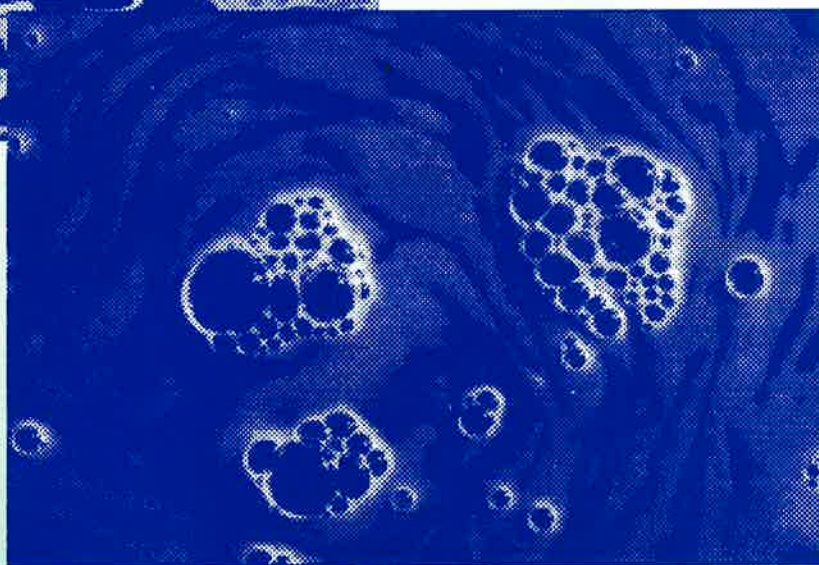
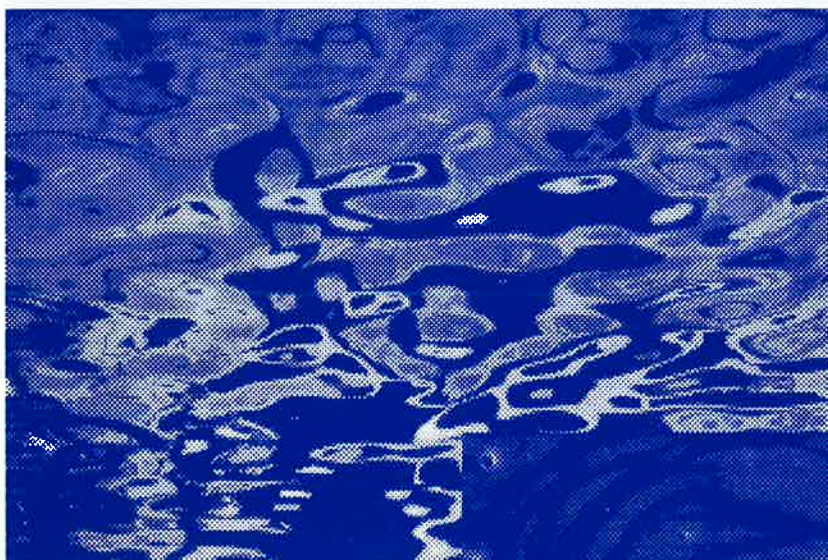


Aspects of water quality

in the Hunter and Mid Coast region of NSW

1960-1975

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PREFACE

This bulletin is a record of the water quality monitoring carried out by the Department of Agriculture in the Hunter Valley from the 1960's to the mid 1970's. A number of people collected the samples, and Mr R S Wetherall, then District Research Agronomist at Maitland, compiled a number of unpublished reports on water quality in the Hunter and Mid Coast regions of NSW.

These reports have not had a wide distribution. However, with current interest in water quality, salinity and the environment, it was felt that they should be available to interested persons. They are, however, reproduced in their original format and there may be some overlap between sections. Original data sheets and manuscripts are held in the library archives at C B Alexander Agricultural College, 'Tocal', Paterson.

We are most grateful for Mr Wetherall's thorough and professional work in compiling this information.

A C ARCHER
Editor

'Tocal'
Paterson

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ASPECTS OF WATER QUALITY IN THE HUNTER VALLEY

INTRODUCTION

Water testing services of the NSW Department of Agriculture were decentralised in 1959 by locating testing equipment in each of the nine extension regions. At Maitland over 3000 water samples were tested between January 1960 and June 1966. Most of these originated from the Hunter Valley with some from the Manning and Macleay Valleys. The following is an attempt to summarise some of the information available from these tests.

No systematic survey of water quality has been attempted and on many aspects information is lacking or is inadequate. However, because of the large number of samples received, the conclusions given below are considered to be quite reliable. They provide a broad outline of the salt status of waters in the Hunter Valley and Mid Coast.

The salinity figures recorded are probably biased towards the high side, because most samples are submitted by farmers in periods of dry weather and low stream flows and virtually none in wet periods. However, the samples submitted do represent the water that is actually used for irrigation.

Water quality tests and recommendations on use were made according to Chatfield (1959). Electrical conductivity corrected to 25°C was converted to total salinity from charts compiled by Chatfield for a composite NSW water sample. Calcium plus magnesium was determined by titration with 0.02N EDTA and total alkalinity by titration with 0.1N sulphuric acid. Results are reported as parts per million (ppm). Sodium hazard ratings were determined from the conductivity and calcium figures using charts developed by the United States Department of Agriculture (Richards, Bower & Fireman, 1956). Recommended limits of salinity are relaxed somewhat during drought periods and in areas of high rainfall where annual application of water are low and natural leaching is high.

RIVERS AND STREAMS

The levels of total salinity recorded from major streams are shown on the map in Figure 1. Characteristic water quality values for 175 individual streams are given in Appendix I. Detailed comments on the Hunter, Paterson, Allyn, Williams and Karuah Rivers are given in Appendix II.

The major rivers, Hunter, Paterson and Williams have good quality water and are suitable for irrigation at all times. In periods of low flow, the salinity rises slightly but the water can still be used for irrigation because of the limited amounts applied. The range of salinities is as shown below.

Total Salinity (ppm)			
	Normal Flow	Low Flow	No Flow (Holes or Spear Points)
Hunter River above Singleton	200-300	300-500	500-900
Hunter River below Singleton	300-500	500-650	650-800
Paterson River	100-300	300-600	600-1000
Williams River	50-150	150-300	300-700
Goulburn River	800	1200	1500

Salinity increases gradually as one moves downstream. On the Hunter River at times of normal flow, the approximate levels at various locations are Hunters Springs 40, Aberdeen 200, Muswellbrook 300, Singleton 400 and Maitland 500.

Tributaries of the Paterson and Williams are generally similar to the main streams except for some small creeks and gullies that may be rather salty.

Tributaries of the Hunter vary considerably. In the upper Hunter, the major tributaries are usually suitable for irrigation in normal seasons but under conditions of low flow they can become too salty, eg Wybong Creek (500 to 3500), Glennies Creek (600 to 4000).

Aspects of Water Quality in the Hunter and Mid Coast Region of New South Wales

Minor tributaries are often too salty even at normal flows and can become extremely salty at low flows, eg Halls Creek (850 to 2520), St. Helliers Brook (1180 to 3090) and unnamed creeks at Muswellbrook (7370 and 10090).

In the mid-Hunter, streams from the north are usually suitable at normal flows but can become too salty at low flows. On the southern side, however, waters from the Wollombi Brook, Black Creek and Wallis Creek are of doubtful quality even at normal flows. These streams drain catchments that include large areas of Permian sedimentary rock that apparently contain considerable amounts of sodium salts. Apart from these three streams, excess sodium is rather rare and only occurs when total salinity exceeds 1500. Excess sodium (a sodium hazard rating of S2 or above) though, becomes evident on the Wollombi Brook whenever the salinity exceeds 800, and in Fishery Creek (tributary of Wallis Creek) whenever salinity exceeds 600.

Twenty four samples from the Wollombi gave salinities ranging from 410 to 1260. Only four were above 1000. However, 14 samples showed some residual alkalinity (10 to 60) and nine samples showed excess sodium (S2 grading).

Water from Black Creek is of poor quality even at times of good flow. It is high in salt and almost invariably contains excess sodium. The following table shows the number of samples occurring in the various salinity and sodium hazard gradings.

No. of samples from Black Creek according to quality gradings

Total Salinity		Sodium Hazard Gradings				
ppm	Grading	S1	S2	S3	S4	Totals
0 - 600	C1					0
600 - 1000	C2	2	4			6
1000 - 1650	C3	1	23			24
1650 - 3300	C4		17	10		27
Over 3300	C5			3	1	4
Totals:		3	44	13	1	61

Soils along Black Creek tend to be clayey and compact with low permeability. Annual rainfall is about 28 inches so that there would not be much natural leaching of salt. These factors increase the risk of damage from irrigation waters high in salt and sodium.

Out of 61 samples tested only seven (those under-lined) would be considered suitable for regular use on tolerant crops. Waters graded C3 S2 (23 samples) could be used in limited amounts under special conditions. The remaining 31 samples are considered completely unsuitable for irrigation.

Water from Black Creek is usually alkaline (pH 8 - 9) but at times it becomes very acid (pH 3). Many of the tributaries of Black Creek show very high levels of salt and also excess sodium (Bellbird Creek 2520, and creeks at Pokolbin 5880, Cessnock 7920, Allandale 23660, and Branxton 19000).

Results from Wallis Creek and its tributary, Fishery Creek may be badly biased because practically all samples were submitted during drought periods in 1964-66. The number of samples in each grading were as follows:

	C1S1	C2S1	C2S2	C3S1	C3S2	C3S3	C4S2	C4S3	C4S4
Wallis Creek	2	3	2	5	5		1	1	
Fishery Creek			6		13	4		6	2

In addition, 24 of the 31 samples from Fishery Creek showed residual alkalinity ranging from 20 to 270 and five samples from Wallis Creek also showed residual alkalinity of 30 to 120.

It is obvious that water from Fishery Creek is generally unsuitable for irrigation. Several cases have been observed of crop damage particularly in lettuce, accompanied by loss of soil structure.

TIDAL WATERS

The limits of tidal influence are approximately at Maitland on the Hunter River, Paterson on the Paterson River and Clarencetown on the Williams River. Irrigation from these tidal reaches is fairly extensive and extends downstream almost to the junction of the Williams and the Hunter at Raymond Terrace.

Sodium Hazard

River water entering these tidal sections contains only 200-500 ppm of salt but it becomes increasingly mixed with sea water containing about 33000 ppm of salt. Since sea water contains a high proportion of sodium, the sodium hazard rating of the tidal waters increases as the total salinity increases. For the lower Hunter the following relationship has been found:

<u>Total Salinity ppm</u>		<u>Sodium Hazard Rating</u>
Less than	1000	S1
1000 -	2000	S2
2000 -	3200	S3
3200 -	5000	S4
Over	5000	S5

Most of the irrigated soils in these tidal areas are clays with slow internal drainage and are therefore susceptible to damage by salt and sodium. Because of this risk, tidal waters with more than 1000 ppm total salts should not be used for irrigation.

River Flow

The general level of salinity depends on distance from the sea and on river flow. In normal seasons, river flow is sufficient to keep the water fresh enough for irrigation

almost to Raymond Terrace. When river flow drops, sea water moves rapidly upstream. Under drought conditions, the Paterson and Williams Rivers virtually ceased to flow from December 1964 to June 1965. By the end of this period, salt had penetrated to the limits of the tidal influence and virtually the whole of the tidal waters was too salty for irrigation.

A more detailed relationship between river flow and salinity has been derived from an extensive series of tests from the Hunter River at Dockyard in the period 1.1.64 to 1.1.66. (Dockyard is about two miles upstream from Raymond Terrace.) In Figure 2 the salinity at Dockyard has been plotted against the river flow at the Belmore Bridge, Maitland. Flow from the tributary Paterson River during this period was only a small proportion of that in the Hunter and has been ignored. The maximum salinity recorded during each month has been plotted against the minimum flow recorded for that month. Similarly, minimum salinity for the month is plotted against the maximum flow for that month.

The graph shows a definite relationship between river flow and salinity. As river flow falls below 200 cusecs, the salinity increases rapidly above the recommended limit of 1000 ppm. With flows of more than 200 cusecs, only low salinities were recorded and the water was fit for irrigation.

Four miles further upstream at Duckenfield, the sampling was less detailed, but Figure 3 shows a similar relationship between river flow and salinity. Here a flow of 100 cusecs appears to be needed to keep salinity below the recommended limit of 1000 ppm.

More accurate relationships could be obtained by regular sampling and relating salinity to river flow on a daily rather than a monthly basis.

Although still only approximate, these relationships are of considerable importance. Records of salinity levels are available for only a few years but records of river flow for much longer periods. These past records can be used to estimate the frequency and

length of period when water at a given point would have been unfit for irrigation. For example, the discharge of the Hunter River at the Belmore Bridge fell below 200 cusecs in the following months:

- 1958 January, March, April, May, June, July, August, September, October, November, December
- 1959 January, February, May, June
- 1960 February, March, April, May, June, September, October, November, December
- 1961 February, April, May, July, October, November
- 1962 Nil
- 1963 Nil
- 1964 February, March, November, December
- 1965 January to December, inclusive.

During these periods it can be assumed that river water at Dockyard would have been too salty for irrigation. Similarly in the months underlined above, flow fell below 100 cusecs indicating periods of salt water at Duckenfield.

It is obvious that a considerable flow of water is needed to maintain salinity below acceptable limits. It would seem impracticable to release water from storages on the upper rivers, merely to keep salt water out of the lower tidal reaches. If the upper rivers are eventually fully regulated by storages and releases are closely matched to pumping demands, there could be an increase in the frequency and duration of periods when the tidal waters are unfit for irrigation.

Tides and Currents

River flow determines the general level of salinity at a given point but the actual level

can fluctuate from hour to hour with the stage of the tide, from day to day with the height of the tide and from bank to bank according to the river currents. These variations are well illustrated by the following readings from the Hunter River at Dockyard.

Sample No	Location	Tide Etc.	Salinity (ppm)
684	North bank	2 hr before high tide on 23.12.64	740
685	North bank	High tide 23.12.64	2360
686	North bank	2 hr after high tide 23.12.64	3450
687	North bank	4 hr after high tide 23.12.64	3930
688	North bank	6 hr after high tide 23.12.64	1030
689	North bank	High tide on 24.12.64	2930
707	South bank	High tide on 23.12.64	8590
708	South bank	Low tide on 23.12.64	730

It is claimed that on the rising tide the upstream current is strongest on the South bank, whereas on the falling tide the current is mainly on the North bank.

The above readings indicate that salinity levels lag behind the tide levels, the peak salinity occurring four hours after high tide. This, however, may be peculiar to this location due to the nature of the currents and further studies are needed.

Stratification of a salt water wedge below fresh surface water is well known but it has not been investigated locally as yet. However, if irrigators use a floating foot valve suspended 2 feet below the water surface, only the freshest water is used.

Irrigation Strategy on Tidal Streams

On tidal streams, irrigation by itself cannot be relied on for drought insurance. In dry periods, the water will be too salty for irrigation anyway. Drought reserves must be provided by cash or by conserving fodder grown from irrigation in more favourable seasons.

For short term periods of unsuitable water, available feed can be extended by irrigating fully whenever possible, thus providing a store of moisture in the soil. In this respect deep rooting plants are preferable.

For example, lucerne fully wet to 6 feet would provide growth for a further six to ten weeks without any further rain or irrigation. Clover with an effective root depth of only 18 inches would grow for only 3-5 weeks without more water. Lucerne is also more tolerant to salt than is clover. On heavy soils unsuitable for lucerne, kikuyu is a useful species, being salt tolerant and deep rooted.

Where seasonal periods of salt water can be reasonably anticipated, it may be worthwhile irrigating fallowed soil to build up a reserve of moisture to be used by a later fodder crop.

In those periods when irrigation is possible, the closest watch must be kept on water salinity, because of the rapid changes that can occur. Frequently, water is quite suitable at low tides but completely unsuitable at high tides. These changes cannot be reliably predicted from day to day or week to week or even from place to place along the river. Because of the high content of sodium, the use of salty tidal water is very dangerous and can have long term ill effects.

It is essential that irrigators in these conditions possess a portable salinity meter to follow changes in salinity on a daily or even hourly basis. Without such equipment the irrigator

runs the risk of serious crop and soil damage from using salty water and fails to make full use of the suitable water when it is available. Because of the rapid variations the irrigator cannot safely rely on readings taken by a neighbour.

These considerations are more important to those lower downstream. Here, the periods of high salt are longer and more frequent (periods of good water are less); the salt levels are higher and the fluctuations, more violent.

UNDERGROUND WATER

Salinity of underground water is extremely variable and frequently the exact location of the sample is not given. Therefore, it has not been possible to accurately define areas of good or bad water. Nevertheless, certain features have emerged from a study of the samples tested.

Underground water suitable in quantity and quality for irrigation is virtually restricted to the alluvium along the major streams and to extensive sand beds between Newcastle, Raymond Terrace and Port Stephens. Bores drilled through rock on hillsides are usually low yielding and frequently very salty.

Water from the alluvium varies greatly in quality. Along the Hunter River there is a trend for salinity to increase as one moves away from the river to the foothills. At Bolwarra near Maitland for example, salinity increases from 800 near the river to over 9000 near the hills. A similar pattern was observed by Williamson (1958) in the upper Hunter.

In the upper Hunter, waters tend to be higher in calcium than elsewhere, and the occurrence of residual alkalinity is more common. In the lower Hunter the occurrence of excess sodium becomes more frequent. Below Maitland and in the Wallis Creek area, much of the deeper alluvium is of estuarine origin and the ground water is very high in salt and in sodium. Salinity increases rapidly downstream, - Bolwarra 800-1000, Pitnacree 1000-1200, Phoenix Park 3000, Hinton 5000, Duckenfield 10000, Millers Forest 12000, Dockyard 20000. In parts of Millers Forest the water table is only two to six feet below the surface and salt damage to crops and soils has been noted.

Underground waters from the alluvium of the Paterson and Williams rivers are generally suitable for irrigation. Waters from along Black Creek and Wallis Creek are usually unsuitable.

In the sand beds near the coast, water quality can vary tremendously over short distances. Some spear points at Anna Bay tested very low in salt while others only 200 metres away were high in salt, sodium and residual alkalinity.

Dissolved iron occurs in ground water from certain localities, notably parts of Bolwarra, Williamtown, Anna Bay and Broke. While underground the iron is in a soluble ferrous form and the water as it emerges is quite clear. When exposed to the air the iron is oxidised to an insoluble ferric form and the water becomes rust coloured. If left standing this iron settles out as a rusty sediment. No reports have been received of injury to stock or crops. It does, however, discolour equipment and buildings and spoils the market appearance of fruit and vegetables, particularly cauliflowers.

Several cases have been noted where the salinity of bore water has increased with pumping, e.g. at Bolwarra the salinity after one hours pumping from a new bore was 2480, and increased to 3240 after six hours. Near Largs, a spear point tested 1240 when first pumped and 4410 an hour later. With further pumping the next day, salinity rose to 7370. Another spear point nearby increased only from 780 to 890 when pumped for an hour but three years later, the salinity was 5880. In other cases there has been a slight drop in salinity with pumping but the drop has always been very small. Most farmers now sink a pilot auger hole and test the water before developing spear points, bores or wells. If water in the pilot hole is salty it seems unlikely that it will improve significantly with pumping. If it is low in salt it may remain suitable when developed but there is the chance that it may increase in salt. Always test new bores after extensive pumping and retest periodically in the following years.

During the peak of the drought in 1965, hundreds of new bores were sunk in a search for irrigation water. Very few of these proved adequate in yield or quality or both. It seems unlikely that any major new sources of underground water remain to be found. There is a need, however, for detailed investigations of known sources to determine the correct rates of withdrawal and possible ways of increasing yields and recharge rates.

FARM DAMS

Surface runoff from heavy rain is normally very low in salt. Dams filled entirely from runoff are usually very low in salt, testing about 100 to 200 ppm (as low as 50 or 70). In many cases this low salt content results in muddy water.

Dams placed in gullies or even those deeply excavated on hillsides may collect considerable amounts of seepage which may be very salty. Stratification of water has been noted with very salty seepage water in the bottom of the dam and with quite fresh runoff water on the surface. At Branxton in a small gully dam, the salinity of the top was 500, middle was 750 and bottom water 2000.

Stock dams excavated in swampy areas near Maitland have sometimes been found to be extremely acid (pH 2.5) and also contain soluble iron. This makes the water very unpalatable and stock have refused to drink it.

SOIL AND CROP DAMAGE

Only isolated cases of crop or soil damage from salty water have been reported. These, however, have been very obvious cases and it is likely that a lot of less obvious damage goes unnoticed. Crops affected have been lettuce (Fishery Creek), potatoes (spear point, Largs), beans (gully dam, Branxton), beans (spear point, Anna Bay) and pastures and lucerne (tidal water, Nelsons Plains).

In higher rainfall areas, saltier waters can be used because of the smaller annual applications and higher natural leaching, but it is difficult to estimate what levels can be tolerated. At Bolwarra, with 825mm rainfall and deep sandy loam to clay loam soils, vegetable growers have been irrigating intensively for many years with water containing 1000-2000 ppm of salt. There have been no apparent ill effects on either crops or soils. Occasionally the surface soil crust shows white salt crystals and the conductivity of a

saturated extract of the top quarter-inch of soil may be six to eight millimhos. However, the conductivity of successive six inch layers down to three feet is seldom more than one millimho.

Small areas of naturally salted soil occur throughout the Hunter Valley but very rarely in the Paterson or Williams Valleys. The affected areas are completely bare of vegetation and range from a few square metres up to two hectares. They occur in drainage lines and are most common in areas of Permian sedimentary rock south of the Hunter River. At Turanville near Scone an area of black alluvial clay has apparently been affected by high levels of sodium salts producing a saline-sodic soil. Parts of the area have apparently been leached giving rise to a sodic soil. Without the flocculating effect of a high salt content the result is an intractable gluey mud.

In parts of the lower Hunter below Maitland, such as Millers Forest, Williamtown and Bobs Farm, there is a very salty water table about four feet below the surface. Shallow rooted crops and pastures do not seem to be affected. Young lucerne also grows well until its roots reach the salt water or the water table rises after rain.

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Figure 1 Characteristic values of Total Salinity (parts per million)

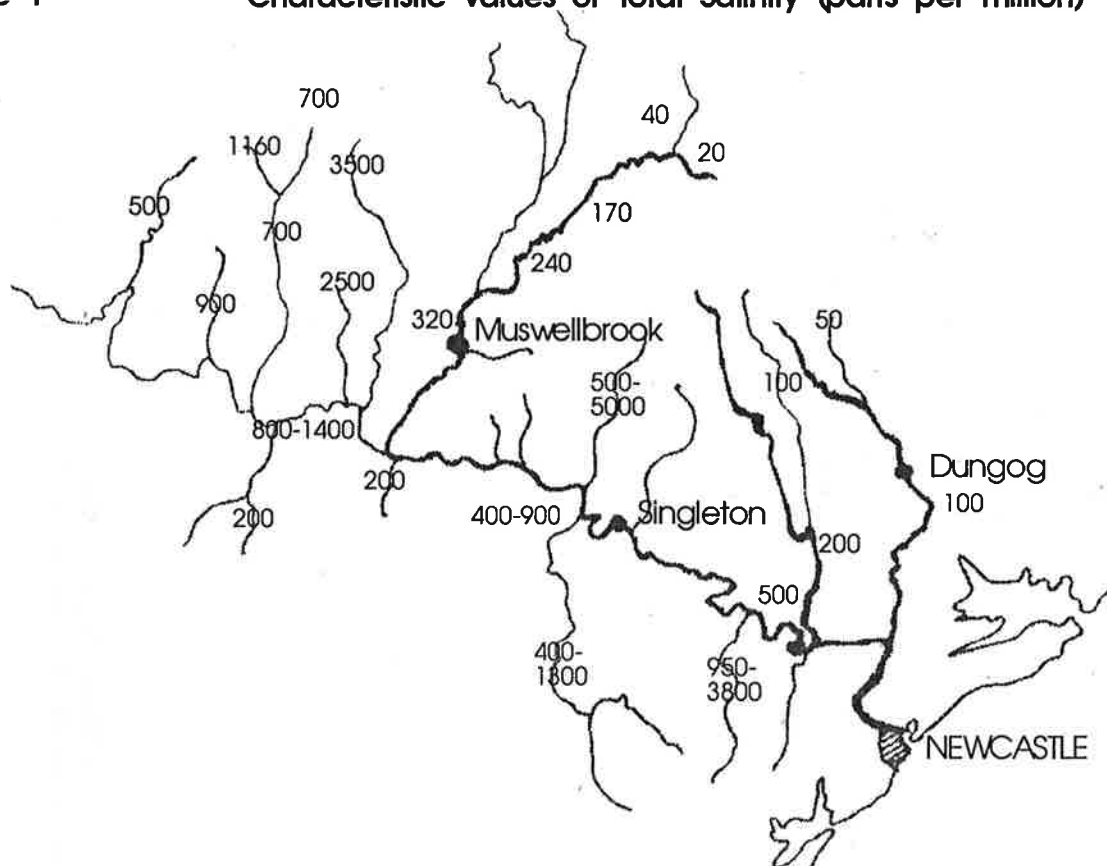


Figure 2

Relation between discharge at Belmore Bridge and Salinity at Dockyard

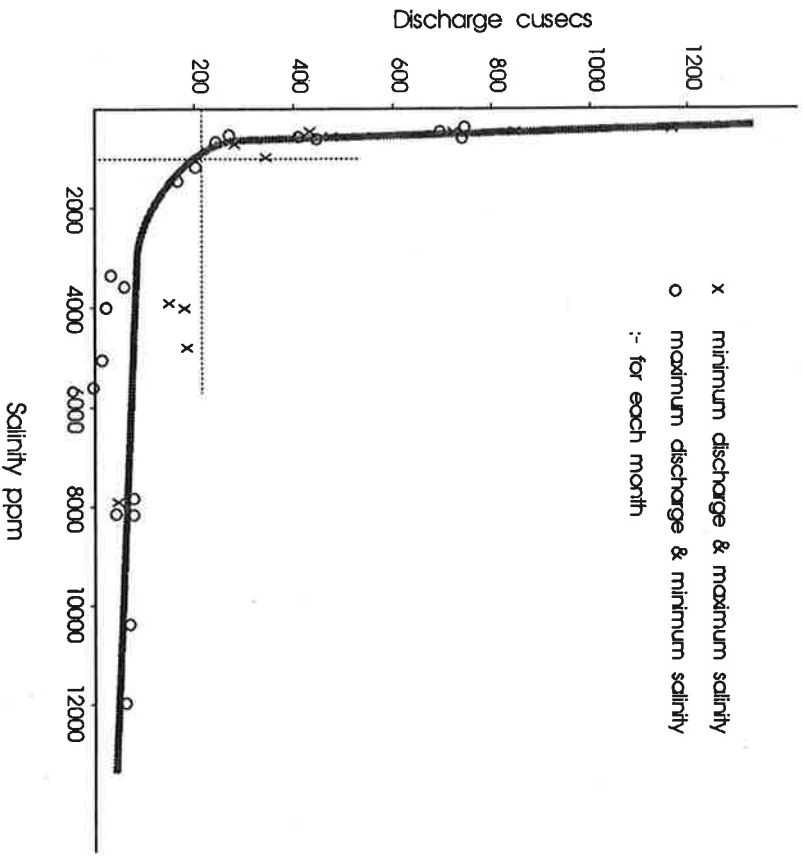
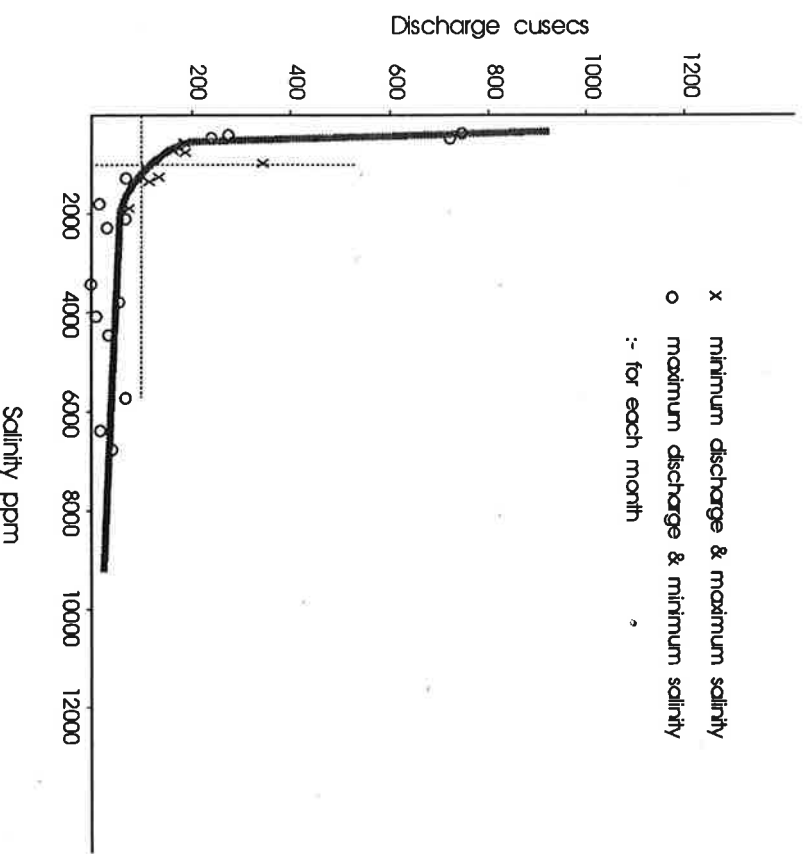


Figure 3

Relation between discharge at Belmore Bridge and Salinity at Duckenfield



CHARACTERISTIC WATER QUALITY OF STREAMS IN THE MID COAST AND HUNTER REGION OF NSW

The 'characteristic water quality' of a stream is here defined as the quality most likely to occur during normal to low flow. It represents the quality of the water that is available for the greatest proportion of the time, and in particular, the water that is likely to be used for irrigation.

The following tables summarise the results from about 1500 samples of stream waters tested by the NSW Department of Agriculture at Maitland from 1960 to 1974. Where there were sufficient samples per site, the characteristic value was calculated by discarding extreme and abnormal values and averaging the remainder. With small numbers per site (2-10) there was some subjective adjustment of the mean towards what was thought to be the most likely values. For many streams there are only single samples that may not be representative but the results are included as still being of some value. In these cases, the date of sampling is given so that if needed, the seasonal conditions or stream flow can be checked.

For individual streams, total salinity increases as the flow declines. This effect is more marked in smaller streams with higher salinities. In most streams, salinity increases slightly from source to mouth.

Salinity differences between streams are related to rainfall and geology.

In high rainfall areas, (Macleay, Hastings, Manning, Myall, Karuah, Williams and Paterson catchments) salinity is generally low (less than 350 ppm) and is not greatly affected by geology. Water from most streams is suitable for irrigation, stock and domestic use even when flow is low. Some localities, however, are characterised by higher salinities which are presumably related to local geology (Wallarobba Creek for example).

In the lower rainfall areas of the Hunter Valley, salinities are generally higher and are

more closely related to geology as follows:

Triassic sandstones	-	low salinity (200-250 ppm)
Permian sediments	-	high salinity (700-1900 ppm) and high sodium and chloride
Carboniferous sediments	-	low to medium salinity (500-800 ppm)
Basalts	-	low to medium salinity (500-900 ppm) and high hardness (400-600 ppm)

Water from the Hunter River is suitable for irrigation even when the flow is very low, but it is always hard and requires softening for dairy and domestic use.

Tributaries of the Hunter vary considerably in salinity and chemical composition. Black, Wallis and Fishery Creeks are characterised by high salinity and high sodium which makes them unsuitable for irrigation except when flows are high. Sandy Creek (St. Helliers Brook), Muscle Creek, Halls Creek, Wybong Creek, Goulburn River, Glennies Creek, Webbers Creek and Monkey Place Creek have moderate salinity at normal flows but often become too salty for irrigation during low flows.

All streams in the Hunter Valley are suitable for stock during normal flows, but when flow stops some streams become too salty. Black Creek and Wallis Creek have occasionally been unfit for stock because of acidic run-off from coal mining activities.

EXPLANATION OF TABLE HEADINGS

- 1 Electrical conductivity of the water is measured, corrected to 25°C and expressed in millimhos. Using charts supplied by Chatfield for a composite sample of NSW waters, this is converted into total salinity and C gradings.
- 2 Samples with pH less than 7 are acid; above 7 are alkaline.
- 3-4 Irrigation gradings indicate suitability for irrigation, with higher figures showing poorer quality. The C gradings are based on the conductivity readings - ie the

total salinity - and the S gradings reflect the hazards from high ratio of sodium to calcium. Waters graded C1S1 can be used without restriction for all crops and soils. Waters graded above C3 or S3 would generally be unsuitable. Intermediate waters could be used under certain conditions such as high rainfall, limited use, tolerant crops, and sandy soils.

- 5 Total salinity is derived from the conductivity reading.
- 6 Total alkalinity indicates the amount of carbonates and bicarbonates. If it exceeds the figure for calcium plus magnesium (Ca+Mg) the difference is called residual alkalinity and is shown in this column in brackets. Residual alkalinity indicates the presence of bicarbonates that can aggravate the adverse effects of sodium on soil structure.
- 7 Ca+Mg is the amount of calcium plus magnesium expressed as the equivalent amount of calcium carbonate and indicates the hardness of the water. When compared with the total salinity it gives an estimate of the amount of sodium and thus the S grading for irrigation.
- 8 Cl is chloride content expressed as equivalent amount of sodium chloride. It was not measured in all samples. Some crops are very sensitive to chloride.
- 9 The number of samples test for that location. If only one sample was available, the date of sampling is given.
- 10 The lowest and highest figures for total salinity recorded for that site.

Creek	Location	Characteristic Water Quality								No of samples (or date of single sample)	Range of total salin.
		Conductivity mMh	pH	Irrigation Grading		parts per million					
				C	S	Total salin.	Total Alkal.	Ca+ Mg	Cl		
<u>MacLeay Valley</u>											
Davis	Bellbrook	0.18		1	1	120	20	70		27.6.72	
Nulla Nulla	Nulla Nulla Creek	0.10	8.0	1	1	60	40	40		30.5.66	
Dondingalong Brk	Dondingalong	0.37		1	1	220	110	100		2.3.64	
Creek	Yarrahipinni	0.53	8.0	1	1	350	40	100		22.8.71	
Christmas	South Kempsey	0.47	7.0	1	1	290	60	110	120	2	265-29
Collombatti	Collombatti	0.41	6.1	1	1	260	20	70		24.8.73	
Creek	Fredrickton	0.47	7.5	1	1	300	20	40		2	300-35
Creek	Upper Belmore	1.41	8.5	2	2	950	170	200		13.1.72	
<u>Hastings Valley</u>											
Pappinbarra	Pappinbarra	0.11	8.0	1	1	70	0	20		3	50-130
Creeks	Comboyne	0.19	8.0	1	1	120	60	100		4	60-149
Bulli	Byabarra	0.44	6.3	1	1	280	190	230	80	2	280-33
Mortons	Beechwood	0.31	6.9	1	1	190	60	100		16.11.73	
Bril Bril	Rollands Plains	0.46	6.0	1	1	300	20	130		5.9.66	
Wilson's River	Telegraph Point	0.11	8.0	1	1	60	20	30		19.4.66	
Gumscrub	Telegraph Point	0.12		2	1	760	130	360		4.2.65	
Kings	Wauchope									6	80-645
Hastings River	Wauchope	0.17	8.0	1	1	120	40	50		3	100-13
Creek	Port Macquarie	0.44		1	1	280	60	120		7.8.64	
<u>Camden Haven Valley</u>											
Little Upsall	Comboyne	0.05	8.0	1	1	40	20	30		3.7.70	
Gills	Lorne	0.19	7.5	1	1	120	20	50	90	5	70-310
Black	Kendall	0.23	7.0	1	1	140	40	100		20.4.66	
Deep	Hannamvale	0.32	6.8	1	1	205	40	50		8.1.74	
Cylers	Hannamvale	0.23	7.4	1	1	140	20	50	90	12.8.74	
Stewarts River		0.13	7.0	1	1	80	20	60		31.3.66	
Creeks	Hannamvale	0.20	8.0	1	1	120	30	60	100	2	110-13

Creek	Location	Characteristic Water Quality								No of samples (or date of single sample)	Range of total salin.
		Conductivity mMh	pH	Irrigation Grading		parts per million					
				C	S	Total salin.	Total Alkal.	Ca+ Mg	Cl		
<u>Camden Haven Valley (cont)</u>											
Creek	Laurieton	0.25	5.5	1	1	150	20	50		8.1.73	
Camden Haven River		0.11	7.5	1	1	60	20	30		28.5.71	
Creek	North Haven	0.26		1	1	170	20	30		17.2.64	
<u>Manning Valley</u>											
Waukivory	Waukivory	0.28	8.0	1	1	170	20	80	80	4	170-680
Avon River	Stratford	0.47	8.0	1	1	300	120	150		2	300-510
Gloucester River	Gloucester	0.30	7.8	1	1	190	120	100	100	1.7.74	
Barrington River	Barrington	0.12	7.5	1	1	70	40	60	30	5	40-75
Pigna Barney R.	Barrington Tops	0.26	8.0	1	1	170	120	120		22.11.65	
Creeks	Burell Creek									2	60-1240
Creek	Killawarra	5.33		5	2	3610		1250		21.12.60	
Bobin	Wingham	0.10		1	1	60				4.9.65	
Mooral	Wingham	0.39	7.0	1	1	240	60	120		2	230-240
Little Run	Wherrol Flat	0.18	8.5	1	1	120	60	80		11.1.66	
Dingo		0.21	8.5	1	1	130	80	100	80	2	60-130
Creek	Bungay	0.49		1	1	320	40	100		30.5.60	
Killabakh	Killabakh	0.62	8.0	1	1	410	150	220		6.8.70	
Killabakh	Cedar Party	1.38		2	1	930	60	310		3	930-1120
Creek	Kolodong	0.43	7.5	1	1	270	60	80		27.8.65	
Lansdowne R.	Central Lansdowne	0.16	6.9	1	1	105	20	40	60	2	70-105
Creek	Purfleet	1.27	8.0	2	1	850	40	260		30.8.72	
Creek	Old Bar	1.13		2	1	760	30	200		5.1.65	
Pipeclay	Moorland	0.31	9.0	1	1	190	0	70		14.11.66	
Swamp Oak	Taree	0.75	8.5	1	1	490	380	360	300		
Swanky Lagoon	Taree	0.30	6.2	1	1	190	40	100	110		
Manning River	Wingham	0.49	8.0	1	1	310	60	80		8	130-2680
Koorainghat		0.58	6.5	1	1	380	60	140		9.2.73	

Creek	Location	Characteristic Water Quality								No of samples (or date of single sample)	Range of total salin
		Conductivity mMh	pH	Irrigation Grading		parts per million					
				C	S	Total salin.	Total Alkal.	Ca+Mg	Cl		
Creek	Kundibakh	0.30	6.4	1	1	190	85	100	150	17.12.73	
Creek	Krambach	1.29	7.5	2	1	860	130	410		3	860-9
Khenbah	Krambach	1.05	8.5	2	1	710	80	350		14.7.70	
Coolambah	Krambach	1.05	8.5	2	1	710	80	350		14.7.70	
Candoomakl	Nabiac	0.28	6.2	1	1	170	20	80	110	2	170-9
Firefly	Krambach	1.25	8.0	2	1	840	170	420	510	11	620-2130
Koribakh	Dyers Crossing	1.20	8.0	2	1	810	80	400	700	4	770-9
Wollomba R	Nabiac	1.31	8.0	2	1	880	150	390		5	850-2600
Bunyah	Krambach	1.91		3	1	1260	400	550		28.12.62	
Kurrajong	Krambach	1.86		3	1	1240	360	450		28.12.62	
Tutt	Krambach	1.52		3	1	1040	320	350		28.12.62	
Cureeky	Coolongolook	0.37	8.0	1	1	230	80	100		6.10.67	
Coolongolook R.	Coolongolook	0.53	8.0	1	1	350	60	130		3	270-9
Wang Wark R.	Wang Wark	1.05	8.0	2	1	710	140	270		4	450-9
<u>Myall Valley</u>											
Black Camp	Bulahdelah	0.57	7.5	1	1	370	20	120		8.10.65	
Myall River	Bulahdelah	0.41	8.0	1	1	260	20	140		3	200-9
<u>Karuah Valley</u>											
Bull	Wards River	4.01		4		2970				7.1.69	
Wards River	Wards River	0.30	8.0	1	1	190	40	110		2	190-9
Lamens	Stroud	0.50	7.0	1	1	325	40	50	180	2	325-9
Booral	Booral	0.34	7.5	1	1	210	40	100		27.9.71	
Lewis	Girvan	1.63	6.8	3	2	1090	120	270	710	8.5.73	
Karuah River	Monkerai	0.12	8.0	1	1	70	20	40		7	70-19
<u>Williams Valley</u>											
Quart Pot	Dungog	0.87	8.5	1	1	580	230	300		31.1.73	
Chichester R.	Bandon Grove	0.06	7.5	1	1	40	20	20	20	2	40-50
Sugarloaf	Dungog	0.76	8.0	1	1	490	190	210	180	2	490-7

Creek	Location	Characteristic Water Quality								No of samples (or date of single sample)	Range of total salin.
		Conductivity mMh	pH	Irrigation Grading		parts per million					
				C	S	Total salin.	Total Alkal.	Ca+ Mg	Cl		
<u>Williams Valley</u>											
Trib.of Tabbil	Dungog	0.46		1	1	310	85	140		16.10.62	
Maxwells	Dungog	1.49	9.0	3	1	1010 1	320	420		3	600- 1010
Welshmans	Wallarobba	1.17	6.8	2	1	780	300	330	410	26.9.73	
Wallarobba - good flow	"	0.41	8.0	1	1	260	80	80		2	260-260
Wallarobba - normal flow	"	0.77	8.0	1	1	500	190	250	250	9	410-730
Wallarobba - low to nil	"	2.07	8.5	3	2	1350	250	430		16	790- 1790
Mares	Marshdale	0.68	7.5	1	1	450	130	170		6.5.71	
Majors	Marshdale	1.17	7.5	2	1	780	210	350		6	450- 1850
Unwarrabin	Clarence Town	0.58	7.0	1	1	380	110	110	280	3	140- 1100
Black Camp	Alison	0.80	8.0	1	1	530	170	180	280	4	350-530
Boatfalls	Clarence Town	2.66		4		1830				2.9.70	
Walleroo	Clarence Town	2.48	8.5	4	2	1750	510	600	103 0	4	1080- 1820
Tumbledown	Glen Oak	0.62	8.0	1	1	400	110	170		9	370- 2280
Deadmans	Seaham	1.24	8.0	2	2	830	230	220		2	830-990
Williams River	Bandon Grove	0.09	7.5	1	1	60	20	40		4	50-60
Williams River	Dungog	0.20	8.0	1	1	130	20	60		6	80-190
Williams River	Clarence Town	0.50	8.0	1	1	310	90	150		11	80-600
<u>Paterson Valley</u>											
Chads	Gresford	0.62	8.5	1	1	410	170	210		24.5.68	
McIntyre(no flow)	Vacy	1.39	8.0	2	1	940	280	500		28.6.65	
Hughes	Hilldale	0.37	7.0	1	1	240	190	120	150	2	190-240
Mirrari	Hilldale	0.70	8.0	1	1	450	170	230		4	450- 1070
Big	Vacy	1.86	8.5	3	2	1240	250	450		9	490- 2170
Allyn River	Gresford	0.39	8.0	1	1	250	120	120	140	19	90-520
Creeks	Hilldale	1.02	8.0	2	1	690	190	300		7	90-1410
Appletree	Gresford	1.22	8.5	2	1	830	340	420		18.8.65	
Creek	Mt Rivers	0.43	7.5	1	1	270	150	170		26.5.65	

Creek	Location	Characteristic Water Quality								No of samples (or date of single sample)	Range of total salin.
		Conductivity mMh	pH	Irrigation Grading		parts per million					
				C	S	Total salin.	Total Alkal.	Ca+Mg	Cl		
Halls (Gungal)	Gungal	1.62	9.0	3	1	1100	670	610	110	25	460-2520
Reedy	Scone	1.58	9.0	3	1	1080	490	700		2	1080-1170
Cuan	Scone	1.09	9.0	2	1	740	400	450		3	740-770
Wybong	Bunnan	0.76	8.0	1	1	500	400	420	80	3	380-500
Wybong	Wybong	1.19	8.5	2	1	800	350	420	360	7	580-920
Wybong	Hollydene	1.62	9.0	3	1	1100	310	540	750	7	750-1560
Wybong - spearpoints		1.62	8.5	3	1	1100	320	580		7	970-1280
Goulburn River	Baerami	0.77	8.5	1	1	500	210	260	170	3	480-890
Goulburn R- high flow	Denman	0.77	9.0	1	1	500	300	320		4	370-690
Goulburn R-normal flow	"	1.05	8.5	2	1	720	300	340	200	6	480-810
Goulburn R-drought	"	2.49	8.0	3	1	1700	500	800		6	1280-2500
Goulburn R-spearpoints	"	1.15	8.3	2	1	770	300	400	350	24	350-2200
<u>Middle Hunter</u>											
Bureen - creek	Martindale	0.68	7.0	1	1	440	140	160		6	150-820
Bureen - spearpoints	"	1.20	8.0	2	1	820	180	240	500	29	210-2710
Bowmans	Hebden	0.64	8.5	1	1	430	150	160	170	8	380-970
Goorangoola	Goorangoola	1.15		2	1	770	190	450		4	700-990
Fal Brook	Glennies Creek	0.89	8.5	1	1	600	190	290		14	450-5090
Webbers	Glendonbrook	0.81	8.5	1	1	520	170	210		3	520-1640
Westbrook	Westbrook									2	810-3400
Miramine	Glendonbrook	0.82	9.0	1	1	530	190	240		16	410-1700
Lambs	Lambs Creek	1.03		2	1	700	130	320		6	490-1410
Stanhope	Stanhope	0.92		1	1	610	150	330		2	550-610
Jump Up	Belford	0.50	8.5	1	1	330	100	110		21.3.68	
Sandy	Quorrobolong	1.13	8.0	2	1	760	130	200		5	540-2020

Creek	Location	Characteristic Water Quality								No of samples (or date of single sample)	Range of total salin.
		Conductivity mMh	pH	Irrigation Grading		parts per million					
				C	S	Total salin.	Total Alkal.	Ca+Mg	Cl		
Ellalong Lagoon	Pelton	0.88	7.3	1	1	590	40	120		14.12.72	
Congewai	Millfield	0.98	8.0	2	1	660	100	190		7	240-1460
Sweetmans	Sweetmans Creek	0.50	8.0	1	1	330	60	150		28.10.68	
Yango	Wollombi	0.39	7.5	1	1	240	40	60		16.2.68	
Watagan (Sugarloaf)	"	0.39	7.0	1	1	250	40	100	180	5	160-280
Blaxland Arm	Laguna	0.30	7.1	1	1	190	20	70		26.10.72	
Houlahans Arm	"	0.35	6.7	1	1	220	40	60		4.10.72	
Monkey Place	Broke	2.60		4	2	1890	320	480		2	1230-1890
Wollombi Brook	"	0.72		1	1	470	150	150	280	32	240-1460
Wollombi Brook (spearpoints)										91	210-3400
<u>Black Creek Catchment</u>											
Tribs. of Bellbird	Pokolbin	2.80	8.0	4	2	2000	400	800	800	8	770-3840
Bellbird	Cessnock	1.22	7.2	2	1	830	40	250	390	6.11.73	
Tribs. of Deep	"	1.69	8.5	3	2	1140	600	600		7	740-9640
Deep	Pokolbin	2.32		3	2	1570	290	520		10	410-2660
Middle	"	1.29	9.0	2	2	870	200	250	410	20	330-6000
First	"	1.68	8.0	3	2	1130	220	260	590	11	60-1370
Rothbury (good flow)	Rothbury	0.59	7.5	1	1	390	100	140	200	5	170-630
Rothbury (low flow)	"	12.00	9.0	5	4	1000 0	750	1610	800 0	6	4570-14460
Sweetwater (good flow)	Branxton	1.02	7.5	2	2	690	80	170	300	6.11.73	
Sweetwater (no flow)	"	8.60		5		6800				4	6200-7400
Deadmans	Cessnock	1.01	7.5	2	2	670	40	130	400	5	310-990
Saltwater	"	2.53	8.0	4	3	1740	150	300	110 0	2	1740-1990
Creeks	Rothbury									8	160-23660

Creek	Location	Characteristic Water Quality								No of samples (or date of single sample)	Range of total salin.
		Conductivity mMh	pH	Irrigation Grading		parts per million					
				C	S	Total salin.	Total Alkal.	Ca+Mg	Cl		
Redhouse	Greta	0.42	7.1	1	1	270	20	50	180	6.11.73	
Anvil	Branxton	0.86	7.5	1	1	570	110	120	280	8	380-4570
Black	Cessnock-Branxton	2.68	8.5	4	2	1890	80	530	730	220	330-9640
Fishery	South Maitland	1.99	8.5	3	2	1330	300 (40)	260		36	370-2330
Wallis	"	2.10	8.0	3	2	1410	250	350		60	350-2320
<u>Hunter River</u>											
	Polblue Creek	0.04	7.5	1	1	20	20	20		22.11.65	
	Hunter Springs	0.07	8.0	1	1	40	40	40		22.11.65	
	Moonan Flat	0.26	8.5	1	1	170	90	120		3	120-170
	Belltrees	0.36	7.5	1	1	220	80	140	110	2	130-220
	Glenbawn Dam	0.24	8.6	1	1	150	120 (20)	100	30	29.8.74	
	Aberdeen	0.40	8.5	1	1	250	170	220	90	4	180-300
	Muswellbrook	0.47	8.5	1	1	300	180	210		17	220-570
	Denman	0.47	8.5	1	1	300	150	210	120	18	230-540
	Jerrys Plains	0.76	8.5	1	1	500	210	270		17	210-970
	Singleton	0.84	8.5	1	1	550	250	300		14	220-670
	Scotts Flat	0.91	9.0	2	1	600	280	330		13	260-1360
	Belford	0.88	8.0	1	1	570	230	280		6	450-1280
	Elderslie	0.84	8.5	1	1	550	210	280	240	10	150-660
	Dalwood	0.85	8.5	1	1	560	230	280	220	10	430-1460
	Luskintyre	0.84	8.5	1	1	550	190	240	220	12	270-970
	Aberglasslyn	0.84	8.0	1	1	550	140	260	250	18	170-850

() Where total alkalinity is greater than Ca+Mg, the excess is called residual alkalinity. It indicates the presence of bicarbonates in the water, which will aggravate the adverse effects of sodium on soil structure.

Ca+Mg is expressed as the equivalent amount of calcium carbonate and indicates the degree of hardness of the water.

Cl is expressed as the equivalent amount of sodium chloride.

APPENDIX II

**WATER QUALITY IN THE HUNTER, PATERSON, ALLYN,
WILLIAMS AND KARUAH RIVERS**

HUNTER RIVER

Between 1960 and 1974 the Department of Agriculture at Maitland tested 145 samples of water taken from the Hunter River above the tidal limit at Maitland.

Results of these tests allow fairly reliable statements to be made about the quality of water from the Hunter River at various locations and under different conditions of flow.

Location and Total number of samples	Total Salinity (parts per million)					Hardness (ppm of CaCO ₃)	
	Range of values recorded	Characteristic values recorded for				Range	Median
		High (1) flows	Normal flows	Low flows	Spear points		
Polblue Creek 1	20		20				20
Hunter Springs 1	40		40				40
Moonan Flat 3	120-170	120	170			100-130	120
Belltrees 2	130-220	130	220			100-140	
Aberdeen 4	180-300		200-300			150-240	200
Muswellbrook 17	220-570	200-300	250-350	350		160-280	210
Denman 18	230-540	350-550	250-350	350-450		140-300	210
Jerrys Plains 17	210-970	300-450	450-650	650-1000		140-440	270
Singleton 14	220-670	200-450	450-700	700		190-410	280
Scotts Flat 13	260-1360	300	500-700	700-1400	600-900	150-560	330
Belford 6	450-1280	450	450-700	1000	1100-1300	220-630	280
Elderslie 10	150-660	150-450	450-650		400	60-350	250
Dalwood 10	430-1460		400-700	700-1400	750-1500	190-810	310
Luskintyre 12	270-970	300-400	400-600	750	300-1000	150-480	290
Gosforth/Maitland 18	170-850	200-300	500-700	600-800	600-900	100-340	260

(1) Mostly less than 2m above normal river height - does not include any flood flows.

Total Salinity For normal flows, the salinity increases steadily from 20 ppm at the river source to about 500 ppm at Jerrys Plains. From Jerrys Plains to Maitland the mean salinity stays at 500 ppm with a range from 400 to 700 ppm.

When flows are above normal the salinity is lower and mostly less than 450 ppm. An anomaly occurs at Denman where salinity recorded during high flows was actually higher than that at normal flows. This was probably caused by an influx of saltier water from the Goulburn River and Dartbrook Creek which tests about 500 ppm at high flows. Normal flows at Denman are largely maintained by release of low salinity water (150 ppm) from Glenbawn Dam.

At times of low flow there is very little increase in salinity between Belltrees and Denman because of water released from Glenbawn Dam - below Denman, salinity does increase when flow declines but generally does not exceed 1000 ppm unless the flow completely stops.

Water from spear points in the dry river bed ranged from 300 to 1500 ppm but most samples were in the range 500 to 1000 ppm.

Hardness Hardness (expressed as ppm of CaCO_3) during normal flows increases steadily downstream from 20 at the source to reach a peak of about 300 below Singleton and then declines slightly to 260 at Maitland. During low flows, hardness increases in proportion to the total salinity and reaches levels about 300 at Muswellbrook and 600 below Singleton.

Except for the headwaters above Belltrees, all water from the Hunter River would require softening for domestic and dairy use.

Sodium Hazard Because of the consistently high proportion of calcium in the water all of the samples were graded S1, indicating no problems from excess sodium.

The ratio of $\text{Ca}+\text{Mg}$ (as CaCO_3) to total salinity declined from 1.0 at the source to 0.7 to 0.8 at Aberdeen to Denman and 0.5 to 0.6 at Jerrys Plains to Maitland. This indicates an increase in sodium content, no doubt associated with Permian rocks in the lower catchment.

Residual Alkalinity Residual alkalinity occurred in 25 samples out of the 145. Only 3 samples exceeded 70 ppm, which is considered the marginal level for safe irrigation, and the other 22 samples were all less than 40 ppm. In general, residual alkalinity would not be a hazard.

pH pH ranged from 7.0 to 9.5: 90% of the samples were in the range 8.0 to 9.0. Lower values tended to be associated with higher flows or spear points.

Chloride Only 31 samples were tested for chloride but these indicate a range of 60 to 120 ppm (NaCl) between Belltrees and Denman with a noticeable increase at Jerrys Plains to 100 to 250 ppm and similar levels from there to Maitland.

Iron Traces of iron (1 ppm or less) were found in 9 out of 23 samples tested.

General conclusions on suitability

Stock Suitable for all stock at all times.

Domestic & Dairy Softening is required in all cases.

Irrigation As long as there is some flow in the river, salinity does not exceed 700 ppm and the water is considered suitable for all plants provided precautions are used with those very sensitive to salt.

When flow ceases and water is drawn from holes and spear points, salinity may increase up to 1500 ppm but this can still be used on all crops and pastures because of the limited amounts applied. These waters may not be suitable for some vegetables and fruits because of high salinity and high chloride levels.

PATERSON RIVER

A Non tidal waters above Paterson

Summary to 31.10.74 of 48 samples from 1965 to 1974 including 28 samples during drought April-July 1965.

During normal flow the water is very low in salinity - about 150 ppm at Gresford and 200 ppm at Paterson - and is suitable for all uses.

When the flow is low, or even when it stops, the salinity does not increase greatly e.g. to about 200 ppm at Gresford and to 300-400 ppm at Paterson.

During the 1965 drought, flow ceased for 5 months and samples were from isolated waterholes. Most of these samples tested 500-700 ppm with the worst 1090 ppm, which was still suitable for irrigation.

Characteristic Values	Conductivity	pH	Irrigation Grade		Total Salinity	Total Alkalinity	Residual Alkalinity	CaCO ₃
			C	S				
Normal flow (range)	0.32	8.2 (7.5-9)	1	1	200 (120-460)	110 (20-230)	0	120 (50-240)
No flow - drought (range)	0.85	7.7 (7-9)	1	1	550 (240-1090)	220 (130-300)	0	300 (160-600)

B Tidal waters from Paterson to Hinton

As total salinity increases because of ingress of sea water, the Sodium Hazard Rating (S) also increases roughly as follows:

<u>Total salinity (ppm)</u>	<u>S grading</u>
less than 1000	S1
1000 - 2000	S2
2000 - 3200	S3
3200 - 5000	S4

The maximum salinity in the Paterson was recorded during the 1965 drought - between 1 and 23 June.

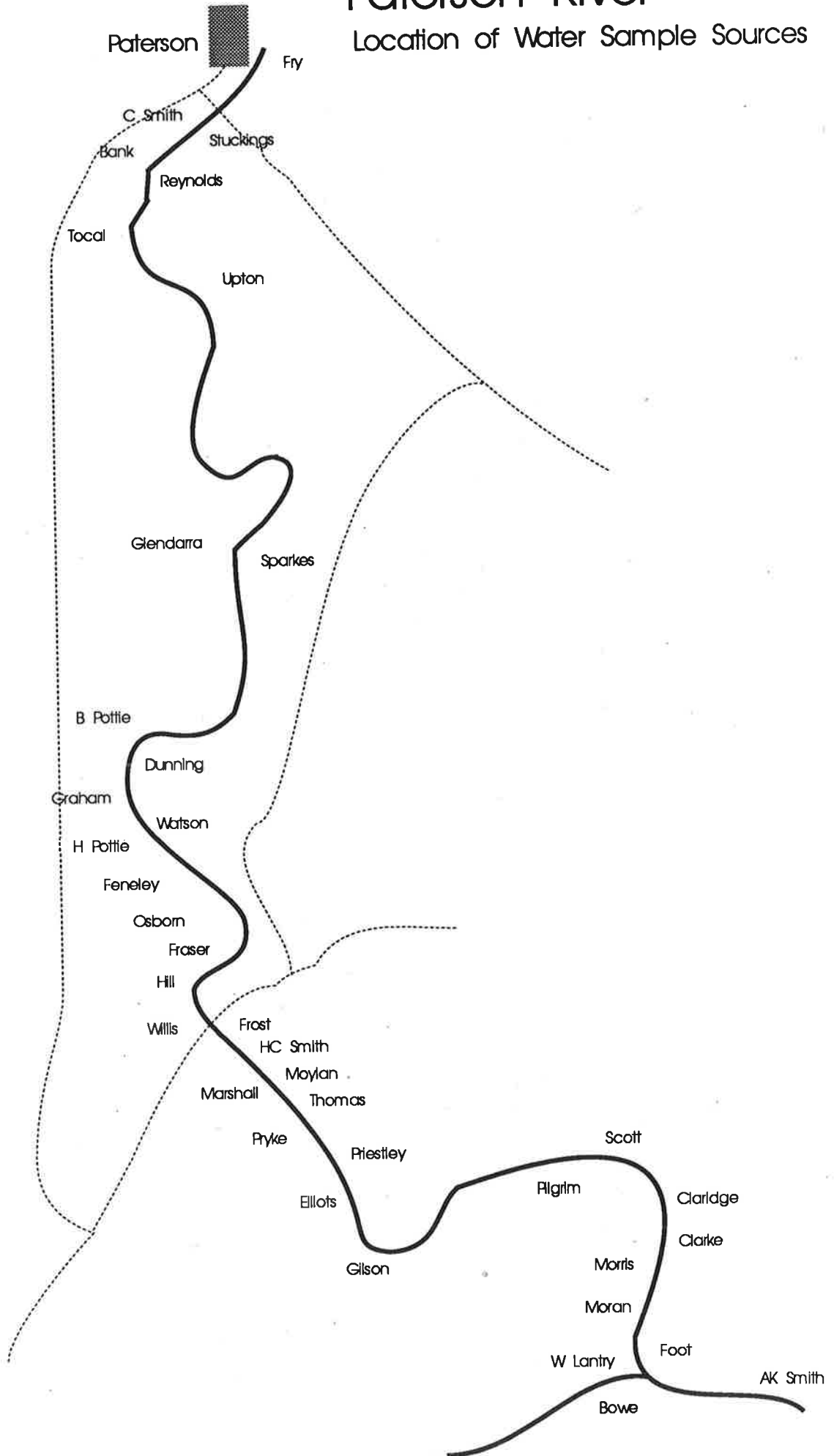
<u>Date</u>	<u>Location</u>	<u>Salinity (ppm)</u>
24.6.65	Gostwyck Bridge	640
21.6	Paterson Rail Bridge	730
21.6	C Smith - Bona Vista	890
21.6	Tocal College (probably at dairy)	950
22.6	Sparkes - "Stradbroke"	1140
3.6	Graham - Mindaribba	1580
7.6	Frost - Dunmore Bridge	2050
9.6	Osborne - Woodville	2330
7.6	Priestley - Wallalong	5090
14.4	Hinton	5380
3.6	Sparkes - Hinton (Hunter River)	6220

Very roughly, the expected salinity (ppm) would be

	<u>Above Paterson</u>	<u>Total</u>	<u>Mindaribba</u>	<u>Hinton</u>
Good flow	150	200	200	300
Normal flow	200	300	300	500
Low flow	350	500	700	1500
No flow	550	900	1400	5000

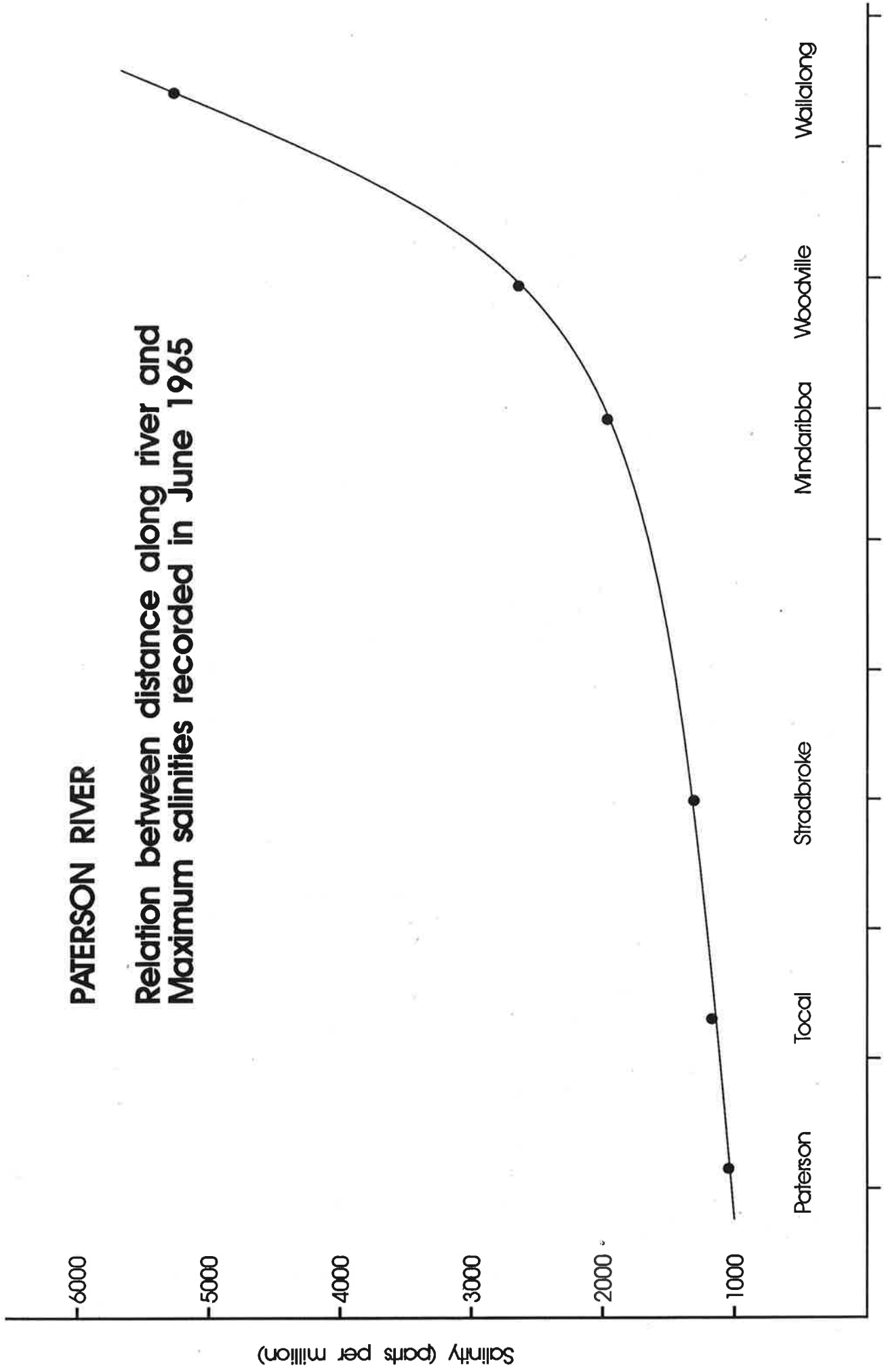
Paterson River

Location of Water Sample Sources



PATERSON RIVER

Relation between distance along river and Maximum salinities recorded in June 1965



River Mileage: 1" = 1 mile

ALLYN RIVER

Summary to 15.3.74 of 22 samples 1965-1973

Even during drought periods when the river ceases to flow, the water remains suitable for irrigation, with the maximum salinity recorded reaching only 520 ppm.

The only occasion when salinity could be a problem would be in extreme drought when the last water in waterholes was being used. The volumes of such water, however, would be extremely small and in any case would be reserved for stock and household use. There are virtually no areas of sand in the river bed, so spear points are not used.

During normal flows, the salinity appears to be less than 350 ppm and generally less than 250 ppm.

The water is low in sodium. Hardness is generally low and acceptable for domestic and dairy use except when flow is very low. The water is slightly alkaline with pH ranging from 7.5 to 9.5.

Characteristic Values	Conductivity	pH	Irrigation Grade		Total Salinity	Total Alkalinity	Residual Alkalinity	CaCo ₃
			C	S				
Normal flow (range)	0.32	8.2 (7.5-9)	1	1	200 (120-460)	110 (20-230)	0	120 (50-240)
No flow - drought (range)	0.85	7.7 (7-9)	1	1	550 (240-1090)	220 (130-300)	0	300 (160-600)

WILLIAMS RIVER

Non tidal above Clarence Town

Summary to 17.4.74 - 30 samples 1961 to 1973

When the river is flowing, total salinity (ppm) is very low, particularly above Dungog, and increases slightly downstream. For example, Chichester River 40,50; Salisbury 60; Bandon Grove 50,60; Bendolba 60; Fosterton 80,120,160; Dungog 80,130; Brookfield 100,190; Glen Martin 180; Clarence Town 80,80,90,280,310.

When flow ceases, salinity increases slightly, but the highest recorded is only 430 ppm at Glen William which is still suitable for all irrigation.

The water is only slightly hard and could generally be used without softening,

although softening would be beneficial for electric hot water systems. The water is less alkaline than other Hunter Valley streams, most pH figures are 7.5 - 8.0 with a few at 8.5.

Tributary streams - 90 samples

The information is fragmentary, but in general, most of the creeks of the Williams River are low in salinity when flowing freely - 50 to 400 ppm. When flows fall, salinity rises to 600-1000 but the water is still suitable for irrigation. When flow ceases the salinity increases to 1000-2000 and the water would not be recommended for irrigation. However, the amount of water available from pools and spearpoints is small and would be reserved for stock and domestic use.

Wallarobba Creek is markedly saltier than other streams, and only has low salinity (260 ppm) when flowing freely after rain. Flow decreases rapidly after rain and salinity rises to 1000 ppm at low flow and 1700 ppm when flow ceases. Excess sodium (S2 grading) is often present. Most of the water available for irrigation would be from pools at low or nil flow and therefore in the higher salinity range. It could be used by restricting it to tolerant crops or sandier soils, rotating irrigated areas and using gypsum to counteract breakdown of soil structure.

Tributaries of Wallarobba Creek - Maxwells, Tudor, Venges - also tend to be salty. Wallaroo Creek, which drains the adjacent catchment, has water similar to Wallarobba Creek with high salinity and excess sodium. It is interesting to note that Big Creek which is opposite Wallarobba Creek on the Paterson River side of the watershed also tends to be salty. The higher salinity of these streams is probably related to the occurrence of Permian rocks in their catchments.

KARUAH RIVER

Summary to 18.9.74 - 15 samples

Water in the Karuah River seems to be very low in salt - 60 to 90 ppm at Monkerai; 130-190 ppm at Stroud Road. The maximum salinity recorded was only 190 ppm during drought in April 1965.

Water in tributary streams tested slightly higher - 190 to 350 ppm. During drought, waterholes in creeks may be rather salty - eg. Lewis Creek 1090 ppm; Bull Creek 2970 ppm.

R WETHERALL

Original data is available from the archives in the Library, C B Alexander Agricultural College, 'Tocal', Paterson, NSW.

POSTSCRIPT

Since Mr Wetherall's monitoring work there have been two major droughts in the region. These notes refer to the impact of those droughts on water quality in the Paterson River at Tocal.

1980 Drought

The salinity at Tocal increased during 1980 and by October reached significant levels. The Paterson River at times ceased to flow, which further exacerbated the situation. Mr Wetherall's data and computed relationship of inflows and salinity in the tidal reach is confirmed by the 1980 experience. (See Appendix II.)

Salinity reached a peak of 1250 in October 1980. In early November a release of water from Lostock Dam decreased salinity significantly.

22 September	1980	480 ppm
2 October	1980	610
6 October	1980	800
13 October	1980	910
17 October	1980	1070
23 October	1980	1250
27 October	1980	1175
3 November	1980	1200
10 November	1980	850
12 November	1980	620
20 November	1980	570

These samples were collected on Glendarra, opposite Stradbroke, formerly owned by the Sparkes family. The data correlates with the Stradbroke data of 1965 and not the Tocal data. The 1965 Tocal data was from further up the river at a Tocal dairy pump.

1991 Drought

Salinity levels did not rise significantly because inflows from the Hunter and Paterson Rivers remained higher than in the 1980 drought. The Upper Hunter did not become drought affected as early as the Lower Hunter.

As a result, no salinity readings were taken at Tocal during this drought.

Reference: Dutton, I., Archer, C., Muddle, R. and Brouwer, D. (1993) The Climate at Tocal. NSW Agriculture, C B Alexander Agricultural College, 'Tocal', Paterson.