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# **TUGGERAH LAKES FLOOD STUDY**

**Compendium of Data** 

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#### FOREWORD

The State Government's Flood Policy is directed to providing solutions to existing flooding problems in developed areas and to ensuring that new development is compatible with the flood hazard and does not create additional flooding problems in other areas.

Under the policy the management of flood liable land remains the responsibility of Local Government. The State subsidises flood mitigation works to alleviate existing problems and provides specialist technical advice to assist Councils in the discharge of their floodplain management responsibilities.

The Policy provides for technical and financial support by the Government through the following four sequential stages:-

1.	Flood Study	-	determines the nature	and extent of
			any flood problem.	

- 2. Floodplain Management Study - evaluates management options for the floodplain in respect of both existing and proposed development.
- 3. Floodplain Management Plan - involves formal adoption by Council of a plan of management for the floodplain.
- 4. Implementation of the Plan - construction of flood mitigation works to protect existing development.

This Compendium of Data constitutes the first phase of a Flood Study for Tuggerah Lakes and has been prepared to identify sources of flood and storm data and to present details of prominent flood events.

## TUGGERAH LAKES FLOOD STUDY COMPENDIUM OF DATA

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## Preface

During the course of this data collection exercise a number of flood levels were found which appeared anomalous. The differences were in the order of 0.5m and therefore could not be easily discounted or ignored.

An investigation into survey datums ensued. It involved scrutinising flood data and verifying the origin of historical flood levels. Results of this investigation are presented in Appendix C.

It was found that in some cases a problem existed with the description of survey datums. Sources reported different levels for given benchmarks supposedly to the same datum. In fact the actual datum used was often not the one guoted and subsequent translations to AHD compounded the confusion.

This survey datum confusion has existed for many years. Investigations and reports to date (including those reports referenced in this document) have the potential to contain flood level data which are in error.

#### **1.0 INTRODUCTION**

Tuggerah Lakes is a water body on the NSW Central Coast comprising the three inter-connected lakes of Tuggerah, Budgewoi and Munmorah. The lakes are open to the Tasman Sea by a narrow channel at The Entrance (Figure 1).

There is considerable demand for land along the foreshores of the lakes largely because of the scenic and recreational value. A large proportion of foreshore land is flood liable. An improved knowledge of local flood behaviour is therefore desirable to enable Council to better manage future development.

The boundary of Wyong Shire approximates the Tuggerah Lakes catchment area and, to The Entrance, this totals approximately 800 km<sup>2</sup>. The surface area of the lakes is about 80 square kilometres. Major inflowing tributaries include Wyong River, Ourimbah Creek and Wallarah Creek.

Water surface elevation in the lakes is influenced by runoff from the catchment, precipitation falling directly onto the surface of the lakes, atmospheric pressure, wind, the channel morphology at The Entrance and ocean conditions. Historically, the normal tidal influence within the lakes has been small.

Flood behaviour can be established most reliably by statistical analysis of historical flood data and numerical modelling of the catchment and floodplain. These analyses require flood height, streamflow and rainfall data (depth, duration, distribution) from across the catchment.

The nature and extent of flooding in Tuggerah Lakes has been the subject of several earlier studies, particularly References 19, 21 and 22. Since these studies were completed, improved flood modelling techniques and a quantity of additional data have become available.

The aim of this document is to present key flood data, and provide references to other sources of flood data for Tuggerah Lakes and, to a limited extend, its tributaries.

#### 2.0 OVERVIEW OF EXISTING REPORTS

#### <u>Caution</u>: Flood level data from some of the following reports may contain survey datum errors - refer Appendix C.

#### 2.1 Recurrence Frequency of Flood Levels in the Tuggerah Lakes System, 1971 (Reference 19)

This study presents the results of two independent methods for defining the recurrence interval of floods in the Lakes; a frequency analysis of nine years of maximum recorded water levels, and a combined mathematical/physical modelling approach. It also presents a quantity of historical flood information.

The mathematical/physical model includes inflows determined from unit hydrographs and outflows based on the results of a mobile bed physical model of scouring of the Entrance Channel. A seismic survey (depth of bedrock) is included.

#### 2.2 Drainage and Flooding Study ~ Gosford/Wyong Area Structure Plan, 1974 (Reference 21)

Historical flood level data are presented. Flood recurrence intervals, determined in Reference 19, are recommended and potential structural works for floodplain management are discussed.

## 2.3 Tuggerah Lakes Study, 1979 (Reference 22)

The report presents information on a wide range of factors and problems associated with the lakes system. Information possibly relevant to a future flood study is summarised as follows:-

- Reference is made to the findings of the reports discussed at 2.1 and 2.2 above.
- The wind and wave climate on the lakes is described as is the impact of wind and waves on lakes levels. Data from anemometers at Munmorah Power Station and Norah Head are presented.
- The behaviour of the entrance channel is discussed both in terms of its hydraulic performance and its morphological behaviour.
- Available hydrosurveys were analysed in order to produce an estimate of the rate of sedimentation in the lakes.
- A hydrodynamic model was developed to predict currents in the lake resulting from wind action, freshwater inflows and tidal influence.

#### 2.4 Lower Wyong River Flood Study, 1984 (Reference 9)

Flood discharges and flood profiles are presented for the lower Wyong River between the Northern Railway and Tuggerah Lakes. The report expresses some reservations about the available stream flow records (Wyong Weir 211007), particularly the large proportion of overland flood flow which could bypass the gauge station and the fact that only small inbank flows had been rated.

Flood discharges are based on synthetic unit hydrographs and a regional flood frequency curve. Flood profiles are produced by backwater analysis. Some aspects of these findings have been superseded by the "Upper Wyong River Flood Study". Historical data from extensive resident interviews are also presented.

#### 2.5 Lower Wyong River Model Investigation, October 1985, (Reference 23)

Flow conditions in the lower Wyong River were investigated with a physical model. Measurements of peak velocities for the 1% and 2% events were made as were flow distributions for in-bank and over-bank areas in the 1% AEP event.

#### 2.6 Upper Wyong River Flood Study, 1988 (Reference 25)

This study presents a definition of design flood behaviour for the Wyong River, between the Northern Railway Line and Woodburys Bridge.

A review of available data on historical floods is produced. This information was subsequently used to construct a non linear catchment hydrologic model (WBNM) and a quasi two dimensional hydraulic model (CELLS) of the floodplain. The study's findings include flood discharges and flood profiles for the study area.

#### 2.7 Berkeley Vale Flood Study and Floodplain Management Study, September 1988 (Reference 27)

Flow estimates were computed using the runoff model RAFTS with synthetic 1% AEP storms and recent events. HEC-2 was used to derive flood profiles. Sections of the existing drainage system were found to be too small to pass the 1% design flows without unacceptable overland flow.

Data from floods in 1978 and 1984 were used to derive a discharge-damage relationship and identify areas of greatest potential damage.

Three structural mitigation schemes were investigated.

# 2.8 Tumbi Umbi Flood Study, February 1991 (Reference 28)

This document was preceded by a corresponding Compendium of Data. Flood hydrographs were estimated using RORB while the CELLS quasi two dimensional hydraulic model was used to estimate flood levels and velocities. Models were calibrated against the February 1981 event and verified with those of January 1978 and November 1984.

Based on historical data, the design 1% AEP rainfall given in ARR for this catchment appeared low. Rainfalls were correspondingly adjusted upward by 33% and design flood profiles generated.

#### 2.9 Lower Ourimbah Creek Flood Study, Preliminary Draft, August 1990 (Reference 36)

In this document significant floods were reported for 1889, 1927, 1930, 1949, 1953, 1974 and 1977. It was the 1949 event which produced the highest recorded levels near the lake while the 1953 flood had the greatest impact upstream along Ourimbah Creek. Flood levels were computed for the 1%, 2% and 5% AEP floods for lower Ourimbah Creek from the Pacific Highway Bridge to Tuggerah Lake. The hydrological methods used include flood frequency, unit hydrographs and runoff routing. HEC-2, the one-dimensional steady state backwater model, was used for the hydraulic modelling. Appendix B of Reference 36 gives an indication of the extent of the 1% floodplain based on geomorphological evidence.

#### 2.10 Wyong River Floodplain Management Study, Draft, September 1991 (Reference 26)

Design levels for the 5%, 2%, 1% AEP floods and an extreme flood were determined. The hydrologic model WBNM was used for rainfall/runoff estimation. The CELL model was then used to convert the runoff hydrographs into flood heights and velocities. The CELL model was calibrated to the 1964 flood and verified using the June 1974 and March 1977 floods. Design rainfall data were taken from 1987 ARR.

The adjacent Mardi Creek was modelled separately. Again WBNM was used to produce runoff hydrographs however the hydraulic modelling was done using RUBICON.

#### 2.11 Sensitivity Analysis The Entrance Channel Tuggerah Lake, July 1992 (Reference 35)

A simple hydrologic (WBNM) and hydraulic (RUBICON) modelling system was established to analyse a range of tidal, flood and entrance channel conditions. Scenarios considered included :

- 3 tidal conditions (regular, high and storm tides)
   4 entrance conditions (50m, 100m, 200m and 300m wide rectangular entrance channels with -2m AHD invert)
- 1% AEP storms of duration 24, 36, 48 and 72 hours (the 36 hour storm was found to be critical)
- 1%, 2%, 5%, 50% and Extreme events were considered for the 36 hour duration over the range of tidal and entrance conditions.
- This report used corrected flood data (Appendix C)

#### 3.0 SUMMARY OF KNOWN FLOODS

An extensive search was undertaken to locate rainfall and flood data. Information was sought from the following sources:

- \* Wyong Shire Council
- \* Bureau of Meteorology
- \* Public Works Department
- \* Roads and Traffic Authority (formerly the
- Department of Main Roads)
- \* State Rail Authority
- \* Pacific Power (formerly Electricity Commission of NSW)
- \* State Emergency Services, Wyong
- \* Wyong Historical Society
- \* Local residents
- \* Local, Newcastle and Sydney newspapers

Descriptive rainfall and flood information from the above sources is contained in Appendix B. Quantitative information on flood heights is presented in Section 4.

The flood behaviour of major tributaries features strongly in the qualitative information presented in Appendix B. This is because the tributaries contribute significantly to extreme water levels in Tuggerah Lakes.

Table 1 summarises significant events on Tuggerah Lakes.

Table 2 shows that major floods have occurred in 1927, 1946, 1949, 1964 and 1990. According to old reports, the floods of 1927, 1946, 1949 and 1964 were generally of a similar size; within 25-50mm of each other.

# SUMMARY OF MAIN FLOOD EVENTS - TUGGERAH LAKES

FLOOD EVENT	SEVERITY CATEGORY	FLOOD LEVELS AVAILABLE	NEWSPAPER REFERENCES (See Appendix B)	REPORT AVAILABLE (See Page 34)
1867	2	-	Yes	Ref. No. 1.
1885 June	3	-	Yes	Ref. No. 1.
1889 May	1	-	Yes	Ref. No. 1.
1893 March	3	-	Yes	-
1903 November	3	-	Yes	Ref. No. 1
1905 April	2	-	Yes	Ref. No. 1
1921 December	2	-	Yes	Ref. No. 1
1927 April	1	Yes	Yes	Ref. No. 1,3,5
1930 June	1	Yes	Yes	Ref. No. 9
1931	2	Yes		Ref. No. 5
1941	2	Yes	-	Ref. No. 5
1946 April	1	Yes	Yes	Ref. No. 1,3,5
1949 June	1	Yes	Yes	Ref. No. 3,7,9
1950 June	2	-	Yes	Ref. No. 1.
1953 May	2	Yes	Yes	Ref. No. 5,9
1962 May	3	Yes	-	Ref. No. 2
1963 April	2	Yes	-	Ref. No. 2,3,7
1964 June	1	Yes	Yes	Ref. No. 2,3,9
1967 March	3	Yes	-	Ref. No. 2
1967 June	3	Yes	-	Ref. No. 2
1967 August	3	Yes	Yes	Ref. No. 2
1974 May/June	2	Yes	Yes	Ref. No. 4,7,9
1977 March	2	Yes	Yes	Ref. No. 9

## TABLE 1 (Cont.)

#### SUMMARY OF MAIN FLOOD EVENTS - TUGGERAH LAKES

FLOOD EVENT	SEVERITY CATEGORY	FLOOD	NEWSPAPER REFERENCES (See Appendix B)	REPORT AVAILABLE (See Page 34)
1978 January	3		Yes	Ref. No. 8
1978 March	3	•	Yes	-
1981 February	3	Yes	Yes	Ref. No. 10
1984 November	3	Yes	-	Ref. No. 11,12,13
1985 October	3	Yes	Yes	Ref. No. 14
1988 April	3	Yes	-	Ref. No. 15
1988 July	3	Yes	-	
1990 February	1	Yes	Yes	Ref. No. 16
1990 August	3	Yes	-	-
1992 February	2	Yes	Yes	Ref. No. 17

# NOTE : Severity Categories

- 1 Most severe floods on record
- 2 Other severe floods on record
- 3 Minor floods

#### 4.0 FLOOD HEIGHT DATA

Flood height data were drawn from a variety of sources.

In some cases flood levels extracted from early reports have been adjusted to account for survey datum anomalies. Details of adjustments can be found in Appendix C.

Formal interviews with residents were not undertaken, however some people did offer specific flood height information.

Flood height data can generally be freely found. The reliability of pieces of data however varies from accurate measurement by water level recording instruments to estimates made by people who were not present during the flood.

Ideally one should seek corroborative evidence before adopting any particular level for a historical flood.

Table 2 provides an indication of the occurrence of significant flood levels in Tuggerah Lakes.

Table 3 elaborates with detailed information about specific flood levels.

For locations and levels of selected flood data, refer to Figures 3a and 3b.

Table 4 highlights the periods of available record as measured by water level recorders in the Tuggerah region.

Table 5 shows (recent) significant lake level rises.

All floodmarks in this document have been reduced to metres AHD using the latest survey Datum information (Appendix C).

Appendix B also contains flood height data. They have been derived from newspapers and other sources.

# SUMMARY OF HISTORICAL FLOOD LEVELS - TUGGERAH LAKES

YEAR/MONTH	(m) AHD
1927/4	1.2 - 1.8
1931	1.2 - 1.8
1941	1.2 - 1.8
1946/4	1.2 - 1.9 *
1949/6	1.8 - 2.1 #
1953/5	1.2 - 1.8
1962/5	1.2
1963/4	1.4 - 1.5
1964/6	1.6 - 1.8
1967/3	0.9 - 1.0
1967/6	1.0 - 1.2
1967/8	0.9 - 1.1
1974/5	1.2 - 1.3
1977/3	1.6 *
1981/2	1.1
1984/11	0.9 - 1.0
1985/10	1.0 - 1.1
1988/4	0.9 - 1.1
1988/7	1.0
1990/2	1.6 - 1.7
1990/8	1.0
1992/2	1.1

- Note : Lake levels generally vary for any given event, depending on the location of observation and the prevailing weather conditions.
  - \* : Caution, see Table 3 for more information about these levels.
  - # : 2.1 m surveyed (June 92) by Wyong Council.

#### **DETAILED HISTORICAL FLOOD LEVELS - TUGGERAH LAKES**

FLOOD EVENT	LOCATION	ORIGINAL R.L. FEET	CONVERSION FACTOR METRES	ADOPTED FLOOD LEVEL AHD METRES		SOURCE OF INFORMATION/COMMENTS
1927 Apr	Tuggerah Lake and Lake Munmorah	101'+(3'to 5')	0.052	1.2 to 1.77	(3),( Year	(5),(6),(8), Surveyed by ELCOM - Conversion Factor = 0.052m 1927 - the highest record at Wyong Weir - (6) page 6.
1927 Apr	No 26 Wolscley Av. Tacoma			1.81	(9)	Surveyed in AHD, so Conversion Factor $= 0$
1930	No 26 Wolselcy Av. Tacoma			1.81	(9)	This event may have occurred in 1930 or 1931, Surveyed in AHD, so Conversion Factor $= 0$
1931	Tuggerah Lake and Lake Munmorah	101 ' + (3 'to 5')	0.052	1.2 to 1.77	(5)	Lake rises of from 3-5 feet - (5) page 2.
1941	Tuggerah Lake and Lake Munmorah	101'+(3'to 5')	0.052	1.2 to 1.77	(5)	Lake rises of from 3-5 feet - (5) page 2.

Notes: 1. List of Sources of Information is attached at the end of this Table,

2. 1927, 1949 and 1964 - floods approximately the same heights within 1" or 2" - (3) page 4,

3. 1927, 1931, 1941, 1946, 1947 & 1953 - lake rises of from 3-5 feet were experienced - (5) page 2, (1947 - maybe 1949 event),

4. Levels quoted by ELCOM surveyed to Power Station Datum (which is 100 feet below Standard Datum), so Conversion Factor = 0.052m,

5. Worked example for conversion of levels:  $107.28' \rightarrow 7.28' \times 0.3048 - 0.399 = 1.82m$  AHD.

6. For Conversion Factors see Table C2 in Appendix C.

# DETAILED HISTORICAL FLOOD LEVELS - TUGGERAH LAKES

FLOOD EVENT	LOCATION	ORIGINAL R.L. FEET	CONVERSION FACTOR METRES	ADOPTED FLOOD LEVEL AHD METRES	SOURCE OF INFORMATION/COMMENTS
1946 Apr	Tuggerah Lake and Lake Munmorah	101'+(3'to 5')	0.052	1.2 to 1.77	(5), (8), (3), Lake riscs of from 3-5 feet - (5) page 2.
1946 Apr	Tuggerah Lake and Lake Munmorah	107.5'	0.052	2.23	(5) If 107.5' was surveyed to Power Station Datum - flood level would be 2.23m AHD, but comparing other information for 1946 flood this level looks high.
1946 Apr	Tuggerah Lake and Lake Munmorah	107.5'	0.400	1.88	(5), (3) It is likely that 107.5' was surveyed to old Datum. Thus the flood level would be around $1.88m$ AHD (Conversion Factor = 0.400m adopted).
1949 June	Southern end of bridge at The Entrance	107.72'	0.436	1. <b>92</b>	(3) Highest flood in boatshed located at southern end of bridge, so Conversion Factor for BM.1 & BM.23/B adopted.
1949 June	Northern end of bridge at North Entrance	107.28'	0.399	1.82	(3) Highest level taken (by Mr Hutton) at North Entrance, so Conversion Factor as for BM.169 adopted.
1949 June	Tacoma	7.25'	0.380	1.83	(7) Surveyed by Council's Surveyor, Conversion Factor for
1949 June	Tacoma No 16 Wolseley Ave			1.86	<ul><li>(9) Surveyed to AHD, so Conversion Factor = 0.</li></ul>
1949 June	Long Jetty			2.1	Surveyed in June 1992 by Wyong Council (Level Book 402)
1953 May	Lake Munmorah	101'+(3'to 5')	0.052	1.2 to 1.77	(5), (8), Flood level only in (5).

Note: List of Sources of Information is attached at the end of this Table.

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# DETAILED HISTORICAL FLOOD LEVELS - TUGGERAH LAKES

FLOOD EVENT	LOCATION	ORIGINAL ( R.L. FEET	CONVERSION FACTOR METRES	ADOPTED FLOOD LEVEL AHD METRES		SOURCE OF INFORMATION/COMMENTS
1962 15-16 May	Elizabeth Bay	1 <b>04.0'</b>	0.052	1.17	(2)	Surveyed by ELCOM to Power Station Standard Datum which is 100 feet below Standard Datum, so 0.052m Conversion Factor was used.
1962 May	Budgewoi Channel	104.0'	0.052	1.17	(2)	Surveyed by ELCOM, Conversion Factor $= 0.052m$
1962 May	Toukley Bridge	104.0'	0.052	1.17	(2)	Surveyed by ELCOM, Conversion Factor = 0.052m
1963 28-29 April	Elizabeth Bay	1 <b>04.8'</b>	0.052	1.41	(2),	(3) Surveyed by ELCOM, Conversion Factor = $0.052m$
1963 Apr	Budgewoi Channel	105.2'	0.052	1.53	(2)	Surveyed by ELCOM, Conversion Factor = $0.052m$
1963 Apr	Toukley Bridge	105.15'	0.052	1.52	(2)	Surveyed by ELCOM, Conversion Factor = 0.052m
1963 <u>A</u> pr	Tacoma	5.79*	0.380	1.38	(7)	Surveyed by Council's Surveyor, Conversion Factor for this area $= 0.380$ m.
1964 9-12 June	Elizabeth Bay	1 <b>05.75'</b>	0.052	1.70	(2)	Surveyed by ELCOM, Conversion Factor = $0.052m$
1964 June	Budgewoi Channel	105.5'	0.052	1.62	(2)	Surveyed by ELCOM, Conversion Factor = $0.052m$
1964 June	Toukley Bridge	105.8'	0.052	1.72	(2)	Surveyed by ELCOM, Conversion Factor $= 0.052m$

## DETAILED HISTORICAL FLOOD LEVELS - TUGGERAH LAKES

FLOOD EVENT	LOCATION	ORIGINAL R.L. FEET	CONVERSION FACTOR METRES	ADOPTED FLOOÐ LEVEL AHD METRES		SOURCE OF INFORMATION/COMMENTS
1964 June	Long Jetty	106.2'	0.052	1.83	(2)	Surveyed by ELCOM, Conversion Factor = 0.052m
1964 June	North Entrance	106.48'	0.399	1.58	(3)	Surveyed to old Datum. Northern side of bridge, Conversion Factor for B.M. 169 adopted.
1964 June	No 55 Wolseley Ave Tacoma			1.87	(9)	Surveyed to AHD, so Conversion Factor $= 0$
1964 June	No 73 Wolscley Ave Tacoma			1.97	(9)	Surveyed to AHD, so Conversion Factor = 0 (2km upstream from the Lake shore)
1967 Mar	Long Jetty	103.0'	0.052	0.9	(2)	Surveyed by ELCOM, Conversion Factor = 0.052m
1967 Mar	Elizabeth Bay	103.0'	0.052	0.9	(2)	Surveyed by ELCOM, Conversion Factor = 0.052m
1967 Mar	Budgewoi Channel	103.6'	0.052	1.0	(2)	Surveyed by ELCOM, Conversion Factor = $0.052m$
1967 Mar	Toukley Bridge	103.1'	0.052	0.9	(2)	Surveyed by ELCOM, Conversion Factor = 0.052m
1967 23-25 June	Budgewoi Channel	104.2'	0.052	1.23	(2)	Surveyed by ELCOM, Conversion Factor = 0.052m
1967 June	Toukley Bridge	104.0'	0.052	1.18	(2)	Surveyed by ELCOM, Conversion Factor = 0.052m
1967 Junc	Long Jetty	103.8'	0.052	1.11	(2)	Surveyed by ELCOM, Conversion Factor = 0.052m
1967 June	Elizabeth Bay	103.4'	0.052	0.98	(2)	Surveyed by ELCOM, Conversion Factor = 0.052m

# DETAILED HISTORICAL FLOOD LEVELS - TUGGERAH LAKES

FLOOD EVENT	LOCATION	ORIGINAL R.L. FEET	CONVERSION FACTOR METRES	ADOPTED FLOOD LEVEL AHD METRES	SOURCE OF INFORMATION/COMMENTS
1967 Aug	Long Jetty	103.0'	0.052	0.86	(2) Surveyed by ELCOM, Conversion Factor = 0.052m
1967 Aug	Elizabeth Bay	103.3'	0.052	0.95	(2) Surveyed by ELCOM, Conversion Factor = 0.052m
1967 Aug	Budgewoi Channel	103.6'	0.052	1.04	(2) Surveyed by ELCOM, Conversion Factor = $0.052m$
1967 Aug	Toukley Bridge	103.8'	0.052	1.11	(2) Surveyed by ELCOM, Conversion Factor = $0.052m$
1974 May/ June	Memorial Park, The Entrance	5.64'	0.430	1.3	<ul> <li>(1), (7), Wyong Council's Flood Report, June 1974.</li> <li>Conversion Factor as for BM.23/B, BM.2, BM.6, BM.10, BM.11.</li> </ul>
1974 May/ Junc	Fisheries Insp. Boat Shed, The Entrance	5.40'	0.430	1.2	(1),(7), Wyong Council's Flood Report, June 1974. Conversion Factor as for BM.23/B, BM.2, BM.6, BM.10, BM.11.
1974 June	Long Jetty (ELCOM)			1.2	(9) Elcom, peak level recorded at Long Jetty (after SKP Lower Wyong River Flood Study Report, 1984).
1974 June	No 73 Wolseley Ave Tacoma			1.39	<ul> <li>(9) Surveyed to AHD, so Conversion Factor = 0</li> <li>(2km upstream from the Lake shore).</li> </ul>
1977 Mar	No 72 Wolseley Ave Tacoma			1.59 ?	<ul> <li>(9) Surveyed to AHD, so Conversion Factor = 0</li> <li>(2km upstream from the Lake shore). Comparing with other information this level looks high. If this level was surveyed to old Datum - flood level would be around 1.21m AHD</li> </ul>

(Conversion Factor = 0.380m adopted).

## DETAILED HISTORICAL FLOOD LEVELS - TUGGERAH LAKES

FLOOD EVENT	LOCATION	ORIGINAL R.L. FEET	CONVERSION FACTOR METRES	ADOPTED FLOOD LEVEL AHD METRES	SOURCE OF INFORMATION/COMMENTS
1981 Feb	No 22 Lakedge Ave				Central Coast Feb. 1981 Flood - PWD Report, Draft.
	Berkeley Vale			1.08	(level at Tumbi Umbi Creck)
1984 Nov	Tacoma at Tacoma Rd opposite Hillcrest Ave				Wyong River November 1984 Flood, PWD Report No 88027, Jan. 1988.
	M 11062			0.99	(BM.1/J RL.2.32m AHD)
1984 Nov	South Tacoma			0.90	Wyong SES
1984 Nov	Chittaway Point,				Flooding on Central Coast Crecks 8 Nov 1984 Flood,
	Lake at Simon Cl.			0.97	PWD, Survey and Property Branch Report.
1984 Nov	Killarney Vate, M11139			0.93	Saltwater, Tumbi and Berkeley Creeks, Nov 1984 Flood, PWD Metrop. District Office Report, Aug. 1985.
1985 Oct	Tacoma, M11062			1.09	Gosford-Wyong Region, Oct. 1985 Flood.
	Tacoma, M11056			1.09	PWD Report No 89036.
1985 Oct	Chittaway, M11119			0.99	Gosford-Wyong Region, Oct. 1985 Flood, PWD Report No 89036.

Note: List of Sources of Information is attached at the end of this Table.

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# DETAILED HISTORICAL FLOOD LEVELS - TUGGERAH LAKES

FLOOD EVENT	LOCATION	ORIGINAL R.L. FEET	CONVERSION FACTOR METRES	ADOPTED FLOOD LEVEL AHD METRES	SOURCE OF INFORMATION/COMMENTS
1988 April	Wyong River at the mouth	-		1. <b>09</b>	Gosford/Wyong Flooding 30 April & 1st May 1988, PWD, Metrop. District Office Report, No. 10.004.874.
1988 April	Lake at Tacoma			0.80	Gosford/Wyong Flooding 30 April & 1st May 1988, PWD, Metrop. District Office Report, No. 10.004.874.
1988 April	South Tacoma Point at the mouth of Wyöng River			0.89	Gosford/Wyong Flooding 30 April & 1st May 1988, PWD, Metrop. District Office Report, No. 10.004.874.
1988 April	Chittaway Point - - South			0.91 0.94	Gosford/Wyong Flooding 30 April & 1st May 1988, PWD, Metrop. District Office Report, No. 10.004.874.
1988 April	Chittaway Point - - North, Vesta Cl			1.12 1.02	Gosford/Wyong Flooding 30 April & 1st May 1988, PWD, Metrop. District Office Report, No. 10.004.874.
1988 April	Barkeley Vale, Lake Edge Drive Culvert			1.25	Gosford/Wyong Flooding 30 April & 1st May 1988, PWD, Metrop. District Office Report, No. 10.004.874. (level- downstream L.H. side of culvert)
1988 July	Killarney Vale			1.03	PWD Manly Hydraulics Laboratory, PWD Water Level Recorder.
1988 July	Toukley			0.92	PWD Manly Hydraulics Laboratory, PWD Water Level Recorder.

## DETAILED HISTORICAL FLOOD LEVELS - TUGGERAH LAKES

FLOOD EVENT	LOCATION	ORIGINAL R.L. FEET	CONVERSION FACTOR METRES	ADOPTED FLOOD LEVEL AHD METRES	SOURCE OF INFORMATION/COMMENTS
1990 Feb	Tacoma Res, M11063			1.74	Flood Data Survey, Fcb. 1990 Flood - PWD, Maniy Lab Report No. 575.
1990 Feb	North Tacoma Jannary St, M11064		u	1.76	Flood Data Survey, Fcb. 1990 Flood - PWD, Manly Lab Report No. 575.
1990 Feb	Chittaway Pt. Kalua Drive, M11119			1.69	Flood Data Survey, Feb. 1990 Flood - PWD, Manly Lab Report No. 575.
1990 Feb	Chittaway Pt. Sunshine Res. M11120		Ϋ _	1.87	Flood Data Survey, Feb. 1990 Flood - PWD, Månly Lab Report No. 575.
1990 Feb	Chittaway/Berkley Vale Lakedge Ave. M11124		<u></u>	1.68	Flood Data Survey, Feb. 1990 Flood - PWD, Manly Lab Report No. 575.
1990 Fcb	Killarney Vale Lions Park, M11140		•-	1.76	Flood Data Survey, Feb. 1990 Flood - PWD, Manly Lab Report No. 575.
1990 Feb	Killarney Vale Gregory St. M11135			1.86	Flood Data Survey, Feb. 1990 Flood - PWD, Manly Lab Report No. 575.
1990 Feb	Killarney Vale, ern Wyong Rd & Shortland Ave. M11137			1.87	Flood Data Survey, Feb. 1990 Flood - PWD, Manly Lab Report No. 575.

# DETAILED HISTORICAL FLOOD LEVELS - TUGGERAH LAKES

FLOOD EVENT	LOCATION	ORIGINAL R.L. FEET	CONVERSION FACTOR METRES	ADOPTED FLOOD LEVEL AHD METRES	SOURCE OF INFORMATION/COMMENTS
1990 Aug	Killarney Vale			0.97	PWD Manly Hydraulics Laboratory PWD Water Level Recorder.
1992 Гев	Killarney Vale, Graham St, Lions Park M11140	-		1.12	Central Coast Feb. 1992 Flood Event - PWD, Manly Lab. Report No. 615.
1992 Feb	Wyong River, McDonagh Rd, M11061	-		1.21	Central Coast Feb. 1992 Flood Event - PWD, Manly Lab. Report No. 615. (1km upstream from the Lake shore)
1992 Feb	Wyong River, Pollock Ave, M11065			1.19	Central Coast Feb. 1992 Flood Event - PWD, Manly Lab. Report No. 615. (2km upstream from the Lake shore)
1992 Feb	Ourimbah Ck, Sunshine Ave, M11120			2.06	Central Coast Feb. 1992 Flood Event - PWD, Manly Lab. Report No. 615. (3km upstream of Ourimbah Ck mouth) <u>Note</u> : This event was the highest on record in the Upper Ourimbah Creek catchment.

# DETAILED HISTORICAL FLOOD LEVELS - TUGGEAH LAKES

FLOOD EVENT	LOCATION	ORIGINAL R.L. FEET	CONVERSION FACTOR METERS	ADOPTEÐ FLOOD LEVEL AHD METRES	SOURCE OF INFORMATION/COMMENTS
1992 Feb	Long Jetty			1.13	Central Coast Feb. 1992 Flood Event - PWD, Manly Lab. Report No. 615. PWD Water Level Recorder.
1992 Feb	Toukley			1. <b>0</b> 6	Central Coast Fcb. 1992 Flood Event - PWD, Manly Lab. Report No. 615. PWD Water Level Recorder.

#### DETAILED HISTORICAL FLOOD LEVELS - TUGGEAH LAKES

#### LIST OF SOURCES OF FLOOD INFORMATION

- (1) Report on Storm and Flooding in Wyong Shire, May 25th to May 31st 1974, State Emergency Services, New South Wales.
- (2) Munmorah area Climatic and Limnological Data Data Set No. C.I. 17., The Electricity Commission of NSW, Power Development Division, Civil Investigations Branch, February 1969.
- (3) Engineering/Investigation Survey at The Entrance, Shire of Wyong, Parish of Tuggerah. Report for DMR, Newcastle, Bannister and Hunter Surveyors, Gosford, 10th December 1964.
- (5) Flood Levels Lake Macquaric and Lake Munmorah Hydraulic Research Note No. 29, The Electricity Commission of NSW, Power Development Branch, Projects Division, 1960-1961.
- (6) Westfield Limited, Flooding advice, Proposed Retail Development, Wyong, Sinclair Knight and Partners Pty Ltd, October 1979.
- (7) Wyong Shire Council, Flood Levels Report, June 1974, Report prepared for the Inter-Departmental Committee, (levels surveyed by Barry Maddy).
- (8) Wyong Shire Council, Flood Records (Peter Preston).
- (9) Lower Wyong River Flood Study, Sinclair Knight and Partners Pty Ltd, January 1984.

#### 4.1 Water Level Recorder Data

Water level recorders have been operated by various authorities, both in the lake system and its tributaries, for a number of years. In addition the Public Works Department has, since 1980, progressively installed peak height gauges throughout the Tuggerah Region. About 50 are currently in operation in proximity to the Lakes. Gauge station locations are shown on Figure 4.

The Department of Water Resources regards the quality of flow record from some stations on Central Coast tributaries as "fair to poor", largely because neither ideal sites nor high flow gaugings are available. Flow information from these gauges should therefore be used with caution, particularly in the context of a flood study.

Automatic water level gauges have been operated at various locations on the lakes, and, apart from periods of gauge malfunction, information is available from June 1972 to present. Unlike flow data, the measurement of water level data is usually quite reliable. Table 4 shows the available water level records.

Daily read staff gauges were installed on the lakes in June 1961, and data from these gauges are available up to December 1978.

Details of significant rises in lake level (greater than 0.38m AHD) since November 1972 are set out at Table 5. The Public Works Department has hydrographs of many of the larger floods in the lake during this period.

Water level data from recorders in Tuggerah Lake at Killarney Vale and Toukley are presented in Figures 8 and 9 respectively. Detailed statistical analyses of data from these sites are readily available from the Public Works Department Manly Hydraulics Laboratory. In mid 1991 the Killarney Vale recorder was relocated to nearby Long Jetty to allow lake foreshore restoration works to proceed.

#### 4.2 Tides and Storm Surge

The PWD and MSB monitor tides at selected sites along the NSW coast primarily to provide data :

- \* for input into tidal prediction programs
- \* for monitoring non predictable events (tidal anomalies) caused by odd meteorological and oceanographic conditions
- \* for analysing datums and tide levels associated with

hydrographic surveys and monitoring sea level variations. The PWD and MSB operate a coastal data collection network consisting of 24 nearshore tide gauges (harbours and rivers), 3 offshore (seabed mounted) and 7 wave rider buoys. Details of the location, equipment type and data collected at each site in the Central Coast region are given on Figure 5 and at Reference 30.

Ocean tide predictions can be found in Reference 34.

#### 4.3 Hydrosurvey

Additional information on water levels can be gleaned from relevant mapping, aerial photography, photogrammetry, hydrosurvey and ground survey. These records are generally quite scattered however some pertinent aspects have been drawn together in Appendix A.

# WATER LEVEL RECORDS

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STATION NUMBER	STATION NAME	CATCHMENT AREA (km <sup>2</sup> )	PERIOD OF RECORD	OPERATING AUTHORITY
211002	Wyong River near Wyong	249	1959-1969	PWD
211004	Jilliby Ck at Olney	8	1961-1986	DWR
211007	Wyong River at Weir	355	1966-Present	PWD
211009	Wyong River at Gracemere	236	1972-Present	DWR
211010	Jilliby Ck u/s Wyong River	92	1972-Present	DWR
211011	Jilliby Ck at Dooralong	49	1966-Present	DWR
211014	Wyong River at Yarramalong	181	1976-Present	DWR
211005	Ourimbah Ck at Tuggerah	153	1965-1989	DWR
211013	Ourimbah Ck u/s Weir	83	1976-Present	DWR
211414	Chittaway Ck Turpentine Road		1990-Present	PWD
211006	Wallarah Ck	9	1965-1976	DWR
211401	Tuggerah Lake at Toukley		1987-Present	PWD
211 <b>402</b>	Tuggerah Lake at Killarney Vale		1985-1991	PWD
211415	Tuggerah Lake at Long Jetty		1991-Present	PWD
	Elizabeth Bay		08/61-03/78	Elcom
	Budgewoi Channel		06/61-12/78	Elcom
211411	Berkeley Vale		02/09/77-27/11/77 02/12/77-11/09/79 01/06/89-Present	PWD
	Toukley Aqu. Club		22/03/78-31/05/78	PWD

# TABLE 4 (Cont.)

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# WATER LEVEL RECORDS

STATION NUMBER	STATION NAME	CATCHMENT AREA (km <sup>2</sup> )	PERIOD OF RECORD	OPERATING AUTHORITY
	Elizabeth Bay		08/61-03/78	Elcom
	Budgewoi Channel		06/61-12/78	Elcom
	Toukley Bridge		06/61-05/78	Elcom
	Long Jetty		11/63-12/78	Elcom
	Munmorah Power Station		13/06/72-07/03/74 30/08/74-27/05/75 04/03/76-18/11/76 11/01/78-09/03/78 05/04/78-23/07/79 22/08/79-17/10/79 14/11/79-11/12/79 17/12/82-18/01/84 08/02/84-03/04/84 03/05/84-23/06/84 25/07/84-25/09/84 23/10/84-12/12/84	Elcom
	Toukley Jetty		21/05/74-25-05/74 31/07/74-12/09/74 18/09/74-31/10/74 02/11/74-06/11/74 09/11/74-12/12/74 06/03/75-22/10/75	PWD
	Budgewoi		21/05/74-16/11/74 20/11/74-17/12/74 14/03/75-18/03/75 21/03/75-28/09/75 29/09/75-09/10/75	₽₩D
	The Entrance		21/05/74-28/05/74 30/07/74-12/12/74 07/03/75-20/09/75 23/09/75-07/10/75 09/10/75-21/10/75	PWD
	Canton Beach		23/09/77-26/10/77 01/12/77-12/12/77 29/02/78-10/04/78 03/05/78-10/08/78 17/08/78-26/09/78 06/02/79-03/03/79	PWD

# SIGNIFICANT WATER LEVEL RISES IN TUGGERAH LAKES SINCE 1972

DATE	GAUGE HEICHT	LOCATION
	(m AHD)	
07/11/72	0.42	Munmorah Power Station
20/02/73	0.77	Munmorah PS
14/06/73	0.41	Munmorah PS
16/10/73	0.58	Munmorah PS
14/10/74	0.81	Munmorah PS
Apr/May/74	>1.19	Budgewoi
26/05/74	>0.79	Budgewoi
28/05/74	>1.13	The Entrance
03/06/74	>1.17	Budgewoi
06/06/74	1.19	Budgewoi
05/08/74	0.49	The Entrance
07/08/74	0.39	Munmorah PS
03.03/75	0.63	Munmorah PS
25/04/75	0.63	Toukley Jetty
25/04/75	0.59	Budgewoi
25/04/75	0.58	The Entrance
23/06/75	>1.25	Toukley Jetty
23/06/75	>1.20	Budgewoi
23/06/75	>1.10	The Entrance
05/03/76	1.16	Munmorah PS
28/03/76	0.71	Munmorah PS
19/04/76	0.42	Munmorah PS
18/06/76	0.44	Munmorah PS
15/08/76	0.43	Munmorah PS
19/10/76	0.51	Munmorah PS
Mar 1977	* 1.59	Tacoma
29/10/78	0.89	Munmorah PS
29/10/78	0.93	Berkeley Vale
22/03/78	0.89	Canton Beach
22/03/78	0.86	Berkeley Vale
17/04/78	0.43	Munmorah PS
17/04/78	0.48	Canton Beach
17/04/78	0.50	Berkeley Vale
25/05/78	0.39	Munmorah PS
03/06/78	1.12	Munmorah PS
03/06/78	1.13	Canton Beach
03/06/78	1.18	Berkeley Vale
22/06/78	0.61	Munmorah PS
23/07/78	0.44	Munmorah PS
23/08/78	0.41	Canton Beach
11/05/79	0.47	Munmorah Beach
11/05/79	0.51	Berkeley Vale

\* Refer to Table 3 for more information about this level.

# TABLE 5 (Cont.)

# SIGNIFICANT WATER LEVEL RISES IN TUGGERAH LAKES SINCE 1972

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DATE	GAUGE HEIGHT (= AHD)	LOCATION
22/06/79	0.66	Munmorah PS
22/06/79	0.68	Berkeley Vale
23/03/83	0.53	Munmorah PS
03/05/83	0.63	Munmorah PS
29/05/83	0.47	Munmorah PS
09/07/83	0.40	Munmorah PS
06/10/83	0.49	Munmorah PS
24/02/84	0.44	Munmorah PS
25/03/84	0.68	Munmorah PS
10/05/84	0.44	Munmorah PS
21/06/84	0.43	Munmorah PS
30/07/84	0.65	Munmorah PS
10/11/84	0.89	Munmorah PS
16/10/85	0.92	Toukley
16/10/85	0.99	Killarney Vale
05/05/85	0.61	Killarney Vale
11/08/86	0.93	Killarney Vale
13/08/86	0.74	Toukley
20/08/87	0.71	Killarney Vale
20/08/8/	0.71	Toukley
20/10/8/	0.48	Toukley
20/01/00	0.57	Killarney Vale
19/02/00	0.47	Toukley
05/04/00	1.04	Toukley
19/06/88	0.93	Toukley
19/06/88	0.92	Toukiey
07/07/88	1 03	Killerner Vele
08/01/89	0.88	Killarnov Vale
04/04/89	0.81	Killarney Vale
21/06/89	0.81	Toukley Vale
04/02/90	1.60	Toukley
06/02/90	* 1.32(rising)	Killarnev Vale
11/02/90	0.83	Toukley
17/06/90	0.80	Killarnev Vale
03/08/90	0.97	Killarney Vale
11/02/92	1.06	Toukley
11/02/92	1.13	Long Jetty

\* Peak Level Not Captured

#### 5.0 RAINFALL DATA

The Bureau of Meteorology is the national authority for rainfall data collection. Other organisations and private individuals however are additional sources of rainfall data.

Rainfall stations are either automatic (pluviographs, which provide a trace of cumulative rainfall vs time) or daily read (giving a 24 hour rainfall total, usually at 9am each morning).

The locations of existing automatic rain gauges lying within or adjacent to the Tuggerah Lakes catchment are shown on Figure 4. Other information about rainfall stations is set out in Table 6.

The June 1964 event is poorly documented largely due to instrument malfunction.

Additional rainfall data can be found throughout Appendix B.

Rainfall intensity/frequency/duration data from Australian Rainfall and Runoff (Ref 33) are given in Table 7 and Figures 10, 11 and 12. The selected locations correspond to Public Works Department pluviographs at Wyong, Toukley and Bateau Bay.

# RAIN GAUGES

LOCATION		rion	OPERATING	RECORD	STATION	
	NO.		AUTHORITY	TYPE	OPENED	CLOSED
			(1)	(2)		
Avoca Beach	061	003	BOM	DR	1934 -	1970
Bateau Bay Treatment Works			PWD	P	1980 -	
Berkeley Vale			PWD	P	1988 -	
Brush Creek	061	137	BOM	DR	1959 -	1970
Bulga	061	143	BOM	DR	1960 -	1983
Chittaway			PWD	P	1989 -	
Congewai (Alara)	061	152	DWR	P	1958 -	1973
Congewai	061	152	BOM	DR	1959 -	
Cooranbong	061	012	BOM	DR	1903 -	
Dooralong	061	219	BOM	DR	1963 -	1976
Dora Creek	061	323	BOM	DR	1972 -	
(Cooranbong Rd)			,			
Glen Alice	061	149	BOM	DR	1914 -	1969
Gosford	061	023	BOM	DR	1877 -	
Gosford North	061	319	BOM	DR	1971 -	1977
Gosford State Nursery	061	108	BOM	DR	1901 -	1946
Holgate	061	253	BOM	DR	1968 -	1971
Karagi	061	236	BOM	DR	1905 ~	1919
Kincumber Treatment Works			PWD	P	1987 -	
Kincumber	061	248	BOM	DR	1967 -	1975
Kulnura (William Road)	061:	029	BOM	Р	1969 -	1981
Kulnura (William Road)	061	029	BOM	DR	1951 -	1981
Kulnura North	061	165	BOM	DR	1959 -	
Kulnurra Ag. Stn.			PWD	P	1989 -	
Laguna (Kalongba)	061	164	BOM	DR	1959 -	
Lisarow			PWD	P	1989 -	
Mangrove Mountain PO	061	036	BOM	DR	1942 -	1979
Mardi Dam			PWD	P	1988 -	
Mount Elliott			PWD	P	1985 -	
Mount Sterland			PWD	Р	1989 -	
Munmorah Power Station	061	262	EC NSW	₽	1963 -	
Munmorah Power Station	061	262	BOM	DR	1963 -	1969
Narara Agr. Res. Stn.	061	087	BOM	DR	1916 -	
Narara Agr. Res. Stn.			PWD	P	1989 -	
Norah Head	061	273	BOM	DR	1969 -	
Olney State Forest	061	057	BOM	DR	1938 -	1967
Ourimbah	061	093	BOM	DR	1953 -	

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<u>KEY</u> :	(1)	BOM	Bureau of Meteorology
		EC NSW	Electricity Commission of New South Wales
		DWR	Department of Water Resources
		PWD	Public Works Department
	(2)	DR	Daily Read
		P	Pluviometer

# TABLE 6 (Cont.)

# RAIN GAUGES

LOCATION	STATION	OPERATING	RECORD	STATION	
	NO.	AUTHORITY (1)	<b>TYPE</b> (2)	OPENED CLOSED	
Booml Booch					
Pearl Beach	061 310	BOM	DR	1953 - 1971	
Peats Ridge	061 351	BOM	P	1981 -	
Somersby	061 218	BOM	DR	1962 - 1968	
Strickland Forest		PWD	₽	1988	
Summerlees Farm		PWD	P	1987 -	
The Entrance PO	061 074	BOM	DR	1943 -	
Toukley		PWD	P	1980 -	
Wamberal	061 255	BOM	DR	1968 -	
Wamberal PO	061 117	BOM	DR	1896 - 1942	
Warnervale School		PWD	P	1000 - 1942	
Watagan Central	061 201	BOM	- DR	1952 -	
Woy Woy	061 318	BOM	DR	1959 -	
Wyee	061 082	BOM	פת	1904 -	
Wyong (North Road)	061 083	BOM		1005	
Wyoming		DUN	DR	1000 -	
Wyong Treatment Works		THD	P 7	1988 ~	
Yarramalong	061 220	FAU	<u>к</u>	1980 - 1992	
	001 220	BOW	DR	1962 -	

KEY: (1) BOM	Bureau of Meteorology
EC NSW	Electricity Commission of New South Wales
DWR	Department of Water Resources
PWD	Public Works Department
(2) DR	Daily Read
P	Pluviometer

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# TABLE 7

# RAINFALL INTENSITIES

### - WYONG TREATMENT WORKS

Rainfall Intensity (mm/h) for WYONG_TW								
	Average Storm Recurrence Interval (years)							
Durat'n	1	2	5	10	20	50	100	
5m	92.49	118.24	150.10	166.84	190.45	221.02	244.08	
6	86.70	110.88	140.91	156.72	178.97	207.81	229.56	
7	81.86	104.74	133.23	148.25	169.37	196.75	217.42	
8	77.74	99.49	126.66	141.00	161.15	187.28	207.01	
9	74.15	94.93	120.95	134.70	154.00	179.04	197.95	
10	70.99	90.91	115.91	129.14	147.69	171.76	189.95	
11	68.18	87.33	111.43	124.19	142.06	165.27	182.82	
12	65.66	84.12	107.39	119.73	137.00	159.43	176.39	
13	63.37	81.21	103.74	115.69	132.41	154.14	170.56	
14	61.29	78.56	100.40	112.01	128.23	149.31	165.25	
15	59.38	76.13	97.35	108.63	124.39	144.87	160.37	
16	57.63	73.89	94.53	105.51	120.85	140.78	155.87	
17	56.00	71.82	91.93	102.63	117.57	137.00	151.70	
18	54.49	69.90	89.51	99.95	114.53	133.48	147.82	
20	51.78	66.43	85.15	95.12	109.03	127.13	140.83	
25	46.30	59.44	76.33	85.36	97.92	114.27	126.66	
30	42.12	54.11	69.59	77.88	89.40	10441	115.79	
35	38.79	49.87	64.22	71.92	82.61	96.55	107.12	
40	36.08	46.39	59.82	67.04	77.04	90.09	99.99	
45	33.80	43.49	56.13	62.94	72.37	84.67	94.01	
50	31.87	41.01	52.99	59.45	68.38	80.04	88.89	
55	30.19	38.87	50.27	56.42	64.92	76.03	84.46	
60	28.73	37.00	47.89	53.77	61.90	72.51	80.58	
75	25.27	32.56	42.22	47.45	54.66	64.09	71.26	
90	22.71	29.29	38.03	42.77	49.30	57.85	64.35	
2.0h	19.16	24.73	32.18	36.24	41.82	49.12	54.68	
3.0	15.03	19.43	25.37	28.62	33.07	38.90	43.36	
4.0	12.65	16.36	21.41	24.18	27.97	32.95	36.75	
5.0	11.06	14.31	18.77	21.22	24.57	28.96	32.32	
6.0	9.91	12.84	16.86	19.08	22.10	26.07	29.11	
8.0	8.35	10.82	14.24	16.13	18.70	22.09	24.69	
10.0	7.30	9.47	12.49	14.17	16.44	19.43	21.73	
12.0	6.55	8.50	11.23	12.74	14.79	17.50	19.58	
14.0	5.98	7.76	10.26	11.66	13.54	16.03	17.94	
10.0	5.52	7.17	9.50	10.79	12.54	14.86	16.64	
18.0	5.15	6.69	8.86	10.08	11.72	13.89	15.56	
20.0	4.83	6.28	8.33	9.48	11.03	13.08	14.65	
22.0	4.56	5.93	7.88	8.96	10.43	12.37	13.87	
24.0	4.33	5.63	7.48	8.52	9.91	11.76	13.19	
30.U 40 A	3.31	4.38	5.85	6.67	7.78	9.25	10.38	
40.0	4.19	3.64	4.87	5.56	6.49	7.73	8.68	
72 0	2.40	5.13	4.20	4.80	5,61	6.68	7.51	
12.0	2.11	2.75	3.69	4.23	4.95	5.90	6.64	

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# TABLE 7 (Cont.)

# RAINFALL INTENSITIES

### - TOUKLEY

Rainfall Intensity (mm/h) for TOUKLEY							
Average Storm Recurrence Interval (years)							
Durat'n	1	2	5	10	20	50	100
5m	92.49	118.24	150.10	166.84	190.45	221.02	244.08
6	86.70	110.88	140.91	156.72	178.97	207.81	229.56
7	81.86	104.74	133.23	148.25	169.37	196.75	217.42
8	77.74	99.49	126.66	141.00	161.15	187.28	207.01
9	74.15	94.93	120.95	134.70	154.00	179.04	197.95
10	70.99	90.91	115.91	129.14	147.69	171.76	189.95
11	68.18	87.33	111.43	124.19	142.06	165.27	182.82
12	65.66	84.12	107.39	119.73	137.00	159.43	176.39
13	63.37	81.21	103.74	115.69	132.41	154.14	170.56
14	61.29	78.56	100.40	112.01	128.23	149.31	165.25
15	59.38	76.13	97.35	108.63	124.39	144.87	160.37
16	57.63	73.89	94.53	105.51	120.85	140.78	155.87
17	56.00	71.82	91.93	102.63	117.57	137.00	151.70
18	54.49	69.90	89.51	99.95	114.53	133.48	147.82
20	51.78	66.43	85.15	95.12	109.03	127.13	140.83
25	46.30	59.44	76.33	85.36	97.92	114.27	126.66
30	42.12	54.11	69.59	77.88	89.40	104.41	115.79
35	38.79	49.87	64.22	71.92	82.61	96.55	107.12
40	36.08	46.39	59.82	67.04	77.04	90.09	99.99
45	33.80	43.49	56.13	62.94	72.37	84.67	94.01
50	31.87	41.01	52.99	59.45	68.38	80.04	88.89
55	30,19	38.87	50.27	56.42	64.92	76.03	84.46
60	28.73	37.00	47.89	53.77	61.90	72.51	80.58
75	25.05	32.32	42.03	47.32	54.58	64.09	71.33
90	22.36	28.89	37.72	42.55	49.17	57.85	64.47
2.05	18.65	24.15	31.74	35.92	41.62	49.12	54.86
3.0	14.40	18.71	24.81	28.21	32.82	38.90	43.57
4.0	11.97	15,59	20.81	23.75	27.71	32.95	36.98
5.0	10.38	13.54	18,16	20.78	24.30	28.96	32.56
0.0	9.23	12.07	16.25	18.64	21.83	26.07	29.35
	1.00	10.07	13.65	15.70	18.44	22.09	24.92
12.0	0.00	0./5	11.92	13.75	16.18	19.43	21.96
14.0	5.93	7.00	10.67	12.34	14.54	17.50	19.80
16.0	1 07	6 52	9.10	11.22	13.23	15.92	18.01
18.0	4.51	0.53	0.94	10.33	12.18	14.66	16.59
20 0	4 32	5.60	0.31	9.01	11.33	13.63	15.43
22 0	4 07	5.09	7 22	9.00	10.61	12.77	14.45
24.0	3 86	5.00	6.0/	0.40	9.99	12.03	13.61
36.0	2.97	3 01	5 35	6 19	9.40	11.39	12.89
48.0	2.45	3 22	4 40	5 00	6 01	0.10 7 00	9.93
60.0	2.09	2 75	3 76	4 35	0.01	1.23	0.19
72.0	1.82	2 40	3 20	3 80	J 10	5 40	0.99
		2.40	0.23	0.00	4.49	5.40	0.11

# TABLE 7 (Cont.)

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# RAINFALL INTENSITIES

# - BATEAU BAY

Rainfall Intensity (mm/h) for BATEAU_BAY									
Average Storm Recurrence Interval (years)									
Durat'n	1 2 5 10 20 50 100								
5m	99.36	126.77	160.08	177.45	202.09	233.93	257.89		
6	93.16	118.94	150.46	166.95	190.28	220.45	243.17		
7	87.98	112.39	142.41	158.15	180.38	209.15	230.83		
8	83.56	106.80	135.53	150.62	171.90	199.45	220.23		
9	79.71	101.94	129.53	144.05	164.50	190.99	210.98		
10	76.33	97.66	124.24	138.26	157.97	183.52	202.81		
11	73.31	93.84	119.52	133.09	152.13	176.84	195.50		
12	70.60	90.41	115.27	128.43	146.88	170.82	188.91		
13	68.15	87.30	111.43	124.21	142.11	165.35	182.92		
14	65.92	84.47	107.91	120.35	137.76	160.36	177.45		
15	63.87	81.88	104.69	116.81	133.76	155.77	172.43		
16	61.99	79.49	101.72	113.55	130.07	151.54	167.79		
17	60.25	77.28	98.97	110.53	126.65	147.62	163.49		
18	58.63	75.22	96.42	107.72	123.47	143.97	159.48		
20	55.71	71.52	91.80	102.64	117.73	137.36	152.24		
25	49.83	64.05	82.47	92.36	106.08	123.97	137.53		
30	45.34	58.34	75.32	84.47	97.13	113.65	126.20		
35	41.78	53.80	69.62	78.17	89.97	105.40	117.12		
40	38.86	50.08	64.94	72.99	84.09	98,60	109.65		
45	36.41	46.96	61.01	68.64	79.14	92.89	103.35		
50	34.33	44.31	57.66	64.93	74.91	87.99	97.96		
55	32.54	42.01	54.75	61.71	71.24	83.74	93.27		
60	30.96	40.00	52.21	58.88	68.02	80.01	89.16		
75	26.93	34.78	45.34	51.11	59.01	69.38	77.28		
90	23.99	30.97	40.34	45.45	52.46	61.64	68.64		
2.0h	19.95	25.74	33.47	37.68	43.46	51.03	56.80		
3.0	15.33	19.76	25.65	28.84	33.24	38,99	43.36		
4.0	12.71	16.37	21.22	23.84	27.45	32.18	35.77		
5.0	10.99	14.15	18.31	20.56	23.67	27.73	30.81		
6.0	9.76	12.56	16.24	18.23	20.97	24.56	27.28		
8.0	8.09	10.41	13.44	15.08	17.34	20.28	22.52		
10.0	7.00	9.01	11.61	13.02	14.96	17.49	19.42		
12.0	6.22	8.00	10.31	11.55	13.26	15.50	17.20		
14.0	5.66	7.28	9.42	10.58	12.18	14.26	15.84		
16.0	5.21	6.71	8.72	9.81	11.30	13.26	14.75		
18.0	4.84	6.25	8.14	9,17	10.58	12.44	13.85		
20.0	4.53	5.86	7.65	8.63	9.98	11.74	13.09		
22.0	4.27	5.52	7.23	8.17	9.45	11.14	12.43		
24.0	4.04	5.23	6.87	7.77	9.00	10.62	11.85		
36.0	3.11	4.04	5.37	6.11	7.11	8.44	9.46		
48.0	2.56	3.34	4.47	5.11	5.97	7.12	8.00		
60.0	2.18	2.86	3.85	4.42	5.18	6.19	6.98		
72.0	1.91	2.50	3.39	3.91	4.59	5.50	6.21		

## 6.0 WEATHER DATA

Analysis of weather information, particularly that coinciding with flood events, can allow components of water elevation (eg. storm surge and wind set-up) to be estimated.

The Bureau of Meteorology has advised that, within an 80 kilometre radius of Tuggerah (reference point 3319, 15127) the following stations have wind and/or pressure records :

### TABLE 8 - AVAILABLE WEATHER DATA

STATIO NUMBER	N STATION DIST NAME (km) TUGG	ANCE FROM ERAH	LAT.	LONG.	ELEVATION (=)	AVAILABLE Data (yis)
067010	Glenorie P.O.	52	3336	15100	168	42
067019	Prospect Dam	74	3349	15055	61	101
067021	Hawkesb. Ag. Stn	73	3337	15045	20	109
067026	Seven Hills Exp Fm	71	3347	15056	55	40
067033	Richmond AMO/MO	69	3336	15047	19	64
067089	West Pennant Hills	62	3345	15102	120	32
066030	Kurnell	79	3400	15112		2
066032	West Lindfield	59	3347	15109	60	42
066037	Sydney Airport	73	3356	15110	6	63
066062	Sydney Region Office	65	3352	15112	42	134
066124	Parramatta North	67	3348	15101	60	25
066131	Riverview Obs.	63	3350	15110	23	73
066156	Marsfield (Macq.Uni)	59	3346	15107	55	20
066169	Villawood Archives	71	3350	15100	30	2
066186	Pittwater AWS	38	3338	15118	3	3
061029	Kulnura (William Rd)	25	3314	15112	312	26
061034	E. Maitland (Bowls)	64	3245	15135	12	90
061055	Newcastle (Nobby Sig)	55	3255	15148	33	126
061057	Olney State Forest	30	3306	15115	152	24
061063	Rathmines AMO	33	3303	15136	9	9
061078	Williamtown AMO	68	3248	15150	9	50
061087	Narara Ag. Res. Stn	14	3324	15120	40	70
061193	Wollombi (Stockyard)	58	3254	15105	95	8
061223	Maryville HVRF	53	3255	15145	8	27
061242	Cessnock (Nulkaba)	56	3249	15121	62	25
061255	Wamberal (Dillon Rd)	11	3325	15127	10	18
061259	Maitland (West Aero)	69	3242	15128	25	5
061273	Norah Head Lighthouse	e 13	3317	15135	27	23

## 7.0 ACKNOWLEDGEMENTS

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- Wyong Shire Council
- Bureau of Meteorology
- Department of Water Resources
- State Emergency Services
- · Electricity Commission of NSW
- Manly Hydraulics Laboratory, PWD
- Gosford City Council
- State Rail Authority
- State Library.

#### 8.0 REFERENCES

- 1. Swancott, C. <u>Bluegum Flats to Budgewoi</u> (available at Wyong Shire Council)
- Electricity Commission of NSW, <u>Munmorah Area</u> <u>Climatic and Limnological Data (Data Set No.C.1.17)</u>, Power Development Division, Civil Investigations Branch February 1969.
- 3. Bannister and Hunter Surveyors, Gosford, <u>Engineering/</u> <u>Investigation Survey at The Entrance, Shire of Wyong,</u> <u>Parish of Tuggerah.</u> Report for DMR, 10th December 1964.
- 4. State Emergency Services, NSW, <u>Report on Storm and</u> <u>Flooding in Wyong Shire, May 25th to May 31st 1974.</u>
- Electricity Commission of NSW, <u>Flood Levels Lake</u> <u>Macquarie and Lake Munmorah</u> - Hydraulic Research Note No. 29, Power Development Branch, Projects Division, 1960 - 1961.
- Sinclair Knight and Partners P/L, <u>Westfield Limited</u>, <u>Flooding Advise</u>, <u>Proposed Retail Development</u>, <u>Wyong</u>, October 1979.
- 7. Wyong Shire Council, <u>Flood Levels Report, June 1974.</u> (Report prepared for the Inter-Departmental Committee)
- NSW Public Works Department, Metrop. District Office, <u>Central Coast January 1978 Flood</u>. Draft Report No. 88029, March 1986.
- 9. Sinclair Knight and Partners P/L, <u>Lower Wyong River</u> <u>Flood Study</u>, January 1984.
- NSW Public Works Department, Metrop. District Office, <u>Central Coast Creeks, February 1981 Flood.</u> Draft Report, March 1987.
- 11. Public Works Department, Metrop. District Office, <u>Wyong</u> <u>River, November 1984 Flood Report,</u> Rpt No. PWD 88027.
- 12. NSW Public Works Department, Survey and Property Branch Flooding on Central Coast Creeks, 8th November 1984.
- NSW Public Works Department, Metrop. District Office, <u>Saltwater, Tumbi and Berkeley Creeks, November 1984</u> <u>Flood Report,</u> August 1985.
- 14. NSW Public Works Department, <u>Gosford-Wyong Region</u>, <u>October 1985 Flood</u>. Report No. 89036.
- 15. NSW Public Works Department, Metrop. District Office, <u>Gosford-Wyong Flooding, 30 April, 1st May 1988,</u> 24 June 1988. (File 10.004.874)

- 16. NSW Public Works Department, Manly Hydraulics Laboratory, <u>Central Coast Region, Flood Data Survey</u>, <u>Flood Event of February 1990.</u> Report No. MHL 575.
- NSW Public Works Department, Manly Hydraulics Laboratory, <u>Central Coast February 1992 Flood Event.</u> Report No. MHL 615.
- Ewers, J.R. and Foster, D.N. <u>Hydraulics Studies for</u> <u>Munmorah Power Station</u>. Report No. 68, Water Research Laboratory, University of NSW, 1964.
- 19. Yong, K.C. and Stone, P.B. <u>Recurrence Frequency of</u> <u>Flood Levels in the Tuggerah Lakes System</u>. Rpt No. 123, Water Research Laboratory, University of NSW, 1971.
- 20. Nelson, R.C. <u>Munmorah Power Station: Changes in Bed</u> <u>Levels of Dredged Channels</u>. Technical Report No. 71/3, Water Research Laboratory, University of NSW, 1971.
- 21. Sinclair Knight and Partners P/L, <u>Drainage and Flooding</u> <u>Study. Gosford/Wyong Area Structure Plan for the Cities</u> <u>Commission</u>, September 1974.
- 22. Tuggerah Lakes Inter-Departmental Committee. <u>Tuggerah</u> <u>Lakes Study Report</u>. New South Wales Government, 1979.
- NSW Public Works Department, Manly Hydraulics Laboratory, <u>Lower Wyong River Model Investigation</u>. Report No. 437, October 1985.
- 24. Sinclair Knight and Partners P/L, <u>Lower Wyong River</u> <u>Flood Study</u> for Public Works Department, NSW, Jan 1988.
- 25. Webb, McKeown and Associates P/L, <u>Upper Wyong River</u> <u>Flood Study</u> for Public Works Department, NSW, Feb 1988.
- 26. Webb, KcKeown and Associates P/L, <u>Wyong River</u> <u>Floodplain Management Study</u>. Draft, September 1991.
- 27. Willing and Partners P/L, <u>Berkeley Vale Floodplain</u> <u>Management Study</u>. Public Works Department, NSW, September 1988.
- 28. Kinhill Engineers P/L, <u>Tumbi Umbi Creek Flood Study</u>. Public Works Department, NSW, Draft, February 1991.
- 29. NSW Department of Water Resources. <u>NSW Gauging</u> <u>Stations Annual Return</u> December 1989.
- 30. NSW Public Works Department, Manly Hydraulics Laboratory, <u>Storm Surges Monitored Along The NSW Coast</u> <u>March-April 1990.</u> Report No. 591, November 1991.
- 31. NSW Public Works Department, <u>Collaroy / Narrabeen</u> <u>Beaches - Coastal Process Hazard Definition Study</u>. December 1987.

- 32. Higginson, F.R. <u>The Distribution of Submerged Aquatic</u> <u>Angiosperms in the Tuggerah Lakes System</u>. Proceedings, Linear Society of NSW, Vol 90, Part 3.
- 33. The Institution of Engineers, Australia. <u>Australian</u> <u>Rainfall and Runoff, A Guide to Flood Estimation</u>. Revised Edition 1987.
- 34. NSW Public Works Department, Coast and Rivers Branch, Ocean Tide Predictions For NSW (yearly publication).
- 35. Webb, McKeown and Associates P/L. <u>Sensitivity Analysis</u> <u>The Entrance Channel, Tuggerah Lake</u>, July 1992.
- 36. Sinclair Knight and Partners P/L. Lower Ourimbah Creek <u>Flood Study</u> for Public Works Department, NSW, Preliminary Draft, August 1990.
- 37. Webb, McKeown & Associates P/L. Lower Wyong River Flood Study Review 1991, for Wyong Shire Council, June 1992.





FIGURE 1





### MAJOR FLOODS

**FIGURE 3a** 



FIGURE 3b



SCALE

TUGGERAH LAKES FLOOD STUDY COMPENDIUM OF DATA

# GAUGE STATION LOCATIONS



**STATION NO. 211013** 



DISCHARGE (MI/Day) (Logarithmic Scale)

TUGGERAH LAKES FLOOD STUDY COMPENDIUM OF DATA

RATING CURVE OURIMBAH CREEK AT U/S WEIR

**STATION NO. 211005** 



# DISCHARGE (MI/Day) (Logarithmic Scale)

TUGGERAH LAKES FLOOD STUDY COMPENDIUM OF DATA

RATING CURVE OURIMBAH CREEK AT TUGGERAH



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TUGGERAH LAKES FLOOD STUDY COMPENDIUM OF DATA

# RAINFALL INTENSITY WYONG TREATMENT WORKS



TUGGERAH LAKES FLOOD STUDY COMPENDIUM OF DATA

> RAINFALL INTENSITY TOUKLEY



TUGGERAH LAKES FLOOD STUDY COMPENDIUM OF DATA

> RAINFALL INTENSITY BATEAU BAY



# APPENDIX A : SURVEY AND MAPPING INFORMATION

In addition to Central Mapping Authority (CMA) topographic and orthophoto maps, the following information is available for hydrologic/hydraulic investigations of Tuggerah Lakes.

#### A.1 Aerial Photography

Early aerial photography includes:-

DATE	HEIGHT FT	APPROXIMATE SCALE	COMMENT
25/11/41	10,000	1/14,550	Negatives held by NCDC (*), Canberra.
07/03/54			Negatives held by Dept. of CALM
04/06/65	5,590 1	/12,500	Negatives held by Dept. of CALM – also some held by PWD Coast & Rivers Branch.
08/03/66	5,590	1/12,500	Copies held by Water Supply and Sewerage Branch, PWD.
30/07/67	16,000	1/42,500	Negatives held by Dept. of CALM.
26/10/67	23,000	1/60,000	Photos held by Dept. of CALM.
30/06/69	7,200	1/18,300	Negatives held by Dept. of CALM.
16/05/70	7,000	1/18,000	Photos held by PWD Coast & Rivers Branch.
22/09/71	18,000	1/58,000	Negatives held by Dept. of CALM.
Feb 1973			Photos held by PWD Survey Branch.
* NOTE :	NCDC CALM	National Capital Conservation and	Development Commission Land Management

PWD Public Works Department

#### A.2 Photogrammetry

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More detailed information regarding ground levels for the lakes foreshores is available from the photogrammetric maps detailed below:

DATE	AUTHORITY SC	ALE	CONTOUR INTERVAL	COMMENT
	Pacific Power (formerly ELCOM)			Extensive mapping during mid 70's.
1973	RTA 1 : 1 (formerly Dept. M	,200 ain Roads)	0.6m	Drawing No. 6003.505.PG.0375
1970's	Wyong Shire 1 : 4 Council 1 :10	,000 ,000	2.Om	Planning Scheme Mapping

#### A.3 Hydrosurvey

Relevant hydrosurveys include:-

DATE	AUTHORITY	TITLE	COMMENT
July 1937	Higgins, P. (PWD)	Soundings in Tuggerah and Budgewoi Lake	Plan Cat. No. 54/59
1955	Pacific Power	Soundings for Lake Munmorah	Plan No. MM 136477K
1961	Pacific Power	Soundings for Budgewoi & Munmorah	Plan No. MM 136478
1963	Higginson, F.		(Ref. 32)
June 1966	Pacific Power	Budgewoi and Munmorah Hydrosurvey	Plan No. MM 228721
Jul 1973 Dec 1974	Geological Survey		Soundings for Lake Munmorah
July 1974	Pacific Power	Soundings for Munmorah Lake	MM 286500 B, MM307 954A, MM136 619B,620B
1974/75	PWD	Tuggerah Lakes Hydrographic Survey	Plant Cat. No. 4399 PWD SLIS.
1992	Wyong Council	Bathymetry Survey	F92/16

### A.4 Ground Survey

The Public Works Department has carried out a number of ground level surveys within the floodplain of the lakes in the course of various investigations. Details can be provided from the Department's Survey and Land Information Service (SLIS).

### APPENDIX B : DESCRIPTIVE FLOOD INFORMATION

Some qualitative information on known flood events is presented below. The list is not exhaustive but spans more than 100 years. The source of the information is acknowledged at the end of each excerpt.

- \* 1867 There was a record flood in 1867 when houses, haystacks and sheds went whirling down the river, most of them with birds and animals perched on them. The ridge pole of one floating house was only 150mm above the water. From "Bluegum Flats to Budgewoi" by C. Swancott (available at Wyong Shire Council).
- \* June 23-25, 1885 Very heavy rain-recorded by Wyong (North Road) rain gauge reader.
- May 1889 Heaviest rains and highest floods ever seen by the oldest inhabitants - Readers Comments from Wyong (North Road) Rain gauge.

There was a furious storm which deluged the district. The creek was overflowing its banks and the kitchen of the Royal Hotel was flooded. From "Bluegum Flats to Budgewoi" by C. Swancott.

- \* March 9th, 1893 Heaviest rain here on record in one night since 1884 - Wyong (North Road) rain gauge reader.
- \* November 1903 From 125mm to 175mm of rain fell during a November night causing serious flooding. From Wyong to the Tuggerah Lakes was a sea of water. From "Bluegum Flats to Budgewoi" by C. Swancott.
- \* April 1905 380mm of rain fell in 48 hours (the heaviest for 20 years) flooding the lake and surrounding areas. From "Bluegum Flats to Budgewoi" by C. Swancott.
- \* April 4th, 1905 380mm of rain fell in 48 hours. Rain commenced at 11.30 Saturday. Till dark 25.4mm fell, from then till morning 170.2mm. A heavy incessant downpour till 5pm gave 193.0mm. Wyong (North Road) rain gauge reader.
- \* **December 1921** There was a flood in Christmas 1921 and The Entrance got another scour out and was responsible for the wonderful entrance they had for many years after. From "Bluegum Flats to Budgewoi" by C. Swancott.
- \* April 1927 Extensive damage occurred at Wyong where the Wyong River overflowed its banks and flooded areas of Mardi Flats. The waters spread with alarming rapidity sweeping over paddocks and orchards carrying away livestock and soil. It rushed into houses and at 40 places was up to the windows. Sgt. Bath and Const. Cross of Wyong Police assisted by fishermen and their boats rescued more than 100 people from their flooded homes. The flood is said to be the highest in Wyong's history. Police began rescue operations at 10.00am Saturday 16th and were kept busy till 5.00pm. By Sunday morning the 17th floodwaters were receding from Mardi Flats but the river was still running a banker. Newcastle Morning Herald Monday, 18th April 1927.

- Of the towns between Sydney and Newcastle, Wyong suffered most. Many residents flooded out of their homes narrowly escaped with their lives. Homes near the Wyong River at Mardi, about a mile from the town were swept with floodwaters up to 1.8m deep. Two of the Tuggerah Lakes ferry boats moored at Wyong, were swept from their moorings one of them was held by the Wyong Bridge. On the Sydney side of the Wyong Bridge the water dammed up by the railway embankment overflowed and swept across the railway line, washing out the ballast and flooding some nearby houses. This caused a big break in the railway line and traffic was held up for hours. About Wyong, miles of low lying country was inundated. Sydney Morning Herald Monday, 18th April 1927.

- Floodwaters cut the railway line between Wyong and Tuggerah. Water was up to the running boards of Ourimbah Creek Bridge. (Entrance Rd. Bridge). Sydney Sun & Guardian, 19 April 1927 (Deck level RL 1.8m AHD up to 1978).

- There came down a flood of water about 2.1m in height, a straight face of water and by midday the flood had topped the bridges and carried away stock and despite the fact that there was such a good channel, the flood remained at a record height for several weeks. From "Bluegum Flat to Budgewoi" by C. Swancott.

June 1930 - The Wyong District suffered one of its worst floods in history. The town was surrounded by water and communications with outlying areas was almost impossible. On Tuesday 17th, afternoon, all creeks rose at an alarming rate and people at Dooralong and Yarramalong were forced to leave their homes, that were half submerged. In some cases water had almost reached the ceilings of houses and families were in terror. On the morning of Thursday, 19th, the scene was one of desolation as almost all settlers had suffered severe losses. The railway line between Tuggerah and Wyong was washed away and trains were held up for a considerable period while temporary repairs were effected. The Tuggerah road was nearly 600mm under water on Tuesday 17th. Newcastle Morning Herald, Thursday, 19th June 1930.

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- Big washaway on railway line at Tuggerah, traffic stopped on Wednesday, 18th. Flooding recalls conditions of April 1927. Wyong Creek was said to have risen 7.6m, the rushing waters placing many residents in danger. Thirty people were rescued by police in boats from their roof tops, the police rowed across swiftly running floodwaters avoiding trees and submerged fences.

- On the Tuggerah Flat, floodwaters collected until the countryside was a huge lake. The railway line was 1.5-1.8m under water in places and much damage was done to the track. Wyong had over 125mm of rain during the storm. Gosford Times, 19th June 1930.

- Wyong was cut off from Gosford by both road routes. The waters at Wyong came to within 100mm of the highest flood in memory. Sydney Morning Herald, Thursday, 19th June 1930.

- On the State Highway, Ourimbah Creek tore away a section of the roadway. The Shire Council warned travellers that this road and also that from Tuggerah Lakes to Wyong was impassable. The bridge over Ourimbah Creek had water swirling several feet over the railing. Sydney Morning Herald, 19 June 1930. April 1946 - Thousands of acres in the Wyong area were flooded and much damage was done to orchards and vegetable gardens. Sgt. H. Fardy of Wyong Police warned occupants of some homes to leave. Sydney Morning Herald, 17th April 1946.

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- Abnormal rains flooded countryside. Great damage to orchards, roads, bridges etc. Reader of Wyong (North Rd) rain gauge.

- The 1946 flood was six feet or more above normal. Tacoma was completely cut off, homes had up to 2 feet (0.61m) of water in them. Eleven homes had been washed off their piers and four smashed up. From "Bluegum Flat to Budgewoi" by C. Swancott.

- 505mm of rain from 14th to 18th caused big flood. C. Groves, 312 Mardi Road.

- Abnormal rains flood countryside - Wyong (North Road) gauge reader.

- June 1949 The Wyong River broke its banks and flooded low lying areas. Families at Mardi had to leave their homes on Friday, 17th June. Wyong Bridge was awash for the first time in twenty-two years. The Regent Guest House on the banks of the river about (550m) 600 yards from Wyong Bridge was completely isolated with water lapping at its sides. Tacoma was flooded out. The main railway line between Sydney and Newcastle was awash for more than half a mile south of Wyong. The Pacific Highway was covered feet deep. Sydney Morning Herald Saturday, 18 June 1949.
  - On Sunday 19 June 1949 the northern approach to the road bridge over Ourimbah Creek began to give way. Half the road was closed. Timber reinforcements along the bridge approach were washed away. This allowed earth and rock fill to erode away, undermining the road. Gosford times, 21 June 1940.
  - Heavy Rains Wyong (North Road) gauge reader.
- June 1950 On June 16th, after eight days of heavy rains, the river at Wyong Creek was approximately (6.7m) 22 feet above sealed road surfaces and was well over Porters Creek Bridge. From "Bluegum Flat to Budgewoi" by C. Swancott.

- Eights days of heavy rains - Wyong (North Road) gauge reader.

- 265.4mm of rain from 13th-17th caused a big flood. C. Groves, 312 Mardi Road.

May 1953 - Road and rail traffic from Wyong to Sydney was stopped. Roads throughout the district were many feet underwater, telephone lines were damaged and farmers ruined. People bordering on the town of Wyong were washed out of their homes. The family of Mr Sharpe of McPherson Road, was forced to move when water rose inside the house to a depth of (0.46m) 1'6". At Mardi, Mr Braithwaite's house was under water. The Entrance Guardian, Thursday, May 14, 1953.

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- Rain last night caused a rail washaway near Wyong stopping all main line traffic. Floodwater swept away the northern end of the Wyong railway viaduct about 9.00pm. The viaduct runs from Wyong Station to Tuggerah crossing. Water rose over the railway line and carried away foundation stones. Roads in Wyong's fruit growing area were blocked by floodwaters. Newcastle Morning Herald, Saturday, May 9, 1953.

- Hundreds of acres of low lying areas around Wyong are underwater and the rain is still pelting down. Sydney Morning Herald, Saturday, May 9, 1953.

- Floodwater damaged stone foundations and abutment on northern side of Ourimbah Creek Railway Bridge. (This bridge was approximately 100m upstream of the existing railway bridge). Water rose to top of piers. Both railway lines blocked for 15 hours, one line opened 11.30am Saturday 9th the other line cleared by 5pm Saturday. Seventy railway men repaired damage. Gosford Times, 12 May, 1953.

- Railway officials said that they could not transport passengers by road because of floodwaters had cut the Pacific Highway at Ourimbah. Newcastle Morning Herald, 9 May, 1953.

- Rain began on Wednesday night the 6th and continued till Saturday morning the 9th where 247.9mm had fallen. By Thursday morning 23.9mm had fallen, another 90.2mm was registered in Wyong on Friday morning and a further 133.8mm fell by Saturday morning. The Entrance Guardian, 14th May, 1953.

June 1964 - Worst floods in 40 years hit Wyong at midnight on Wednesday, 10th June, 1964. Pacific Highway at Tuggerah blocked from 8 o'clock Wednesday night to 10 o'clock Thursday morning. Water was 1.8m deep over the highway at Tuggerah at one stage, 0.9m deep by 3 o'clock Thursday morning and cleared to only 50mm by 10 o'clock Thursday morning. Water was 4.9m over roads at Brush Creek and Yarramalong while roads between Wyong and The Entrance were cut. Central Coast Express, Friday, 12th June, 1964.

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- The level of Wyong Creek during the maximum flood period was fixed on the new Wyong Road bridge at a point 0.6m above the bottom of the main horizontal support. To the east of the railway line in an area that is included largely in the property of the Pioneer Dairy Farm, the manager indicated that the whole property had been covered with water to a depth of 0.6m but had drained away relatively quickly. From Electricity Commission of NSW Tuggerah Area Flood levels.

June 10, 1964 - 9.00am to 2.30pm, 179.6mm of rain on June 10 - gauge reader at Dooralong.

August 1967 - Heavy rains were experienced at Wyong during Saturday, 5th night and Sunday 6th morning. Central Coast Express, Monday, 7th August 1967.

- The manager of the Pioneer Dairy Farm stated that the water in his property was slow to drain away - Electricity Commission of NSW Flooding at Tuggerah Power Station report. August 6th, 1967 - Up to 127.0mm of rain reported in Wyong during Saturday night the 5th August 1967 and Sunday morning 6th August 1967. Central Coast Express, Monday 7th August, 1967.

- \* June 1974 Wyong Civil Defence issued a general warning to farmers. Urban areas of Tuggerah, Tacoma and Mardi were threatened by the rising Wyong Creek on Wednesday 5th. Roads to the rural area of Jilliby and Dooralong were closed late on Tuesday 4th. Newcastle Morning Herald, Wednesday 5th June, 1974.
- March 1977 Wyong Shire's worst flood for at least 12 years. Widespread flooding on Friday 4th and Saturday 5th following torrential rain on Thursday 3rd. Most of the roads in Wyong were impassable. By 10.00am Friday 4th all roads leading into the Wyong Valley system were closed because of floodwaters. At one stage the highway was cut both north and south of Wyong on Friday 4th. Worst flood seen by Mr Wilson of the Wyong SES. Tuggerah Lakes had peaked at 120 cm above normal level last Friday. This was the highest the Lakes had reached since 1965 when the level was 30 cm. Major losses were suffered by Central Coast Timber Building components of McPherson Road, their timber yard bore a large part of the water coming down from the Mardi Area and timber trusses tied by steel bands were lifted and carried away. The manager Mr J. Grieves estimated the water reached a depth of 0.8m above ground level and was up to the verandah level around his office. Damages were estimated at \$65,000. GO Coastal Caravans south of the Wyong Bridge lost two plywood caravans in the floods. The vans were parked at the rear of the property under nearly 3m of water. The water rose to within 0.9m of the Wyong Nursing Home building. Three people were trapped on a small knoll of high land near the junction of Porters Creek and Wyong River for several hours. From Tuggerah Lakes Advocate, Wednesday 9th March 1977 and Central Coast Express, Saturday 5th March 1977.

March 3rd, 1977 - Torrential rain hit Wyong on Thursday 3rd March 1977. Tuggerah Lakes Advocate, Wednesday, 9th March, 1977.

- January 28th, 1978 Devastating rain fell on Saturday night 28th January 1978. Up to 9.00am on Sunday 235.2mm had fallen. Tuggerah Lakes Advocate, Wednesday, 1st February, 1978.
- × March 1978 - SES and police were prepared to evacuate residents of the Wyong Nursing Home if waters on the Wyong River kept rising. Valleys west of Wyong were flooded with many roads through Yarramalong and Jilliby being closed. Mr Wilson of the Wyong SES said a 600mm wall of water came down the Wyong River at about 2pm on Monday 20th. Porters Creek was running backwards on Monday 20th as water was forced back up the creek by the floodwaters in Wyong River. Dunks Swamp north-east of Wyong looked like an inland sea with several square kilometres inundated with water to an average depth of about 1m. On Monday 20th, three Shire Council workers were rescued by the SES boat from Woodburys Bridge as their vehicle became almost completely submerged. Porters Creek Bridge was untrafficable to small vehicles. The whole of the recently opened Braithwaite Park adjacent to Woodbury's bridge was inundated, with only the memorial stone visible. Tuggerah Lakes Advocate, Wednesday 22nd March 1978.
- February 7th, 1981 Lake rose to about 700mm above normal level after heavy rain on Friday. 164mm fell in the 24 hours before 9.00am, Saturday, 7th at Wyong. From Tuggerah Lakes Advocate, Wednesday 11th February, 1981.
- October 1985 The Wyong SES was kept busy over the 2 day deluge from Sunday 13th to Monday 14th, clearing roads and attempting to evacuate families who didn't want to be evacuated. Roads in the Yarramalong and Jilliby areas were still closed due to floods on Monday 14th. Tuggerah Lakes Advocate, Wednesday 16th October 1985.

October 13th, 1985 to October 14th, 1985 - 2 day deluge. Tuggerah Lakes Advocate, Wednesday, 16th October 1985.

**February 1990** - Cyclone Nancy's tail lashed some parts of the Central Coast and left others merely deluged.

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- Roads were cut in many areas. All roads suffered some damage.

- Woy Woy copped 270mm in 24hours from 7am Friday to 7am Saturday with a weekend total of 514mm. Lisarow received a punishing 492mm in two days with a one day high of 307mm on Friday. Radio 2GO recorded 405mm for the centre of Gosford on the weekend and Wyong fared slightly worse with 443mm. At Wyee meters recorded 468mm from Friday to Sunday. Gosford Star, Tuesday 6th February 1990.

**February 1990** - Rising tides and storm surge from Cyclone Nancy are keeping floodwaters in Wyong at a dangerous level. The level of the sea at high tide today is higher than the lakes. This has a plug-like effect not allowing water to escape from Tuggerah Lakes through The Entrance Channel. Areas worst hit by the downpours are Chittaway Bay, parts of Buff Point, North Entrance, Tuggerah Pde, The Entrance and Long Jetty. Other affected areas include Budgewoi, San Remo, Lake Egde Avenue, Berkeley Vale Tuggerawong, The Corso, Gorokan, Blue Haven and those living at Tacoma have been stranded by the Wyong River. Central Coast Express Wednesday 7th February, 1990.

February 1992 - The Central Coast is still a sea of mud and brown water after more than 500mm of rain at the weekend. Hundreds were evacuated at the height of the deluge which overwhelmed rescue services and cost millions. From the air on Monday the coast was a patchwork of shimmering brown lakes and swollen creeks and rivers. Floodwaters swept through houses, businesses and shopping centres and damaged public facilities. A new bushfire tanker worth \$160,000, a support vehicle worth \$50,000 and equipment worth \$60,000 were lost when the Chittaway bushfire station was engulfed by floodwaters. By Tuesday water was still thigh high in parts of Chittaway Point. Children at St Cecilia's School Wyong sandbagged rooms devastated by floods two years ago. Central Coast Express, Wednesday 12th February, 1992.

# APPENDIX C : SUMMARY OF AN INVESTIGATION INTO TUGGERAH LAKES SURVEY DATUMS

#### INTRODUCTION

During the preparation of the *Compendium of Data* report for the *Tuggerah Lakes Flood Study* certain **survey anomalies** arose **among the Datums** in use in the Tuggerah Lakes area over the last 64 years.

The inconsistencies were of such magnitude (300 - 800mm) that the issue had to be resolved before reliable interpretation of recorded flood levels could be established.

This report documents the investigation into these survey anomalies and recommends procedures for interpretation of historical data. Mine subsidence was examined by the Mine Subsidence Board (Wyong and Newcastle) and found to be insignificant south of about Toukley.

An example of the inconsistencies encountered is illustrated in **Table C1** (see next page) where it can be seen that a unique Bench Mark has been subject to various interpretations by different organisations over the years. This also applies to numerous other Bench Marks within the Tuggerah Lakes area.

<u>Table C2</u> contains a number of Bench Marks, commonly used within the Tuggerah Lakes area, with the original level (feet), current (measured) level (m AHD) and the derived <u>Conversion Factor</u>.

# SAMPLE OF ANOMALY FOR BM.23/B

Stated Level	Stated Datum	Source	Reference
7.04'	100' below Entrance Water Supply	Bannister & Hunter	Flood Survey Report for DMR 10 Dec 1964
7.04'	98.86' below Standard	Bannister & Hunter	The Entrance Bridge Drawings, Ref No. 335 B 908
7.04'	Water Supply Standard	DMR (RTA)	Wyong Shire Council Ref No. 0335 505 RC 0952
7.04'	Standard	GHD	Wyong Shire Council Ref No. 5188/74070

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#### BACKGROUND

The preparation of the **Historical Flood Levels** section for the **Tuggerah Lakes Compendium of Data** report required a search through a number of reports and other references containing flood data.

In the course of this search considerable historical flood level data were found. Levels for major floods were presented however, in some cases, no Datum was specified and converting these levels to AHD (Australian Height Datum) was not possible. These data are therefore of limited value.

The search commenced with Table 1 from K. Yong & P. Stone Report No. 123, "Recurrence Frequency of Flood Levels in the Tuggerah Lakes System", and continued through RTA records in Sydney and Newcastle, (RTA - Roads and Traffic Authority, former DMR - Department of Main Roads). Data sources from the following organisations were also investigated :

Wyong Shire Council Electricity Commission of NSW Department of Lands PWD Survey Branch in Gosford and Sydney Bannister and Hunter Surveyors, Gosford Water Research Laboratory, Manly Vale

#### FINDINGS

Levels of major historical flood events in 1927, 1946, 1949, and 1964 are contained in an engineering flood survey report (Bannister and Hunter Surveyors, Gosford, 10th December 1964) prepared for the DMR. The report can be found in RTA Archives, *File 505.1216 part 1*,.

Some difficulties arose when an attempt was made to interpret the Datum defined in this Report. The Datum described by Bannister and Hunter did not comply with Wyong Council's Diagram of Datums.

- It was also found that this Datum (called here the "Bannister and Hunter Datum" which was defined as: Water Supply Wyong Council @ The Entrance Datum - 100") was used in the design and construction of The Entrance Bridge over Tuggerah Lake. The Datum was also described as: 98.86' below Standard Datum, (DMR, Main Road No. 335, Set of Design Drawings, Registration No. 335 B 908).
- Further investigation revealed that the same Datum (but called Water Supply Standard Datum) was used by Wyong Council and Department of Main Roads for design and construction of roads and drainage in the Wyong Council area (*ie: DMR Set of Works as Executed Drawings No.* 0335 505 RC 0952, Plan No. 2309, 411/1 - 411/8, RTA Plan Room, Newcastle).
  - It was also found that the same Datum, but this time called **Standard Datum**, was used in 1964 by GHD (Gutteridge Haskins and Davey) in survey work and preparation of the Design Sheets for Water Supply and Sewerage Schemes for Wyong Council (Wyong Council Plan Room Ref. No. 5188/74070).
    - Works as Executed Drawings of Sewerage Sheets prepared in 1971 for The Entrance Scheme show the same Datum and the same Bench Marks used in the survey. The Datum was called **Standard Datum**, (Wyong Council Plan Room Ref. No. 74070 -  $12^{\circ}$ ,  $13^{\circ}$ ,  $14^{\circ}$ ).

Close examination of R.L. figures of Bench Marks contained on these Sewerage Plans revealed that the Datum used for that survey was <u>not</u> the Standard Datum as shown on these Drawings. A set of Drawings called "Wyong District W.S. General Plan - Key Diagram for Stage I and stage II Reticulation Plans" (*PWD Plan Room - Ref. No. 60102-1-126*) contained a tabulated **Bench Mark Schedule** prepared in 1953. The Datum used on these Drawings is also called **Standard Datum**.

After comparing the R.L.'s of Bench Marks shown in this Schedule with current AHD figures it was discovered that the Datum used was <u>not</u> the Standard Datum.

During the search through various documents and Drawings it was found that generally the same Bench Marks were used in the past but the description of Datums varied (ie: Wyong Water Supply Datum, Wyong Council W.S. @ The Entrance Datum, Water Supply Standard Datum, and other "versions" of Standard Datum). No information was found for a reliable explanation of the differences between "True Standard", "Survey Co-ordination Standard", and "Standard Datum". It was also discovered in old survey records of Lands Department and Electricity Commission that the "Provisional Standard Datum" was used, and again no definition for this Datum was found.

Various Datums with various inconsistent names used in the past caused confusion and misinterpretation of data. A number of instances were encountered where there was an incorrect conversion of old levels (in feet) into AHD figures.

The current AHD value for many Bench Marks in the Tuggerah Lakes area was established in 1973 (Precise Runs for Hydrosurvey). Some old Bench Marks have been resurveyed recently, as part of this investigation, using Lands Department PM's and SSM's as an Origin of Levels (PM - Permanent Mark, SSM - State Survey Mark).

**Table C2** contains a number of Bench Marks, commonly used within the Tuggerah Lakes area, with the original level (feet), current (measured) level (m AHD) and the derived **Conversion Factor**.

#### CONCLUSION

• It is concluded that historical Datum descriptions used within the Tuggerah Lakes area can be unreliable, particularly when used to compare historical flood levels.

### RECOMMENDATION

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- It is recommended that all flood level data be reliably related to AHD using as an origin of levels:
  - (i) Bench Marks (and Conversion Factors) given in the attached Table C2
  - (ii) Current RL for Lands Department PM's or SSM's

## **TUGGERAH LAKES - SURVEY DATUMS INVESTIGATION**

# **Relating Historical Bench Marks to AHD**

BM NUMBER	LOCATION/DESCRIPTION	ORIGINAL RL FEET	SOURCË OF INFORMATION OR/AND SURVEY REGISTER PAGE REF. NO	RL AHD METRES	SOURCE OF INFORMATION	CONVERSION FACTOR METRES
BM. 1	Bolt in kerb SW corner Oakland Avenue and The Entrance Road, The Entrance.	8.56'	The Entrance Sewerage Scheme, Wyong Council Ref No 5188 74070. Bannister & Hunter Report, 10.12.1964	2.173	PR 1973* T/111	0.436
BM. 2	Bolt in NE kerb of The Entrance Road about 60m north of The Entrance Hotel.	6.95'	The Entrance Sewerage Scheme, Wyong Council Ref No 5188 74070.	1.685	PR 1973* T/111	0.433
BM. 23/B	▲ cut in SW kerb of The Entrance Road, about 70m north of The Entrance Hotel.	7.04'	The Entrance Sewerage Scheme, Wyong Council Ref No 5188 74070. Bannister & Hunter Report, 10.12.1964	1.709	PR 1973* T/111	0.437
BM. 36	Bolt in kerb East side of The Entrance Road, about 200m North of Archbold Road, Long Jetty.	87.27'	Wyong Council Survey Records, (M. Harris).	26.165	PR 1973* T/110	0.435
BM. 159	Bolt in concrete floor SW corner Toilets Eastern side Hutton Road, about 250m North of Simpson Street, North Entrance.	9.12'	Main Road 335 - Entrance Bridge Approaches, DMR No 335 505 RC 0952, (Plan No 411) RTA Newcastle.	2.345	PR 1973* T/113 T/144	0.435
BM. fd	Garage concrete Floor Level, 2 storey cone block and fibro garage. Bondi Road Lot No 189, North Entrance.	6.71'	Main Road 335 - Entrance Bridge Approaches, DMR No 335 505 RC 0952 (Plan No 411) RTA Newcastle.	1.595	Wyong Council L.B. 455, Surveyed 31.10.91.	0.450

Notes: (1) Bench Marks shown in this Table are known to have been used by: Public Works, Wyong Council, DMR (now RTA), Bannister & Hunter Surveyors, Gosford (2) Worked example for conversion: 8.56' x 0.3048 - 0.436 = 2.173m.

\* PR 1973 - Precise Runs done by PWD for Tuggerah Lakes Hydrosurvey in 1973.

BM NUMBER	LOCATION/DESCRIPTION	ORIGINAL RL FEET	SOURCE OF INFORMATION OR/AND SURVEY REGISTER PAGE REF. NO	RL AHD METRES	SOURCE OF INFORMATION	CONVERSION FACTOR METRES
BM. 169	Bolt in kerb Southern side of Hargraves Strect (Northern end of existing bridge), North Entrance.	5.49'	The Entrance Sewerage Scheme, Wyong Council Ref No 5188 74070. Bannister & Hunter Report, 10.12.1964	1.274	Wyong Council Survey Register	0.399
BM. 9	Bolt in kerb West side of The Entrance Road, about 50m South of Ocean Parade, The Entrance.	38.69'	The Entrance Sewerage Scheme, Wyong Council Ref No 5188 74070.	11.393	Wyong Council Survey Register	0.400
BM. 11	Bolt in kerb SE corner of Ocean Parade and Beach Street, The Entrance.	47.40'	The Entrance Sewerage Scheme, Wyong Council Ref No 5188 74070.	14.048	Wyong Council Survey Register	0.400
BM. 135	Bolt in ▲ in Headwall NW intersection McLean Street and Main Road 335, Killarney Vale.	11.13'	Wyong Council Survey Records, (M. Harris).	2.975	PR 1973* T/108	0.417
BM. 203	Bolt in ▲ in Headwall culvert Lots 88, 89 Brenda Crescent, Tumbi-Umbi.	10.76'	Wyong Council Survey Records, (M. Harris).	2.858	PR 1973* T/106	0.422
BM. 205	Bolt in ▲ SE corner Tumbi Ck Road and Main Road 335, Bridge, Tumbi-Umbi.	16.86'	Wyong Council Survey Records, (M. Harris).	4.717	PR 1973* T/106	0.422
BM. 202	Bolt in ▲ in Headwall culvert SW intersection Florence and Adelaide Street, Tumbi-Umbi.	10.35'	Wyong Council Survey Records, (M. Harris).	2.729	PR 1973* T/106	0.426
BM. 121	Bolt in ▲ in Headwall, East side of Cornish Avenue, about 20m off Trelawncy Street, Killarney Vale.	42.62'	Wyong Council Survey Records, (M. Harris).	12.562	PR 1973* T/107	0.429

BM NUMBER	LOCATION/DESCRIPTION	ORIGINAL RL FEET	SOURCE OF INFORMATION OR/AND SURVEY REGISTER PAGE REF. NO	RL AHD METRES	SOURCE OF INFORMATION	CONVERSION FACTOR METRES
BM. 122	Bolt in ▲ in Headwall, SW intersection Trelawney and Carlyon Street, Killarney Vale.	33.07'	Wyong Council Survey Records, (M. Harris).	9.652	PR 1973* T/107	0.428
BM. 126	Bolt in A in Headwall SE intersection Lucinda Avenue and Crosby Crescent, Killarney Vale.	4.40'	Wyong Council Survey Records, (M. Harris).	0.914	PR 1973* T/108	0.427
BM. 125	Bolt in A in Headwall SE intersection Lucinda Avenue and Norton Street, Killarney Vale.	4.56'	Wyong Council Survey Records, (M. Harris).	0.955	PR 1973* T/108	0.435
BM. 68	Bolt in A in kerb NE corner Surf Street and Main Road 336, Long Jetty.	14.27'	Wyong Council Survey Records, (M. Harris).	3.915	PR 1973* T/109	0.434
BM. 60	Bolt in ▲ in kerb NE corner Elsiemer Street and Main Road 336, Long Jetty.	21.30'	Wyong Council Survey Records, (M. Harris).	6.059	PR 1973* T/109	0.433
BM. 51	Bolt in A in kerb NW corner Thompson Street and Main Road 336, Long Jetty.	26.53'	Wyong Council Survey Records, (M. Harris).	7.649	PR 1973* T/109	0.437
BM⊹ 6	Bolt in kerb NW corner The Entrance Road and Coral Street, The Entrance.	11.24' 11.26'	The Entrance Sewerage Scheme, Wyong Council Ref No 5188 74070. Main Road 335 - Entrance Bridge Approaches, DMR No 335 505 RC 0952, (Plan No 411), RTA Newcastle.	2.982	PR 1973* T/111 T/112	0.450
BM. 10	Bolt in SW kerb of Marine Parade about 30m NW of Beach Street, The Entrance.	9.77'	The Entrance Sewerage Scheme, Wyong Council Ref No 5188 74070.	2.534	PR 1973* T/112	0.444

BM NUMBER	LOCATION/DESCRIPTION	ORIGINAL RL FEET	SOURCE OF INFORMATION OR/AND SURVEY REGISTER PAGE REF. NO	RL AHD METRES	SOURCE OF INFORMATION	CONVERSION FACTOR METRES
BM. 170	Bolt in kerb NW corner of intersection of Hutton Road and Hargreaves Street, North Entrance.	8.39'	The Entrance Sewerage Scheme, Wyong Council Ref No 5188 74070.	2.112	PR 1973* T/112	0.445
BM. 3/Q	▲ cut in kerb SE corner The Entrance Road (Main Road 336) and Anzac Road, The Entrance.	72.39'	Wyong Council Survey Records, (M. Harris).	21.613	PR 1973* T/110	0.451
BM. 30	Bold in kerb SE corner of The Entrance Road (Main Road 336) and Gosford Road, The Entrance.	63.4]'	Wyong Council Survey Records, (M. Harris).	18.866	PR 1973* T/110	0.461
The Entrance Bridge	Centre Line at South abutment.	24.10'	DMR Main Road 335 Drwg No 335 B 908.	6.902	Wyong Council L.B. 455, Surveyed 31.10.91 Origin PM 17594.	0.444
The Entrance Bridge	Centre Line at 1 pillar.	26.98'	DMR Main Road 335 Drwg No 335 B 908.	7.755	Wyong Council L.B. 455, Surveyed 31.10.91 Origin PM 17594.	0.469
The Entrance Bridge	Centre Line at 2 pillar.	29.20'	DMR Main Road 335 Drwg No 335 B 908.	8.432	Wyong Council L.B. 455, Surveyed 31.10.91 Origin PM 17594.	0.468
The Entrance Bridge	Centre Line at 3 pillar.	30.80'	DMR Main Road 335 Drwg No 335 B 908.	8.918	Wyong Council L.B. 455, Surveyed 31.10.91 Origin PM 17594.	0.470
BM. 40/M	Bridge Pile castern side of Toukley Bridge, Toukley.	7.21'	Schedule of Bench Marks Table, Wyong District Water Supply Gen. Plan, PWD Ref No 60102-1-126	1.727	PR 1973* T/117	0.470

\* PR 1973 - Precise Runs done by PWD for Tuggerah Lakes Hydrosurvey in 1973.

BM NUMBER	LOCATION/DESCRIPTION	ORIGINAL RL FEET	SOURCE OF INFORMATION OR/AND SURVEY REGISTER PAGE REF. NO	RL AHD METRES	SOURCE OF INFORMATION	CONVERSION FACTOR METRES
BM. 6/M	▲ Brick West Platform Wyong Railway Station.	45.52'	Schedule of Bench Marks Table, Wyong District Water Supply Gen. Plan, PWD Ref No 60102-1-126	13.429	Wyong Council L.B. 455, Surveyed 04.12.91 Origin SSM 19719.	0.445
BM. 52/M	South East corner Ouringo Street and Munmorah Road, Budgewoi.	7.44'	Schedule of Bench Marks Table, Wyong District Water Supply Gen. Plan, PWD Ref No 60102-1-126	1.835	PR 1973* T/122	0.433
BM. 63/M	▲ Brick East Platform Tuggerah Railway Station.	22.58'	Schedule of Bench Marks Table, Wyong District Water Supply Gen. Plan, PWD Ref No 60102-1-126, See Tag 7, also E/15 and W/50 PWD Survey Reg.	6.512	PR 1973* T/105 & T/135	0.370
BM. 1/H	Cut on Gum Black/Butt Less Reserve, opposite Geoffrey Road.	16.51'	PWD Survey Reg E/20. Wyong Council Survey Records, (M. Harris).	4.669	PR 1973* T/105	0.363
BM. 1/GHD	Bolt in kerb corner Howarth and Panonia Road, Wyong.	10.61'	Wyong Sewerage Detail Drwg, PWD Plan Room Ref No 73860-30x.	2.846	Wyong Council L.B. 455, Surveyed 04.03.92 Origin SSM 19719.	0.388
BM. 11/GHD	Bolt in kerb, Pacific Highway (opposite Grand Hotel), Wyong.	55.71'	Wyong Sewerage Detail Drwg, PWD Plan Room Ref No 73860-31x.	16.583	Wyong Council L.B. 455, Surveyed 05.03.92 Origin PM 17359.	0.397
BM. 18/GHD	Bolt in kerb, NE corner Alison and Hope Street, Wyong.	46.84'	Wyong Sewerage Detail Drwg, PWD Plan Room Ref No 73860-33x, Sheet No 6.	13.890	Wyong Council Register	0.387
BM. 32/Q	▲ cut on concrete abutment South West corner of railway bridge over the Wyong River, Wyong.	17.00'	PWD Survey Branch, Survey Reg W/80.	4.798	PWD Survey Register T/125, W/184, T/135 & W/242	0.384

BM NUMBER	LOCATION/DESCRIPTION	ORIGINAL RL FEET	SOURCE OF INFORMATION OR/AND SURVEY REGISTER PAGE REF. NO	RL AHD METRES	SOURCE OF INFORMATION	CONVERSION FACTOR METRES
BM. 22/Q	▲ cut on base of bubbler stand in Ourimbah Public School Ground.	71.20'	PWD Survey Reg W/78, W/79.	21.342	PWD Register Schedule Of Bench Marks Established for Wyong Shire Sewerage Ourimbah.	<b>0.360</b> d at
BM. 21/Q	▲ on conc kerb at SW corner of Electricity Commission Subst'n, about 50m East of EBL of Pacific Highway, Ourimbah.	<i>59.13'</i> of	PWD Survey Reg W/78.	17.657	PWD Register Schedule Of Bench Marks Established for Wyong Shire Sewerage Ourimbah.	0.366 J at
BM. 20/Q	▲ cut on western headwall culvert under disused section of Pacific H'way, approx. 150m north of Burns Rd, Ourimbah.	59.14'	PWD Survey Reg W/78.	17.703	PWD Register Schedule Of Bench Marks Established for Wyong Shire Sewerage a Ourimbah	0.323 i at
BM. 15/Q	▲ cut on east corner, bridge over Kangy Angy Ck. @ Pacific H'way.	37.20'	PWD Survey Reg W/78.	10.952	PR 1973 * T/150	0.386
° BM. 23/B	▲ cut on concrete kerb opposite west end of Bridge between The Entrance and North Entrance.	7.68'	PWD Survey Rcg E/5.	1.709	PR 1973 * T/111	0.632
° BM. 26/B	▲ cut on north headwall concrete culvert in Hutton Rd, North Entrance. North Entrance.	6.13'	PWD Survey Rcg E/5.	1.168	PR 1973 * T/112	0.700
°° BM. 42/M	▲ cut on conc. pit P.M.G. near inst'n of Toukley Rd & Dunleigh Street, Toukley.	19.48'	Schedule of Bench Marks, PWD Ref No 60102-1-126, See Tag 7, also E/15 and W/150 PWD Survey Reg.	5.121	PR 1973 * T/118	0.816

Notes: • A second, less popular, "Standard" Datum, 0.64' (feet) lower, was also used.

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\*\* The reason for high conversion factor of BM.42/M is not known.

\* PR 1973 - Precise Runs done by PWD for Tuggerah Lakes Hydrosurvey in 1973.