NERMN River and Stream Channel Monitoring Programme - 2002/03, 2003/04, 2004/05 and 2005/06

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Cover Photo: Aerial photograph of Upper Whakatane River near Waikirikiri (rotated 90^0 clockwise).

Executive Summary

The Environment Bay of Plenty Natural Environmental Regional Monitoring Network (NERMN) River and Stream Channel Monitoring was included as part of the network for the first time in 1993/94.

The River and Stream Channel Monitoring Programme provides Environment Bay of Plenty with:

- Reliable data to identify the quantity of gravel available for extraction and the present extraction rates in the Bay of Plenty region.
- Data to allow setting maximum annual extraction rates available based on river control and river maintenance criteria.
- Data with which Environment Bay of Plenty can meet its statutory obligations under the Resource Management Act, and more effectively manage the region's resources.

Cross section surveys are carried out regularly on 15 rivers and streams, with occasional additional surveys. The data is entered into Environment Bay of Plenty's cross-sections archive system, which is used as the main tool to store and analyse the data.

Completion of the fourteenth year's monitoring programme adds to the baseline information for comparison with future surveys and allows analysis of the surveyed rivers and streams. This helps develop an understanding of the movement of gravel in the river systems of the Bay of Plenty region.

The floods experienced in the Eastern Bay of Plenty in July 1998 and July 2004 were a major influence on the changes to gravel volumes over this period. Data analysed for a previous report has shown a net deposition of some 1,900,000m^3 on the floodplains of the Whakatane-Waimana and Waioeka-Otara schemes during the 1998 flood, but the majority of this was silt and sand sized particles.

The total volume of extracted material reported has been variable over the years:

Period	Total volume extracted (m^3)
1992/93	159,000
1993/94	197,000
1994/95	241,000
1995/96	203,000
1996/97	198,000
1997/98	148,000
1998/99	107,000
1999/00	69,000
2000/01	65,500
2001/02	75,000
2002/03	102,000
2003/04	141,000
2004/05	88,000
2005/06	141,300

In the **Otara River**, with a small extraction rate and continued relatively substantial deposition on the floodplain and in the main channel, it is recommended that extraction should be increased to keep the river at its recommended bed level.

Following the considerable damage caused by the 1998 storm in the upper **Waioeka Catchment**, and the likelihood of an increased supply rate over the decade following the storm, gravel accumulations and bed level changes should be carefully monitored and managed. Visual inspection of the Waioeka Gorge suggests some aggradation. New monitoring cross-sections have been established in the Gorge but to date have not been resurveyed.

In the **Waimana River**, further extractions should be limited currently in the upper reaches of the river, except where major build-ups are surveyed. It may however be necessary to use a selective combination of extraction and channel reshaping to arrest the degrading processes currently occurring, particularly to thalweg invert levels. Extraction should be suspended from the Gorge until desirable bed levels have been established.

Although river bed levels on the **Upper Whakatane River above Pekatahi** are on the rise, the previously set extraction limits of 20-30,000m^3 per year from existing beaches should be adhered to until desirable bed levels have been reviewed and met. Some extra demand may be able to be met by widening the floodway where appropriate after careful assessment of the gravel movement. Extraction should be suspended within the active channel over the reach from approximately 1km upstream of the Waimana confluence to Ruatoki Bridge.

In the **Lower Whakatane River below Pekatahi** significant volume was lost during the July 2004 flood, especially in the lower sandy reaches around town. Extraction rates in this reach are fairly small.

Desirable bed levels for the **Ruarepuae Stream** were set in 1986, and surveys in recent years have shown that bed levels are near those desired. Extraction should now be limited to where gravel builds up excessively.

Continuous losses are occurring in the Lower **Rangitaiki River** through bank erosion and degradation, particularly during the July 2004 flood. There is little demand for extraction of gravel/sand from the Rangitaiki River at present. Gravel or sand extraction is not required, nor should it be encouraged anywhere along the surveyed part of the river at this stage (the heads of the hydro lakes are not surveyed). The exception is in the lower reaches, where morphological processes consequent from the effects of the Edgecumbe earthquake are likely to cause some degradation. This could be artificially encouraged to give adequate flood capacity.

Estimates for the **Whirinaki River** indicate supplies are typically of the order of 23-24,000m^3 per year. Extraction should generally be encouraged in the aggrading reaches.

Gravel extraction in the **Horomanga River** should be suspended in the upper part of the reach and instead directed to the lower reaches. In the lower reaches the bed is severely perched and significant extraction is required to avoid undue flooding or avulsion (migration of the river channel). The bed level needs to initially be lowered by an average of 0.50 metres over the 70 metre design fairway width.

No extraction is currently carried out on the **Kopuriki Stream**, although resource consent applications have been made. Extraction should be encouraged in the lower reach of the stream where bed levels are aggrading and volume has been accumulating over the years.

Some extraction (of silt and/or sand) may be beneficial in some areas of the **Kaituna River** below Te Matai, if build-ups are excessive. However, the supply of sediment to the coast may be reduced by extraction.

No extraction is carried out in **Tarawera River** at present, and with the lowering of the whole bed it is recommended no sand extraction be allowed in the short to medium term.

When pressure increases on the resource, it may be necessary to redirect extractions more often. The Operations & Rural Services department of Environment Bay of Plenty has moved to ensure that appropriate extraction on the Waioeka River continues and that extraction increases on the Otara River. Extraction on the Waimana and Whakatane rivers has also been carefully directed to certain locations.

Estimates of average annual gravel supply have been included for some rivers, however these are subject to a high degree of uncertainty and the variation from year to year is large.

Contents

Chapter 1: Introduction

1.1 Background

Environment Bay of Plenty initiated a natural environment regional monitoring network (NERMN) in July 1990. In 1993/94 an initial River and Stream Channel Monitoring programme was included as part of this network which also forms an important part of the Impact Assessment monitoring as part of the consent process. This is the fourteenth year the programme has been included. It assesses and surveys the gravel and sand resources of the Bay of Plenty region and monitors the effects of mining gravel and sand on the river systems.

This report presents the work carried out to date to develop a resource monitoring programme. The gravel resource availability and river yields, demand for aggregate, record keeping and gravel allocation systems are described and discussed.

Gravel has long been taken from some rivers and apart from monitoring by means of cross-sections, little in the way of hard data has been gathered on the effect of this extraction. On some rivers, for example, the Whakatane and Horomanga, there is concern about possible over-extraction, whilst on other rivers, e.g. the Otara, there is concern because of an abundance of gravel.

Sand has long been mined directly from the coast in the Bay of Plenty. There is a strong demand for the resource with sand continuing to be taken from old dune systems. While Environment Bay of Plenty has been in favour of mining to remove excess (but not beach mining, where it is removing more than excess), the demand is recognised. In the long term there is the possibility that extraction may be shifted to some of the region's rivers, e.g. the Kaituna River where the bed level has been rising in some places.

Figure 1.1 shows the gravel extraction sites for 1993 to 2006 in the river systems of the Bay of Plenty region.

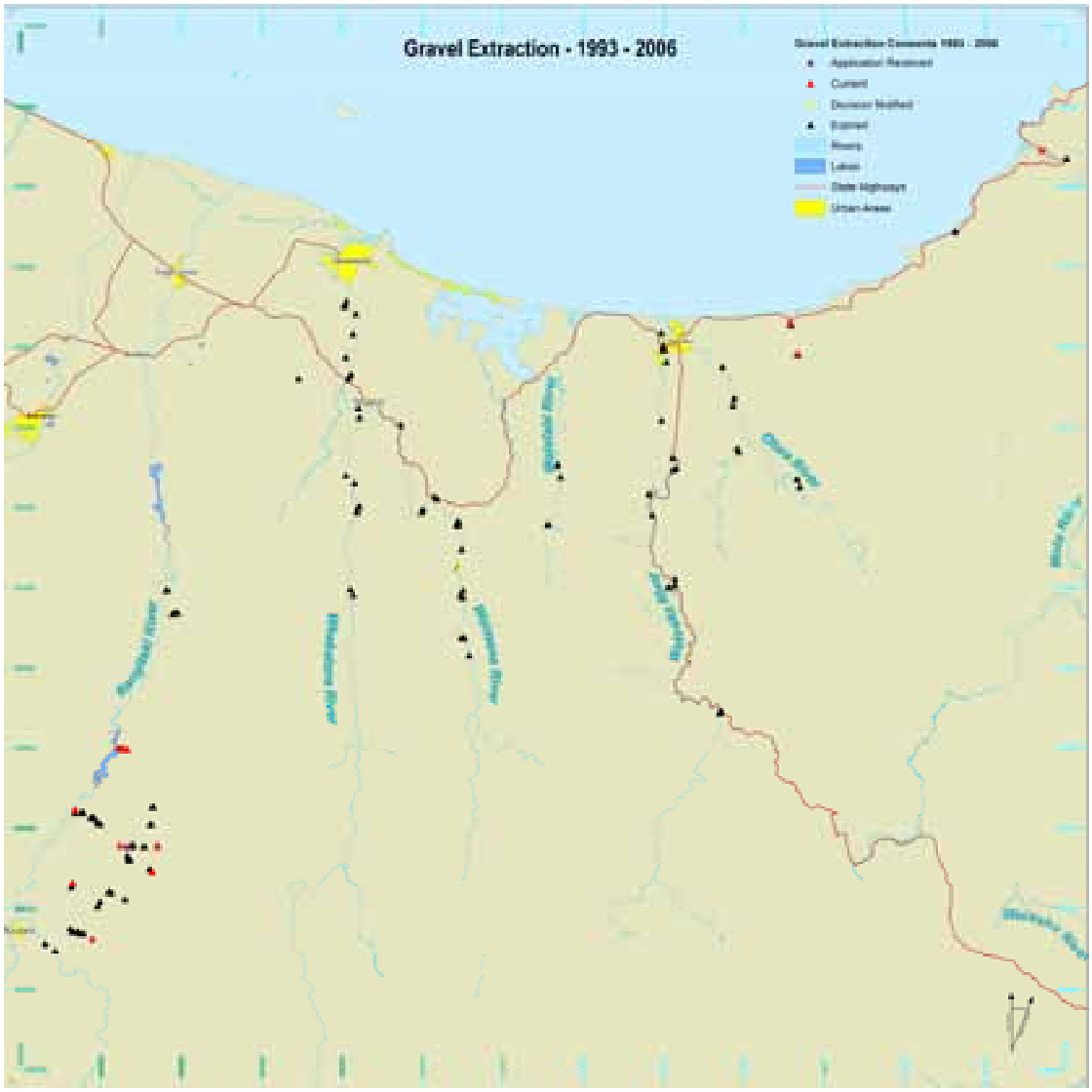


Figure 1.1 Gravel Extraction sites in the Bay of Plenty

1.2 Specific Objectives of the River and Stream Channel Monitoring Programme

The specific objectives of Environment Bay of Plenty's NERMN River and Stream Channel Monitoring Programme are:

- To provide Environment Bay of Plenty with reliable data to identify the quantity of gravel available for extraction and the present extraction rates in the Bay of Plenty region.
- To provide a basis for setting maximum annual extraction rates.

1.3 Relevant Factors to Consider when Setting Extraction Levels

While this report concentrates on the overall state of the rivers in the region, it is also pertinent to consider the reasons for encouraging or limiting extraction for the stability of river systems. These are illustrated on the next two pages and noted below:

- If the bed level is too high or the waterway congested, flooding is more likely.
- If the bed level is too low, banks are high and have to take the full force of the flow during a flood. Protection works are undermined, more gravel is transported downstream to build up elsewhere. Bank protection works are more costly.

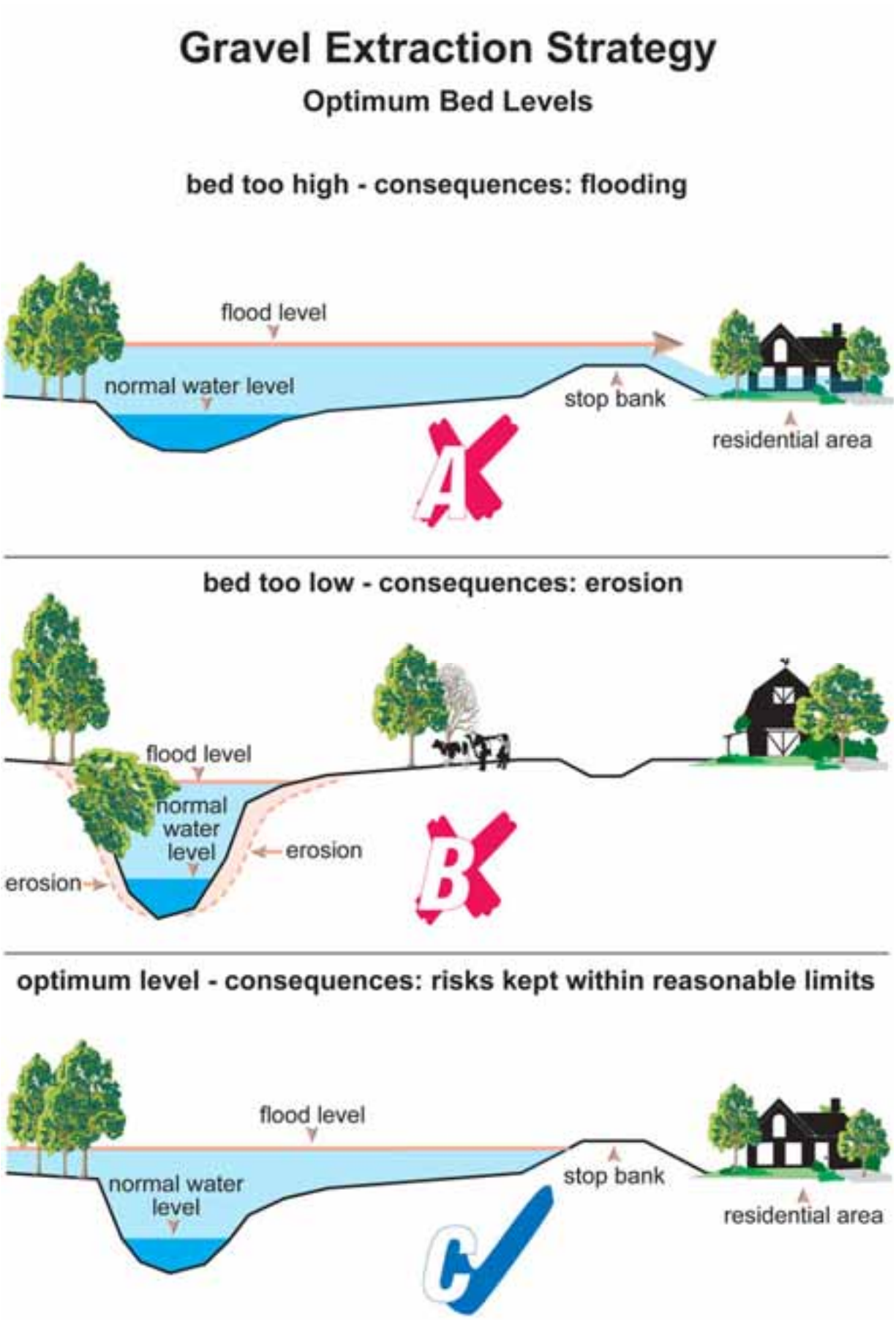
Work needs to be done to define desirable bed levels around the region, for the protection of assets of each river scheme and of the public in general.

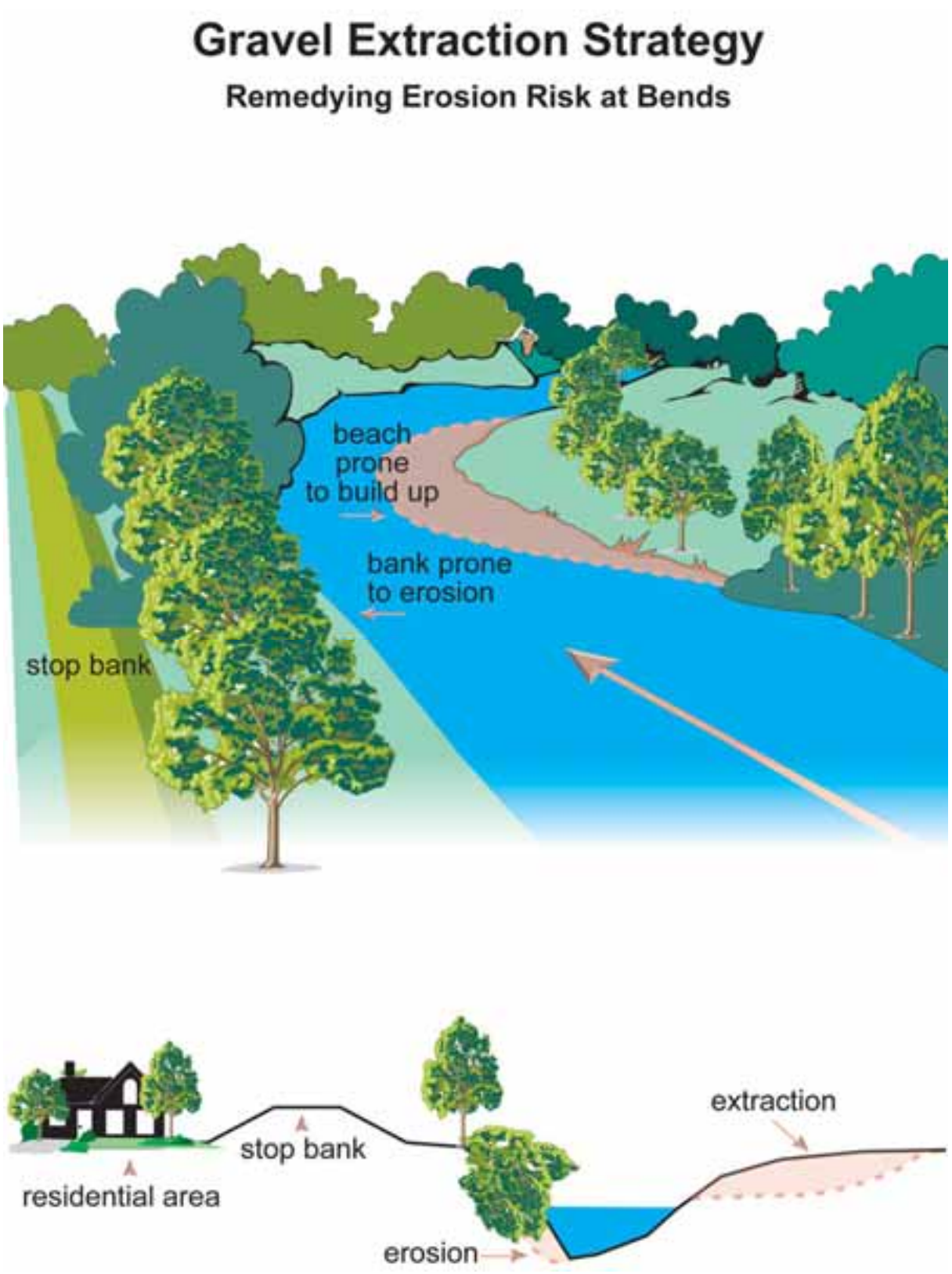
To encourage stable channels, the following factors need to be promoted:

- Maintaining bed levels within a desirable range
- Maintaining good river alignments
- Keeping roughly in balance with natural supply rates
- Compatibility with existing assets

Gravel Extraction Strategy

Optimum Bed Levels




Gravel Extraction Strategy
Remedying Erosion Risk at Bends
beach prone to build up
bank prone to erosion
stop bank
residential area
stop bank
extraction
erosion

Chapter 2: Data Collection and Survey Methods

2.1 Introduction

Prudent river management and the Resource Management Act require an adequate understanding of both the movement of gravel down rivers and the effects of extraction. Before 1993, only intermittent resurveying of river cross sections took place on some rivers. Gravel extraction declaration returns from commercial extractors were not detailed and did not provide sufficient information on the extraction locations.

To effectively monitor gravel extraction, accurate records need to be kept of the amount of gravel removed, and the river cross sections need to be resurveyed at regular intervals. Over a sufficiently long period it is possible to determine the average annual rate of deposition.

Environment Bay of Plenty has a comprehensive system of river cross-sections established and these are regularly resurveyed. The results of the analysis of these surveys is checked against gravel extraction records to develop an understanding of the movement of gravel in the river systems of the Bay of Plenty region.

Considerable data collection has to be undertaken before the analysis can be carried out. Environment Bay of Plenty is now in a position to make an initial assessment of the resource availability and sustainability, however the variability of supply is large, so ongoing data collection will be required to update these assessments.

2.2 Cross-Sections

The surveyed cross-sections provide the raw data that is entered into the "Hilltop" Software package. Hilltop has been developed by Mark Rodgers and replaces the formerly used Ricoda software. Hilltop is now Environment Bay of Plenty's cross-section archive system and the main tool to store and analyse the cross-section data. Appendix I sets out some details of Hilltop and how it is used along with gravel extraction records to ascertain gravel transport and extraction rates.

The cross-section surveys are as programmed in Table 2.1. This programme may vary as there is a need to survey the cross-sections after significant freshes in the river systems. For example, the rivers most affected by the major floods in July 1998 and July 2004 were resurveyed ahead of the programmed date.

Table 2.2 Cross-Section Survey Programme as at June 2006

River Name	Date of Last Survey	No. of Cross Sections	Cross Section Spacing	Suggested Frequency of Survey	Relative Extraction Pressure	Next Survey due
Otara	January 2004	37	300-800 m	2-5 year	Low	2006-09
Waioeka	May 2004	20	300-800 m	2-5 year	Med	2006-09
Waimana *	January 2006	35	400-1200 m	1-2 year	Med	2007-08
Whakatane (below Pekatahi Bridge)	July 2004 (prior July flood)	35	300-750 m	2-5 year	Med	2006
Whakatane* (above Pekatahi Bridge)	November 2005	34	500 - 1200 m	1-2 year	Med	2006-07
Rangitaiki (Lower)	August 2004	67	300 - 700 m	3-5 year		2007-09
Rangitaiki (Waiohau)	February 1996	12	900-1200 m	5 year	Low	2006
Rangitaiki (above Aniwhenua)	November 2001	28	800-1300 m	5 year	High	2006
Whirinaki *	September 2005	8	500-1000 m	1-2 year	Med	2006-07
Tarawera	February 2006	18	700-1500 m	5 year		2011
Ohutu *	June 2004	6	400-600 m	1-2 year	Med	2006
Mangamate *	January 2006	7	350 - 550 m	1-2 year	Med	2007-08
Ruarepuae *	December 2005	7	100 m	1-2 year	Med	2006-07
Horomanga *	September 2004	14	300 - 800 m	1-2 year	Med	2006
Kopuriki *	September 2005	9	250 m	1-2 year	Med	2006-07
Kaituna (below Te Matai)	April 2005	26	500 - 600 m	3-5 year		2008-10
Kaituna (above Te Matai)	May 2005	17	400 - 800 m	3-5 year		2008-10
Mangorewa	October 2001	3	500 m	3-5 year		2006
Waiotahi	-	7			Low	
Waikokopu *	December 1996			2 year	Med	

* More frequent surveys may be appropriate to match extraction activities.

There is no uniform approach to spacing of cross-sections. On some rivers they are only 100m apart while on others they are as far as one kilometre apart. Environment Bay of Plenty will need to assess what distance is appropriate to effectively monitor the river system - in general this will depend on the size of the river. This non-uniformity is not a problem in itself, rather monitoring requirements should be tailored to the level of detail and accuracy of monitoring required for each river. For long-term monitoring, it is more important to be comparing new data with as long a record as possible, so existing sites should in general be maintained.

Cross-section data and in particular plots allow a ready visual appreciation of what is happening in the river at each site.

2.3 Gravel Extraction

The amounts of gravel extracted in the Bay of Plenty region over the periods July 2002 to June 2003, July 2003 to June 2004, July 2004 to June 2005, and July 2005 to June 2006 are summarised in Table 2.2. The table shows both the extractions under Resource Consent and under the Regional River Gravel Management Plan.

The information tabled here is taken from the operators' quarterly returns. In the past, operators have not provided details of the sites when submitting their returns. They are starting to supply site information with their returns and in the future they should be required to provide details associated with cross-sections where applicable.

While operators' records used to be in relation to gravel after it has been screened and processed or sold, operators are now asked to record the total quantities that have been removed from the river and not just the commercial components of the gravel removed, as this is the relevant measure required for river management purposes and determining the amount of material available for extraction. This should form the basis of a more consistent and comprehensive record of the extraction of the resource.

Reliable estimates of the gravel yield can be derived from these records and using the information from the cross-section surveys.

Contractors need to be provided with a set of plans showing the location of the cross-sections when their consent is issued.

The quantity of gravel transported by the river can be derived from "gravel balance" calculations as the difference between net change in river storage (estimated from inter-survey bed level differences), and gravel extracted (estimated from gravel extraction declaration returns over the period between cross-section surveys).

Table 2.2 Shingle Extraction in the Bay of Plenty 2002/03, 2003/04, 2004/05 and 2005/06.

SHINGLE EXTRACTION BAY OF PLENTY 2002/2003

River	Location	Expiry	Consent or Allocation No.	Site/ Km	Contractor	Shingle Extracted				Subtotal	Cumulative Total
						Sep-02	Dec-02	Mar-03	Jun-03		
Whakatane River											
	Below Pekatahi										
	Van Boheman	31/05/2002	06 0232	1	J Swaps	0	0	0	0	**0**	**0**
	Blacks	30/04/2000	06 0235	1	Tracks	569	392	966		**1927**	**1927**
	Sykes	31/10/96	05 0372	1	Waiotahi	0	424	499	0	**923**	**2850**
	Pekatahi To Ruatoki Bridge										
	Lyfords		05 0372	1	Waiotahi	0	0	0	0	**0**	**2850**
	Reids Rd	31/10/96	05 0372	3	Waiotahi	7679	7505	6806	0	**21990**	**24840**
	Lillas			4		0	0	0	0	**0**	**24840**
	Rawson			5		0	0	0	0	**0**	**24840**
	Richardsons	31/10/96	05 0372	7	Waiotahi	0	0	0	0	**0**	**24840**
	Yeoman			9		0	0	0	0	**0**	**24840**
	Davies			10		0	0	0	0	**0**	**24840**
	Mahurihuri	31/10/96	05 0372	11	Waiotahi	0	0	0	0	**0**	**24840**
	Above Ruatoki Bridge										
	Te Kaiti Trust	31/10/96	05 0372	12	Waiotahi	0	0	0	0	**0**	**24840**
	Ngati Rongo	31/10/96	05 0372	13	Waiotahi	0	0	0	0	**0**	**24840**
	Opurana	31/10/96	05 0372	14	Waiotahi	0	0	0	0	**0**	**24840**
	Limeworks	31/10/96	05 0372	15	Waiotahi	0	0	0	0	**0**	**24840**
	Waikirikiri	31/10/96	05 0372	16?	Waiotahi	0	0	0	0	**0**	**24840**
Waimana River											
	Below Ruddicks Rd Bridge										
	Waimana Gorge, Dunstans 1					0	0	0	0	**0**	**24840**
	Waimana Gorge, Dunstans 2			2	Waiotahi	0	0	0	0	**0**	**24840**
	Wardlaw Rd	30/11/1996	05 0449	2	Wilson Brothers	0	4066	0	0	**4066**	**28906**
	Waimana Gorge, Dunstans 3			3	Waiotahi	0	0	0	0	**0**	**28906**
	Waimana Gorge, Dunstans 4			4	Waiotahi	0	0	0	0	**0**	**28906**
	Wardlaw/Ruddicks			5	Waiotahi	0	0	0	0	**0**	**28906**
	Above Ruddicks Rd Bridge							0	0		
	Flemings/Clarks / Takao's		05 0371		Waiotahi	0	0	10500	2117	**12617**	**41523**
	Above Waimana Bridge										
	Tanatana/Rokuraku (Bells Rd)		05 0449		Wilson Bros	0	0	0	0	**0**	**41523**
	Lowes					0	0	0	0	**0**	**41523**
	Mexteds					0	0	0	0	**0**	**41523**
	Lowes/Mexteds	30/11/96	05 0449	1	Wilson Brothers	0	0	2652	1070	**3722**	**45245**
	Lowes/Mexteds	31/10/96	06 0284	7	Waiotahi	0	0	0	994	**994**	**46239**
	Claytons	31/10/96	06 0284	8	Waiotahi	0	0	2454	0	**2454**	**48693**
	Len Browns	31/10/1996	06 0284	9	Waiotahi			368	0	**368**	**49061**
Horomanga River											**49061**
	Above Troutbeck Rd										**49061**
	LOWER - Galatea Rd End 0.6 to 3.2 Km		61429	0.6-3.2km	Fletcher Challenge Forests	1046	1370	0	10452	**12868**	**61929**
	LOWER - Galatea Rd End 0.6 to 3.2 Km		61429	0.6-3.2km	D Bockman	0	0	0	1345	**1345**	**63274**
	MIDDLE - to Ohutu Outlet 3.2 to 5.7 Km		61429	3.2-5.7km	Waiotahi	0	0	0	1887	**1887**	**65161**
	TOP - downstream Troutbeck Rd 5.7 to 7.3 Km		61429	5.7-7.3km							**65161**
	Galatea Road Bridge	31/08/2008	05 0706	10	Waiotahi	0	0	0	0	**0**	**65161**
	Galatea Road Bridge	30/09/01	05 0737	1	Edelsten	0	0	0	0	**0**	**65161**
	Galatea Road Bridge	31/08/2008	05 0706	1	Waiotahi	0	0	0	0	**0**	**65161**
	Troutbeck Rd	30/11/2003	05 0828		Wilson Bros	3382	0	6337	0	**9719**	**74880**
	Troutbeck Rd	30/06/2004	05 0851	1	Robinsons Transport	0	40	0	0	**40**	**74920**
	Troutbeck Rd	30/06/2004	06 0300	1	Robinsons Transport	105	0	0	0	**105**	**75025**
Mangamate Stm											
	Troutbeck Rd	30/06/2004	06 0300	1	Robinsons Transport	0	0	0	0	**0**	**75025**
	Troutbeck Rd		05 0828	1	Wilson Bros	0	0	0	0	**0**	**75025**
Kopuriki Stm											
	Blacks	31/08/2008	06 0023	1	Waiotahi	0	0	0	0	**0**	**75025**
	Galatea Road Bridge	30/09/01	05 0737	1	Edelsten	0	0	0	0	**0**	**75025**
Waikokopu Stm											
	Galatea Road	30/06/2003	05 0706		Waiotahi	0	0	0	0	**0**	**75025**
Waihui Stream											
	Ruatahuna	30/04/2000	06 0443	1	Waiotahi	0	0	1798	0	**1798**	**76823**
Waioeka River											
	S/Highway 2 Bridge	31/01/2002	05 1060	1	E·B·O·P/M Kennon	0	0	0	0	**0**	**76823**
	S/Highway 2 Bridge	1/06/1999	05 1060	1	E·B·O·P/Works Infrastructure	0	0	0	0	**0**	**76823**
	S/Highway 2 Bridge	31/12/1999	05 1060	1	E·B·O·P/Waiotahi	0	97	0	1635	**1732**	**78555**
	Petersons (Robbie's)	1/06/1999	05 0705	3	E·B·O·P/Waiotahi			6040	643	**6683**	**85238**
	S/Highway 2 Bridge	31/01/2002	05 1060	2	E.B.O.P/Eastern Bay Concrete	80	110	50	0	**240**	**85478**
	S/Highway 2 Bridge	31/12/1999	05 1060	2	E·B·O·P	0	0	0	0	**0**	**85478**
	B Smith		05 1060		E·B·O·P	2548	0	0	2662	**5210**	**90688**
	Youngs	1/06/1999	05 1060	4	E·B·O·P	0	0	0	0	**0**	**90688**
	Browns	1/06/1999	05 1060	5	E·B·O·P	0	0	0	0	**0**	**90688**
	Browns Pipeline	1/06/1999	05 1060	6	E·B·O·P	0	0	0	0	**0**	**90688**
	Michaels	30/04/2002	06 0304		Waiotahi	407	0	0	0	**407**	**91095**

	Maxwell			7		0	0	0	0	**0**	**91095**
	Youngs	31/12/2002	05 1060	8	E·B·O·P - ORS	0	0	0	0	**0**	**91095**
	Graemes Bridge	31/12/2002	05 1060	9	EBOP - ORS	0	0	0	0	**0**	**91095**
	Wairata	31/12/2002	05 1060	10	EBOP - ORS	0	0	0	0	**0**	**91095**
Otara River											
	Scheme Area										
	Gows Road	31/01/2002	05 1061	1	E·B·O·P - ORS	0	0	0	0	**0**	**91095**
	Gows Road	31/01/2002	05 1061	1	Waiotahi	0	0	0	84	**84**	**91179**
	Carters	31/01/2002	05 1061	1	E.B.O.P - ORS/EBC	200	170	0	200	**570**	**91749**
	Goult	31/12/2002	05 1061	2	E·B·O·P - ORS	0	0	0	0	**0**	**91749**
	Lockhead		?	3	E·B·O·P-Waiotahi Contractors	0	0	0	0	**0**	**91749**
	EBA5	31/12/1999	05 1061	3	E·B·O·P-Works Infrastructure	0	0	0	0	**0**	**91749**
	Carters	?	05 1061	4	E·B·O·P-Waiotahi Contractors	0	0	0	0	**0**	**91749**
	Carters	?	05 1061	4	E·B·O·P-M Kennon	126	180	0	0	**306**	**92055**
	Carters	31/12/2002	05 1061	4	E·B·O·P - ORS	0	0	0	0	**0**	**92055**
	Kellers	31/12/2002	05 1061	5	E·B·O·P - ORS	0	0	0	0	**0**	**92055**
	M Brown	31/12/2002	05 1061	6	E·B·O·P - ORS	0	0	0	0	**0**	**92055**
	Watsons	31/12/2002	05 1061	?	E·B·O·P - ORS	0	0	0	0	**0**	**92055**
Waiotahi River											
	Youngs		05 0448	1	Wilson Brothers	0	4006	1520	0	**5526**	**97581**
East Coast Rivers											**97581**
Hawai River											**97581**
	SH35 Bridge					0	0	0	0	**0**	**97581**
Raukokore River											**97581**
	Raukokore River	31/07/2011	51035-0		Waiotahi Contractors	776	0	0	0	**776**	**98357**
Reg. River Gravel Management Plan Extractions											
			Allocation #								
Waioeka River			1107		Waiotahi Contractors	285	0	0	0	**285**	**98642**
Whangaoroa											**98642**
	Waititi										**98642**
Whakatane River											**98642**
	Lillas Pit (26.8 Km River Distance)		04/23	26.8	J Swap				420	**420**	**99062**
Waimana River											**99062**
	Kirkbride Rd Bridge		-		Whakatane District Council				350	**350**	**99412**
Waiaua River											**99412**
Motu River											**99412**
Otara River											**99412**
	Turaetoko		1115					935		**935**	**100347**
Raukokore River											**100347**
	D/S State Highway Bridge		03/12		J Swap				1600	**1600**	**101947**
					Total	**17203**	**18360**	**40925**	**25459**	**101947**	**101947**

SHINGLE EXTRACTION BAY OF PLENTY 2003/2004

River	Location	Expiry	Consent or Allocation No.	Site/ Km	Contractor	Shingle Extracted				Subtotal	Cumulative Total
						Sep-02	Dec-02	Mar-03	Jun-03		
Whakatane River											
	Below Pekatahi										
	Van Boheman	31/05/2002	06 0232	1	J Swaps	0	0	0	0	**0**	**0**
	Blacks	30/04/2000	06 0235	1	Tracks	569	392	966		**1927**	**1927**
	Sykes	31/10/96	05 0372	1	Waiotahi	0	424	499	0	**923**	**2850**
	Pekatahi To Ruatoki Bridge										
	Lyfords		05 0372	1	Waiotahi	0	0	0	0	**0**	**2850**
	Reids Rd	31/10/96	05 0372	3	Waiotahi	7679	7505	6806	0	**21990**	**24840**
	Lillas			4		0	0	0	0	**0**	**24840**
	Rawson			5		0	0	0	0	**0**	**24840**
	Richardsons	31/10/96	05 0372	7	Waiotahi	0	0	0	0	**0**	**24840**
	Yeoman			9		0	0	0	0	**0**	**24840**
	Davies			10		0	0	0	0	**0**	**24840**
	Mahurihuri	31/10/96	05 0372	11	Waiotahi	0	0	0	0	**0**	**24840**
	Above Ruatoki Bridge										
	Te Kaiti Trust	31/10/96	05 0372	12	Waiotahi	0	0	0	0	**0**	**24840**
	Ngati Rongo	31/10/96	05 0372	13	Waiotahi	0	0	0	0	**0**	**24840**
	Opurana	31/10/96	05 0372	14	Waiotahi	0	0	0	0	**0**	**24840**
	Limeworks	31/10/96	05 0372	15	Waiotahi	0	0	0	0	**0**	**24840**
	Waikirikiri	31/10/96	05 0372	16?	Waiotahi	0	0	0	0	**0**	**24840**
Waimana River											
	Below Ruddicks Rd Bridge										
	Waimana Gorge, Dunstans 1					0	0	0	0	**0**	**24840**
	Waimana Gorge, Dunstans 2			2	Waiotahi	0	0	0	0	**0**	**24840**
	Wardlaw Rd	30/11/1996	05 0449	2	Wilson Brothers	0	4066	0	0	**4066**	**28906**
	Waimana Gorge, Dunstans 3			3	Waiotahi	0	0	0	0	**0**	**28906**
	Waimana Gorge, Dunstans 4			4	Waiotahi	0	0	0	0	**0**	**28906**
	Wardlaw/Ruddicks			5	Waiotahi	0	0	0	0	**0**	**28906**
	Above Ruddicks Rd Bridge							0	0		
	Flemings/Clarks / Takao's		05 0371		Waiotahi	0	0	10500	2117	**12617**	**41523**
	Above Waimana Bridge										
	Tanatana/Rokuraku (Bells Rd)		05 0449		Wilson Bros	0	0	0	0	**0**	**41523**
	Lowes					0	0	0	0	**0**	**41523**
	Mexteds					0	0	0	0	**0**	**41523**
	Lowes/Mexteds	30/11/96	05 0449	1	Wilson Brothers	0	0	2652	1070	**3722**	**45245**
	Lowes/Mexteds	31/10/96	06 0284	7	Waiotahi	0	0	0	994	**994**	**46239**
	Claytons	31/10/96	06 0284	8	Waiotahi	0	0	2454	0	**2454**	**48693**
	Len Browns	31/10/1996	06 0284	9	Waiotahi			368	0	**368**	**49061**
Horomanga River											**49061**
	Above Troutbeck Rd										**49061**
	LOWER - Galatea Rd End 0.6 to 3.2 Km		61429	0.6-3.2km	Fletcher Challenge Forests	1046	1370	0	10452	**12868**	**61929**
	LOWER - Galatea Rd End 0.6 to 3.2 Km		61429	0.6-3.2km	D Bockman	0	0	0	1345	**1345**	**63274**
	MIDDLE - to Ohutu Outlet 3.2 to 5.7 Km		61429	3.2-5.7km	Waiotahi	0	0	0	1887	**1887**	**65161**
	TOP - downstream Troutbeck Rd 5.7 to 7.3 Km		61429	5.7-7.3km							**65161**
	Galatea Road Bridge	31/08/2008	05 0706	10	Waiotahi	0	0	0	0	**0**	**65161**
	Galatea Road Bridge	30/09/01	05 0737	1	Edelsten	0	0	0	0	**0**	**65161**
	Galatea Road Bridge	31/08/2008	05 0706	1	Waiotahi	0	0	0	0	**0**	**65161**
	Troutbeck Rd	30/11/2003	05 0828		Wilson Bros	3382	0	6337	0	**9719**	**74880**
	Troutbeck Rd	30/06/2004	05 0851	1	Robinsons Transport	0	40	0	0	**40**	**74920**
	Troutbeck Rd	30/06/2004	06 0300	1	Robinsons Transport	105	0	0	0	**105**	**75025**
Mangamate Stm											
	Troutbeck Rd	30/06/2004	06 0300	1	Robinsons Transport	0	0	0	0	**0**	**75025**
	Troutbeck Rd		05 0828	1	Wilson Bros	0	0	0	0	**0**	**75025**
Kopuriki Stm											
	Blacks	31/08/2008	06 0023	1	Waiotahi	0	0	0	0	**0**	**75025**
	Galatea Road Bridge	30/09/01	05 0737	1	Edelsten	0	0	0	0	**0**	**75025**
Waikokopu Stm											
	Galatea Road	30/06/2003	05 0706		Waiotahi	0	0	0	0	**0**	**75025**
Waihui Stream											
	Ruatahuna	30/04/2000	06 0443	1	Waiotahi	0	0	1798	0	**1798**	**76823**
Waioeka River											
	S/Highway 2 Bridge	31/01/2002	05 1060	1	E·B·O·P/M Kennon	0	0	0	0	**0**	**76823**
	S/Highway 2 Bridge	1/06/1999	05 1060	1	E·B·O·P/Works Infrastructure	0	0	0	0	**0**	**76823**
	S/Highway 2 Bridge	31/12/1999	05 1060	1	E·B·O·P/Waiotahi	0	97	0	1635	**1732**	**78555**
	Petersons (Robbie's)	1/06/1999	05 0705	3	E·B·O·P/Waiotahi			6040	643	**6683**	**85238**
	S/Highway 2 Bridge	31/01/2002	05 1060	2	E.B.O.P/Eastern Bay Concrete	80	110	50	0	**240**	**85478**
	S/Highway 2 Bridge	31/12/1999	05 1060	2	E·B·O·P	0	0	0	0	**0**	**85478**
	B Smith		05 1060		E·B·O·P	2548	0	0	2662	**5210**	**90688**
	Youngs	1/06/1999	05 1060	4	E·B·O·P	0	0	0	0	**0**	**90688**
	Browns	1/06/1999	05 1060	5	E·B·O·P	0	0	0	0	**0**	**90688**
	Browns Pipeline	1/06/1999	05 1060	6	E·B·O·P	0	0	0	0	**0**	**90688**
	Michaels	30/04/2002	06 0304		Waiotahi	407	0	0	0	**407**	**91095**

	Maxwell			7		0	0	0	0	**0**	**91095**
	Youngs	31/12/2002	05 1060	8	E·B·O·P - ORS	0	0	0	0	**0**	**91095**
	Graemes Bridge	31/12/2002	05 1060	9	EBOP - ORS	0	0	0	0	**0**	**91095**
	Wairata	31/12/2002	05 1060	10	EBOP - ORS	0	0	0	0	**0**	**91095**
Otara River											
	Scheme Area										
	Gows Road	31/01/2002	05 1061	1	E·B·O·P - ORS	0	0	0	0	**0**	**91095**
	Gows Road	31/01/2002	05 1061	1	Waiotahi	0	0	0	84	**84**	**91179**
	Carters	31/01/2002	05 1061	1	E.B.O.P - ORS/EBC	200	170	0	200	**570**	**91749**
	Goult	31/12/2002	05 1061	2	E·B·O·P - ORS	0	0	0	0	**0**	**91749**
	Lockhead		?	3	E·B·O·P-Waiotahi Contractors	0	0	0	0	**0**	**91749**
	EBA5	31/12/1999	05 1061	3	E·B·O·P-Works Infrastructure	0	0	0	0	**0**	**91749**
	Carters	?	05 1061	4	E·B·O·P-Waiotahi Contractors	0	0	0	0	**0**	**91749**
	Carters	?	05 1061	4	E·B·O·P-M Kennon	126	180	0	0	**306**	**92055**
	Carters	31/12/2002	05 1061	4	E·B·O·P - ORS	0	0	0	0	**0**	**92055**
	Kellers	31/12/2002	05 1061	5	E·B·O·P - ORS	0	0	0	0	**0**	**92055**
	M Brown	31/12/2002	05 1061	6	E·B·O·P - ORS	0	0	0	0	**0**	**92055**
	Watsons	31/12/2002	05 1061	?	E·B·O·P - ORS	0	0	0	0	**0**	**92055**
Waiotahi River											
	Youngs		05 0448	1	Wilson Brothers	0	4006	1520	0	**5526**	**97581**
East Coast Rivers											**97581**
Hawai River											**97581**
	SH35 Bridge					0	0	0	0	**0**	**97581**
Raukokore River											**97581**
	Raukokore River	31/07/2011	51035-0		Waiotahi Contractors	776	0	0	0	**776**	**98357**
Reg. River Gravel Management Plan Extractions											
			Allocation #								
Waioeka River			1107		Waiotahi Contractors	285	0	0	0	**285**	**98642**
Whangaoroa											**98642**
	Waititi										**98642**
Whakatane River											**98642**
	Lillas Pit (26.8 Km River Distance)		04/23	26.8	J Swap				420	**420**	**99062**
Waimana River											**99062**
	Kirkbride Rd Bridge		-		Whakatane District Council				350	**350**	**99412**
Waiaua River											**99412**
Motu River											**99412**
Otara River											**99412**
	Turaetoko		1115					935		**935**	**100347**
Raukokore River											**100347**
	D/S State Highway Bridge		03/12		J Swap				1600	**1600**	**101947**
					Total	**17203**	**18360**	**40925**	**25459**	**101947**	**101947**

SHINGLE EXTRACTION BAY OF PLENTY 2003/2004

River	Location/Site	Expiry	Consent or Allocation No.	Contractor	Shingle Extracted				Subtotal	Cumulative Total
					Sep-03	Dec-03	Mar-04	Jun-04		
Whakatane River										
	Below Pekatahi									
	Blacks		61602	Tracks	528	618	466	608	**2220**	**2220**
	Sykes		50704	Waiotahi		388	5273		**5661**	**7881**
	Boheemans		50704	Waiotahi	1783				**1783**	**9664**
	Pekatahi To Ruatoki Bridge									**9664**
	Lyfords		50704	Waiotahi					**0**	**9664**
	Reids Rd		50704	Waiotahi					**0**	**9664**
	Richardsons		50704	Waiotahi					**0**	**9664**
	Mahurihuri		50704	Waiotahi					**0**	**9664**
	Above Ruatoki Bridge									**9664**
	Te Kaiti Trust		50704	Waiotahi					**0**	**9664**
	Ngati Rongo		50704	Waiotahi					**0**	**9664**
	Opurana		50704	Waiotahi					**0**	**9664**
	Limeworks		50704	Waiotahi					**0**	**9664**
	Waikirikiri		50704	Waiotahi					**0**	**9664**
Waimana River										**9664**
	Below Waimana West Bridge									**9664**
	Waimana Gorge, Dunstans 2		50704	Waiotahi					**0**	**9664**
	Dunstans 1		50704	Waiotahi	1574	440			**2014**	**11678**
	Wardlaw Rd		50721	Wilson Brothers			0		**0**	**11678**
	Above Waimana West Bridge									**11678**
	Flemings/Clarks / Takao's	24/06/2003	50130	Waiotahi					**0**	**11678**
	Above Waimana East Bridge									**11678**
	Tanatana/Rokuraku (Bells Rd)		50721	Wilson Bros			0		**0**	**11678**
	Takao		60525	Waiotahi	5069	2233	1363	7309	**15974**	**27652**
	Lowes/Mexteds		50721	Wilson Brothers	840	2569	0	2206	**5615**	**33267**
	Lowes/Mexteds		60525 (EBOP's)	Waiotahi				4125	**4125**	**37392**
	Len Browns		60525 (EBOP's)	Waiotahi					**0**	**37392**
Horomanga River										**37392**
	LOWER - Galatea Rd End 0.6 to 3.2 Km	31/03/2012	61429 (EBOP's)				525	0	**525**	**37917**
										37917
	MIDDLE - to Ohutu Outlet 3.2 to 5.7 Km	31/03/2012	61429 (EBOP's)						**0**	**37917**
										37917
	TOP - downstream Troutbeck Rd 5.7 to 7.3 Km	31/03/2012	61429 (EBOP's)						**0**	**37917**
									0	**37917**
Ohutu Stream										**37917**
		31/03/2012	61429 (EBOP's)	Fletcher Challenge Forests			3525	0	**3525**	**41442**
									0	**41442**
	Galatea Road Bridge	31/08/2008	05 0706	Waiotahi					**0**	**41442**
	Galatea Road Bridge	31/08/2008	05 0706	Waiotahi					**0**	**41442**
	Troutbeck Rd	30/06/2004	05 0851	Robinsons Transport				0	**0**	**41442**
	Troutbeck Rd	30/06/2004	06 0300	Robinsons Transport				0	**0**	**41442**
Mangamate Stream										**41442**
	Troutbeck Rd	31/03/2012	61429 (EBOP's)	Kaingaroa Roading		2616	0		**2616**	**44058**
Kopuriki Stm										**44058**
	Blacks	31/08/2008	06 0023	Waiotahi					**0**	**44058**
	Galatea Road Bridge	31/08/2008	61437	Edelsten	522	0	0	0	**522**	**44580**
Waikokopu Stm										**44580**
	Galatea Road	30/06/2003	05 0706	Waiotahi					**0**	**44580**
Waihui Stream										**44580**
	Ruatahuna	30/04/2000	06 0443	Waiotahi					**0**	**44580**
Waioeka River										**44580**
	S/Highway 2 Bridge		61321 (EBOP's)	E·B·O·P/M Kennon			0		**0**	**44580**
	S/Highway 2 Bridge		61321 (EBOP's)	E·B·O·P/Works Infrastructure	100				**100**	**44680**
	S/Highway 2 Bridge		61321 (EBOP's)	E·B·O·P/Waiotahi			56	1676	**1732**	**46412**
	Petersons (Robbie's)		51130	E·B·O·P/Waiotahi		340	189		**529**	**46941**
	S/Highway 2 Bridge		61321 (EBOP's)	E.B.O.P/Eastern Bay Concrete			0		**0**	**46941**
	S/Highway 2 Bridge		61321 (EBOP's)	E·B·O·P					**0**	**46941**
	B Smith		61321 (EBOP's)	E·B·O·P			4192		**4192**	**51133**
	Youngs		61321 (EBOP's)	E·B·O·P/Waiotahi		5727			**5727**	**56860**
	Browns		61321 (EBOP's)	E·B·O·P			1249	3298	**4547**	**61407**
	Browns Pipeline		61321 (EBOP's)	E·B·O·P					**0**	**61407**
	Graemes Bridge		61321 (EBOP's)	EBOP - ORS					**0**	**61407**
	Wairata		61321 (EBOP's)	EBOP - ORS					**0**	**61407**
Otara River										**61407**
	Scheme Area									**61407**
	Gows Road		61322 (EBOP's)	E.B.O.P - ORS/EBC				220	**220**	**61627**
	Carters		61322 (EBOP's)	E.B.O.P - ORS/EBC		200	190	0	**390**	**62017**
	Goult		61322 (EBOP's)	E·B·O·P - ORS					**0**	**62017**
	Lockhead		61322 (EBOP's)	E·B·O·P-Waiotahi Contractors					**0**	**62017**
	EBA5		61322 (EBOP's)	E·B·O·P-Works Infrastructure					**0**	**62017**

	Carters		61322 (EBOP's)	E-B-O-P-Waiotahi Contractors					**0**	**62017**
	Carters		61322 (EBOP's)	E-B-O-P-M Kennon	258		0	140	**398**	**62415**
	Carters		61322 (EBOP's)	E-B-O-P - ORS					**0**	**62415**
	Kellers		61322 (EBOP's)	E-B-O-P - ORS					**0**	**62415**
	Kellers		61322 (EBOP's)	E-B-O-P - ORS					**0**	**62415**
	Kellers		61322 (EBOP's)	E-B-O-P - ORS					**0**	**62415**
	M Brown		61322 (EBOP's)	E-B-O-P - ORS					**0**	**62415**
	Watsons		61322 (EBOP's)	E-B-O-P - ORS					**0**	**62415**
Waiotahi River										**62415**
	Youngs		50722	Wilson Brothers			0		**0**	**62415**
East Coast Rivers			50922	Works Infratructure			850	0		**62415**
Hawai River										**62415**
	SH35 Bridge								**0**	**62415**
Raukokore River										**62415**
	Raukokore River	31/07/2011	51035-0	Waiotahi Contractors					**0**	**62415**
										62415
Reg. River Gravel Management Plan Extractions										**62415**
			Allocation #							**62415**
										62415
Hikurangi Stream									**0**	**62415**
	R Armstongs		04/34	Fletcher Challenge Forests		2745			**2745**	**65160**
Waioeka River									**0**	**65160**
	B Smiths (Gorge)		04/25	Waiotahi Contractors	3110				**3110**	**68270**
Whangaoroa										**68270**
	Waititi									**68270**
Waimana River										**68270**
	Clarkes		03/18	Works Opotiki	300				**300**	**68570**
	L. Browns		04/29	A Rust Contracting		600	1400	0	**2000**	**70570**
Waiaua River										**70570**
Motu River			4-Mar	Motu Metal Crushing Ltd		2000	0	0		**70570**
Otara River										**70570**
	Turaetoko								**0**	**70570**
										70570
				Total	**14084**	**20476**	**19278**	**19582**	**70570**	**141140**

SHINGLE EXTRACTION BAY OF PLENTY 2004/2005

River	Location/Site	Expiry	Consent or Allocation No.	Contractor	Shingle Extracted				Subtotal	Cumulative Total
					Sep-04	Dec-04	Mar-05	Jun-05		
Whakatane River										
	Below Pekatahi									
	Blacks		61602	Tracks	1113	1137	316	488	**3054**	**3054**
	Sykes		50704	Waiotahi					**0**	**3054**
	Boheemans		50704	Waiotahi					**0**	**3054**
	Pekatahi To Ruatoki Bridge									**3054**
	Lyfords		50704	Waiotahi					**0**	**3054**
	Reids Rd		50704	Waiotahi	4616				**4616**	**7670**
	Richardsons		50704	Waiotahi					**0**	**7670**
	Mahurihuri		50704	Waiotahi					**0**	**7670**
	Above Ruatoki Bridge									**7670**
	Te Kaiti Trust		50704	Waiotahi					**0**	**7670**
	Ngati Rongo		50704	Waiotahi					**0**	**7670**
	Opurana		50704	Waiotahi					**0**	**7670**
	Limeworks		50704	Waiotahi					**0**	**7670**
	Waikirikiri		50704	Waiotahi					**0**	**7670**
Waimana River										**7670**
	Below Waimana West Bridge									**7670**
	Waimana Gorge, Dunstans 2		50704	Waiotahi		1820			**1820**	**9490**
	Dunstans 1		50704	Waiotahi	5834	109	3686		**9629**	**19119**
	Wardlaw Rd		50721	Wilson Brothers	0	0			**0**	**19119**
	Above Waimana West Bridge									**19119**
	Flemings/Clarks / Takao's	24/06/2003	50130	Waiotahi					**0**	**19119**
	Above Waimana East Bridge									**19119**
	Tanatana/Rokuraku (Bells Rd)		50721	Wilson Bros	0	0	0	0	**0**	**19119**
	Takao		60525	Waiotahi	1561		1022	3477	**6060**	**25179**
	Lowes/Mexteds		50721	Wilson Brothers	0	0		0	**0**	**25179**
	Lowes/Mexteds		60525 (EBOP's)	Waiotahi					**0**	**25179**
	DeGroots1			Waiotahi		2488	513		**3001**	**28180**
	DeGroots2			Waiotahi		1385	1638		**3023**	**31203**
	Len Browns		60525 (EBOP's)	Waiotahi					**0**	**31203**
Horomanga River									**0**	**31203**
	LOWER - Galatea Rd End 0.6 to 3.2 Km	31/03/2012	61429 (EBOP's)	Wilsom Bros			0	0	**0**	**31203**
				Kaingaroa Timberlands					**0**	**31203**
				Kaingaroa Roading				4960	**4960**	**36163**
				Robinson Tspt				48	**48**	**36211**
	MIDDLE - to Ohutu Outlet 3.2 to 5.7 Km	31/03/2012	61429 (EBOP's)	Wilson Bros		140	0		**140**	**36351**
				Kaingaroa Timberlands					**0**	**36351**
				Kaingaroa Roading					**0**	**36351**
				Robinson Tspt					**0**	**36351**
									0	**36351**
	TOP - downstream Troutbeck Rd 5.7 to 7.3 Km	31/03/2012	61429 (EBOP's)	Wilsom Bros	1267	5989	0		**7256**	**43607**
				Kaingaroa Timberlands			0	3000	**3000**	**46607**
				Kaingaroa Roading			0		**0**	**46607**
				Robinson Tspt			0		**0**	**46607**
Ohutu Stream										**46607**
		31/03/2012	61429 (EBOP's)	Fletcher Challenge Forests					**0**	**46607**
									0	**46607**
	Galatea Road Bridge	31/08/2008	05 0706	Waiotahi					**0**	**46607**
	Galatea Road Bridge	31/08/2008	05 0706	Waiotahi					**0**	**46607**
	Troutbeck Rd	30/06/2004	05 0851	Robinsons Transport	0				**0**	**46607**
	Troutbeck Rd	30/06/2004	06 0300	Robinsons Transport	0				**0**	**46607**
Mangamate Stream										**46607**
	Troutbeck Rd	31/03/2012	61429 (EBOP's)	Kaingaroa Roading	4103				**4103**	**50710**
Kopuriki Stm				Kaingaroa Timberlands				3000	**3000**	**53710**
	Blacks	31/08/2008	06 0023	Waiotahi					**0**	**53710**
	Galatea Road Bridge	31/08/2008	61437	Edelsten	0	0	0	0	**0**	**53710**
Waikokopu Stm										**53710**
	Galatea Road	30/06/2003	05 0706	Waiotahi					**0**	**53710**
Waihui Stream										**53710**
	Ruatahuna	30/04/2000	06 0443	Waiotahi					**0**	**53710**
Waioeka River										**53710**
	S/Highway 2 Bridge		61321 (EBOP's)	E·B·O·P/M Kennon			0	0	**0**	**53710**
	S/Highway 2 Bridge		61321 (EBOP's)	E·B·O·P/Works Infrastructure			1010	150	**1160**	**54870**
	S/Highway 2 Bridge		61321 (EBOP's)	E·B·O·P/Waiotahi	9440	82	1041	0	**10563**	**65433**
	Petersons (Robbie's)		51130	E·B·O·P/Waiotahi		4794		528	**5322**	**70755**
	S/Highway 2 Bridge		61321 (EBOP's)	E.B.O.P/Eastern Bay Concrete		120	0		**120**	**70875**
	S/Highway 2 Bridge		61321 (EBOP's)	E·B·O·P					**0**	**70875**
	B Smith		61321 (EBOP's)	E·B·O·P			348		**348**	**71223**
	Youngs		61321 (EBOP's)	E·B·O·P/Waiotahi	186	4351	4287	2630	**11454**	**82677**
	Browns		61321 (EBOP's)	E·B·O·P					**0**	**82677**
	Browns Pipeline		61321 (EBOP's)	E·B·O·P					**0**	**82677**

	Graemes Bridge		61321 (EBOP's)	EBOP - ORS					**0**	**82677**
	Wairata		61321 (EBOP's)	EBOP - ORS					**0**	**82677**
Otara River										**82677**
	Scheme Area									**82677**
	Gows Road		61322 (EBOP's)	E.B.O.P - ORS/EBC	180				**180**	**82857**
	Carters		61322 (EBOP's)	E.B.O.P - ORS/EBC	0			60	**60**	**82917**
	Goult		61322 (EBOP's)	E·B·O·P - ORS					**0**	**82917**
	Lockhead		61322 (EBOP's)	E·B·O·P-Waiotahi Contractors					**0**	**82917**
	EBA5		61322 (EBOP's)	E·B·O·P-Works Infrastructure	0	0			**0**	**82917**
	Carters		61322 (EBOP's)	E·B·O·P-Waiotahi Contractors	1165				**1165**	**84082**
	Carters		61322 (EBOP's)	E·B·O·P-M Kennon	130		0	699	**829**	**84911**
	Carters		61322 (EBOP's)	E·B·O·P/Eastern Bay concrete			150		**150**	**85061**
	Kellers		61322 (EBOP's)	E·B·O·P - ORS					**0**	**85061**
	Kellers		61322 (EBOP's)	E·B·O·P - ORS					**0**	**85061**
	Kellers		61322 (EBOP's)	E·B·O·P - ORS					**0**	**85061**
	M Brown		61322 (EBOP's)	E·B·O·P - ORS					**0**	**85061**
	Watsons		61322 (EBOP's)	E·B·O·P - ORS					**0**	**85061**
Waiotahi River										**85061**
	Youngs		50722	Wilson Brothers	0	0	0	0	**0**	**85061**
East Coast Rivers			50922	Works Infratructure	0	0			**0**	**85061**
Waiaua River										
Hawai River										**85061**
	SH35 Bridge								**0**	**85061**
Raukokore River										**85061**
	Raukokore River	31/07/2011	51035-0	Waiotahi Contractors					**0**	**85061**
										85061
Reg. River Gravel Management Plan Extractions										**85061**
			Allocation #							**85061**
										85061
Hikurangi Stream									**0**	**85061**
	R Armstongs		04/34	Fletcher Challenge Forests					**0**	**85061**
Waioeka River									**0**	**85061**
	B Smiths (Gorge)		04/25	Waiotahi Contractors					**0**	**85061**
	Anstis (Opo Dept)		Apr-48	Waiotahi Contractors				2945	**2945**	**88006**
Whangaparaoa									**0**	**88006**
	Waititi								**0**	**88006**
Waimana River									**0**	**88006**
	Clarkes		03/18	Works Opotiki					**0**	**88006**
	L. Browns		04/29	A Rust Contracting	0	0	0	0	**0**	**88006**
Waiaua River									**0**	**88006**
Motu River			4-Mar	Motu Metal Crushing Ltd	0	0	0	0	**0**	**88006**
Otara River										**88006**
	Turaetoko								**0**	**88006**
										88006
				Total	**29595**	**22415**	**14011**	**21985**	**88006**	**88006**

SHINGLE EXTRACTION BAY OF PLENTY 2005/2006

River	Location/Site	Expiry	Consent or Allocation No.	Contractor	Shingle Extracted				Subtotal	Cumulative Total
					Sep-05	Dec-05	Mar-06	Jun-06		
Whakatane River										
	Below Pekatahi									
	Blacks		61602	Tracks	1175	631	556	113	**2475**	**2475**
	Sykes		50704	Waiotahi	6562	1487	0	0	**8049**	**10524**
	Boheemans		50704	Waiotahi	0	0	0	0	**0**	**10524**
	Pekatahi To Ruatoki Bridge									**10524**
	Lyfords		50704	Waiotahi	0	0	5530	0	**5530**	**16054**
	Reids Rd		50704	Waiotahi	0	0	0	0	**0**	**16054**
	Richardsons		50704	Waiotahi	0	0	0	0	**0**	**16054**
	Mahurihuri		50704	Waiotahi	0	0	0	0	**0**	**16054**
	Above Ruatoki Bridge									**16054**
	Te Kaiti Trust		50704	Waiotahi	0	0	0	0	**0**	**16054**
	Ngati Rongo		50704	Waiotahi	0	0	0	0	**0**	**16054**
	Opurana		50704	Waiotahi	0	0	0	0	**0**	**16054**
	Limeworks		50704	Waiotahi	0	0	0	0	**0**	**16054**
	Waikirikiri		50704	Waiotahi	0	0	0	0	**0**	**16054**
Waimana River										**16054**
	Below Waimana West Bridge									**16054**
	Waimana Gorge, Dunstans 2		50704	Waiotahi	0	0	0	0	**0**	**16054**
	Dunstans 1		50704	Waiotahi	0	0	0	0	**0**	**16054**
	Wardlaw Rd		50721	Wilson Brothers	0	0	0	0	**0**	**16054**
	Above Waimana West Bridge									**16054**
	Takaos		60525 (EBOP's)	Wilson Brothers	0	0	0	183	**183**	**16237**
	Flemings/Clarks / Takao 1	24/06/2003	50130	Waiotahi	1203	0	0	0	**1203**	**17440**
	Above Waimana East Bridge									**17440**
	Tanatana/Rokuraku (Bells Rd)		50721	Wilson Bros	0	0	0	0	**0**	**17440**
	Takao 2		60525	Waiotahi	497	0	0	0	**497**	**17937**
	Lowes/Mexteds		50721	Wilson Brothers	2662	2373	1765	0	**6800**	**24737**
	Lowes/Mexteds		60525 (EBOP's)	Waiotahi	0	0	0	0	**0**	**24737**
	DeGroots1			Waiotahi	9240	0	0	0	**9240**	**33977**
	DeGroots2			Waiotahi	0	0	0	0	**0**	**33977**
	Len Browns		60525 (EBOP's)	Waiotahi	0	0	0	0	**0**	**33977**
Horomanga River									**0**	**33977**
	LOWER - Galatea Rd End 0.6 to 3.2 Km	31/03/2012	61429 (EBOP's)	Wilsom Bros	0	0	0	0	**0**	**33977**
				Kaingaroa Timberlands	0	0	0	0	**0**	**33977**
				Kaingaroa Roading	0	0	0	0	**0**	**33977**
				Robinson Tspt	100	0	0	0	**100**	**34077**
	MIDDLE - to Ohutu Outlet 3.2 to 5.7 Km	31/03/2012	61429 (EBOP's)	Wilson Bros	0	0	0	0	**0**	**34077**
				Kaingaroa Timberlands	0	0	0	0	**0**	**34077**
				Kaingaroa Roading	0	0	0	120	**120**	**34197**
				Robinson Tspt	0	0	0	0	**0**	**34197**
									0	**34197**
	TOP - downstream Troutbeck Rd 5.7 to 7.3 Km	31/03/2012	61429 (EBOP's)	Wilsom Bros	0	0	0	0	**0**	**34197**
				Kaingaroa Timberlands	0	0	0	4805	**4805**	**39002**
				Kaingaroa Roading	0	4121	1675	1311	**7107**	**46109**
				Robinson Tspt	0	0	0	0	**0**	**46109**
Ohutu Stream									**0**	**46109**
		31/03/2012	61429 (EBOP's)	Fletcher Challenge Forests	0	0	0	0	**0**	**46109**
	Galatea Road Bridge	31/08/2008	05 0706	Waiotahi	0	0	0	0	**0**	**46109**
	Galatea Road Bridge	31/08/2008	05 0706	Waiotahi	0	0	0	0	**0**	**46109**
	Troutbeck Rd	31/03/2012	61429	Kaingaroa Roading	1055	0	0	0	**1055**	**47164**
	Troutbeck Rd	30/06/2004	05 0851	Robinsons Transport	0	0	0	0	**0**	**47164**
	Troutbeck Rd	30/06/2004	06 0300	Robinsons Transport	0	0	0	0	**0**	**47164**
Mangamate Stream										**47164**
	Troutbeck Rd	31/03/2012	61429 (EBOP's)	Kaingaroa Timberlands	6000	0	0	0	**6000**	**53164**
Kopuriki Stm				Kaingaroa Timberlands	0	0	0	0	**0**	**53164**
	Blacks	31/08/2008	06 0023	Waiotahi	0	0	0	0	**0**	**53164**
	Galatea Road Bridge	31/08/2008	61437	Edelsten	0	0	450	0	**450**	**53614**
Waikokopu Stm										**53614**
	Galatea Road	30/06/2003	05 0706	Waiotahi	0	0	0	0	**0**	**53614**
Waihui Stream										**53614**
	Ruatahuna	30/04/2000	06 0443	Waiotahi	0	0	0	0	**0**	**53614**
Waioeka River										**53614**
	S/Highway 2 Bridge		61321 (EBOP's)	E·B·O·P/M Kennon	0	0	0	0	**0**	**53614**
	S/Highway 2 Bridge		61321 (EBOP's)	E·B·O·P/Works Infrastructure	200	0	0	206	**406**	**54020**
	S/Highway 2 Bridge		61321 (EBOP's)	E·B·O·P/Waiotahi	204	0	0	0	**204**	**54224**
	Petersons (Robbie's)		51130	E·B·O·P/Waiotahi	1055	192	0	0	**1247**	**55471**
	S/Highway 2 Bridge		61321 (EBOP's)	E.B.O.P/Eastern Bay Concrete	0	0	0	0	**0**	**55471**
	S/Highway 2 Bridge		61321 (EBOP's)	E·B·O·P	0	0	0	0	**0**	**55471**
	B Smith		61321 (EBOP's)	E·B·O·P	927	5290	1749	0	**7966**	**63437**
	Youngs		61321 (EBOP's)	E·B·O·P/Waiotahi	0	0	1754	4634	**6388**	**69825**
	Mikes				0	3403	0	0	**3403**	**73228**

	Youngs		61322 (EBOP's)	E B O P / Works Infrastructure	0	0	650	0	**650**	**73878**
	Riverloch		61321 (EBOP's)	E·B·O·P/Waiotahi	518	0	951	0	**1469**	**75347**
	Browns		61321 (EBOP's)	E·B·O·P	0	0	0	0	**0**	**75347**
	Browns Pipeline		61321 (EBOP's)	E·B·O·P	0	0	0	0	**0**	**75347**
	Graemes Bridge		61321 (EBOP's)	EBOP - ORS	0	0	0	0	**0**	**75347**
	Wairata		61321 (EBOP's)	EBOP - ORS	750	0	0	0	**750**	**76097**
Otara River										**76097**
	Scheme Area									**76097**
	Gows Road		61322 (EBOP's)	E.B.O.P - ORS/EBC	150	120	130	100	**500**	**76597**
	Carters		61322 (EBOP's)	E.B.O.P - ORS/EBC	0	0	0	0	**0**	**76597**
	Goult		61322 (EBOP's)	E·B·O·P - ORS	0	0	0	0	**0**	**76597**
	Lockhead		61322 (EBOP's)	E·B·O·P-Waiotahi Contractors	0	0	0	0	**0**	**76597**
	EBA5		61322 (EBOP's)	E·B·O·P-Works Infrastructure	0	0	0	0	**0**	**76597**
	Carters		61322 (EBOP's)	E·B·O·P-Waiotahi Contractors	0	1176	36	4828	**6040**	**82637**
	Carters		61322 (EBOP's)	E·B·O·P-M Kennon	80	166	0	0	**246**	**82883**
	Carters		61322 (EBOP's)	E·B·O·P/Eastern Bay concrete	0	0	0	0	**0**	**82883**
	Carters		61323 (EBOP's)	E·B·O·P-Works Infrastructure	0	0	0	135	**135**	**83018**
	Kellers		61322 (EBOP's)	E·B·O·P - Works Infractructure	0	72	0	0	**72**	**83090**
	Kellers		61322 (EBOP's)	E·B·O·P - ORS	0	0	0	0	**0**	**83090**
	Kellers		61322 (EBOP's)	E·B·O·P - ORS	0	0	0	0	**0**	**83090**
	M Brown		61322 (EBOP's)	E·B·O·P - ORS	0	0	0	0	**0**	**83090**
	Watsons		61322 (EBOP's)	E·B·O·P - ORS					**0**	**83090**
Waiotahi River										**83090**
	Youngs		50722	Wilson Brothers	0	0	0	0	**0**	**83090**
	Addisons		50722	Wilson Brothers	2095	981	248	2078	**5402**	**88492**
East Coast Rivers			50922	Works Infratructure	0	0	0	0	**0**	**88492**
Waiaua River							0		**0**	**88492**
Wairata River				E·B·O·P - Works Infractructure	0	0	300	0	**300**	**88792**
Hawai River										**88792**
	SH35 Bridge				0	0	0	0	**0**	**88792**
Raukokore River										**88792**
	Raukokore River	31/07/2011	51035-0	Waiotahi Contractors	0	0	0	0	**0**	**88792**
										88792
Reg. River Gravel Management Plan Extractions										**88792**
			Allocation #							**88792**
										88792
Hikurangi Stream										**88792**
	R Armstongs		04/34	Fletcher Challenge Forests	0	0	0	0	**0**	**88792**
Waioeka River										**88792**
	B Smiths (Gorge)		04/25	Waiotahi Contractors	0	0	0	0	**0**	**88792**
	Anstis (Opo Dept)		Apr-48	Waiotahi Contractors	120	0	272	0	**392**	**89184**
Whangaparaoa									**0**	**89184**
	Waititi				0	0	0	0	**0**	**89184**
Waimana River									**0**	**89184**
	Clarkes		03/18	Works Opotiki	0	0	0	0	**0**	**89184**
	L. Browns		04/29	A Rust Contracting	0	0	0	0	**0**	**89184**
Waiaua River				Works Infratructure	0	0	120	0	**120**	**89304**
Motu River			19-Oct	Works Infratructure	50000	0	0	0	**50000**	**139304**
Motu River			2/21/06	K and M Earthworks	0	0	1000	0	**1000**	**140304**
Otara River					0	0	0	0	**0**	**140304**
Raukokore				Works Infratructure	0	0	983	0	**983**	**141287**
	Turaetoko				0	0	0	0	**0**	**141287**
										141287
				Total	**84593**	**20012**	**18169**	**18513**	**141287**	**141287**

2.4 Aerial Photography

Regular aerial photography enables visual evaluation of gravel accumulations and identification of areas where extraction can be directed to. A regular programme of aerial photography is undertaken on the river systems.

2.5 Benchmark (BM) Locations

The horizontal location of each of the benchmarks does not need to be accurately defined for the use of the volume calculation command in Hilltop, as the process of determining the volumes between cross-sections only uses the cross-sectional area and the channel distance between each cross-section. Locating the benchmarks is, however, important for other river management work.

There are a total of 746 benchmarks (more or less) in the cross-section survey programme. Most benchmarks were established prior to 1996. Most rivers' benchmarks have now been located by GPS. Some benchmarks that are difficult to

locate because of tree cover have not been precisely located. A few benchmarks are replaced each year through loss or damage, and require relocating. New benchmarks on the Kopuriki, Waikokopu and Waihua streams have not yet been located by GPS.

In the past, the GPS (Global Positioning System) unit has been used to locate the benchmarks to a position accuracy of within 2-4 metres horizontally. More recently, the RTK (Real Time Kinematic) GPS unit has been used to relocate existing benchmarks to achieve survey grade results, i.e. centimetre accuracy.

Chapter 3: Results

3.1 Introduction

The data collected for this report allows a comparison with the previously collected and the baseline information. Environment Bay of Plenty can now develop a methodology to allocate gravel extraction in each resource area. The following pages summarise the situation that exists at present in each of the region's river/stream systems.

The floods in July 1998 and the more recent flood in July 2004 have caused significant changes to gravel volumes and will affect the management of gravel for several years. The analysis has been more complex than in the past because of the need to separate out changes in gravel volumes from deposition of silt. For the wider rivers with obvious floodplains, this has been done by defining the limits of the main channel (the "design channel"), and running the analysis separately for the full channel width as well as the active channel width. Material within the active channel limits is assumed to be predominantly gravel, whereas material outside these limits is assumed to be silt or sand.

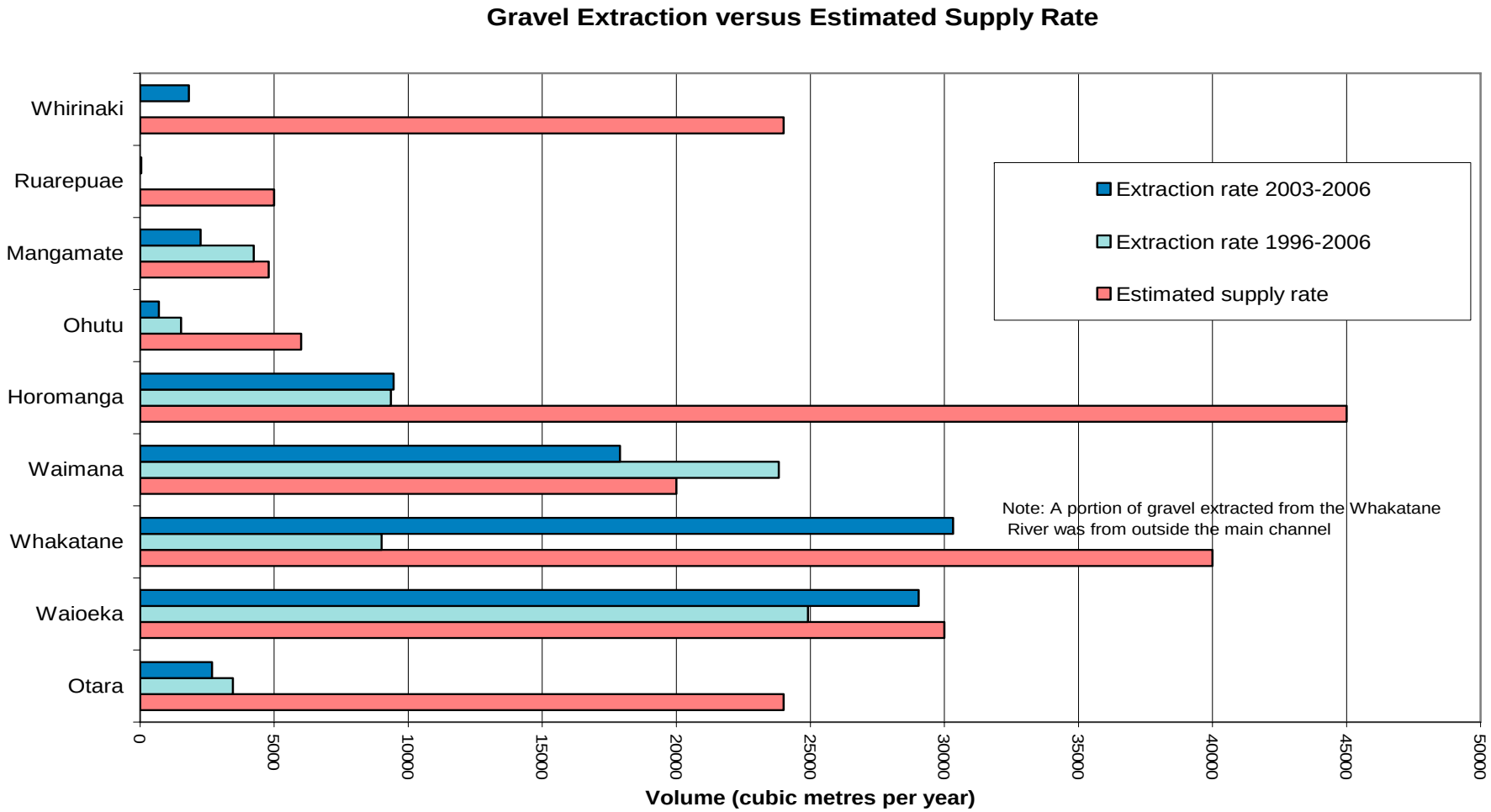
Table 3.1 Comparison of Riverbed Volume Changes between the reports 1998/99, 1999/2000, 2000-2002, and 2002-2006.

River	Floodplain deposition (m^3) (mainly silt and sand)							Active chanel change (m^3) (mainly gravel)						
	1998/99	1999/00	2000/02	2002/03	2003/04	2004/05	2005/06	1998/99	1999/00	2000/02	2002/03	2003/04	2004/05	2005/06
Otara	204,500	310,800	---	---	189,000	---	---	57,600	83,400	---	---	139,200	---	---
Waioeka	510,000	162,200	---	---	160,900	---	---	2,500	6,000	---	---	14,900	---	---
Waimana	493,000	65,000	60,000	---	-83,000	184,900	-3,700	3,000	-165,000	-47,300	---	-10,200	-43,100	7,400
Whakatane from Treatment Plant to Pekatahi (XS15 - XS25)	141,200	---	---	23,000	65,000	---	---	40,700	---	---	30,000	1,300	---	---
Whakatane above Pekatahi (XS25a – XS44)	300,800	19,300	-2,600	-61,400	123,000	---	-38.700	18,600	40,300	78,300	19,000	-56,400	---	125,600

During the 1998 floods, an estimated (net) 1,900,000m^3 of sediment was deposited on the floodplains of the Whakatane-Waimana and Waioeka-Otara schemes, the majority of which was sand and silt sized particles. But it is evident from the surveys taken in between the years 1999 and 2000 that there has actually been a loss of this sediment in the Whakatane-Waimana scheme and to a lesser extent in the Waioeka

floodplain whilst the Otara River sees continuing deposition on its floodplains due to settlement of the silt (refer Table 3.1).

Figure 3.1 shows estimates of average gravel supply rates and short and medium term (2yr and 10yr) extraction rates for many of the Bay of Plenty rivers. Note that these are indicative estimates only and should be revised as more information becomes available. Gravel supply will vary greatly from year to year.


Gravel Extraction versus Estimated Supply Rate
Whirinaki
Ruarepuae
Mangamate
Ohutu
Horomanga
Waimana
Whakatane
Waioeka
Otara
Extraction rate 2003-2006
Extraction rate 1996-2006
Estimated supply rate
Note: A portion of gravel extracted from the Whakatane River was from outside the main channel
0
5000
10000
15000
20000
25000
30000
35000
40000
45000
50000
Volume (cubic metres per year)

3.2 Otara River

The most recent survey on the Otara River has been completed in January 2004.

A baseline survey was done in 1993 with resurveys in January 1996, October 1998 and July 2000. A comparison has also been made with surveys in 1966 and 1980, although some interpretation is required when assessing these older surveys which may not have been in exactly the same place as more recent surveys.

The volume analysis has been split into a "design width" (which attempts to describe the changes in gravel volume in the main river channel), and the full surveyed width, (which includes changes of the berms that are more likely to contain a large proportion of silt and sand). The gravel/sand interface across and down the river will change with time, but the comparison is still useful.

Full width analysis:

2000-2004:

For the full width, the 2004 survey shows that a total volume of **328,200m^3 were deposited** since the previous survey in 2000. Note that this period covers the floods in October 2003. The largest deposition occurred again in the reach of cross-sections 31 and 32, but generally the volume gains were spread relatively evenly over the entire river reach analysed.

1996-1998-2000:

The deposition between October 1998 and August 2000 was around one and a half (1.5) times as high as the deposition between March 96 and October 98 (including the floods of July 1998) at 394,000 m^3. The major sites of deposition were sections 31-36, where around 293,000 m^3 of material was deposited. The most significant effect of this deposition is likely to be a reduced floodway capacity of the river between sections 31 – 36, although the propensity for channels to meander may also increase. Floodway capacity has been examined as part of the Floodplain Management Plan for the Waioeka-Otara scheme. (Cross-sections 12 and 31 prior to 1993 were left out of the analysis, as their locations do not appear to correspond with more recent cross-sections).

The full width analysis indicates there has been an overall increase in bed levels at almost every cross-section since 1966, with an average rate of deposition at 88,000 m^3 per year.

Design width analysis:

2000-2004:

The design width analysis for the 2004 survey shows that a total volume of **139,200m^3 were gained** within the channel since 2000. This is a significantly larger number than between previous surveys. Some losses occurred at the upstream end (cross-sections 34 and 35 and 37 to 40) totalling some 33,000m^3, but these were by far outweighed by the gains further downstream.

1993-1996-1998-2000:

Between October 1998 and July 2000, the design width analysis shows that net deposition within the normal channel and immediate fairway has increased to about

83,400 m^3 as compared to 57,600 m^3 between 1996 and 1998. Between sections 16 to 26, there has been a marked increase in bed level. The most significant gain is at section 34, where 24,910 m^3 of gravel was deposited between 1998 and 2000.

Since 1993, there seems to be a trend of increasing net deposition of gravel in the river. In general, a loss of gravel has occurred above section 34, with gains at most sections below section 34. A net deposition of one million m^3 on the floodplain was observed, with only 281,400 m^3 of this within the design channel main fairway (1993-2004). This shows that a large proportion of the deposition that has occurred is outside the main fairway, on the floodplain between the stopbanks.

Gravel extraction and recommendation:

Little extraction is carried out on this river. The amount of gravel extracted was 1,895m^3 during 2002/03, 1,008m^3 during 2003/04, 2,384m^3 during 2004/05, and 6993m^3 during 2005/06. Initially, some 2,200m^3 per year averaged over the decade ended in 1999 was estimated. The average extraction for the last decade (1996 to 2006) has was close to 2,700m^3 per year.

The Operations and Rural Services Department of Environment Bay of Plenty has moved to increase extraction on this river by obtaining resource consent to remove gravel at specific sites. It may also be necessary to encourage removal of silt and sand (for use as fill) from the main fairway, which has been done recently along parts of the river where stopbank upgrades were carried out.

The long-term analysis put the average net supply rate of deposited material into this system to around 55,600 m^3 annually, although only a portion is gravel. In 1996 to 2000, this portion was around 20%. Analysis of data collected since 1993 shows that the gravel supply rate is expected to average 25,600m^3 per year.

With a small extraction rate and substantial deposition on the floodplain and in the main channel over the past years, it is recommended that extraction should be increased in this river to keep the river at its recommended bed level. However, the lack of demand for gravel from this river (poor quality and remoteness of sites) proves to make a sound gravel management difficult.

3.3 Waioeka River

The most recent survey on the Waioeka River was completed in May 2004.

A baseline survey was completed in October 1993, with resurveys carried out in January 1996, September 1998 and September 2000. A comparison has also been made with surveys in 1966 and 1980, although some interpretation is required when assessing these older surveys that may not have been in exactly the same place as more recent surveys.

Full width analysis:

2000-2004:

The full width analysis for the 2004 survey shows a total **volume gain 175,800m^3**. The bulk of this gain occurred at cross-sections 9 and 10 (70,600m^3 and 79,800m^3), with some more gains in the reach downstream of cross-section 13, and some losses in the reach upstream of cross-section 13.

1993-1996-1998-2000:

Over the full width of the sections, a net increase in volume of material stored of 512,000m^3 has been calculated between 1996 and 1998 and 182,000 m^3 has been calculated between 1998 and 2000. From the 2000 survey, gains are evident at all cross-sections above the confluence with the Otara River except at cross-sections 3, 8, 11 to13, and 18 to 19. The largest gains are at cross sections 19 and 20, with estimated gains in the region of 80 – 90,000 m^3. A large portion of this gain is silt and sand sized particles. The largest loss is at cross-section 12 with an estimated 20,000 m^3 of material lost.

The net increase in volume of material over the full width of the river between 1996 and 1998 includes an increase of 100,000m^3 at section 19. The total material stored is larger than that of 1999/2000. Most of it is the contribution from the flood of July 1998. Between 1993 and 1996 there was a net aggradation of some 24,000m^3, mostly between cross-sections 10 and 16.

Design width analysis:

2000-2004:

The 2004 analysis for the design width shows a total **volume gain of 14,900m^3**. The losses in the upper reach (46,200m3 between cross-sections 14 and 20) were outweighed by the gains in the lower reach (cross-section 2 and 4 to 13).

1998-2000:

Between September 1998 and September 2000, within the design width of the river fairway there were gains amounting to only 5,980 m^3. It is worth noting that the reach between the river mouth and section 4 were not resurveyed in 2000 and therefore is not inclusive of the value stated above. The largest loss was noted at cross-section 12, where scouring of the bed has been observed. Conversely, the bed level has aggraded at cross-sections 9-10. Sections 15 to 17 have all experienced some right bank erosion. The thalweg level has decreased by some 2m at cross-section 7, but has increased by around 1.5m at cross-section 9. The small channel volume change indicates that this river system was fairly stable at the time.

The large difference between the deposition on the full width (175,800m^3) and the deposition within the channel (14,900m^3) suggests that most of the deposition is made up of silt deposited on the floodplain.

Gravel extractions and recommendations:

The amount of gravel extracted was 14,557m^3 in 2002/03, 19.937m^3 in 2003/04, 31,912m^3 in 2004/05, and 22,875m^3 in 2005/06.

A moderate amount of extraction, some 29,000m^3 on average over the last ten years, is taken from the Waioeka River each year. 45,000m^3 were removed in 1997/1998, 36,000m^3 in 1998/99, 25,440m^3 in 1999/2000, 19,086m^3 in 2000/01, and 24,523m^3 in 2002/03.

The Operations and Rural Services department of Environment Bay of Plenty has moved to control extraction on this river by obtaining resource consent to remove gravel at specific sites. The purpose is to prevent potential flooding in some areas (although the river has widened in some places) and decrease the stability of the river meander pattern that may occur due to continued aggradation of the river bed. Gravel extraction in appropriate locations can reduce the flood risk and help to

stabilise the river. The main deposition within the fairway in between 1996 and 1998 has been in the stretch from cross-section 10 to cross-section 14 and at cross-sections 7 and 8, whereas, in 1999 to 2000, the main deposition within the fairway has been at cross-sections 9 to 10 and 14 to 15.

Over the longer term, comparisons with surveys in 1966 and 1980 show further deposition of some 350,000m^3, mostly since 1980 (although diversion cuts in the 1970's may affect the validity of the 1966 calculations). All cross-sections except 2, 12, 13, and 20 have aggraded since 1966, particularly 5, 6, 7, 14 and 15. Gravel extraction over the last 10 years (29,000m^3 per year) is very similar to the estimated long term supply rate of 30,000m^3 per year in this river (inclusive of the large silt deposition in 1998).

No particular need to change typical gravel extraction practices on this river is evident from the analysis, even following the major flood in 1998. However, a catchment condition survey carried out after the flood showed there was considerable damage caused to the upper Waioeka catchment by this storm. Therefore, it is likely that the supply rate will increase over the next decade and should be carefully monitored and managed. Visual inspections of the Waioeka Gorge suggest some aggradation; new monitoring cross-sections have been established here but they have not been resurveyed as yet.

Sediment build-up on the berms is of more concern for flood capacity. In the first July 1998 flood peak, overtopping of rural stopbanks (between section 16 and 17) at below design flood flows indicate that bed and/or berm levels may have increased in this reach in recent years.

3.4 Waimana River

Since the last report, the Waimana River has been resurveyed in December 2003, September 2004 (after the floods in July that year), and in January 2006.

The analysis has tried to separate out changes in gravel volumes and silt deposition by dividing each cross-section into the "active channel" and the wider floodplain since 1992.

Full Width Analysis:

1998-1999:

Over the full floodplain width, the overall loss for 1998/1999 was calculated to be 100,000 m^3. Since this is smaller than the design channel losses, one can assume that there has been some build up of silt along the floodplain. This amounted to aggradation on the floodplain to the order of 62,700 m^3. The major losses (of around 40,000 m^3 and 60,000 m^3) were found at sections 29 and 30, where there had been major gains in 1996/1998. It can be argued that the river has returned these sections to their equilibrium levels. The previous analysis (1996 to 1998) showed a net aggradation of some 496,000 m^3 of material, which was attributed to a build up of silt along the floodplain. The river system appears to have naturally balanced itself.

1999-2001:

Over the full width including the floodplain, the 2001 survey showed an overall volume gain of 12,500m^3. Taking into the account the losses in the active channel this suggests that there has been a build up on the floodplains of 60,000m^3. Major

losses were observed at cross-sections 30 to 32 (50,000m^3), and cross-sections 4 to 6 (41,500m^3). (Some of the cross-sections had an incomplete survey done on the floodplains. Therefore these cross-sections were limited to the active channel widths for the volume analysis.)

2001-2003:

Looking at the full width of the surveyed cross-sections, including the floodplain, a total **volume loss of 93,000m^3** was observed in the period from July 2001 to December 2003. Major volume losses at cross-sections 22 to 24 and 27 to 32 outweighed some gains in the gorge at cross-sections 2 to 8, and cross-sections 17, 25 and 26.

2003-2004:

The following survey after the floods in July 2004 showed that a total volume of **142,000m^3 was gained** over the full width in the period from December 2003 to September 2004. Most of this gain occurred at cross-sections 2 and 3, 6a to 17, 20 to 22, 28 to 30, and 33. Some losses occurred at cross-sections 4 and 5, 18 and 19, 23 to 27, and 31. The figures that were calculated for the active channel and the full width for this period suggest that the floods in July 2004 have deposited 99,000m^3 of sediment onto the floodplain, most of which can be expected to be fine sediment rather than gravel.

2004-2006:

Between the September 2004 and February 2006 surveys, only **3,700m^3 of volume were gained** over the full width. Some losses in the upper reach at cross-sections 27, 28, 30 and 31 were outweighed by volume gains at cross-sections 6, 8 and 9, and between cross-sections 17 and 26.

Active Channel Analysis:

1992-1996:

In the active channel, between 1992 and 1996, the major losses were in the gorge, below section 10, where some 120,000m^3 were lost, and between sections 20 and 30, where some 85,000m^3 were lost. 51,000m^3 were gained between sections 13 and 19 and 49,000m^3 were gained between sections 30 and 32. Above cross-section 13, 64,000m^3 was lost between 1992 and 1994, but 81,000m^3 were gained between 1994 and 1996. The largest losses were at cross-sections 6a, 7, 20 and 29, while the largest gains were at cross-sections 14, 15 and 30-32.

1996-1998:

In the active channel, between 1996 and 1998, the net bed change over the whole length surveyed was a tiny 3,000m^3 (aggradation). The major losses (bank erosion) observed at cross-section 3, 4, 5, 23, 25, 29, 30, and 31 were entirely compensated for by a rise in level, particularly at cross-section 1, 6a, 19, 20, 26, 27, 28, 32, and 33. Relatively small cross-section changes were observed between cross-section 7 and 16 and a bank erosion of about 60m wide was observed at cross-section 3.

1998-1999:

From the analysis of the river active channel changes between 1998 and 1999, it was observed that there had been a large decrease in the river channel volume, amounting to a net loss of 165,000 m^3 of material. Most of this degradation is

centred on the upper reach between cross sections 29-32. There was bank erosion at cross-sections 7, 30, 31, 32 and 33 and a decrease in bed level at cross-sections 10a and 14. Conversely, bed aggradation was observed at cross-section 18 and 19. Sections 22 and 23 experienced a build up of gravel on the left bank and a loss on the right bank, suggesting a small change beginning in the river meandering pattern. There was a large amount of bank erosion at cross-section 29, which was somewhat tempered by an increase in the bed level. The large losses in the upper reaches of the river suggest that the excess of gravel that was apparent in 1998 has moved downstream.

1999-2001:

The analysis of the 2001 survey shows that a total volume of 47,000m^3 has been lost in the active channel since the previous survey in 1999. Again, losses are centred around cross-sections 27 to 32 where a total volume of 78,500m^3 was lost. Bed levels have dropped in this reach too, and bank erosion seems to be an ongoing process. An estimated volume of 212,500m^3 was eroded from the banks in this reach. 12,000m^3 were lost at cross-sections 23 to 25, and 16,000m^3 were lost just above the confluence into the Whakatane River at cross-sections 1 to 6 with the river degrading in this lower reach. Bank erosion is also observed at cross-sections 18 and 24. Rising river levels and the highest volume gains were observed between cross-sections 17 and 19.

It is noted that the 2001 survey at cross-section 33 has not been included in any volume analysis as the data suggests there may have been a survey error. Volume analysis at this site has been carried out again from the 2003 survey onwards.

Also, the 2001 surveys at cross-sections 13 and 29 were incomplete and therefore have been omitted from the analysis. To still be able to get volume figures at and around these cross-sections it has been assumed that the change in cross-sectional area was zero and the volumes have been calculated from this assumption.

2001-2003:

In the active channel, the December 2003 survey showed an overall **volume loss of 10,000m^3** over the entire reach. The bulk of these losses occurred in the upper reach at cross-sections 27 to 32, and also at cross-sections 22 to 24 and 11 to 12. Contrary to earlier surveys, the reach through the gorge accumulated volume between cross-sections 1 to 8 and at cross-section 10.

2003-2004:

The next survey was completed in September 2004 after the extensive floods in July 2004. Volume analysis shows that over the period from December 2003 to September 2004, **43,000m^3 of volume were lost** in the active channel over the entire reach. It can be expected that most of this was shifted during the floods. Most of this loss occurred at cross-sections 4 and 5, 18 and 19, 23 to 27, and 31 and 32. Volume gains occurred at cross-sections 2 and 3, 6a and 7, 11 and 12, 20 and 21, 28 and 29, and 33. At cross-section 4 erosion has been taking place on the right bank and at cross-sections 24 and 31 on the left bank. Extraction was carried out at the time of survey at cross-section 18.

2004-2006:

During the following period from September 2004 to February 2006, some **7,400m^3 of volume were gained** overall in the active channel, with some significant gains

centred around cross-sections 18 and 19 (33,300m^3). Losses occurred at 30 and 31 (34,500m^3).

Gravel Extraction and Recommendations:

Moderate extraction is carried out on this river: 33,890m^3 in 1996/97, 16,400m^3 in 1997/98, 10,580m^3 in 1998/99, 7,530 m^3 in 1999/2000, 2,030 m^3 in 2000/01, 6,934 m^3 in 2001/02, 24,571 m^3 in 2002/03, 30,028m^3 in 2003/04, 23,533m^3 in 2004/05, and 17,923m^3 in 2005/06.

Extraction has generally been delicately directed towards specific locations or reaches where it is seen to be beneficial to the system. Desirable bed levels have not yet been defined for this river. A careful assessment of desirable bed levels is needed, over the whole of the river, before any major extraction can be carried out.

An attempt has been made to utilise cross-section surveys from 1964 to gain an understanding of long-term bed level developments. Not all of the 1964 cross-sections match the locations of the current cross-section benchmarks (the locations of the 1964 cross-sections were taken from the original scheme plans), so a comparison of bed levels is limited. However, for most of the cross-sections the match looks reasonable. Generally, there are more cross-sections where degradation has occurred since 1964 than aggrading cross-sections (9:4).

In light of the analysis of the recent surveys, where large material losses and bank erosion were observed between cross-section 27 to 32, it is advisable to limit gravel extraction at the upper reach of the river until further evidence of aggradation is confirmed by survey. It may however be necessary to use a selective combination of extraction and channel reshaping to arrest the degrading processes currently occurring.

Close monitoring will need to continue over the next few years to assess the effects of extraction, the river training works of the Middle Reaches scheme and the effects of the floods in July 1998 and July 2004. Extraction should be discouraged from the gorge until desirable bed levels have been established.

The average gravel extraction rate on this river over the last 10 year is 18,000m^3 per year, whereas the gravel supply rate is estimated to around 20,000 m^3 per year. This indicates this level of extraction is sustainable in the long term. The loss of volume in the active channel should be carefully monitored and extraction adjusted accordingly. Of the estimated net supply rate of gravel into the Waimana River, a considerable throughput is to the Whakatane River. There may be a lag of several years before a wave of gravel passes completely through the system.

3.5 Whakatane River above Pekatahi Bridge

Resurveys of the Upper Whakatane River cross-sections were completed in June 2003, August 2004 and January 2006.

As in previous reports, at cross-sections 25a to 44 the analysis was run on the full width as well as the “active channel” width, where the gravel is assumed to be mainly stored. In the braided reach above cross-section 44 this distinction has not been made as the gravel can potentially be stored throughout the cross-section.

Full width analysis:

1998-2000-2002:

Within the full floodplain width and over the entire reach of the Upper Whakatane River, past NERMN reports have noted an overall volume gain of 55,000m^3 between the 1998 and 2000 survey, and a gain of 92,000m^3 for the period September 2000 to July 2002. The largest volume gains from 2000 to 2002 were at cross-sections 26, 27 (Pekatahi Bridge) and 55.

2002-2003:

The 2003 survey showed that since the 2002 survey there had been a major volume loss of 260,000m^3 over the full floodplain width of the river. The majority of these losses occurred in the braided reach above cross-section 44, where a total of 217,000 m^3 were lost. Volume losses were especially large in the reach between cross-sections 53 and 58. A profile of minimum bed levels shows that the river bed has dropped significantly at cross-sections 47 and 48 just below Ohutu Bridge, at cross-section 54, and at cross-section 56, whereas it has significantly risen only at cross-section 53. The volume losses in the upper parts of this reach may be a result of the 1998 floods, during which large amounts of material were transported from the catchment and deposited in the upper parts of the floodplain. This material now becomes available to be transported further downstream.

2003-2004:

After the massive losses between the 2002 and 2003 surveys, the following survey in August 2004 showed a total **volume gain of 378,000m^3** for the entire reach and the full width (channel and floodplain). Most of these gains occurred in the braided reach from cross-section 45 to 57, with a gain of 87,000m^3 at cross-section 50 alone. Further gains occurred at cross-sections 29 to 33. The major gains can be attributed to sediment deposits during the July 2004 floods. Volume losses occurred again just upstream of Pekatahi Bridge (cross-sections 27 and 28). Note that the volume analysis on the floodplain is based on the 2004 survey (post 2004 flood) and the survey from 1998 (post 1998 flood). The surveys in between those dates were limited to the main channel only since no major changes are expected during times without major flooding. Along section of the minimum bed levels (thalweg line) shows that bed levels have risen in the reach between cross-sections 28 to 30, and at cross-sections 44, 48, 50, 54, and 56 between 2003 and 2004. The bed level has dropped at cross-sections 27, 31, 34, 35, 38, 42, 45 to 47, 51, to 53, 55, and 57.

2004-2006:

The most recent survey from January 2006 shows a **small loss of 16,500m^3** for the entire reach and full width. Gains occurred upstream of Pekatahi Bridge at cross-sections 26 to 28, in the reach between cross-sections 38 to 42and at cross-sections 48, 49 and 51. These gains were outweighed, however, by losses in the reach from cross-section 29 to 33, at cross-sections 43, 45 and 46, and in the upper reach from cross-sections 52 to 57. As for the active channel, the development in this last period up to the most recent survey in 2006 shows the opposite trend to the development in the period before (2003 to 2004). Minimum bed levels have generally risen since 2004 . Exceptions are at cross-sections 29, 33, 44, 54 and 56 where they have fallen.

Active Channel analysis:

1998-2000-2002-2003:

The 2003 survey showed that within the active channel in the reach from cross-section 25a to 44, there has been a volume gain of 19,000m^3 since 2002, compared to gains of 78,000 m^3 from 2000 to 2002, 40,267m^3 from 1998 to 2000, and 18,551m^3 from April to December 1998. In between 1998 and 2000, major gains were made at cross sections 30 and 33b, with around 22,000m^3 and 12,000m^3 deposited respectively. The survey in 2003 showed little volume changes compared to previous years. This is likely to be because of the short period since the previous survey which only had few floods of significant size. Also a stabilisation of gravel movement after the 1998 floods may have started to set in. Minimum bed levels at and near Pekatahi Bridge (cross-sections 26 and 27) have dropped, and so have minimum bed levels in the reach from cross-section 34 to 40.

2003-2004:

The analysis carried out on the August 2004 survey, which was taken immediately after the July 2004 floods, showed a **volume loss of 56,400m^3** since June 2003 in the active channel. Significant losses occurred around the Pekatahi Bridge (cross-sections 27 and 28) and in the upper reach from cross-section 37 to 42, while volume gains occurred in the reach from cross-section 29 to 33. It can be assumed that most of this gravel movement occurred during the floods in July 2004.

2004-2006:

For the active channel, the survey from January 2006 showed an overall **volume gain of 125,600m^3** in the period August 2004 to January 2006 in the reach from cross-sections 25a to 44. The bulk of this gain occurred at cross-sections 26 to 28 (around Pekatahi Bridge) and 38 to 42. Losses occurred in the reach from cross-section 29 to 33 and 43 to 44. This is the opposite of the gravel movement observed in the previous period which covered the July 2004 floods, and it indicates a settling process after these floods.

Extraction and bed levels:

Significant gravel extraction is carried out in the reach above Pekatahi, however, the amount taken is generally decreasing from year to year. Extraction volumes from recent years are listed in Table 3.5.

Period	Extraction volume (m^3)
2005/06	5,530
2004/05	4,600
2003/04	0
2002/03	22,000
2001/02	16,900
2000/01	24,600
1999/00	20,400
1998/99	39,700
1997/98	59,400

Table 3.5 Extraction Volumes Upper Whakatane River (above Pekatahi Bridge)

Average extraction on the whole Whakatane River since 1996 is around 30,000m^3 per year, most of which has been extracted from above the Pekatahi Bridge. A

portion of the extraction has been from outside the "design channel", to allow bed levels to aggrade in some places. Staff undertake regular visual inspections to monitor gravel extraction and in some areas extractions have been suspended.

The long-term extraction rate for this part of the river has decreased from an estimated 72,000m^3 per year over the last 20 years to around 30,000 m^3 over the past ten years (1996-2006). This figure is now lower than the estimated supply rate of around 40,000 m^3 and is hoped to aid the recovery of degrading bed levels.

From 1998 to 2000, at cross-sections 47 and 48 the left side of the bank has eroded heavily, while the right bank has been built up somewhat. Sections 49 and 50 had heavy erosion on their right banks with build up on the left. This suggested the beginning of a change in the rivers meander pattern. In the period 2000 to 2002, again major gains were observed at cross-section 30 with over 12,000m^3, and at cross-sections 28 and 37 with over 9,000m^3 each. A long-section plot of the minimum bed levels confirmed that the river is recovering with significant aggradation in this reach.

For the integrity of the existing bank protection works, an ideal minimum bed level was estimated in 1996 to be between the 1996 minimum bed level at each cross-section and 0.5m higher, i.e. some recovery was desired along most of the river. In places, the ideal bed level may be higher still, so as the recovery target is approached, a careful review of desirable levels will be required (based on balancing the risks of erosion, aggradation and flooding). It has been proposed that until adequate recovery is achieved, extraction should be suspended within the active channel over the reach from approximately 1km upstream of the confluence of the Waimana River to Ruatoki Bridge and also in the lower reaches of the Waimana River.

A comparison of the 2002 survey to the 1996 survey shows that the minimum bed levels have risen by up to one metre over most of the river reach, except at cross-section 49, 54, and 55, where it has dropped by about half a metre. A significant rise of almost four metres occurred at cross-section 47, where the main channel has been filled in over time. Whilst thalweg levels are improving, a significant volume of gravel is required to effect the recovery of bed levels yet.

A further comparison of the 2003 survey to the 1996 survey shows that the 2003 bed level is still below the ideal bed level in several places, including cross-sections 25a to 27, 29, 32, 35 to 39, 43, 49, and 54 to 57.

A comparison of the minimum bed levels of the most recent survey (2006) to the bed levels from 1996, shows that the river is generally recovering (aggrading) and the desired bed levels have been reached for most of the reach. The only exceptions are at cross-sections 35, 38 to 39, 43, and 55 to 56, where the current levels are below the 1996 levels. Possibly a combination of two major floods within this period transporting gravel from the catchments into the river system and a carefully directed gravel management within the system has achieved this desired partial recovery of bed levels in this reach.

<u>Recommendation:</u>

A limit for the active river of around 20-30,000m^3 per year from the existing beaches should continue to aid recovery over the next few years - any extra demand should be met by widening the floodway where appropriate (e.g., ahead of traditional beaches extraction should target where the river floodway is deemed too narrow). There are significant resources available in some areas. Following the large input of gravel in 1998 and 2004, it is likely that some beaches and floodway constrictions

will develop where extraction is desirable, especially above Ruatoki. However, it is also desirable that some throughput to the rest of the river is allowed.

The proposal that until adequate recovery is achieved, extraction should be suspended within the active channel over the reach from approximately 1km upstream of the confluence of the Waimana River to Ruatoki Bridge and also in the lower reaches of the Waimana River, is still valid at this point in time.

There is a diversity of viewpoints on how the gravel in the vicinity of the Holmes bend should be managed. On the one hand there is strong pressure for the extraction in this reach to be ceased until bed levels recover and bank erosion problems are reduced, both through the reach and downstream. Management was adjusted during the 1990's to encourage recovery of bed levels. This viewpoint was again strongly enunciated following significant erosion during the July 1998 floods at the Holmes bend. Factors causing this erosion were several, including undermining caused by lower than optimum bed levels, the extreme nature of the succession of events (cumulatively at least a one in one hundred years event) and severe sharpness of the bend. This recovery has already occurred in the first one kilometre above the confluence with the Waimana River. The recent surveys show levels upstream of this to also be showing some recovery. On the other hand there is a view that the river should remain entrenched to avoid the severe adverse effects forecast from overflows onto the surrounding farmland. This occurred several times in the 1960s, with large scale deposition of silt and debris. Had the river not been entrenched in July 1998 similar adverse effects were likely. It is difficult to exactly balance these opposite objectives. Current river management practices also focus on emulating the natural processes of a river as far as practicable, as these have been shown to often produce the least adverse effects in terms of erosion (although not always, particularly where adverse river misalignments occur due to geological or other factors). In the meantime the policy of allowing some bed recovery should continue, with careful monitoring. Possibly a hydraulic model of the reach which has been produced for the Whakatane/Waimana Floodplain Management Strategy could be used to define optimum bed levels.

3.6 Whakatane River below Pekatahi

The Whakatane River below Pekatahi has been resurveyed in June 2004, just before the big flood in July 2004. To date no survey has been undertaken after these floods.

As in previous reports, the reach between cross-sections 15 to 25, which is assumed to be gravel, has been analysed for both the full width (including the wider floodplain) and the design width.

Full width analysis:

2003-2004:

Over the full width of the cross-sections and the entire reach from Pakatahi to the mouth there has been a total **volume loss of 670,000m^3** between 2003 and 2004 (before the July 04 flood). These losses occurred in the lower reach of the river downstream of cross-section 17, with the bulk of the volume lost below cross-section 7a. Some volume gains occurred at cross-sections 14 to 17 and at cross-section 25. The channel has deepened significantly at cross-sections 2, 3, 3b, 5 to 7, 15, and 24. Bank erosion has taken place on the left bank at cross-sections 1 and 2a.

1998-2003:

The survey in June 2003 shows that over the full width of cross-sections and the entire reach from Pekatahi to the mouth, there has been a substantial volume gain of 303,500m^3 of material since 1998. Major losses were observed near the river mouth between cross-sections 1 and 1a, due to dredging. Further losses occurred at cross-sections 8a, 12, 17a, and 24a and 25. Note that extraction sites are located near cross-sections 17 and 24a. In all other parts of the reach volume gains were observed. Especially in the lower reaches (cross-sections 1a to 7a) this partly compensated for major volume losses between the 1996 and 1998 survey.

The thalweg line of the Lower Whakatane River shows that the river is generally aggrading in the sandy reach from cross-section 13 downstream, except at cross-sections 1, 2b, 2a, and 12 where the invert levels have dropped by up to 1.8 metres at cross-section 2b.

Design width analysis:

2003-2004:

The 2004 survey shows an overall **volume gain of only 1,300m^3** since 2003 within the design channel in the reach between cross-sections 15 to 20. Depositions occurred downstream of Pekatahi Bridge between cross-sections 23a and 25, and at cross-section 18. Losses occurred at cross-sections 16 and 17, and 19 to 23. Note that the survey in 2004 was taken before the big flood in July, so to date any volume change from the flood is not captured yet.

1998-2003 (and earlier):

A comparison of volume changes within the design channel in the reach between cross-section 15 to 25, which is assumed to be gravel, reveals a net deposition of 30,000m^3 from 1998 to 2003. The largest increases have been at cross-sections 20 and 21. The volume analysis indicates that a general loss from 1977 to 1985 has been regained by 1998 and now further material has accumulated since 1998.

Extraction and sediment movement:

The amount of gravel extracted in recent years was 2,850m^3 in 2002/03, 3,317m^3 in 2003/04, 3,054m^3 in 2004/05, and 10,524m^3 in 2005/06.

Substantial deposition of material must have occurred at or just beyond the Whakatane River mouth as a result of the floods in July 1998. A rough measure of the quantity deposited can be made by adding the estimated suspended sediment transported past the Valley Rd recorder station (3.3 million tonnes, equivalent to about 1.6 million cubic metres in situ), to the loss of material below this point (320,000m^3) for the period before to after the 1998 floods. This gives a total of around 2 million cubic metres. This material is now providing good replenishment to the beach at Ohope, particularly at West End.

It can be assumed that similarly high sediment loads have been transported to sea and deposited beyond the river mouth during the flood in July 2004.

3.7 Ruarepuae Stream

The Ruarepuae Stream has been resurveyed in June 2004 (prior to the floods in July 2004) and in December 2005.

Previous surveys have been carried out in March 1993, March 1995, January 1997, April 1998, and June 2000. No gravel has been extracted in recent years.

1995-1997-1998:

Around 14,000m^3 was extracted between March 1995 and January 1997, during which the volume changes have been calculated to be a loss of 7,000m^3. Between January 1997 and April 1998, there was no reported extraction, and only a negligible net change volume was observed. Some gravel was lost at cross-section 6, but there were compensating gains at other cross-sections.

1998-2000:

Between April 1998 and June 2000, the stream had a net volume gain of 762m^3 of material. The main area of aggradation was at cross-section 4 where the bed level has risen with a gain of around 1,000m^3. However this was countered by a loss of 900m^3 at cross-section 2 where erosion of the left bank and a small drop in the bed level occurred.

2000-2004:

The survey from June 2004 shows an overall **volume gain of 25,760m^3**. The main portion of this was gained at cross-sections 4 and 6, while some losses occurred at cross-section 2 due to eroding banks on the right bank at cross-section 1 and on the left bank at cross-section 2. The river bed is aggrading over the entire reach by up to 2.3m at cross-section 3 (thalweg line).

2004-2005:

The survey from December 2005 shows an overall **volume loss of only 760m^3**, most of which was lost at the upper end of the reach (cross-section 6), while some gains occurred at cross-sections 2 and 3. The river bed is further aggrading in the lower reach (cross-sections 1 to 3) and degrading in the upper reach (cross-sections 4 to 6).

1993-2005 (long-term):

The long term development from 1993 to 2005 shows a small volume gain of almost 1,900m^3 over this period.

<u>Gravel extractions and recommendations:</u>

The Ruarepuae Stream has had high rates of extraction in the past (up to 21,000m^3 per year), but extraction has reduced in later years, and there has been no extraction over the past nine years. A desirable bed level was set in 1986 (refer plan R553), and surveys in recent years have shown that bed levels are near those desired. Extraction should now be limited to where gravel builds up excessively.

Estimates put average gravel supply at around 5,000m^3 per year, although because the catchment is very steep, the supply is likely to be irregular.

3.8 Rangitaiki River

Lower Rangitaiki River (mouth to Te Teko):

The Lower Rangitaiki River between the river mouth and Te Teko has been resurveyed in August 2004 following the large flood in July of that year.

Earlier surveys on the Rangitaiki River below Te Teko have been done in June 1987, October 1993, December 1995, January 1999, and between April 2002 and June 2003. Part of the 1987 data is incompatible with the more recent surveying – comparisons have been made where possible. The benchmarks at these cross-sections have been re-levelled since the 1999 survey, and most of them had settled over time. This will account for some volume losses in the volume calculations.

1999-2003:

The total volume loss from 1999 to 2003 was 67,000m^3 over the reach from the river mouth to Te Teko. It can be expected that only part of this is due to gravel movement, whereas part of it is caused by the settlement of benchmarks. At cross-sections 5 to 8 and 15 the left stop banks have been raised between the two survey dates. When setting the offset limits to exclude the stopbanks at the cross-sections where stopbanks have been raised, the resulting volume figures only insignificantly differ. Figures provided in the Appendix therefore represent calculations including these stopbanks. Minimum bed levels since the last survey have risen in some places in the reach, especially in the lower parts from cross-section 1 to 10. Considering the settlement of most benchmarks aggradation can be expected to be greater than shown by the survey data.

2003-2004:

The survey from 2004 shows a total **volume loss of 158,000m^3** over the reach from the mouth to Te Teko. This can be seen as the result of the July 04 flood, which has been assessed as a one hundred year flood. Some volumes were gained at cross-sections 8 to 10, 13 to 15, 28b to 30, 33 to 34, and 43c. But these gains were by far outweighed by losses at cross-sections 1 to 7, 11 to 12, 16 to 28b, 31 to 32, 35 to 43b, 44 to 48, and 50 to 59. The larges losses occurred at cross-section 51b (24,000m^3) where a new channel has formed on the left berm, and at cross-section 51c (25,000m^3) where the left bank is eroding. Erosion is also occurring on the left bank at cross-sections 18, 27, 35, 41a, 44, and 51a, and on the right bank at cross-sections 39, 40, 50, and 51a. Some stopbank top-ups were completed since the last survey on the right bank from cross-section 5 to 15 and on the left bank from cross-section 10 to 14. At cross-section 9 a floodwall was constructed. These top-up volumes are partially included in the volume analysis as the offsets for the volume calculations are now set to reach from stopbank to stopbank.

Minimum bed levels show that during the period 2003 to 2004 the bed is degrading in the reaches from cross-section 1 to 3, 33 to 37, 43b to 47a, and 49 to 52.

The factors that have influenced the changing rate of loss or gain may include:

- Floods, particularly in July 1998 and July 2004, may have transported more sediment from upstream.
- Conversely, the Rangitaiki River has not experienced a significant flood between January 1999 and June 2003. Thus there has been no ability to flush sediment from the lower reaches during this period.

- Matahina Power Station may limit sediment transport, especially of larger grain sizes. While the repair works were underway, more sediment than normal may have passed the station.

- Changes to the river gradient following the earthquake in 1987 may have slowed as the river readjusts to a new gradient. Losses have been similar both above and below the fault scarp.

No extraction is carried out in the lower reaches below Matahina.

In the lower reaches morphological processes consequent from the effects of the Edgecumbe earthquake are likely to cause some further degradation. This could be artificially encouraged to give adequate flood capacity.

Upper Rangitaiki River (above Aniwhenau):

The Upper Rangitaiki River cross-sections above Aniwhenua have not been resurveyed since the last NERMN report, and the cross-sections at Waiohau have not been resurveyed since 1996.

Above Aniwhenua surveys were done in December 1992, March 1996 and November 2001 (refer to previous NERMN report).

1996-2001:

Between 1996 and 2001 a total volume of 95,000m^3 was gained. Main volume gains were observed at cross-sections 3 to 5, and 11. Minimum bed levels have slightly dropped at cross-sections 1, 7, 12, and 14 to 18, while they have risen at cross-sections 2 to 4, and 24.

There was no shingle extracted in recent years. nor was any reported in the upper reaches of the river in this period.

Previous extractions above Lake Aniwhenua have been minor (e.g. 3,000m^3 was extracted in 1994/95).

Rangitiaki River – Waiohau area:

There was no new survey done in the in the Waiohau area. The last surveys were undertaken in February 1993 and March 1996. The changes in bed level then were relatively minor, with an overall loss of 6,000m^3 over the 11km surveyed. The largest changes were at and just upstream of the Galatea Road Bridge.

Overall Recommendations:

Gravel or sand extraction is not required, nor should it be encouraged anywhere along the surveyed part of the river at this stage (the heads of the hydro lakes are not surveyed). There is little demand for extraction of gravel/sand from the river at present. The consents for extraction in the Waiohau section have expired.

3.9 Whirinaki River

A new survey has been completed on the Whirinaki River in September 2005.

Previous surveys were done in November 1994, November 1997, July 1999, and August 2003. There was no gravel extracted on this river since 1997.

1994-1997:

In the river channel between 1994 and 1997, the main changes in volume were a 61,500m^3 loss above cross-section 7 and a 43,100m^3 gain near cross-sections 4 and 5. (The calculation has included more of cross-section 4, so is slightly different to the previous report). The net loss for the river was 7,100m^3.

1997-1999:

Between 1997 and 1999, the loss above section 7 was replaced (26,200m^3) while further gains (especially at section 4), amounted to 38,400m^3. The net gain for the river was 60,000m^3.

1999-2003:

The survey in August 2003 shows a total volume gain of 9,000m^3 since the previous survey in July 1999. Volume losses occurred between cross-sections 3 and 5, and between cross-sections 7 and 8, while gains were observed in the other parts of the monitored reach. The thalweg line shows that the river bed is generally aggrading, except at cross-section 4 where the bed level is dropping and at cross-section 7 and 8 where it has been fairly stable since 1994.

2003-2005:

The most recent survey (September 2005) shows a substantial **volume gain of 83,500m^3** since the previous survey in 2003 (full width). Volume gains occurred throughout the reach fairly evenly. The thalweg line shows some continuous aggradation at cross-sections 5 and 6 since 1999 and in the lower reach at cross-sections 1 and 3.

1994-2005 (long-term):

The total gain since 1994 adds up to 160,000m^3, which largely stems from the 1998 and 2004 floods.

In the Fluvial Processes Report for the Whakatane and Whirinaki Rivers (Balley, 2006) river characteristics and sediment processes have been studied on the Whirinaki River. Design channel widths of 50m plus a buffer zone of 30m have been developed for the narrow managed fairway option on the lower Whirinaki River. Bed load transport equations were developed to estimate an average annual bedload transport of 23,000m^3/year. This compares well to the initial estimate of 24,000m^3 per year supply.

Detailed design is required to define desirable bed levels at each cross-section.

It is recommended that extraction be encouraged at the aggrading reaches around cross-sections 4 and 5.

3.10 Horomanga River

The Horomanga River has been resurveyed twice since the last NERMN report, once in July 2004 just before the big flood and once after the flood in September 2004. In December 2001, some new cross-sections were established and surveyed to improve the precision of the volume calculations. These are now utilised for the volume analysis. Surveys have been done intermittently since 1956 on this river.

1996-1999-2001:

The 2001 survey data showed a loss of 61,000m^3 over the whole reach of the river since the 1999 survey. Sections 9 to 12 lost over 74,000m^3 in total, where almost 56,000m^3 are lost between cross-sections 9a and 11. This adds up to a loss of 78,000m^3 between 1996 and 2001, giving an average loss of 13,000m^3 per year for these six years.

2001-July 2004:

The data from the survey prior to the July 2004 flood shows an overall **loss of 41,000m^3** over the whole reach, with the biggest losses at cross-section 1 and at cross-section 8a to 9a.

July 2004-Sept 2004:

The survey after the July 2004 flood showed that the flood had deposited more gravel than it had taken away, with a total **gain of 67,300m^3** over the whole reach. The largest gains were recorded at cross-section 1 with 24,000m^3 alone, and at cross-section 3 and 3a. Some losses occurred at cross-sections 8a to 11.

Between 1996 to September 2004, the total volume changes add up to a loss of 51,600m^3, giving an average loss of 6,500m^3 per year for the past eight years.

Gravel Extraction and Recommendations:

The river has traditionally had a high extraction rate, hence a good picture can be built up of the effect of extraction. Considerable extraction was carried out in the Horomanga River until 1996, averaging 55,000m^3 annually since 1979. Extractions have dropped considerably to 19,000m^3 in 1996/97, 9,000m^3 in 1997/98, 500m^3 in 1998/99, 3,600m^3 in 1999/2000, none in 2000/2001, and 8,204m^3 in 2001/2002, but have increased again in 2002/2003 when 25,964 m^3 were extracted. In 2003/2004 only 525m^3 were extracted, in 2004/2005 15,404m^3, and in 2005/06 12,132m^3.

Previous reports indicated that the supply of gravel appeared to have been smaller between 1991 and 1996 than prior to 1991 (15,000m^3 per year as opposed to 45,000m^3 per year).

The data suggests that **gravel extraction should be suspended in the upper part of the reach (above cross-section 8).** In the lower reaches the bed is severely perched and significant extraction is required to avoid undue flooding or avulsion (migration of the river channel). The bed level needs to initially be lowered by an average of 0.50 metres over the 70 metre design fairway width.

Work to create a stable river pattern has continued with plantings and gravel extraction directed to areas which have a higher than desirable bed level. The desirable level to which extraction can take place should now be reviewed in light of the apparent reduction in supply. In the past there was surplus gravel, but we may now have reached the stage where extraction must meet supply since there is no longer an overall surplus of gravel.

Supply of gravel is dependent on many processes within the catchment. The Horomanga is a particularly long, narrow catchment in steep country, which will tend to produce an irregular supply on the floodplain, depending on slip activity, where material is stored within the catchment, and when floods occur.

Desirable bed levels that limit both erosion and flooding should be set to maintain a stable river profile. Extraction should then be limited to the input as measured by subsequent surveys. In recent years, the net change in volume appears to have varied from a loss of about 32,400m^3 (1997-1998) to a gain of 7,000m^3 per year (1998-1999), however, over the longer term net change in volume has averaged a gain of 45,000m^3 (1977-1996, refer 1995/1996 report by Surman).

3.11 Mangamate Stream.

The Mangamate Stream has been resurveyed twice since the last report, in June 2004 and October 2005/January 2006. Note that the 2004 survey was completed before the July 2004 floods. Previous surveys have been carried out in May 1993 (baseline survey), February 1995, August 1995, January 1997, June 1999 and June 2004.

1999-2004-2005:

The recent surveys show an overall **gain of 1,900m^3** between 1999 and 2004 and an overall **loss of 24,700m^3** between 2004 (before the floods) and 2005. Between 1999 and 2004 some losses occurred at cross-sections 4, 5, and 6, partly due to the removal of a shingle bank on both sides of the stream. Between 2004 and 2005 the most significant portion of the loss was at cross-section 8 and 9 with 5,500m^3 and almost 23,200m^3, respectively.

Since the base line survey in 1993, almost 108,000m^3 of volume have been lost over the entire reach, particularly at cross-section 9, and except below cross-section 2, where 900m^3 have accumulated over those 12 years.

1997-1999:

Between January 1997 and June 1999, there was only a small net loss of 2,000m^3 between cross-sections 1 and 8. Cross-section 9 has experienced a much larger change, with a loss of 128m^2 of cross-sectional area – the right bank has eroded by about 5m while the bed has dropped by about 1m. If this is representative, the net loss in this vicinity is estimated at 26,000m^3.

Overall, since 1993 up to 1999, all cross-sections have lost material and the stream appears to have lost about 85,000m^3.

1993-1995-1997:

About 15,000m^3 of gravel was extracted between August 1995 and January 1997, but there was a net gain of 2,000m^3 in this time. Previously, there had been a loss of about 58,000m^3 since May 1993, despite extraction of only 16,000m^3. A substantial proportion of this calculated loss is from one eroding bank at cross section 9; the bank is 13m high and has moved back about 15m in six years. The material from this bank has not reappeared at any particular cross-section – most other sections appear relatively unchanged over this time, with slightly lower bed levels than in 1993. A proportion of this loss may be silt and sand sized fractions that are less likely to remain on the riverbed once mobilised.

<u>Gravel Extraction and Recommendations:</u>

After an extraction of 6,003m^3 during 2001/2002 and no extraction during 2002/03, 2,616m^3 have been extracted in 2003/04, 4,103m^3 in 2004/2005, and 6000m^3 in 2005/06. No extraction has taken place between 1998 and 2000.

Desirable bed levels have not been defined for this stream. Initial estimates put average gravel supply at around 4,000 - 7,000m^3 per year, although the stream appears to be steep enough to transport significant quantities of gravel right through the system. Extraction should not be encouraged on this stream unless bed levels rise or a detailed design is undertaken.

3.12 Ohutu Stream

The Ohutu Stream has been resurveyed in June 2004. Note that this survey took place before the floods in July 2004.

1999-2004:

The volume analysis shows a net **loss of 13,850m^3** between June 1999 and June 2004, most of which occurred at cross-sections 5 and 6. Bed levels have remained fairly stable over this period.

1997-1999:

The previous survey for this stream was carried out in June 1999. The net change between the January 1997 and June 1999 surveys is a loss of about 4,000m^3. Bed levels have dropped slightly at cross-sections 1 to 5. Section 6 rose moderately. And only a small amount of extraction (2,400m^3) has taken place in 1996-99.

Gravel extraction and Recommendations:

In 2003/2004 a gravel volume of 3,525m^3 was extracted, and in 2005/06 a volume of 1,055m^3.

Desirable bed levels have not been defined for this stream. Initial estimates put average gravel supply at around 5,000 - 8,000m^3 per year, although the stream appears to be steep enough to transport significant quantities of gravel right through the system to the Horomanga River.

However, taking into account the continuous overall losses on this stream over the past years, there does not seem to be any surplus gravel for extraction.

3.13 Kopuriki Stream

The Kopuriki Stream has been resurveyed in October 2005. Previous surveys took place in August 2003, March 1998, and August 1996. The baseline survey was carried out in 1996 following applications to extract gravel from this stream.

2003-2005:

The recent analysis shows a further **gain of 28,500m^3** between the 2003 and 2005 survey. This accumulated to a total gain of almost 53,000m^3 since 1996, with the main gains concentrated in the lower reach of the stream (cross-section 1 to 5).

Comparison of the 2005 thalweg line to the design thalweg established for the reach from cross-section 5 to 9 (Surman, 1998) indicates that the current minimum bed level meet the desired level at cross-section 5, then exceed the desired level at cross-sections 6 to 8 by up to 1.36m (at cross-section6), and are slightly below desired level at cross-section 9.

1998-2003:

The previous survey of the Kopuriki Stream has been undertaken in August 2003.

The volume calculations show an increase of 14,000m^3 since the previous survey in March 1998, which is mainly accumulated at the lower four cross-sections of the stream. The thalweg line indicates that the river in this reach (cross-section 1 to 4) is slightly aggrading, while further upstream it is fairly stable. Comparison of the 2003 thalweg line to the design thalweg established for the reach from cross-section 5 to 9 (Surman, 1998) indicates that the current minimum bed levels are very close to the desired, except at cross-section 6 where the current bed level is almost 1.3 metres above the desired bed level.

1996-1998:

The stream was resurveyed in March 1998, with calculations showing an increase of 10,000m^3. No extraction has been reported in this time, although resource consent applications have been made to extract from this stream.

Gravel extraction and recommendations:

Only 522m^3 and 450m^3 of gravel were extracted in recent years (2003/04 and 2005/06, respectively).

No estimates of long term supply have been made, however minor resources exist within the stream floodway. A desirable bed level and meander pattern has been established (Surman, 1998).

Any extraction should be focused on the lower reach of the stream (i.e. cross-sections 1 to 4) where bed levels are aggrading and volume has been accumulating over the years.

3.14 Waikokopu Stream

Waikokopu Stream (Waiohau) has not been resurveyed since the baseline survey of 1996.

Extraction commenced on this stream in mid-1997, following a baseline survey and establishment of desirable meander pattern and bed levels in December 1996. A volume of 1700m^3 of gravel was removed in 1997/98, around 1000m^3 in both 1998/1999 and 1999/2000, 334m^3 in 2000/2001, 430m^3 in 2001/2002, and none since.

3.15 Waihua Stream

Waihua Stream (Waiohau) has not been surveyed since the 1997/1998 NERMN report.

A baseline survey and establishment of desirable meander pattern and bed levels was carried out in December 1996. No extraction has taken place.

3.16 Waihui Stream

Waihui Stream (Ruatahuna, tributary of Whakatane River) has not been surveyed since the 1996/1997 NERMN report.

A baseline survey and establishment of desirable meander pattern and bed levels was done in December 1996. Approximately 14,000m^3 of gravel has been extracted in 1998/1999, just about 3,800m^3 in 1999/2000, 6,449m^3 in 2000/2001, only 628m^3 in 2001/2002, 1,798 m^3 in 2002/2003 and none in 2005/06.

3.17 Kaituna/Mangorewa Rivers

The Kaituna River has been resurveyed in April/May 2005. The previous surveys on the lower Kaituna River (below Te Matai) were done in February 1992, June 1997 and October 2001. Previous surveys on the Upper Kaituna River (above Te Matai) are from June 1989 (baseline survey), May/June 1997, and October 2001.

During the period 1997 to 2001 the Kaituna River sustained a major flood event (1 May 1999). This event would have transported significant quantities of sediment.

Lower Kaituna (below Te Matai):

2001-2005:

The latest survey from April 2005 shows an overall **volume gain of 94,700m^3** since the 2001 survey. This continues the trend of volume gains in this reach of the river. The largest gains were at cross-sections 11 to 15. Some losses occurred at cross-sections 2 to 5 and at 7 and 9. Minimum bed levels have generally risen, by as much as approximately 2m and 2.5m at cross-sections 11 and 12, respectively.

1997-2001:

The 2001 survey below Te Matai shows an over all net volume gain of 163,000m^3, following a net gain of 39,000m^3 between February 1995 and June 1997. The thalweg profile shows that minimum bed levels have significantly risen around cross-section 13 to 16, where the bed levels used to be particularly deep. The volume gain at these sections was over 106,000m^3. Minimum bed levels have dropped near the river mouth from cross-section 1a to 4. At cross-section 12 the channel has shifted towards the left by about 15 metres.

No extraction has been carried out in this river in recent years (since the major works of the Lower Kaituna River Scheme). Some extraction (of silt and/or sand) may be beneficial in some areas of the Kaituna River below Te Matai, if build-ups are excessive. However, the supply of sediment to the coast may be reduced by extraction. To date, build-ups do not appear to have adversely affected predicted flood levels significantly (the predicted flood levels were reviewed in September 1998 based on the 1997 cross-sections), but there have been reports of more difficulty in navigation. Build-ups may also be forcing the river to the outside of bends, which may increase erosion at these sites.

Upper Kaituna (above Te Matai):

2001-2005:

The latest survey on the Kaituna River above Te Matai from May 2005 shows a total **loss of 40,000m^3**. The major losses have been in the reach between cross-sections 43 to 49. Erosion is occurring on the right bank at cross-section 44.

1997-2001 (and earlier):

Above Te Matai, the 2001 survey showed a total loss of 13,000m^3. Compared to the net losses of 57,000m^3 between October 1993 and June 1997 and 56,000m^3 between 1990 and October 1993 this shows that volume losses have slowed down considerably in the recent years. The major losses have been at cross-sections 40, 41, and 44.

Mangorewa River:

The Mangorewa River has not been resurveyed since the previous report. It has last been surveyed in October 2001.

Since the previous survey in June 1997 the reach of 2.4 km has gained a volume of 25,000m^3. Since 1990 the volume gain was 16,000m^3. The minimum bed level at cross-section 1 has dropped about 0.5 metres since the last survey, while it has risen at cross-section 3 by about 0.4 metres, and the channel has slightly shifted towards the left here. Cross-section 2 shows a significant build up of silt from floods on the left berm.

3.18 Tarawera River

The Tarawera River has been resurveyed in February 2006. Previous surveys were the baseline survey in 1993, followed by resurveys in March 1998 and October 2000. Some cross-sections near the mouth have been resurveyed between these dates also.

Between the survey in 1998 and 2000 the benchmarks had been resurveyed as well, and most of them had settled slightly over time. As this has some effect on the volume calculations, the volume loss between 1998 and 2000 might really be less than shown in the figures.

2000-2006:

The 2006 survey shows another **volume loss of 86,600m^3** since the 2000 survey. This continues the trend which has been observed since the baseline survey. Note that the losses at cross-sections 16 and 17, which contribute significantly to the overall losses, are exaggerated due to the settlement of new benchmarks and a possible error at cross-section 16. These two cross-sections haven't been surveyed since the renewal of the benchmarks, so this issue arises here only now, while at the rest of the cross-sections this problem occurred already in the last analysis. The only cross-sections at which minor gains occurred were cross-sections 6, 10 and 11. Bed levels have dropped since the last survey over the entire reach, except at cross-sections 1b, 2, 7, and 10.

1998-2000 (and earlier):

The 2000 survey showed a volume loss of 87,000m^3 since 1998. With the volume loss of 83,000m^3 between 1993 and 1998, this adds up to a total loss of 170,000m^3

since 1993. The trend of dropping minimum bed levels which was observed from the 1998 survey is continuing at most of the cross-sections, particularly at cross-sections 5 to 8 where bed levels have dropped by up to 1 metre since 1993.

The riverbed is particularly mobile because of its low-density particles. The river is relatively straight, so flows fairly quickly down the floodplain. The bed level drop indicates the supply of sediment has been less than the transporting capacity of the river.

No extraction is carried out in this river at present, and with the lowering of the whole bed, it is recommended no sand extraction be allowed in the short to medium term. This analysis clearly shows there are factors other than extraction that may cause degradation.

3.19 Other Locations

Some minor extraction is carried out occasionally in some other streams and rivers, e.g. Hikurangi, Haparapara, and Hawai Rivers. Consents have expired for most of these and have not been reapplied for.

A total of 5,402m^3 were removed from the Waiotahi River in 2005/06, 5,526 m^3 in 2002/2003, 4,000m^3 in 2000/2001, and 5,300m^3 in 1997/98 (with consent). There was no gravel removed in 2004/05, 2003/04, 2002/2001, 1999/2000, and 1998/99. If extractions continue at this rate, regular surveys will be required. Four parties either have consent or have applied for consent to extract from this river, although the quantities involved are fairly small.

A total volume of 51,000m^3 was extracted from the Motu River, 983m^3 from the Raukokore Stream, 300m^3 from the Wairata Stream, and 120m^3 from the Waiaua Stream during the period 2005/06. Interest has also been shown in extracting from the Kereu, Petipeti, Whitikau, and Whangaparaoa Rivers. Cross-section surveys may need to be set up to assess and monitor the resources if the extent of extraction and the quantities involved are significant.

In other streams, the levels of extraction are minor, 100 to 500m^3, and do not warrant detailed monitoring.

Chapter 4: Conclusion

The continuing accumulation of data will allow Environment Bay of Plenty to set and refine appropriate rates and volumes for each section of river.

Definition of desirable bed levels at each cross-section would aid gravel management and development of stable river channels. A balance of risks of erosion, aggradation and deposition is required.

For most rivers, allocations will be advised to each contractor as part of the resource consent process. The Operations and Rural Services department of Environment Bay of Plenty has secured resource consents for extraction on the Waioeka, Otara and Waimana rivers to better manage the allocation of resources and to ensure sufficient gravel is removed for flood control purposes.

Allocation on other rivers, in terms of sites and volumes, tends to be in response to a request for the gravel. With there being, in most instances, an abundance of gravel, this is satisfactory. However, as demand begins to exceed supply, as is happening in some locations, allocations in terms of sites and volumes need to be rigorously controlled in terms of maximum annual extraction rates, minimum bed levels and defined extraction locations.

This can only be done when sufficient data exists and a full understanding of the resource is gained. Initial estimates of gravel supply have been included where possible to aid the consent process. These will need to be refined as data and understanding increase.

In many cases, extraction records are in terms of reaches of river (e.g. between Pekatahi and Ruatoki Bridges on the Whakatane River), and may need to be further defined to match with cross-section information to allow for detailed analysis within a reach. Having said this, Environment Bay of Plenty is interested in long-term trends and the health of each river as a whole. An ongoing assessment of the information required will continue.

The 1998 floods caused massive deposition on the floodplains of the affected rivers. Some of this deposition has been counteracted by settlement of the sediment. Further deposition has also occurred during the October 2003 floods on the Waioeka and Otara Rivers and during the July 2004 floods (mainly Waimana/Whakatane and Rangitiaki Rivers). The Waioeka-Otara scheme is still experiencing considerable deposition on their floodplains, and in the design channel in the case of the Otara River. Consequently, it is recommended that extraction on the Otara River be encouraged and extraction on the Whakatane River continues to be limited within the active channel to those reaches where it is beneficial. Extraction on the Waioeka and Waimana rivers should be carefully directed to appropriate locations. The cross-section monitoring programme should be extended to include the Waiotahi River if extraction is again carried out at larger rates.

References

P Balley, 2006: Fluvial Processess Report for the Whakatane and Whirinaki Rivers (Operations Publication 2006/01).

Bay of Plenty Catchment Commission, 1986: Plan R553.

M R Surman, 1998: Gravel Extraction – Kopuriki Stream, Waiotahi Contractors Application, Environment Bay of Plenty. (File 5920 R01)

Appendices

Appendix I – Hilltop

1 Introduction

The Hilltop software package has now replaced Ricoda which had been used for the analysis of previous NERMN reports. The user-friendly, windows-based program offers a number of processes which allow capture, archiving, correction, presentation and analysis of cross-section data.

Hilltop software consists of several modules, of which Hilltop Manager and Hilltop Hydro are currently available at Environment Bay of Plenty and have been used for this report.

Hilltop Manager is a program to let you look at the data stored in a file and then do the standard database management functions of add, edit, and delete.

Hilltop Hydro and its add-in Hilltop Reach lets you store and analyse reduced level sections.

2 Sections

Cross-sections always contain the bed level measured to a survey datum, so they are always in terms of a reduced level (RL), i.e. all levels are known as a height above or below a fixed point, e.g. Moturiki datum (a fixed point on Moturiki Island near Tauranga).

Hilltop can also store data for profiles (these were known as long-sections in Ricoda). Profiles run up a river and are used to describe elevations of the river bed, such as the thalweg line (minimum bed level) or mean bed levels. Profiles can be entered manually, or are derived from cross-section data.

3 Reaches

A reach is a group of cross-sections that are linked together for the purposes of multi-section analysis.

The sections must be stored in the same file, be to a common datum, and be defined in order of increasing upstream distance.

The reach description is stored in the file with the sections. A reach has a time associated with it, and this is a very important parameter in carrying out the analysis.

4 Face Cards

A face card is a database record that contains additional information to sections and reaches, but does not vary in time.

The key fields in a face card are the section name and date/time because they identify the face card in space and time. All other fields on the face card are optional, but there are important fields in the Cross Section Details section. These fields let you specify the upstream distance of the section and the pin positions on the section.

Both the upstream distance and the pin positions of the cross-section will be transferred into the reach definition when creating a reach. The following Figure 1 is an example of the information contained in a face card:

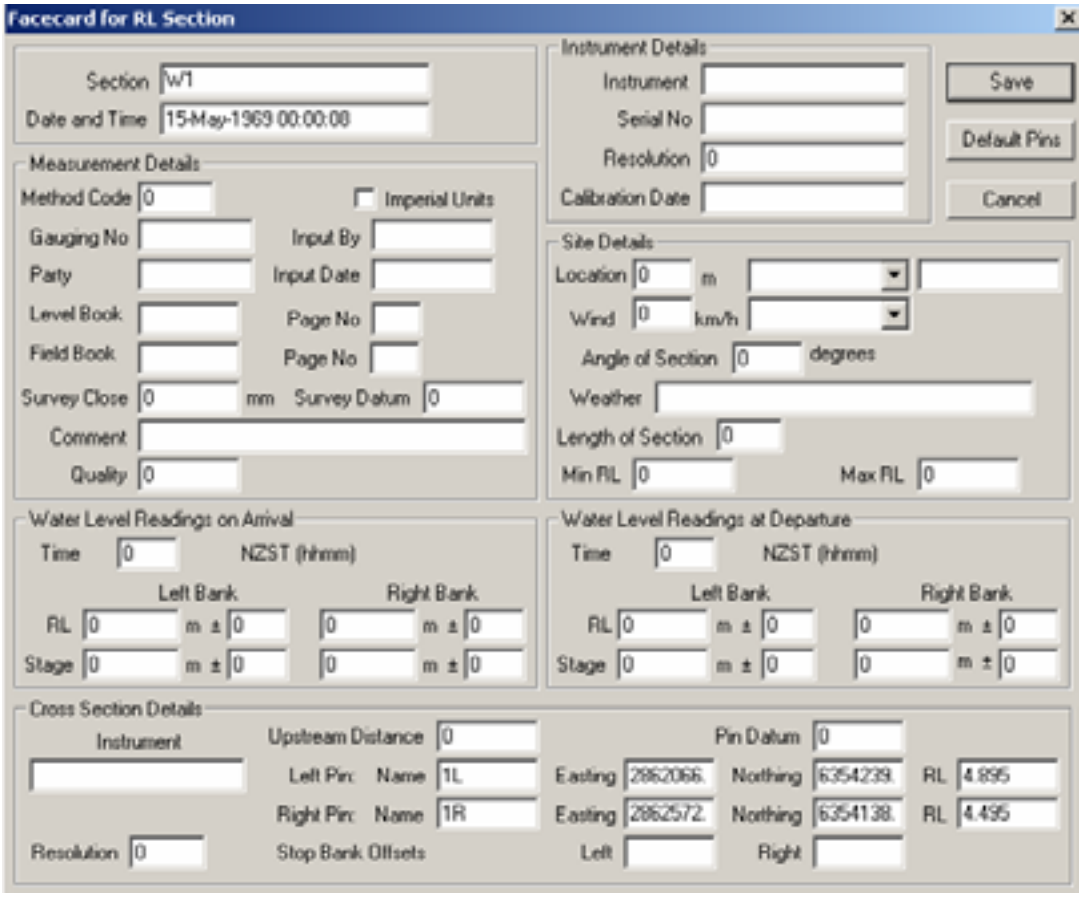


Figure 1 Face card

The pin positions are important for sections because they define the offset origin and orientation of the section. However, because pin positions are difficult to maintain in the river environment and are likely to change over time, they are not used in the volume calculations undertaken for this report.

5 Processes

There are a number of processes available in Hilltop, but the main features being used for gravel analysis are the "Graph Sections", “Edit Reach Details” and "Volume Calculations" processes in the Hydro Reach menu.

5.1 Plotting Sections

The “Graph Sections” command (“PLSection”) draws a graph of one or more RL sections at a site.

Figure 2 shows an example of a plot of a cross-section on the Whakatane River for two survey dates.

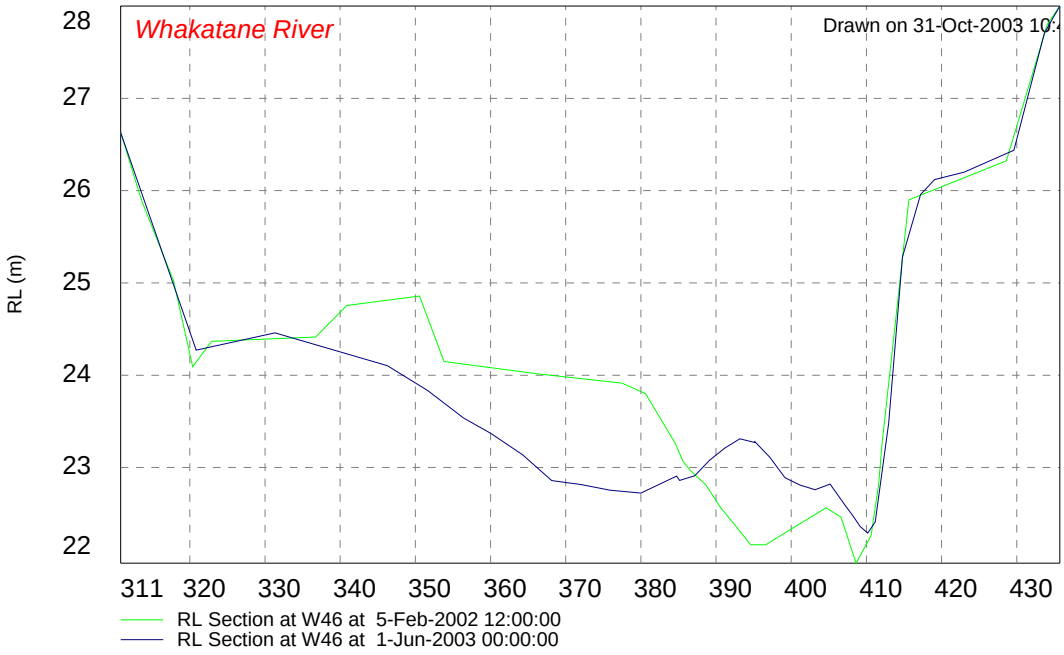


Figure 2 Cross-section plot

Graphical outputs are very useful and by visual inspection of the plot it can be seen whether aggradation or degradation is occurring.

The same command is used to plot a profile of the river, thalweg or mean bed level, by deriving it from cross-sections in a reach definition.

Figures 3 and 4 are plots of the profile of the Whakatane River showing the thalweg level (lowest invert in a cross-section) and the mean bed level at two different survey dates. This is useful for obtaining a feel as to what is happening in the river system.

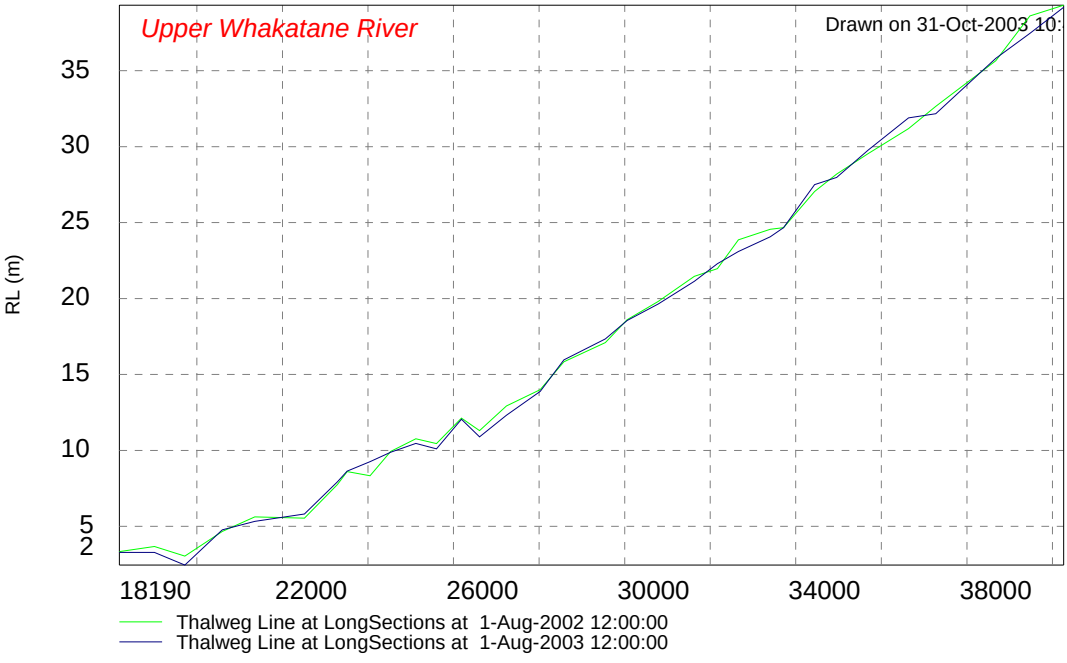


Figure 3 Profile of Minimum Bed Level (Thalweg)

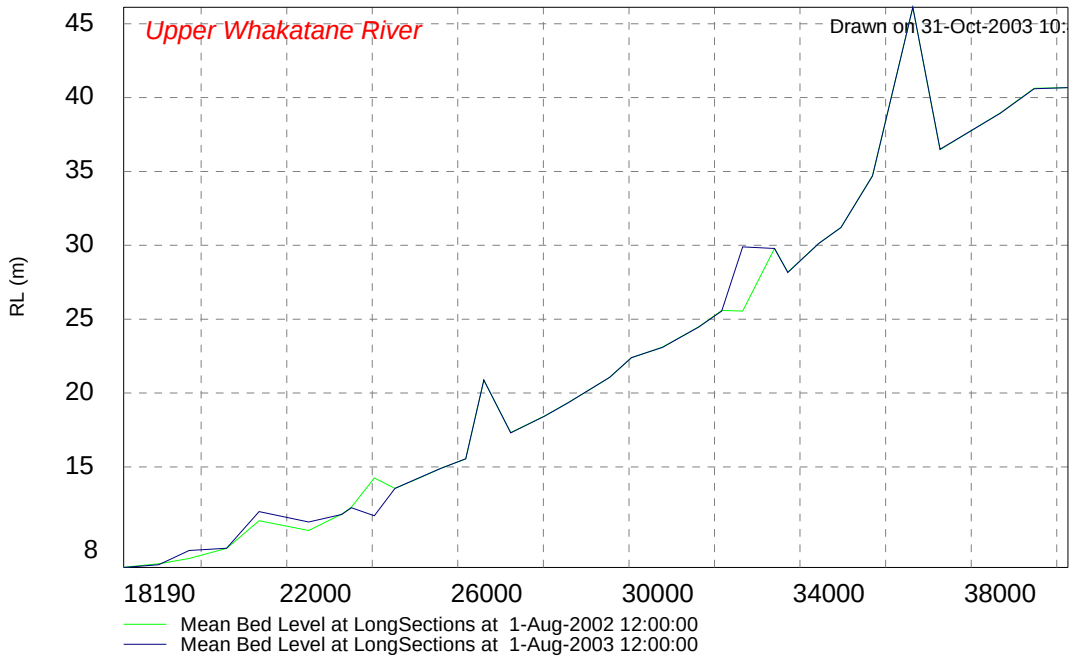
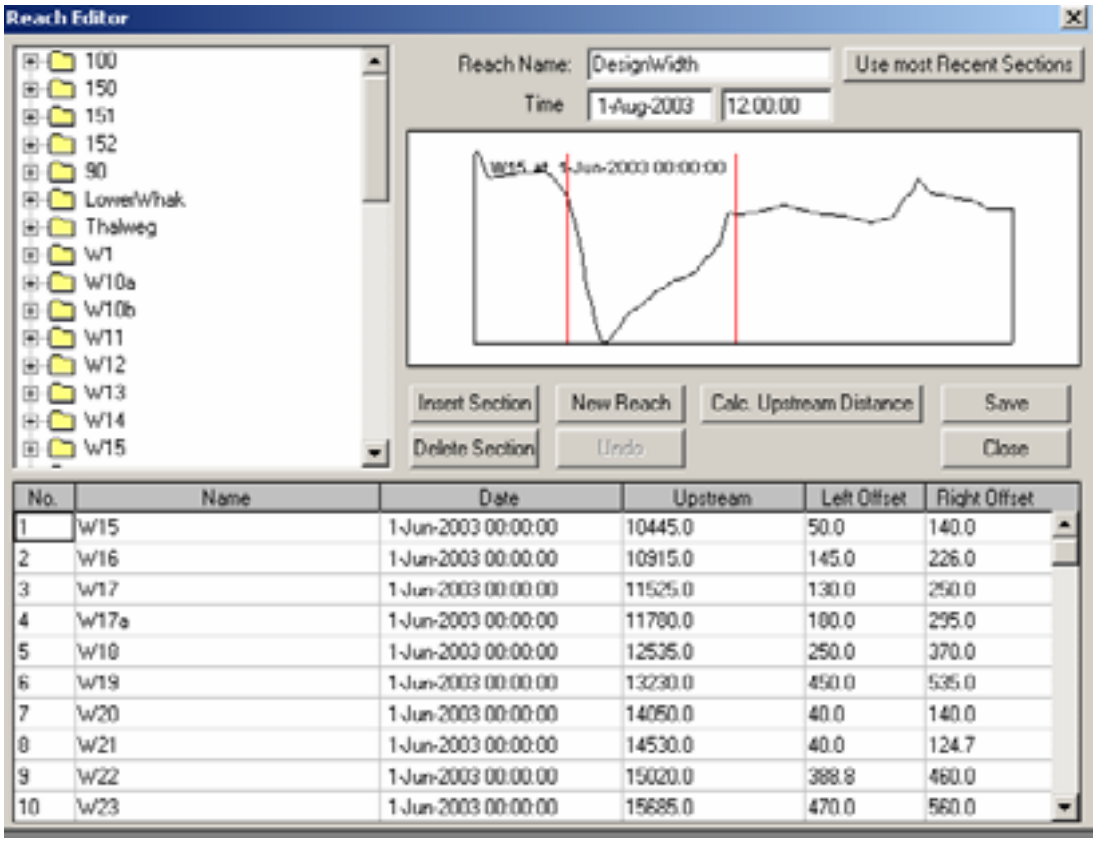


Figure 4 Profile of Mean Bed Level

5.2 Reach Editor

The reach editor lets you define a new reach or a new date of a reach, and edit an existing reach.

Each section in a reach is identified by the site name and a survey time. For each section the left and right offsets can be specified. The left and right offsets define the part of the section which are used for the volume calculations. A graph gives a thumbnail sketch of a section in the reach and its offsets. Figure 5 illustrates the information displayed in the Reach Editor.



No.	Name	Date	Upstream	Left Offset	Right Offset
1	W15	1-Jun-2003 00:00:00	10445.0	50.0	140.0
2	W16	1-Jun-2003 00:00:00	10915.0	145.0	226.0
3	W17	1-Jun-2003 00:00:00	11525.0	130.0	250.0
4	W17a	1-Jun-2003 00:00:00	11780.0	180.0	295.0
5	W18	1-Jun-2003 00:00:00	12535.0	250.0	370.0
6	W19	1-Jun-2003 00:00:00	13230.0	450.0	535.0
7	W20	1-Jun-2003 00:00:00	14060.0	40.0	140.0
8	W21	1-Jun-2003 00:00:00	14530.0	40.0	124.7
9	W22	1-Jun-2003 00:00:00	15020.0	388.8	460.0
10	W23	1-Jun-2003 00:00:00	15685.0	470.0	560.0

Figure 5 Reach Editor

5.3 Volume Calculations

The “Volume Calculations” command (“Volume”) is used as one of the main tools for analysis of gravel movement. This command calculates the volume under the river bed level in a reach to a specified horizontal datum.

By running the volume calculations command for a particular reach at different times it is possible to derive the volume change between two survey dates between the sections.

There are two methods of calculating volumes available: a simple “End Area” method which multiplies the change in cross-section area at two cross-sections by the distance between them, and the “Ricoda Triangle” method, a more complicated general surface algorithm which takes into account the orientation of the cross-sections. The two methods can give quite different results from the same cross-section information.

For this report and in accordance with previous reports the “End Area” method is used as it has been assessed as being the most appropriate method for calculating the volumes. This is because the cross-sections are generally a long distance apart compared to their width. Changes in the channel cross-section between measured cross-sections, around a bend, say, are much greater than the error introduced by assuming the cross-sections are parallel. Thus, the error in the calculations is much more related to the distance between the cross-sections than the method of calculation.

Once the volumes under the river are calculated in Hilltop they are exported into Excel to calculate the volume changes from one survey date to the next.

Appendix II - River Summaries

Volume calculations and graphs for the following rivers and streams are presented on the next pages:

- Otara River
- Waioeka River
- Waimana River
- Whakatane River (Lower and Upper)
- Ruarepuae
- Rangitaiki River
- Whirinaki River
- Horomanga River
- Magamate Stream
- Ohutu Stream
- Kopuriki Stream
- Kaituna River (Lower and Upper)
- Tarawera River

Otara River above confluence
Full width of cross-sections

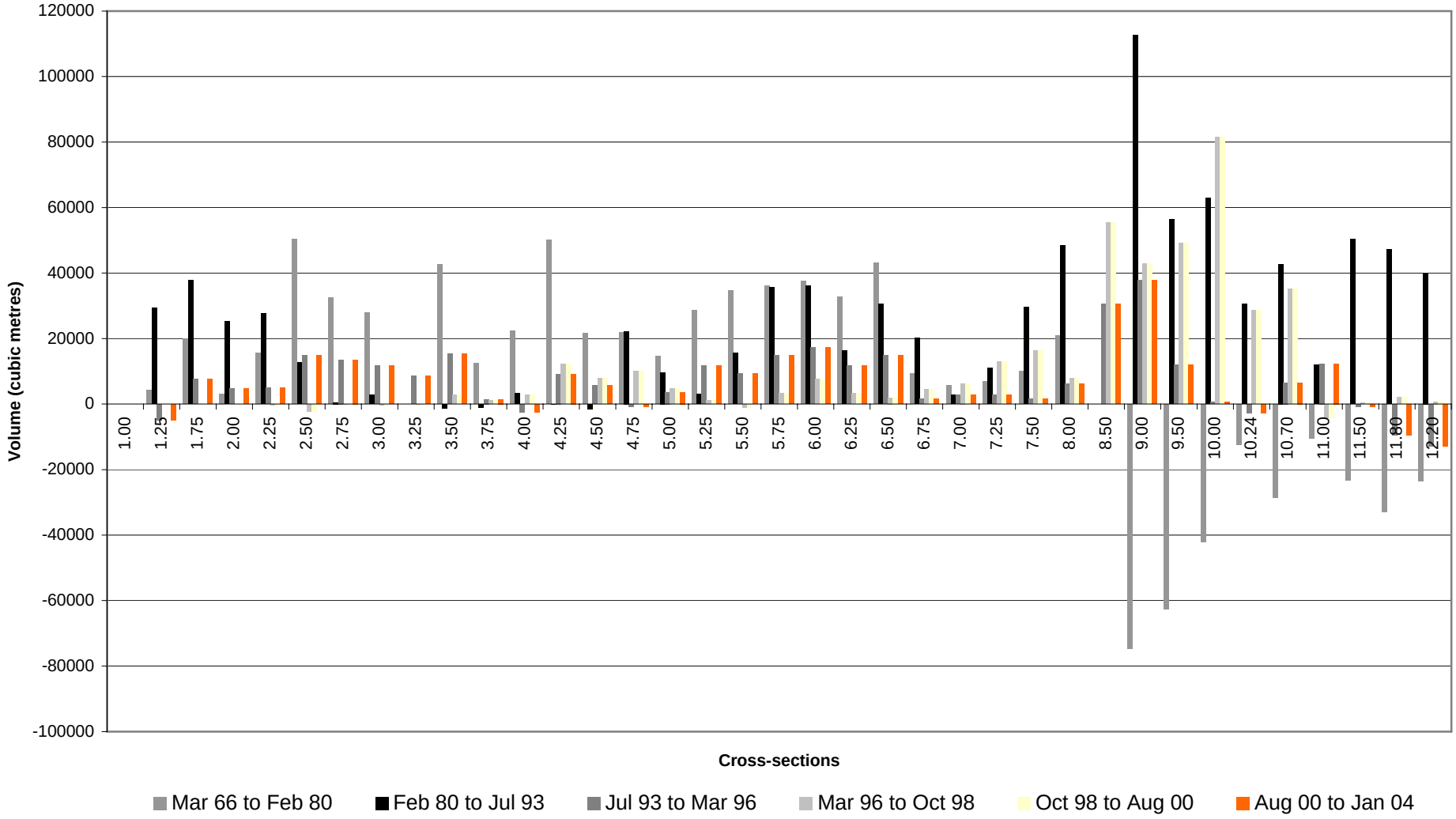
Section	Label	Upstream dist (km)	Volume Change							Area Change						
			Mar 66 to Feb 80	Feb 80 to Jul 93	Jul 93 to Mar 96	Mar 96 to Oct 98	Oct 98 to Aug 00	Aug 00 to Jan-04	Mar 66 to Jan-04	Mar 66 to Feb 80	Feb 80 to Jul 93	Jul 93 to Mar 96	Mar 96 to Oct 98	Oct 98 to Aug 00	Aug 00 to Jan-04	Mar 66 to Jan-04
4	1.00	1.57								-9	48	-1	-36	0	43	45
5	1.25	2.025	4210	29367	-1381	-5039	0	14732	41889	28	81	-5	13	0	22	139
6	1.75	2.645	20023	37764	-3320	7578	0	13841	75886	37	41	-5	10	0	23	106
7	2.00	3.075	2998	25332	-2694	4732	0	8470	38838	-22	77	-7	11	0	17	76
8	2.25	3.555	15615	27789	-2462	4959	-308	-4756	40848	88	39	-4	10	-1	-36	96
9	2.50	4.14	50286	12818	11839	14997	-2372	3866	91434	85	5	44	42	-7	50	219
10	2.75	4.63	32557	499	15881	13547	-233	16230	78481	48	-3	21	14	6	17	103
11	3.00	5.085	27962	2859	7194	11786	-374	9236	58663	74	16	11	38	-8	24	155
12	3.25	5.39			-270	8573	-121	5951	14133			-12	20	6	17	31
13	3.50	6.02	42706	-1354	-322	15396	2837	1726	60989	17	-19	11	29	2	-11	29
14	3.75	6.355	12541	-1128	9359	1466	1057	-551	22744	58	12	44	-20	5	8	107
15	4.00	6.635	22306	3350	10597	-2521	2760	4422	40914	102	12	31	2	15	24	186
16	4.25	7.075	50164	-52	7599	9226	12297	10007	89241	126	-12	3	41	40	22	220
17	4.50	7.365	21734	-1586	761	5646	7941	3063	37559	24	1	2	-2	15	-1	40
18	4.75	7.925	21915	22248	-2511	-705	9960	4223	55130	55	78	-11	-1	22	16	159
19	5.00	8.22	14660	9695	3147	3651	4784	4531	40468	44	-12	32	26	11	15	116
20	5.25	8.595	28633	2999	7603	11650	1002	3490	55377	109	28	8	37	-6	4	180
21	5.50	8.965	34598	15486	2461	9396	-1021	4171	65091	79	55	6	14	0	19	173
22	5.75	9.44	36018	35567	-737	14889	3261	12022	101020	73	94	-8	48	14	32	253
23	6.00	9.92	37627	36130	-1757	17202	7561	16933	113696	84	56	1	23	18	39	221
24	6.25	10.225	32797	16349	-647	11718	3193	18555	81965	131	51	-5	53	3	83	316
25	6.50	10.695	43217	30571	273	14924	1955	29617	120557	53	79	6	10	6	43	197
26	6.75	11.105	9288	20179	7320	1614	4545	15462	58408	-7	19	29	-2	17	32	88
27	7.00	11.48	5751	2699	4179	2848	6335	8083	29895	38	-5	-7	18	17	11	72
28	7.25	11.785	6929	10941	-1296	2775	13010	6585	38944	7	76	-2	1	68	32	182
29	7.50	12.235	9995	29628	-92	1690	16349	15917	73487	37	55	1	7	5	39	144
30	8.00	13.025	20797	48440	3486	6151	7995	28509	115378	16	67	8	9	16	34	150
31	8.50	13.875			3660	30662	56390	15510	105112			1	63	115	3	182
32	9.00	14.65	-74741	112550	4776	37886	42953	16158	139582	-107	71	12	35	-4	39	46
33	9.50	15.37	-62736	56317	1465	12095	49190	23908	80239	-67	85	-7	-2	141	28	178
34	10.00	16.295	-42136	62922	-3218	532	81588	-5114	94575	-24	51	1	2	36	-39	27
35	10.24	16.73	-12449	30509	2129	-2837	28649	2667	48668	-32	89	10	-16	96	51	198
36	10.70	17.58	-26534	42776	3495	6561	35044	21615	80957	-35	11	-1	31	-13	0	-7
37	11.00	18.08	-10579	11938	-1607	12379	-4256	-2494	5381	-8	37	-5	18	-4	-10	28
38	11.50	18.93	-23288	50308	-7248	-822	443	-6682	13711	-47	82	-12	-20	5	-3	5
39	11.80	19.515	-32822	47126	-3747	-9509	2035	2116	5199	-66	80	-1	-12	2	11	14
40	12.20	20.23	-23608	39877	-5058	-12864	729	5208	4284	-1	32	-13	-24	-1	4	-3
		Total	**294400**	**870900**	**68900**	**262100**	**394200**	**328200**	**2218700**	**988**	**1477**	**176**	**490**	**637**	**696**	**4464**
Rate (cubic metres/yr)			21000	67000	23000	131100	197100	164100	69300							

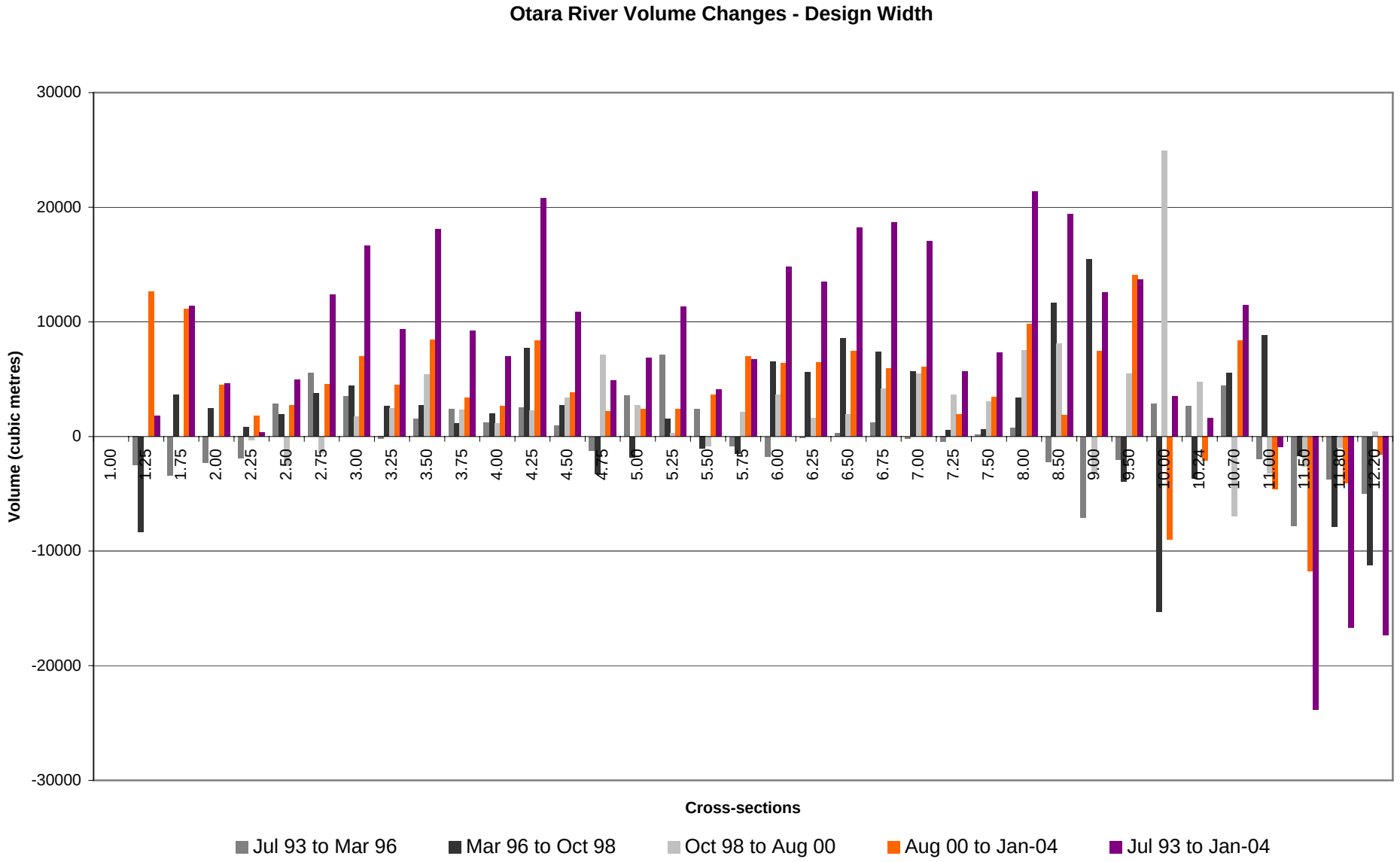
Otara River above confluence

Design width

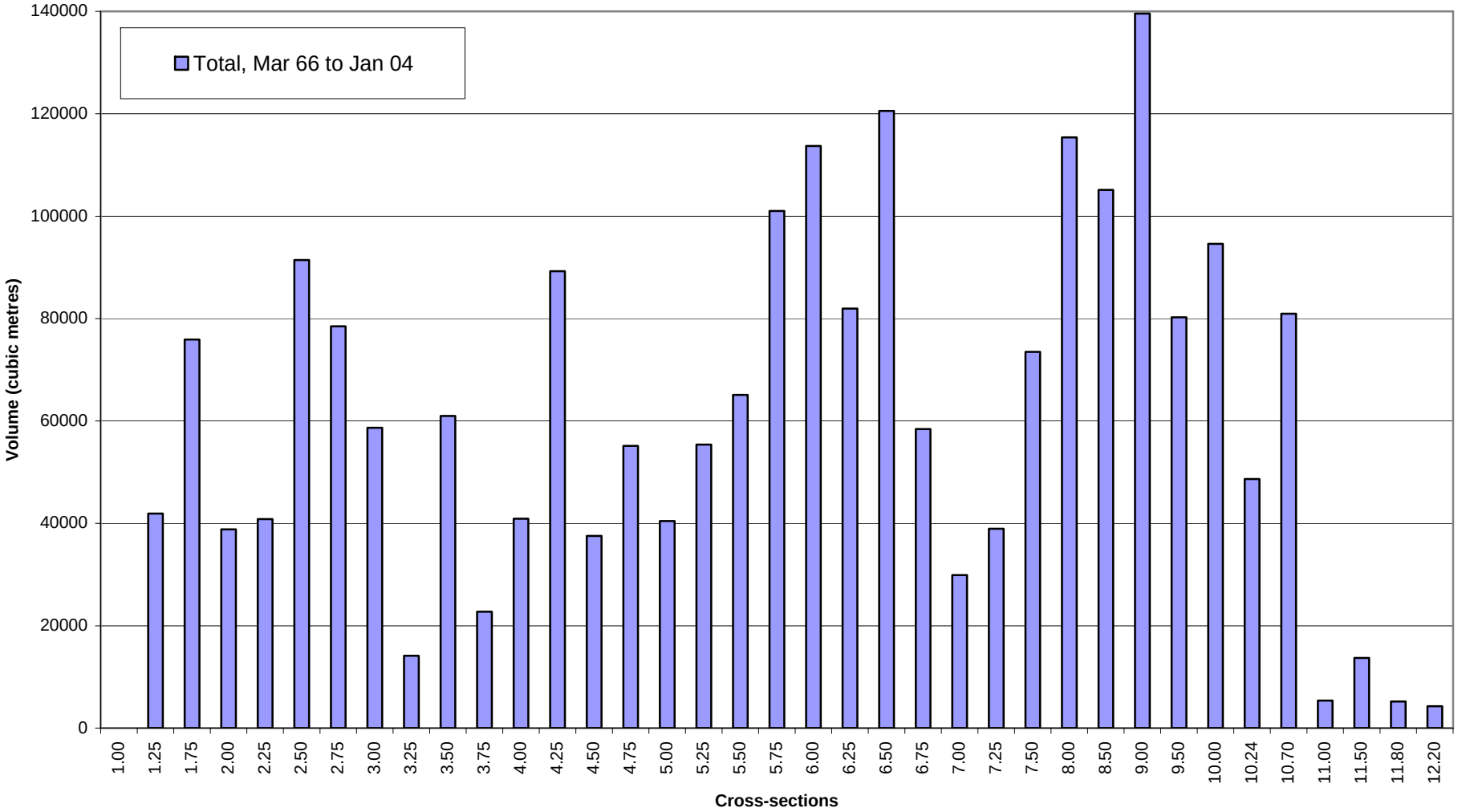
			Volume Change					Area Change				
Section	Label	Upstream dist (km)	Jul 93 to Mar 96	Mar 96 to Oct 98	Oct 98 to Aug 00	Aug 00 to Jan-04	Jul 93 to Jan-04	Jul 93 to Mar 96	Mar 96 to Oct 98	Oct 98 to Aug 00	Aug 00 to Jan-04	Jul 93 to Jan-04
4	1.00	1.57	0	0	0	0	0	-7	-40	0	35	-13
5	1.25	2.025	-2509	-8299	0	12619	1811	-5	4	0	21	20
6	1.75	2.645	-3382	3611	0	11156	11385	-6	7	0	15	16
7	2.00	3.075	-2316	2463	0	4484	4631	-5	4	0	6	5
8	2.25	3.555	-1928	821	-345	1801	349	-4	-1	-1	2	-4
9	2.50	4.14	2816	1956	-2535	2745	4982	13	7	-7	8	21
10	2.75	4.63	5573	3747	-1462	4534	12392	10	8	1	11	30
11	3.00	5.085	3493	4428	1743	7007	16671	5	12	6	20	43
12	3.25	5.38	-205	2639	2452	4464	9350	-7	6	10	10	19
13	3.50	6.02	1554	2709	5435	8407	18105	11	3	6	16	36
14	3.75	6.355	2400	1148	2323	3370	9241	2	5	7	4	18
15	4.00	6.635	1190	1970	1145	2675	6980	6	9	1	15	31
16	4.25	7.075	2511	7681	2244	8366	20802	6	25	10	23	64
17	4.50	7.365	951	2714	3398	3820	10883	1	-7	14	3	11
18	4.75	7.925	-1220	-3240	7125	2196	4861	-5	-5	11	5	6
19	5.00	8.22	3582	-1819	2737	2365	6865	30	-8	8	12	42
20	5.25	8.595	7088	1556	263	2419	11326	8	16	-6	1	19
21	5.50	8.965	2411	-1064	-870	3614	4091	5	-22	2	18	3
22	5.75	9.44	-837	-1503	2096	6996	6752	-8	15	8	11	26
23	6.00	9.92	-1766	6547	3630	6409	14820	1	12	8	15	36
24	6.25	10.225	-112	5613	1567	6436	13504	-2	25	2	27	52
25	6.50	10.695	296	8585	1947	7413	18241	3	12	5	5	25
26	6.75	11.105	1215	7372	4168	5950	18705	2	25	14	24	65
27	7.00	11.48	-174	5682	5485	6035	17028	-4	6	15	8	25
28	7.25	11.785	-484	566	3623	1955	5660	0	-2	9	5	12
29	7.50	12.235	169	620	3068	3445	7302	0	5	4	10	19
30	8.00	13.025	717	3349	7508	9805	21379	2	3	15	15	35
31	8.50	13.875	-2226	11656	8076	1866	19372	-6	24	4	-10	12
32	9.00	14.65	-7078	15431	-3218	7438	12573	-11	16	-13	29	21
33	9.50	15.37	-1994	-3938	5489	14105	13662	5	-26	28	10	17
34	10.00	16.295	2860	-15273	24910	-8992	3505	0	-6	26	-29	-9
35	10.24	16.73	2614	-3678	4744	-2110	1570	11	-10	-4	20	17
36	10.70	17.58	4439	5571	-6929	8361	11442	-2	24	-12	0	10
37	11.00	18.08	-1958	8845	-3214	-4570	-897	-7	12	-1	-18	-14
38	11.50	18.93	-7771	-1728	-2613	-11747	-23859	-12	-15	-6	-9	-42
39	11.80	19.515	-3744	-7901	-970	-4081	-16696	-2	-11	2	-5	-16
40	12.20	20.23	-4985	-11217	418	-1566	-17350	-12	-21	-1	0	-34
		Total	**1200**	**57600**	**83400**	**139200**	**281400**	**16**	**111**	**165**	**331**	**623**

Otara River Volume Changes - Full Width of cross-sections




Otara River Volume Changes - Design Width
Volume (cubic metres)
30000
20000
10000
0
-10000
-20000
-30000
1.00
1.25
1.75
2.00
2.25
2.50
2.75
3.00
3.25
3.50
3.75
4.00
4.25
4.50
4.75
5.00
5.25
5.50
5.75
6.00
6.25
6.50
6.75
7.00
7.25
7.50
8.00
8.50
9.00
9.50
10.00
10.24
10.70
11.00
11.50
11.80
12.20
Cross-sections
Jul 93 to Mar 96
Mar 96 to Oct 98
Oct 98 to Aug 00
Aug 00 to Jan-04
Jul 93 to Jan-04

Otara River Volume Changes 1996 - 2004 - Full width of cross-sections



Waioeka River

Full width of cross-sections

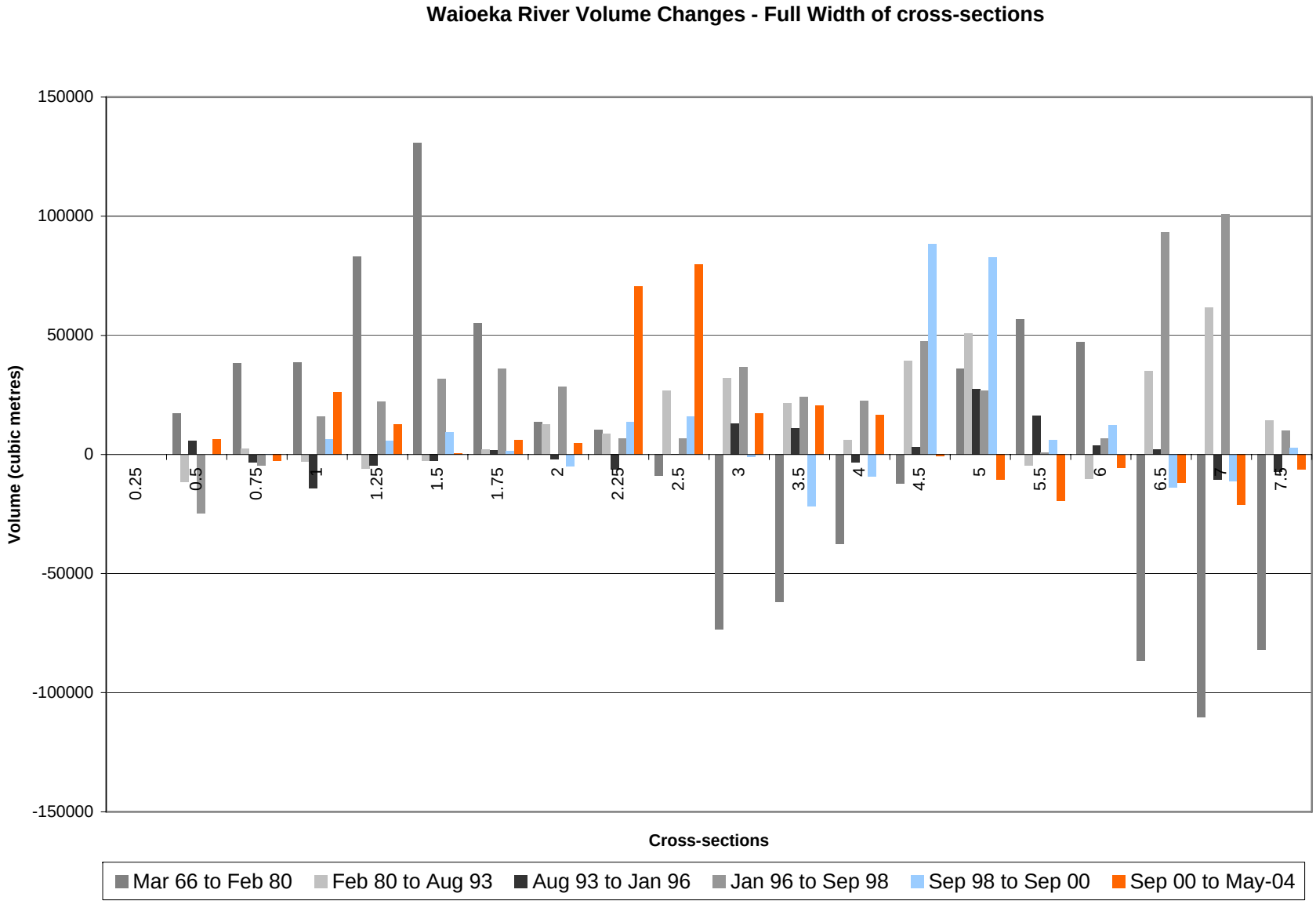
			Volume Change							Area Change						
Section	Label	Upstream dist (km)	Mar 66 to Feb 80	Feb 80 to Aug 93	Aug 93 to Jan 96	Jan 96 to Sep 98	Sep 98 to Sep 00	Sep 00 to May-04	Mar 66 to May-04	Mar 66 to Feb 80	Feb 80 to Aug 93	Aug 93 to Jan 96	Jan 96 to Sep 98	Sep 98 to Sep 00	Sep 00 to May-04	Mar 66 to Sep 00
1	0.25	0.40								0	-64	17	-179	0	68	-226
2	0.5	0.67	17176	-11745	5735	-24630	0	6397	-7067.4	128	-23	25	-4	0	-21	126
3	0.75	1.07	38416	2493	-3322	-4667	-207	-2758	29954.9	67	35	-41	-21	-1	7	39
4	1	1.66	38521	-2975	-14118	15948	6302	26114	69791.6	62	-45	-6	74	22	81	107
5	1.25	2.08	83201	-5950	-4750	22221	5710	12541	112972.5	338	17	-17	33	6	-21	377
6	1.5	2.53	130748	-2735	-2826	31825	9445	346	166803.2	236	-28	4	107	36	22	355
7	1.75	2.92	55073	2102	1898	36006	1378	6181	102637.8	46	40	5	78	-29	10	140
8	2	3.37	13595	12630	-1959	28407	-4853	4824	52643.7	15	17	-14	50	7	12	75
9	2.25	3.76	10299	8698	-6381	6645	13504	70573	103338.2	37	27	-19	-16	61	345	90
10	2.5	4.19	-9034	26965	13	6816	15907	79776	120443.2	-79	98	19	47	13	26	98
11	3	5.02	-73430	32165	12818	36638	-990	17187	24387.7	-98	-21	12	41	-15	16	-81
12	3.5	5.82	-62021	21696	10978	24242	-21885	20463	-6527.2	-57	75	15	20	-39	36	14
13	4	6.67	-37428	5918	-3268	22547	-9320	16619	-4932.3	-31	-62	-22	33	18	4	-64
14	4.5	7.47	-12242	39277	3027	47462	88290	-794	165019.6	1	159	30	85	202	-6	477
15	5	8.33	35814	50975	27341	26668	82621	-10596	212823	83	-39	33	-22	-9	-19	46
16	5.5	9.27	56749	-4753	16158	921	6151	-19585	55641.5	37	30	0	25	21	-22	113
17	6	10.12	47187	-10379	3896	6655	12354	-5616	54096.8	74	-54	9	-9	8	9	28
18	6.5	11.11	-86722	35018	1991	93170	-13907	-12012	17537.6	-249	124	-4	195	-35	-33	31
19	7	11.97	-110287	61657	-10538	100671	-11171	-21171	9161.3	-8	19	-20	39	9	-16	39
20	7.5	12.85	-82039	14117	-7280	10033	2726	-6311	-68754.4	-179	13	3	-16	-3	2	-182
		Total	53576	275174	29413	487578	182055	182175	1209971	423	318	29	560	272	499	1602
Total excl. section 1-2			**36400**	**286919**	**23678**	**512208**	**182055**	**175779**	**1217039**	**423**	**382**	**12**	**739**	**272**	**431**	**1828**

Note: section 1 is close to the river mouth. The position of the mouth can change considerably, without a major change in sediment volume.
For volume analyses, it may be prudent to leave this section out.

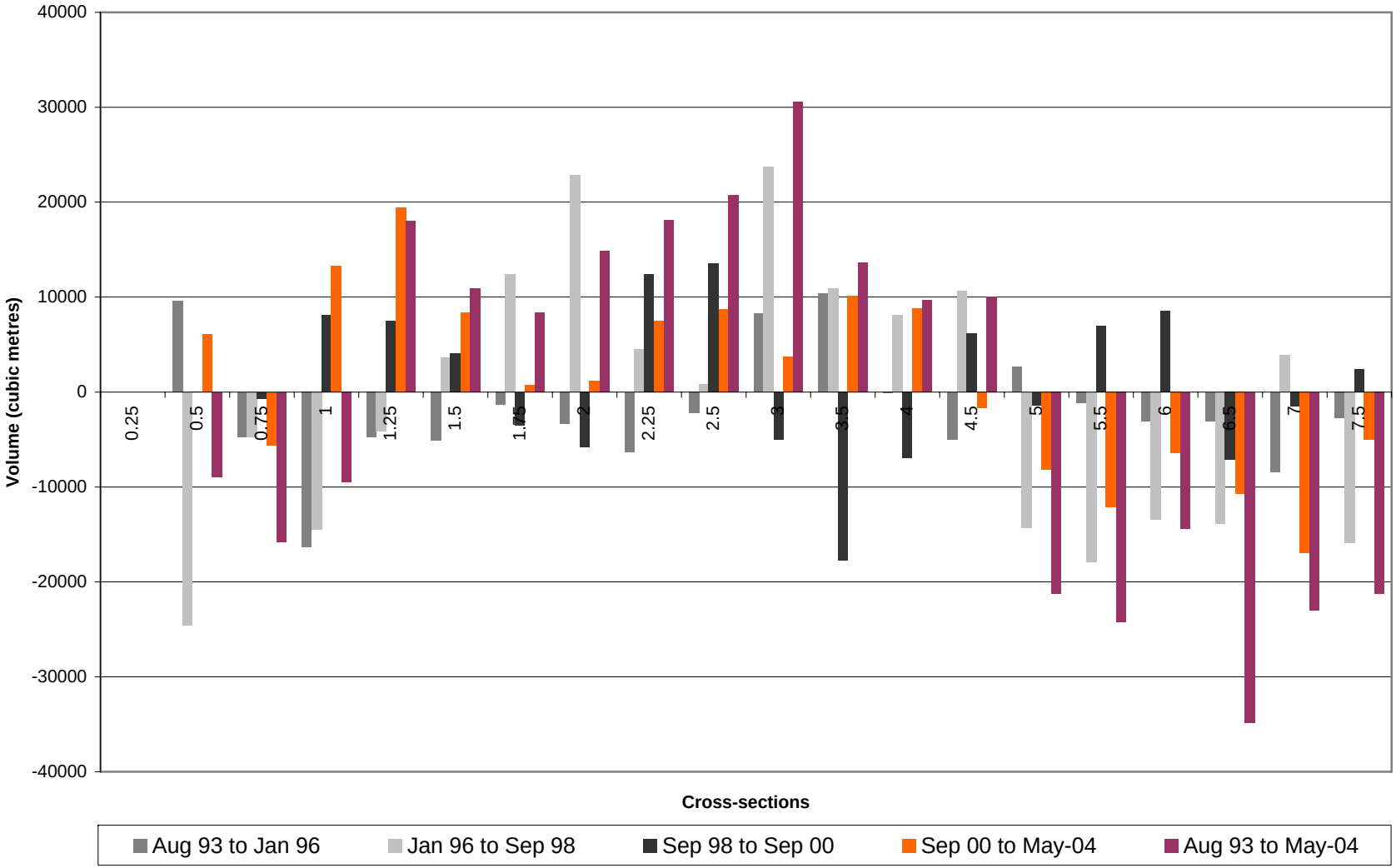
Waioeka River
Design width

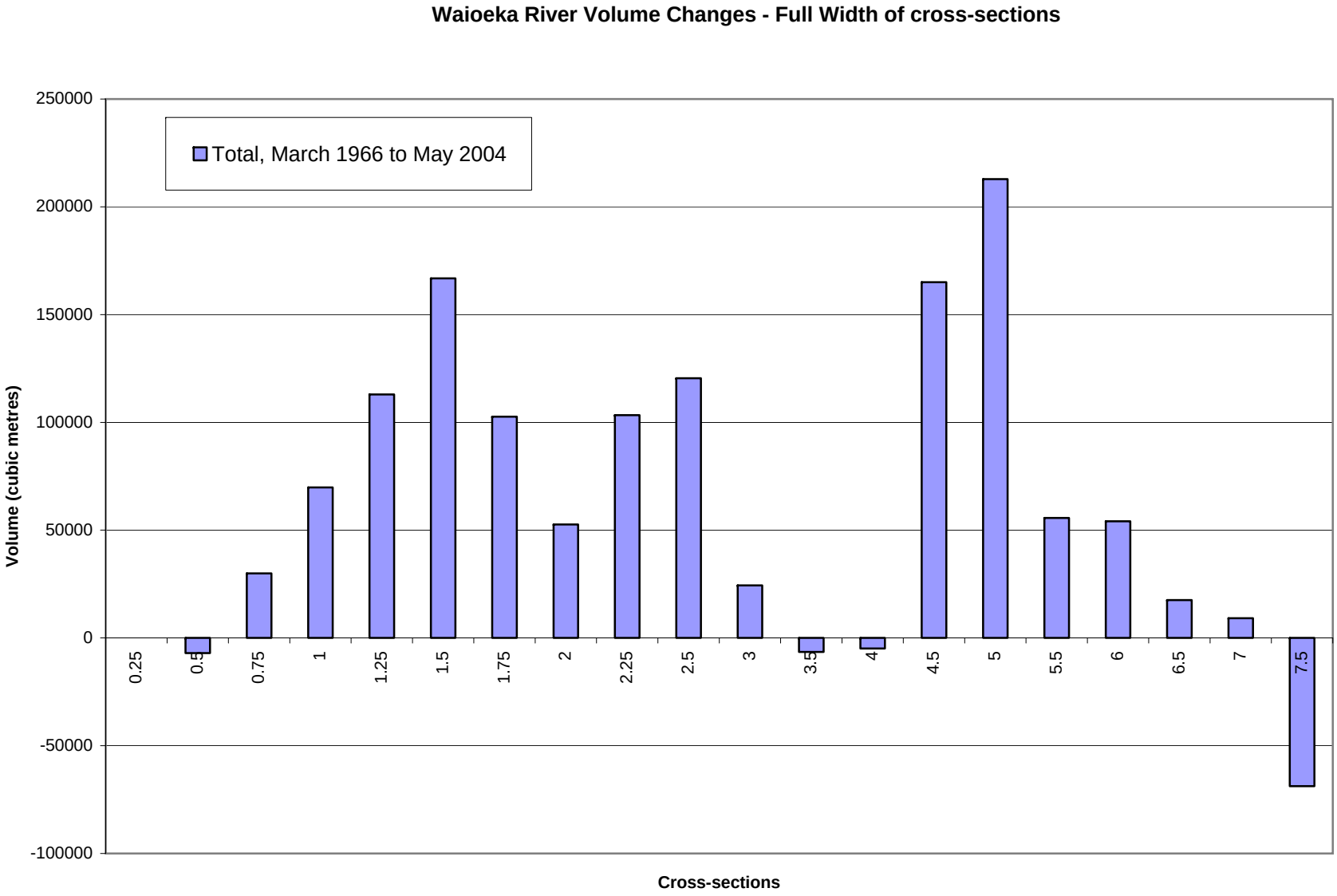
			Volume Change					Area Change				
Section	Label	Upstream dist (km)	Aug 93 to Jan 96	Jan 96 to Sep 98	Sep 98 to Sep 00	Sep 00 to May-04	Aug 93 to May-04	Aug 93 to Jan 96	Jan 96 to Sep 98	Sep 98 to Sep 00	Sep 00 to May-04	Aug 93 to May-04
1	0.25	0.40						46	-179	0	65	-68
2	0.5	0.67	9606	-24610	0	6061	-8943	25	-3	0	-20	2
3	0.75	1.07	-4721	-4764	-700	-5608	-15793	-50	-20	-4	-9	-83
4	1	1.66	-16373	-14540	8118	13261	-9535	-6	-28	31	53	50
5	1.25	2.08	-4750	-4106	7483	19412	18038	-16	8	5	40	37
6	1.5	2.53	-5105	3621	4055	8363	10934	-5	7	13	-4	11
7	1.75	2.92	-1324	12422	-3495	745	8348	-1	56	-30	7	32
8	2	3.37	-3355	22850	-5829	1191	14857	-13	46	4	-2	35
9	2.25	3.76	-6306	4480	12448	7538	18160	-18	-24	59	40	57
10	2.5	4.19	-2239	789	13519	8697	20766	8	28	4	0	40
11	3	5.02	8244	23705	-5041	3715	30623	12	30	-17	9	34
12	3.5	5.82	10371	10886	-17749	10101	13609	14	-3	-28	17	-1
13	4	6.67	-103	8059	-6996	8770	9730	-14	21	12	4	23
14	4.5	7.47	-4983	10620	6146	-1716	10067	2	5	3	-9	2
15	5	8.33	2643	-14302	-1388	-8223	-21270	4	-38	-7	-11	-52
16	5.5	9.27	-1179	-17887	6959	-12164	-24271	-7	0	22	-15	0
17	6	10.12	-3091	-13448	8567	-6431	-14403	0	-33	-1	0	-34
18	6.5	11.11	-3066	-13866	-7155	-10756	-34843	-6	4	-12	-21	-35
19	7	11.97	-8412	3929	-1533	-16960	-22976	-13	5	9	-18	-17
20	7.5	12.85	-2761	-15924	2416	-4994	-21263	8	-41	-4	7	-30
		Total	-36904	-22086	19825	21000	-18165	-30	-159	59	134	4
Total excl. section 1-2			**-46510**	**2524**	**19825**	**14939**	**-9222**	**-76**	**20**	**59**	**70**	**73**

Note: section 1 is close to the river mouth. The position of the mouth can change considerably, without a major change in sediment volume.
For volume analyses, it may be prudent to leave this section out.


Waioeka River Volume Changes - Full Width of cross-sections
150000
100000
50000
0
-50000
-100000
-150000
Volume (cubic metres)
0.25
0.5
0.75
1
1.25
1.5
1.75
2
2.25
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
Cross-sections
Mar 66 to Feb 80
Feb 80 to Aug 93
Aug 93 to Jan 96
Jan 96 to Sep 98
Sep 98 to Sep 00
Sep 00 to May-04

Waioeka River Volume Changes - Design Width




Waioeka River Volume Changes - Full Width of cross-sections
Total, March 1966 to May 2004
Volume (cubic metres)
250000
200000
150000
100000
50000
0
-50000
-100000
0.25
0.5
0.75
1
1.25
1.5
1.75
2
2.25
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
Cross-sections

Waimana River Volume Changes - Full width including floodplain

Section	Ricoda Section	Upstream dist (km)	Area Changes (m^2)								Volume Changes (m^3)							Total
			Aug 92 to Dec 96	Dec 96 to Oct 98	Oct 98 to Nov 99	Nov 99 to Jul 01	Jul 01 to Dec-03	Dec-03 to Sep-04	Sep 04 to Feb 06	Aug 92 to Feb 06	Aug 92 to Dec 96	Dec 96 to Oct 98	Oct 98 to Nov 99	Nov 99 to Jul 01	Jul 01 to Dec 03	Dec-03 to Sep-04	Sep 04 to Feb 06	Aug 92 to Feb 06
1	1	0.43	1	60	4	4	7	15	-2	88	0	0	0	0	0	0	0	0
2	2	0.98	-10	7	1	-4	0	21	0	15	-2737	18477	1460	-76	1736	9745	-578	28028
3	3	1.6	-15	-101	6	0	12	27	4	-67	-7768	-28882	2206	-1186	3460	14957	1381	-15943
4	4	2.61	-5	14	-17	0	1	-50	-3	-61	-10139	-43869	-5834	153	6163	-11802	383	-64946
5	5	3.27	-19	-21	8	-64	31	0	-6	-72	-8090	-2446	-3081	-21187	10295	-16541	-3236	-44286
6	6	4.03	-16	-16	-10	10	8	-2	10	-16	-13438	-13926	-598	-20351	14600	-555	1318	-32950
6a	7	4.83	-82	33	7	27	17	32	1	34	-39241	6787	-805	15148	9866	12021	4110	7886
7	8	5.43	-53	-3	-17	5	7	24	-4	-42	-40572	8892	-2941	9531	6975	16644	-1095	-2666
8	9	6.44	-4	-3	3	7	-1	-11	15	6	-28959	-3151	-7276	5804	2941	6304	5402	-18935
9	10	7.16	-6	13	-1	16	-9	16	-6	24	-3712	3607	591	8225	-3668	1849	3352	10345
10	11	7.79	-1	-9	9	3	0	-5	-3	-6	-2199	1425	2416	5867	-2917	3517	-2572	5537
10a	12	7.99	3	-4	-8	20	-16	-5	20	11	248	-1271	48	2228	-1565	-982	1760	466
11	13	8.49	-7	20	2	-7	-24	31	-6	9	-950	3913	-1531	3190	-9895	6601	3510	4838
12	14	9.08	51	-1	8	-2	1	6	-5	57	13066	5426	3110	-2775	-6784	10887	-3627	19303
13	15	9.74	3	1	10	0	0	1	5	20	17695	-125	5860	-1212	330	2124	-367	24304
14	16	10.4	21	2	-4	1	10	-2	-1	27	7629	985	1823	44	3300	-435	1220	14566
15	17	11.225	19	76	4	10	-17	39	-1	130	16255	32248	182	4430	-2949	15296	-1006	64456
16	18	12.035	-25	51	6	-1	22	19	-11	62	-2764	51629	3892	3737	2311	23374	-4748	77430
17	19	12.95	10	39	2	7	-2	27	15	98	6834	41284	3344	3478	9381	20708	2237	73697
18	20	13.665	13	34	-15	14	6	-52	16	17	8359	26200	-4834	7866	1614	-9147	11337	41394
19	21	14.61	7	22	3	6	-8	12	8	49	9319	26702	-6194	9332	-848	-19151	11486	30647
20	22	15.165	-36	70	15	10	21	21	-7	94	-7874	25401	4764	4385	3469	9025	397	39567
21	23	15.825	37	6	16	7	-25	23	12	76	633	25050	9948	5807	-1363	14445	1748	56168
22	24	17.04	-2	-21	15	5	-13	-7	7	-16	21116	-9031	18347	7819	-23168	9832	11705	36620
23	25	17.815	5	8	-9	6	-12	-26	5	-23	1427	-5367	2502	4687	-9579	-12763	4809	-14284
24	26	18.41	-6	93	-20	-21	-19	-27	-2	-2	-174	29984	-8374	-4388	-8987	-15827	921	-6845
25	27	19.175	-8	-48	-13	2	35	2	15	-15	-5668	17428	-12837	-7390	6361	-9516	4964	-6657
26	28	20.12	-10	21	5	4	-2	-21	-5	-8	-8431	-12680	-4201	2866	15701	-8863	4655	-11013
27	29	20.665	-21	98	32	-2	-12	2	-10	87	-8183	31967	9835	650	-3668	-5079	-4033	21519
28	30	21.495	2	69	2	-13	-13	28	-5	70	-7985	70152	13945	-6355	-10149	12403	-6262	65749
29	31	22.455	-48	1	-90	0	0	26	3	-109	-22014	33628	-42471	12874	-6240	25671	-1148	300
30	32	23.805	37	-20	26	-27	-27	11	-36	-37	-7531	-12044	-43324	9454	-18225	24665	-22686	-69691
31	33	24.945	45	118	-39	-35	-46	-20	-1	22	46936	56000	-7779	-35017	-42061	-4993	-21240	-8145
32	34	25.98	13	38	-9	6	-30	24	5	47	30388	80646	-25072	-15088	-39723	2356	1951	35457
33	35	26.68	-2	51	-11			19	-12	45	4053	31282	-7053			15138	-2387	41033
		Total	**-109**	**698**	**-79**	**-6**	**-99**	**196**	**14**	**614**	**-58300**	**496341**	**-99932**	**12550**	**-93174**	**141806**	**3659**	**402950**

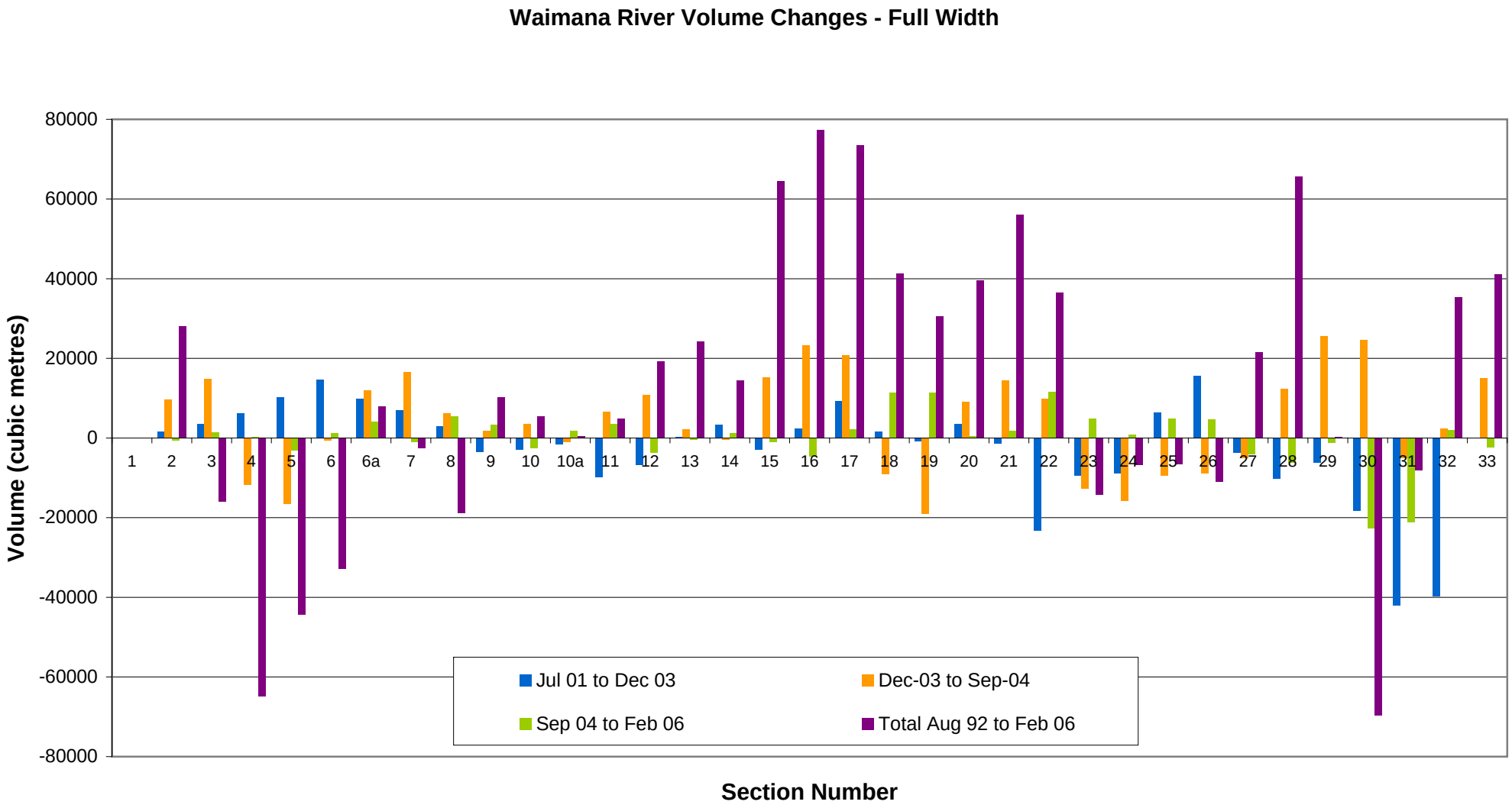
Waimana River Volume Changes - Active Channel

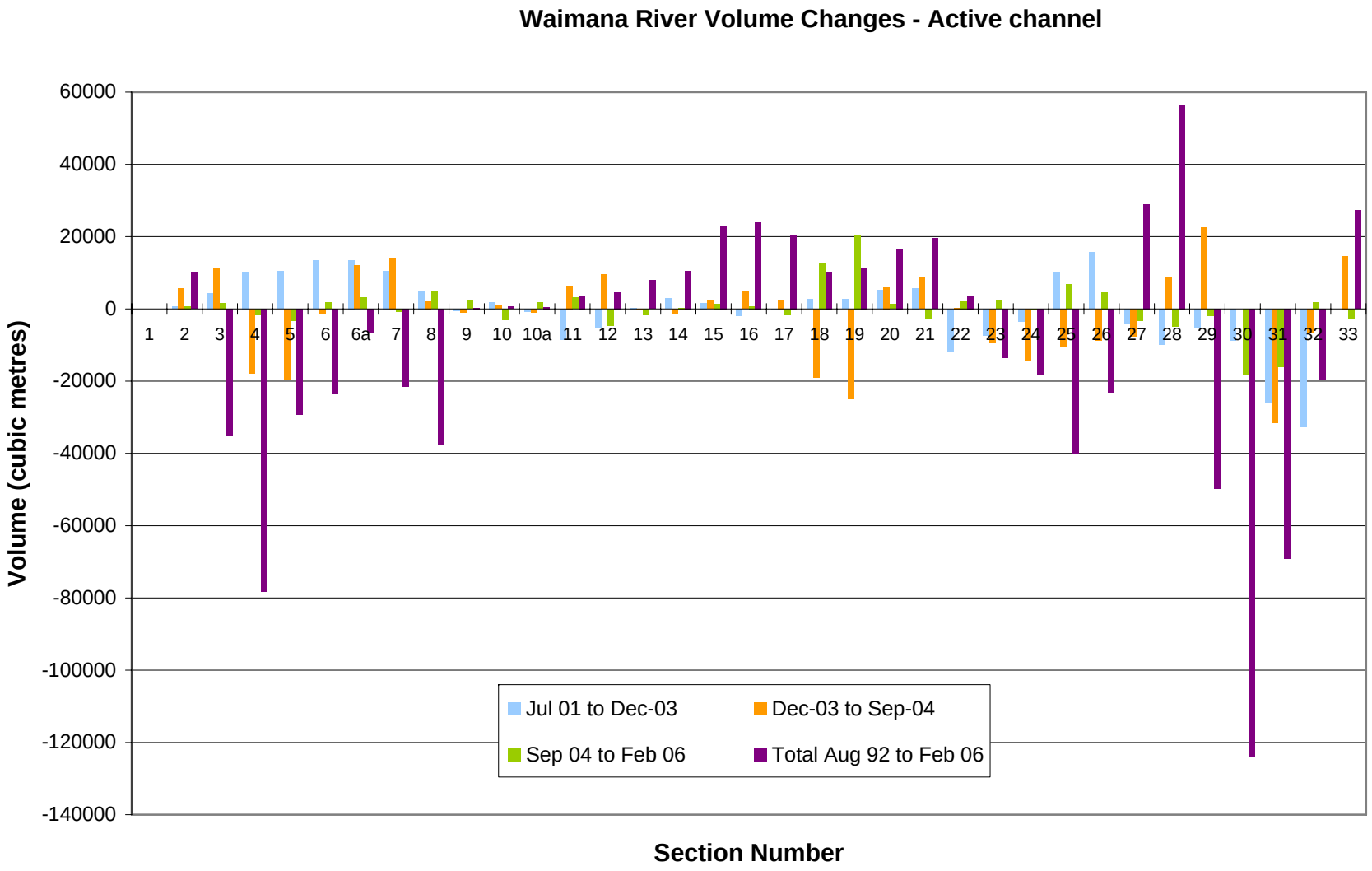
Section	Ricoda Section	Upstream dist (km)	Area Changes (m^2)								Volume Changes (m^3)							Total
			Aug 92 to Dec 96	Dec 96 to Oct 98	Oct 98 to Nov 99	Nov 99 to Jul 01	Jul 01 to Dec-03	Dec-03 to Sep-04	Sep 04 to Feb 06	Aug 92 to Feb 06	Aug 92 to Dec 96	Dec 96 to Oct 98	Oct 98 to Nov 99	Nov 99 to Jul 01	Jul 01 to Dec-03	Dec-03 to Sep-04	Sep 04 to Feb 06	Aug 92 to Feb 06
1	1	0.43	1	26	5	3	4	6	1	46								
2	2	0.98	0	6	2	-7	-2	15	2	16	187	8790	2137	-901	662	5706	729	10213
3	3	1.60	-19	-107	10	0	16	21	4	-76	-5830	-31357	4010	-2136	4350	11211	1613	-36313
4	4	2.61	-3	-23	-14	1	5	-56	-7	-98	-11150	-65510	-1686	93	10342	-17813	-1730	-78063
5	5	3.27	-12	-18	4	-23	27	-3	-3	-28	-5164	-13408	-3048	-7574	10418	-19465	-3268	-29194
6	6	4.03	-13	-8	0	8	8	-1	7	1	-9801	-9541	1308	-5552	13337	-1566	1747	-23568
6a	7	4.83	-56	34	14	4	25	31	1	53	-27749	10697	5478	5117	13506	12026	3133	-6457
7	8	5.43	-41	-10	-18	1	10	16	-3	-45	-29336	7380	-950	1441	10668	14134	-876	-21465
8	9	6.44	-4	-3	-4	4	0	-12	13	-6	-23347	-6139	-10785	2552	4803	2095	4911	-37719
9	10	7.16	-10	9	-1	9	-2	9	-7	7	-4980	2107	-1505	4907	-660	-1087	2237	309
10	11	7.79	-3	-9	8	-2	7	-5	-3	-7	-3729	-60	2161	2235	1832	1093	-3077	607
10a	12	7.99	3	-4	-8	20	-15	-5	20	12	39	-1262	-90	1793	-778	-964	1742	480
11	13	8.49	-5	18	0	-9	-19	30	-8	7	-489	3588	-2097	2408	-6656	6408	3165	3410
12	14	9.08	6	-2	9	0	1	2	-8	8	81	5043	2442	-2949	-5340	9462	-4578	4617
13	15	9.74	3	1	10	0	0	-2	3	14	2662	-125	5860	-415	330	-136	-1730	7882
14	16	10.40	21	2	-4	1	9	-2	-2	25	7629	985	1823	44	2970	-1541	286	10491
15	17	11.23	19	4	1	11	-5	8	5	44	16383	2450	-1052	5285	1645	2417	1495	23066
16	18	12.04	5	15	6	-2	0	4	-3	24	9568	7887	2692	3815	-1949	4748	786	23962
17	19	12.95	10	8	-2	5	-1	2	0	22	6506	11184	1308	1508	-232	2510	-1624	20506
18	20	13.67	8	4	-20	15	8	-55	36	-4	6391	4742	-8153	7357	2683	-19065	12782	10337
19	21	14.61	2	14	-1	1	-3	3	8	23	4574	8581	-9648	7627	2656	-24955	20537	11234
20	22	15.17	-37	67	11	3	21	19	-3	81	-9850	22305	3022	1055	5120	5994	1314	16532
21	23	15.83	0	12	-1	4	-4	7	-5	13	-12093	25862	3398	2348	5737	8585	-2548	19515
22	24	17.04	-8	-14	9	3	-16	-7	8	-24	-4745	-1387	5089	4465	-11932	249	2105	3422
23	25	17.82	0	-46	15	7	-3	-18	-3	-48	-3149	-23396	9361	3747	-7310	-9570	2260	-13437
24	26	18.41	-6	10	-19	-21	-9	-30	3	-72	-1712	-10890	-1395	-4447	-3563	-14327	36	-18384
25	27	19.18	-8	-48	-13	2	35	2	15	-15	-5473	-14527	-12755	-7465	10078	-10692	6711	-40220
26	28	20.12	-10	20	3	6	-2	-21	-5	-9	-8830	-13019	-5127	3840	15701	-8863	4655	-23136
27	29	20.66	-22	81	31	-1	-13	-8	-8	61	-8572	27156	9081	1383	-3926	-7655	-3417	29048
28	30	21.50	3	54	1	-14	-11	29	-4	57	-8061	56760	13650	-6037	-10028	8678	-4863	56312
29	31	22.46	-31	-21	-96	0	0	19	0	-130	-13986	15696	-45363	-6266	-5280	22593	-1983	-49919
30	32	23.81	16	-30	4	-25	-13	-19	-27	-93	-10989	-34410	-61903	-16772	-9775	9	-18405	-124074
31	33	24.95	31	-25	-58	-35	-33	-37	-1	-158	26207	-30747	-30284	-34390	-25854	-31519	-16049	-69214
32	34	25.98	13	39	-10	6	-30	24	5	47	22676	7257	-34679	-15088	-32612	-6636	1950	-19834
33	35	26.68	-1	49	-11			18	-12	43	4326	30285	-7296			14710	-2626	27316
		Total	-148	105	-137	-25	-2	-18	18	-206	-101806	3057	-164945	-47272	-10158	-43120	7390	-310966

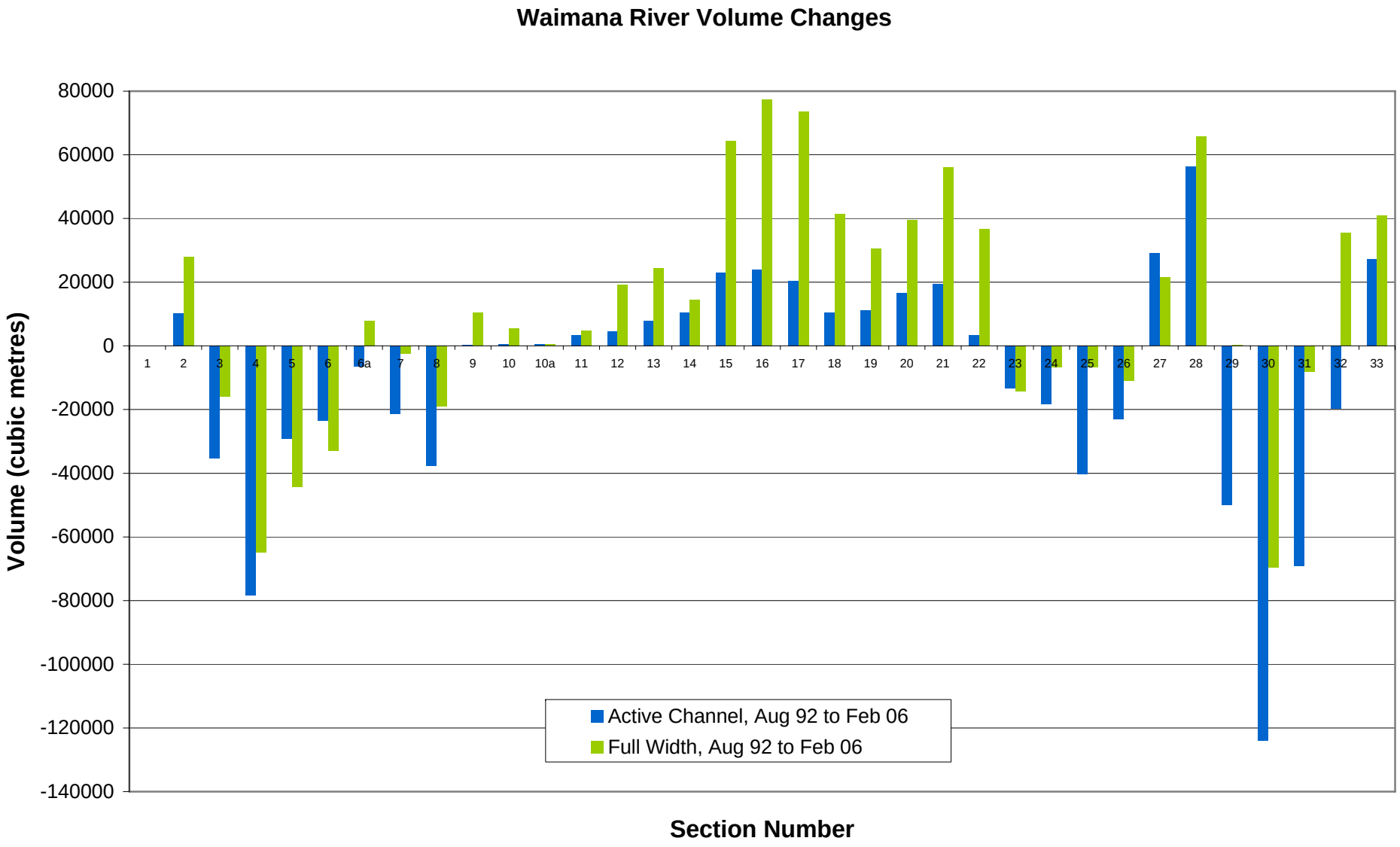
blue indicates where 2001 surveys have been omitted due to incomplete or suspect survey.
It has been assumed that the area change was zero and the volume change accordingly calculated. IP

Waimana River Volume Changes - Floodplain only

Section	Ricoda Section	Upstream dist (km)	Area Changes (m^2)								Volume Changes (m^3)							
			Aug 92 to Dec 96	Dec 96 to Oct 98	Oct 98 to Nov 99	Nov 99 to Jul 01	Jul 01 to Dec-03	Dec-03 to Sep-04	Sep 04 to Feb 06	Aug 92 to Feb 06	Aug 92 to Dec 96	Dec 96 to Oct 98	Oct 98 to Nov 99	Nov 99 to Jul 01	Jul 01 to Dec 03	Dec-03 to Sep-04	Sep 04 to Feb 06	Aug 92 to Feb 06
1	1	0.43	0	34	-1	1	3	9	-4	42	0	0	0	0	0	0	0	0
2	2	0.98	-10	1	-1	3	1	6	-1	-1	-2924	9687	-677	825	1074	4038	-1307	10716
3	3	1.6	4	6	-4	0	-4	6	0	8	-1938	2475	-1804	950	-901	3645	-232	2196
4	4	2.61	-2	37	-3	-1	-4	6	4	37	1011	21641	-4138	60	-4179	6011	2113	22518
5	5	3.27	-7	-3	4	-41	4	3	-3	-44	-2926	10962	-33	-13613	-123	2924	32	-2777
6	6	4.03	-3	-8	-10	2	0	0	2	-17	-3637	-4385	-1906	-14799	1263	1011	-429	-22882
6a	7	4.83	-26	-1	-7	23	-9	0	0	-19	-11432	-3910	-6283	10031	-3640	-5	577	-14322
7	8	5.43	-12	7	1	4	-3	8	-1	4	-11236	1512	-1991	8090	-3692	2510	-219	-4926
8	9	6.44	0	0	7	3	-1	0	2	12	-5612	2988	3509	3252	-1862	4209	491	6976
9	10	7.16	4	4	0	7	-8	8	1	17	1268	1420	2096	3618	-2908	2936	1115	9545
10	11	7.79	2	0	1	5	-7	0	0	1	1530	1486	256	3632	-4749	2423	505	5081
10a	12	7.99	0	0	0	0	0	0	0	0	209	-9	138	435	-787	-18	18	-14
11	13	8.49	-2	2	2	2	-6	1	1	2	-461	325	566	782	-1239	193	345	511
12	14	9.08	45	1	-1	-2	0	4	2	48	12985	383	668	174	-1444	1424	951	15141
13	15	9.74	0	0	0	0	0	3	2	5	15133	0	0	-797	0	2260	1362	17958
14	16	10.4	0	0	0	0	1	0	1	2	0	0	0	0	330	1106	934	2370
15	17	11.225	0	72	3	-1	-12	31	-7	87	-128	29798	1234	-865	-4594	12879	-2471	36863
16	18	12.035	-30	36	0	1	22	15	-7	37	-12332	43742	1200	-78	4259	18625	-6534	49883
17	19	12.95	0	31	4	2	-1	25	15	76	-13340	30100	2036	1970	9613	18197	3860	52436
18	20	13.665	5	30	5	-1	-2	3	-20	21	1968	21458	3319	509	-1089	9918	-1446	34657
19	21	14.61	5	8	4	5	-5	9	0	26	4645	18121	3454	1705	-3503	5804	-9051	21175
20	22	15.165	1	3	4	7	0	2	-4	13	1976	3096	1742	3330	-1660	3031	-917	10608
21	23	15.825	37	-6	17	3	-21	16	17	62	12626	-812	6550	3459	-7100	5860	4297	24880
22	24	17.04	6	-7	6	2	3	0	-1	9	25851	-7644	13258	3354	-11236	9583	9600	42776
23	25	17.815	5	54	-24	-1	-9	-8	8	25	4576	18029	-6859	940	-2269	-3192	2549	13773
24	26	18.41	0	83	-1	0	-10	3	-5	71	1538	40874	-7039	59	-5423	-1500	885	29393
25	27	19.175	0	0	0	0	0	0	0	0	-195	31955	-62	75	-3716	1176	-1747	27466
26	28	20.12	0	1	2	-2	0	0	0	1	339	339	926	-974	0	0	0	630
27	29	20.665	1	17	1	-1	1	10	-2	26	389	4831	754	-733	268	2576	-616	7469
28	30	21.495	-1	15	1	1	-1	-1	-1	13	76	13392	295	-318	-122	3725	-1399	15649
29	31	22.455	-17	22	6	0	0	7	3	21	-8020	17932	2892	19140	-960	3078	835	34889
30	32	23.805	21	10	22	-2	-15	29	-9	57	3458	22366	18579	26226	-9450	24666	-4281	81565
31	33	24.945	14	143	19	0	-14	17	0	180	20728	86747	22506	-627	-16197	26525	-5191	134490
32	34	25.98	0	-1	1	0	0	0	0	0	7712	73089	9607	0	-7111	8892	1	92490
33	35	26.68	-1	2	0			1	1	3	-273	997	242			427	239	1632
		Total	**39**	**593**	**58**	**19**	**-97**	**213**	**-4**	**709**	**43506**	**493284**	**65013**	**59822**	**-83016**	**184927**	**-3731**	**661625**


Waimana River Volume Changes - Full Width
Volume (cubic metres)
80000
60000
40000
20000
0
-20000
-40000
-60000
-80000
1
2
3
4
5
6
6a
7
8
9
10
10a
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
Jul 01 to Dec 03
Dec-03 to Sep-04
Sep 04 to Feb 06
Total Aug 92 to Feb 06
Section Number


Waimana River Volume Changes - Active channel
Volume (cubic metres)
60000
40000
20000
0
-20000
-40000
-60000
-80000
-100000
-120000
-140000
1 2 3 4 5 6 6a 7 8 9 10 10a 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33
Jul 01 to Dec-03
Dec-03 to Sep-04
Sep 04 to Feb 06
Total Aug 92 to Feb 06
Section Number


Waimana River Volume Changes
Volume (cubic metres)
80000
60000
40000
20000
0
-20000
-40000
-60000
-80000
-100000
-120000
-140000
1
2
3
4
5
6
6a
7
8
9
10
10a
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
Active Channel, Aug 92 to Feb 06
Full Width, Aug 92 to Feb 06
Section Number

Whakatane River Volume Changes above Pekatahi

		Full width											
		Area Change (m^2)						Volume Change (m^3)					
Section number	Distance (km)	Apr 98 to Dec 98	Dec 98 to Sep 00	Sep 00 to Jul 02	July 02 to Jun 03	Jun 03 to Aug 04	Aug 04 to Jan 06	Apr 98 to Dec 98	Dec 98 to Sep 00	Sep 00 to Jul 02	July 02 to Jun 03	Jun 03 to Aug 04	Aug 04 to Jan 06
25a *	18.19	90	9	0	-3	30	16	0	0	0	0	0	0
26 *	19.01	32	65	0	7	12	7	50302	30465	0	1434	17117	9051
27	19.72	-48	12	11	-57	-74	60	-5352	27330	3891	-17722	-22216	23509
28	20.595	52	3	11	2	23	-11	2320	6377	9734	-23857	-22628	21373
29	21.355	162	6	17	-1	23	-15	81604	3144	11012	352	17172	-9989
30	22.515	51	16	14	3	20	-16	123410	12290	18731	808	24478	-18085
31	23.285	91	-7	-70	-6	41	-2	54787	3299	-21506	-1359	23349	-6943
32	23.515	44	31	5	-22	33	-23	15694	2706	-7546	-3200	8520	-2919
33b	24.05	119	16	13	-1	25	-16	43716	12388	4680	-6069	15607	-10471
34	24.53	4	0	3	3	-14	14	29441	3831	3795	504	2785	-491
35	25.12	2	5	12	8	21	-6	1727	1550	4444	3149	2075	2507
36	25.601	20	0	23	2	8	-3	5226	1264	8514	2381	6818	-2090
37	26.185	65	-43	8	7	16	4	24949	-12620	9214	2796	6984	226
38	26.61	-16	15	-16	5	-48	76	10345	-5869	-1804	2587	-6708	16944
39	27.235	-58	-29	7	-11	12	19	-23361	-4186	-2957	-2005	-11352	29604
40	28.025	52	4	-2	-3	-8	14	-2413	-9790	1922	-5641	1608	13093
41	28.58	-164	-4	3	-8	-18	19	-31155	120	340	-2935	-7007	9185
42	29.55	0	-1	6	6	36	14	-79648	-2161	4381	-623	8876	15710
43	30.06	1	-16	25	2	-10	-29	213	-4134	7629	2156	6537	-3994
44	30.785	47	-2	34	11	-5	31	17504	-6463	21210	4814	-5379	653
45	31.63	77	8	14	-6	115	-46	52513	2328	20085	2130	46753	-6320
46	32.17	-18	-3	37	-27	1	10	16006	1194	13692	-8925	31341	-9600
47	32.66	-10	-27	5	-27	-41	22	-6788	-7552	10599	-13218	-9710	7851
48	33.405	63	-53	13	-14	57	6	19864	-29950	6934	-15238	5982	10290
49	33.715	55	-3	-12	-6	69	-23	18336	-8650	27	-3090	19427	-2658
50	34.44	-101	-94	14	-4	171	24	-16704	-35299	710	-3496	86912	380
51	34.955	173	37	-42	-7	-54	15	18380	-14869	-6967	-2697	30063	10111
52	35.695	13	-15	-16	-33	36	-59	68815	7894	-21082	-14739	-6662	-16096
53	36.635	46	15	1	-54	8	-3	27872	124	-7015	-40614	20974	-29157
54	37.275	-8	39	-2	-68	-50	-12	11806	17536	-265	-38963	-13253	-4871
55	38.675	168	9	-11	-13	80	11	111556	33612	-8638	-56691	21028	-855
56	39.475	63	19	9	-22	73	-88	92435	11156	-511	-14011	61122	-30795
57	40.26	108	9	5	3	-28	7	66983	11116	5656	-7608	17550	-31597
58	41.66	0	0	0	0	0	0	75503	6556	3273	0	0	0
	Total	**1114**	**109**	**88**	**-333**	**559**	**15**	**875886**	**54737**	**92182**	**-259589**	**378162**	**-16444**

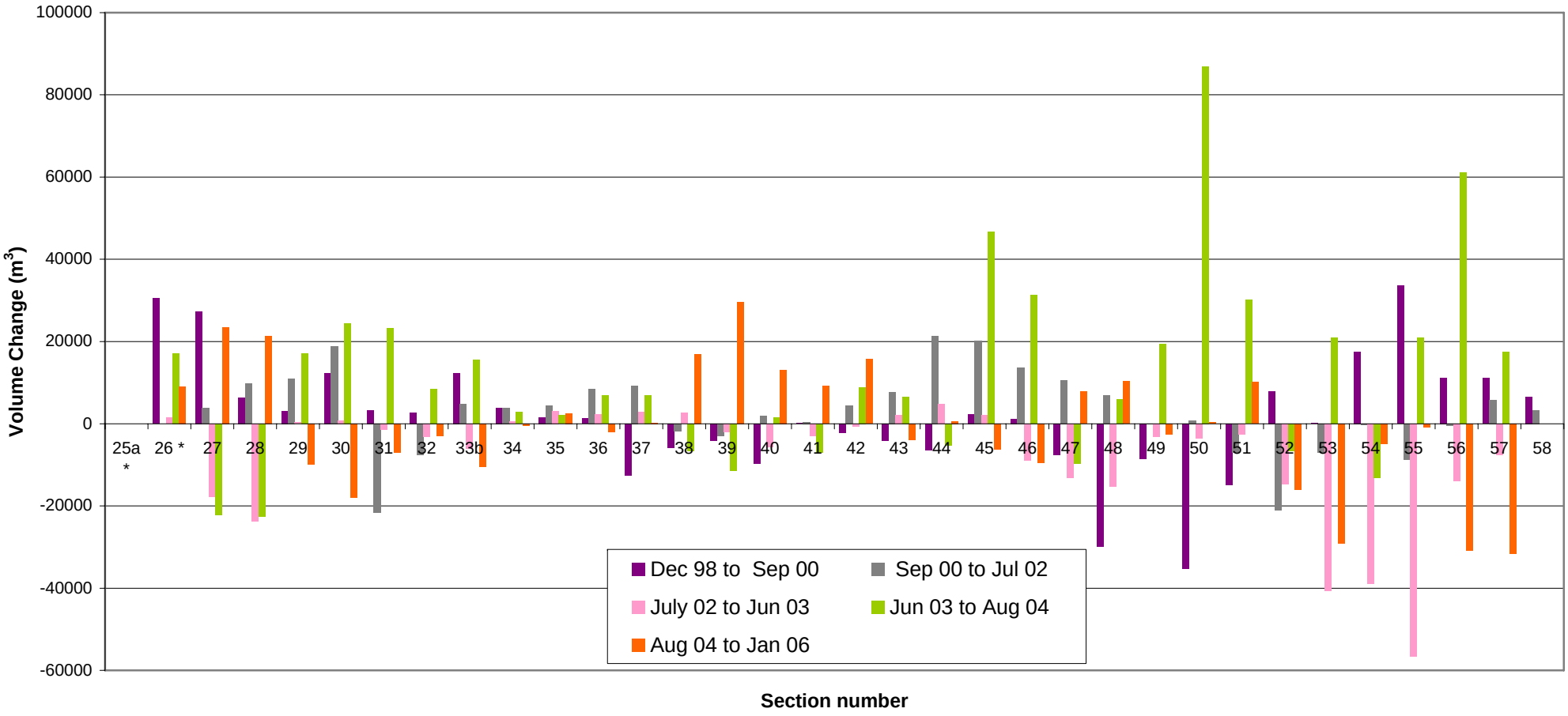
* Note: Section 25a and 26 have not been surveyed in July 2002. Volume changes therefore refer to period 2000-2003. IP

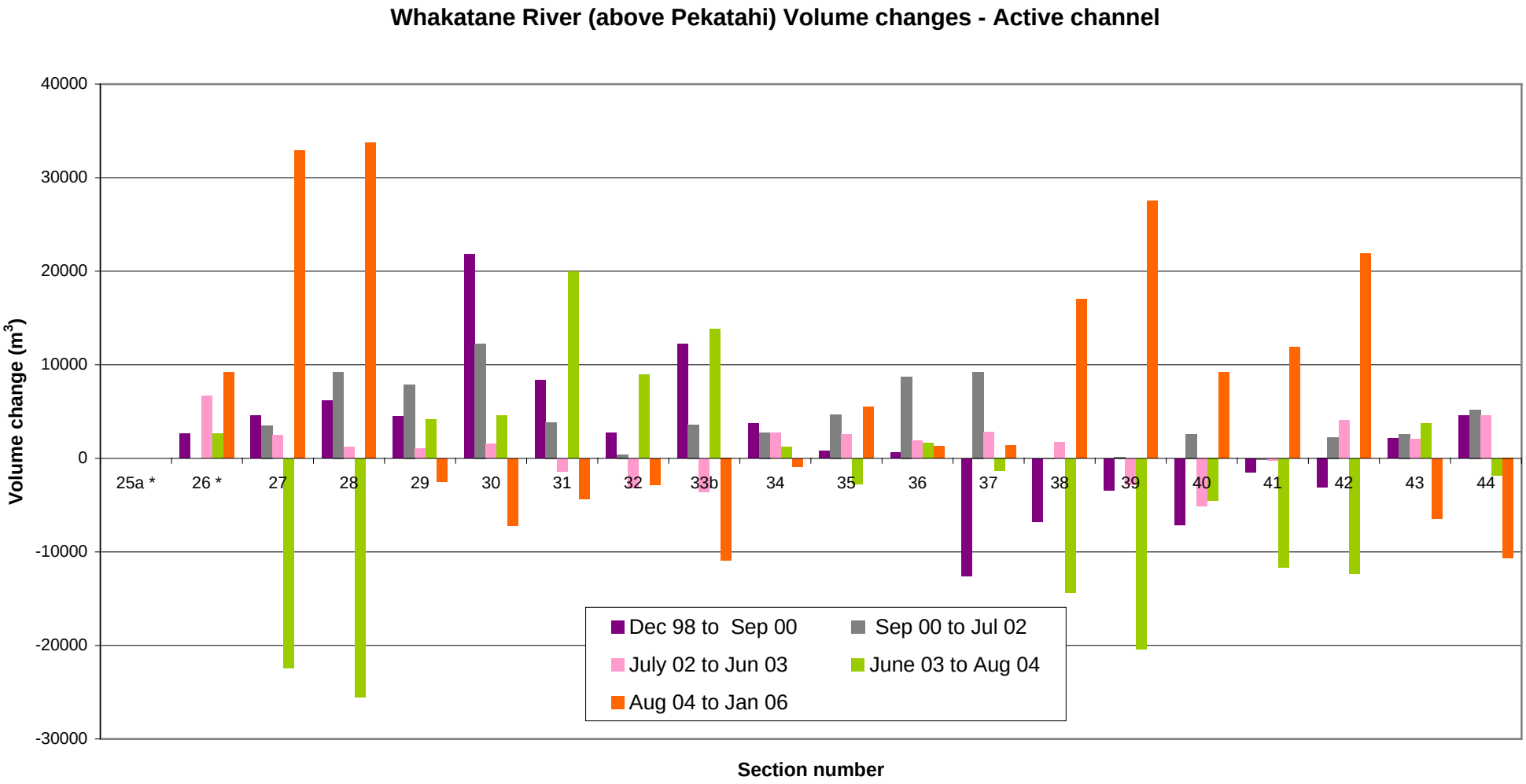
Whakatane River Volume Changes above Pekatahi

		Active Channel												
		Area Change (m^2)						Volume Change (m^3)						
Section number	Distance (km)	Apr 98 to Dec 98	Dec 98 to Sep 00	Sep 00 to Jul 02	July 02 to Jun 03	June 03 to Aug 04	Aug 04 to Jan 06	Apr 98 to Dec 98	Dec 98 to Sep 00	Sep 00 to Jul 02	July 02 to Jun 03	June 03 to Aug 04	Aug 04 to Jan 06	Apr 98 to Jan 06
25a *	18.19	12	5	0	10	2	11	0	0	0	0	0	0	0
26 *	19.01	19	1	0	7	4	12	12691	2637	0	6694	2654	9159	33835
27	19.72	-27	12	10	0	-67	81	-2676	4579	3514	2455	-22417	32880	18335
28	20.595	17	3	11	3	9	-4	-4188	6210	9185	1243	-25489	33712	20673
29	21.355	4	9	9	0	2	-3	7873	4502	7822	1058	4140	-2510	22885
30	22.515	37	28	12	2	6	-10	23820	21783	12215	1519	4602	-7174	56765
31	23.285	56	-7	-2	-6	46	-2	35865	8313	3816	-1434	19977	-4334	62203
32	23.515	32	31	5	-22	32	-23	10160	2712	388	-3199	8913	-2854	16120
33b	24.05	49	15	8	8	20	-18	21611	12249	3527	-3549	13841	-10937	36741
34	24.53	5	0	3	3	-15	14	12619	3727	2712	2762	1242	-909	22152
35	25.12	-10	3	12	6	5	5	-1772	763	4644	2564	-2784	5522	8938
36	25.601	7	0	23	2	2	1	-833	622	8685	1904	1675	1295	13348
37	26.185	45	-43	8	7	-6	4	15150	-12620	9218	2796	-1356	1352	14540
38	26.61	-1	11	-8	1	-61	76	9373	-6765	-36	1762	-14368	16971	6937
39	27.235	-121	-22	9	-10	-4	12	-38086	-3417	153	-2822	-20418	27485	-37105
40	28.025	12	4	-2	-3	-8	11	-43311	-7153	2554	-5144	-4550	9226	-48379
41	28.58	-137	-10	2	2	-34	32	-34956	-1495	-121	-248	-11645	11929	-36537
42	29.55	52	3	3	6	9	14	-41402	-3139	2254	4075	-12337	21907	-28642
43	30.06	21	5	7	2	6	-39	18587	2150	2599	2013	3704	-6405	22649
44	30.785	29	7	7	11	-11	9	18026	4609	5148	4582	-1814	-10688	19863
45	31.63													
46	32.17													
47	32.66													
48	33.405													
49	33.715													
50	34.44													
51	34.955													
52	35.695													
53	36.635													
54	37.275													
55	38.675													
56	39.475													
57	40.26													
58	41.66													
	Total	**101**	**55**	**117**	**30**	**-64**	**183**	**18551**	**40267**	**78277**	**19029.6**	**-56430**	**125626**	**225321**

* Note: Section 25a and 26 have not been surveyed in July 2002. Volume changes therefore refer to period 2000-2003. IP

Whakatane River (above Pekatahi) Volume Changes - Full Width




Whakatane River (above Pekatahi) Volume changes - Active channel
Volume change (m3)
40000
30000
20000
10000
0
-10000
-20000
-30000
25a *
26 *
27
28
29
30
31
32
33b
34
35
36
37
38
39
40
41
42
43
44
Dec 98 to Sep 00
Sep 00 to Jul 02
July 02 to Jun 03
June 03 to Aug 04
Aug 04 to Jan 06
Section number

Whakatane River below Pekatahi - Full Width

Initial calculation on full width of surveyed sections (first survey 1963-70)

1963 sections used where possible - available from section 15 up - 1970 otherwise

Question marks where change of alignment makes comparison unrepresentative

	Upstream	Area Change (m^2)									Volume Change (m^3)								
Section	dist (km)	63/70-77	77-84	84/77-92	92/84-93	93-96	96-98	98-2003	2003-04	63/70-04	63/70-77	77-84	84/77-92	92/84-93	93-96	96-98	98-2003	2003-04	63/70-04
1	0	185	-24		-321	98	274	-534	-1	-323	0	0		0	0	0	0	0	0
1a	0.265	46	26		-20	-62	-40	49	-144	-144	30509	227		-45058	4766	31037	-64203	-19190	-61911
2	0.82	15	13		15	-20	-12	73	-117	-33	16882	10858		-1408	-22582	-14508	34038	-72424	-49144
2b	1.195	-47	16	-80	17	22	-117	55	-192	-326	-6053	5430	-14945	6019	508	-24314	23992	-57937	-67300
2a	1.67	0	0	-87	-4	-20	-102	45	-79	-247	-11253	3651	-39620	3200	467	-51987	23757	-64365	-136151
3	2.195	49	0	-11	-22	0	-59	41	-76	-78	12689	0	-25907	-6682	-5222	-42327	22661	-40678	-85465
3a	2.735	-66	-42	18	-13	17	-128	91	-63	-186	-4684	-11291	1603	-9406	4810	-50591	35607	-37523	-71475
3b	3.2	60	-25	-8	-11	6	-47	49	-109	-85	-1497	-15587	2295	-5692	5380	-40668	32497	-40100	-63372
4	4.09	40	-39	-20	-8	-6	-64	37	16	-43	44263	-28330	-12411	-8658	-165	-49331	38309	-41223	-57546
5	4.55	3	-52	0	24	10	-87	59	-266	-309	9758	-20740	-4572	3601	773	-34547	22210	-57310	-80827
6	4.96	34	0	-41	-10	-7	-56	51	-233	-262	7560	-10606	-8303	2846	526	-29205	22647	-102169	-116704
6a	5.415	9		-21	-21	19	-23	12	-58	-84	9770		-14009	-7120	2799	-18121	14287	-66143	-78536
7	5.95	-36		37	-25	18	-27	35	-61	-60	-7450		4522	-12359	9778	-13495	12332	-31886	-38558
7/1a	6.31	23		-36	-12	18	-16	-5	-7	-35	-2378		334	-6615	6313	-7657	5382	-12263	-16883
8a	6.845	-13		-33	-19	36	-1	-1	-19	-50	2865		-18399	-8355	14470	-4467	-1598	-6875	-22358
10a	7.48	145		-73	32	-22	-43	22	-21	40	42101		-33675	4102	4419	-13886	6613	-12572	-2899
10b	7.92	-2		53	-51	60	-44	9	-19	6	31434		-4321	-4112	8172	-19056	6845	-8862	10100
11	8.395	134		-49	-60	-12	60	3	-20	56	31243		1094	-26241	11155	3899	2736	-9242	14644
12	8.98	-67		17	-23	-8	2	-5	18	-67	19472		-9057	-24345	-6033	18229	-799	-500	-3032
13	9.485	54		-22	-23	-6	-12	24	-11	4	-3331		-949	-11784	-3553	-2485	4722	1744	-15636
14	9.885	16		-6	36	6	-29	19	-27	15	13975		-5448	2668	-36	-8181	8537	-7563	3952
15	10.445	5		-19	-24	-15	16	-12	-14	-63	5876		-6861	3448	-2731	-3696	1839	-11358	-13483
16	10.915	81		-66	21	14	2	28	-14	66	20312		-20047	-507	-459	4151	3795	-6518	727
17	11.525	-299		147	-11	34	70	-10	-8	-77	-66536		24562	3517	14558	21634	5733	-6882	-3414
17a	11.78	101		17	13	4	69	3	20	227	-25336		20905	410	4829	17661	-789	1475	19156
18	12.535	110		30	35	16	-32	14	80	254	79361		17885	18090	7732	13883	6581	37854	181386
19	13.23	50		74	-12	17	-74	5	-14	46	55592		36104	8027	11650	-37210	6532	23120	103815
20	14.05	196		-32	-5	-10	28	19	26	221	100910		17312	-6926	3101	-19155	9473	4993	109707
21	14.53	98		27	3	-18	-2	18	-7	119	70521		-1050	-648	-6469	6294	8805	4496	81949
22	15.02	296		?	-1	-24	31	10	6	319	96680		?	393	-10180	7267	6975	-227	100908
23	15.685	123		9	-18	18	34	17	-6	177	139365		?	-6494	-1916	21545	8957	109	161566
23a	16.275	155		-43	-27	11	14	11	2	124	81867		-9745	-13629	8718	14035	8266	-1053	88459
24	16.89	78		38	-4	6	44	-6	2	158	71681		-1429	-9631	5122	18000	1782	1315	86839
24a	17.29	?		78	7	32	70	-37	0	150	?		23282	709	7475	22920	-8471	398	46314
25	17.71	587		-125	10	-20	380	6	88	926	?		-9659	3469	2554	94565	-6519	18511	102922
Total (excl.XS1)		**1978**	**-103**	**-227**	**-211**	**114**	**-195**	**729**	**-1324**	762	**866168**	**-66388**	**-90509**	**-155171**	**80729**	**-189767**	**303532**	**-620845**	**127749**

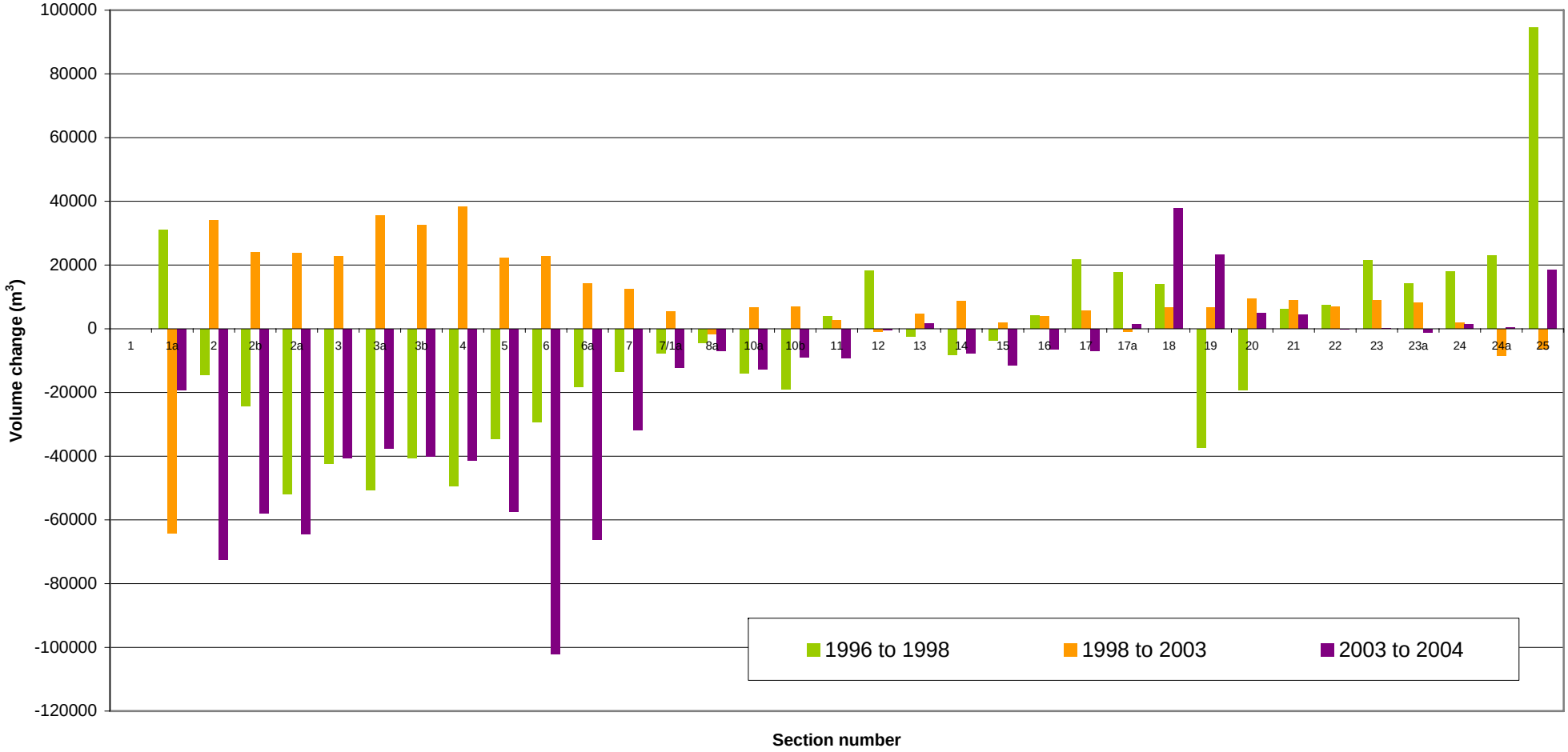
Whakatane River below Pekatahi - Active Channel

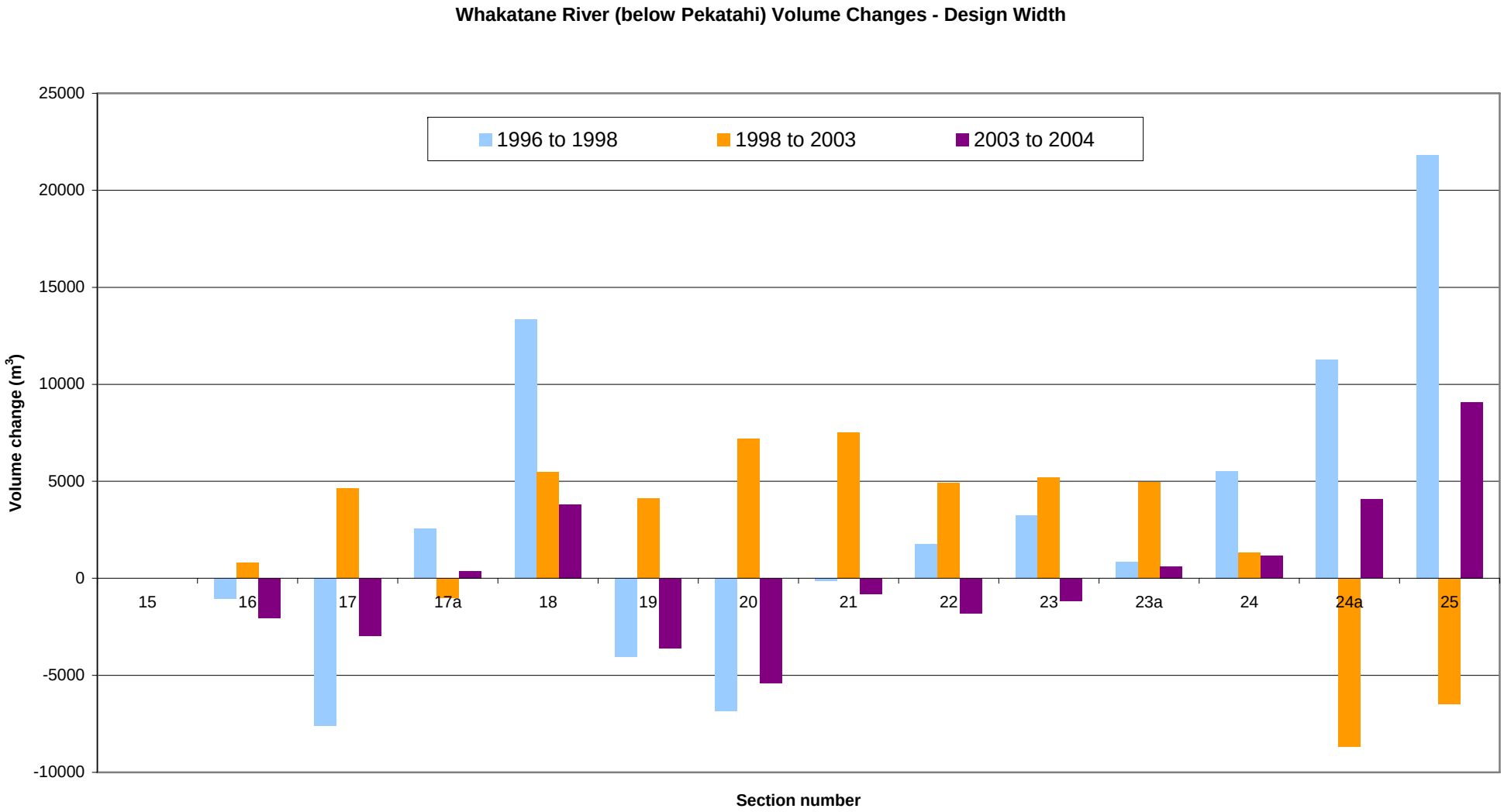
Active Channel above cross-section 15 (approx phase change from gravel to sand bed)

(Note: cross-sections 17 and 24a omitted from 1962-1977 analysis due to channel alignment changes)

		Area Change (m^2)											Volume Change (m^3)											
Section	Upstream dist (km)	63-77	77-85	85-90	90-93	93-96	96-98	77-98	63-98	98-03	2003-04	63-04	63-77	77-85	85-90	90-93	93-96	96-98	77-98	63-98	77-03	63-03	98-03	2003-04	63-04
15	10.445	74	-36	7	-24	-9	10	-52	22	-23	-3	-4	0	0	0	0	0	0	0	0	0	0	0	0	0
16	10.915	19	-78	12	21	12	-15	-48	-29	26	-5	-8	21826	-26616	4362	-807	721	-1056	-23396	-1570	-22573	-747	823	-2046	-2793
17	11.525		20	7	-11	21	-11	34	34	-11	-4	19		-14705	5510	3310	9747	-7507	-3797		636	4633	4633	-2960	-2124
17a	11.780	-24	-69	-16	14	20	31	-19	-43	3	7	-33	-2447	-5044	-1292	552	5214	2544	1974	-4270	961	-5293	-1013	368	-1110
18	12.535	29	18	10	15	13	5	81	90	12	3	105	1677	-18961	-2505	11341	12592	13332	15799	17476	21291	22968	5492	3818	26785
19	13.230	10	-17	23	-9	14	-16	-5	5	0	-13	-8	13479	452	11468	2317	9316	-4052	19502	32981	23613	37092	4111	-3591	33500
20	14.050	-4	-50	47	-6	-10	-1	-20	-24	17	0	-7	2382	-27059	28698	-6317	1586	-6061	-9953	-7571	-2741	-359	7212	-5419	-5778
21	14.530	12	-15	2	-3	4	-1	-13	-1	14	-3	10	1887	-15482	11641	-2276	-1397	-130	-7652	-5765	-139	1748	7513	-813	935
22	15.020	90	-58	-13	-11	15	7	-60	30	6	-4	32	24913	-17772	-2835	-3468	4722	1749	-17604	7309	-12701	12212	4903	-1815	10397
23	15.685	17	-14	8	-17	8	2	-13	4	10	1	14	35437	-23722	-1572	-9301	7657	3233	-23705	11732	-18493	16944	5212	-1191	15753
23a	16.275	44	-6	-15	-28	27	1	-21	23	7	2	32	18027	-5891	-1736	-13324	10329	862	-9760	8267	-4809	13218	4951	617	13835
24	16.890	2	-8	8	-3	9	17	23	25	-3	2	24	14379	-4300	-2027	-9577	11097	5538	721	15100	2039	16418	1318	1148	17566
24a	17.280		-106	120	7	-1	39	59	59	-41	18	37		-22690	25467	848	1540	11265	16430		7737	-8693	-8693	4080	11817
24/25	17.710	-43	0	0	68	-16	65	117	74	10	25	109	-16586	-22015	25098	15788	-3644	21831	37058	38902	30578	30422	-6480	8082	23074
	Total	**226**	**-410**	**200**	**13**	**107**	**133**	**43**	**269**	**28**	**24**	**321**	**118974**	**-203885**	**100286**	**-10914**	**69470**	**40660**	**-4383**	**110591**	**25599**	**140573**	**29982**	**1277**	**141849**

Whakatane River (below Pekatahi) Volume Changes - Full Width

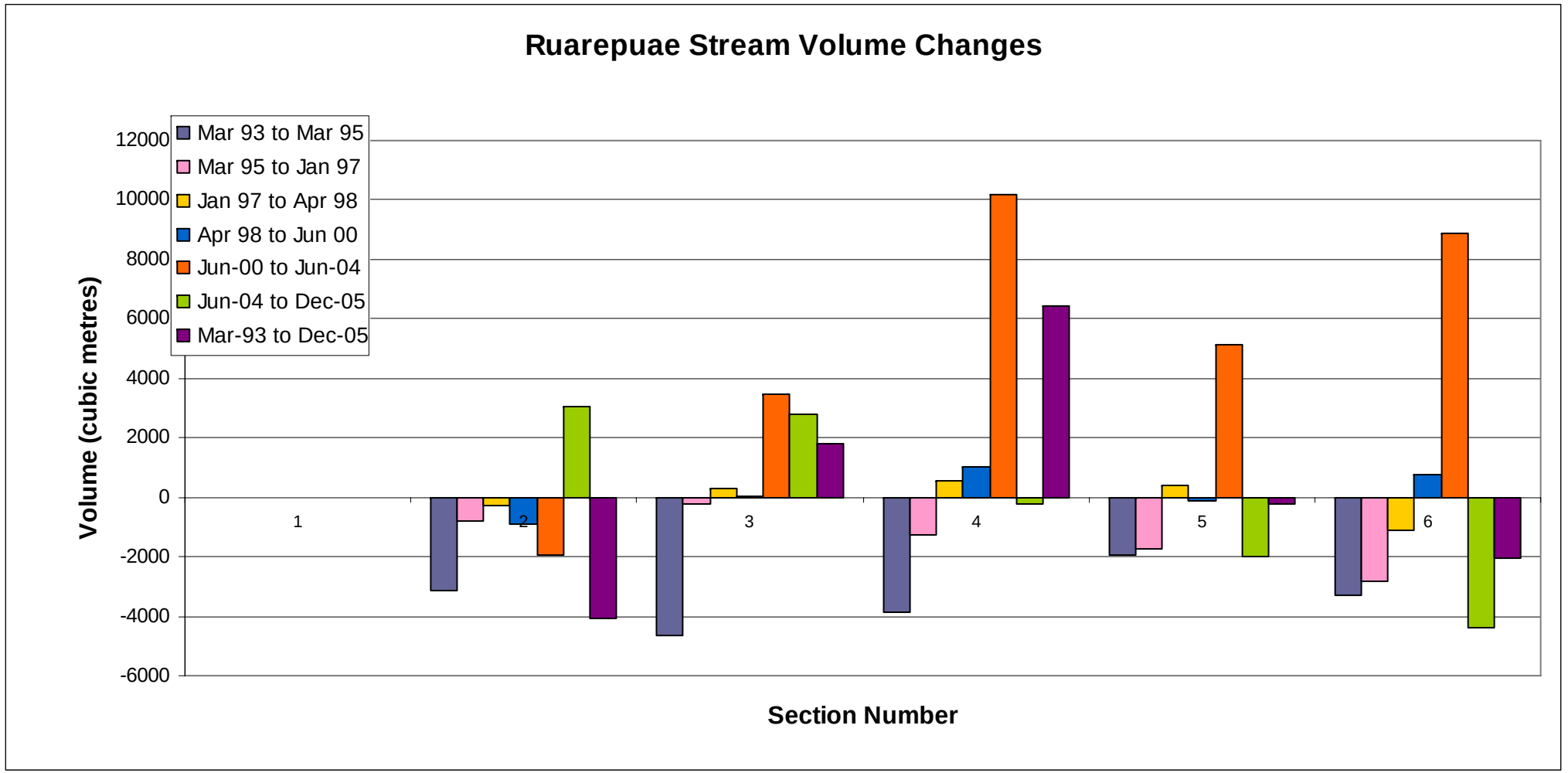



Whakatane River (below Pekatahi) Volume Changes - Design Width
1996 to 1998
1998 to 2003
2003 to 2004
Volume change (m3)
25000
20000
15000
10000
5000
0
-5000
-10000
15
16
17
17a
18
19
20
21
22
23
23a
24
24a
25
Section number

Ruarepuae Stream Changes

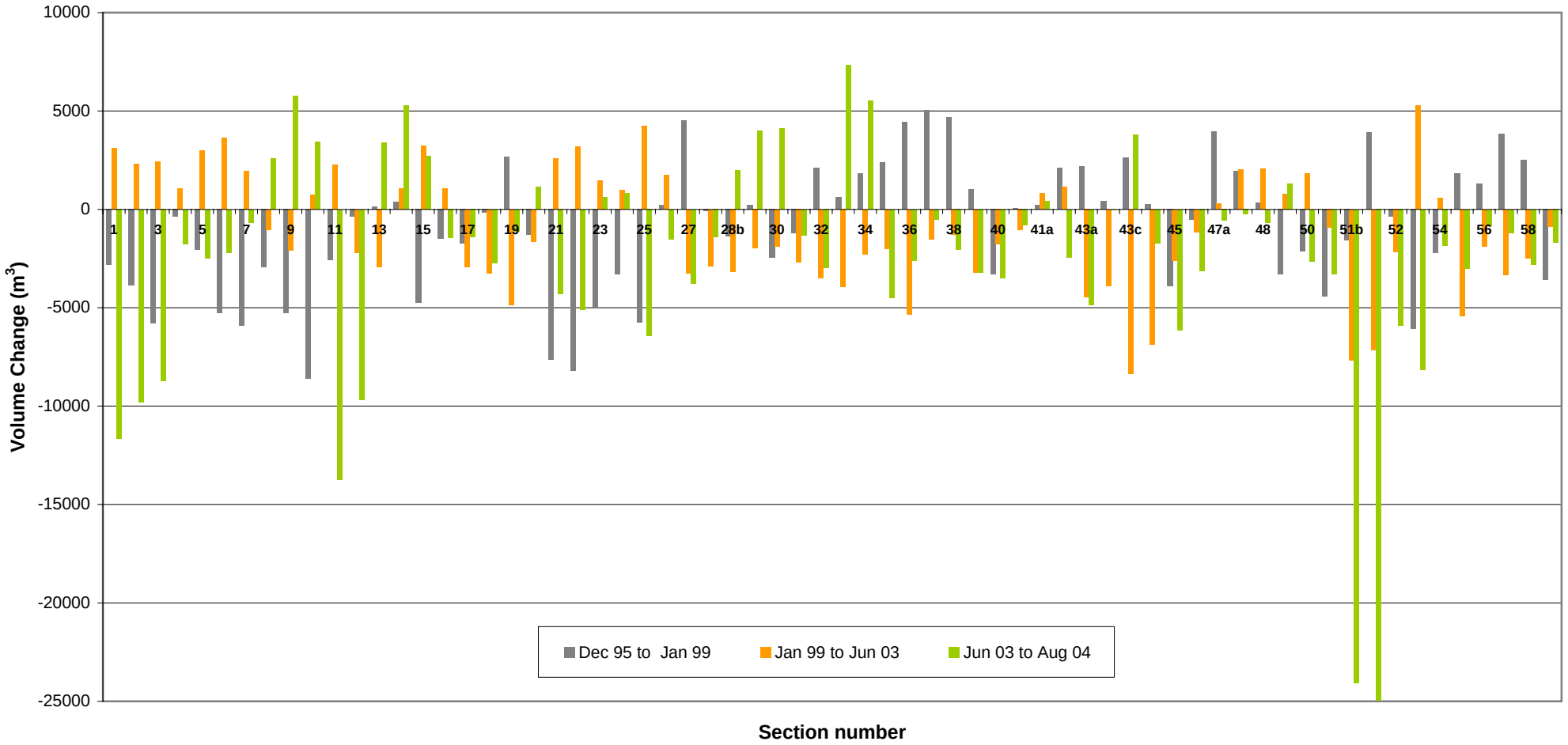
surveyed Mar 93, Mar 95, Jan 97, Apr 98, Jun 00, Jun 04, Dec 05

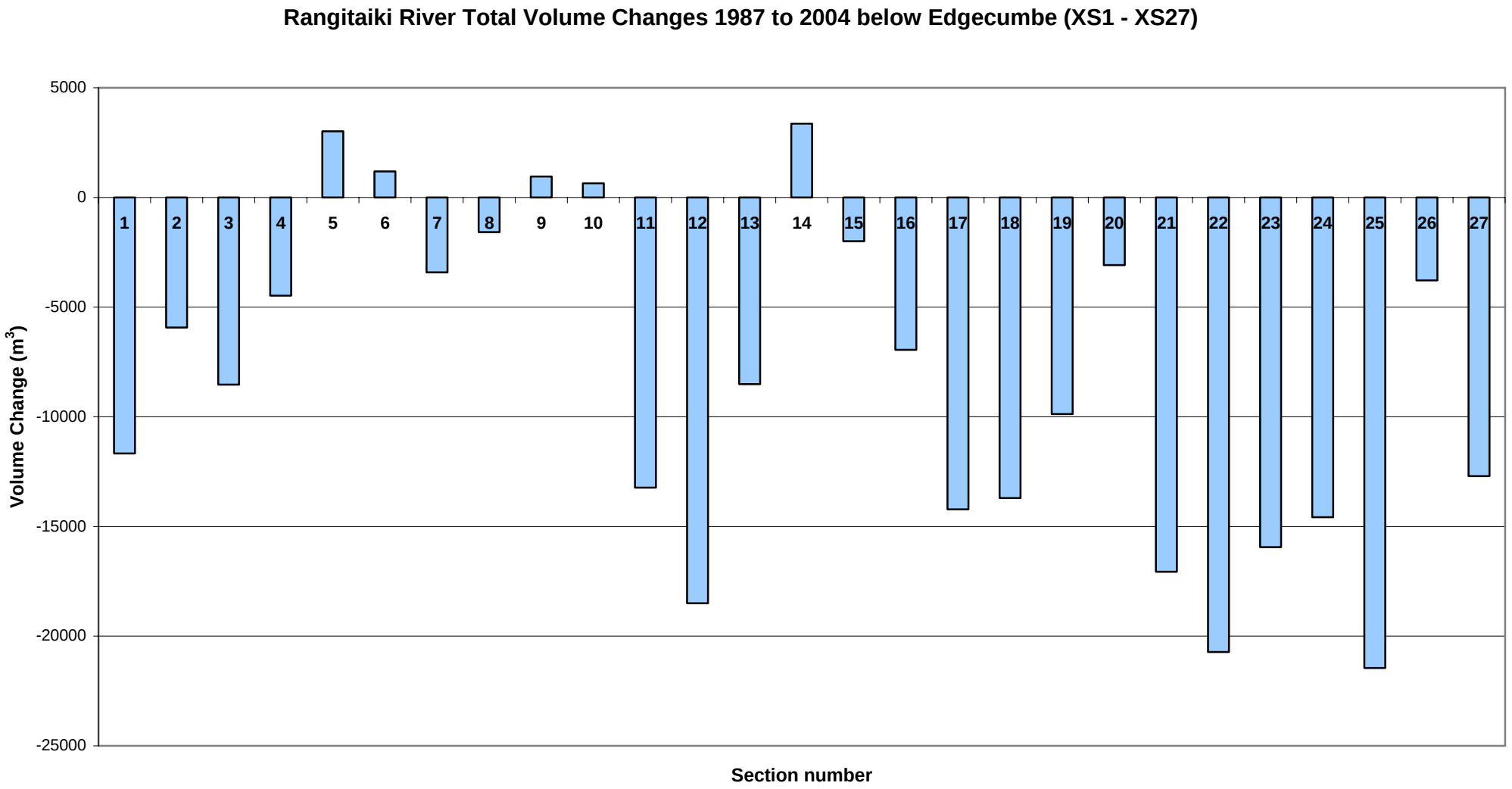
		Volume changes (m^3)							Area changes (m^2)						
Section number	**Distance (km)**	Mar 93 to Mar 95	Mar 95 to Jan 97	Jan 97 to Apr 98	Apr 98 to Jun-00	Jun-00 to Jun-04	Jun-04 to Dec-05	Mar-93 to Dec-05	Mar 93 to Mar 95	Mar 95 to Jan 97	Jan 97 to Apr 98	Apr 98 to Jun-00	Jun-00 to Jun-04	Jun-04 to Dec-05	Mar-93 to Dec-05
1	1.22								-30	-17	-6	-10	2	26	-35
2	1.32	-3152	-819	-271	-927	-1945	3033	-4081	-33	1	0	-8	-41	34	-46
3	1.435	-4638	-207	290	44	3488	2807	1784	-48	-4	5	9	101	14	78
4	1.53	-3849	-1285	571	1007	10205	-215	6435	-33	-23	8	11	114	-19	58
5	1.61	-1955	-1734	403	-120	5140	-1972	-238	-15	-21	3	-15	15	-30	-64
6	1.70	-3304	-2844	-1095	758	8872	-4413	-2026	-57	-43	-27	32	182	-68	20
	Total	**-16898**	**-6889**	**-102**	**762**	**25760**	**-759**	**1874**	**-216**	**-107**	**-17**	**19**	**373**	**-42**	**10**


Ruarepuae Stream Volume Changes
Mar 93 to Mar 95
Mar 95 to Jan 97
Jan 97 to Apr 98
Apr 98 to Jun 00
Jun-00 to Jun-04
Jun-04 to Dec-05
Mar-93 to Dec-05
12000
10000
8000
6000
4000
2000
0
-2000
-4000
-6000
Volume (cubic metres)
1
2
3
4
5
6
Section Number

Lower Rangitaiki River Volume Changes

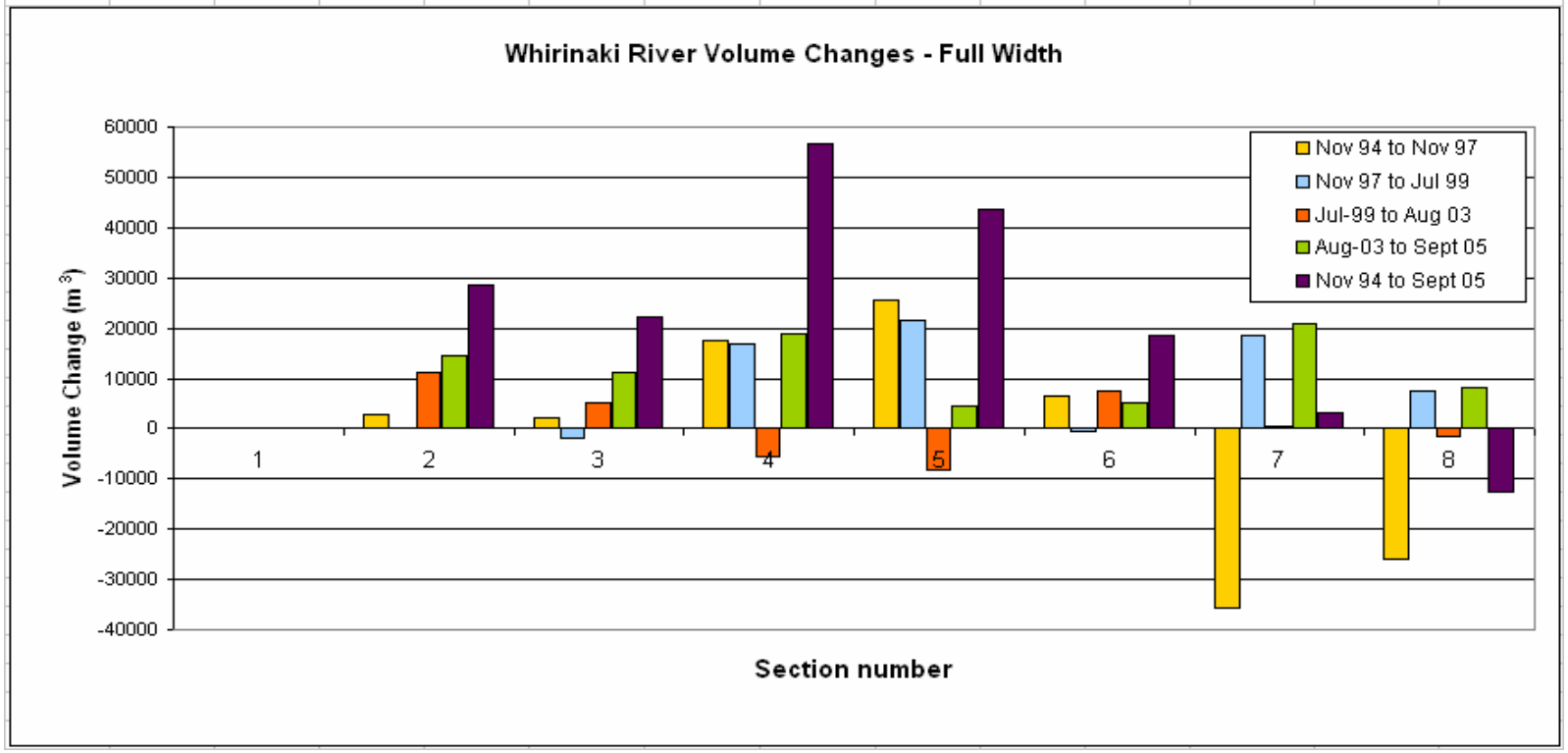
			Area Change (m^2)						Volume Change (m^3)					
	Section	Distance	Jun 87 to	Oct 93 to	Dec 95 to	Jan 99 to	Jun 03 to	Jun 87 to	Jun 87 to	Oct 93 to	Dec 95 to	Jan 99 to	Jun 03 to	Jun 87 to
Location	Number	(km)	Oct 93	Dec 95	Jan 99	Jun 03	Aug 04	Aug 04	Oct 93	Dec 95	Jan 99	Jun 03	Aug 04	Aug 04
near mouth	1	0.58	15	-16	-10	11	-40	-40	4271	-4602	-2778	3096	-11660	-11673
	2	0.89	24	12	-15	4	-23	2	6004	-587	-3845	2295	-8797	-6930
	3	1.43	-22	-1	-6	5	-9	-34	436	3085	-5776	2451	-8729	-8534
	4	1.68	-6	2	3	4	-5	-2	-3520	103	-361	1070	-1770	-4479
	5	2.23	19	2	-10	7	-4	13	3547	1013	-2047	2965	-2479	3019
	6	2.63	15	-11	-15	11	-7	-7	6695	-1595	-5258	3648	-2209	1181
	7	3.04	4	-2	-13	-1	4	-9	3613	-2422	-5884	1959	-687	-3421
	8	3.43	4	-6	-2	-4	10	2	1415	-1616	-2905	-1060	2574	-1580
Greg Rd	9	3.81	9	7	-26	-7	21	4	2356	189	-5260	-2090	5761	956
	10	4.17	3	9	-22	11	-2	-1	2079	2998	-8565	717	3419	647
	11	4.63	26	-36	11	-1	-58	-57	6781	-9906	-2558	2268	-13733	-13228
	12	4.96	-31	1	-12	-12	-1	-55	-714	-6661	-363	-2193	9683	-10604
	13	5.37	-3	-12	13	-2	17	13	-6849	-2226	111	-2943	3397	-8511
	14	5.77	6	-8	-11	8	9	4	732	-4083	385	1069	5272	3364
	15	6.34	-1	-8	-5	4	0	-10	1372	-4594	-4719	3244	2700	-1998
	16	6.74	-6	-10	-2	2	-8	-24	-1612	-3498	-1464	1075	-1451	-6951
	17	7.11	-30	2	-8	-18	0	-54	-6673	-1459	-1730	-2939	-1422	-14223
	18	7.43	-21	2	6	-3	-17	-33	-8214	603	-138	-3237	-2718	-13704
	19	7.84	-14	8	4	-16	13	-6	-9217	2661	2662	-4864	-1118	-9876
	20	8.2	7	-11	-13	4	-4	-17	-963	-340	-1262	-1655	1130	-3090
I	21	8.75	-28	3	-14	6	-12	-45	-5615	-2105	-7635	2605	-4316	-17066
I	22	9.15	-23	-6	-27	10	-14	-60	-8963	-637	-8191	3171	-6102	-20723
I	23	9.51	9	-52	-1	-2	17	-29	-3569	-10422	-4986	1439	597	-15941
I	24	9.89	-24	-2	-16	7	-13	-48	-2993	-10084	-3277	-998	816	-14583
I	25	10.39	-9	-19	-7	10	-13	-38	-8332	-5205	-5713	4236	-6438	-21452
I	26	10.74	2	2	8	0	5	16	-1145	-3050	210	1725	-1520	-3780
Edgecumbe	27	11.19	-1	-49	12	-14	-21	-74	806	-10600	4510	-3240	-3791	-12705
I	28a	11.34		5	-14	-24	2			-3264	-79	-3880	-1424	
I	28b	11.54		-21	0	-8	18			-1533	-1351	-3186	1990	
I	29	11.85		-5	1	-5	8			-3926	301	-1984	3975	
	30	12.14		14	-18	-8	20			1345	-2437	-1894	4105	
	31	12.51		-13	11	-7	-28			119	-1191	-2797	-1319	
	32	12.86		6	0	-13	10			-1326	2115	-3486	-2985	
	33	13.23		-2	3	-8	28			758	605	-3949	7311	
	34	13.68		1	6	-2	-5			-157	1834	-2300	5514	
	35	14.08		-3	6	-8	-18			-412	2373	-2007	-4501	
	36	14.49		-2	15	-18	5			-1212	4495	-5329	-2604	
	37	14.86		-41	12	10	-8			-8168	5032	-1528	-527	
	38	15.11		-13	26	-20	-9			-6704	4661	-1278	-2060	
	39	15.46		6	-20	2	-10			-1248	1009	-3199	-3193	
	40	15.77		-14	-2	-13	-13			-1425	-3294	-1777	-3495	
	41	15.96		3	2	2	4			-1039	36	-1062	-815	
	41a	16.16		-8	0	6	0			-451	224	806	415	
	42	16.54		-5	11	0	-13			-2540	2100	1119	-2461	
	43a	16.97		-34	-1	-21	-10			-8421	2180	-4479	-4857	
	43b	17.14		-36	6	-25	10			-5910	423	-3895	-19	
	43c	17.46		-10	10	-27	14			-7360	2617	-8364	3791	
	44	17.85		2	-9	-8	-23			-1573	236	-6849	-1728	
	45	18.26		-3	-10	-5	-8			-169	-3900	-3615	-6128	
	46	18.61		-7	7	-1	-10			-1807	-494	-1147	-3146	
	47a	19.12		-30	8	2	8			-9509	3958	290	-574	
	47b	19.34		-21	10	16	-10			-6607	1930	2041	-246	
	48	19.56		-20	-7	3	4			-4526	317	2075	-664	
	49	20.09		-25	-6	0	1			-11961	-3275	767	1313	
	50	20.36		-23	-9	13	-20			-6803	-2120	1839	-2634	
	51a	20.61		8	-26	-20	-6			-1867	-4093	-940	-3280	
	51b	20.86		-59	17	-24	-131			-8500	-1566	-7672	-24053	
	51c	21.31		-19	6	-17	-12			-13644	3907	-7145	-24977	
	52	21.61		-2	-7	3	-28			-3048	-354	-2187	-5922	
	53	22.03		-4	-21	23	-11			-1268	-6032	5290	-8134	
	54	22.24		-10	0	-17	-7			-1554	-2211	576	-1864	
	55	22.953		8	6	2	-2			-1096	1843	-5419	-2999	
	56	23.456		-7	0	-8	-2			-112	1301	-1886	-822	
I	57	23.757		16	26	-13	-6			1146	3842	-3329	-1203	
Te Teko	58	24.16		-1	-13	0	-8			2912	2515	-2472	-2807	
I	59	24.55		2	-5	-5	-1			306	-3578	-870	-1698	
		Total	-77	-565	-159	-224	-416	-587	-28773	-111997	-63408	-47218	-157672	-222786


Rangitaiki River Volume Changes below Te Teko
10000
5000
0
-5000
-10000
-15000
-20000
-25000
Volume Change (m3)
1
3
5
7
9
11
13
15
17
19
21
23
25
27
28b
30
32
34
36
38
40
41a
43a
43c
45
47a
48
50
51b
52
54
56
58
Dec 95 to Jan 99
Jan 99 to Jun 03
Jun 03 to Aug 04
Section number


Rangitaiki River Total Volume Changes 1987 to 2004 below Edgecumbe (XS1 - XS27)
5000
0
-5000
-10000
-15000
-20000
-25000
Volume Change (m3)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
Section number

Whirinaki River Changes, Full Width of cross-section
Surveyed Nov 94, Nov 97, Jul 99, Aug 03, Sept 05

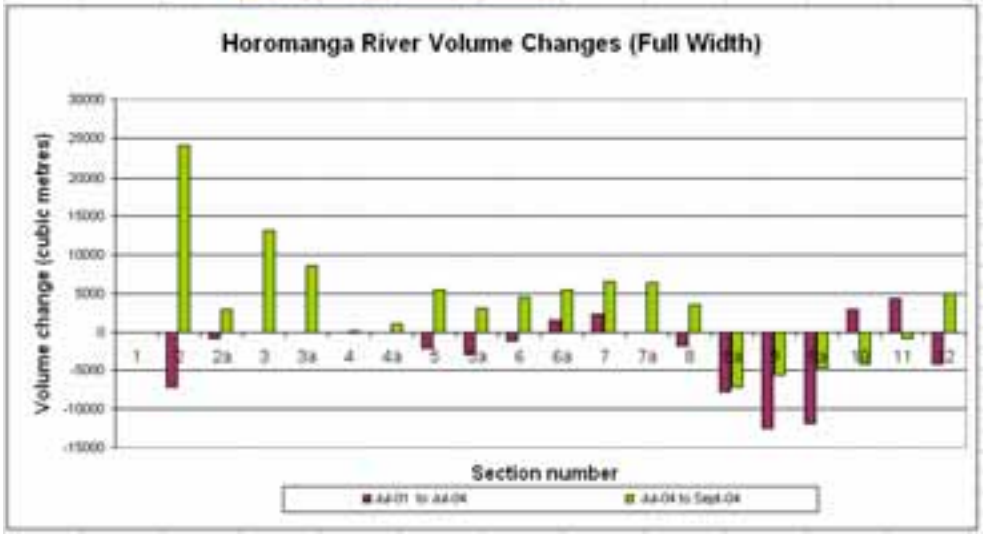
		Volume Change (m^3)						Area Change (m^2)					
Section number	Distance (km)	Nov 94 to Nov 97	Nov 97 to Jul 99	Nov 94 to Jul 99	Jul-99 to Aug 03	Aug-03 to Sept 05	Nov 94 to Sept 05	Nov 94 to Nov 97	Nov 97 to Jul 99	Nov 94 to Jul 99	Jul-99 to Aug 03	Aug-03 to Sept 05	Nov 94 to Sept 05
1	0.570				0	0	0	4	-2	2	13	17	32
2	1.520	2802	202	3004	11076	14638	28717	2	2	4	10	14	28
3	2.160	2100	-1878	222	5158	11156	22340	4	-8	-4	6	21	42
4	3.160	17475	16826	34301	-5601	18751	56537	31	42	73	-17	16	72
5	4.570	25660	21600	47260	-8199	4433	43520	6	-11	-5	5	-10	-10
6	5.870	6349	-668	5681	7599	5309	18589	4	10	14	6	18	38
7	6.665	-35713	18644	-17069	585	20995	3044	-93	36	-57	-5	35	-31
8	7.210	-25826	7568	-18258	-1571	8192	-12641	-1	-9	-10	-1	-5	-16
	Total	**-7153**	**62294**	**55141**	**9047**	**83475**	**160106**	**-43**	**60**	**17**	**18**	**107**	**156**



Horomanga River Volume Changes
Surveyed Mar 96, Jan 97, Mar 98, Jul 99, Jul 01,
Full Width

			Volume Change (m^3)						Area Change (m^2)					
Section number	Ricoda number	Distance (km)	Mar 96 to Jan 97	Jan 97 to Mar 98	Mar 98 to Jul 99	Jul 99 to Jul 01	Mar 96 to Jul 99	Mar 96 to Jul 01	Mar 96 to Jan 97	Jan 97 to Mar 98	Mar 98 to Jul 99	Jul 99 to Jul 01	Mar 96 to Jul 99	Mar 96 to Jul 01
1	1	0.256	0	0	0	0	0	0	-6	6	2	10	2	12
2	2	0.968	-2487	4401	4722	4097	6636	10733	-1	6	12	1	17	18
2a	3	1.128	278	470	1392	-410	2130	1720	5	0	5	-6	10	4
3	4	1.760	3099	-872	4875	1692	7092	8644	6	-2	10	11	13	24
4	5	2.552	-1489	-657	10812	2318	8666	10984	-9	1	18	-6	10	4
5	6	3.520	899	-9619	11677	-678	2957	2079	11	-21	7	3	-3	0
6	7	4.312	1991	-10206	-1159	-1867	-9374	-11241	-6	-5	-9	-8	-20	-28
7	8	4.976	2609	-5240	-5170	2653	-7801	-5148	14	-11	-6	16	-3	13
8	9	5.688	7204	-6496	-1478	6903	-730	5173	7	-8	2	1	1	2
9	10	6.512	-1354	-2642	-4340	-5348	-8336	-13684	-10	1	-12	-14	-21	-35
9a	11	6.920	-552	2100	-1478	-9091	70	-9021	7	9	5	-31	21	-10
10	12	7.360	3199	2748	-3486	-23546	2461	-21085	7	4	-21	-76	-10	-86
11	13	8.016	-2065	-2437	2144	-32241	-2358	-34599	-13	-11	28	-23	4	-19
12	14	8.416	-2577	-4027	-11515	-4208	-18119	-22327	1	-10	-85	1	-94	-93
		Total	**8745**	**-32837**	**61986**	**-61066**	**-16706**	**-77772**	**12**	**-41**	**-44**	**-121**	**-73**	**-194**

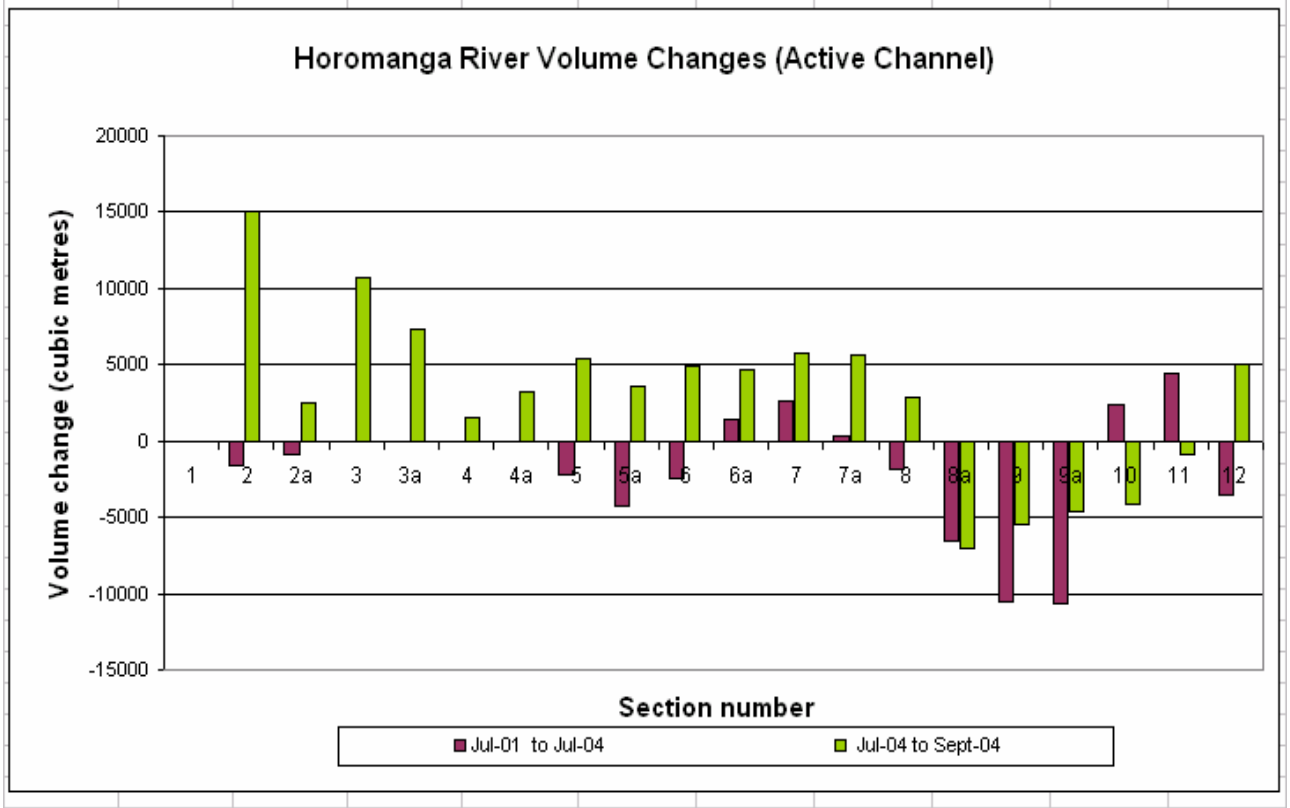
Full Width			Volume Change (m^3)		Area Change (m^2)	
Section number	Ricoda number	Distance (km)	Jul-01 to Jul-04	Jul-04 to Sept-04	Jul-01 to Jul-04	Jul-04 to Sept-04
1	1	0.256	0	0	-10	40
2	2	0.968	-7108	24031	-10	39
2a	3	1.128	-830	2875	0	8
3	4	1.760	0	13101	0	33
3a		2.200	0	8601	0	6
4	5	2.552	0	56	0	-6
4a		3.052	0	1062	0	10
5	6	3.520	-2161	6424	-9	13
5a		3.960	-2917	3057	-4	1
6	7	4.312	-1143	4557	-2	25
6a		4.612	1586	5420	13	11
7	8	4.976	2268	6633	-1	26
7a		5.316	-98	6372	0	12
8	9	5.688	-1772	3496	-10	7
8a		6.128	-7744	-7157	-36	-40
9	10	6.512	-12495	-6522	-39	11
9a	11	6.920	-11787	-4663	-18	-34
10	12	7.360	3000	-4176	32	15
11	13	8.016	4430	-843	-19	-17
12	14	8.416	-4090	4092	-2	42
		Total	**-40863**	**67308**	**-105**	**191**



Horomanga River Volume Changes

Active Channel

Active Channel			Volume Change (m^3)		Area Change (m^2)	
Section number	Ricoda number	Distance (km)	Jul-01 to Jul-04	Jul-04 to Sept-04	Jul-01 to Jul-04	Jul-04 to Sept-04
1	1	0.256	0	0	6	17
2	2	0.968	-1646	15028	-11	26
2a	3	1.128	-849	2530	0	6
3	4	1.760	0	10708	0	28
3a		2.200	0	7367	0	6
4	5	2.552	0	1547	0	3
4a		3.052	0	3274	0	10
5	6	3.520	-2161	5424	-9	13
5a		3.960	-4254	3573	-10	3
6	7	4.312	-2394	4924	-4	25
6a		4.612	1378	4665	13	6
7	8	4.976	2638	5751	2	26
7a		5.316	307	5663	0	8
8	9	5.688	-1877	2842	-10	8
8a		6.128	-6509	-7041	-20	-40
9	10	6.512	-10554	-5522	-35	11
9a	11	6.920	-10639	-4663	-17	-34
10	12	7.360	2405	-4176	28	15
11	13	8.016	4454	-843	-14	-17
12	14	8.416	-3511	4992	-4	42
		Total	**-33210**	**56043**	**-85**	**160**



Acknowledgement

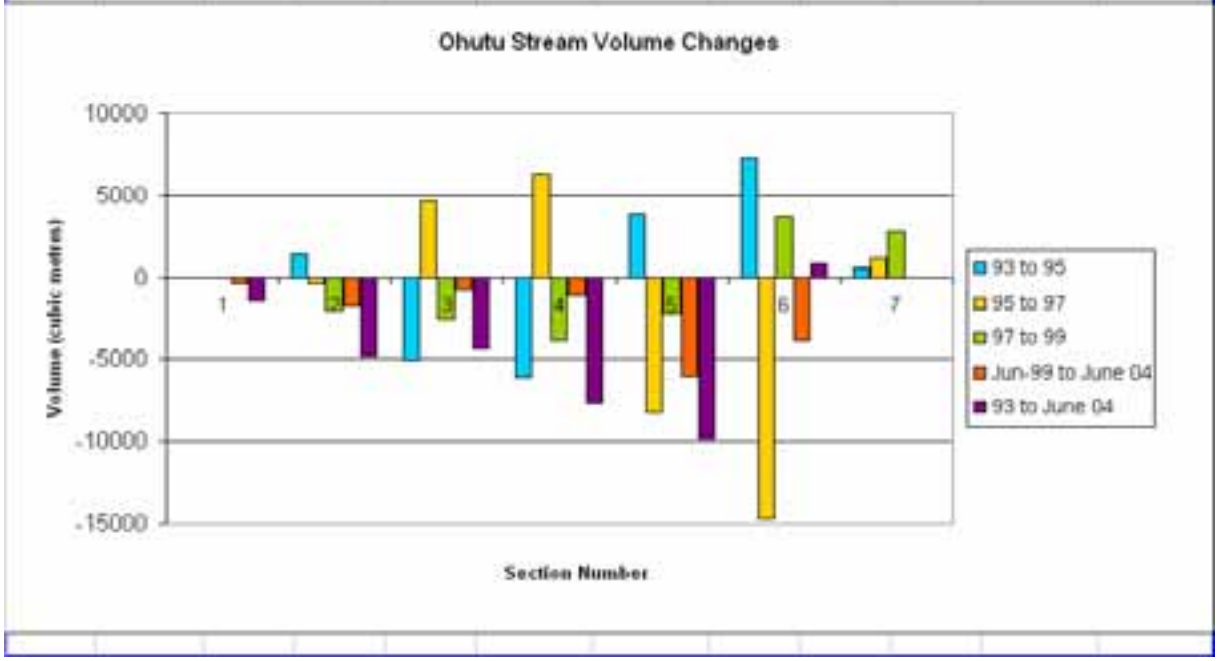
Efforts in data collection and manipulation by Carl Iverson, Peter Vercoe and David Marven are acknowledged, as is guidance from Peter Blackwood.

Cover Photo: Aerial photograph of Upper Whakatane River near Waikirikiri (rotated 90^0 clockwise).

Ohutu Stream Changes

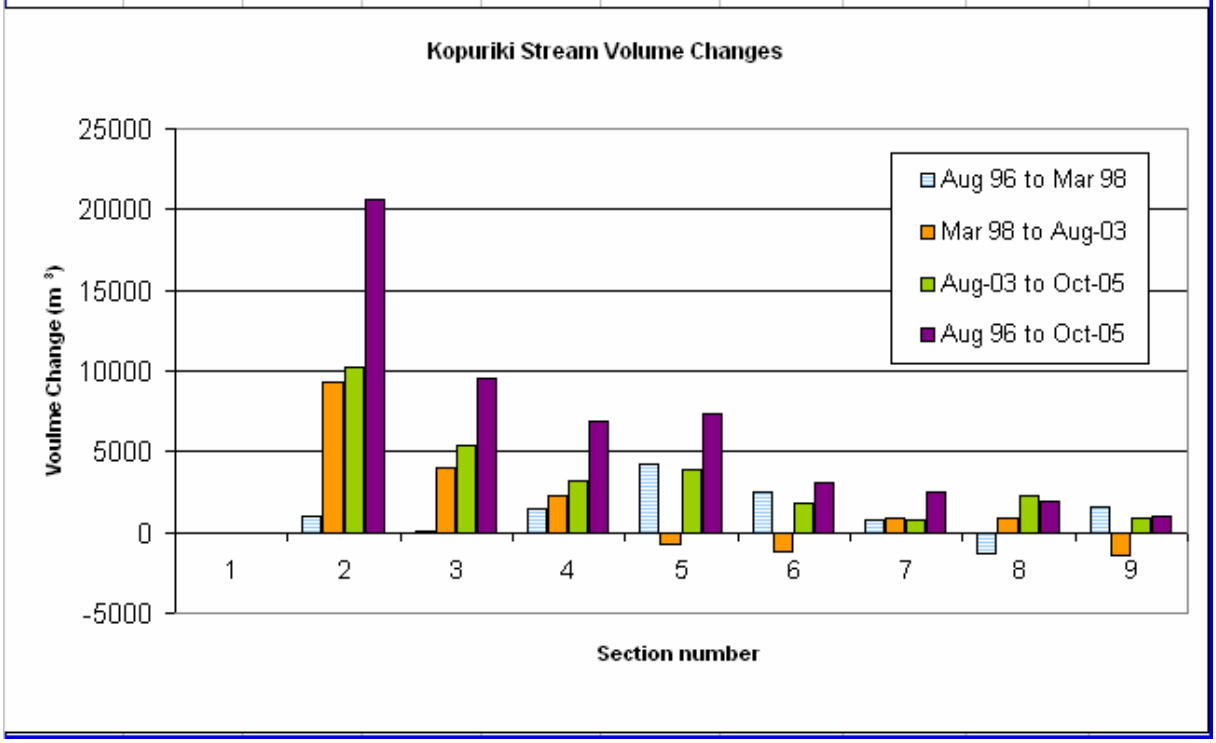
Mar 93, Mar 95, Jan 97, Jun 99, Jun 04

Section number	Distance (km)	Volume Change (m^3) 93 to 95	95 to 97	97 to 99	Jun-99 to June 04	93 to June 04	Area Change (m^2) 93 to 95	95 to 97	97 to 99	Jun-99 to June 04	93 to June 04
1	0.19						-3	1	-7	0	-9
2	0.71	1396	-395	-2057	-364	-1420	8	-2	-1	-1	5
3	1.21	-5054	4597	-2560	-1795	-4802	-29	21	-10	-6	103
4	1.71	-6063	6320	-3875	-747	-4365	5	4	-6	3	-10
5	2.11	3956	-8217	-2159	-1100	-7620	15	-46	-4	-9	-43
6	2.71	7260	-14711	3672	-6013	-9792	10	-4	17	-11	183
7	3.11	611	1217	2813	-3843	798	-6	9	-3	-8	-5
	Total	2006	-11189	-4166	-13851	-27200	0	-17	-14	-32	224



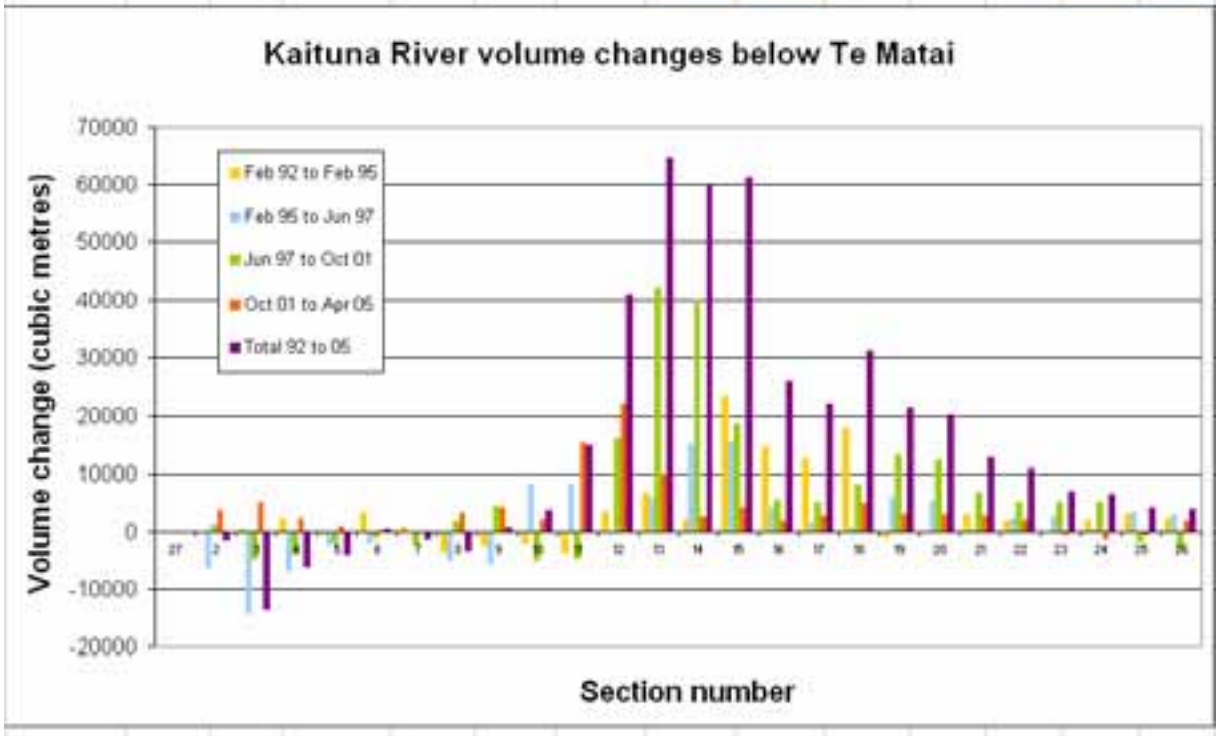
Kopuriki Stream Volume Changes

		Area Change (m^2)				Volume Change (m^3)			
Section number	**Distance (km)**	Aug 96 to Mar 98	Mar 98 to Aug-03	Aug-03 to Oct-05	Aug 96 to Oct-05	Aug 96 to Mar 98	Mar 98 to Aug-03	Aug-03 to Oct-05	Aug 96 to Oct-05
1	0.10	12	54	44	109	0	0	0	0
2	0.30	-1	40	59	97	1043	9357	10234	20635
3	0.44	2	18	18	38	70	4054	5380	9504
4	0.60	16	10	22	48	1459	2230	3214	6902
5	0.80	26	-17	17	26	4223	-765	3917	7374
6	0.96	5	2	6	13	2501	-1209	1814	3106
7	1.21	1	5	1	7	764	876	806	2446
8	1.47	-10	2	17	8	-1262	936	2265	1939
9	1.64	28	-19	-7	3	1534	-1445	857	946
	Total	**79**	**94**	**176**	**349**	**10332**	**14034**	**28487**	**52852**



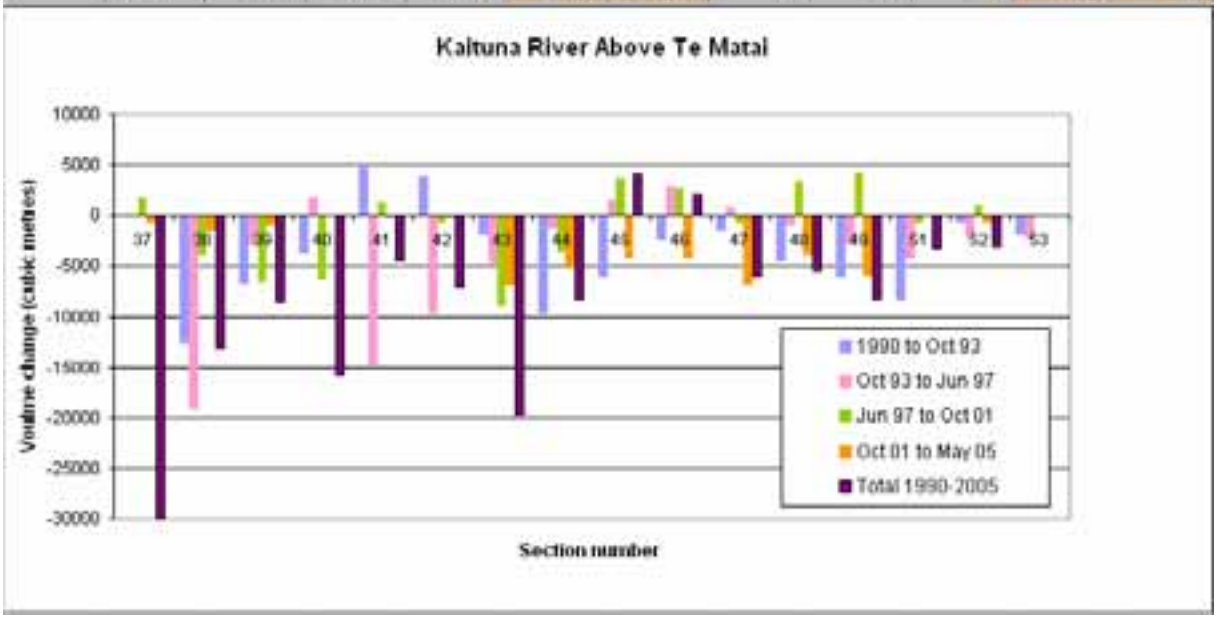
Kaituna River below Te Matai - Volume changes
Surveys Feb 92, Feb 95, Jun 97, Oct 01, Apr 05;

				Volume Change (m^3)					Area Change (m^2)				
Location	River Section	Ricoda XS No	Distance (km)	Feb 92 to Feb 95	Feb 95 to Jun 97	Jun 97 to Oct 01	Oct 01 to Apr 05	Feb 92 to Apr 05	Feb 92 to Feb 95	Feb 95 to Jun 97	Jun 97 to Oct 01	Oct 01 to Apr 05	Feb 92 to Apr 05
River mouth	1a	27	0.130	0	0	0	0	0	0	-3	19	11	27
	2	2	0.482	0	-6247	1214	3614	-1419	-11	-33	-12	11	-45
	3	3	1.005	349	-14297	-4636	5152	-13432	12	-21	-6	10	-6
	4	4	1.528	2267	-6795	-3882	2325	-6085	-3	-4	-9	0	-16
	5	5	2.011	-617	-2334	-1860	778	-4033	1	-5	1	4	1
Diagonal dr	6	6	2.497	3086	-1893	-868	114	439	12	-2	-5	-3	2
	7	7	3.017	952	-39	-2053	-115	-1255	-9	3	-3	3	-6
	8	8	3.500	-3511	-4839	1887	3195	-3268	-6	-23	11	11	-7
	9	9	4.023	-2265	-5613	4311	4157	590	-2	1	6	5	10
	10	10	4.506	-1930	8267	-4871	2135	3601	-6	33	-26	4	5
	11	11	5.029	-3807	8045	-4643	15273	14868	-9	-3	8	56	52
Bell Rd B	12	12	5.507	3439	-283	15843	21994	40993	24	1	58	38	121
Bell Rd A	13	13	6.018	6700	5668	42262	10009	64639	3	21	107	2	133
Kopuaroa \	14	14	6.500	2122	15079	40038	2562	59801	6	42	58	10	116
Kopuaroa /	15	15	7.000	23302	15253	18462	4181	61198	87	20	15	8	130
	16	16	7.250	14573	4060	5571	1812	26016	29	13	30	7	79
Raparapahoe	17	17	7.500	12565	1673	5113	2663	22014	71	0	11	16	98
	18	18	8.000	17852	692	8001	4751	31296	1	2	21	4	28
Waiari just d/s	19	19	8.503	-883	5926	13246	3052	21343	-4	22	32	8	58
	20	20	9.000	-117	5229	12181	2879	20172	3	0	17	4	24
	21	21	9.500	2931	399	6764	2623	12717	9	1	10	8	28
	22	22	10.000	1705	2213	5012	1980	10910	-2	7	10	2	17
	23	23	10.550	-149	2446	5154	-581	6870	1	1	9	-3	9
	24	24	11.000	2063	343	5094	-1167	6333	9	-1	14	-1	21
	25	25	11.511	2861	3403	-1629	-419	4216	4	13	-20	1	-2
Te Matai	26	26	12.000	2266	3019	-3073	1714	3925	6	-1	8	7	20
			Total	85753	39377	162638	94680	382447.7	226	84	364	222	896



Kaituna River above Te Matai Changes from 1990 to May 2005

		Volume Change (m^3)					Area Change (m^2)				
Section number	Distance (km)	1990 to Oct 93	Oct 93 to Jun 97	Jun 97 to Oct 01	Oct 01 to May 05	1990 to May 05	1990 to Oct 93	Oct 93 to Jun 97	Jun 97 to Oct 01	Oct 01 to May 05	1990 to May 05
37	12.82						-9	0	7	3	-2
38	13.76	-12608	-19051	1699	-617	-29960	-17	-40	-4	-4	-61
39	14.21	-6689	-2722	-3956	-1398	-13267	-14	27	-14	-2	-1
40	14.65	-3710	1683	-6526	-857	-8553	-6	-18	-21	-2	-45
41	15.16	5161	-14672	-6299	24	-15810	26	-39	-4	2	-17
42	15.67	3847	-9665	1283	-146	-4535	-5	-15	11	-3	-9
43	16.09	-1830	-4593	-643	-107	-7066	-4	-9	-14	3	-27
44	16.65	-9552	-1282	-8844	-8819	-19678	-25	5	-14	-24	-34
45	17.185	-6063	1409	-3604	-6078	-8258	-6	2	-5	-2	-9
46	17.94	-2277	2769	3583	-4145	4075	1	4	13	-7	18
47	18.365	-1399	802	2629	-4102	2032	-8	0	1	-15	-7
48	19.155	-4547	-860	-637	-6751	-6044	-3	-2	-3	-2	-8
49	19.99	-5962	-2776	3307	-3790	-5431	-11	-6	12	-7	-5
51	21.685	-8205	-4219	4245	-5820	-8179	-3	-2	-4	-3	-9
52	22.15	-516	-2049	-632	-2	-3197	0	-8	1	3	-7
53	22.77	-1861	-2162	896	-630	-3127	-6	1	2	-5	-3
	Total	**-56211**	**-57388**	**-13399**	**-40236**	**-126998**	**-90**	**-100**	**-36**	**-66.1**	**-226**



Tarawera River - Volume changes
Surveys 1993, (1996), 1998, 2000

River Section	Ricoda XS No	Distance (km)	Volume Change (m^3) Feb 93 to Feb 98	Feb 98 Oct 00	Oct 00 to Feb-06	Feb 93 to Feb-06	Area Change (m^2) Feb 93 to Feb 98	Feb 98 Oct 00	Oct 00 to Feb-06	Feb 93 to Feb-06
1b	18	0.51	0	0	0	0	4	12	-4	16
2	2	0.71	391	2808	-1613	3199	0	17	-11	17
3	3	2.24	-226	12494	-11152	12268	-1	0	-3	-1
4	4	3.12	-204	-731	-9371	-935	0	-2	-17	-2
5	5	4.32	-1793	-10793	-8492	-12586	-2	-17	4	-19
6	6	5.06	-3617	-10223	1209	-13840	-7	-11	0	-18
7	7	6.50	-12572	-20064	-1268	-33626	-10	-16	-1	-26
8	8	7.56	-10062	-14248	-937	-24310	-9	-11	0	-20
9	9	9.00	-13653	-10470	-619	-24123	-10	-4	0	-14
10	10	10.14	-10078	-7513	1802	-17591	-7	-9	4	-16
11	11	11.22	-9384	-7412	2678	-16796	-10	-5	2	-15
12	12	12.50	-7772	-5917	-444	-13689	-2	-5	-2	-7
13	13	13.30	-5013	-2856	-1732	-7869	-10	-3	-1	-13
14	14	14.48	-7801	-5714	-1647	-13515	-2	-8	0	-10
15	15	15.68	1471	-5440	-4818	-3969	5	-2	-7	3
16	16	17.00	1198	-1062	-29688	136	-4	0	-37	-4
17	17	17.85	-4189	0	-20649	-4189	-7	0	-11	-7
		Total	-83304	-87131	-86641.2	-170435	-72	-64	-81.6	-136

benchmarks reserveyed since 2000 survey -> benchmarks approx. 200mm lower than before -> volume change too high!!!!