Sediment Sources, Transport and Deposition in the Moreton Bay Catchment: Existing Data and Previous Research

Frances Marston

CSIRO Land and Water
Technical Report 27/00, August 2000

CSIRO LAND and WATER

Sediment Sources, Transport and Deposition in the Moreton Bay Catchment: Existing Data and Previous Research

Frances Marston

CSIRO Land and Water
Technical Report 27/00, August 2000

Table of Contents

Maps

Sediment Sources, Transport and Deposition in the Moreton Bay Catchment: Existing Data and Previous Research

Introduction

The impacts of urban development and settlement on the Bay and all its waterways has upset the complex interactions essential for maintaining the integrity of ecosystem function. Habitats have been so changed that in the past hundred years entire communities have disappeared. The severity of the changes has resulted in expressions of concern from the community and government, and initiatives to ameliorate the situation have been implemented.

One of these initiatives is the SE Queensland Regional Water Quality Management Strategy (SEQRWQMS), a staged approach to planning and management in the region. Work undertaken in the earlier stages[1] identified sediments as playing a role in the degradation of numerous habitats within the Catchment. Since settlement, rates of sediment delivery to the Bay from major rivers have increased markedly[2] and the pattern of sediment movement within the Bay and estuary has been altered[3] with consequent ecological changes.

Sediment discharge from coastal catchments influences their ecosystems directly by increasing water turbidity and sedimentation, and indirectly as a medium for the transport of nutrients and pollutants. Of particular concern within Moreton Bay are the impacts of sediment on seagrass communities, which are habitat for animals such as dugong and turtles. These populations have experienced significant decline, especially over the past few decades. Reduction in light penetration due to high levels of turbidity and smothering of seagrass plants with fine sediment has contributed to this. Increased levels of nutrients have also resulted in toxic algal blooms in parts of the river network.

From a commercial viewpoint, local fisheries are being affected as habitat conditions alter population dynamics and dredging operations, needed to maintain shipping channels for port development, are impacted.

This report is part of work commissioned by the SEQRWQMS (Phase 1 & 2 of Project SS: Sediment Sourcing, within Stage 3 of the Strategy) to determine the sources of sediment delivered to Moreton Bay. The Strategy is a very large undertaking with numerous concurrent studies commissioned, building on other work and data collected over many years of investigation. Consequently there have already been many publications and reports documenting various aspects of life in the catchment. Rather than reproducing that information here, the reader will be directed to the works that provide useful information on basic topics. The focus of this report will be on the status of sedimentation in the Catchment.

---

[1] WBM Oceanics and Sinclair Knight Merz (1995)

[2] Neil (1998)

[3] Patterson (1992), Davie *et al.* (1990)

Knowledge Acquisition

Researching the topic involved searching a wide variety of source materials including published and unpublished papers and reports, online databases and internet sites. High priority was given to finding primary source material. However, this proved more difficult than anticipated. Much of the work draws on anecdotal or descriptive and qualitative rather than quantitative data.

Search Strategies

Comprehensive structured searches, incorporating elements (not keywords) of the topic (sediment(s), sedimentation, sediment budget, siltation, erosion, runoff, water quality, sea grass, Brisbane River, Moreton Bay etc.) were conducted, targeting a variety of sources:

- **NUMEROUS ELECTRONIC AND ONLINE DATABASE SEARCHES INCLUDING:**

Australian Earth Sciences, Australian Rural Research in Progress, CAB Abstracts, Current Contents, GeoRef, ScanFile, Science Citation Index, Streamline, Web of Science.

- **VARIOUS WEB SITES INCLUDING:**

Brisbane Region Environment Council. Brisbane region environment council memo commenting on SEQ regional planning issues including Brisbane River and Moreton Bay. URL:*http://user.pasdex.net.au/~webink/news/rfgminstreview.html.*

Brisbane River Managment Group. Healthy waterways initiative. URL:*http://www.brmbwms.qld.gov.au.*

Port of Brisbane Corporation. Fisherman Islands proposed port expansion. URL:*http://www.portbris.com.au/pages/inf.htm*

QLD EPA. Moreton Bay strategic plan. URL:*http://www.env.qld.gov.au/environment/business/policies/mbsp.html.*

University of Queensland Marine Botany. Moreton Bay study. URL:*http://www.botany.uq.edu.au/research/marine_botany/marbot/mbstudy.htm.*

All these and other sites provided further references, contacts and online links.

Literature Review

References were also obtained from citation lists and bibliographies contained within primary source documents reviewed. As well as providing direct references, the literature review process was a good way to source the key works.

Many other studies[4] have already presented comprehensive literature reviews. This report assembles the information into a selected annotated bibliography, thereby reflecting the focus on sediment transport processes in the catchment.

---

[4] Crimp (1992), Davie *et al.* (1990), Envirotest (1996), Neil (1998), Sinclair Knight Merz and WBM Oceanics, Australia (1998), Stephens (1992), Tibbetts *et al.* (1998), WBM Oceanics and Sinclair Knight Merz (1995), WBM Pty Ltd (1992).

Key Documents

A comprehensive bibliographic database containing over 100 records was assembled. Of these there are a number of key documents that contain data directly related to the sediment transport in the catchment. Key documents are presented as a group in the bibliography section as well as being highlighted in the complete bibliographic listing.

Types of data, studies and research

Scientific studies of Moreton Bay and its catchment have filled innumerable books, journals and reports and have been the focus of many symposia and workshops. However, targeting information specifically about sedimentation in the catchment involves sifting through data collected primarily for all sorts of other purposes.

Historical data can provide information on how the environment has changed over the years. Descriptions of the rivers and Bay can be found in old newspaper articles and the like. In a similar fashion oral histories can provide useful accounts of how things have changed. Histories of land settlement and urbanisation provide many records about features of the landscape and the necessary construction needed to establish roads and ports etc. From these sources we know for example that the Brisbane River used to run much clearer (except during floods) than it does today[5]. Source items providing or based on historical data included in the bibliography are Ref. Nos: 4, 14, 15, 54, 64, 71, 81, 84, 85.

Water quality data that includes suspended sediment and nutrient concentrations can provide information about the source of these materials. Source items providing or based on water quality data included in the bibliography are Ref. Nos: 13, 19, 20, 21, 23, 27, 31, 32, 33, 35, 36, 37, 38, 39, 40, 43, 49, 50, 58, 59, 61, 72, 73, 76, 91, 93.

Hydrodynamic data can give information about the ability of a waterbody to transport sediment from one place to another or its potential for resuspending sediment already deposited, as in the case of tides and currents. Source items providing or based on hydrodynamic data included in the bibliography are Ref. Nos: 5, 6, 22, 26, 35, 37, 52, 53, 66, 67, 68, 95, 96, 97.

Geomorphological data may be useful for understanding sediment transport processes and for building a historical perspective of sedimentation and sediment transport in the catchment. A catchment's geomorphology will reflect and influence such things as channelisation potential, characteristics of sediment (types, particle size, source etc), load capacity of a waterbody, stream power, etc. Source items providing or based on geomorphological data included in the bibliography are Ref. Nos: 4, 37, 42, 47, 54, 82, 83, 84, 85.

Geotechnical data related to construction and development may provide information relating to sedimentation rates and sediment movement, particularly data related to dredging operations for navigation and port facilities. Source items providing or based on geotechnical data included in the bibliography are Ref. Nos: 12, 16, 44, 52, 53, 54, 57, 63, 67, 77, 96, 97, 98, 99.

---

[5] Stock & Neller (1990)

Biological and ecological data collected for monitoring or field/case studies of populations or communities often include parameters relating to sediments. Studies of seagrass communities and other ecologically sensitive environments of the Moreton Bay catchment are included in this category. In this way data related to sediment transport characteristics can be obtained from nutrient studies because of the association with increased or changed turbidity levels. Source items providing or based on biological or ecological data included in the bibliography are Ref. Nos: 1, 2, 7, 8, 9, 10, 11, 14, 15, 17, 27, 40, 46, 48, 49, 50, 60, 73, 77, 86, 89, 90, 92, 94.

Estuarine studies provide an important source of information covering a vast array of data. The complex nature of estuaries means that estuarine ecology has become a specific field of study. For this reason estuarine studies are grouped together. And, because estuaries are thought of as sinks of sediment that can completely fill from upstream by direct river input, and from marine environments by tidal and salt-wedge circulations[6], sediment dynamics can be quite variable. Source items providing or based on estuarine studies included in the bibliography are Ref. Nos: 26, 35, 36, 39, 42, 45, 47, 59, 60, 61, 70.

Catchment Characteristics

Geography

The Moreton Bay catchment is located in south-east Queensland (Map 1) in a sub-tropical/tropical zone of transition where the climate is controlled by moist unstable summer conditions and relatively stable and drier winter conditions. There is a pronounced east-west rainfall gradient across the catchment due to the proximity of the ocean (east) and the Great Dividing Range (west).

In the past, the catchment has been mapped in various ways and it is difficult to find a common definition of catchment and sub-catchment boundaries. However, many of the studies and much of the literature provides information in a way that can be matched fairly well with the broad boundaries defined for the 'State Of' reports[7]. This literature review has used a similar definition as shown in Map 2, making an area of approximately 21844 square kilometres.

The catchment largely consists of coastal and sub-coastal lowlands with smaller regions of coastal and sub-coastal ranges. Urban and agricultural areas are mainly located on the lowlands whereas land uses in the ranges are a mix of grazing, forestry and national parks.

The main waterways draining into Moreton Bay itself include the Brisbane, Caboolture, North and South Pine, and Logan rivers. Discharge is mainly in response to the summer rainfall.

Source items providing descriptions of the region's geography included in the bibliography are Ref. Nos: 3, 7, 8, 9, 11, 14, 15, 40, 46, 51, 56, 64, 69, 74, 84.

---

6 Kench (1999)

7 Brisbane River Management Group and the Brisbane River & Moreton Bay Wastewater Management Study (1997)

Settlement History and Land Use

Before European settlement the catchment was in a relatively stable condition with periodic cyclones and Aboriginal fire management practices the only substantial disturbance. Subsequent development pressures have resulted in major changes. Sediment yields increased rapidly in the 19th century but have been relatively stable since the 1920s (although markedly higher than pre-settlement).

Only about 35% of the original vegetation remains[8] with clearing for cropping, plantation forestry and urban purposes and partial removal for grazing and low density residential areas. The consequent soil disturbance and removal of riparian vegetation has led to bank slumping and extensive erosion[9]. Active clearing in the catchment has, however, now virtually ceased.

Grazing and private forestry now make up the bulk of the land use activities in the catchment (65%) with public land 17%, urbanization 13% (but rapidly on the increase) and cropping 5%.

Source items providing descriptions of the region's settlement history and land use characteristics included in the bibliography are Ref. N^{os}: 7, 8, 9, 10, 11, 12, 14, 15, 30, 31, 32, 64, 71, 74.

Factors influencing sediment dynamics in the catchment

The impacts of European development and settlement in the catchment have led to significant increases in suspended sediment export. This has come about through the extensive clearing in upper parts of the catchment, cultivation on the floodplains, and local development of urban centres which have significantly changed the catchment hydrologic characteristics.

Because the catchment is dominated by episodic, short-lived, large summer floods, and little or no flow in winter, most sediment delivery to Moreton Bay is associated with large summer floods. This is because minor floods are incapable of flushing the saline wedge from the Brisbane River estuary[10]. Most of the total suspended load becomes trapped within the to be redistributed and deposited in deep reaches.

Source items providing descriptions of sediment dynamics in the catchment included in the bibliography are Ref. N^{os}: 4, 22, 23, 26, 29, 34, 35, 36, 37, 42, 43, 45, 53, 62, 65, 67, 95, 96, 97.

Findings

Prior Research

Ever since settlement first began there has been interest in the sediment dynamics of the Moreton Bay catchment. Initially, interest stemmed from a farming viewpoint related to alluvial depositions and the benefits for agriculture. This grew into interest in aggregate resources for building and construction purposes[11]. As development and settlement grew the interest became more focussed on the problems

---

8 Capelin *et al.* (1998)

9 Eyre *et al.* (1998)

10 Druery (1979)

11 Holmes (1980), Neil (1998)

caused by deposition – particularly during flood events – to properties, transport, navigation and port facilities. Eventually erosion and runoff impacts became so intense that soil loss, water turbidity and consequent habitat degradation became the focus. By the late 1970s a number of workshops and symposia had convened to begin addressing these and many other environmental and ecological issues. In response numerous studies were initiated from which much of the current research has evolved[12].

Early studies tended to be concentrated on 'hot spots' or problems and were not integrated, whole-of-catchment studies. Even today, given the geographic extent and complexity of the catchment, this integration is difficult to achieve. There have been relatively few studies specifically targeting sediment-related issues in the catchment[13] but many other studies have considered aspects of sediment dynamics while addressing other issues. The bulk of the work has focused on the Brisbane River and its tributaries.

Currently, most of the research is being undertaken under the umbrella of the SEQRWQMS, much of it arisen from earlier work carried out for the 1994 Brisbane River and Moreton Bay Wastewater Management Study, which was the first attempt at an integrated whole-of-catchment investigation. This study and the subsequent Strategy, aimed to develop a wastewater management strategy to protect and enhance the social, economic and environmental values of the SE Queensland Region. Understanding the sediment inputs, outputs and storage within the system is a necessary part of that aim.

Major sources of sediment within the catchment

- Since European settlement there has been an increase in sediment delivery to Moreton Bay from the catchment.
- However there has been little work undertaken to determine the actual sources of the material.
- Unit-per-area loads have been estimated (primarily based on Cosser's land use generation rates[14]) for most of the major waterways within the catchment and water quality monitoring studies have provided data for suspended sediment.
- Previous studies suggest that most of the sediment delivered to Moreton Bay is derived from the Brisbane River (Table 1).

---

[12] Crimp (1992), Davie *et al.* (1990), Tibbetts *et al.* (1998)

[13] The most significant of these include

[14] Cosser (1989)

Table 1: Estimated suspended sediment loads[15]

Catchment	Load (tonnes/year)
Caboolture River	23777
Burpengary Creek	5602
Boundary Creek	12954
North & South Pine Rivers	61788
Cabbage Tree Creek	7773
Tidal Brisbane River	117468
Fresh Brisbane	15228
Tidal Bremer	18863
Fresh Bremer	83846
(All Brisbane River)	*235405*
Other	25644
NB: the rate of sediment entering the Brisbane River is some 140000 t/yr which is somewhat less than the typical rate of sediment removal, however no allowance was made in the calculation for the effects of Wivenhoe Dam or contribution from tidal inflows to the river from Moreton Bay	

Various modelling studies have estimated sediment exports from different parts of the catchment. Some of these are set out below in Table 2.

Table 2 Modelled Estimates of Sediment Exports

Catchment	WBM-SKM (1995) tonnes/year (estimated)	Envirotest (1996) tonnes/year (estimated)	Envirotest (1996) tonnes/year (1991 projection)	SKM-WBM (1998) Kg For 1996 (wet year)
Brisbane River Estuary	117468	117468	234832	
Brisbane River Fresh (above Wivenhoe Dam)	15228	109700	-	
Brisbane River Fresh (below Wivenhoe Dam)		15228	13175	
Bremer River Estuary	18863	18863	10174	
Bremer River Fresh	83846	83846	37661	
Lockyer Creek		52926	67079	
Stanley River		27033	-	
Total Brisbane River (to MB)		316131		77.60E+07
Freshwater Catchments		179033		
Northern Catchments		112069		
Caboolture River	23777			7.50E+06
Boundary Creek	12954			
MB Others	25644	26821		
Burpengary Creek	5602			
North & South Pine Rivers	61788			
Cabbage Tree Creek	7773			
Brisbane Urban			106743	
North Moreton Bay			76122	
Southern MB			18983	1.20E+06
MB Catchment			329937	1.90E+08

15 WBM Oceanics and Sinclair Knight Merz (1995) - these are simulated estimations but have become the 'standard' accepted for the catchment.

Bibliography

Complete bibliography with selected annotations

This bibliography contains most of the references collected for the project. However, because of their transient nature, internet sites are not included. Selected items have annotations in the form of notes and comments. The collection is held in a *ProCite*©® bibliographic database and can be easily searched and edited as the need arises.

The listing is alphabetical and sorted by date. Reference numbers (Ref. N^os.^) only relate to this document and are not database defined. Key documents are indicated with the key symbol in the bibliography listing.

N° CITATION DETAILS

1. **Abal, E.G. and Dennison, W.C.** (1996). Seagrass depth range and water quality in Southern Moreton Bay, Queensland, Australia. *Marine and Freshwater Research,* 47:763-771.

   Notes: Correlations between water quality parameters and seagrass depth penetration were developed for use as a biological indicator of integrated light availability and long-term trends in water quality. A year-long water quality monitoring programme in Moreton Bay was coupled with a series of seagrass depth transects. A strong gradient between the western (landward) and eastern (seaward) portions of Moreton Bay was observed in both water quality and seagrass depth range. Higher concentrations of chlorophyll a, total suspended solids, dissolved and total nutrients, and light attenuation coefficients in the water column and correspondingly shallower depth limits of the seagrass *Zostera capricorni* were observed in the western portions of the bay. Relatively high correlation coefficient values ($r^2 > 0.8$) were observed between light attenuation coefficient, total suspended solids, chlorophyll a, total Kjeldahl nitrogen and *Zostera capricorni* depth range. Low correlation coefficient values ($r^2 < 0.8$) between seagrass depth range and dissolved inorganic nutrients were observed. Seagrasses had disappeared over a five-year period near the mouth of the Logan River, a turbid river with increased land use in its watershed. At a site 9 km from the river mouth, a significant decrease in seagrass depth range corresponded to higher light attenuation, chlorophyll a, total suspended solids and total nitrogen content relative to a site 21 km from the river mouth. Seagrass depth penetration thus appears to be a sensitive bio-indicator of some water quality parameters, with application for water quality management.

2. **Arthington, A.H.** (1985). The biological resources of urban creeks. *Australian Society for Limnology Bulletin,* 10:33-39.

   Notes: The diversity of plant communities, their associated terrestrial fauna, and the diversity of aquatic invertebrates and fishes in the Brisbane QLD region are described, and the scientific, educational and recreational values of these resources are discussed. Some effects of the creek hydrology, urban development, water pollution and the establishment of introduced plants and fishes on the creek communities are described. While multiple uses of urban creeks need not be incompatible, management strategies are required to set constraints and priorities.

3. **Bailey, A. and Stevens, N. C.** (Eds.) (1979). Northern Moreton Bay symposium. Royal Society of Queensland, Brisbane, Queensland.

   Comment: Unable to source this document for review but it is cited as a major primary source in other works.

4. **Beckmann, G.G. and Stevens, N.C.** (1978). Geological history of the Brisbane River System. *Proceedings of the*

Royal Society of Queensland, 89:77-85.

Notes: Restricted to the Brisbane River catchment this paper covers the geological history from Palaeozoic times. A map of erosional and depositional surfaces in the area and a landscape cross-section showing remnants of Miocene and older surfaces may provide some clues re sources of basaltic sediments. Relict sediments in Moreton Bay are referenced in the bibliography.

5. **Boughton, W.C.** (1993). A hydrograph-based model for estimating the water yield of ungauged catchments. In: Towards the 21st century: Hydrology and Water Resources Symposium, pp 317-324. Institution of Engineers Australia, Barton ACT.

   Notes: Use of the saturation overland flow AWBM model for extending the stream flow records of gauged catchments and estimating the water yield of ungauged catchments is illustrated through application in four Queensland case studies, Back Creek, Brigalow, Munduran Creek and Oxley Creek. The model can be used as a simple one parameter model on small ungauged catchments where there is no baseflow, or a three parameter model on ungauged catchments which have a significant baseflow component of runoff. Where stream flow data are available for calibration, the parameters in the model can be directly evaluated without any need for trial and error optimization, eliminating the problem of parameter interaction which occurs with trial and error fitting. It is concluded that despite the model's simplicity, the accuracy of reproducing the stream flow pattern of gauged catchments is equal to those of far more complicated models.

6. **Boughton, W.C. and Carroll, D.G.** (1993). A simple combined water balance/flood hydrograph model. In: Towards the 21st century: Hydrology and Water Resources Symposium, pp 299-304. Institution of Engineers Australia, Barton ACT.

   Notes: The AWBM water balance model is combined with the URBS runoff routing model and tested as a flood forecasting model for Oxley Creek, the largest of Brisbane's metropolitan creeks. Five flood events with a range of peak discharges are used to demonstrate the accuracy of the combined modelling system. The last of the five events occurred after a sustained dry period of ten months, yet the start of surface runoff was estimated to within two hours, the peak rate of runoff to within 5% and the timing of the peak to within two hours. Significant features of the combined system are the calculation of rainfall excess from partial areas of the catchment in the AWBM model and the integration and distribution of this excess by the URBS model to calculate the flood hydrograph .

7. **Brisbane City Council** (1996). State of the environment report. Brisbane City Council.

8. **Brisbane City Council** (1998). State of the environment report 2. Brisbane City Council.

   Notes: The 1998 State of the Environment Report is a study of Brisbane's environment and the changes that have taken place since the first report was published in 1996. It outlines the pressures on the environment and actions required to ensure that Brisbane's environmental qualities are retained.
   The report constitutes a valuable resource for community groups, schools and tertiary facilities and government policy-makers. It will also be used to increase public awareness about the need for action on important environmental issues and to monitor the success of these actions.
   Two new, very important topics are covered in the 1998 Report. Chapters are devoted to protection of our cultural heritage - places that give Brisbane its special character - and ecologically sustainable development and what it means for Brisbane.
   For the first time, environmental issues of concern to Aboriginal people are included in each section of the report. These were compiled in consultation with Brisbane's Aboriginal community and acknowledge the important relationship between Aboriginal people and the land.
   Brisbane has a great deal to be proud of in our environmental record. However, many challenges still remain -

challenges such as improving water quality in the Brisbane River and Moreton Bay, maintaining air quality at acceptable levels, reducing reliance on private transport and protecting bushland corridors.

9. **Brisbane River Management Group** (1998). 1998 waterways management plan. A framework for the management of the waterways of the Brisbane River and Moreton Bay catchment. Brisbane River Management Group.

10. **Brisbane River Management Group** (1998). Working paper on river uses and activities management. Brisbane River Management Group.

11. **Brisbane River Management Group and the Brisbane River & Moreton Bay Wastewater Management Study** (1997). State of the Brisbane River, Moreton Bay and waterways. QLD Department of Environment. RE173.

    Comment: Data for this report has come from a number of earlier reports prepared for different parts of the Strategy. Of particular interest are the following: Envirotest (1996); SKM & WBM Oceanics (1995) - Task G4; SKM & WBM Oceanics (1996) - Task S4; Davie *et al.* (1990); QDEH (1991) - Moreton Bay Strategic Plan; Brisbane City Council (1996) - SOE Rpt.

12. **Broughton, W.C.** (1981). Modifications to stream channels in the Brisbane metropolitan area, Australia. *Environmental Conservation,* 8(4):299-306.

    Notes: This paper reports the results of a case-study in which the major modifications to stream channels in the city of Brisbane, Australia, are documented and used to illustrate the scope and magnitude of environmental impacts which have occurred.

13. **Bycroft, B., Mack, P., and McAlister, T.** (1995). Stormwater quality data collection program for Brisbane City Council. In: Integrated management of urban environments: 2nd International Symposium on Urban Stormwater Management, pp 483-487. Institution of Engineers, Australia, Barton, ACT.

    Notes: Brisbane City Council has established a stormwater quality data collection program that will allow quantification of locally specific runoff and pollutant loadings entering the waterways and assist in the planning and evaluation of methods of control. As part of this program, three stormwater quality monitoring stations are being established, on Enoggera Creek, Sandy Creek and a tributary of Kedron Brook. The stations collect data on rainfall and stormwater runoff and also sample stormwater for subsequent laboratory analysis to provide accurate data for impact assessment and mathematical modelling purposes. Currently data is only available for Sandy Creek, where evidence of a first flush effect has been found, which could reduce the volume of runoff that may need to be treated. However, there is also a relationship between the rate of stormwater runoff and the concentration of pollutant present in the stormwater.

14. **Capelin, M.** (1990). Land use, land capability and land management. In: P. Davie et al., (Eds.), The Brisbane River: A source book for the future, pp 217-224. The Australian Littoral Society, Brisbane, Queensland.

    Comment: For erosion studies see: Queensland Department of Primary Industries (1974). Moreton Region Non-Urban Land Suitability Study. *Division of Land Utilisation Technical Bulletin 14.* QDPI, Brisbane.; Johnston, P.J.M. (1979). Bremer catchment land degradation study. Moreton Region Non-Urban Land Suitability Study. *Division of Land Utilisation Technical Bulletin 40.* QDPI, Brisbane.; Shaw, J.H. (1979). Land degradation in the Lockyer Valley. Moreton Region Non-Urban Land Suitability Study. *Division of Land Utilisation Technical Bulletin 39.* QDPI, Brisbane.
    Notes: A description of land use throughout the catchment is presented with comments on capability and management options to address impacts. A discussion about soil erosion is included. Includes data from the Moreton Region Non-Urban Land Suitability Study which found that 14% of the catchment was severely eroded as a result of agricultural practices. Worst affected catchments are the Bremer and Lockyer.

15. **Capelin, M. and others** (1998). Land use, land cover and land degradation in the catchment of Moreton Bay. In: I.R. Tibbetts et al., (Eds.), Moreton Bay and catchment, pp 55-56. School of Marine Science, University of Queensland, Brisbane, Queensland.

16. **Carroll, D.G.** (1993). PROPHET: the Brisbane City Council creek flood monitoring and forecasting system. In: Effective use of technology: 7th National Local Government Engineering Conference, pp 1-7. Institution of Engineers, Australia, Barton ACT.

    <u>Notes:</u> A flood monitoring and forecasting system, PROPHET, has been developed by the Brisbane City Council for use with event based radio telemetry field stations. This follows trialing of the ALERT system designed by the United States National Weather Service which was found to have software interfaces and methodologies inappropriate for the local situation. PROPHET was developed particularly to meet local requirements especially in interrogation procedures for non specialist users and in flood forecasting for specialist users. The design objectives of providing a functionally sophisticated yet operationally simple system and to permit remote access to non technical personnel have been achieved. The system is now operational for the city's largest creek system, Oxley Creek and it is contended that the presentation, data analysis and flood forecasting developments, represent significant advances over existing systems.

17. **Carter, D.** (1997). State of the Rivers: Lockyer Creek and major tributaries. Department of Natural Resources Resource Sciences Centre.

18. **Clark, M.W.** (1998). Management implications of metal transfer pathways from a refuse tip to mangrove sediments. *The Science of the Total Environment,* 222:17-34.

    <u>Notes:</u> Mangroves have often been thought of as wasteland, and because of this attitude, many mangrove forests have been used as sites for refuse tips, sewage outfalls and as illegal dumping grounds. The transfer of metals from a refuse tip to mangrove sediments is investigated and four pathways of heavy metal migration are identified. These are direct seepage across the tip-cell floor to groundwater, tidal over-topping of the bund wall and capillary suction of leachates to groundwaters, direct seepage through the cell wall of leachates to surficial sediments, and surface runoff during rainfall events. Metal input by surficial runoff indicates that significant quantities of metals have been transferred to the mangroves via this mechanism. However, metal transfer via surface runoff is probably small in comparison to the other three mechanisms discussed. The variable nature of the transfer mechanisms operating, the variability in sediment texture both vertically and laterally, and the number of transfer pathways makes potential management of the site difficult. Any management plan for this site must consider both the feedback mechanisms that operate, and that the whole sediment column is involved in metal transfer.

19. **Connell, D. and Miller, G.** (1998). Moreton Bay Catchment: water quality of catchment rivers and water storage. In: I.R. Tibbetts et al., (Eds.), Moreton Bay and catchment, pp 153-164. School of Marine Science, University of Queensland., Brisbane, Queensland.

    <u>Notes:</u> An overview is provided which identifies toxic algal blooms as a major management problem and identifies some of the roles played by nutrients and turbidity. Sediment load data derived from WBM-SKM (1995) are presented for the Brisbane river above Wivenhoe Dam and for the other catchments as set out in that report. Sediment loads for Lockyer Ck are estimated.

20. **Connell, D.W., Morton. H.C., and Bycroft, B.M.** (1982). Oxygen budget for an urban estuary. *Australian Journal of Marine and Freshwater Research,* 33(4):607-616.

    <u>Notes:</u> Various processes affecting the dissolved oxygen content of waters of the Norman Creek estuary, Brisbane, were measured or estimated and standardised for the midtide daylight situation. Over a 9-week period, accrual, aeration and photosynthetic processes resulted in the daily addition of 76,225 and 214 kg oxygen, respectively, and export, deaeration, biochemical oxygen demand, plant respiration and benthic respiration in the daily loss of 30,89,91,97 and 335 kg oxygen, respectively. These processes are highly dynamic, with substantial daily turnover in the water mass. Benthic sediments, enriched with organic matter, exercise a major influence on the dissolved oxygen content of the water.

21. **Cosser, P.R.** (1989). Nutrient concentration-flow relationships and loads in the South Pine River, south eastern Queensland. I. Phosphorus loads. *Australian Journal of Marine and Freshwater Research,* 40:613-630.

    <u>Notes:</u> Total P (TP), particulate P (PP), and total dissolved P (TDP) were monitored over 24 months in the South Pine River QLD, with sampling intervals from 13-16 days during baseflow, to less than 30 min during storm flow. Baseflow TP was relatively constant at 0.03 mg/L. During storm flow TDP and PP increased significantly and were positively correlated with flow. TP loads were 8950kg and 3980kg in 1984 and 1985 respectively, with PP the dominant P fraction, comprising 77% of the TP load. By expressing load in terms of mass per unit runoff per unit area, variance due to discharge was removed and storm flow export was relatively constant (0.46-0.54kg/mm/sq km). A method of predicting load from the flow record using this coefficient is proposed.

22. **Cossins, G.** (1990). Surface hydrology: water supply and flooding. In: P. Davie et al., (Eds.), The Brisbane River: A source book for the future, pp 55-62. Australian Littoral Society, Brisbane, Queensland.

    <u>Notes:</u> A lay person's outline of the physical laws appropriate to the tidal zone of the Brisbane River is presented. A summary of the results of physical measurements of parameters of scientific and engineering are also provided.

23. **Cox, M.E.** (1998). Chemical and turbidity character of the tidal Brisbane River, Moreton Bay. In: I.R. Tibbetts et al., (Eds.), Moreton Bay and catchment, pp 175-184. School of Marine Science, University of Queensland,

    <u>Notes:</u> Water sampling was conducted on established traverses. Sampling was during a low flow regime after a prolonged dry period and at high water. Trends for turbidity and suspended matter were found to be similar to each other; both decrease downstream but are lowest where salinities are >20. Both turbidity and suspended matter are greater in near bottom waters than at 0.5m deep.

24. **Crimp, O.N.** (Ed.) (1992). Moreton Bay in the balance. Australian Littoral Society Inc., Moorooka, Queensland.

    <u>Notes:</u> This book pulls together information related to the ecology, geology, chemistry and climate of Moreton Bay. Issues which threaten to "tip the balance" of the entire ecosystem are presented and a comprehensive description of the environment it provided.

25. **Davie, P., Stock, E., and Choy, D. L.** (Eds.) (1990). The Brisbane River: A source book for the future. Australian Littoral Society Inc., Brisbane.

26. **Davies, P.L. and Eyre, B.** (1989). Nutrient and suspended sediment input to Moreton Bay - the role of episodic events and estuarine processes. In: I.R. Tibbetts et al., (Eds.), Moreton Bay and catchment, pp 545-552. School of Marine Science, University of Queensland, Brisbane, Queensland.

    <u>Notes:</u> Phosphorus, nitrogen, suspended sediment concentrations and salinity were examined in the Brisbane River estuary during a 20 year return interval flood and during four sampling runs after the flood event. During the flood peak, 150000t/day were discharged directly into the Bay. Some of this material was scoured from the bottom of the estuarine basin highlighting the importance of including estuarine processes when calculating terrestrial fluxes to Moreton Bay.

27. **Dennison, W.C., Orth, R.J., Moore, K.A., Stevenson, J.C., Carter, V., Kollar, S., Bergstrom, P.W., and**

Batiuk, R.A. (1993). Assessing water quality with submersed aquatic vegetation. *BioScience,* 43(2):86-94.

Notes: Habitat requirements of submersed aquatic vegetation are used to characterise the water quality of Chesapeake Bay, USA, because of their widespread distribution in the bay, important ecological role, and sensitivity to water quality parameters. The primary goal was to synthesise information leading to the establishment of quantitative levels of relevant water quality parameters necessary to support submersed aquatic vegetation, a major resource of Chesapeake Bay. The development of a habitat requirement approach for Chesapeake Bay could prove useful in other estuaries experiencing water quality degradation.

28. **Department of Environment and Heritage** (1993). Moreton Bay strategic plan. Department of Environment and Heritage.

29. **Druery, B.M.** (1979). Port of Brisbane siltation study, 8th report: The suspended sediment load of the Brisbane River and siltation in the estuary. Hydraulics Research Station, Wallingford, Oxon. Report No. EX893.

Notes: This report analyses discharge and suspended sediment records of the Brisbane and Bremer rivers and the methods and assumptions used to derive the influx of suspended sediments into the estuary. The findings are summarised below.

During low flows very little sediment is carried downstream to the estuary and none enters the mouth of the Brisbane River from Moreton Bay. The limit of saline intrusion is gradually established in reaches well upstream of the port. The longitudinal salinity gradient drives a gravitational circulation which is manifest as a tendency for a net landward flow near the river bed and a net seaward flow near the river surface. The saline water promotes flocculation and settling with the result that there is always a higher concentration of suspended sediment near the river bed. This ensures a net landward movement of sediment that tends to concentrate near the limit of saline intrusion. The tidal velocities periodically erode the settled muds and this resuspension, coupled with the gravitational circulation, carries the suspended muds upstream, effectively trapping it in the upper estuary. Under these conditions it has been observed that the water within the port area becomes distinctly clearer. Essentially the dry season processes represent a redistribution of suspended sediment which is already contained within the estuary.

During wet periods (but not extreme floods) higher river flows cause the saline intrusion to move seawards into the upstream reaches of the port. Settling of the suspended mud fractions leads to a significant build up of the estuary bed due to lower currents and bed stresses in the deepened port area. The gravitational circulation is more pronounced than in the dry season because of the increased longitudinal salinity gradient and this leads to a concentration of mud deposits in the upper reaches of the port. The presence of the larger fluvial flows therefore tends to compress the area of deposition with the result that siltation is more intense and over a smaller reach than during the dry season.

During high flows the surface layer of water continually moves seawards and the sediment which remains suspended within the top layer is carried out of the estuary and deposited in Moreton Bay. As flows increase, the limit of saline intrusion is forced further seaward and the flow becomes more and more stratified. During extreme flood events it is *likely* that all the saline water is completely flushed from the estuary.

The report also presents a recent history of sediment loads, siltation and dredging.

30. **Ellis, C.A.** (1997). Trialing of integrated catchment management in an urban setting: the Oxley Creek catchment experience. In: Landcare Changing Australia: National Conference, pp 196-197.

Notes: In late 1995, integrated catchment management started in the approximately 260 sq km catchment of Oxley Creek, QLD. Population growth in the large urban catchment has been rapid, averaging 3.5% per annum over the last five years. The upper part of the catchment is steep, with pockets of forest and grazing land, the middle section contains rural residential areas, a transfer station, landfill, a liquid waste treatment plant and areas of sand extraction and the lower section contains industrial and residential areas. A Catchment Association was established, as the involvement of community, industry and government was important, and working groups were set up.

31. Envirotest (1996). Foundation paper - Water quality - Brisbane River Catchment and Moreton Bay, stage one. BRMG.

Notes: An inventory and overview of the state of water quality within the Brisbane River catchment and Moreton Bay is presented. The sources, locations and pollutant loads derived for each of the major sub-catchments (Upper Brisbane River, Stanley River, Lockyer Creek, Bremer River and Lower Brisbane River) and Moreton Bay are reviewed together with known or likely impacts on water quality. Issues regarding changes to water quality in the future are discussed with a view to providing a baseline from which to make assessments and provide policy guidance.

32. **Envirotest** (1996). Water quality - Brisbane River catchment and Moreton Bay. Stage two foundation paper. Brisbane River Management Group (BRMG).

Comment: Data for this report has come from a number of earlier reports prepared for different parts of the Strategy. Of particular interest are the following: WBM Oceanics & SKM (1995) - Task G4; GHD (1996a) - Task M2 draft V 1.3; Stephens (1992), Crimp (1992), Davie *et al.* (1990).
Notes: A synthesis of information relevant to future water quality management of Brisbane River and Moreton Bay. It provides a summary of the condition the catchment, a number of options for future management scenarios, water quality assessment, and a statement of preferred options for improving and managing water quality in the catchment. Estimates of sediment loads and export rates are estimated/predicted using data from GHD (1996a) and WBM & SKM (1995).

33. **Eyre, B.** (1997). Water quality changes in an episodically flushed sub-tropical Australian estuary: A 50 year perspective. *Marine Chemistry,* 59(1-2):177-187.

Notes: Recent and historical data sets from the Richmond River estuary (New South Wales, Australia) were examined for possible impacts of changing land use patterns in the catchment and estuary floodplain on water quality over the last 50 years. Floodplain management practices, including further draining and disturbance of acid sulphate soils appear to have had no appreciable effect on the processes that control the degree of oxygen saturation in the estuary. Following runoff events phosphate and nitrate concentrations at a given salinity are respectively 2.5 and 3.0 times higher than 50 years ago, due to leaching from agricultural areas where fertilisers are applied. However, these concentrations quickly decrease after the runoff event due to rapid flushing of the system. Land use changes in the last 50 years appear to have had no impact on dry or low-flow phosphate and nitrate concentrations in the estuary, which are dominantly controlled by internal processes due to long water residence times. Particulate and bottom sediment phosphorus buffering apparently maintain dry season phosphate concentrations in the estuarine water column between about 0.30 and 0.80 mu M. Nitrate levels are quite low (<4.00 mu M) during the dry season, being regularly depleted by denitrification and/or phytoplankton blooms. Unlike poorly flushed estuaries, the episodically flushed Richmond River estuary shows no major signs of nutrient enrichment and associated eutrophication over time, despite increased loading of nutrients; most likely due to its low nutrient retention efficiency.

34. **Eyre, B. and France, L.** (1997). Importance of marine inputs to the sediment and nutrient load of coastal-plain estuaries: a case study of Pumicestone Passage, south-eastern Queensland, Australia. *Marine and Freshwater Research,* 48(4):277-286.

Notes: Sediment and nutrient exchange between Deception Bay and Pumicestone Passage QLD was studied to test the hypothesis that marine input of sediment and associated particulate nutrients may dominate the nutrient loading of coastal plain estuaries. Estimates suggest that Deception Bay contributes 110000 tons of sediment and 68-74 tons of phosphorus (P) annually to Pumicestone Passage. These yearly transports were ten times the sediment and two times the P contributed from the catchment. In contrast, Deception Bay contributed only 100- 220 tons of nitrogen (N) annually to Pumicestone Passage, or 12-25% of the N contributed by the catchment as a result of leaching from agricultural and horticultural areas and/or from groundwater.

35. **Eyre, B. and Hossain, S.** (1998). Task estuarine turbidity processes (ETP). Phase 2 final report. South East Queensland Water Quality Management Strategy.

Comment: Data from other documents included: Capelin *et al.* (1998), Davie *et al.* (1990), Envirotest (1996), Mayo (1978), Stock and Neller (1990).
Notes: A number of turbidity profiles were undertaken in the BR Estuary during a range of tidal conditions (low, high, medium, neap, spring) to give some insight into the development and migration of tidally-induced turbidity maximum. Maximum suspended sediment concentrations occurred in the lower estuary during high spring tides. The upper estuary maximum centred around 50-55km from the mouth and results from a complex interplay of an increased supply of sediment to the estuary, flocculation and increased turbulence in the water column where the tide dissipates energy. The high spring tide had lower suspended sediment concentrations than the low spring tide, most likely due to asymmetry in current velocities which results in a longer time for the settlement of suspended sediment out of the water column.

36. **Eyre, B., Hossain, S., and McKee, L.** (1998). A suspended sediment budget for the modified subtropical Brisbane River estuary, Australia. *Estuarine, Coastal and Shelf Science,* 47:513-522.

Comment: Significant reference to other work including: Davie *et al.* (1990), Druery (1979), Envirotest (1996), Eyre & Hossain (1998), Eyre & McConchie (1993), Eyre & Twigg (1997), Hashimoto & Meleo (1997), Mayo (1978), Stephens (1992).
Notes: Annual suspended sediment budgets, for an average flow year and a wet year, were constructed for the sub-tropical Brisbane River estuary. The input of marine sediment from Moreton Bay is the dominant source of suspended sediment to the estuary during an average flow year, contributing more than 1.5 times the sediment delivered from the catchment and urban areas combined. As the volume of water discharged during flood increases, the sediment retention efficiency of the estuary decreases rapidly due to the flushing of sediment through its mouth. Dredging has increased the sediment trapping capacity of the estuary with more than a two-fold increase in the flood water volume needed to flush the estuary fresh at the mouth compared to pre-1962. An upstream dam traps a large proportion of the catchment sediment load, but the upstream retention of flood water has also increased the trapping capacity of the estuary by reducing the freshwater flow. The estuary has a lower and more variable sediment trapping efficiency than typical temperate Northern Hemisphere estuaries.

37. **Eyre, B. and McConchie, D.** (1993). Implications of sedimentological studies for environmental pollution assessment and management: examples from fluvial systems in North Queensland and Western Australia. *Sedimentary Geology,* 85(1-4):235-252.

Notes: Sedimentology is of increasing importance in environmental research, particularly environmental pollution studies, where past trends in environmental processes need to be combined with data on present conditions to predict likely future changes--the past and present as a key to the future. Two examples are used to illustrate the role of sedimentology in assessing the influence of major processes on the transport, accumulation, deposition and modification of contaminants in fluvial/estuarine systems and in developing environmental management plans. Example 1 shows that when assessing nutrient behaviour in fluvial/estuarine depositional settings, it is important to examine the partitioning of phosphorus between grain size fractions to evaluate the sedimentological processes which control the dispersion and trapping of these contaminants. Example 2 shows that in studies of anthropogenic metal inputs to modern depositional settings, lateral and stratigraphic trends in sediment texture and mineralogy should be examined, in addition to trends in metal loads and evaluation of the prevailing physical, chemical and biological processes that may influence metal mobility and dispersion. Clearly, basic sedimentological data should form part of any assessment of potentially contaminated sites and part of investigations into the dispersion and trapping of contaminants in fluvial systems. These data are also required for rational environmental management to ensure that planning decisions are compatible with natural environmental constraints.

38. **Eyre, B. and McKee, L.** (1998). Task Nutrient Budget (NB) for Moreton Bay. Phase 2 Final report. South East Queensland Water Quality Management Strategy.

<u>**Comment:**</u> Data from other studies including: Eyre & France (1997), Eyre *et al.* (1998), Eyre & Hossain (1998), SKM & WBM (1998)
<u>**Notes:**</u> While not specifically about sedimentation, this report provides a useful source of input data.

39. **Eyre, B. and Twigg, C.** (1997). Nutrient behaviour during post-flood recovery of the Richmond River estuary, northern New South Wales, Australia. *Estuarine, Coastal and Shelf Science,* 44:311-326.

<u>**Notes:**</u> Dissolved and particulate inorganic and organic forms of phosphorus and nitrogen, suspended sediments, dissolved silica and physicochemical parameters were examined in the Richmond River NSW estuary following a small flood event. Under flood conditions, nutrient concentrations were elevated, estuarine processes were bypassed and freshwater, sediments and nutrients were discharged directly onto the continental shelf. The estuary recovered by way of a salt wedge penetrating landward along the channel bottom, and progressed from a small, highly stratified, through a moderately stratified, to a largely vertical homogenous system. Flushing times were the dominant control on the degree to which nutrients were internally processed, with most of the river supplied nutrients transformed under normal conditions due to very long flushing times. A three stage conceptual model is presented, which may be more applicable to highly variable Australian estuaries than the typical estuarine models found in the literature.

40. **Gutteridge Haskins & Davey** (1996). Task M2: State of the Brisbane River and Moreton Bay waterways. Working Draft Version 1.3. BRMG and Brisbane River and Moreton Bay wastewater management study.

<u>**Comment:**</u> This report has provided data to a number of other studies/reports of the strategy. Of interest to us are the following: for Envirotest (1996); BRMG (1996) - State of Brisbane River & Moreton Bay waterways. It drew on data from Others:
Cosser (1989); Moss *et al* (1993)
<u>**Notes:**</u> This report is the draft of the State of the Brisbane River and Moreton Bay Report and contains much of the data the study used. It is also source material for many of the other reports and studies undertaken as part of the Strategy.

41. **Gutteridge Haskins & Davey and FRC Coastal Resource and Environmental and Hendricks Consulting** (1996). Task M1. Brisbane River and Moreton Bay illustrative model.

<u>**Comment:**</u> Unable to source this document for review but it is cited as a major primary source in other works including WBM Oceanics & SKM (1995), Envirotest (1996).
<u>**Notes:**</u> An overview of the catchment and a summary of the issues is presented. A number of newsletters are included which cover a range of topics including pollutants, sediments, water movement and pollutant processes, river flows, river deepening and dredging, plants of Moreton Bay and its estuaries, riparian vegetation, freshwater wetlands, and fish.

42. **Hashimoto, T.R. and Meleo, J.F.** (1997). Estuarine evolution and sediment dynamics - implications for coastal management. In: The Coastal Zone - Beyond Beaches. 7th Annual New South Wales Coastal Conference, pp 35-45. Ballina Shire Council, Ballina, NSW.

<u>**Notes:**</u> Estuaries are sinks for catchment derived sediment reaching the coastal zone. Therefore estuaries undergo geomorphic evolution as they infill with sediments. The degree of sediment trapping, and the type of sediment trapped, will depend on the stage of estuarine evolution. In largely unfilled estuaries, a high proportion of both

coarse and fine fluvial sediments entering the estuary will be retained. As infilling continues, an increasing proportion of fine sediments will bypass the estuaries, while coarse sediment continues to be trapped. In completely infilled estuaries (riverine estuaries), there is potential for both coarse and fine sediments to reach the coast, although channel/floodplain storage of sandy sediments may place a major constraint in some systems.
The degree of infilling, in turn, appears to be largely controlled by: the three-dimensional morphology of the receiving basin; discharge characteristics of the catchment; sediment supply; estuarine hydrodynamics; and the inlet characteristics. Estuaries in NSW exhibit great variation in the degree of infilling, reflecting the complex interaction between these parameters.
For example, in southern NSW there are numerous small lagoonal estuaries still being infilled, while in northern NSW, large unfilled estuaries are common. Therefore, perceived problems in estuaries such as siltation, bank erosion, pollution and wetland degradation require a management approach that recognises the variability of present-day sediment dynamics and its relationship with the geomorphic history of the estuaries. For example, measures to combat siltation may, in the long-term, prove ineffectual in a system that is approaching a mature stage of infilling. Also, human impacts on estuaries need to be assessed in light of continually evolving depositional patterns.

43. **Heggie, D. and others** (1999). Task sediment nutrient toxicant dynamics (SNTD). Phase 2 final report. South East Queensland Water Quality Management Strategy.

Notes: The major sediment types of Moreton Bay and the Brisbane River were sampled in an attempt to survey the sediment-water interactions and fluxes of matabolites (N and P) across the sediment water interface.
This report is an important data source for any future work as numerous cores have been taken throughout the bay and river.
The study found that sediments in Moreton Bay and Brisbane River are dominated by sand and mud, gravel rarely constituting a significant component of the sediment.
Light grey, quartzose sand of marine origin are found in the north of the Bay and along the eastern margin. Olive black shelly sands are found along the western side of the bay, at the mouths of the Brisbane, Pine and Caboolture Rivers.
Muddy sediments in the Bay are terrigenous in origin and accumulate from the supply of suspended sediments discharged into the Bay from the major rivers. Deposition of muds only occurs where hydrodynamic energy levels are sufficiently low to allow silt and clay sized material to settle from suspension, though some resuspension and movement may occur in the central Bay.
Core samples were analysed for: total nutrient concentrations (nitrogen, carbon, phosphorus) of the solid phase; solid phase exchangeable nutrients; biogenic silica; major elements (by XRF); and dissolved inorganic nutrient concentrations (N, P, Si) in porewaters.
Maps, plots and tables present the findings.

44. **Holmes, K.H.** (1980). Aggregate resources of the Brisbane River between the Bremer River and the Captain Cook Bridge. Queensland Department of Mines. Geological Survey of Queensland Publication 375.

45. **Hossain, S., Donnelly, R., and Eyre, B.** (1997). Increased suspended sediment transport to the Richmond River Estuary since European settlement. In: The Coastal Zone - Beyond Beaches. 7th annual New South Wales Coastal Conference, pp 70-76. Ballina Shire Council, Ballina, NSW.

46. **Johnson, D.** (1997). An ecological survey of the Upper Brisbane River. Monsildale Creek to Wivenhoe Dam resumption level. Queensland Natural Resources.

47. **Kench, P.S.** (1999). Geomorphology of Australian estuaries: review and prospect. *Australian Journal of Ecology,* 24(4):367-380.

Notes: Over the past 30 years there has been a wealth of research examining the geomorphology of Australian estuaries. This paper reviews the major regional controls on estuarine geomorphic development and discusses the focus of research efforts to understand estuarine evolution, configuration and processes controlling geomorphic development and change. The presence and position of estuaries along the Australian coastline is controlled by large-scale climate-led changes in sea-level, the antecedent structure of the coast and tectonic activity. The configuration of Australia's estuaries is controlled by a number of environmental factors identified by Jennings & Bird (1967) including climate, oceanographic regime, sediment availability, structure and mineralogy, and tectonics. Interaction of these factors produce a range of estuarine configurations around the Australian continent from wave-dominated, microtidal, bar-built estuaries in the south to low energy macrotidal estuaries in the north which have produced extensive low-lying coastal plains. The principle focus of geomorphologists during the past 30 years has been understanding the medium to long-term development of estuaries in response to fluctuating sea-level over the past 125 000 years. Classifications and models of estuarine development and associated biological community response to estuary development have been identified based on lateral and vertical sedimentary sequences. Results have provided essential information on the physical resources and characteristics of estuarine systems including the distribution of sediment facies that host a variety of different ecological communities. There has been a paucity of research examining contemporary processes controlling geomorphic change in Australia's estuaries. A morphodynamic approach to the study of estuaries is advocated that evaluates morphology-process responses as estuaries evolve. This approach requires increased research efforts to identify regional differences in estuarine geomorphic development, hydrodynamic processes and sedimentation. It is also advocated that studies examine how the morphodynamic behaviour of estuaries over thousands of years has influenced estuary ecology. Such studies will provide a more complete understanding of the factors influencing the morphology and ecology of contemporary estuaries.

48. **Longstaff, B.J., Loneragan, N.R., O'Donohue, M.J., and Dennison, W.** (1999). Effects of light deprivation on the survival and recovery of the seagrass *Halophila ovalis* (R.Br.) Hook. *Journal of Experimental Marine Biology and Ecology,* 234(1):1-27.

Notes: Survival and recovery of the seagrass *Halophila ovalis* (R.Br.) Hook during and after light deprivation was investigated to assist in the interpretation of recent losses of Halophila spp. in Queensland, Australia. Light deprivation experiments were conducted in outdoor aquaria and in situ at two water depths. *Halophila ovalis* plants were deprived of light for a maximum of 30 days, and recovery processes were investigated for up to 18 days following 15 days of light deprivation. Measurements of *H. ovalis* biomass, storage carbohydrate concentrations, chlorophyll a+b concentrations, stable carbon isotopes ratios ($\delta^{13}C$) and chlorophyll a fluorescence parameters (F_0, F_m and F_v/F_m) were made during and at the end of the light deprivation and recovery periods. Biomass declined after 3-6 days in the dark and complete plant death occurred after 30 days. During the recovery period, biomass continued to decline for a short duration of time before stabilising. Sugar concentrations declined rapidly for the first 2 days of light deprivation before stabilising, then increased rapidly during the recovery period. Chlorophyll a+b concentrations were sensitive to very small differences in light availability: concentration decreased in total darkness, remained unchanged at 0.1% of surface irradiance and increased at 0.5% of surface irradiance. Photochemical efficiency of photosystem II (F_v/F_m) remained unchanged during the light deprivation and recovery periods. The lack of response in δC during light deprivation indicated the cessation of carbon fixation. Decreased sugar utilisation after 2 days of light deprivation indicated a reduction in respiration and growth. Starch concentrations did not change during light deprivation, suggesting the inhibition of starch utilisation by anaerobic conditions within the plant. Plant death after 30 days was notably faster than previously reported for other species of seagrass. The rapid die-off may be due to a shortage of available carbohydrates or due to a build-up of the phytotoxic end products of anaerobic respiration. Overall, *H. ovalis* has a very limited tolerance to light deprivation when compared to larger species of seagrass. Consequently, the persistence of this species in coastal marine environments may be dependent upon the occurrence and duration of transient light deprivation events.

49. **Mackey, A.P. and Hodgkinson, M.** (1995). Concentrations and spatial distribution of trace metals in mangrove sediments from the Brisbane River, Australia. *Environmental Pollution,* 90(2):181-186.

Notes: Mangroves are the most important habitat along tropical and subtropical coasts and are the dominant vegetation of the tropical shorelines of Queensland. Fifty surface sediment samples were collected from 12 transects through a mangrove woodland near the mouth of the Brisbane River and analyzed for ten trace metals. Sediments were moderately contaminated, with molybdenum being enriched by up to 30 times background levels. Spatial variation was considerable and canonical trend analysis showed that concentrations of all metals except silver and chromium tended to increase down shore, suggesting tidal deposition was important in determining metal concentrations, while silver and chromium concentrations appeared to be a consequence of contamination from landward point sources. This study is the first to demonstrate that tidal inundation can cause a high degree of spatial variation in a variety of metal concentrations in mangrove sediment and this variation will affect conclusions drawn about the pollution load of the sediments and its possible effects.

50. **Mackey, A.P., Hodgkinson, M., and Nardella, R.** (1992). Nutrient levels and heavy metals in mangrove sediments from the Brisbane River. *Marine Pollution Bulletin,* 24(8):418-420.

Comment: The study described here is a potential data source for tracing origins of the sediments so is probably worth following up
Notes: Results are presented of the first analysis of Brisbane River QLD sediments for nutrients and heavy metals. The study site, located in Boggy Creek three kilometres from the mouth of the highly industrialized and polluted estuary, represents one of the few remaining areas of mangroves thought to be important breeding and feeding areas for the local commercial fish and prawn stock. Nutrient levels are high, probably due to the influence of a downstream sewage outlet. Heavy metal levels are elevated, reflecting the industrial and urban nature of the estuary. The patterns of deposition of both nutrients and metals appear to be variable as a result of tidal activity, with maximum levels occurring at the seaward edge of the mangrove stand and minimum levels at the landward edge, indicating that sampling programs for evaluation of contaminants in such an intertidal environment requires careful planning.

51. **Magee, A.** (1996). Inland water. In: Brisbane City Council, State of the environment report. Brisbane 1996, pp 50-59. Brisbane City Council, Brisbane.

Notes: This chapter provides background to the initiatives being undertaken as part of the State of the Environment process. WaterWise, WaterWatch, Integrated Catchment Management, Brisbane River Management Group, water quality monitoring and stormwater research are all programs being run by government which address many of the issues. The chapter lists many of the activities and programs including:
Mogill Creek: water quality studies, fresh water fish biodiversity studies
Oxley Creek: catchment management plan, establishment of catchment coordinating committee
Sandy Creek, Indooroopilly: stormwater monitoring, bushland and waterway rehabilitation programs
Enoggera Creek: city Landcare initiative by Save Our Waterways Now community group
Nundah Creek: catchment management plan, water quality studies
Norman Creek: catchment management plan, community, schools and government participation
Bulimba Creek: revegetation project

52. **Mann, K.** (1978). Port of Brisbane siltation study, first report: dry season simulation exercise 1977. Hydraulics Research Station, Wallingford, Oxon.

Notes: The report describes and intensive hydraulic survey in the port are during a period of low fluvial flows in August 77.
Results showed that in the dry season, in the absence of intensive wave action, very little mud enters the estuary from Moreton Bay and that any siltation is due to a redistribution of sediment already in the river system. It is almost certain that most of the sediment causing siltation in the estuary enters the system during fluvial floods and is then redistributed during the ensuing drier periods.

53. **Mayo, M.M.** (1978). Port of Brisbane siltation study, 3rd report: Tidal propagation in the Brisbane River in the dry season. Hydraulics Research Station, Wallingford, Oxon. Report No. EX829.

54. **McCleod, G.R.C.** (1977). A short history of the dredging of the Brisbane River 1860-1910. *Journal of the Royal Historical Society of Queensland*, X(3):137-148.

Notes: Back in the mid 1800s 2 sand bars prevented sizeable ships from passage up to Brisbane City necessitating goods and people being ferried on smaller boats which was a pain. Initially (1855ish) a channel was cut across the bar and snags were removed but as the channel was not dredged it was subject to significant change especially after floods. This indicates that flooding has carried significant loads since at least early European settlement. No mention is made of where the dredged material was deposited.

55. **McKee, L. and Eyre, B.** (1997). A nutrient budget for the Richmond River Estuary, northern NSW. In: The Coastal Zone - Beyond Beaches. 7th annual New South Wales Coastal Conference, pp 136-142. Ballina Shire Council, Ballina, NSW.

56. **Moreton Bay Catchment Water Quality Management Strategy Team** (1998). The crew member's guide to the health of our waterways. Moreton Bay Catchment Water Quality Management Strategy Team, Brisbane.

57. **Morris, K.J. and Sivell, R.A.** (1983). Flood mitigation works on Brisbane creeks. In: 2nd National Conference on Local Government Engineering, pp 382-386. Institution of Engineers, Australia, Barton, ACT.

Notes: Following major flooding in the late 1960s and early 1970s and culminating in the disastrous flood of 1974, the Brisbane City Council has undertaken the design, construction and maintenance of a wide variety of structural flood mitigation works on Brisbane creeks. These works include raising Enoggera Dam to increase flood storage, dredging of 6.4km of tidal stream, major channelisation of 4.5km of a 'dry' stream, a retarding basin, levee and associated works such as bridge improvements and concrete lined open channels.

58. **Moss, A. and others** (1992). Water quality in Moreton Bay. In: O.N. Crimp, (Ed.), Moreton Bay in the balance, pp 103-114. Australian Littoral Society, Brisbane.

Notes: Major factors determining water quality in Moreton Bay are the tidal exchange of large volumes of sea water and inputs from terrestrial sources discharging into the Bay. It is mainly runoff and point source pollution from the catchments that have been implicated in impacting water quality and of this point sources are thought to be less significant. These diffuse source inputs are largely associated with suspendable inorganic sediments and organic particulates usually associated with intermittent storm events.
This is primarily a descriptive review paper drawing on many other studies, providing background for characterising the Bay. Moss concludes that from the available data (reviewed in the paper) the major potential water quality problem in Moreton Bay is the continuing increase in nutrients loading and resultant increased aquatic plant production. The role of suspended sediments is clearly implicated as well.
Moss draws heavily on information from Bailey and Stevens (1979), Crimp (1992) and Davie *et al.* (1990).

59. **Moss, A. and Costanzo, S.** (1998). Levels of heavy metals in the sediments of Queensland rivers, estuaries and coastal waters. QLD Department of Environment. Environment Technical Report No. 20 (RE200).

Notes: The report covers data collected from 1979 to 1982. Samples were collected from a wide range of estuarine waters and in some rivers affected by point sources. Samples in each water body were collected over varying time periods - usually 1-2 years but sometimes considerably longer. Sample frequency was most commonly quarterly but sometimes more frequent.
Measurements were taken for zinc, copper, cadmium, lead, nickel, mercury, chromium, and cobalt. Data are presented in graphs showing the median value together with the 10 to 90 percentile range. Where fewer than five

results are available only the median is shown. Data for the Brisbane River is presented as an entity of its own.

60. **Moss, A.J.** (1987). Studies of the trophic status of the Brisbane River estuary. *Water,* 14(1):11-14.

Notes: Data are presented relating to the trophic status of the Brisbane River estuary and to unpolluted Queensland estuaries for comparison. Monitoring of the estuary included determination of dissolved oxygen, salinity, pH, temperature, nutrients, surface chlorophyll and Secchi depth at 27 sites. Much of the estuary was highly nutrient enriched because of adverse physical conditions, in particular high turbidity. There were few significant eutrophic effects evident in phytoplankton, macrophytes or macroalgae. The possible consequences of increased nutrient loading are discussed. Long term management of eutrophication would require specific nutrient criteria for each section of the estuary.

61. **Moss, A.J.** (1990). Turbidity and nutrient behaviour in the estuary. In: P. Davie et al., (Eds.), The Brisbane River: A source book for the future, pp 307-311. Australian Littoral Society, Brisbane, Queensland.

Notes: Water quality monitoring results from 1983-1985 are presented, comparing data from different southern Qld estuaries.

62. **Moss, A.J., Rayment, G.E., Reilly, N., and Best, E.K.** (1993). A preliminary assessment of sediment and nutrient exports from Queensland coastal catchments. QDPI. Environmental Technical Report No. 5.

Notes: This report documents a desktop study to estimate sediment, nitrogen and phosphorus exports from Queensland coastal catchments. A modelling approach was adopted, supported by published and unpublished data and best estimates made by the study team. Has some values taken from Cosser's (1989) work for the South Pine catchment, but no primary data suitable for our purposes.

63. **Munro, C.H.** (1976). A case study of effect of increased urbanisation on flood damage for Moggill Creek, Brisbane. In: Hydrology Symposium, pp 67-72. Institution of Engineers, Australia , Barton, ACT.

Notes: The effect of increased urbanisation of metropolitan suburbs on flood discharges is discussed, and a case study is presented for Moggill Creek, a tributary of the Brisbane River, with some reference to Breakfast Creek and Kedron Brook. Conclusion is reached that increases in peak discharge, peak flood levels and average annual flood damages are minor.

64. **Neil, D.T.** (1998). Moreton Bay and its catchment: seascape and landscape, development and degradation. In: I.R. Tibbetts et al., (Eds.), Moreton Bay and catchment, pp 3-54. School of Marine Science, Brisbane, Australia.

Notes: Neil describes the potential for sedimentation in the catchment based on theoretical processes and the work of others in similar situations in eastern Australia (land use intensification to grazing, particularly sown pasture, increases catchment sediment yields, often by a factor of 4-5). Neil acknowledges that there has been insufficient research in the Moreton Bay catchment to adequately characterise the total landscape response. Furthermore he notes that such responses are likely to be different in humid coastal catchments than the drier catchments of most other studies.
He identifies that concern over increased sediment levels in the lower reaches of the Brisbane River was expressed as long ago as 1917. The source of was attributed to upstream transport of sediments resuspended by wave action in the western Moreton Bay.
Land use history indicates that the critical period for sediment impacts on the Bay was probably the fist few decades of this century, although this conclusion is based on the rural land use history alone.
A simple model estimating the changes in sediment yield has been developed by Neil & Yu, (1996) and indicate an upward trend.

65. **Neil, D.T. and Yu, B.** (1996). Fluvial sediment yield to the Great Barrier Reef Lagoon: spatial patterns and the effect of land use. In: Downstream effects of land use, H.M. Hunter, A.G. Eyles, and G.E. Rayment, (Eds.), pp 281-286. Department of Natural Resources, Queensland, Australia,

Notes: A simple model is proposed for estimating the sediment yield from catchments emptying into the Great Barrier Reef Lagoon. Unit sediment yield is predicted from mean annual catchment runoff.

66. **Newell, B.S.** (1971). The hydrological environment of Moreton Bay, Queensland, 1967-1968. CSIRO, Melbourne. Division of Fisheries and Oceanography Technical Paper No. 30.

Notes: Characterisation of the Bay. This work is cited in Crimp (1992) and many others in Tibbetts *et al.* (1998).

67. **Odd, N.V.M. and Openshaw, J.A.** (1979). Port of Brisbane siltation study, 6th report: Wet season simulation exercise, April 1978. Hydraulics Research Station, Wallingford, Oxon.

Notes: The report describes the analysis of simultaneous observations of tidal velocity, salinity and suspended sediment transport made in April 78 in the Brisbane port area during the latter stages of a fluvial flood in the Brisbane River. It also describes the results of longitudinal salinity and suspended sediment surveys made proir to and during the course of the flood.
Results showed that at the later stages of a moderate fluvial flood very little of the suspended sediment brought down by the Brisbane River leaves the estuary. It appears that most of the flood water passed fairly rapidly out of the estuary via the surface layers without greatly affecting the longitudinal salinity distribution in the lower layers in the port area. However, there were considerably longer periods of slack-water in the saline wedge near the bed on the ebb tide in the Fisherman Islands Swing Basin and in Hamilton Reach than during dry periods.
The flood - estimated to have carried about 10000 tonnes of suspended mud into the tidal compartment - increased suspended solids concentrations about 4 times at the landward limit of saline intrusion which was near the port area, compared with the dry season conditions. The longitudinal gravitational circulation in the port area traps nearly all the suspended sediment that settles from the brackish surface layers, and deposits it in the zones of low bed stress.

68. **Patterson, D.** (1992). Hydraulic processes in Moreton Bay. In: O.N. Crimp, (Ed.), Moreton Bay in the balance, pp 25-39. Australian Littoral Society, Brisbane.

Notes: This paper deals predominantly with water levels and current patterns in Moreton Bay, as determined by tidal and climate related processes. Various key factors controlling these processes are discussed, particularly recent work on tides and currents in the Bay which have been quantified and understood, both in detail and in the broader regional sense, using computer modelling techniques. A clear characterisation of the Bay is provided with information provided in maps and graphs. Other work is also well referenced.

69. **Port of Brisbane Authority** (1992). Brisbane's port environmental study. Volume 1 - baseline data, 1991-1992. Port of Brisbane Authority, Brisbane, Queensland.

70. **Rankin, R.O. and Milford, S.N.** (1980). Investigation of estuarine salinity and dissolved oxygen in the Brisbane River. *Water,* 7(1):12-13, 23.

Notes: Data collection methods used in a field program to monitor salinity and dissolved oxygen levels in the Brisbane and Bremer Rivers are described.

71. **Resource Sciences and Knowledge** (1999). Land cover change in South-East Queensland, 1988-1997. Queensland Department of Natural Resources.

72. **Scientific Assessment Section Qld DOE** (Undated). Queensland water quality guidelines. QLD Department of

Environment, Scientific Assessment Section.

73. **Semple, P. and Dunlop, K.** (1998). Logan, Coomera and South Moreton Bay regional wastewater management study environmental monitoring program annual report, 1996. Department of Environment. RE207 March 1998.

<u>**Notes:**</u> Summaries are presented of a monitoring program which aimed to: monitor the status of ecosystem health, monitor the potential impacts of wastewater discharges, collect data for future calibration and re-running of the hydrodynamic model, monitor the bacteriological water quality of recreational waters. Suspended solids concentrations were measured at all monitoring sites.

74. **Shilton, P.** (1996). Coast and Moreton Bay. In: Brisbane City Council, State of the environment report: Brisbane 1996, pp 19-30. Brisbane City Council, Brisbane.

<u>**Notes:**</u> The issues are presented and pressures on the area outlined as catchment urbanisation, demand for recreation and tourism facilities on the Bay, commercial and residential development on the Bay, mining and spoil dumping in the Bay, fisheries productivity, and the ability of the Bay islands to cope with urbanisation, weeds, domestic animals and bushfire.
Condition is assessed for mangroves, saltmarshes, seagrasses, general native flora and fauna, coral reefs, migratory waders, dolphins, sharks, dugong and turtles. Siltation and increased turbidity is identified as a potential culprit in the degradation of seagrass communities.
Various initiatives undertaken to address some of these are outlined including the establishment of Moreton Bay Marine Park, identification of Ramsar protected areas, extension of parks and reserves, protection of wetland areas and the establishment of community groups.
A substantial reference list is provided.

75. **Sinclair Knight Merz** (1994). Appraisal of scientific data - Brisbane River. 2 Volumes.

<u>**Comment:**</u> Unable to source this document for review but it is cited as a major primary source in other works including WBM Oceanics & SKM (1995).

76. **Sinclair Knight Merz and WBM Oceanics, Australia** (1998). Task Catchment runoff loads (PL2). Phase 2 final report. South East Queensland Water Quality Management Strategy.

<u>**Comment:**</u> Other works cited include: Envirotest (1996), Moss *et al.* (1993), Cosser (1989). Phase 1 of this project is mentioned but have been unable to source any documentation of it for review.
<u>**Notes:**</u> The approach, analyses and findings of the study are presented. A catchment runoff model of nonpoint source pollution was developed for the catchments draining into Moreton Bay. The model was calibrated and verified as best as was possible using available data. A review of previous investigations of nonpoint source pollution processes within the catchment is included and outlined below.
<u>Brisbane City Council:</u> Ongoing stormwater quantity and quality data collection program begun in 1984, sampling at sites in 4 urban catchments
<u>Dept Environment:</u> Instrumentation installed on Enoggera Creek to collect nonpoint source pollutant export data from this predominantly undisturbed catchment. The data is however rather erratic and based around only a few storm events.
<u>DNR:</u> Laidley Creek monitoring of storm events and water quality/pollutant loads.
<u>Southern Cross Uni:</u> Extensive field measurements of flow taken during 1996 based on a flow weighted basis and analysed for a range of nutrient species and suspended solids.
Available data for modelling purposes included rainfall, evaporation, streamflow, runoff water quality - land use.
Emphasis was more on nutrients than sediment transport as such.

77. **Solly, W.W.** (1980). Wivenhoe Dam: a survey in advance of the establishment of a large scale water storage. In: Salinity and water quality, A.J. Rixon and R.J. Smith, (Eds), pp 131-168. Darling Downs Institute of Advanced Education, Toowoomba, Qld.

Notes: This paper describes a project instigated to ascertain the qualities of streams which would flow to Wivenhoe Dam (under construction at time of writing) on the Brisbane River, which was begun in August 1973 and continued to 1981. Information was gathered to determine a status quo for contributing streams at the (then) present level of catchment activity and through the seasonal climatic changes of the period. Guided forecasts were made of future stored water characteristics embracing experience with the other established storages for Brisbane, namely, Somerset, North Pine River and Enoggera Dams. Analyses of the streams which would contribute to Wivenhoe provided considerable material for interpretation of the multiple leaching effects of runoff.

78. **South East Queensland Regional Water Quality Management Strategy** (1999). Stage 3. Initiation workshop. Mercure Hotel, North Quay, Brisbane, 3 August 1999.

Notes: Background to the strategy and outline of Stage 3 proposals

79. **South East Queensland Regional Water Quality Management Strategy** (1999). Stage 3. Joint TAG/ICAG workshop No. 2. Wanganui River Gardens, Yeronga, August 1999. South East Queensland Regional Water Quality Management Strategy,

80. **South East Queensland Regional Water Quality Management Strategy** (1999). Stage 3. Phase 1 Review / Phase 2 Design workshop. Conference Room, Parkroyal Brisbane Hotel, 13 December, 1999. SEQRWQMS, Brisbane.

Notes: Review of all tasks undertaken in Phase 2 and outline of proposed tasks for Phase 3.

81. **Stanaway, N.** (1983). Moreton Bay development. In: The development of Moreton Bay, its islands and foreshores, Urban Design Advisory Council, Brisbane,

Notes: Commentary on the changes which development has brought in 'a lifetime' to the beaches and islands of the Bay is presented by an 'old timer' boating enthusiast. Observations about beach erosion, scouring and shoaling are made and a 'users' perspective given. Confirmation that the rivers have increased their deposition and are increasingly turbid with associated impacts to seagrasses in the Bay etc.

82. **Stephens, A.** (1992). Geological evolution and earth resources of Moreton Bay. In: O.N. Crimp, (Ed.), Moreton Bay in the balance, pp 3-22. Australian Littoral Society, Brisbane.

Notes: This paper provides a summary of the characteristics of the Bay in terms of its geological evolution. Physical processes are described and an overview of the major events in time is presented. Sedimentation is described for periods during the Holocene, Pleistocene, and the Late Pleistocene. Earth resources such as coral deposits, sand and gravels are discussed and the pro-delta mud deposits on the western side of the Bay are described.
Differences of thought are identified between various authors - Moss (1990), Hegerl *et al.* (1990) and Stock and Neller (1990) - as to whether increasing turbidity levels are due to human activities or just normal estuarine processes. Some estimates of the long-term rate of mud supply to the Bay are explored and it is noted that deposition of fluvial sand is restricted to the river channel and the delta front. Gravel is restricted to reworking of older deposits in the upper estuary of the Brisbane River.
An extensive reference list is provided.

83. **Stevens, N.** (1990). Aspects of the geology and geochemistry of the catchment. In: P. Davie et al., (Eds.), The Brisbane River: A source book for the future, pp 17-28. Australian Littoral Society, Brisbane, Queensland.

Notes: An explanation is given of the geological history with the details of the geological units, faulting and lineaments. Available stream water analyses are examined and an attempt is made to relate waters containing high contents of dissolved salts to particular geological formations and rock types.

84. **Stock, E.** (1990). The physical environment of the Brisbane River: an overview. In: P. Davie et al., (Eds.), The Brisbane River: A source book for the future, pp 3-6. Australian Littoral Society, Brisbane, Queensland.

Notes: The main elements of the Brisbane River catchment are described in summary

85. **Stock, E. and Neller, R.J.** (1990). Geomorphic transitions of the Brisbane River. In: P. Davie et al., (Eds.), The Brisbane River: A source book for the future, pp 43-54. Australian Littoral Society, Brisbane.

Notes: A geomorphic perspective of the past and present condition of the Brisbane River and the kinds and rates of change to it are presented. Attention is directed towards clarifying some basic criteria of water quality and channel features and when significant thresholds were passed. The urbanising areas of the catchment are much underrated as contributing directly and indirectly to these changes.
Turbidity in Brisbane River is caused by the excessive production of suspended sediments from rural and urban sources and the persistent re-suspension of these sediments by natural processes (tidal action, physico-chemical processes) and in-channel activities (dredging). Under original conditions naturally generated suspended sediments would be flushed from the system during floods, and an armour of gravel and sand would prevent resuspension by tidal action at other times.
Data from an oral history project is presented describing some of the changes in water quality this century. Some bed profiles showing the effects of channelisation are presented for Kedron Brook.

86. **Straughan, D.** (1967). Intertidal fouling in the Brisbane River, Queensland. *Proceedings of the Royal Society of Queensland,* 79(4):25-40.

Notes: Details of the distribution and larval settlement of fouling organisms, generally excluding the boring component, are given for 1960-61. These are compared with results recorded during wetter conditions in winter and summer 1962-63.
The fouling community was composed of marine, brackish, and freshwater components. Marine and brackish water components penetrated further upstream during summer than during winter, and during 1960-61 than during 1962-63. While salinity was important in controlling distribution and larval settlement, waterflow and turbidity were also considered to be important.

87. **Telfer, D., Carter, D., Johnson, D., and Moller, G.** (1998). State of the rivers: Bremer river and major tributaries. Department of Natural Resources Resource Sciences Centre.

Comment: Cites works in Davie *et al.* (1990)
Notes: Uses the Anderson method and identifies conditions relating to erosion, bed and bank stability from which potential sediment sources can be inferred.

88. **Tibbetts, I.R., Hall, N. J., and Dennison, W. C.** (Eds.) (1998). Moreton Bay and catchment. School of marine Science, The University of Queensland, Brisbane, QLD.

Notes: This book is a collection of significant articles on most aspects of the MB Catchment. Sections are included on the changes happening in the catchment, geology and geomorphology, catchment rivers and lakes, water quality, marine plants, marine fauna, corals, flood effects, and management options. It is a most comprehensive compendium and an essential for source for this project.

89. **Udy, J.W. and Dennison, W.C.** (1997). Growth and physiological responses of three seagrass species to elevated sediment nutrients in Moreton Bay, Australia. *Journal of Experimental Marine Biology and Ecology,* 217(2):253-277.

Notes: Seagrasses, marine angiosperms with high rates of primary productivity, are often limited by the supply of nutrients, particularly nitrogen (N) and phosphorus (P). We investigated growth and physiological responses of three seagrass species (*Halodule uninervis* (Forsk.), *Zostera capricorni Aschers* and *Cymodocea serrulata* (r.Br.) Aschers) to elevated sediment N (100 x control) and/or P (10 x control) in adjacent monospecific beds over a 3 month period from spring to early summer. Each species exhibited different growth and biomass responses to both N and P additions. *Halodule uninervis* growth and biomass increased in response to N and N + P additions, indicative of exclusive N limitation of growth. In contrast, growth and biomass of *Z. capricorni* increased in response to N + P additions only, indicative of balanced N and P limitation. *Cymodocea serrulata* growth and biomass were not affected by any of the nutrient additions. Physiological characteristics (amino acid composition, tissue nutrient content, delta super(15)N) of all three seagrass species responded to N additions (+ N and N + P). Total amino acid content of seagrass leaves increased by 2 to 4 fold in N additions compared with controls. Concentrations of the N-rich amino acids, glutamine and asparagine, increased by 10-1000 fold in N additions, suggesting that these amino acids may be a metabolic storage for N. Tissue N content of leaves, roots and rhizomes increased and delta super(15)N of the leaves decreased in response to N additions. Although seagrass growth and biomass responses to nutrient additions were species specific, metabolic responses were similar for all species. This suggests physiological characteristics of seagrasses are useful for identifying saturating nutrient supply to an environment, but should not be used to determine whether nutrient availability is limiting the seagrass growth rate.

90. **Udy, J.W. and Dennison, W.C.** (1997). Physiological responses of seagrasses used to identify anthropogenic nutrient inputs. *Marine and Freshwater Research,* 48(7):605-614.

Notes: Fertilization experiments have established that seagrass growth in Moreton Bay QLD can be limited by the supply of both nitrogen (N) and phosphorus (P). In this study, morphological and physiological characteristics of *Zostera capricorni Aschers* in Moreton Bay, close to and distant from nutrient sources, were compared. *Z. capricorni* at the sites close to nutrient sources had physiological characteristics representative of high nutrient availability and at the sites distant from nutrient sources had physiological characteristics representative of low nutrient availability. Differences in sediment nutrient concentration, seagrass morphology and growth were not related to proximity to nutrient sources. However, the nutrient content of the seagrasses and their amino acid concentrations were consistently higher at sites close to a nutrient source. These results demonstrate the physiological characteristics of seagrasses can be used to identify the nutrient load and source affecting marine ecosystems.

91. **Walden, W. and Bycroft, B.** (1998). Non-point source pollutant estimation in Brisbane River and Moreton Bay. In: I.R. Tibbetts et al., (Eds.), Moreton Bay and catchment, pp 229-238. School of Marine Science, University of Queensland., Brisbane, Queensland.

Notes: Non-point source pollutant estimation techniques are reviewed as related to BR and MB. Sediments are lumped into the work merely as a pollutant source. Existing data is reviewed including:
Stormwater quality data from Laidley Creek (WBM-SKM, 1998), South Pine river (Cosser, 1989), stormwater data collection in Brisbane (WBM, 1995), non-point source pollutant export from undisturbed catchment (WBM-SKM, 1998), Ipswich stormwater data collection program, Southern Cross Uni monitoring stormwater at various BR and MB sites and development of the predictive modelling approach using the AQUALM-XP model (WBM-SKM, 1998).

92. **Walker, D.I. and McComb, A.J.** (1992). Seagrass degradation in Australian coastal waters. *Marine Pollution Bulletin,* 25(5-8):191-195.

Notes: Australia has large areas of seagrass, rich in diversity, which flourish in clear, relatively low-nutrient coastal waters. Seagrass losses in recent years have been extensive with over 45,000 ha lost. The major widespread humaninduced declines of seagrass, from 11 sets of locations around Australia, are summarised. The reasons for these losses are discussed, most being attributable to reduced light intensity, but in many cases, other factors interact to make the process of loss more complex. These declines result in loss of habitat and productivity, and increased sediment mobility. Recovery and recolonisation from such losses are rare; thus, the destruction of seagrass has long-term consequences. Increasing awareness of the risks and better understanding of seagrass systems is leading to better management practices.

93. **WBM Oceanics and Sinclair Knight Merz** (1995). Task G4: Preliminary conceptual model study. Brisbane City Council and Brisbane River and Moreton Bay Wastewater Management Study Technical Advisory Group.

Comment: This report contains estimated load data for much of the catchment. This seems to have become the 'standard' applied to and reported by numerous other studies including Connell and Miller (1998), Envirotest (1996), SKM-WBM (1998) and the various 'state of' reports.
Notes: Report documents the development of the wastewater management study for MB catchment. The study focused on establishing the relationships between wastewater and other pollutants/nutrients, water quality, and various living resources, particularly habitat requirements for aquatic ecosystems within the waters of the Catchment. Existing data on physical and nutrient related processes are reviewed and, using the AEAM approach, the conceptual model was developed. The study identified the need for sediment dynamics information and estimation/prediction of sediment loads was given based on work by others including Moss *et al.* (1993) and Cosser (1989) by simulation modelling.

94. **WBM Pty Ltd** (1992). Fisheries adjacent to Fisherman Islands. In: Port of Brisbane Authority, Brisbane's port environmental study. Volume 1 - baseline data, 1991-1992, pp 167-189. Port of Brisbane Authority, Brisbane, Queensland.

Notes: Some of the impacts of sedimentation on the fisheries are identified, mainly as anecdotal evidence. Some of the data on degradation of seagrass communities are presented. Obstruction to fish passage due to dredging and construction and some siltation from a spillage some years earlier are mentioned.

95. **WBM Pty Ltd** (1992). Marine currents and sediments near Fisherman Islands. In: Port of Brisbane Authority, Brisbane's port environmental study. Volume 1 - baseline data, 1991-1992, pp 109-134. Port of Brisbane Authority, Brisbane, Australia.

Notes: Modelling study undertaken to understand the general current patterns and velocities of MB around Fisherman Islands as influenced by tide and wind and the effects on the bed. Found that there were 5 distinct zones of different hydrodynamic character which would be expected to display different sedimentation patterns.
Maps of silt content distribution, median grain size distribution, and different bed shear stresses under different tidal conditions (modelled) are presented.
Sediment sampling was undertaken to identify bed sediment properties and shell and silt content and sample size gradings were determined. These data were generally consistent with the model results. Some implications for seagrass communities were noted.

96. **You, B., Hatton, D., and Turnbull, J.** (1998). Task RD: Resuspension dynamics. Phase 2 Final report. Marine and Freshwater Resources Institute.

Notes: Field study conducted to investigate sediment resuspension dynamics in Moreton Bay and the Brisbane River. There were 4 field study sites in MB and 1 in BR. At the sites field measurements of tides, currents, waves, suspended sediment concentrations, and light intensities were taken with an instrumented unit sitting on the bottom. Cylinder-type sediment traps were also used to measure sediment deposition rates at different levels above the bed. In summary, the main driving forces for sediment resuspension are tidal currents in the Brisbane River, but a

combination of tidal currents, wind-waves and ocean swell for the sites in Moreton Bay. The wind-waves are only playing an important role in sediment resuspension in shallow water but not in deep water. The ocean swell penetrating from the ocean side to the Bay is important for sediment resuspension only in the region close to the north opening of the Bay. Therefore the main driving forces for sediment resuspension in Moreton Bay are location dependent.
Sediments in Moreton Bay generally consist of sand, muddy sand, sandy mud and mud. The grain size of sand in Moreton Bay was found to be from 0.17-0.25mm. Mud was generally finer than 0.0625mm.
Rates of deposition were modelled and are given for each site based on its characteristic sediment type (mud or sand) and a number of input parameters (median grain size, median settling velocity, physical bed roughness, critical bed stress for erosion of cohesive sediment and also for its deposition. Deposition rate generally decreased exponentially with height above the bed in Moreton Bay but hardly changes with height in Brisbane River.
For more information regarding sediment properties for cohesive and non-cohesive sediment see review by You *et al.* (1997). Spatial distribution of sediment types in Moreton Bay was studied by Maxwell (1970).

97. **You, Z.J., Hatton, D., Turnbull, J., and Greilach, P.** (1979). Task RD: Resuspension dynamics. Phase 1 report. Marine and Freshwater Resources Institute.

98. **Yu, B.** (1993). A link between at-a-station hydraulic geometry and runoff routing models. In: Towards the 21st century: Hydrology and Water Resources Symposium, pp 141-146. Institution of Engineers Australia, Barton ACT.

Notes: There is a similarity between at-a-station hydraulic geometry and storage formulation in runoff routing models. A link between parameters in runoff routing models and those describing at-a-station hydraulic geometry is therefore proposed. The hypothesis was tested on two catchments in Queensland, Oxley Creek and the Isaac River. Testing examined whether at-a-station hydraulic geometry relations have similar parameters in different parts of the same catchment and whether parameters describing at-a-station relations can be used to predict observed hydrographs. The first test was passed convincingly. When parameters were used to predict the observed hydrographs, it was found that for Oxley Creek, the predicted hydrographs fitted observed hydrographs very well, while for the Isaac River, the hydrographs were underestimated by about 50%. Poor data quality and spatial heterogeneity in the storage-discharge relationship are among the possible sources of errors.

99. **Yuge, Y. and Yu, B.** (1994). Stream network and runoff estimation: a case study of the Oxley Creek in southeast Queensland. In: Water Down Under 94, pp 433-438. Institution of Engineers, Australia. Barton, ACT.

Notes: A stream network and runoff estimation model (SNARE) was developed as a tool to predict flood hydrographs. For catchments disaggregated into a number of identical square cells, this model combines a network generation scheme with the Sugawara water balance model for individual cells to produce a hydrograph at the catchment outlet. Four flood events recorded at New Beith, QLD, in the Oxley Creek catchment, were used to test the applicability of this model. Parameters were estimated using one of the four flood events and the model was then used to predict the remaining three flood hydrographs. The overall fit was reasonably good with a mean percentage error of 26% with respect to the peak discharge. Significant features of this network runoff model also include a coherent framework in which the temporal variation of rainfall and spatial variation of catchment characteristics can be integrated.

Key documents

A number of key documents were identified. These are highlighted with the key symbol in the bibliography listing and include Ref. N^{os}: 11, 17, 24, 25, 29, 31, 32, 35, 36, 38, 40, 41, 43, 52, 64, 66, 67, 68, 69, 75, 76, 82, 87, 88, 91, 93, 96.

Three of these key documents – Crimp (1992), Davie *et al.* (1990) and Tibbetts *et al.* (1998) – are extensive volumes and should be considered a fundamental resource.

Crimp, O.N. (Ed.) (1992). Moreton Bay in the balance. Australian Littoral Society Inc., Moorooka, Queensland.

Davie, P., Stock, E., and Choy, D. L. (Eds.) (1990). The Brisbane River: A source book for the future. Australian Littoral Society Inc., Brisbane.

Tibbetts, I.R., Hall, N. J., and Dennison, W. C. (Eds.) (1998). Moreton Bay and catchment. School of marine Science, The University of Queensland, Brisbane, QLD.

Non catchment specific documents

Not all the references contained in the bibliography are specifically about the Moreton Bay Catchment. However they are included because they provide additional information either relating to sedimentation processes in general or describing similar issues and concerns as those found in the Moreton Bay Catchment. Source items which are not specific to the catchment are Ref. N^{os}: 18, 27, 33, 37, 39, 42, 45, 47, 55, 65, 72.

Strategy Documents

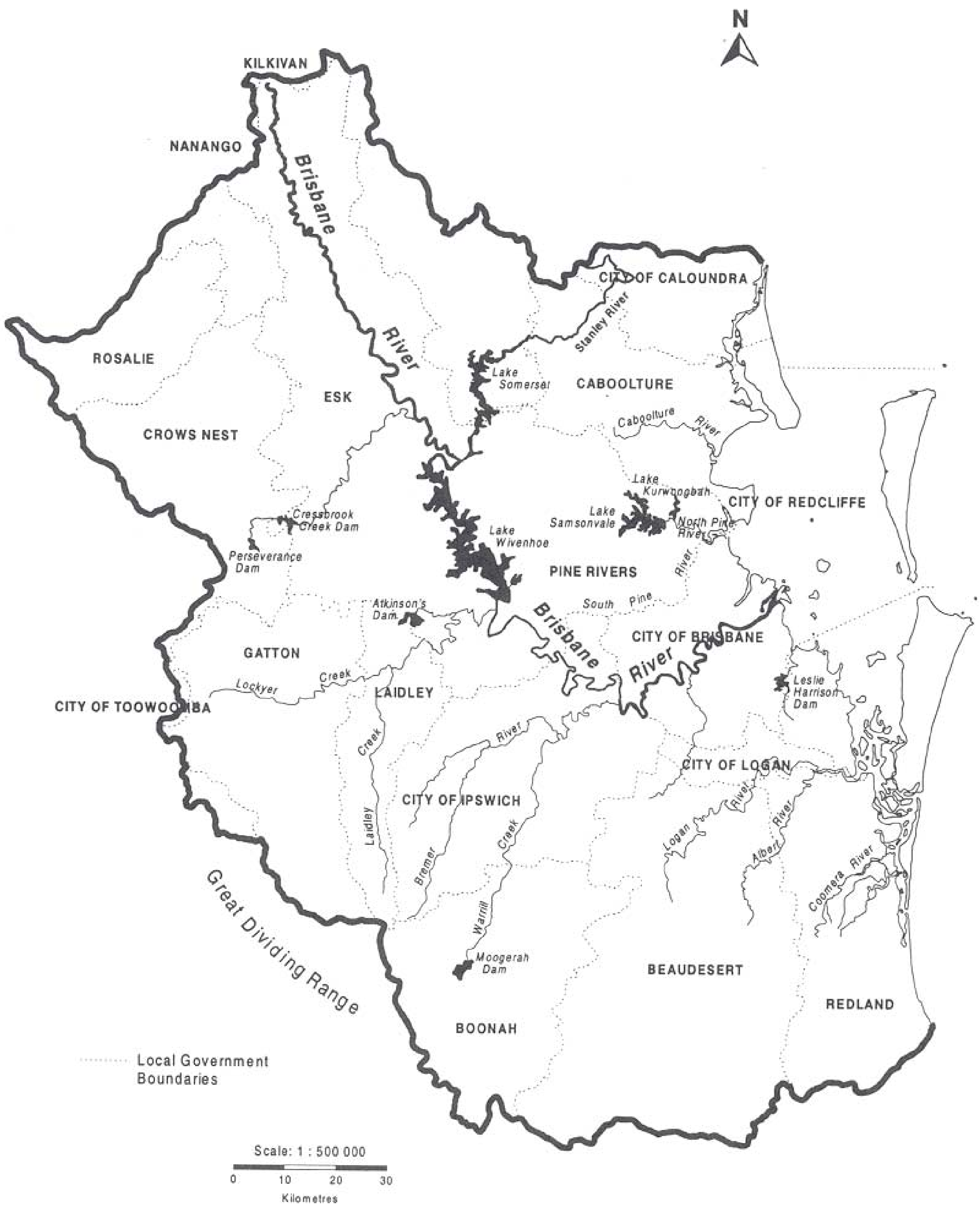
Many of the documents have been in direct response to initiatives of the SEQRWQMS. Included in this category are Ref. N^{os}: 9, 10, 11, 31, 32, 35, 38, 40, 43, 56, 75, 76, 78, 79, 80, 93, 96, 97.

State of Reports

With the current trend towards environmental management requirements, state agencies and local governments are fulfilling legislative requirements by undertaking wide ranging environmental assessments. Typically these are being documented and reported on by means of 'State of' reports. A number of these have been undertaken in various parts of the Moreton Bay Catchment including Ref. N^{os}: 7, 8, 11, 17, 40, 46, 51, 74, 87.

Map 1: Moreton Bay and Catchment

(Source: Tibbetts *et al.* 1998)



Map 2: Subcatchments