department or Minister of the Crown or organisation.

2. Why has GWRC not used the consent granted and cut the Waikanae River mouth?

Under Rule 214 of the Natural Resources Plan for the Wellington Region 2023 (NRP) cutting is a permitted activity providing a list of conditions are adhered to. It can only be cut as a permitted activity (i.e., without requiring a resource consent) if the NRP Schedule T (river mouth cutting triggers) are equalled or exceeded and the cutting is only allowed to be carried out for the purposes of flood protection and/or erosion mitigation. The rule also specifies that the cutting shall only be carried out by or for a local authority. The triggers are defined in the NRP as:

- **Waikanae River Erosion** – When the channel outlet within the coastal marine area migrates either 500m south or 200m north of a projected line parallel to the centreline of the groyne to the south bank of the river.
- **Flooding** – When the water level increases 300mm or more above the normal river levels at the Otaihanga footbridge.

The Waikanae River Mouth contains a Scientific Reserve that is managed by the Department of Conservation. Greater Wellington does not have an open consent from the Department of Conservation to cut the Waikanae River Mouth. Every mouth cut requires approval from the Minister of Conservation. Thus, whilst the river mouth is allowed to be cut when a trigger is breached, it is not required to do so, and it still requires approval from the Department of Conservation.

The NRP can be accessed online: https://www.gw.govt.nz/your-region/plans-policies-and-bylaws/plans-and-reports/environmental-plans/natural-resources-plan/

3. ***How much does it cost GWRC to cut the Waikanae River mouth?***

We are refusing this part of your request under section 17(g) of the Act on the basis that the information requested is not held by Greater Wellington and there are no grounds for believing that the information is either –

(i) Held by another local authority or a department or Minister of the Crown or organisation; or

(ii) Connected more closely with the functions of another local authority, or a department or Minister of the Crown or organisation.

We do not have any current estimates as to the cost to cut the Waikanae River Mouth, but it is likely to be in the order of tens of thousands of dollars. As a guide, a cut of the Waimeha Stream mouth costs in the order of $10,000.

4. I note an 'informal' approach was made by KCDC to GWRC in 2018 and they were told GWRC were 'monitoring the situation'. What monitoring has been done and what are the findings?

Greater Wellington operational staff monitor the location for the Waikanae River mouth. This is undertaken on an annual basis and at times when a severe weather warning is issued and following flood events.

No action has been considered necessary from those inspections.

Following the last mouth cut in December 2001, an analysis was undertaken to assess what effect the works might have had on the coastal marine area. This assessment is contained in the report: 'Evaluation of Coastal Monitoring Surveys around the Waikanae River Mouth' (**Attachment 2**). In summary, the analysis showed that there were no clear trends associated with the mouth cutting.

5. *According to a recent OIA request from KCDC, the last aerial photo they have was taken in 2021. Does GWRC have aerial photographs from 2022 and 2023 and could they supply them?*

See the attached aerial photographs for the Waikanae River Mouth downloaded from the NearMap satellite subscription service dated from 8 February 2019 to 11 November 2023 (**Attachment 1**).

Greater Wellington and Kāpiti Coast District Council also have aerial photographic coverage for the Waikanae River Mouth for the following dates/years:

- 22 March 2021 Video (Waikanae River Scientific Reserve & Mouth)
- 2021 local and regional scale
- 18 February 2019
- 11 February 2017
- 2017 local scale
- 2 February 2016
- 2013 local and regional scale
- 2010 local and regional scale
- 20 December 2008
- 13 February 2007
- 18 February 2005

- 25 February 2004
- 21 February 2002
- 2001
- 18 March 1999
- 1998
- 1995
- 1991
- 1990
- March 1987
- 1985
- 1973
- 1968
- 1967
- 1966 + 2021 comparative 3D Flythrough
- 1957
- 1954
- 1942

6. ***Does GWRC consider it has a responsibility to cut the river so as to protect residents' properties on adjacent land accreted due to historical river management?***

A decision to cut the mouth is undertaken with discretion in order to minimise disturbance to the habitat of the estuary and coastal environment. The aim is to allow the river mouth to operate as naturally as possible. Specifically, the mouth cuts are to be used for the purposes of flood and erosion control within the river mouth and estuary. They have not been developed for the purposes of coastal and dune management of the shoreline outside the estuary environment. If erosion within the estuary were to be directly threatening houses, Greater Wellington would start the process to initiate a cut in consultation with the Greater Wellington Environmental Regulation team and the Department of Conservation.

The archives indicate that the river mouth was cut 11 times between 1930 and 2001, with 6 of these cuts occurring between 1960 and 1990. The southern part of the estuary was reclaimed during this time to enable subdivision at the northern end of Manly Street. What is clear is that the estuary envelope is reasonably stable and has remained within its current configuration for the past 40-50 years. Aside from 2001, it has not been considered necessary to cut the mouth in order to prevent the river from entering its old configuration at the northern end of Manly Street.

The river mouth outlet is more mobile and ranges across a distance of shoreline of around 900m from north to south, but predominantly to the south. The exit is controlled by two dynamic sand spits that grow and erode in response to the dynamic interplay between fluvial and coastal processes, sediment transport, wind and wave activity, storm events and ongoing sea level rise.
The northern spit is usually larger, containing more sand and generally holding the river mouth in a more southerly position. This is due to the predominant north and northwest wind and wave conditions that drive a southern directed longshore sediment transport system. Occasionally, large floods will break through the northern spit and cause the channel to flow on a straight westward path to the sea. After this occurs there is usually a southward progression of the river mouth again until the cycle repeats. The southern spit is generally smaller, but no less dynamic and is subject to

the same cycles of erosion and growth seen in the northern spit. These changes are natural and are part of the geomorphic processes of Waikanae River mouth and estuary environment. Greater Wellington does not manage the river mouth to control or inhibit these natural processes unless there is clear and present risk to property and housing.

It is evident that the northern part of Paraparaumu Beach, extending over a kilometre south from the river mouth, has been experiencing periodic episodes of erosion for many decades, with the most recent episode starting in mid-2016, during which time there has been a sustained period of erosion in response to a series of significant winter storms, particularly July 2016, July 2018 and July 2022. These storms have caused substantial erosion to the dunes, that have struggled to recover from the impacts they have sustained.

Whilst it is distressing to see the dunes being eroded, the current phase of erosion is not yet directly threatening houses from being undermined and as discussed, the number of intersecting variables makes it difficult to link any one process, such as erosion, with another, such as river mouth alignment, with any degree of certainty.

7. ***Have local iwi expressed that they do not want the river cut? If so, has this influenced GWRC's actions, and what was their objection?***

Iwi views have been taken into account when deciding what management activities are undertaken in relation to the Waikanae River Mouth and this does influence our decisions, but the overall management of the River is guided by the Floodplain Management Plan: https://www.gw.govt.nz/assets/Documents/2021/11/FP-Waikanae-FMP.pdf

If you have any concerns with the decision(s) referred to in this letter, you have the right to request an investigation and review by the Ombudsman under section 27(3) of the Local Government Official Information and Meetings Act 1987.

Please note that it is our policy to proactively release our responses to official information requests where possible. Our response to your request will be published shortly on Greater Wellington's website with your personal information removed.

Nāku iti noa, nā

Lian Butcher
Kaiwhakahaere Matua, Taiao | Group Manager, Environment

Attachment 1 – Aerial photographs for the Waikanae River Mouth 8 February 2019 to 11 November 2023

Figure 1: *11 November 2023*

Figure 2: *16 June 2023*

Figure 3: *30 April 2023*

Figure 4: *5 June 2022*

Figure 5: *17 April 2022*

Figure 6: *17 March 2021*

Figure 7: *15 December 2020*

Figure 8: *5 May 2020*

Figure 9: *12 February 2020*

Figure 10: *8 February 2019*

NOVEMBER 2003

Evaluation of Coastal Monitoring Surveys around the Waikanae River Mouth

FOR FURTHER INFORMATION

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1. Introduction

The Waikanae floodplain has formed over the last 6,000 years from a combination of longshore drift and deposition of alluvial material from the Tararua Ranges. At the coast, predominant longshore transport of sediments from the north to the south causes the Waikanae River mouth to migrate to the south. This promotes the formation of an estuary with prominent sand spit. The estuary is a reserve of national significance, with several rare and vulnerable species and is managed by the Department of Conservation. Residential development has been rapid around the coastal fringes of the Waikanae floodplain over recent years and houses now flank the estuary and river.

Unchecked migration of the river mouth causes constriction and periodic blocking of the river, which has the effect of increasing flood levels in the lower reaches. It also causes erosion of vulnerable coastal areas to the north or south, which can encroach into properties. To minimise flooding and erosion, the Waikanae River mouth is cut periodically.

Conditions 35, 36 and 37 of Resource Consent No. WGN 980256(06) for cutting the river mouth require that the coastline to the north and south of the river mouth be monitored and surveyed at fixed intervals, aerial photographs of the river mouth and adjacent coastal areas be taken, and reporting on the effects of the cut on the coastal marine area be carried out. This report has been prepared specifically to meet condition 37 of the resource consent, and to confirm that conditions 35 and 36 have been complied with. In this report, an analysis of the cross-section survey results is carried out, these results are compared with survey results from nearby cross-sections taken over a longer timeframe, and the effects on the coastal marine area are described.

2. Discussion and conclusions

Cross-section surveys have been carried out along the coastline around the mouth of the Waikanae River to monitor the effects on the beach of cutting the mouth. The monitoring surveys have been carried out at sections WM01 through WM06 since 6 December 2001. Surveys have been carried out at other cross-sections along the Waikanae coastline over a longer timeframe, and the results of these surveys have been used in the present analysis to extend the available survey record and provide comparison data for the WM0 series surveys. Recent cuts have been made in the river mouth in 1989, February 1995 and on 10 December 2001.

From the volumetric changes in Tables 2 and 3, and changes in dune line position in Table 4 there appear to be no clear trends associated with the mouth cuts. The calculated volume changes immediately following the cut are relatively small scale and the change in dune line position is of the same or lesser order of magnitude than that occurring in other surveyed intervals. Furthermore, the measured erosion and accretion is similar or smaller in scale to the changes measured to the south, out of the estuary area, over the longer surveyed period.

The analysis of the survey results may be briefly summarised as follows:

- It is difficult to obtain a feel for changes over sections WM02, WM03 and WM04 as they are within the river delta area and thus are very dynamic and mobile. Section WM02 is also within the area affected by a 'rounding effect' from the river channel allowing larger waves to approach further inshore.

- Sections WM05 and WM06 may be considered comparable to Sections 42 and 43 as they are relatively proximal and have a similar orientation to the wave and wind conditions. Viewed over the monitored period, section WM05 has eroded, section WM06 has remained reasonably static and sections 42 and 43 have accreted.

- The erosion at section WM05 is likely to be a localised effect from the river mouth. Cutting the river mouth resulted in the outlet channel being located near this section and the deeper river outlet channel allowed larger waves to approach closer to the shore, causing a localised rounding effect at the river mouth.

- Section WM06 appears to be at the pivot point for the change in trend from erosion at section WM05 and accretion at section 42. It could also be surmised that the effect of the mouth cut is likely to extend only to section WM06, as this appears to be the likely point of change (from erosion to accretion over the section) in the longshore sediment transport regime.

- Section WM01 is expected to exhibit similar behaviour to the sections at 131, 163 and 202 Manly Street. There has been foredune retreat at all of these sections, which is likely to be from other influences than just the mouth cut (e.g. foredune realignment). However, viewed on a 'whole section' basis, these sections have all accreted.

- The trend of accretion of the beach level seawards of the dunes at the sections at 163 and 202 Manly Street is borne out by site measurements taken by Mr Frank Glover, a Manly Street resident, at stormwater pipes to the south and north of these sections (respectively), and in front of the block wall at the Waters Edge subdivision. The general beach levels at the stormwater pipes showed no change over the period 10 December 2001 to 20 January 2002, but were then observed to accrete up to 0.3m from 20 January 2002 to 30 October 2002. Beach levels at the wall in front of the waters edge subdivision were observed to accrete 0.7m from 10 December 2001 to 31 October 2002.

The river mouth cut appears to have only local effects on the Waikanae Beach coastline. There is a small amount of rounding of the 'corners' of the river mouth observed near section WM05 and straightening of the old rounded area at section WM02. No influence of the mouth cut is observed at sections WM01 and WM06. Whether changes would be observed following subsequent mouth cuts is uncertain because of background influences such as floods, droughts etc. Changes in the direction of the prevailing wind (from Northwest to North-Northwest) will also have an influence on any observed changes.

3. River mouth cutting and survey data

Trigger points for cutting the Waikanae River mouth are set out in the Regional Coastal Plan. They are when the channel outlet migrates either 500m to the south or 200m to the north of groyne on the south bank of the river, or when tide levels at the Otaihanga footbridge rise more than 300mm above normal sea levels.

The river mouth is known to have been cut 1930, c. 1938, 1947, c. 1955, 1960, 1971, 1976, 1984, 1989, February 1995 and on 10 December 2001 (Gibb 2002). The latter cuts required resource consent under the current regulatory regime (Resource Management Act, 1991) and also approval from the Minister of Conservation. Under conditions 35, 36 and 37 of Resource Consent No. WGN 980256(06) for cutting the Waikanae River mouth and also under the Waikanae Floodplain Management Plan, the mouth and its reaction to the works is to be monitored on an ongoing basis.

Conditions 35, 36 and 37 for Resource Consent WGN 980256(06) to cut the Waikanae River Mouth are as follows:

35. The consent holder shall monitor the coastline north and south of the river by establishing and surveying at least six profiles at locations to be selected in consultation with Kapiti Coast District Council, to the satisfaction of the Manager, Consents Management, Wellington Regional Council. The profiles are to be surveyed within 3 months before the river diversion and at one, three and six months after completion of the diversion and six monthly thereafter for a period of three years. The profiles shall extend from a fixed point at the back of the dunes and across the beach to a point at least one metre below mean low water.

36. The consent holder shall arrange for aerial photographs to be taken of the river mouth and adjacent coastal zones (north and south) at least every two years.

    These photos should be taken at the same state of the tide, preferably at low water, on each occasion.

37. Twelve months after the completion of the diversion the consent holder shall arrange preparation of an independent report describing the effects on the coastal marine area. This report shall include the result of the first twelve months monitoring and provide a realistic assessment of the effects of the diversion and any related activities. The report is to be carried out by appropriately skilled personnel, in consultation with Kapiti Coast District Council, to the satisfaction of the Manager, Consents Management, Wellington Regional Council.

3.1 Condition 35

Cross-section surveys of beach profiles have been taken around the Waikanae River mouth since December 2001, specifically to monitor the ongoing effects of the cut on the local beach regime. These sections are taken along profile lines WM01 through WM06, as shown in **Appendix 1**. Of these cross-sections, WM01 and WM02 are to the south of the river mouth, cross-sections WM03 and WM04 are through the Waikanae River estuary and WM05 and WM06 are taken to the north of the river mouth. The dates of monitoring surveys for these sections are given in Table 1 (in red).

Additionally, Greater Wellington and the Kapiti Coast District Council have carried out cross-section surveys along the Kapiti Coast over a longer time period. These profiles are at 131 Manly Street, 163 Manly Street and 202 Manly Street, which are to the Southwest of the WM0 series profiles, and Section 42 and Section 43, which are to the Northeast of the WM0 series profiles. The locations of these profiles are also shown in **Appendix 1**, and the dates of these surveys are also shown in Table 1 (in black).

The coastal profile database includes surveys at some of the sections given above that have been saved under a different section number, possibly for historic reasons. For completeness, the data from these other records has been added to the record for the appropriate section. These are Section 17a, which is at 202 Manly Street, Section 32, which is at WM02 and Section 34, which is at WM04. The dates of these surveys are also shown in Table 1 (in blue).

Condition 35 of the resource consent requires surveys at set intervals. These are within 3 months before the river diversion and at one, three and six months after completion of the diversion and six monthly thereafter for a period of three years. The cut took place on 10 December 2001, so it may be seen from Table 1 that the survey on 6 December 2001 was carried out before the cut, and the surveys in 2002 and 2003 are at the stated intervals required by the consent condition. Surveys still have to be carried out in December 2003 and in June and December 2004 to fulfil this condition completely.

3.2 Condition 36

Aerial photographs of the river mouth and adjacent coastal zones have been taken to fulfil Condition 36 of the resource consent. These photographs are available for viewing at the office of Greater Wellington Regional Council. One of the aerial photographs from February 2002 is used as background in **Appendix 1**.

3.3 Condition 37

Condition 37 has been met by this report, which has been prepared by Sharyn Westlake. During preparation, this report has been discussed with Blair Murray of the Kapiti Coast District Council. A brief summary of Sharyn's professional expertise is given below.

Sharyn Westlake (*MSc, DipHE, BE (Hons), M.IPENZ, RegEng*).

Prior to July 2003, Sharyn was a Principal Coastal/Marine Engineer at Opus International Consultants Ltd. She has a diverse range of Civil and Hydraulics Engineering experience in New Zealand and abroad, including specialist knowledge of coastal environments and morphology, the physical processes of the sea, the interrelationships between sea, wind and shore, and engineering design experience with coastal protection structures and marine developments. Sharyn has carried out design of nourished beaches, coastal zone management and environmental impact assessments.

Her Masters research was carried out on the 'Behaviour of a Shoreface Nourishment, Terschelling, The Netherlands', at the National Institute for Coastal and Marine Management/RIKZ, The Hague, The Netherlands. Following completion of her thesis, a further year of work followed, involved with analysis of bathymetric survey information from monitoring of the shoreface nourishment carried out at Terschelling. The project was part of an EC-funded international collaboration between The Netherlands, Germany and Denmark, researching morphological behaviour and possible design tools for future beach and shoreface nourishment schemes.

New Zealand projects Sharyn has been involved with have included development of new beaches and beach retention structures, feasibility and costing studies for submarine pipelines, studies of options to mitigate and reduce the effects of coastal erosion, coastal road protection and dune management strategies, and design of coastal protection structures. Sharyn has experience in coastal hazard mapping in projects in New Zealand and Samoa and has carried out cost/risk/benefit/social impact assessments for coastal projects. She has also presented papers on coastal risk assessment and shoreface nourishment at international conferences.

Table 1: Dates of coastal profile surveys

Survey Date	Time between surveys (days)	Cumulative time between surveys	Section									
			131 Manly St	163 Manly St	202 Manly St	WM01	WM02	WM03	WM04	WM05	WM06	42	43
29-Nov-84					*								
07-Mar-85	98	98			*								
09-Sep-85	186	284			*								
17-Mar-86	189	473			*								
29-Sep-93	2753	3226			*								
01-Nov-94	398	3624	*	*									
15-Nov-94	14	3638	*	*									
28-Nov-94	13	3651	*	*									
11-Jan-95	44	3695	*	*									
28-Mar-95	76	3771	*	*									
29-Jun-95	93	3864	*	*									
14-Sep-95	77	3941	*	*									
28-Mar-96	196	4137	*	*									
29-Apr-96	32	4169	*	*	*								
06-Nov-96	191	4360	*	*	*								
09-Dec-96	33	4393	*	*	*								
30-Oct-97	325	4718	*	*	*								
11-Nov-98	377	5095	*	*	*								
10-May-99	180	5275	*	*	*								
01-Mar-00	296	5571	*	*	*								
06-Jun-00	97	5668	*	*	*								
16-Aug-00	71	5739	*		*		*		*			*	*
22-Feb-01	190	5929	*	*	*							*	*
15-Jun-01	113	6042	*	*									
11-Sep-01	88	6130	*	*	*		*		*			*	*
06-Dec-01	86	6216				*	*	*	*	*	*		
22-Jan-02	47	6263				*	*	*	*	*	*		
07-Mar-02	44	6307				*	*	*	*	*	*		
24-Apr-02	48	6355	*	*	*		*					*	*
10-May-02	16	6371				*	*	*	*	*	*		
03-Dec-02	207	6578				*	*	*	*	*	*		
26-Feb-03	85	6663	*	*	*							*	*
26-Jun-03	120	6783				*	*	*	*	*	*		

4. The Kapiti Coast

A full description of the Kapiti Coast beach morphology and sediment transport regime is given in Gibb (2002). From Gibb, the points considered pertinent to the present analysis are given below:

- The beach sand at Waikanae is identified as "very well sorted fine sand", with a mean grain size of 0.15–0.125mm, with shell fragments and occasional hypersthene andesite pebbles.

- Sediment for the beaches is supplied from actively eroding seacliffs and rivers between Wanganui and Cape Egmont. The sediment is transported alongshore and offshore by waves and currents, with sand deposited in the nearshore beach environment out to about 20m water depth and mud deposited out beyond this depth on the inner continental shelf.

- Geologic evidence indicates a net southerly longshore drift of sediment between Cape Egmont and Paraparaumu out to about 20m water depth. At the Waikanae River mouth this is estimated by Gibb to be of the order of 70 – 90% of the gross drift both north and south.

- The breakwater effect of Kapiti Island has resulted in the formation of a cuspate foreland formed from sediment deposition.

- At Waikanae, historic net rates for advance of the coastline adjacent to the sewerage settling ponds are 0.42m/year from about 7,000 to 1,800 years ago, 0.43m/year between 1,800 and 1,100 years ago and 0.64m/year from 1,100 years ago to the present.

- Over approximately the last century (1892-2002), Waikanae and Paraparaumu beaches (monitored at cross-section locations shown in Figure 2) have continued to advance from accretion at 0.16 to 1.04m/year, with the greatest rates closer to the apex of the cuspate foreland.

- The trend of accretion has shown reversals, to short term erosion, at different times and at different profiles. About 1991, the Northeast flank of the cuspate foreland was eroding at rates of about –1.0 to –2.0m/year.

- Gibb suggests a frequency of 15 to 20 years for widespread erosion episodes along the Kapiti Coast, from evidence of erosion observed in the 1950s, 1970s and 1990s.

- The cuspate foreland is observed to have migrated to the Southwest. From 1948 to 1980 the migration was about 430m and from 1980 to March 2002 the migration was about 430m. The migration indicates a swing in prevailing wave approach from prevailing Northwest to prevailing North-Northwest. The migration of the cuspate foreland would have caused an ongoing adjustment in shoreline position, with erosion on the Northwest flank and accretion on the Southwest flank.

5. Background influences and tidal levels

5.1 Background influences

Background influences such as floods and droughts are likely to influence sediment movement in the river mouth area, and thus the apparent results of the river mouth cut. The following key events are likely to have had an influence over the monitoring period:

- Floods in October 1998, where a 30-year return period event occurred on 20 October and a 15-year return period event that occurred on 27 October.
- A 5-year return period event flood in October 2000.
- A 30-year return period drought in 2002/2003.
- Large sea swell events.

Following the flood events, observations from aerial photographs appear to indicate a loss of material in the estuary area, which was washed into deeper water into the tidal delta area. The consequent movement of this material, whether back onshore, or alongshore, is unknown. It is however felt that the estuary area is still in a "recovery phase" from the floods and that this influence will be evident in the survey results.

It is surmised that the drought is likely to have also had effect on development of the channel subsequent to the mouth cut, although the nature of this effect is unknown. The weather patterns that resulted in the low rainfall will affect sea conditions as well as the river flows.

Large sea swell events are likely to cause erosion of the dune or upper beach profile. This material will be deposited elsewhere in the beach profile and may also be carried alongshore, depending on the angle of the waves approaching the shore. The Kapiti Coast District Council were approached for information on sea swell events, and the dates that these occurred, but unfortunately no data is available.

5.2 Tidal levels

Tidal levels from the New Zealand Nautical Almanac (2002/2003 Edition) for Kapiti Island (Waiorua Bay) are as follows:

Mean High Water Spring	1.7
Mean High Water Neap	1.2
Mean Low Water Neap	0.9
Mean Low Water Spring	0.4
Mean Sea Level	1.1

The levels at the Waikanae River mouth are expected to be similar to those given above.

6. Results of beach profile monitoring

The results of beach profile monitoring at Paraparaumu and Raumati may be used to evaluate changes in the sediment transport regime, and possibly any influence of cutting the Waikanae River mouth. This analysis is carried out as a continuation of the trends presented in Gibb (2002) and Lumsden (2000, 2003), who evaluated the following aspects as a comparison of the survey data:

- Change observed at each cross-section from an overlay of the cross-section plots.
- Net change in beach profile volumes for each cross-section on a cubic metres per metre of beach basis.
- Position of the dune line (defined as 1.75m above Mean Sea Level)

The present analysis uses the survey data from the WM0 series surveys taken from 6 December 2001 to meet condition 35 of the mouth cut consent. The 131, 163 and 202 Manly Street and Section 42 and 42 survey data is also used in the analysis as a comparison, where possible, to try to see if any observed trends are confined to the river mouth area and/or whether these reflect the 'bigger picture'.

Lumsden (2000, 2003) carried out an analysis of the beach profile changes using volumetric changes over beach profiles. However, the volumetric changes as calculated by Lumsden and those calculated in the present analysis give different results. This is because the present analysis uses cross-section volume changes calculated over a common offset distance (distance in the cross-shore direction measured in a seawards direction) for all sections. Lumsden (2000, 2003) has calculated the changes between consecutive sections, using varying offset distances which makes it difficult to provide an overall comparison of volumetric changes.

6.1 Cross-sections

The results of drawing each cross-section survey on an overlay plot are presented in **Appendix 2**. For Sections WM01 through WM06, the first plot for each section shows the survey results including and after the 6 December 2001 survey. For Sections WM02 and WM04 a second plot is included which shows the results of every survey.

For the Sections at 131, 163 and 202 Manly Street and Sections 42 and 43, survey results from 11 August 2000 have been shown in the plots in **Appendix 2**.

6.2 Change in beach profile volumes

Changes in beach profile volumes (on a cubic metre per metre of beach basis) between surveys for each section are given in Table 2. Negative values indicate that the section eroded, while positive values indicate that accretion took place. The offset range for each section is shown in each column of Table 2 below the section name. The offset range is the length of cross-section that the net change in beach profile volume is calculated over and for each survey this needs to be a common length. In Table 2, the Offset Range is shown in the row below the section (third row down in the title block).

Lengthening the offset range, assuming sufficient data is still available as some surveys will then be neglected, is likely to alter the calculated volume changes between surveys

as a greater length of profile will include more of the offshore sediment movement. In Table 2, the short sections from each of the 131 Manly Street, 163 Manly Street and 202 Manly Street cross-sections have been removed and the changes in beach profile volumes recalculated. As it is considered that the greater distance measured offshore provides more accurate results, the data given in Table 2 is used for this analysis.

Table 2: Changes in beach profile volumes

Survey Date	Time between surveys (days)	Cumulative time between surveys	Section Name and Offset Range (m)										
			131 Manly St	163 Manly St	202 Manly St	WM01	WM02	WM03	WM04	WM05	WM06	42	43
			290.2	191.4	158.7	200.1	242.5	722.1	632.5	235.2	195.9	206.6	216.1
29-Nov-84													
07-Mar-85	98	98			0.0								
09-Sep-85	186	284			22.5								
17-Mar-86	189	473			-9.9								
29-Sep-93	2753	3226			83.9								
01-Nov-94	398	3624	0.0	0.0									
15-Nov-94	14	3638											
28-Nov-94	13	3651	-37.4	-60.4									
11-Jan-95	44	3695	-17.3	3.2									
28-Mar-95	76	3771	-0.9	-11.7									
29-Jun-95	93	3864	20.4	20.5									
14-Sep-95	77	3941											
28-Mar-96	196	4137	-21.2	-40.7									
29-Apr-96	32	4169	-41.3	11.8	-60.9								
06-Nov-96	191	4360	58.3	6.0	10.4								
09-Dec-96	33	4393	-43.9	-24.8	-23.1								
30-Oct-97	325	4718	78.0	4.5	-21.6								
11-Nov-98	377	5095	-70.3	-53.4	-27.5								
10-May-99	180	5275	28.3	10.5	-26.5								
01-Mar-00	296	5571	21.6	-9.0	1.8								
06-Jun-00	97	5668	2.3	11.8	10.1								
16-Aug-00	71	5739	-11.3		-11.2		0.0		0.0			0.0	0.0
22-Feb-01	190	5929	-26.1	-33.3	12.2							-8.2	-19.4
15-Jun-01	113	6042	6.2	-1.0									
11-Sep-01	88	6130	31.9	10.1	-21.0		-60.6		35.7			11.4	8.9
06-Dec-01	86	6216				0.0	-3.8	0.0	42.9	0.0	0.0		
22-Jan-02	47	6263				6.8	17.5	24.5	-8.3	-16.9	7.7		
07-Mar-02	44	6307				-19.5	15.5	11.4	34.3	0.4	1.4		
24-Apr-02	48	6355	23.4	15.7	0.1		-14.1					3.0	25.1
10-May-02	16	6371				-2.8	-1.9	-7.9	14.7	-23.9	-1.8		
03-Dec-02	207	6578				27.6	-55	119.2	-123.5	-22.0	-7.6		
26-Feb-03	85	6663	-5.3	35.4	34.4							7.7	-19.0
26-Jun-03	120	6783				9.9	-14.5	51	-48.6	-12.9	-16.0		
Total Change			*-4.6*	*-104.8*	*-26.3*	*22.0*	*-116.9*	*198.2*	*-52.8*	*-75.3*	*-16.3*	*13.9*	*-4.4*
Total Change from 6-Dec-01 (WMO's) or 11-Sep-01 (rest)			*18.1*	*51.1*	*34.5*	*22.0*	*-56.3*	*198.2*	*-88.5*	*-75.3*	*-16.3*	*10.7*	*6.1*

The complete results from all surveyed data with a shorter offset distance are given in **Appendix 3**. Comparing the results of Table 2 with those in **Appendix 3**, it may be seen that the offset ranges have increased considerably in Table 2 from those in

Appendix 3, as have a number of the calculated changes in beach volumes. It may also be noted that some of the changes that were registered as positive (accretion) in **Appendix 3** are registering as negative (erosion). This is because the changes in Table 2 are now calculated over a longer cross-section length which includes more of the off shore bar movement.

6.3 Position of the dune line

The position of the dune line is defined as the position of RL +1.75 m. This is shown in Table 3 as a distance from Chainage 0.0 for each section. The position of the dune line is also shown graphically in the Figures in **Appendix 4**.

Table 3: Position of the dune line (RL +1.75 m)

Survey Date	Time between surveys (days)	Cumulative time between surveys	Section									
			131 Manly St	163 Manly St	202 Manly St	WM01	WM02	WM03	WM04	WM05	WM06	42	43
29-Nov-84					13.902								
07-Mar-85	98	98			16.982								
09-Sep-85	186	284			13.43								
17-Mar-86	189	473			14.11								
01-Dec-89	1355	1828											
01-Dec-89	1355	1828											
29-Sep-93	2753	3226			30.40								
01-Nov-94	398	3624	81.99	43.11									
15-Nov-94	14	3638	73.09	37.67									
28-Nov-94	13	3651	71.90	33.77									
11-Jan-95	44	3695	70.50	33.72									
01-Feb-95	21	3716											
01-Feb-95	21	3716											
28-Mar-95	76	3771	69.37	34.25									
29-Jun-95	93	3864	70.42	33.39									
14-Sep-95	77	3941	69.74	31.96									
28-Mar-96	196	4137	68.24	29.14									
29-Apr-96	32	4169	67.25	27.13	18.82								
06-Nov-96	191	4360	70.17	28.60	17.58								
09-Dec-96	33	4393	57.95	23.42	17.13								
30-Oct-97	325	4718	67.26	21.89	14.60								
11-Nov-98	377	5095	63.99	20.58	7.97								
10-May-99	180	5275	65.51	18.10	6.63								
01-Mar-00	296	5571	69.03	18.27	8.60								
06-Jun-00	97	5668	63.70	14.61	3.47								
16-Aug-00	71	5739	64.50		3.42		23.907		31.424			26.842	25.416
22-Feb-01	190	5929	68.73	17.40	3.12							27.33	26.46
15-Jun-01	113	6042	67.69	13.46									
11-Sep-01	88	6130	67.34	12.52	1.63		14.31		35.21			24.57	23.363
06-Dec-01	86	6216				19.194	12.94	43.085	33.50	44.396	23.516		
10-Dec-01	4	6220											
10-Dec-01	4	6222											
22-Jan-02	47	6263				19.21	14.24	16.31	31.54	45.82	27.47		
07-Mar-02	44	6307				18.61	17.14	15.33	29.27	44.01	27.19		
24-Apr-02	48	6355	69.36	10.64	0.24		13.62					26.61	28.24

Survey Date	Time between surveys (days)	Cumulative time between surveys	Section										
			131 Manly St	163 Manly St	202 Manly St	WM01	WM02	WM03	WM04	WM05	WM06	42	43
10-May-02	16	6371				16.85	15.98	48.71	28.02	34.97	23.95		
03-Dec-02	207	6578				18.15	12.07	15.40	26.95	30.16	24.64		
26-Feb-03	85	6663	76.79	15.78	2.79							30.27	28.57
26-Jun-03	120	6783				17.11	14.48	16.12	34.56	29.58	23.96		

7. Results for section monitored for the mouth cut resource consent

These sections are monitored specifically to fulfil the resource consent conditions for the mouth cut, with the expectation that they would show any trends or influence of the mouth cut on the beach morphology.

7.1 Section WM01

Section WM01 is situated Southwest of the Waikanae River mouth. The survey record for this section started 6 December 2001, just before the mouth cut of 10 December 2001 (Table 1). From the cross-section data in **Appendix 2** it may be seen that the highest dune crest (near horizontal distance 0m) accreted over the surveyed intervals, whereas the second dune crest showed little movement. Between the surveys of 6 December 2001 and 22 January 2001, minor accretion occurred generally over the dune face (it moved seawards) before eroding over the following survey periods. The overall pattern of movement from the beach profile envelope is that far greater movement takes place over the seawards part of the profile, probably associated with bar movement in the wave zone as the surveys only extend to about RL-2m. No trends in nearshore bar movement can be differentiated.

The volumetric changes over the beach profile (in Table 2) show that over the survey intervals, initial accretion occurred, then erosion and then accretion again, with a positive overall change of 22m^3/m of beach width over the section. The dune line (RL +1.75m) trends are relatively similar, and show a slight retreat following small fluctuations.

7.2 Section WM02

Section WM02 is also Southwest of the Waikanae River mouth. This section has survey records from 16 August 2000 (as shown in Table 1). Beach profiles for this section (from **Appendix 2**) show that the upper dune crest (around horizontal distance 0m) has initial accretion then is relatively stable. The dune face showed a general trend of erosion, except between the surveys of 6 December 2001 to 22 January 2002 when accretion took place. The nearshore beach area shows considerable movement over the intervals between surveys, with no apparent trends except for the latter surveys of 3 December 2002 and 26 June 2003 where a trough at about 220m appears to have migrated landwards to about 160m.

Volumetric changes over the beach profiles (Table 2) show initial erosion (until 6 December 2001) followed by accretion (to 7 March 2003), followed by erosion over the remainder of the survey intervals. From the survey of 6 December 2001, erosion of

56m^3/m of beach took place, while the overall trend is erosion of 117m^3/m. The position of the dune line (RL +1.75m), as given in Table 3 and shown graphically in **Appendix 4**, shows initial retreat (until 11 September 2001) but then only undergoes minor fluctuations.

7.3 Section WM03

Section WM03 is situated across Waikanae River estuary, with about 1/3 of the estuary to the south of the section, and in the area greatly affected by the river mouth bars and sandspit. When the river channel has migrated fully to the south, section WM03 may cross the river channel virtually perpendicularly. This section is particularly mobile and dynamic, and as a result of the influence of the river delta area, it is difficult to get a feel for overall trends and changes in this section.

From the cross-section plot in **Appendix 2**, section WM03 shows a weak trend of landwards bar movement. This is most obvious for the bars at horizontal distance 60m and 550m. The deep trough evident in earlier surveys, at distance 140m, appears to have filled by 3 December 2002, with the additional formation of a larger bar seawards of the trough over this time. This trough is likely to be the old river channel, which filled with sand after the mouth cut was made.

Volumetric changes over this section (Table 2) generally show accretion, but with minor erosion between the surveys of 7 March 2002 and 10 May 2002. A large volume of accretion is shown between the surveys of 10 May 2002 and 3 December 2002, and considerable further accretion until 26 June 2003 probably associated with movement of the spit at the river mouth. The overall change in sand volume for section WM03 is accretion of 198.2m^3/m.

The position of the dune line (Table 3 and **Appendix 4**) shows an initial retreat of 27m and then aside from the 10 May 2002 survey position, appears relatively constant. The advance then retreat of the dune line from the survey of 10 May 2002 is anomalous to the expected results, and appears because the trough at the dune toe is higher than +1.75m at this date. Allowing for this anomaly, the dune at cross-section WM03 appears relatively static after its initial retreat.

7.4 Section WM04

Section WM04 is placed across the Waikanae River estuary, with about 1/3 of the estuary to the north of the section. This section is also affected by the estuary sandspit growth and southwards river migration, which make it very dynamic and hence difficult to get a feel for changes in the area.

From the surveyed cross-sectional data (**Appendix 2**), section WM04 shows a slight trend of erosion of the highest dune (at horizontal distance 15m), coupled with a deepening of the trough between the dunes (horizontal distance 40m), although by the latest survey at 26 June 2003, some recovery appears evident.

Movement around the bar and spit area shows different trends. (Note that the surveys of 11 September 2001 and 14 September 2001 are identical and overplot). Between the 16 August 2001 and 11 September 2001 surveys the seawards face of the bar area between about 400m and 600m appears to become steeper and erode, while the spit height between 200m and 350m accretes. From 14 September 2001 until 10 May 2002, accretion appears to be taking place over most of the section. From 10 May 2003 until

3 December 2002 the spit narrows and moves shoreward, with the profile between 300m and 600m flattening out. This is likely to be caused by southwards river channel migration. From 3 December 2002 until 26 June 2003 the profile shows a marked erosion of the spit between about 170m and 400m, and slight accretion of the seaward bar area around 600m.

These trends are generally supported by the volume change calculations (Table 2), which show slight volume loss between 6 December 2001 and 22 January 2002 and also between 10 May 2002 to 3 December 2002, otherwise accretion takes place. The volume change for this section from 6 December 2001 until 26 June 2003 is –88.5m^3/m.

The position of the dune line (+1.75 m) fluctuates about the median, but the net result is little overall change, as shown in Table 3 and **Appendix 4**.

7.5 Section WM05

Section WM05 is to the Northeast of the Waikanae River mouth. This section appears relatively unaffected by river channel migration or river mouth bar movement.

From the cross-section plots in **Appendix 2**, section WM05 seems to be generally eroding, with the dune face retreating and beach level lowering. Trends of bar movement (around horizontal distance 600m) seem to indicate a trend of seawards migration. However, at the seawards limit of the survey data, trends in movement are difficult to discern.

Volume changes (Table 2) support the observation of seawards bar movement, with a general decrease in beach sand volume over this section except over the interval 22 January 2002 to 7 March 2002. The total volumetric change for section WM05 between 6 December 2001 and 26 June 2003 is –75.3m^3/m.

Position of the dune line (RL+1.75 m), as given in Table 3 and **Appendix 4** shows that the dune face initially migrated seawards about 1.5m over about 1 month, then migrated landwards about 16m, with 10m of this migration occurring over about two months (7 March 2002 to 10 May 2002).

7.6 Section WM06

Section WM06 is situated to the north of the Waikanae River mouth. This section appears to show relatively little overall movement, with no apparent trends.

Volume changes between surveys over this section (Table 2) are generally small and positive over the first surveys, then tending negative. The larger volume change over the latter survey interval appears connected with seaward bar movement, which is outside the horizontal range of volume change calculation. The total volumetric change over the period between 6 December 2001 and 26 June 2003 is –16.3m^3/m.

The position of the dune line (RL +1.75 m) from Table 3 and **Appendix 4** shows a slight seawards movement over the initial surveys, but returns to its initial position and then stays relatively constant.

8. Results for comparison sections

These sections are included in this analysis as a base line and are not expected to be influenced by the mouth cut. They are used in comparison with the WM0 series sections to evaluate overall morphological trends. As few surveys are available for these sections, the comparison surveys used in this analysis are those from 11 September 2001 until 26 February 2003, which includes data from 3 surveys.

8.1 Section at 131 Manly Street

The section at 131 Manly Street is situated near the point of the cuspate foreland, and is the furthest south of the comparison sections used for this analysis. As shown in Table 1, this section has survey records available from 1 November 1994, although the data over the period of the WM0 series monitoring surveys are of primary interest (for comparative purposes).

From the cross-section surveys in **Appendix 2** for this section, over the surveys from 11 September 2001 the main trend of movement is accretion for the dune and beach face between distances 40m to 120m. Seaward of 120m, sandbars are present and it appears that the general direction of bar movement is landwards. This trend is supported by the change in the position of the bars and also because the landward bar face is generally steeper than the seaward bar face.

Looking at the second cross-section plot in **Appendix 2** taken over the longer surveyed period, it appears that the general envelope of beach profile movement is similar to that over the latter period from 11 September 2001 to 26 June 2003.

Volume changes for the section at 131 Manly Street are extremely variable. Comparison between the volume changes in Table 2 and **Appendix 3** indicates that the bar movement strongly influences the volume change, as volume change taken over the longer offset range (290.2m versus 156.1m) alters markedly in size and in direction. Total volume change over this section for the 290.2m offset length since 11 September 2001 is 18.1m^3/m, as compared to total volume change over the entire survey period of –4.6m^3/m.

The dune line position (RL+1.75m) has moved seawards since 11 September 2001, although the overall position has retreated landwards since survey records started in 1 November 1994. The range of movement in the dune line position over the entire surveyed period is about 24m, however the final position of the dune line is only about 5m seawards of the initial position, as shown in **Appendix 4** and listed in Table 3.

8.2 Section at 163 Manly Street

The section at 163 Manly Street is situated to the north of the cuspate foreland, to the south of the Waikanae River Mouth. This section has been surveyed since 1 November 1994, on the survey dates as shown in Table 1. For comparison with the WM0 series sections, surveys of this section since 11 September 2001 are used.

From the cross-section plot in **Appendix 2**, the section at 163 Manly St has a relatively high and steep dune face that has eroded and flattened over the surveyed period since 11 September 2001, whereas the beach area seawards of the dunes has generally accreted.

Sandbar movement in the nearshore zone has a marked influence on measured changes over this section, as is evidenced in the variable volumetric changes for different offset distances (105 and 163m) in Table 2 and **Appendix 3**. From Table 2 and **Appendix 3**, although the scale of change varies the trend remains consistent. This section shows accretion from the survey of 11 September 2001, although this behaviour is not consistent over the entire surveyed period. Since the beginning of surveying in 1 November 1994, this section appears to have no clear volumetric trend, although considerably greater volumes of beach material have eroded than accreted. Since 11 September 2001, over the longer offset distance of 191m, the overall change in sand volume is accretion of $51m^3/m$ while over the total surveyed period since 1 November 1994, erosion of $105m^3/m$ has taken place.

From Table 3 and **Appendix 4**, the position of the dune line over the surveys since 11 September 2001 shows retreat of 2m followed by an advance of 5m. This 5m advance is however only a small recovery from the very strong retreating trend of 33m that has taken place since survey records began on 1 November 1994.

8.3 Section at 202 Manly Street

The section at 202 Manly Street is south of the Waikanae River mouth, and south of section WM01. Over the surveyed intervals since 4 September 2001 the crest of the dune has substantially retreated, while the front face of the dune has become less steep. The upper beach shows initial bar movement, but no marked change in level, but the final survey shows a rise in beach level. The nearshore zone is strongly influenced by sandbar movement, and it appears that the bars have an overall trend of shorewards migration.

Over the monitored period from 11 September 2001, it is clear that volume changes over the section are strongly influenced by the sandbar movement, as evidenced by the variation from $25m^3/m$ over an offset distance of 130m, to $35.5m^3/m$ over the same interval using an offset distance of 159m. Over the total surveyed interval, the volume changes fluctuate markedly in size and direction of change, but the overall change is still only $11m^3/m$ over the 130m offset distance and $–26m^3/m$ over the 159m offset distance.

The position of the dune line (RL+1.75m) over the period from 11 September 2001 shows a small retreat that recovers by the final survey. However, over the total survey interval it may be seen that the position of the dune line advances seawards about 15m, then retreats about 30m, with one small reversal in these trends over the total period.

8.4 Section 42

Section 42 is situated to the north of the Waikanae River mouth and to the north of section WM06.

Surveys have been carried out sporadically at section 42 since 16 August 2000. From the cross-section profiles for Section 42 since 11 September 2001, it may be observed that the height of the dune has increased, the dune face has flattened slightly and the upper beach level has also increased in height. Similarly to the other sections, sandbars are also present, and these appear to be moving landwards.

Apart from erosion over the first survey interval of 16 August 2000 to 22 February 2001, the volume changes between surveys are all positive (i.e. accretionary) for Section 42, with a small overall accretion resulting over the surveyed period.

Section 42 has a relatively steep dune face and overall height of about 3m. From the cross-section plots in **Appendix 3**, RL +1.75m (defined as the position of the dune line) is actually on the beach face as the top of the beach/toe of the dune is at about RL+2m. Reviewing the RL +1.75m position for Section 42 (Table 2) shows that the dune has advanced over the surveyed period except over 22 February 2001 to 11 September 2001, when retreat took place. The final position of the dune line is about 3m seaward of the initial position.

8.5 Section 43

This section is the most northwards evaluated as part of this comparison.

Section 43 has about a 4m high dune, with the dune toe at about RL+2m, similarly to Section 42. The cross-section comparison plots in **Appendix 3** show that very little movement has taken place over the dune face for Section 43. The beach face appears to have been influenced by the shorewards migration of sandbars, although these seem have had little influence over the upper beach face.

Volumetric changes for this section show that erosion has occurred over 16 August 2000 to 22 February 2001 and 24 April 2002 to 26 February 2003, with accretion taking place otherwise. Most of the volumetric change appears to be influenced by the sandbar movement at the seaward extent of the 216m offset distance. The change over all the surveys was an accretion of 14.6m^3/m.

The position of the dune line (RL+1.75m) is misleading for this section as this level is at a position on the beach face rather than the dune. Notwithstanding, the RL+1.75 m position has migrated seawards about 3m over the total surveyed period following a landwards migration at mid interval.

9. References

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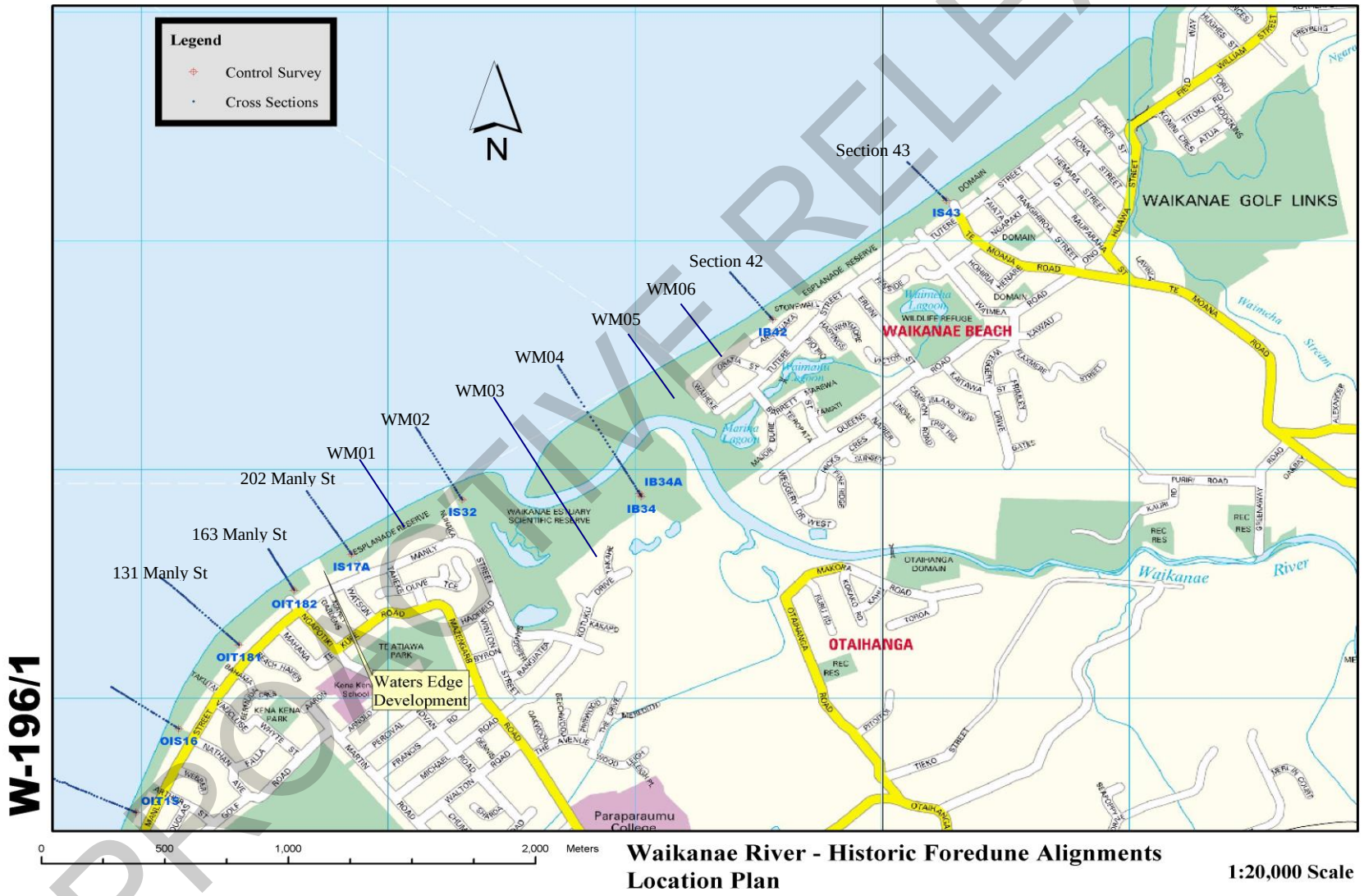
Lumsden J.L., 2000. *Beach Profile Monitoring at Paraparaumu and Raumati. Report No. 5.* 2 August 2000.

Lumsden J.L., 2003. *Beach Profile Monitoring at Raumati, Paraparaumu and Waikanae. Report No. 7.* 28 August 2003.

Land Information New Zealand, 2001. *New Zealand Nautical Almanac 2003/03.* NZ 204.

Appendix 1: Locations of surveyed sections



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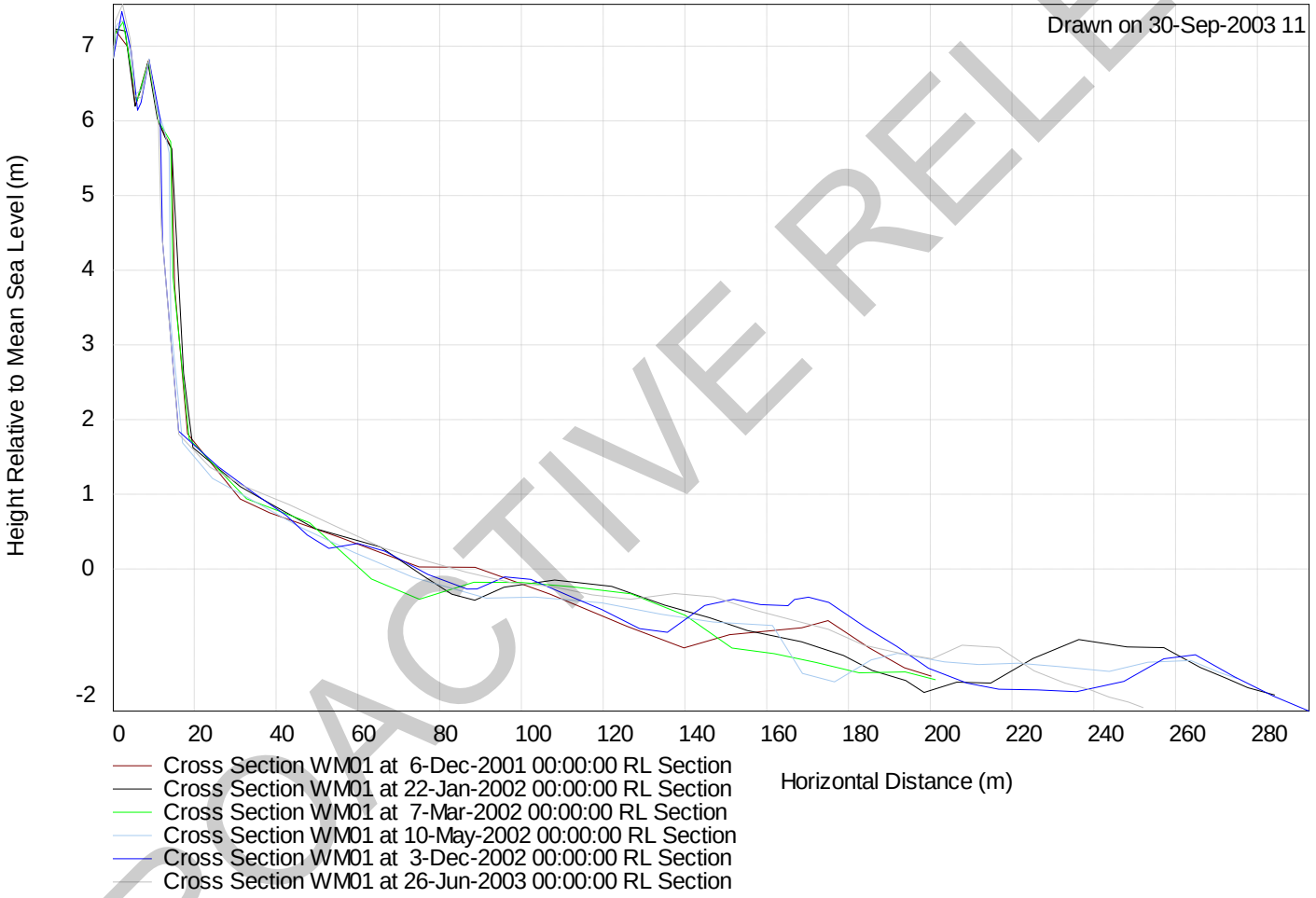
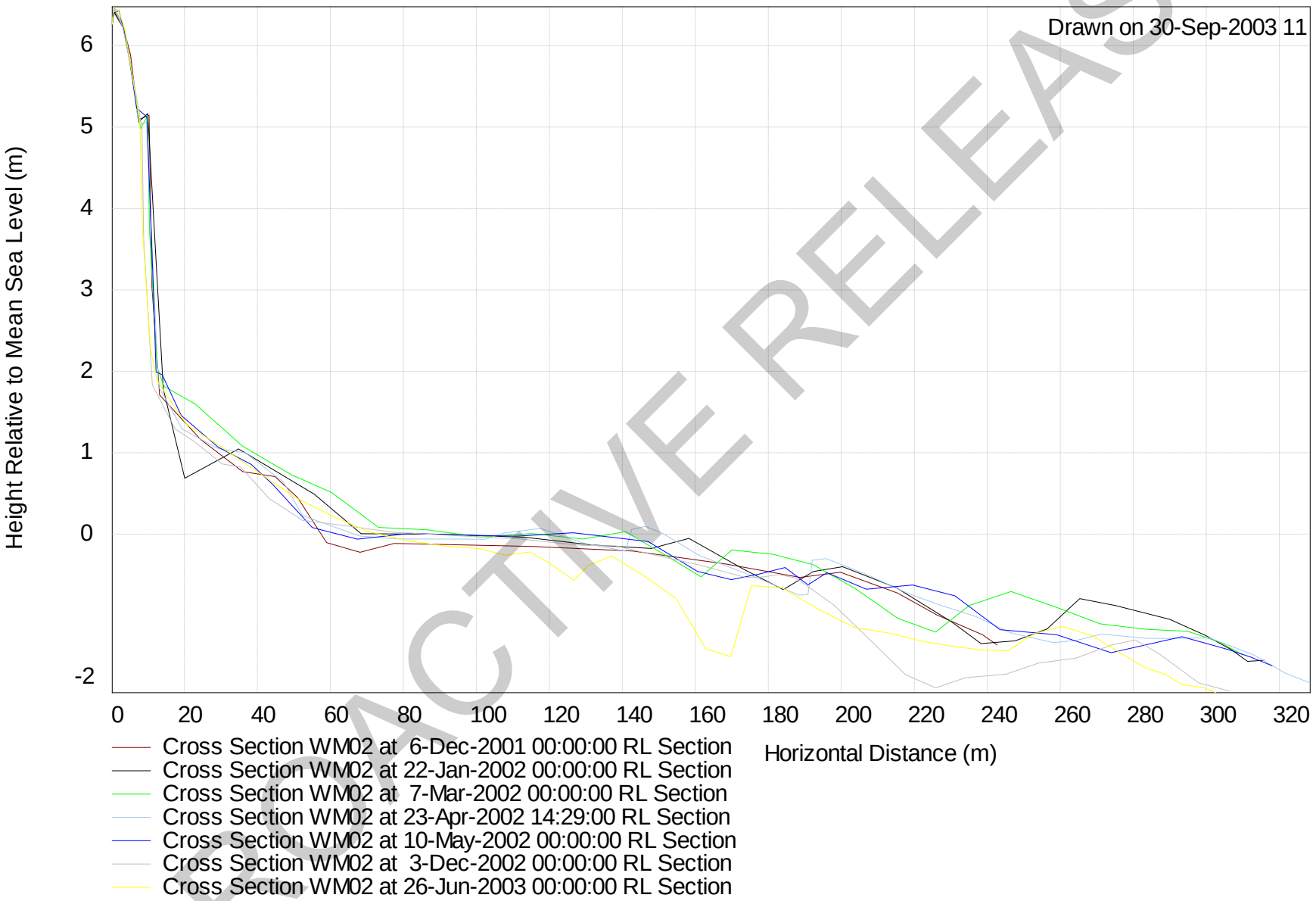
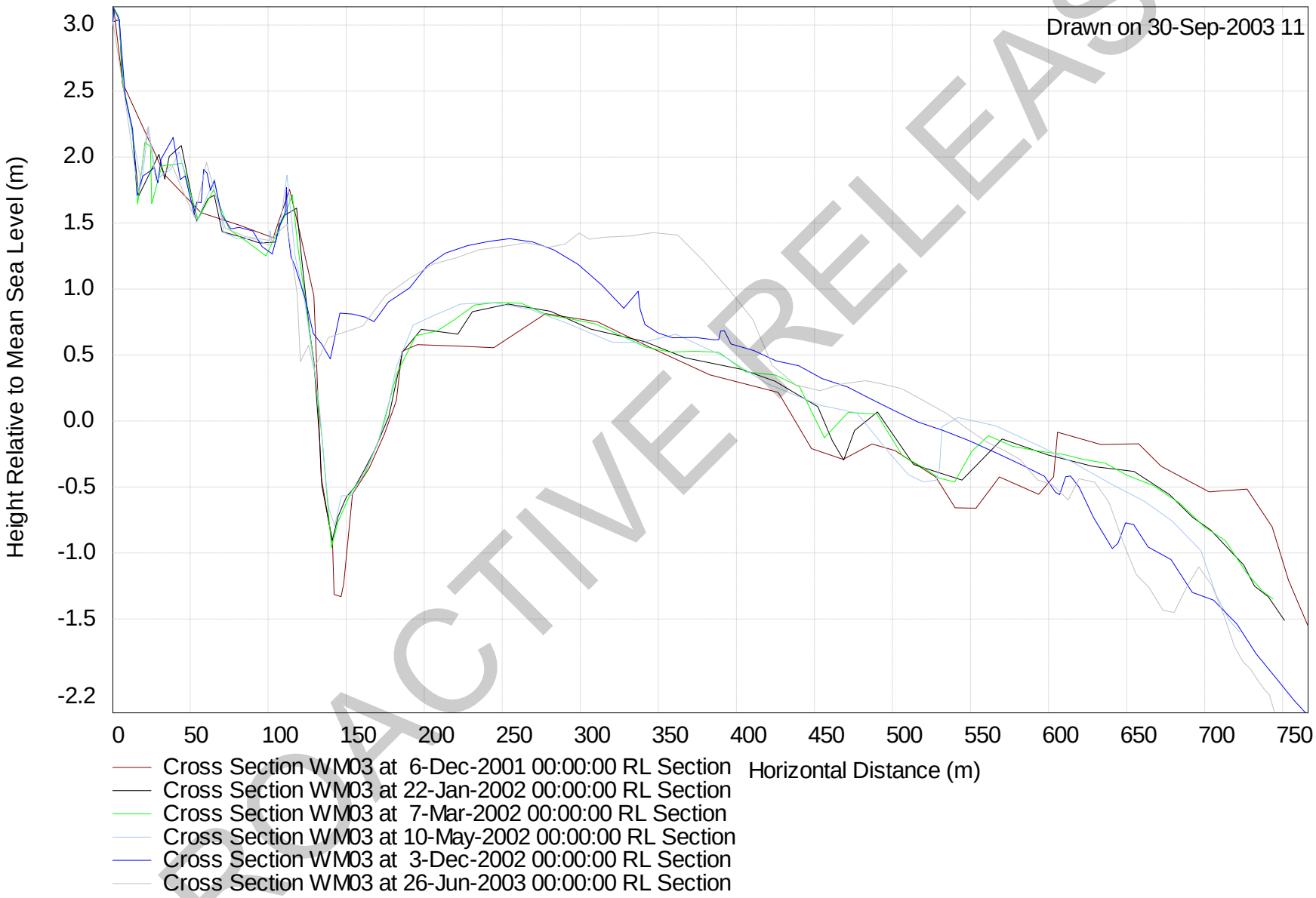
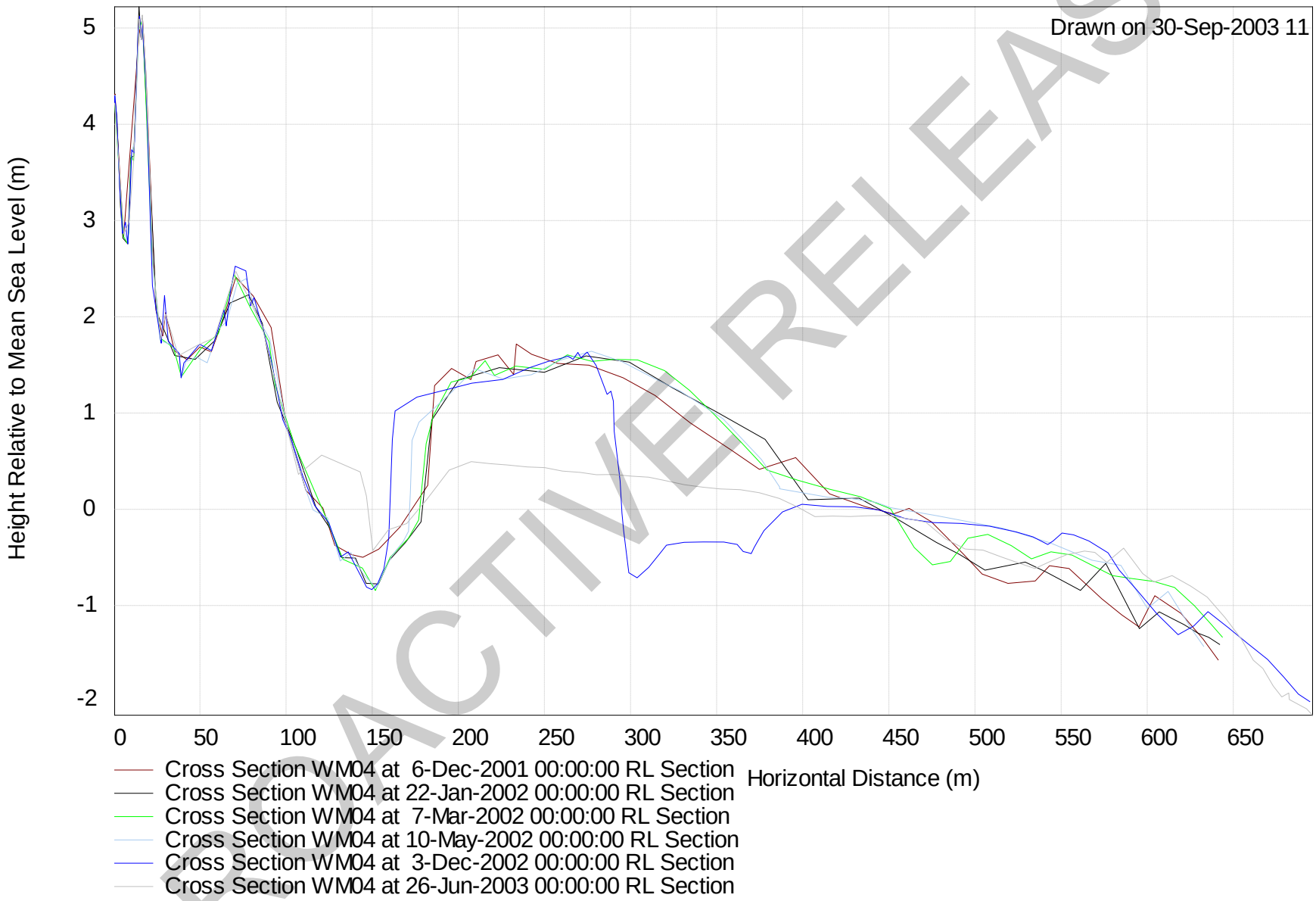
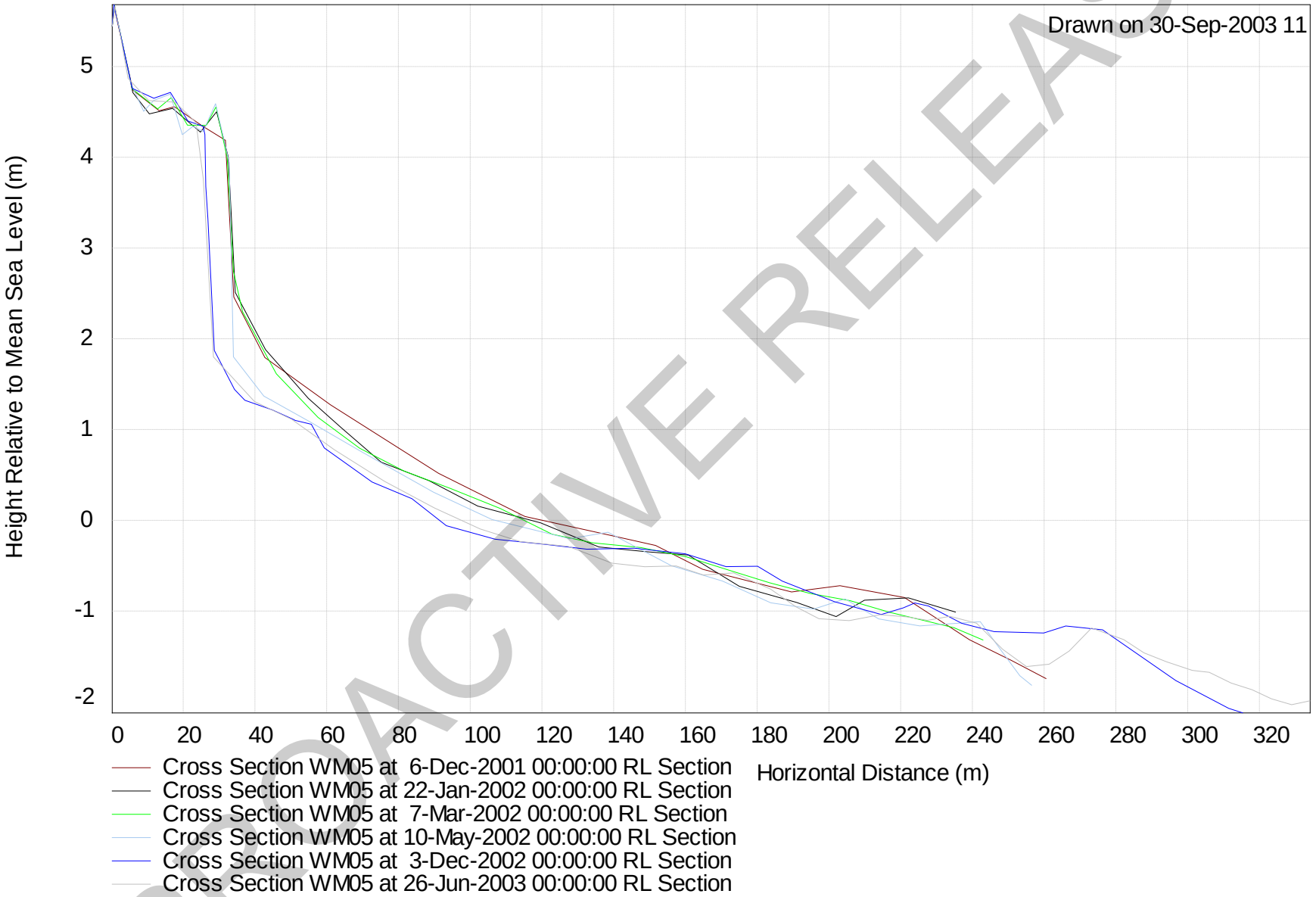
Appendix 2: Cross-sections

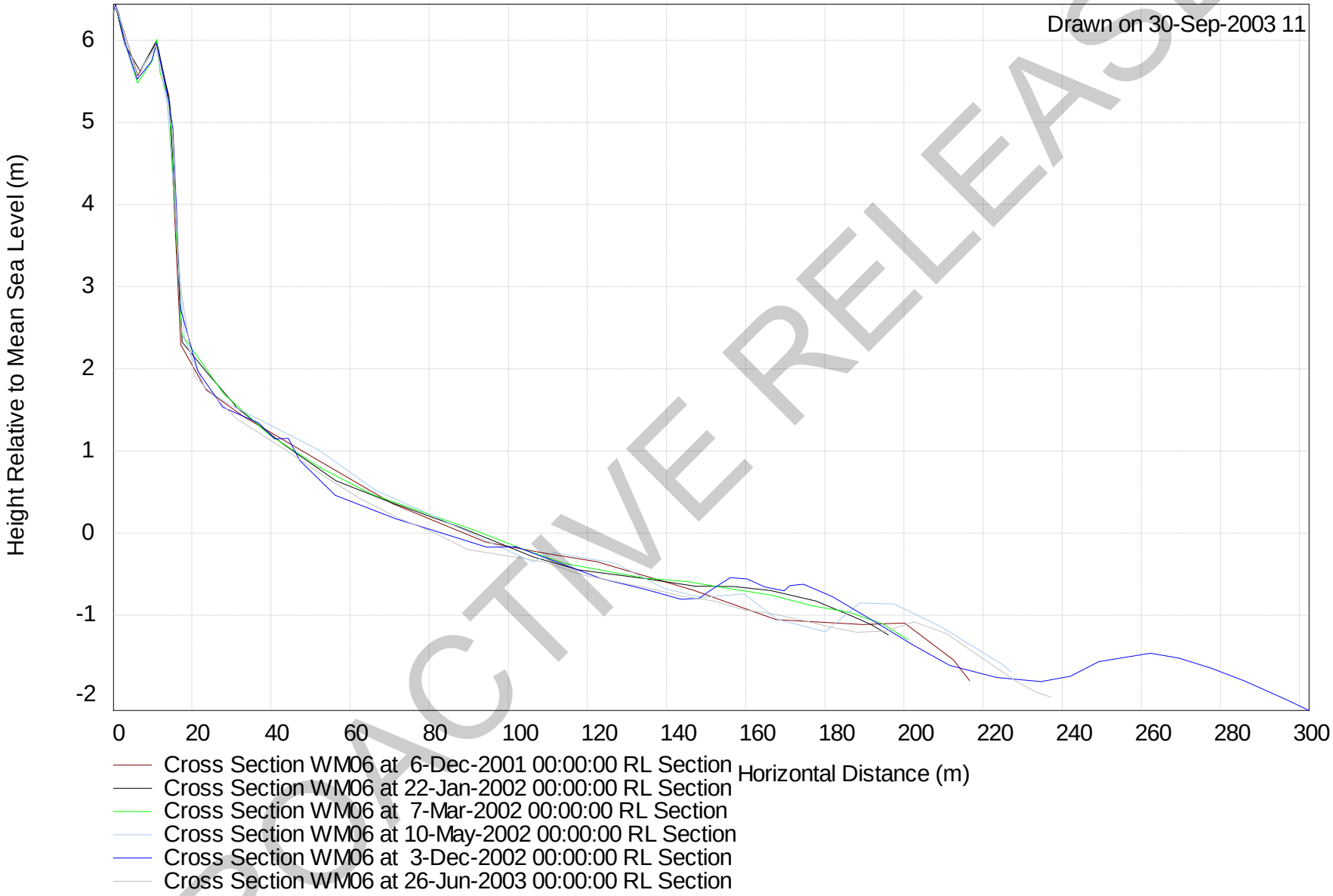


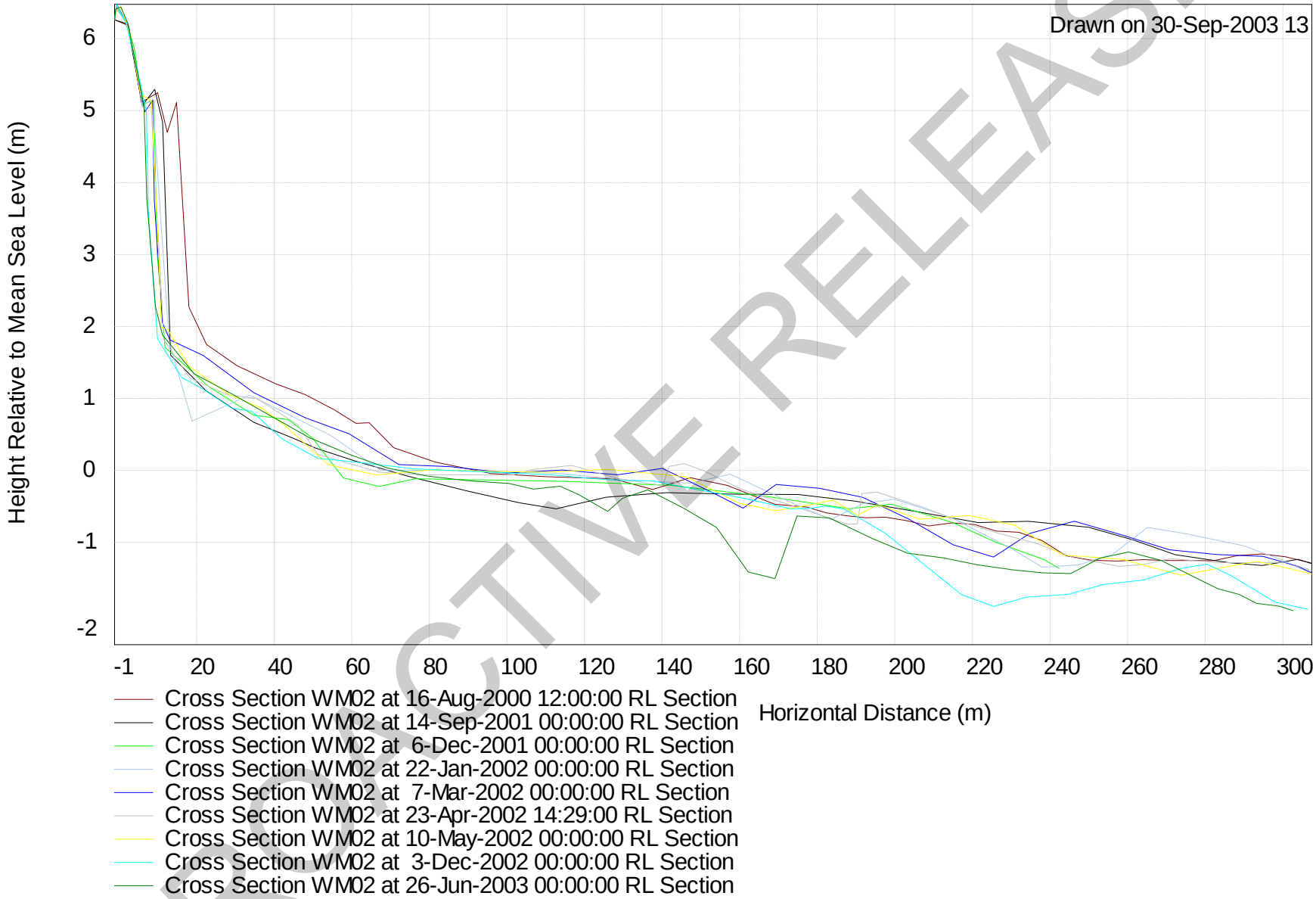


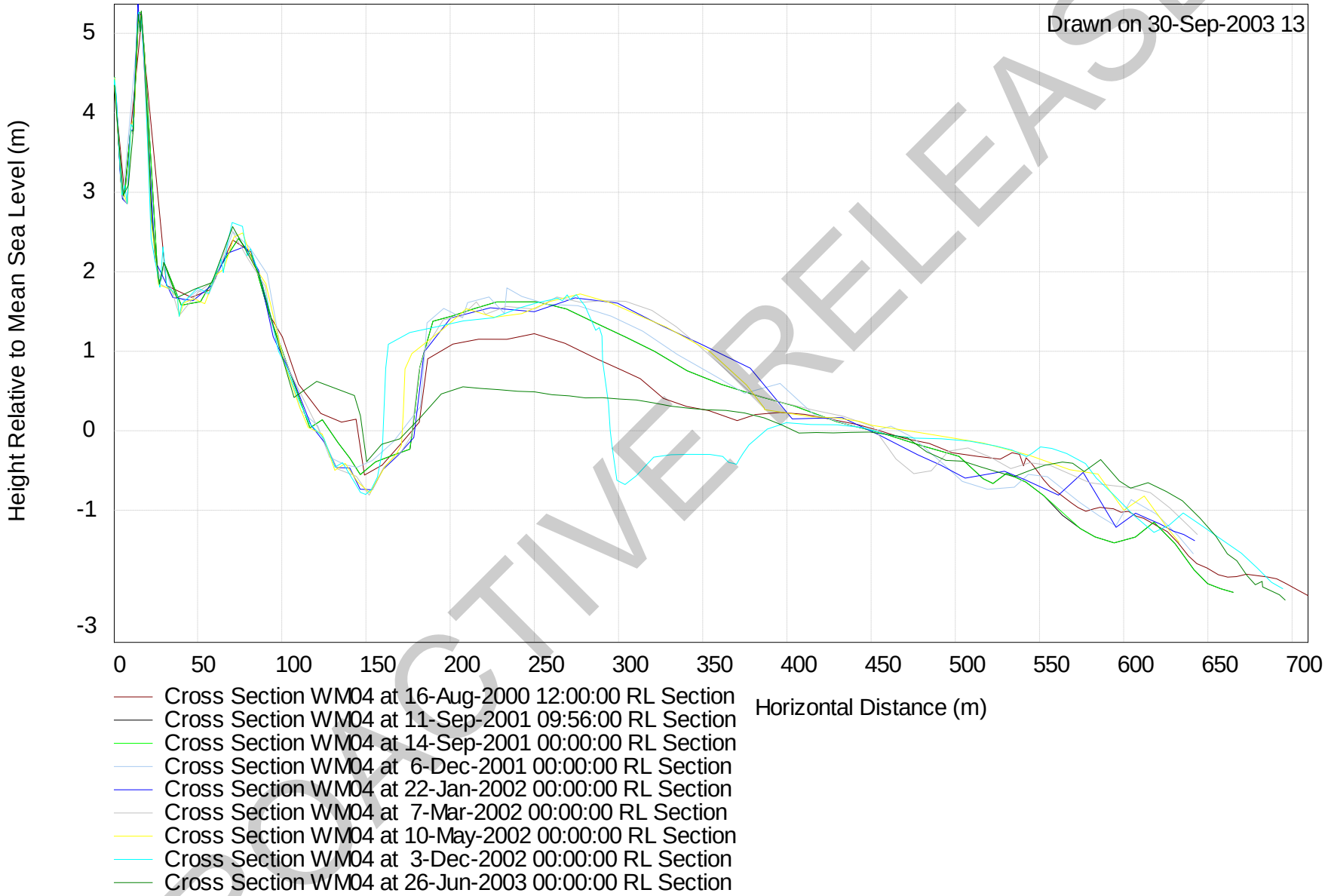


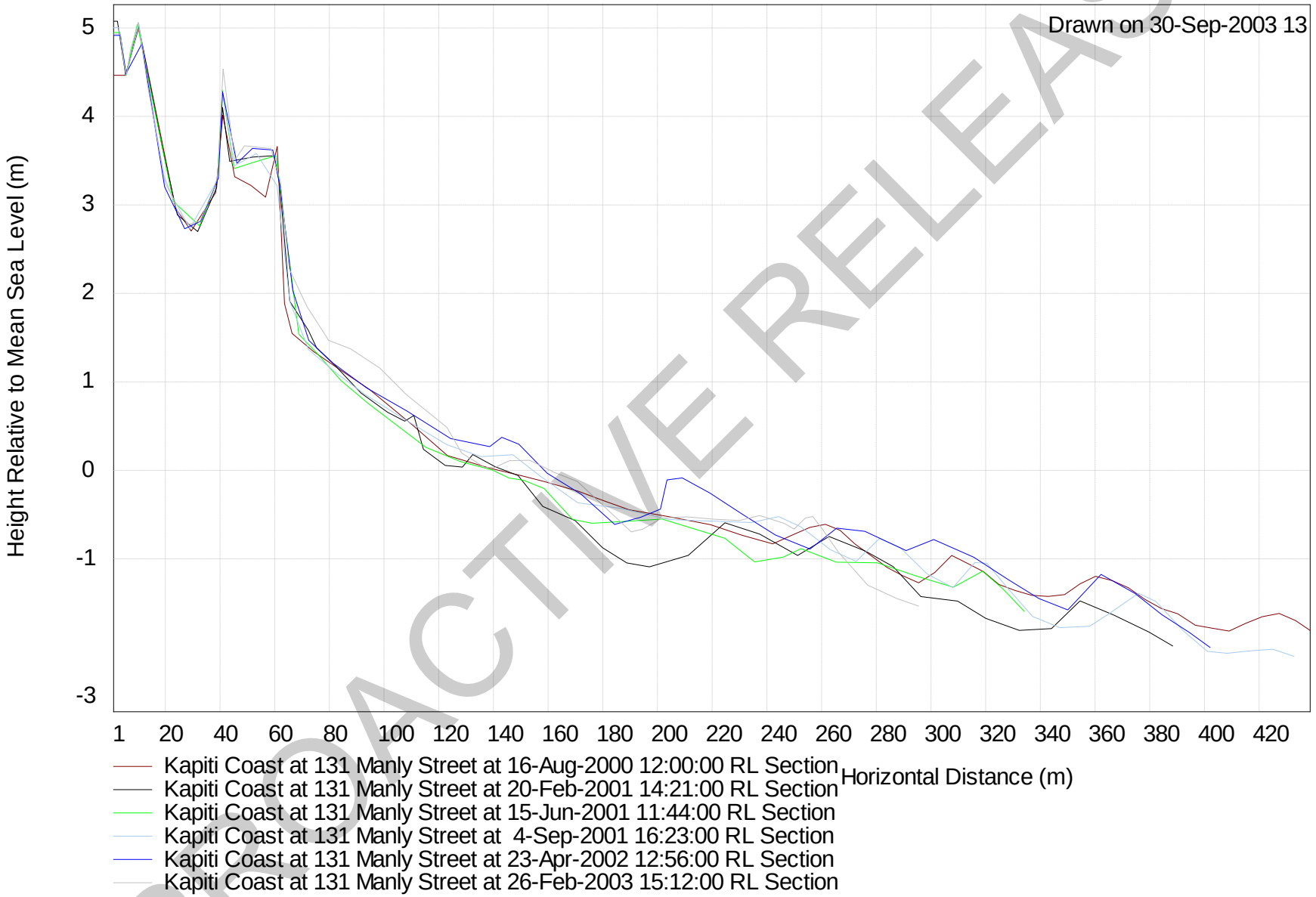


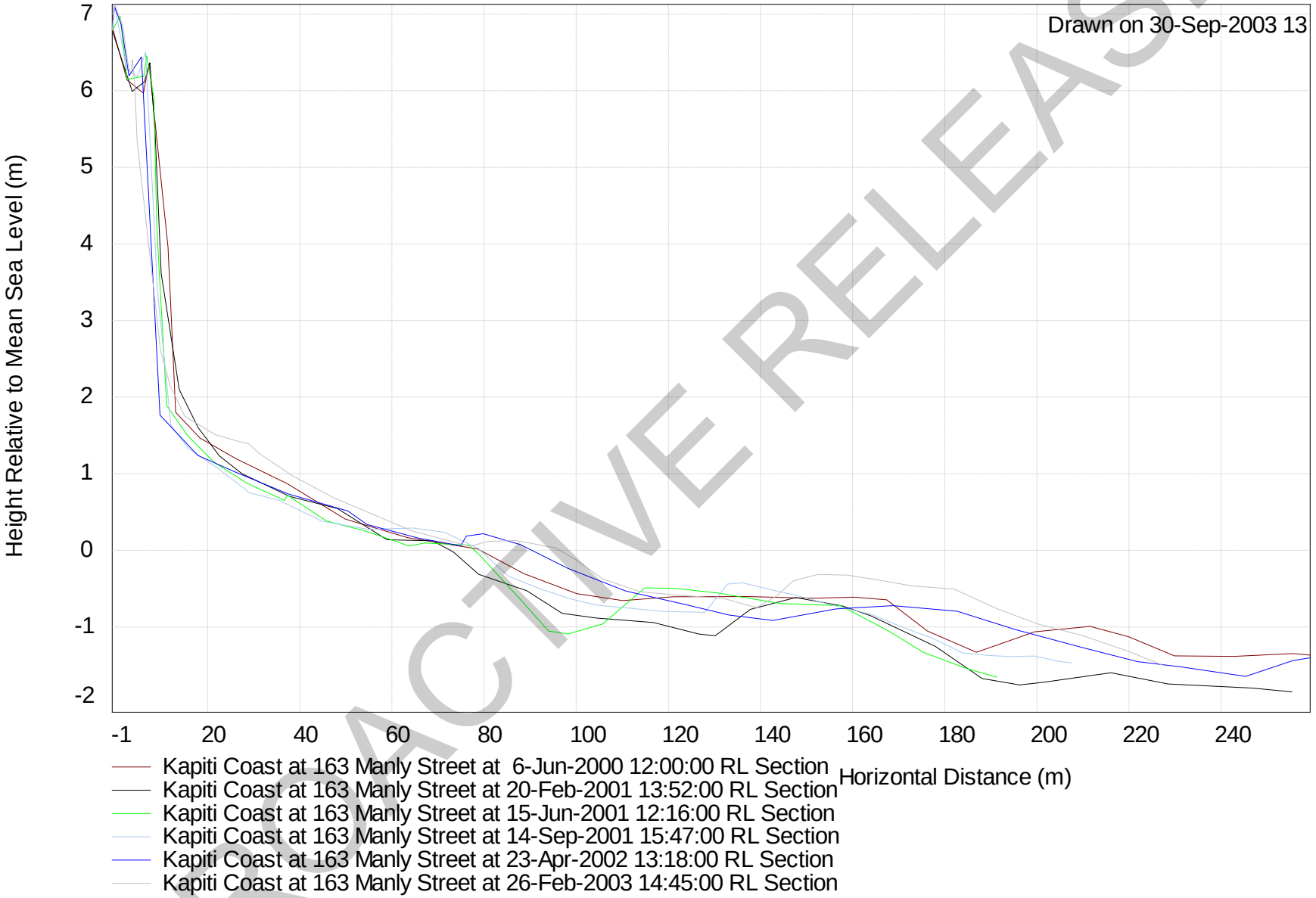


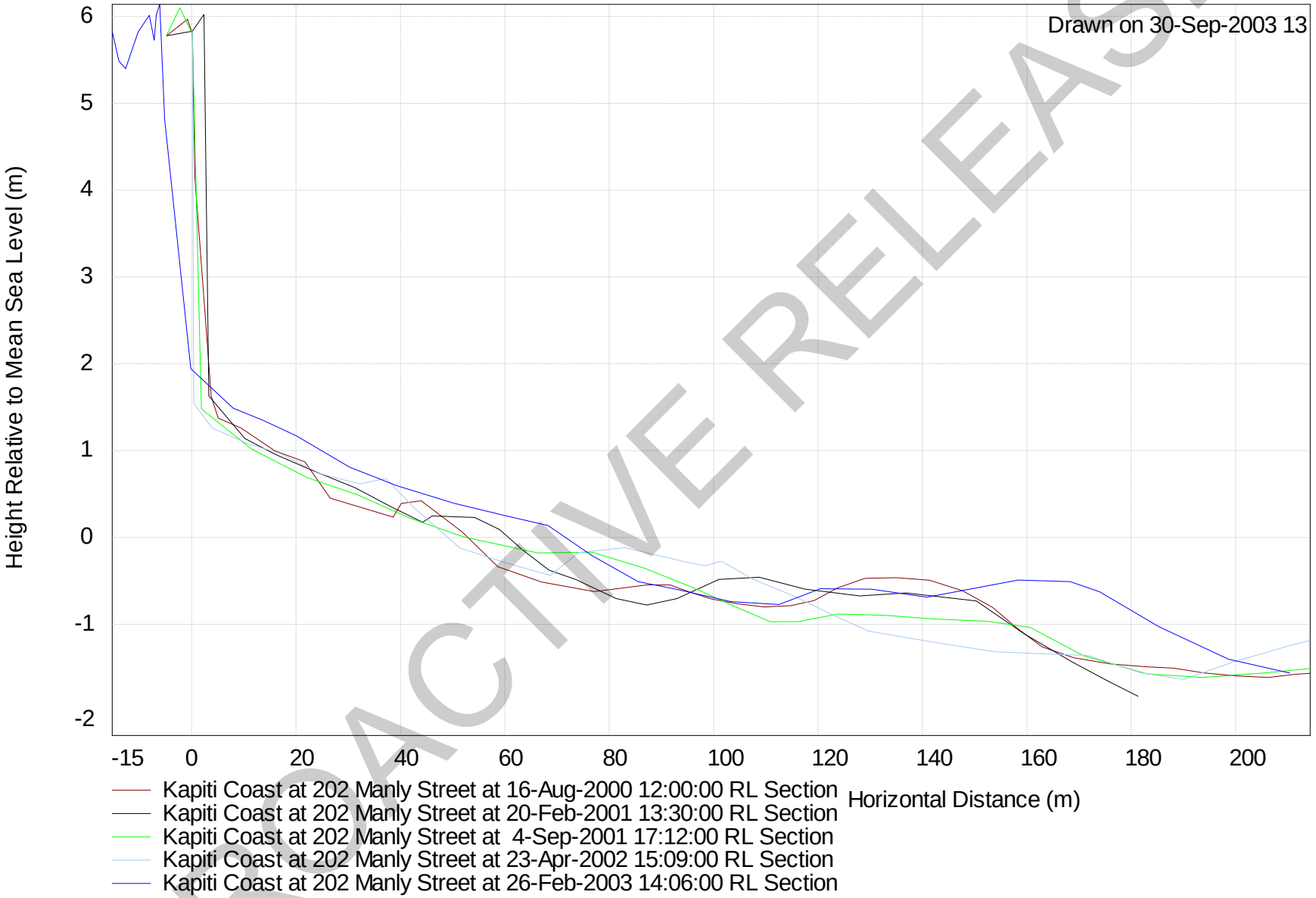


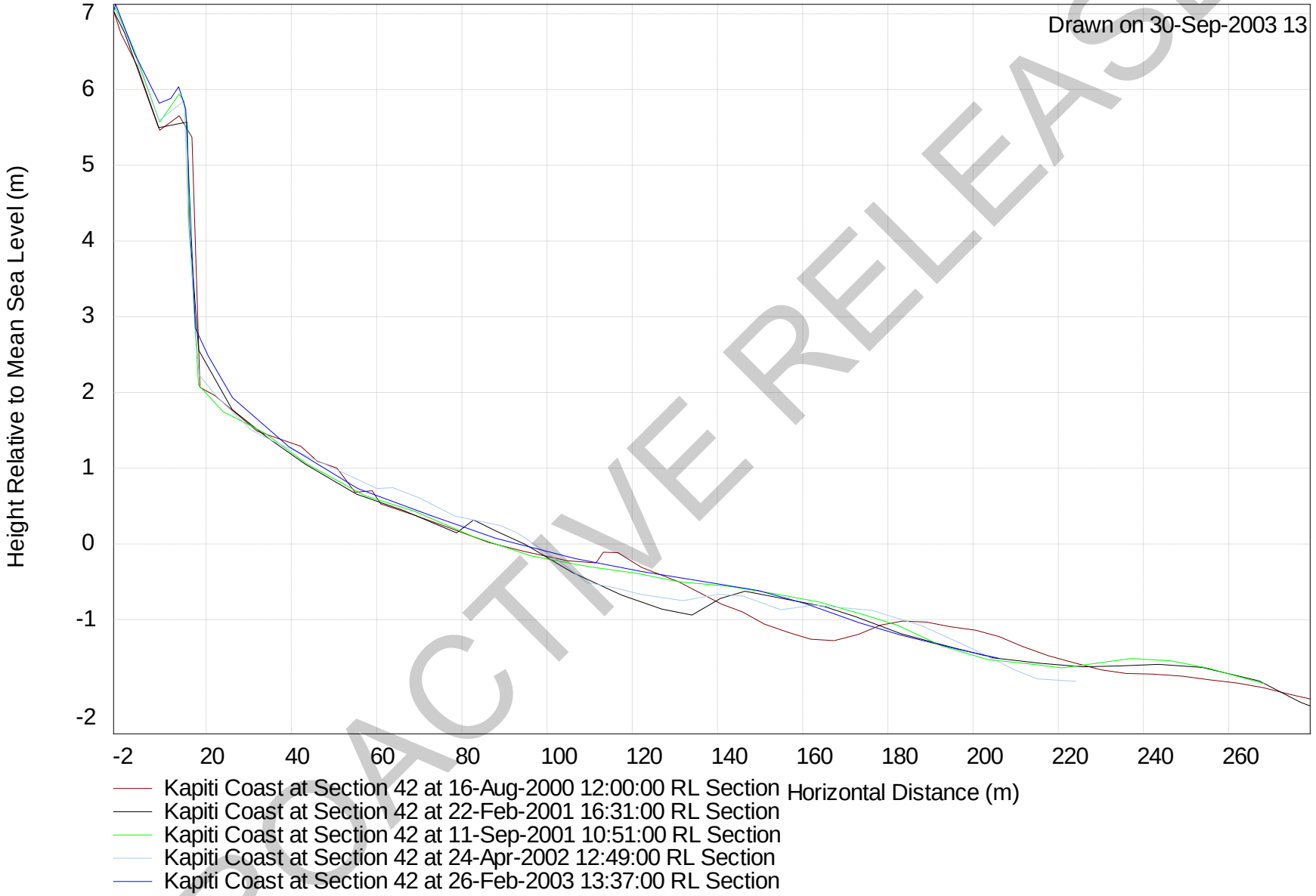


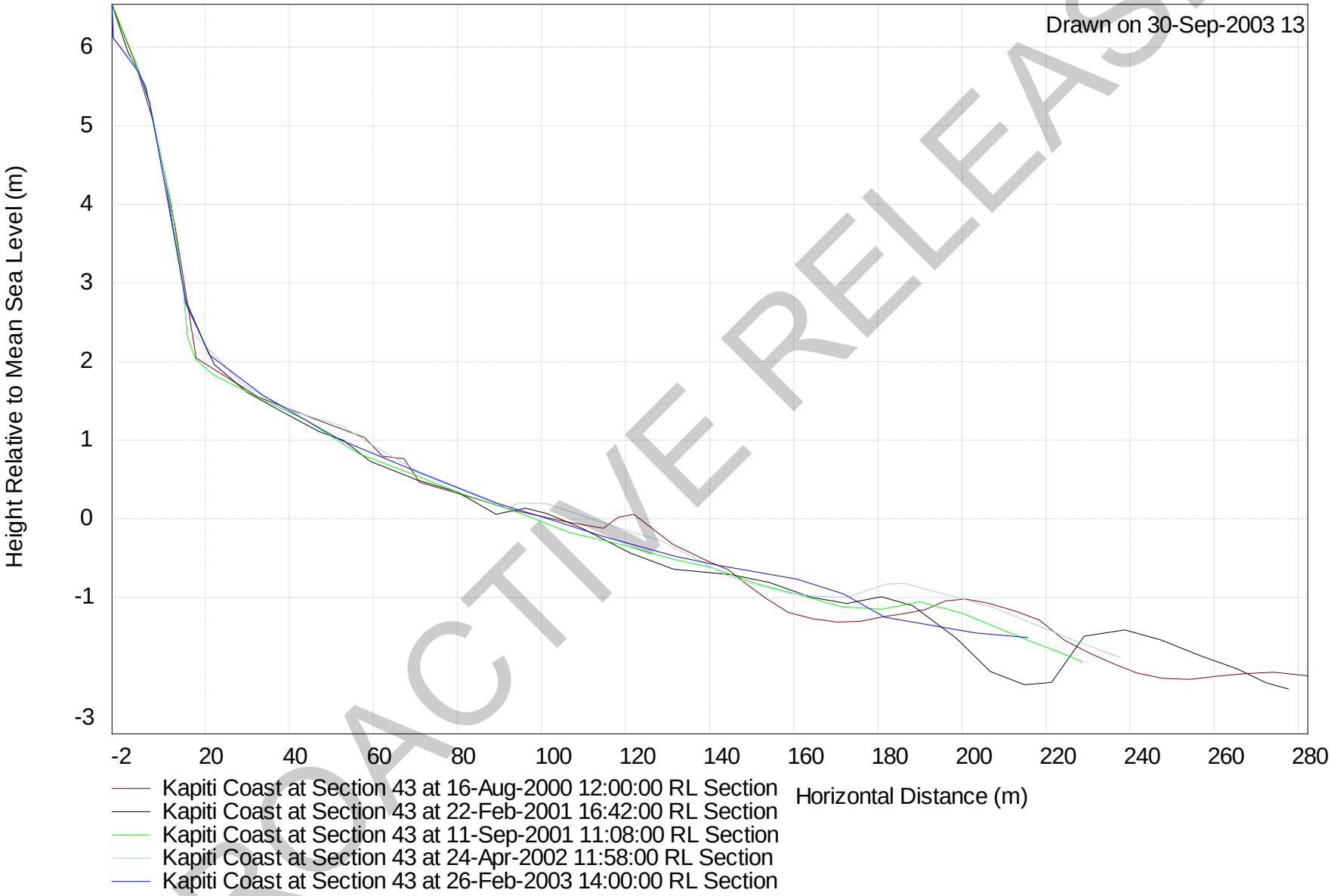












Appendix 3: Changes in beach profile volumes

Survey Date	Time between surveys (days)	Cumulative time between surveys	Section Name and Offset Range (m)		
			131 Manly St	163 Manly St	202 Manly St
			156.1	105.2	130.0
29-Nov-84					0.0
07-Mar-85	98	98			49.7
09-Sep-85	186	284			2.3
17-Mar-86	189	473			-7.3
29-Sep-93	2753	3226			87.8
01-Nov-94	398	3624	0.0	0.0	
15-Nov-94	14	3638	-29.9	-22.3	
28-Nov-94	13	3651	5.3	-10.2	
11-Jan-95	44	3695	-19.1	3.2	
28-Mar-95	76	3771	2.4	-7.4	
29-Jun-95	93	3864	-1.2	7.4	
14-Sep-95	77	3941	6.9	-14.8	
28-Mar-96	196	4137	-4.0	-9.8	
29-Apr-96	32	4169	-45.8	12.4	-56.0
06-Nov-96	191	4360	50.8	-14.9	12.4
09-Dec-96	33	4393	-47.6	-10.6	-14.0
30-Oct-97	325	4718	54.3	-6.3	-16.0
11-Nov-98	377	5095	-19.5	-20.9	-41.9
10-May-99	180	5275	-5.5	-11.4	-11.8
01-Mar-00	296	5571	3.6	-9.5	-8.3
06-Jun-00	97	5668	-2	1.0	3.0
16-Aug-00	71	5739	-11.3		-13.8
22-Feb-01	190	5929	4.8	-12.5	15.6
15-Jun-01	113	6042	-1.9	-10.9	
11-Sep-01	88	6130	6.3	5.9	-15.3
06-Dec-01	86	6216			
22-Jan-02	47	6263			
07-Mar-02	44	6307			
24-Apr-02	48	6355	12.4	9.6	8.0
10-May-02	16	6371			
03-Dec-02	207	6578			
26-Feb-03	85	6663	11.3	14.4	16.8
26-Jun-03	120	6783			
Total Change			*-29.7*	*-107.6*	*11.2*
Total Change from 11-Sep-01			*23.7*	*24.0*	*24.8*

Appendix 4: Position of the dune line (RL +1.75m)