Controlling Pollution in the Derwent Estuary, Tasmania: Issues of Standards and Management

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Statement

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university and to the best of the author's knowledge and belief the thesis contains no copy or paraphrase of material previously published or written by other persons except when due reference is made in the text of the thesis.

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Abstract

The Derwent estuary, Tasmania has been described as one of the most polluted estuaries in Australia, yet it supports a population of only 172 000 people and has only 3 major industries discharging effluent into its waters.

This study aims to provide an historical overview of the use of the estuary that has caused it to receive such a reputation and to examine the responses by governments to controlling pollution since the problems were recognised in the early 1970's.

A review of the major reports by scientists and other professionals concerning the impacts of pollution on the estuarine system over the last twenty years has been included to indicate the types of projects that have been undertaken in response to the perceived problems. Most studies, until recently, have been done to examine a single issue, such as heavy metals in fish, or the impact of wood fibre or sewage effluent. The review also provides a comprehensive summary of the current state of knowledge about the Derwent estuary and a background of information on which the political response and management strategies to date can be assessed.

The rehabilitation of the tidal Thames, England is examined with a view to determining the processes that made it successsful and which may be modified to suit a programme of rehabilitation for the Derwent estuary. A possible future institutional arrangement for care of the Derwent catchment is proposed. This entails the establishment of a central body which would concentrate on consulting the community to determine their priorities for the estuary. The task of undertaking a systematic baseline study of the estuary would be also be the responsibility of such a body. Both these tasks must be undertaken before making decisions about future management strategies.

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1. An historical overview of the Derwent estuary, Tasmania

1.1 Introduction

The Derwent River in Tasmania rises at Lake St Clair in the Traveller Range of Tasmania's central plateau. It flows approximately in a north-south direction for 182 km and is Tasmania's third longest river (see Figure 1). The catchment area covers about 8 500 sq kms (Hepper and Marriott 1985).

Since European settlement, nearly 200 years ago, the catchment area has been modified by agricultural development, hydro-electric power generation, forestry, industrial uses, and urban development. The river has been used simultaneously by the population for recreational purposes, aesthetic appreciation of its considerable natural beauty, commercial and amateur fishing, and as a waste dump for domestic and industrial waste (Hepper and Marriot 1985). The area of the Derwent River that has been most severely compromised by the last of these uses is the Derwent estuary. It is this part of the river that is the focus of the thesis.

1.1.1 Aim of the study

A number of reports and surveys have been completed about the uses of the estuary described above. The aim of this study is to review these reports and surveys to demonstrate that there are significant pollution problems which remain to be addressed. No Tasmanian government has had the political will to tackle the problem despite legislation available to protect the environment and scientific evidence showing that the quality of the estuary has degenerated rapidly since the turn of the century. However this is not a scientific study intending to increase the information available. Bringing together the reports and their recommendations does help to emphasise the extent of the degradation of the estuary. The most important insight, however, arises from the demonstration that the management of the Derwent estuary has been haphazard and that the existing structures of authority are cumbersome and inadequate.

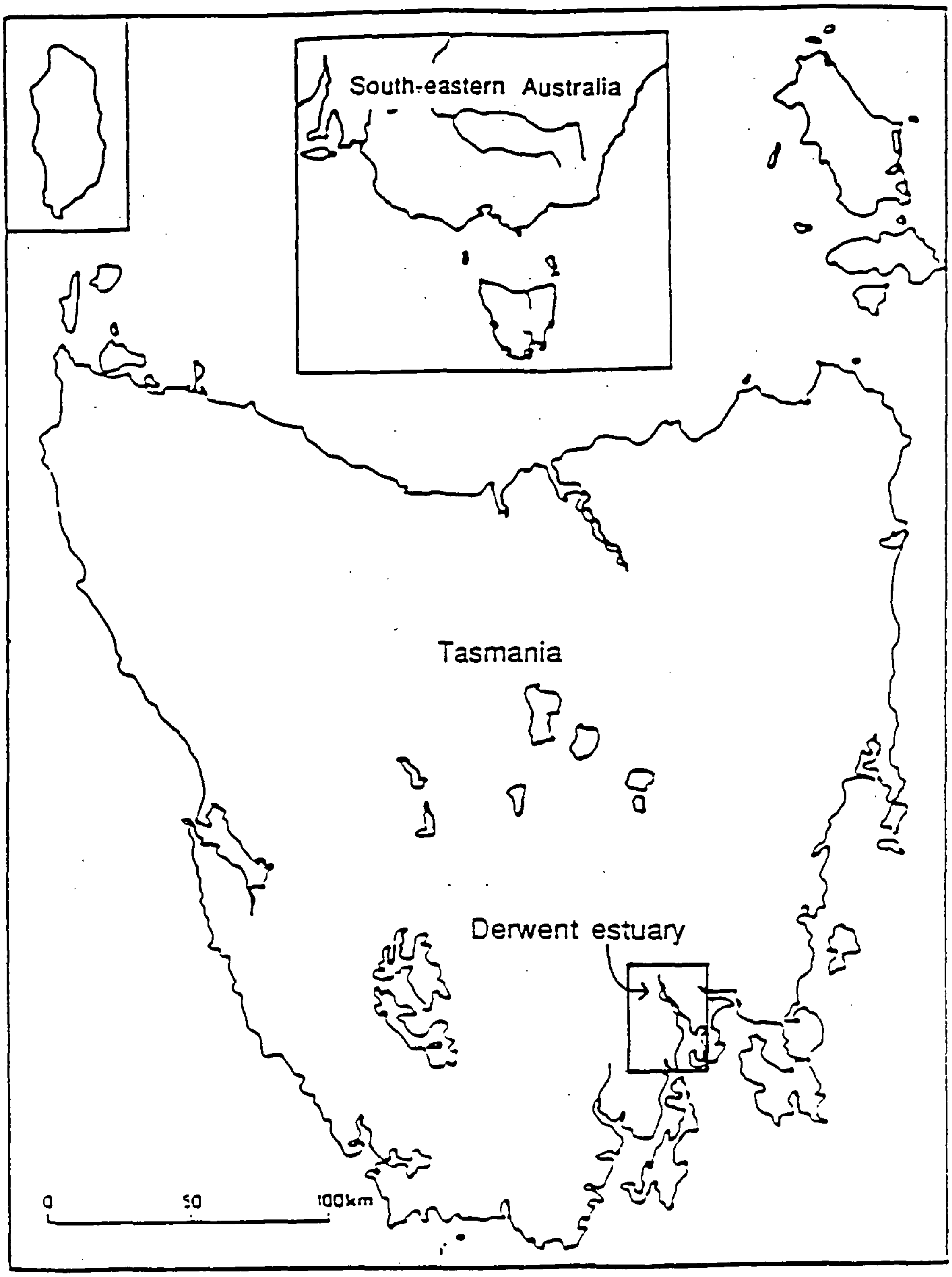


Figure 1. The location of the Derwent estuary in relation to Tasmania and Tasmania in relation to South-eastern Australia.

These factors create the most significant constraints which limit the opportunity for redressing the adverse effects on all uses of the estuarine environment, causing loss of amenity to the 172 000 people of the greater Hobart area, over one third of Tasmania's total population.

The study provides an overview of the historical development of the use of the estuary, including studies that have been done to examine the pollution problems arising from that use. The concurrent political, legislative, and regulatory responses to the pollution problems in the estuary are also discussed. Over the years the problems caused by patterns of misuse have compounded and it is now necessary for a major infrastructure rearrangement to undo them. One example of a major rearrangement is an overview of the successful rehabilitation of the Thames estuary, England. Although circumstances were different it is offered as a comparison with a view to finding a possible model on which to base a management programme for the Derwent estuary.

1.1.2 General description of the Derwent estuary

The Derwent estuary is variously described by scientists and bureaucrats. The area referred to as the Derwent estuary for the purposes of this study is that used by the Department of Environment and Planning (Tasmania) in their consideration of estuarine management (see Figure 2).

> The area extends from the New Norfolk Bridge to a line from Cape Direction to Tinderbox. It involves all areas up to high water mark including Ralphs Bay, but excluding the Jordan River and other tributaries which are treated as inputs to the Derwent system (Department of Environment and Planning 1989).

The estuary was described in glowing terms by the early explorers who ventured onto it. The water was deep and contained ideal places for a harbour. The considerable natural beauty of the surroundings were also commented upon, with the Wellington Range on the western side and

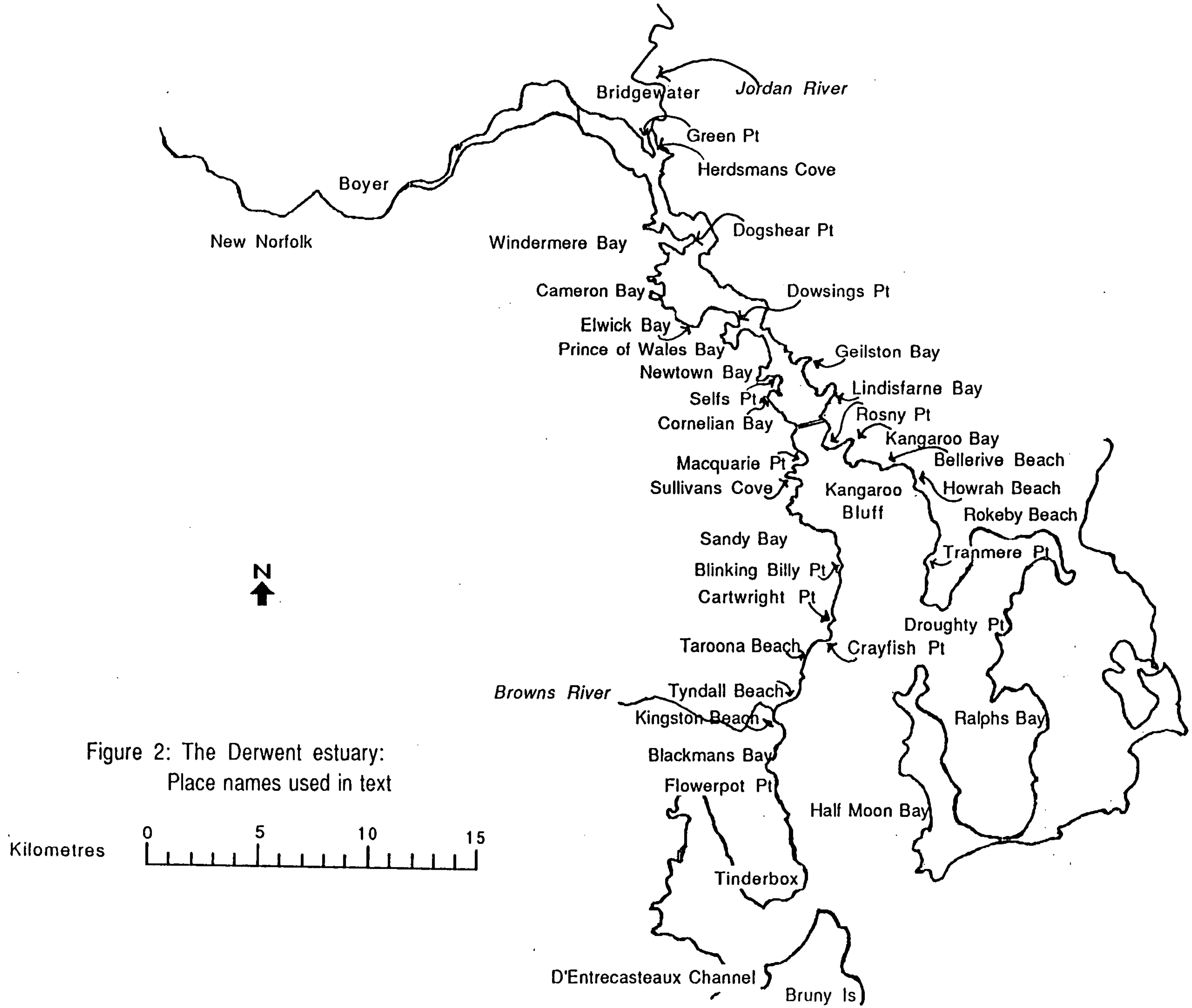


Figure 2: The Derwent estuary:
Place names used in text

smaller hills on the eastern side providing a forested backdrop to the broad expanse of clear water, sheltered inlets, sandy beaches, and rocky reefs at the foot of cliffs, which characterise the foreshore of the estuary. Parts of the estuary, even now, after nearly two hundred years of neglect remain relatively unspoilt as a reminder of its original beauty.

Like most other estuaries the Derwent has been used and abused by its human inhabitants, in its case to the point where it is described as one of the most polluted estuaries in Australia (Bloom 1975). Looks are deceiving and the casual observer may see little to convince them that this is the case. The water still looks blue and inviting, the beaches still entice with their stretches of white and yellow sand. The industries that have dumped untreated waste into the estuary have left their mark below the surface, and pollutants have worked their way into the food chain leaving long term problems, the full impact of which have yet to be assessed. In the upper reaches of the estuary the evidence of pollution is more obvious. On hot days, especially at low tide, the river smells like rotten eggs. This is because large parts of the upper estuary are starved of oxygen and the sulphide content of the water is high. Not far below the surface, the quality of the water is so bad that life cannot survive. Consequently much of the upper estuary is "dead", despite the presence of fish which migrate through this area, or manage to live in the small proportion of it that can still support life. Many of those fish that do live in this region are diseased (Davies, Fulton and Kalish 1988).

The main events that have occurred over the past twenty years to bring the estuary into the public eye are as follows:
In 1972, a group of people eating oysters from a commercial oyster farm in Ralphs Bay were affected by vomiting and nausea. The oysters were found to contain high levels of zinc.

The release of information from Prof. Harry Bloom's report in 1975 (Bloom

1975) caused a flurry of concern, confirming the fears of serious heavy metal contamination in the estuary. These two events had the ultimate public effect of convincing the population not to eat shellfish and to think twice about eating fish caught in the estuary and were followed by national publicity on the severity of pollution in the Derwent (*The Bulletin*, January 17, 1978). The results of these studies also generated further work on the background levels of heavy metals on oysters (Thomson 1979) and the possible use of various species of invertebrates as biomonitors (Beckman 1987).

In 1975 the Tasman Bridge was rammed by a ship carrying ore to the zinc works. The bridge collapsed and the ship, *Lake Illawarra*, sank. It is still on the bottom of the estuary, under the Tasman Bridge, covered by sediment with a full load of zinc ore aboard. So far there is no evidence that the zinc is leaching into the system, but it is a potential threat. The ship has sunk deep into the mud on the bottom of the river.

Since 1987, there has been dispute each summer over whether Councils should display warning signs at beaches where the bacteria levels are marginal. Some days they exceed the limit for safe swimming. So far the Councils have managed to resist posting warnings, and in 1990 although the Minister has once more raised the issue, it has received little media attention and no noticeable public reaction.

In 1987, at the height of the Wesley Vale debate in an attempt to prove the Gray Liberal Government was "environmentally friendly" the then Minister for Environment, Peter Hodgman placed sunset clauses on the exemptions for major industries. The Minister knew that the industries had already started to upgrade their plants, including pollution control mechanisms that would bring them into line with the required regulations. The general public were, for the most part, unaware that these changes were taking place (R.J.K. Chapman pers.comm. 1990).

In 1988 a flood event occurred which caused rafts of sludge to break away from sludge deposits on the bottom of the river and float in a stinking mass downstream and onto beaches near residential areas. There was loud public concern. The Department of the Environment reacted by initiating a study into the problem ("Sludge" work phases 1, 2, and 3). The first of these phases was a preliminary survey. The second phase was completed in 1991 and if accepted it will lead to the adoption of Phase 3.

In 1989 the first Derwent River clean-up was held following a successful community event in Sydney Harbour. The "Friends of the Derwent", a community based group affiliated with the Tasmanian Conservation Trust organised this event. The response from all river users was encouraging with industries being open about their polluting for the first time and sponsoring the event with donations of equipment. This was obviously a public relations event for industry to prove what good corporate citizens they were, but for all that it was a sign that they wanted the community to think well of them. In the past they have considered their presence and contribution to the economy of Tasmania to be enough. Now the perception is that the community are no longer willing to accept development at any price.

In March 1990, Greenpeace, as part of their crusade against ocean dumping, ran a campaign against EZ's daily jarosite dumping off the Continental Shelf, beyond Storm Bay, which marks the mouth of the Derwent River.

In July 1990, the Department of Environment released findings of heavy metal contamination of soils in the suburb of Lutana, adjacent to the EZ works at Risdon. Levels of cadmium and zinc were reported to be five times higher than acceptable levels, which constituted a possible serious health risk to the residents living there. This again focussed public attention on the polluting capacity of the EZ works.

The public perceive the river as being polluted, but are concerned only when it directly affects their activites or impinges on their way of life.

A prime motivating force in initiating action in the case of the Thames was the look and smell of the water. It is interesting to note that conditions had to reach such an extreme point of degradation with regard to the Thames before action was taken. Some commentators have put this down to the interruption to the normal course of the city's life caused by the Second World War (Bates 1977). However this claim is somewhat weakened by past events which showed that the tidal Thames had reached a similar state in the mid 1850's before action was taken and sewerage works overhauled and upgraded (Morrison 1974, Wood 1981). The sight and smell of the tidal Thames in the 1950's was unavoidable evidence that action needed to be taken. It was black and oily and had a strong offensive smell of sulphur all the time.

The Derwent in contrast looks all right for the most part, and doesn't smell except for isolated pockets in the middle estuary and at low tide in the upper estuary. It looks blue and inviting to the casual onlooker. Fish still swim in it, people still swim in it. It is still a far cry from the visual pollution of the Thames in the 1950's. Could the impression that the Derwent estuary looks all right lull both the population and the governing bodies into a collective false sense of security? If the estuary showed obvious signs of pollution as the Thames did, would the Government find the political will to act? Would the population put up with such a situation?

Although there are no possible answers to these questions it is my contention that how the estuary looks and smells has a significant bearing on people's perceptions of the environmental problems and in motivating the political will required to confront the problems.. The idea that action is fuelled by seeing evidence is borne out by the public complaints received by the DOE in 1988 when sludge rafts landed on beaches in residential areas.

Public and government agency concern has centred around heavy metal contamination, high bacterial loadings leading to the closure of beaches and calls for improvement of waste treatment facilities; odour problems associated with organic material and aquatic plant decay in shallow bays in the middle sections of the estuary have also been of concern. High sulphide levels in the upper estuary and flushing organic materials, that is Derwent sludge rafts or "Derwent hippos" found in the vicinity of urban development have been a source of unpleasant odours as well (Davies and Kalish 1989).

All these events have occurred as isolated incidents, and have caused initial bursts of public outrage. The authorities have responded in order to ameliorate the immediate concern. The outrage has dissipated with the apparent disappearance of the problem. When the river smells, when beaches are closed or under threat of closure, when sludge rafts are seen and smelled, people are indignant about the state of the river, about the pollution levels and the lack of action by the state and local governments, but their indignation is never sustained long enough to force any real change in the political arena. The long term commitment required to clean up the Derwent is not there.

There are some areas of the estuary where no one has swum for years. The state of those areas has apparently been absorbed into the social consciousness and nobody expects those parts of the river to be suitable for swimming, or in some cases, for any type of recreation. So far there are other places to go, but bit by bit choices are being whittled away. The indications are that the public would accept over time that beaches on the estuary are unfit for swimming. Already they have accepted that it is unwise to eat too much fish, that it is downright foolish to eat shellfish, and that certain areas of the estuary are unusable.

About 20 years ago, when I was a child my family moved to Taroona, a suburb in the vicinity of the near shore part of the river. My childhood from that point on became centred on the beach five minutes from my home, on endless summer days of swimming, fishing, snorkelling, and exploring. From our dinghy and in nets we caught perch, cod, flathead, rainbow fish, trumpeter, leatherjacket, and mullet. Snorkelling and spearfishing off the reefs at either end of the beach, my friends caught crayfish, as well as a variety of other fish and there were plenty of fish to look at. At low tide, the mussels covering the rocks were big and densely packed. We used to collect them for bait.

Twenty years before, in the same spot, crayfish could be readily picked from amongst the rocks of the reef. After a southerly storm, people could walk along the beach and pick up a sugar bag full of scallops. The estuary was an abundant place (J.Doughty pers. comm. 1990).

I still live in the same area. Now my children are growing up in my childhood paradise. It is different now. The abundance is less. Those who are still willing to fish in the waters off the beach catch little more than flathead. Sometimes you can be lucky and catch an Atlantic salmon, escaped from a fish farm in the D'Entrecasteaux Channel. The mussels on the rocks are little and fewer. We still swim there, but not with the same carefree attitude. Some days the water just doesn't look right . There is a greasy film on the surface and it is frequently murky and sometimes smells. We swim at our own risk, not really wanting to admit that this is another case of paradise lost, nor that we are also responsible for this loss.

The cost of cleaning up degraded areas is rising all the time. Ultimately the community will bear that cost, either through rates, taxes, or increased prices of goods. In a city with a population of 172 000 people what will be the cost per household? It is a question that is being shunned by politicians and councillors. It would be better to let the community know what the problems are and let them decide whether they are willing to pay for the rehabilitation of the estuary, instead of the authorities assuming that they know what public reaction will be. Community involvement has been very limited in the management of the estuary.

1.1.3 Physical characteristics of the Derwent estuary

The Derwent estuary is a drowned valley, with one major source of fresh water from the head of the estuary. It has a median flow of about 120 cumecs with seasonal variations, ranging from 30 cumecs in the summer months to >300 cumec flows during winter. "It is a highly stratified salt wedge/partially mixed estuarine system" (Davies and Kalish 1989:3). Depending on the volume of freshwater flow the toe of the salt wedge typically lies between the Bridgewater causeway and the New Norfolk Bridge. The exchange rate and circulation of water in this area is quite slow and inefficient in terms of flushing and reoxygenation of the bottom layer of saline water.

Studies of the estuary have divided it into two distinct sections, the upper and lower. The upper estuary refers to the area between New Norfolk Bridge and Dogshear Pt. New Norfolk Bridge conveniently marks the outer limit of the salt wedge boundary, and at Dogshear Pt there is a sharp depth change. The upper estuary has an average depth of about 4m. At Dogshear Pt the depth of the river drops to about 11m and remains considerably deeper than the upper estuary throughout its remaining length.

The dynamics of the upper estuary are quite different from the lower estuary. The upper estuary is partitioned into a bottom salt layer and a surface layer of fresh water which becomes progressively more saline heading downstream and there is upward mixing of salt water from the wedge. Complete mixing of the the salt wedge with the upper layer ranges from 35-45 days at times of low flow to 3 days when the flows are around 110 cumec (Davies and Kalish 1989). The surface layer by the time it reaches Dogshear Pt is essentially floating over the top of ocean water. Near the

Tasman Bridge , the surface layer frequently separates from the west bank and continues out to sea along the east bank (Thomson and Godfrey 1985).

The upper estuary relies on freshwater flows to reoxygenate and to remove waste, whereas the lower estuary water is much deeper and is dominated by wind-wave and tidally-driven mixing. At times of low flow the upper estuary is assisted little by oxygenated saline water from the lower estuary as tidal influences are not great. Tidal variation is around 1m. The upper estuary is relatively narrow ranging from 93m at New Norfolk Bridge to 800m at Dogshear Pt. The middle estuary is around 1000m wide increasing to 6000m in the lower estuary.

The upper estuary is characterised by estuarine wetlands that support a diverse collection of wildlife especially water fowl (see Plate 1.1). The river channel has been designated a wildlife sanctuary for this reason, but unfortunately that has not included reservation of the wetland areas. As a consequence some of these wetland areas have been degraded by landfill and rubbish and attempts at drainage. The wetlands and reed beds in the river provide suitable nursery areas for fish species (Davies, Fulton and Kalish 1988). Due to the high organic content of the soils and the anaerobic microbial activity taking place in the mud the release of odorous gases, notably hydrogen sulphide, is a common occurrence. Thus these areas are not considered of high value to the general community, being regarded as wastelands by many.

The middle and lower sections of the estuary are characterised by its sandy bottom, rocky reefs, small sheltered bays and sandy beaches. One of the initial attractions for settlement was the deep harbour. Urban development stretches the entire length of the river to Tinderbox on the western shore and the eastern shore is being developed in a similar way (see Plates 1.2 and 1.3). Real estate overlooking the estuary is sought after by home owners and those suburbs which have the most panoramic views of the estuary are the ones in which real estate is most expensive.

Plate 1.1: Views of the upper Derwent estuary, Tasmania
Photographs: P. Horwitz

Plate1.2: Views of the middle Derwent estuary, Tasmania

Plate 1.3 Views of the lower Derwent estuary, Tasmania

Both taken from the Signal Station, Mt Nelson Photographs: author

This can be taken as an indication of the importance placed on the aesthetic values of the estuary to the population inhabiting its banks.

The impact of urban development appears to be less in the lower part of the estuary. Most areas in this zone readily meet criteria for primary contact recreation, except near sewage outfalls. However some of the bays in this zone, especially Ralphs Bay and sometimes Blackmans Bay, seem to take some time to flush waste. Ralphs Bay seems to accumulate sediment carrying heavy metals as well as from sewage effluent from Rokeby (Scott and Furphy 1977).

The larger proportion of bays within the middle estuarine area of the river are severely degraded either by sewage, heavy metal pollution, or both. Many of the once sandy beaches have been silted up and a lot of areas have been reclaimed. Examples of this can be found in Lindisfarne Bay, Geilston Bay, and Marieville Esplanade. Over the years people living in these areas have come to accept that these parts of the river are unfit for swimming or in some cases secondary contact, i.e. sailing, boating. However many of these areas are important to the biota of the river as nurseries for fish species - often species that are part of the commercial sea fishery of the State. It is becoming increasingly important that these areas are not degraded any further (Thorp 1981).

1.2 **Historical overview**

The Derwent estuary ranks "with the most polluted waterways in the world. It is severely affected by metallurgical waste, raw and partly treated sewage and effluents from the processing of milk, vegetables and meat" (Bloom and Ayling 1977: 3). Whether this is still the case has yet to be determined.

Not mentioned in the above list of polluting sources is the greatest polluter in the upper estuary, namely the Australian Newsprint Mill (ANM) pulp and paper factory.

A brief historical survey of the development of the greater Hobart area since European settlement shows how this state of pollution has occurred in an estuary that supports a city of only 172 000 people.

The formal annexation and permanent settlement of Tasmania were made in 1803 to block French claims for possession. Lieutenant John Bowen and his party of settlers in two ships anchored off Risdon Cove and established a penal settlement there. It was found to be unsuitable within a short time as it was a poor landing place and had inadequate water supplies. In 1804 the Risdon settlement was closed and re-established at Sullivans Cove by Lieutenant David Collins. This site had a permanent fresh water stream running from Mt Wellington (Hobart Rivulet) and a deep anchorage for larger vessels. The settlement was named Hobart Town and had a population of 262, mostly convicts and soldiers (Hepper and Marriott 1985).

1.2.1 Hobart Rivulet

For the first 15 years of settlement, the town clung to the banks of the rivulet spreading little further than the original area mapped out for the camp. The inhabitants drank straight from the stream and filled cooking pots and buckets to carry back to their homes. As the population increased a number of small industries started to harness the energy of the stream and housing pressures increased. Real estate prices were higher for places close to or backing onto the rivulet. Carrying water was an unpleasant chore.

With increased use for both industry and domestic purposes the rivulet was rapidly changed from a sparkling stream to little more than a drain. Residents threw their rubbish into it hoping the flow would carry it away, at the same time expecting the water flowing past their door to be clean enough to drink, despite the fact that their neighbours upstream had polluted the water in the same manner. Mill wheels churned up mud during low summer flows. The streets became so dirty and the water so polluted that Governor Sorell issued regulations in an effort to make the town clean.

Animals were prohibited from wandering the streets. Constables made a daily check of footpaths and drains to make sure rubbish was not being dumped. Rubbish included stones, earth, clay, skins, offal, filth, dirty water, and any other refuse. In 1829 it was found that effluent from the overcrowded Female Factory housing female convicts was being discharged into the rivulet. This was the final straw. A town water supply was built in 1832 after "an inspection of the rivulet found it fouled by sawdust, greenhides, effluent from a distillery, and pig's dung and muck running off properties all the way along its banks" (De Quincey 1987: 45).

Despite all this, Hobart was still more sanitary than "back home" where the Thames was thick with pollution and the plague was still well known.

The systematic destruction of waterways seems to be a characteristic of humanity. The reason this cameo of the rapid degradation of the Hobart Rivulet has been included is to highlight the careless attitude of the population, and to suggest that the demise over 15 years of this small stream, is no different in principle to the more gradual degradation of the estuary into which it flows. Although history has shown time and again that it is not possible to use waterways as dumping grounds for waste and provide our water needs without strict controls, people have continued to expect that this will somehow occur. The assumption has been that waste will be flushed away, in much the same way as it disappears from the toilet bowl, leaving clear fresh water in its place.

1.2.2 Industrial development

Despite the most concentrated area of settlement being around the rivulet, land grants were made along the river banks, so that by 1811 settlement was thinly spread over a wide area and much of the land along the foreshore of the estuary was being farmed. Population increased steadily at first and then rapidly with increasing arrivals of free settlers. By the late 1830s the population was 14 000 and the face of the city was changing from a large military structure to a more trade oriented one. The 1830s were the beginning of a boom time that saw trade flourish. Many public buildings were erected, wharves extended and warehousing built.

The first 20 years of the 20th century brought a change in the composition of land use along the estuary. The advent of hydro-electric power generation gave the State the capacity to accomodate large industry. The siting of industry was in the Glenorchy area, changing it from an agricultural base to an industrial base. The first of the larger industries was Richardsons Abattoir which was established at Derwent Park in 1907. The waste from this industry was disposed of untreated into the Derwent estuary.

Three major developments have followed, the Electrolytic Zinc Works (EZ) at Risdon, Cadbury chocolate factory at Dogshear Pt, and Australian Newsprint Mills (ANM) pulp and paper mill at Boyer (see Figure 3).

EZ, Risdon

The First World War brought a shortage of zinc to the Allies as their main supplier, Belgium, was occupied by the enemy. Pressure was put on the Australian Government to set up a zinc refinery in Australia. Tasmania was chosen as the most suitable site, due to its capacity to generate hydro-electricity. A metallurgist, sent to investigate the proposed site in 1915 found the site at Risdon was well suited to their needs (see Plate 1.4). Land was cheap, flat, and readily available. Transport was excellent by road, rail, or river. Labour was readily available from Hobart and Glenorchy. The main transmission lines from the State's infant hydro-electric development passed through Glenorchy and the Government guaranteed the supply of power at very cheap rates.

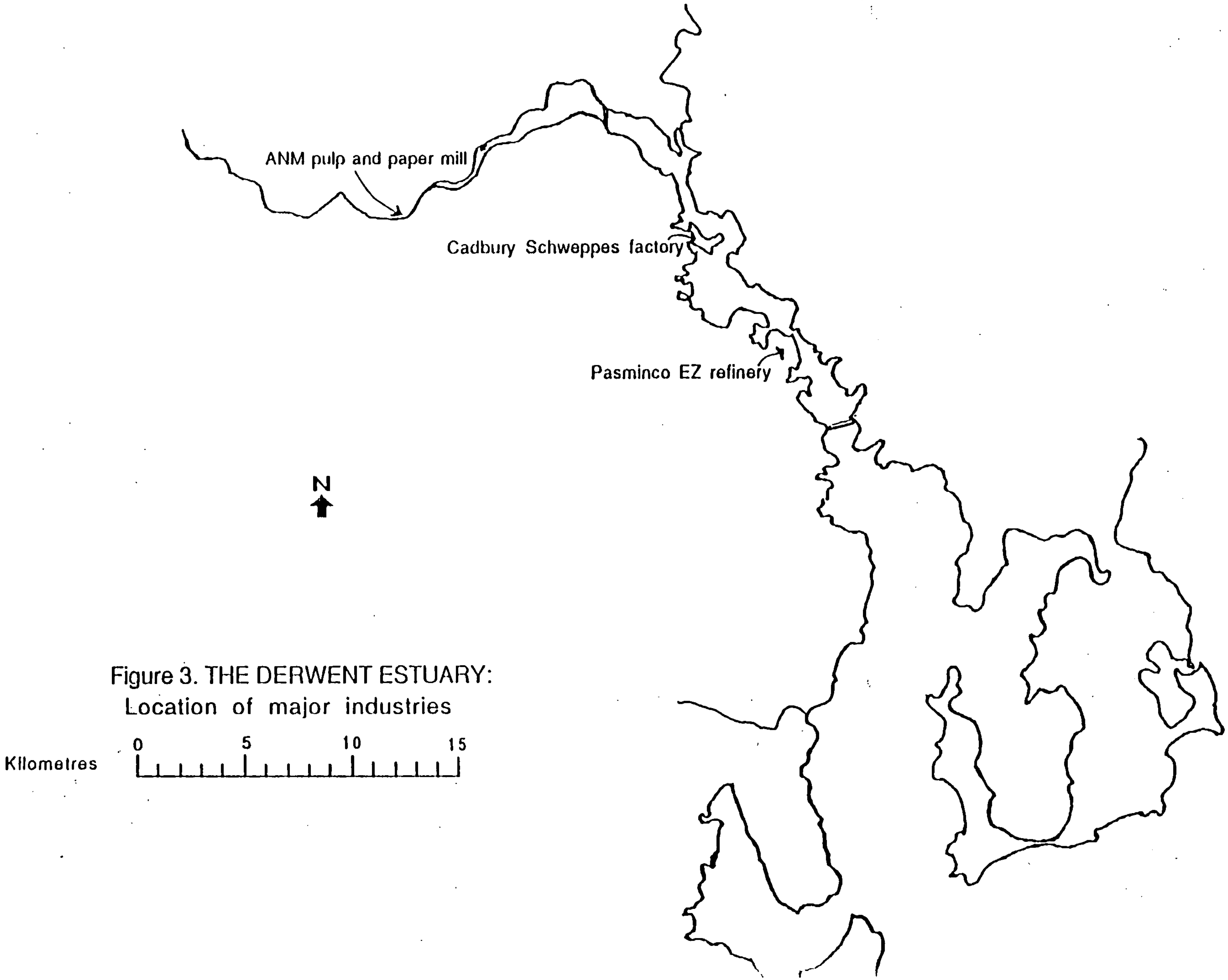


Figure 3. THE DERWENT ESTUARY:
Location of major industries

Plate 1.4 The Pasminco EZ plant
Photograph: P.Horwitz

Plate 1.5 The Cadbury Schweppes factory, Dogshear Pt Photograph: author

However the establishment of an electrolytic zinc refinery was not without challenge even in 1915. The Government's Chief Health Officer was against the project because of the sulphur dioxide fumes produced by the roasting ore, which would adversely affect the nearby population. Public opinion was against the project because there was a chance of the area becoming like Queenstown, on the west coast of Tasmania, where the Mt Lyell copper mining activities had devastated the surrounding land and water. The metallurgist decided against continuing with the project early in 1916. However in July of that year the Tasmanian Government signed an agreement with the Amalgamated Zinc Company. "The Government leased them 50 acres at Risdon and guaranteed a supply of electricity, and the Company agreed not to produce dangerous fumes or smoke, or pollute the river" (Alexander 1986: 162).

The agreement was either not binding or never invoked because the Company has always done exactly what it agreed not to do. For 70 years or so it pumped noxious fumes into the air and metallurgical waste unchecked into the river. This is one of the sources which has caused the Derwent estuary to have some of the highest levels of zinc and cadmium recorded anywhere in the world.

EZ provided employment for many and made the unpleasantness of the work and environment bearable by the provision of fringe benefits, such as cheap housing and Christmas bonuses. Security of employment was also a strong incentive especially after the Second World War when many unskilled returned soldiers were employed as the Company gave preference to returned men. "Although Moonah and Derwent Park were often covered with a pall of smoke and dust from the plant, the Zinc Works was generally considered a blessing, providing employment for so many and a stimulus for the whole district" (Alexander 1986: 168).

<u>Cadburys</u>

The next large industry to settle on the banks of the Derwent estuary was the Cadbury Fry Pascall confectionery factory (see Plate 1.5). After the First World War the Australian confectionery industry was protected by high tariffs. The pre-war practice of importing chocolate from their factories in England was no longer viable so the two companies amalgamated and joined with Pascall to set up a factory in Australia. A four man commission was sent to investigate sites in Sydney, Melbourne, and Hobart. The Commission finally decided on Dogshear Pt at Claremont where the water was deep, there were road and rail facilities and town water supply. The price was also good - 11 000 pounds for 246 acres as opposed to 30 000 pounds for 76 acres for the favoured Melbourne site. The Cadbury ideal for a factory site was also satisfied as the area was picturesque (Alexander 1986). The factory started operation in 1920.

Until recently no waste treatment has been required from what is now the Cadbury Schweppes factory until recently. In 1979 a proposal was put forward to the State Government in conjunction with the Glenorchy City Council to treat factory waste in a centralised council waste treatment plant. However this did not eventuate for various reasons and the Cadbury factory reluctantly had to commit itself to treating all trade waste on site. Eventually after various experiments, the State Government accepted a proposal from the Glenorchy City Council to establish a $6.4 million treatment plant in the "enterprise development zone, north of 10 Mile Hill at Austins Ferry Bay" (Wells 1989: 36) which could accept waste from Cadbury. That plant remains in the planning stages and the situation stands as it always was although Cadbury have spent $2 million on investigation and internal works. Where there were once 14 separate drains going into the estuary from the plant " there is now a single drain waiting for a system of treatment" (Wells 1989: 36). So the waste still goes untreated into the estuary.

ANM, Boyer

In 1938 Australian Newsprint Mills Pty Ltd. (ANM) was formed with the express aim of building a pulp and paper mill at Boyer, slightly downstream of New Norfolk and 36 km from Hobart. The site was 56 acres alongside the Derwent River. It was to be the first mill to produce newsprint from eucalypt hardwood. It was successfully started up in February 1941 (see Plate 1.6).

The Tasmanian Government put $500 000 into the launching of the venture, "the Government being eager to see a basic industry of this size established in the island. The industry would be a large consumer of electricity which suited the state's Hydro-Electric schemes and would use considerable numbers of unskilled workers" (Greenslade 1971: 8).

Over the years techniques and pulping methods have changed dramatically. More efficient methods have increased production and newsprint quality. Production has increased from 30 000 tonnes in the first year of operation to approximately 240 000 tonnes, the equivalent of 40% of Australia's newsprint. On a daily basis the mill produces about 700 tonnes of newsprint

The mill has also discharged an estimated 1.5 million tonnes of wood fibre into the river which has settled on the bottom of the estuary combining with other organic material to form about 4 million tonnes of stinking gelatinous sludge extending downstream of the mill from Bridgewater to the Bowen Bridge close to areas of urban development (HECEC/TASUNI 1989). At times of flood in recent years rafts of this sludge have surfaced and landed on beaches causing serious odour problems and environmental degradation of the foreshore.

Plate 1.6: ANM pulp and paper mill, Boyer
Photograph: author

1.2.3 Sewage treatment

Although these four industries have been the major industrial polluters of the Derwent estuary, domestic waste also contributes significantly. Most sewage is treated only to primary level and there is still a substantial amount of raw sewage entering the system. There are currently 15 sewerage treatment plants that discharge effluent into the river from 5 separate municipalities (see Figure 4).

The following table shows the historical development of sewerage treatment plants that discharge effluent into the estuary or its tributaries.

1920's	Blinking Billy Pt	1971	Rokeby
1944	Prince of Wales Bay		Droughty Pt
1959	East Risdon	1973	Selfs Pt
1960	Rosny	1974	Macquarie St
1963	Kingston	1977	Brighton,
1964	Cameron Bay		Blackmans Bay
1967	Macquarie Pt		Selfs Pt improved
1968	Taroona	1983	E. Risdon improved

(Hepper, Marriott and Associates 1985)

Many of these plants are still at primary treatment level and require exemptions from the Department of Environment and Planning to operate. The 1990 Minister for the Environment and Planning gave councils until 1994 to upgrade all plants to meet required standards. From then on tough penalties will apply to those councils unable to meet the deadline. Details of necessary expenditure are shown on Figure 5, taken from a report in *The Mercury* (August 23 1990: 8).

1.2.4 The Derwent River Wildlife Sanctuary

In 1941 the area between New Norfolk and Dogshear Pt was declared a wildlife sanctuary. The mill at Boyer falls in the middle of this area, yet at that time there was apparently no perceived contradiction between the activities of a pulp and paper mill and the reservation of the stretch of river alongside it as a conservation area. It is ironic that this particular stretch of

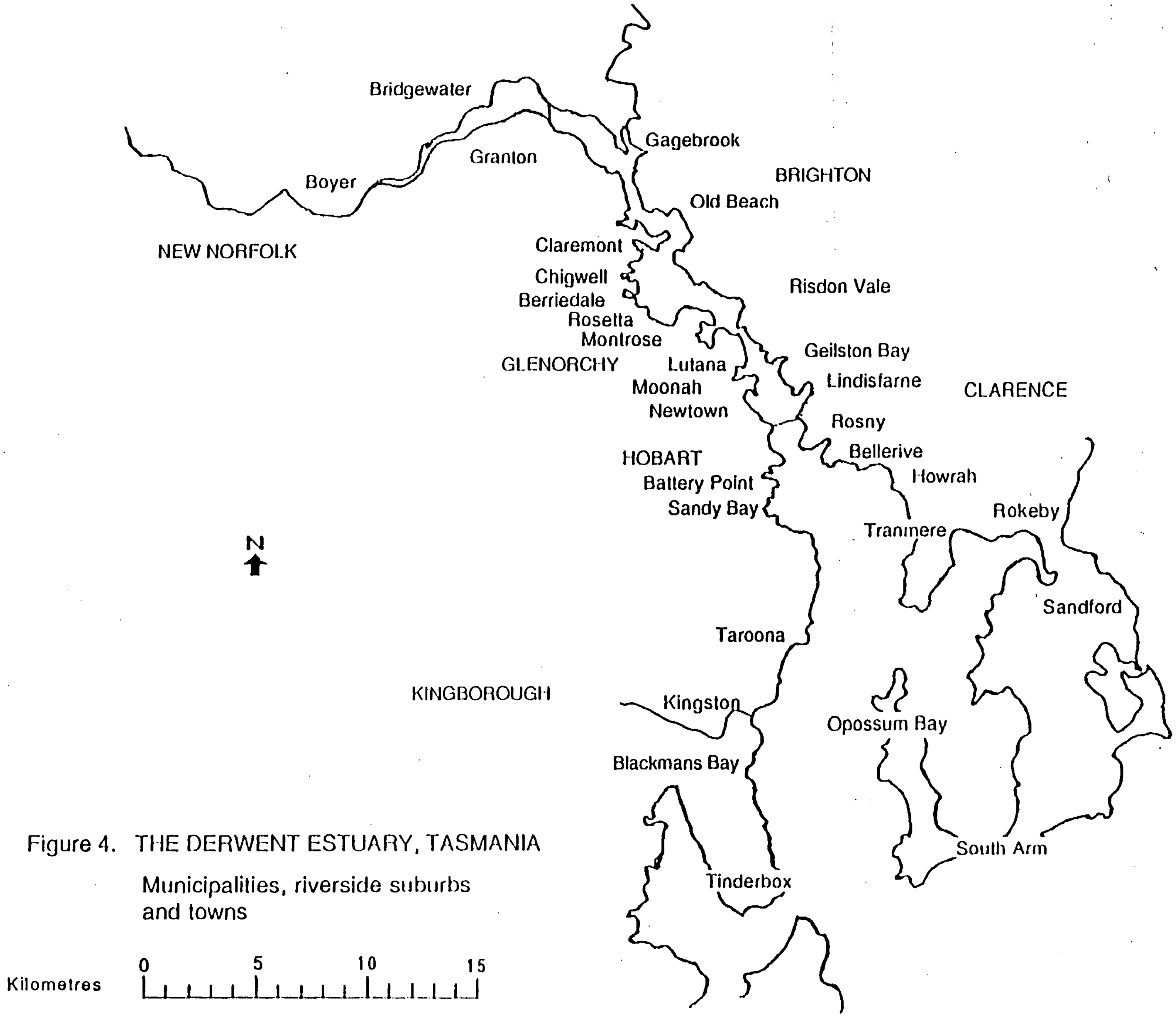
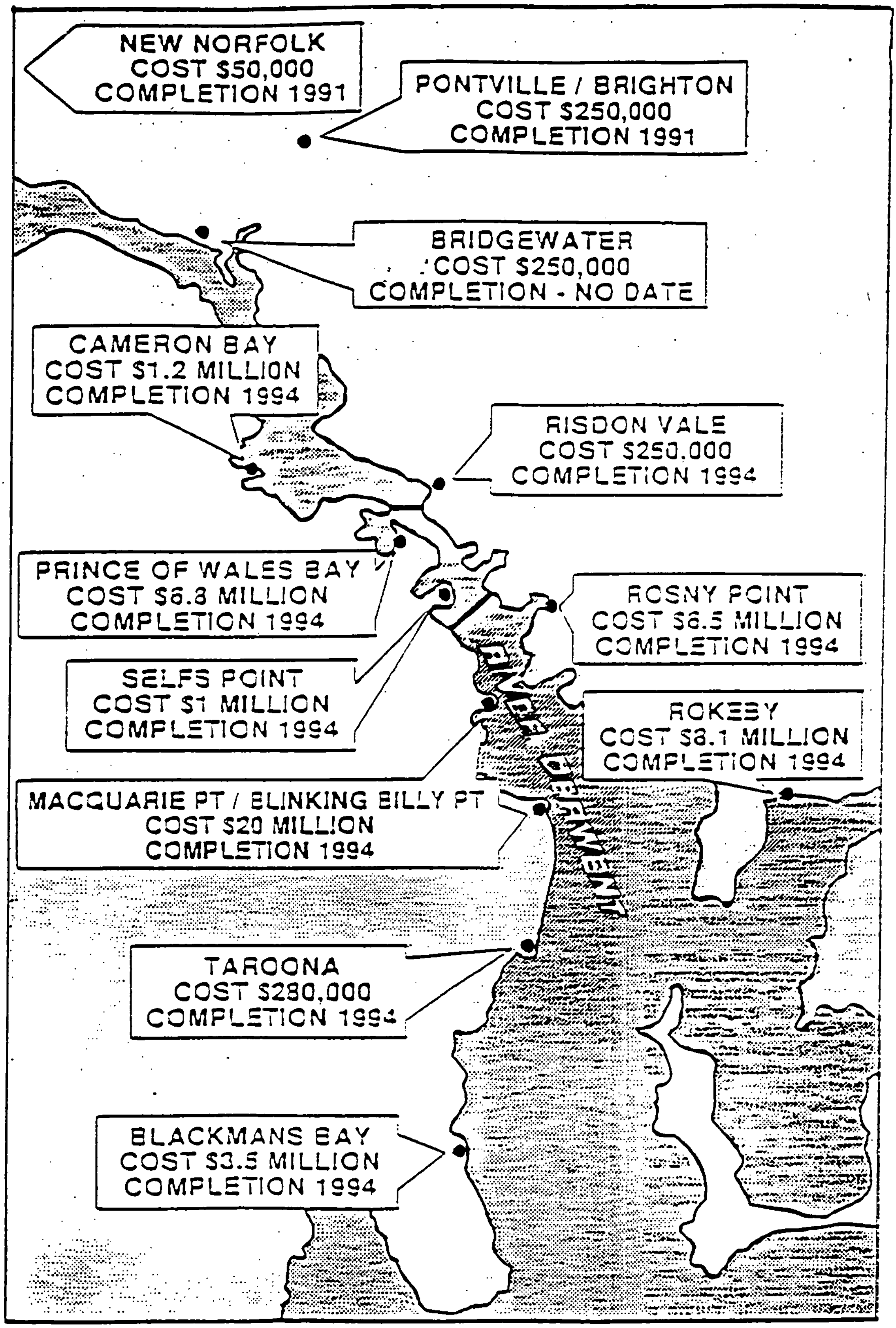


Figure 4. THE DERWENT ESTUARY, TASMANIA

Municipalities, riverside suburbs and towns



Where the money is being spent ... the metropolitan councils' sewage plants

Figure 5. Planned upgrading of sewage treatment facilities in the Greater Hobart area, Tasmania
Source: *The Mercury* 23.8.1990

river is one of the most polluted areas in the estuary and indicates the priority given to industry by successive Tasmanian governments (and the public) above conservation and protection of wildlife.

1.3 Attitude to pollution prior to the 1970s

Little thought appears to have been given to environmental damage or conservation before the 1970s when the Lake Pedder controversy polarised the Tasmanian community. The attitude to effluent entering the estuary and the level of understanding about pollution is encapsulated in the following statement made by a scientist in the introduction to a report on the hydrology of the river in 1955. The River Derwent ..."has the advantage of being reasonably free from factory pollution with the possible exception of two small areas ...By European standards the river is virtually unpolluted. In the case of the two major industrial concerns, care is taken that no products are emptied into the river which would cause serious pollution" (Guiler 1955: 65).

1.4 Legislation

The 1970s brought environmental issues onto the map in Australia. In all states there was a push from the Federal government to bring in legislation to protect the environment. In 1973 the Environment Protection Act was passed in Tasmania after a difficult passage through the Legislative Council where it was amended 39 times. A Director of the Environment was appointed and a Department of the Environment set up (Department of Environment and Planning 1989).

Although legal mechanisms were put in place to change the manner in which the river was being used and abused, the political will was not sufficient to bring about major changes. In the main, advances that have been made are a result of industry's need to modernise their plants which has included pollution control, and events related to the estuary that have affected people's lifestyle and caused them to react with indignation towards industry and government.

Chapter 2 considers the studies made of the Derwent estuary between 1972 and 1989 and integrates the information and data as far as is possible. This chapter deals with publicly available scientific data concerning the levels of pollutants in the estuary. Secondary sources have been used as this study deals with management of the estuary and the purpose of including these reports is to look at the information that has been behind management decisions, or has been initiated to respond to a perceived problem.

The result is a general description of what is known about the state of the Derwent estuary, including the main pollutants and some of their effects. It also becomes evident that there are large gaps in the database indicating an urgent need for a systematic baseline study of the estuary and some clear direction in management.

2. Reports and studies on the Derwent estuary 1972-1989

2.1 Introduction

The first public overview of environmental pollution in Tasmania, prepared by the Director of Environment, was presented to both houses of Parliament in October 1972. He concluded:

> Existing data on the concentration of pollutants in air, water and soil is meagre, nevertheless it is known that many of the State's main river systems are badly polluted. Sewage is a major contribution to pollution of the Derwent and Tamar Rivers (DOE 1972: 8).

Prior to this report there had been little investigation into the pollution of the estuary. [1]DOE was responsible for instigating various studies into the impact of pollutants on the estuary. Other government departments with jurisdiction over areas of the estuary have also prepared reports, notably the Inland Fisheries Commission (IFC), which in recent years has completed reports on the impact of the effluent from ANM on the upper estuary. The association of local councils, (which has changed names over the years) has also commissioned various studies into the state of the estuary. Other work has been contributed by independent organisations, such as CSIRO and the University of Tasmania. (See Table 1).

Results of monitoring done by DOE make up a major part of the data available. The Department of Environment began monitoring the estuary in July 1972. They set 14 monitoring sites between Lawitta, just north of New Norfolk Bridge, and Cape Direction (see Figure 6). The water column has been monitored at each of these sites between 3-8 times per year between 1972 and 1987. Parameters measured to begin

[1]The Department of Environment (DOE) was amalgamated with other government departments in 1989 and is now the Department of Environment and Planning (DEP). It is referred to as both DOE and DEP in the text according to the date of the reference.

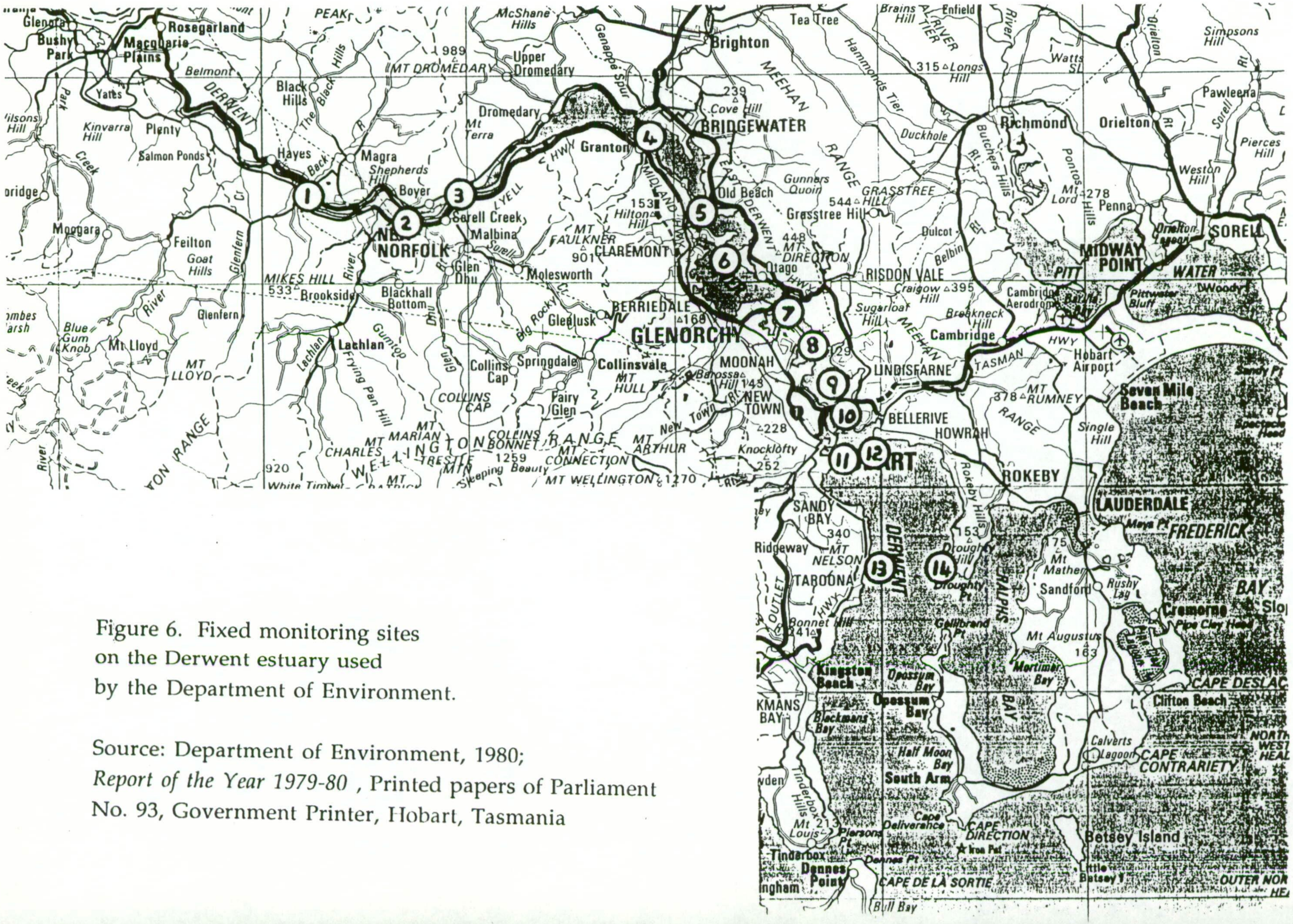


Figure 6. Fixed monitoring sites on the Derwent estuary used by the Department of Environment.

Source: Department of Environment, 1980; *Report of the Year 1979-80* , Printed papers of Parliament No. 93, Government Printer, Hobart, Tasmania

Table 1. Studies providing the main information base about the Derwent estuary, 1972-1989

Year published	Author	Subject	Sponsor	Temporal features of sampling design	Spatial features of sampling design
1972-1989	Department of Environment	Annual reports on the state of Tasmania's environment, containing averaged results of water monitoring surveys.	Tasmanian Government	River sampled approximately once every three months.	14 sites from Lawitta, upstream of New Norfolk to Cartwrights Pt on the western side of the river and to Tryworks Pt on the eastern side (see Fig. 6)
1974	Eustace	Heavy metal content in edible parts of finfish and shellfish.	Australian Fishing Industry Council and CSIRO	8 weeks; November 1972 to January 1973	64 fishing sites offshore from Windermere Bay to the mouth of the estuary.
1974	Ratkowsky, Dix & Wilson	Mercury content of finfish and shellfish .	As above	As above	Water monitoring sites were those used by DOE. Mid stream from Windermere Bay to Droughty Pt.
1975	Bloom	Heavy metals in the water, sediment, finfish & shellfish.	University of Tasmania		51 water sample sites 75 shellfish collection sites 137 sediment sites.
1977	Bloom and Ayling	As above			As above
1977	Scott and Furphy	Sewage treatment in the southern metropolitan area in Tasmania.	Southern Metropolitan Planning Authority		
1979	Matthews	Investigation of the effects of effluent from ANM Boyer on the upper estuary	ANM and DOE	3 years: June 1976-Dec. 1979 Samples taken monthly. 4x24 hr. sampling at one site during 1978-79.	8 sites between New Norfolk Bridge and 500m downstream of Bridgewater causeway.
1981	Thorp	Planning implications of coastal management issues in the southern metropolitan area	Southern Metropolitan Planning Authority		literature survey
1983	Coleman	Review of management of the aquatic environment	Centre for Environmental Studies, University of Tasmania		literature survey
1985	Hepper, Marriott & Assocs.	Derwent River Management Plan, with emphasis on foreshore areas.	Commonwealth grant from Local Government Administrative Services.	3 months.	literature survey plus investigation of 61 foreshore sites.
1985	Winter	Survey of fishers using the estuary and surrounding waters.	Centre for Env. Studies and Dept of Sport and Recreation.		
1988	Wood	Investigation into the rate and sources of sedimentation in Lindisfarne Bay.	National Estate, Clarence Council, Australian Nuclear Science and Technology Organisation and Centre for Env. Studies	8 months: March to Nov. 1987	Core sampling sites in Lindisfarne Bay and the surrounding catchment area
1988	Davies, Fulton & Kalish	Study of the impact of ANM effluent on finfish in the upper estuary	ANM and IFC	1 year: 4/1986-6/1988	3 whitebait traps, above and below effluent outfall. 10 netting sites. 4 water quality stations below the outfall.
1989	Davies & Kalish	Water quality in the upper estuary	ANM and IFC	1 year: 7/1988-7/1989	12 sampling sites.
1989	HECEC/ TASUNI	Sludge -its characerisitics, the extent of the problem and how to get rid of it.	DOE, EZ, ANM, Cadburys		50 surface sites between New Norfolk and the Tasman Bridge.

with were pH, dissolved oxygen, transparency, using a Secchi disc, and suspended solids. Measurements for the heavy metals zinc, manganese, arsenic, copper, lead and mercury were also taken. Later the measurements included cadmium, coliforms, faecal coliforms and faecal streptococci. Averages of the 3-8 samples for the year for each site are presented in table form in the DOE's Annual Report which is tabled in Parliament.

In 1988 the DOE carried out a study to determine the short-term variations in zinc concentrations in surface waters. The sample site was near Selfs Point in the middle estuary not far downstream from EZ Risdon. There were two study periods, one in October, one in December. Samples were taken at two-hourly intervals. It was found that there were ten-fold variations in aqueous zinc solutions in a very short time (84-760 µg/L in 8 hours) (DOE 1989:62). The timing of the increase in concentrations made officers of the Department suspicious as high concentrations always occurred in the middle of the night . A letter to EZ and a repeat of the 24 hour sampling a few months later confirmed their suspicions as the results of the second trial showed much less variation (Bartle, pers. comm. Feb. 1992). However there was still enough variation to indicate that the monitoring programme had serious shortcomings.

> The variations did not appear to be correlated with tides and emphasise the hazards of drawing conclusions from one-off grab samples of water (DEP 1989:63).

The results of DOE surveys have been used in many of the studies concerning the estuary, as providing a measure of the water quality in the estuary especially in the years between 1980 and 1988, where studies relied on the scientific work already done to discuss aspects of the estuary, rather than doing their own field work. This is partly due to the nature of the reports commissioned during this time, which tended to deal with management issues rather than attempts to further understand the ecology of the estuary. However the results of sampling in surface waters done by the DOE over the years are by no means a conclusive indication of the state of the estuary. The results of 24 hour sampling programmes have shown large variations in parameters such as aqueous metals. These results call into question the validity of the results tabled each year for the past 20 years. This is recognised in the section of the Department of Environment and Planning (DEP 1990) report dealing with the matter.

It appears that as a result of these and other developments in assessing the quality of the estuary, that the Department has abandoned this broad water quality type of sampling.

> Instead there is to be "a comprehensive study of heavy metal and organic contaminants in the estuary. This is to be a staged survey, with the first stage being the determination of heavy metal loads in the biological indicators *Crassostrea gigas, Ostrea angasi* and *Mytilus edulis*. Later stages will determine other parameters (such as organometallics, pesticide residues polychlorinated biphenyls, organochlorines and sewage indicators) in waters, particulates, sediments and fish (DEP 1990:60).

The above description is a summary of an Environmental Baseline Monitoring Programme prepared for DOE by National Environmental Consultancy (1989).

So far in the case of the Derwent estuary, the official public monitoring of the water body has done little to inform either the Parliament or the general public of the effects of pollution in the river. It could be expected that during the past twenty years, since the inception of the Department of Environment, a solid foundation of knowledge about the dynamics of the estuary and the impact of pollutants on the aquatic biota of the estuary would have been amassed. However this has not been the case. The Department's role has been largely confined to pollution control and the focus has been on emissions rather than the ambient environment receiving them.

The problems with the research done on the Derwent have been pinpointed in the background information provided in the programme for an environmental baseline monitoring study of the estuary (National Environmental Consultancy 1989). They found studies were: limited to a localised area around a pollutant point source and not able to provide a measure of the effect of that source on regional environments; not based on an understanding of the dynamic operation of the environmental system and therefore not able to establish cause-effect influences and pathways between pollutant sources and environmental quality; not linked into an effective management framework to enable development planning and pollution control strategies to be put in place as a result of the findings. The reports have either been scientifically oriented or management oriented so the results are generally either difficult to relate to practical management or are not based on a sufficiently large and reliable body of scientific data to allow confident conclusions to be reached (National Environmental Consultancy 1989).

The following sections discuss the pollutants entering the estuary. The findings of the various reports are summarised in relation to the pollutants, their sources and impact on water quality, the aquatic ecosystems and human health. The limited nature of the data is demonstrated and prevents any specific conclusions about the estuary.

2.2 Pollutants

Tables 2-4 provide an overview of the results from the scientific data collected from 1972-1989. As most of the numbers given are ranges of averages, their value as indicators of the state of the estuary are questionable. They do serve both to expose the gaps in the knowledge base and as comparisons between studies and with standards. All standards mentioned below are those set out in the *Environment Protection (Water Pollution) Regulations 1974*, unless otherwise specified as these have been and still are the basis of water quality management in Tasmania. National guidelines such as the ANZECC water quality guidelines now under preparation may supersede the old State regulations in the near future. There is already a strong move in the DEP to base management on the ambient environment, rather than on point source.

The major sources of pollution appear to be the ANM pulp and paper mill at Boyer, Cadburys chocolate and confectionery factory, Pasminco EZ metal refinery, the 15 STPs releasing effluent into the estuary, and urban runoff. Other sources may be present, but scientific studies undertaken indicate that the impact of effluent from these sources is considered the most significant. However there is no integrated research on which prioritising can be based, nor is there any possibility of synthesising the results of these studies in any significant way, since as previously mentioned they were not based on comparable or cumulative research.

The main pollutants known to be entering the estuary are the heavy metals, zinc, cadmium, copper, mercury, lead, magnesium, chromium, arsenic (Eustace 1974, Ratkowsky , Dix and Wilson 1974, Bloom 1975, Bloom and Ayling 1977); treated and untreated sewage effluent; food wastes; by-products of wood processing such as cellulose, sugars, tannins, lignins and phenolics; slimicides, resin acids, sulphides, chlorine, chlorinated organic compounds, and dyes (Scott and Furphy 1977, Matthews 1979, Davies and Kalish 1989).

It is known that these pollutants have affected water quality, especially in the upper estuary and shallow bays (Matthews 1979, Davies and Kalish 1989). They have also affected the aquatic biota (Eustace 1974, Ratkowsky, Dix and Wilson 1974, Matthews 1979, Davies, Fulton and Kalish 1988, Davies and Kalish 1989), diminished the recreational and commercial use of the estuary

(Scott and Furphy 1977, Thorp 1981, Hepper, Marriott and Assoc., 1985) and have contributed to long term environmental degradation (Matthews 1979, Coleman 1983, Wood 1988, Davies and Kalish 1989).

2.2.1 Heavy metals

Table 2 shows ranges of values for heavy metals in surface waters, sediments and finfish and shellfish. It is evident that the focus of the DOE has been on the metal content in the water. Sampling of sediments has only been done by the DOE after the ship, *Lake Illawarra*, sank with a load of zinc ore on board and during and after the visit of a nuclear warship to the Port of Hobart to determine if there was any radioactive material left by the ship (DOE 1984/85). Work done on the extent of "sludge" in the estuary in 1989 (HECEC/TASUNI 1989) was also commissioned and paid for at least in part by the DOE.

Heavy metals in solution in water are available for ingestion by fish, shellfish and humans. Metals can exist in waters and organisms in a wide variety of chemical forms and combinations with other materials. In water they can exist as free metal ions, inorganic complexes, organic complexes and compounds. They can also be associated with colloidal or particulate matter, usually adsorbed onto the surface. This presents problems in assessing the effect of metals in waterways and organisms as they can occur in all of the forms mentioned above. The biological properties and availability of the metal vary considerably according to its chemical form. Another factor is the dynamic nature of metals in water. Concentration and form can be altered by such factors as pH, eH and other materials being present. (Connell 1981). The issue of the toxicity of the various metals and the synergistic effects of metals in combination with each other, organics and other compounds is complex and beyond the scope of this thesis.

Table 2. Ranges of values for heavy metal concentrations in water, sediment, finfish and shellfish in the Derwent estuary.

Author of study	Year	Medium	Values zinc	cadmium	mercury	copper	manganese	lead	iron	arsenic	chromium	cobalt	nickel
DOE	1972	surface water	0.01-0.78 mg/l.		<0.1-1.1	0.9-7.2 ug/l.	0.01-0.12mg /l.	1.3 -18.4		0.8-5.8			
	1973		2.53-348.7	0.1-4.6	<0.1-1.5	3.2-8.0		0.7-6.6		0.1-6.1			
	1974		12-420	0.3-5.0	<0.1-0.5	10-27	4.8-74.8	2-28		<1-6			
	1975		13-560	<0.5-9.5	<0.1-0.8	3.0-9.5	15-60	5-35		1-5			
	1976		9-339	<0.5-4.4	<0.1-0.5	3.0-9.7	7-82	3.0-49.3		1.9-3.7			
	1977		18-434	<0.5-9.4	<0.06-0.25	5.9-18.7	19-173	6-21		<0.1-2.8			
	1978						10-25						
	1979		20-1044	<0.5-3.1	<0.01-0.09	<0.8-<5.1		<5-<7		<2-<4			
	1980		10-369	<0.5-1.7	<0.04-0.55	1.5-3.8	<5-54	<5-6		<4.0-4.3			
	1981		4.8-512	<0.5-1.9	0.06-0.54	1.5-4.3	9-33	5-10		<3			
	1982		<6-1256	<0.5-<3.5	<0.05-1.24	<1-<10	13.3-49	5-8					
	1983		<5-775	<1.0	<0.1-0.84		<10-<36.7						
	1984												
	1985		14-149	<1	<0.1-0.32	<2-23							
	1986		5.2-230	<0.05-1.4	0.03-1.0	<2-12.5		1-18					
	1987												
	1988		0-1000	0-30									
	1989												
Eustace	1974	water	71 -760	0.7-3.9		2.8-6.6							
Bloom	1975	water	12-1500	<0.5-15	0.1-16	0.5-21	25-100	<3-33	2-42				
		sediment	22-104 000	0.3-1400	<0.01-1130	1.0-1310	0.8-8900	0.7-41 700	570-161 000		1.1-258	0.4-103	0.5-33
HECEC/ TASUNI	1989	sediment	20- 98 300	<0.5-510	0.2-504	4-5750		<10-33 000			<2-52		0.5-26
Eustace	1974	Elasmobranchii (6 spp) Holocephali (1 sp) Teleostomi (22 spp)	4.1-9.6 5.0 (6.7) 5.0 -146.7	<0.05 <0.05 <0.05-0.3		<0.25-1.0 (4.3) 0.4 (3.6) <0.25-9.0 (14.4)	<0.5-1.6 <0.5 (0.6) <0.25-15						
Bloom	1975	Teleostomi	3.04-34.2	<0.01-0.07	0.39-1.01	0.48-1.22				3.34-12.51			
Eustace	1974	*Ostrea angasi* *Mytilus edulis*	5657.0 45.8	10.7 5.5		57.9 3.1	2.5 2.5						
Bloom	1975	*Ostrea angasi* *Mytilus edulis*	24-6450 9-602	0.1-25 0.2-5.3	0.08-1.85 0.02-1.3	0.1-158 0.9-14	0.4-259 0.3-9.8	<0.1-73 <0.1-78	3-1-107 12-214		0.6-0.9 <0.1-0.8	0.1	0.1-3.1 <0.1-3.3

The values are given in µg /l. for water, µg/g for sediments and ppm wet weight for finfish and shellfish, unless otherwise stated. The DOE sources of levels of heavy metals in surface waters are the ranges taken from results tabled in DOE Annual Reports 1972 - 1989.

However it is evident that more work in this area is needed with regard to the current cocktail that makes up the waters of the Derwent estuary.

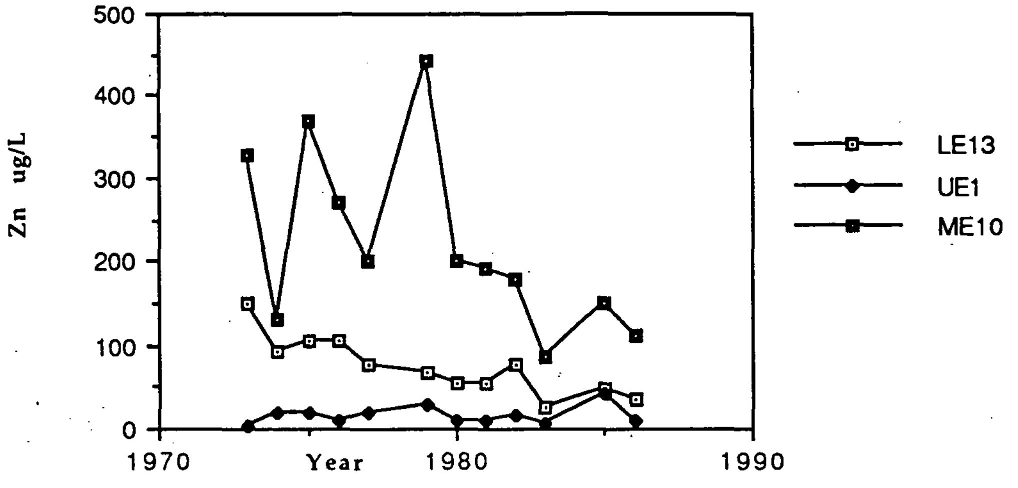
2.2.1.1 Surface waters

The ranges shown in Table 2 do not indicate a pattern of increase or decline in heavy metal concentrations in the surface waters of the estuary. The average yearly values for each of the 14 sampling sites aforementioned was given in the DOE Annual Reports from 1972-1986.

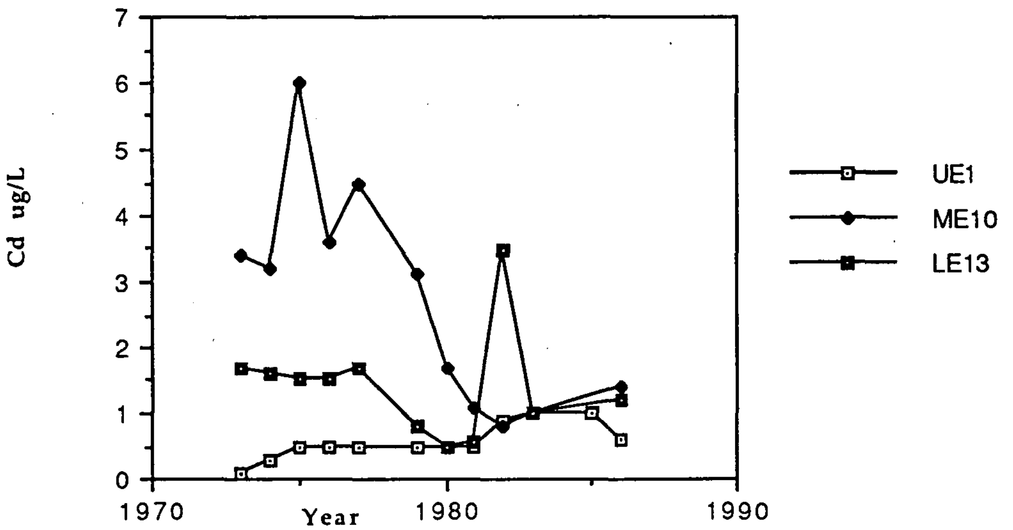
In order to determine if aqueous metal levels were reducing in the estuary over the years of DOE monitoring, average metal concentrations gained over twenty years from three of the DOE fixed monitoring sites were graphed. The three sites were chosen to represent the upper, middle and lower reaches of the estuary. The data used was taken from the DOE Annual Reports 1973-1986. Each of these reports contained average results of a year's monitoring for aqueous heavy metals, zinc, copper, lead, cadmium, and mercury.

The legend in Graphs 1-5 refers to to 3 site numbers UE1, ME10 and LE13. The initials refer to the location of the site in the estuary, ie UE - upper estuary, ME - middle estuary and LE - lower estuary. The numbers correspond to the numbering of sites shown in Figure 6. UE1 is at Lawitta, north of New Norfolk, and according to Thomson and Godfrey (1985) and Davies and Kalish (1989) it is beyond the influence of the salt wedge. It is assumed that the water at this site is fresh and levels of metals should be akin to background levels. ME10 is adjacent to the Tasman Bridge in the middle of the estuary. LE13 is near Cartwrights Pt on the western shore of the river. As expected the lowest concentrations of metals were in the upper estuary, the highest in the middle estuary , closest to EZ, lessening as the estuary widens and increases in depth.

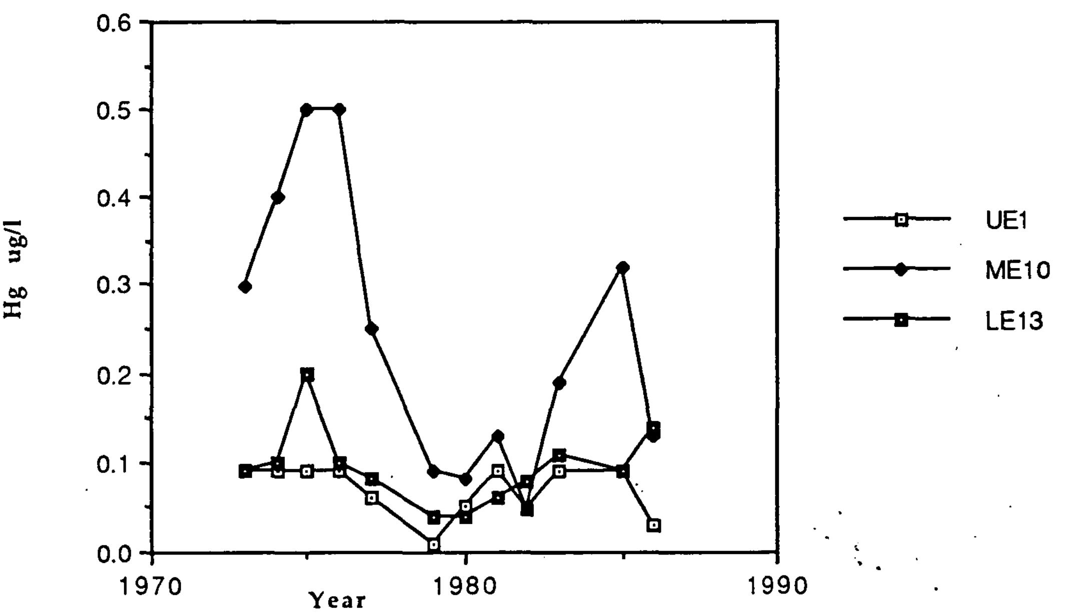
1. Average zinc concentrations in water taken from 3 DOE fixed monitoring sites representing the upper, middle and lower reaches of the Derwent estuary.
Data taken from DOE Annual Reports 1973-86.



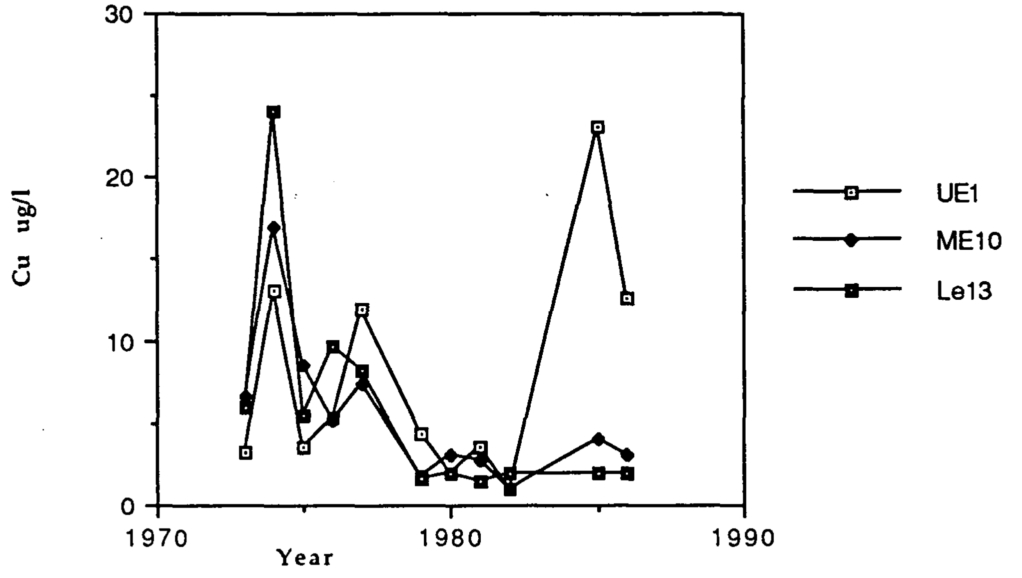
2. Average cadmium concentrations in water taken from 3 DOE fixed monitoring sites representing the upper, middle and lower reaches of the Derwent estuary.
Data taken from DOE Annual Reports 1973-86.



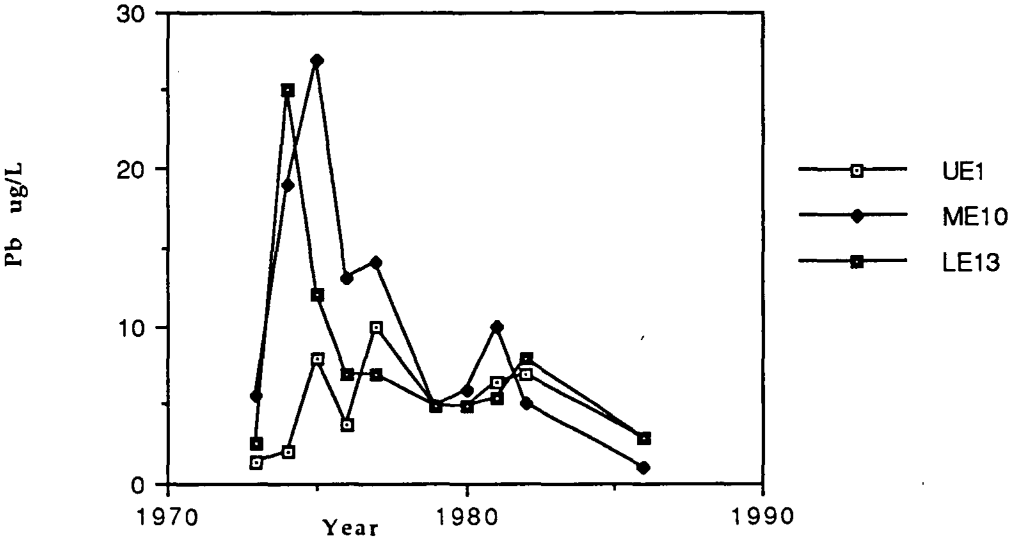
3. Average mercury concentrations in water, taken from 3 DOE fixed monitoring sites representing the upper, middle and lower sections of the Derwent estuary.
Data taken from DOE Annual Reports 1973-86.



4. Average copper concentrations in water, taken from 3 DOE fixed monitoring sites representing the upper, middle and lower reaches of the Derwent estuary.
Data taken from DOE Annual Reports 1973-86.



5. Average lead concentrations in water, taken from 3 DOE fixed monitoring sites representing the upper, middle and lower reaches of the Derwent estuary.
Data taken from DOE Annual Reports 1973-86.



There is a clear downward trend for most metals at the 3 sites, although the early 80's show a sharp increase, followed by a sharp drop the following year. These trends should be treated with considerable caution, as the methods used to calculate them take no account of whether sampling strategies and analytical techniques were kept at a constant. Altered patterns of effluent release have also occurred over the period. Also for some of the metals the downward trend has only occurred for 2 or 3 years and this may not be a long enough sampling time to reach any meaningful conclusions.

Zinc

Zinc values at the site in the middle estuary in Graph 1 show a series of peaks and lows until the late 1980's, when values show an overall marked decrease. At the lower estuary site there appears to have been a steady decrease since 1973, from about 170μg/L to less than 50 μg/L in 1986. The site above New Norfolk Bridge had consistently less than 50 μg/L over the 23 year sampling period.

Many of the highest concentrations found for zinc in surface waters over the years have been in the upper estuary near the Boyer mill, rather than near EZ as one would expect. The flow of salt water up the western side of the river possibly carrying aqueous zinc upstream plus the use of zinc in the pulp mill operations may account for this anomaly.

The range of values in Table 2 (Bloom 1975) are markedly higher in the upper register than those recorded by the DOE for the same year. The range of values for Bloom's work were taken from his original data, whereas the DOE values are averages from the year's sampling. Bloom also sampled 51 sites as opposed to the DOE's 14 sites.

The point source standard for zinc is 5.0 mg/L (5000 μg/L). This standard has been consistently exceeded by EZ since its inception, hence the high levels in receiving waters. In recent years, EZ has been upgrading its plant to comply with standards and to become more commercially viable. It appears that zinc levels are dropping in accordance with this work.

Cadmium

In the case of cadmium the point source standard is 0.01 mg/L (10μg/L) or 0.03 mg/L (30 μg/L) for a metallurgical industry such as EZ. There are three readings that are close to, or above the standard (9.4-15 μg/L). These occur in 1975 and 1977. These levels were recorded in receiving waters, not at point source.

Graph 2 shows a marked decline in cadmium levels at the middle estuary site since 1975 (6 μg/L), with the lowest level being reached in 1982 (0.079 μg/L). Since then levels have increased slightly (1.4 μg/L in 1986). The lower estuary site shows a steady cadmium level of just below 2 μg/L until the late 1970's where there is a drop to below 1μg/L for 3 years. In 1982 there was a sharp rise for no apparent reason, which was not repeated the following year. Levels returned to much the same as they had been in the early years. The upper estuary site showed a steady increase over the years from very low levels to almost 1 μg/L. The final average given in 1986 , showed a decrease again for the upper estuary, but the other 2 sites were indicating a slight increase in levels. Again no firm conclusions can be drawn, as more data is needed to determine if concentrations have levelled off, increased or decreased since 1986.

Mercury

The point source standard varies according to the type of industry involved. For general effluent from small industry or sewage outfalls it is 0.002 mg/L (2.0 μg/L); for pulp mills (ANM Boyer), the standard is 0.005 mg/L (5.0 μg/L), and for metallurgical industry (Pasminco EZ) it is 0.01 mg/L (10μg/L). The highest concentration of mercury in the estuary was 16 μg/L recorded by Bloom (1975) at a site adjacent to EZ, which is above the standard for point source emissions from a metallurgical industry. Again these levels exceeding the standards are recorded in the receiving environment and the standards relate to point source emissions. This most contaminated Derwent estuary water contains the same mercury concentration as the top 12% of the most contaminated industrial discharges in the United States (Bloom and Ayling 1977:13) However, in general mercury concentrations in the water of the Derwent estuary average between 0.05- 0.4 µg/L in the receiving environment.

Graph 3 shows that mercury levels over all sites have dropped, risen again, and may now be dropping again. The levels at the upper estuary site dropped from just below 0.1 µg/L to almost zero, then rose quite sharply to previous levels. In 1986 the concentration are dropping again. The middle estuary site again showed the highest concentrations, although nowhere near the levels found by Bloom (1975) near EZ. Bloom found levels in the same area as site ME10 to be 0.53 µg/L which corresponds with DOE averages for the same year. There was a sharp increase in levels from about 0.05 µg/L in 1982 to 0.2 µg/L in 1983 to 0.35 µg/L in 1985. However there was another sharp drop in 1986, so concentrations could again be decreasing. The lower estuary site has a low range of changes in mercury concentrations from between 0.05 to 0.2 µg/L, with most levels being between 0.05 and 0.1 µg/L. However levels have been increasing steadily since 1980 and in 1986 were around 0.15 µg/L.

Copper

Copper concentrations have varied considerably at the upper estuary site, suggesting a possible source close to the site. The greatest variation occurred between 1982 when the average concentration was about 1µg/L and 1985 when there was a sudden 25-fold increase. In 1986 the level dropped to about 12 µg/L. This is particularly noticeable , because the other 2 sites show consistently lower concentrations of copper than the upper estuary site from 1977 onwards, at which time both sites show a decrease in copper levels to below 5 μg/L.

Lead

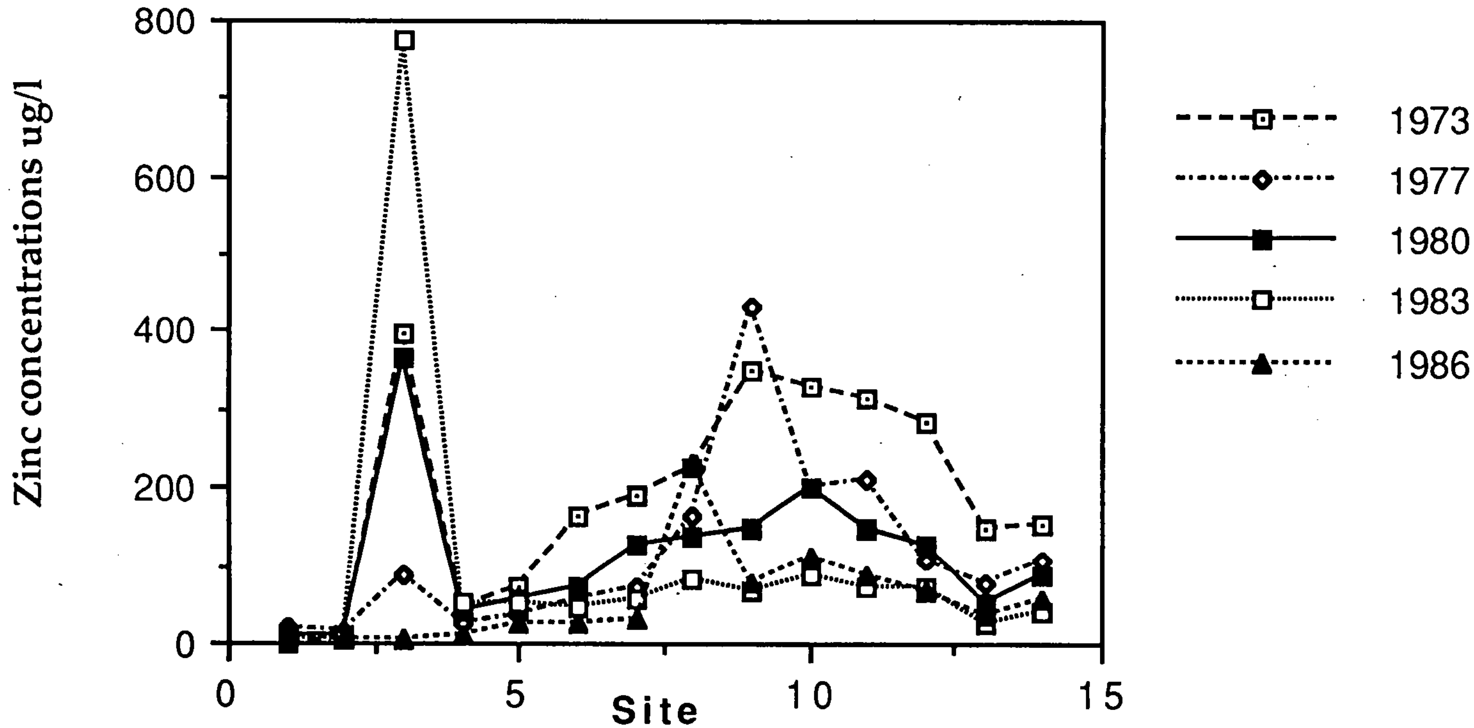
Lead levels at the upper estuary site rose to a peak of 10 μg/L in 1977 then dropped to around 5 μg/L and has remained at about that average concentration since. Concentrations of lead rose sharply at both other sites from around 5μg/L or less in 1973 to a peak of >25 μg/L for both sites in 1974 and 1975. Then both experienced a sharp drop to < 10 μg/L with in 2 years and all sites recorded <5 μg/L in 1986. It appears that lead is the only heavy metal that is decreasing in all parts of the estuary, although samples were not taken between 1983-5.

Graph 6 was done for just one metal over all the sites to confirm the results shown in the other graphs. Apart from the site near the ANM Boyer outfall in several years which shows higher levels of zinc than near EZ Risdon, the pattern of low metal levels in the upper estuary, high in the middle and decreasing towards the lower reaches of the river is confirmed, at least for zinc. The levels of aqueous heavy metals seem to be diminishing, but this apparent trend needs to be confirmed. A repeat of Bloom's heavy metal survey (1975) has been conducted, but has yet to be interpreted.

2.2.1.2 Sediments

Bloom and Ayling (1977) claim there are no known natural sources of lead, zinc, cadmium and mercury in the catchment area of the river. The HECEC/TASUNI sludge study (1989) claims that heavy metals in sediments can be classed in two categories when compared to levels in average soils. The first category refers to those metals that are less in river sediments than in soils and the second refers to copper, cadmium, lead, and zinc, the highest concentrations of these being respectively 300, 100, 2000, and 15 000 times greater than in average soils (HECEC/TASUNI 1989).

6. Average zinc concentrations over the years from DOE fixed monitoring stations as shown in Figure 6.



The relationships between organics, heavy metals and physicochemical properties of the aquatic environment are currently being investigated in Tasmania by CSIRO as most of the State's main river systems are contaminated by heavy metal pollution.

Mercury

The concentration of mercury usually found in uncontaminated sediments was about 0.02 μg/g (Bloom and Ayling 1977:10). The highest level found in the Derwent estuary was 1130μg/g in 1975 (Bloom 1975), at which time mercury concentrations in the sediments near the EZ plant were higher than those recorded anywhere else in the world apart from Minimata Bay in Japan. In 1988 levels found in sludge in the upper estuary ranged from 0.2-540 μg/g (HECEC/TASUNI 1989) showing levels to be still very high.

Cadmium

Similar results were found with cadmium in sediments. Compared to other sites around the world known to be contaminated with cadmium, the sediments within the vicinity of EZ in the Derwent estuary were significantly higher. For example the highest concentration in the Derwent was 862 μg/g. The highest concentration found from a literature survey included in Bloom's study (1975) was 363-382 μg/g at a mine site in Japan. Background levels of about 1 μg/g were found upstream of Bridgewater. The HECEC/TASUNI study (1989) found the higher cadmium concentrations were about half as much as Bloom found (510 μg/g).

Zinc and lead

Extremely high levels of zinc and lead were also found. Sediments adjacent to the EZ wharf contained over 4% lead and 10% zinc while high concentrations of lead and a level of 1% zinc were found throughout midstream sediments as far down the river as the Tasman Bridge. Significant levels of all metals were found in the sediments as far down the river as D'Entrecasteaux Channel (Bloom and Ayling 1977). The highest zinc level found, nearly 15 years after Bloom's report, showed a relatively small decrease in zinc from 104 000 µg/g (Bloom 1975) to 98 300 µg/g (HECEC/TASUNI 1989). Lead and nickel also remained much the same at highest concentrations (see Table 2).

Sludge was found to contain toxic levels of methane and hydrogen sulphide and several heavy metals (see Table 2) which were bound to organics, in a non-volatile form (HECEC/TASUNI 1989).

The heavy metal content of the sediment samples taken by HECEC/TASUNI (1989) show that the concentrations of heavy metals remain high. The highest copper levels had increased fivefold (from 1310 µg/g to 5750 µg/g) and those for chromium had decreased considerably, probably due to the closure of all but one tannery in the area (Brett pers. comm. Feb. 1992).

A study by Wood (1988) of Lindisfarne Bay an area of the Derwent estuary used a radiotracer technique to date the sediment. He found the rate of sedimentation to be in the order of 2-4 cm per year. By dating the sediments he was able to determine if there had been changes in heavy metal concentrations after the introduction of a metal recovery process by EZ in 1974, which, it was claimed, reduced the discharge of metals by 80%. Levels of heavy metals found in the sediments were indeed found to vary according to depth. The higher levels were detected in deeper sediments and around about a depth of 0.5-0.6m heavy metal concentrations decreased, suggesting an association with the introduction of new technology at EZ and the move to ocean dumping of jarosite waste (Wood 1988).

Sediment samples taken since Wood's study and in different parts of the estuary have not dated sediment so it is difficult to determine if the levels of heavy metals are in fact diminishing in the sediment that is accumulating now, or whether metal-laden sediment is being transported around the estuary. The HECEC/TASUNI study (1989) claimed high levels of metals in the top 1m of sediment around Bridgewater and Austins Ferry, with deeper sediments containing levels akin to average soil concentrations. The rate of sedimentation is also unknown in other parts of the estuary. Lindisfarne Bay the area of Wood's study was observed to be accumulating sediment quite rapidly, but the rate mentioned above is not necessarily representative of the whole estuary. In all probability there are areas where existing sediment is being scoured and deposited elsewhere. The transport of sediments and the pollutants contained therein is poorly documented at this point in time, although studies underway to examine the sludge problem may shed some light on this area.

2.2.1.3 Aquatic biota

Heavy metals are known to have lethal and sublethal effects on aquatic biota. A variety of factors influence the toxicity of metal on an aquatic organism. These include the chemical form the metal takes; the presence of other metals, salts and other substances; environmental factors, such as temperature, salinity, dissolved oxygen, pH and so on; the condition of the organism, its life stage, history, size age , acclimatisation and so on (Connell 1981).

Fish and shellfish were tested for heavy metal content in 1972. This was a result of the Ralphs Bay oyster incident aforementioned which sparked a series of scientific investigations into the state of finfish and shellfish populations in Tasmanian waters and the Derwent estuary. CSIRO carried out two studies in 1973 at the request of the Australian Fishing Industry Council to ascertain whether any of the fish commonly caught in the Derwent estuary contained such concentrations of heavy metals as to prohibit them from being sold. One dealt with most commonly found heavy metals except mercury (Eustace 1974). The other study using the same samples, dealt exclusively with mercury (Ratkowsky, Dix and Wilson 1974).

The samples of shellfish and finfish were collected and caught by a professional fisherman systematically fishing the 64 chosen sites over an 8 week period in the 1972-73 early summer.

Eustace's study (1974) included objectives to establish the levels and ranges of each of the metals in the different species of fish, and also to determine the effect of the metals on different species according to their size, stage of development, and habitat. These factors had been reported to influence the level of metals in fish.

Thirty-nine marine species were obtained from the river and analysed for zinc, cadmium, copper and manganese. The finfish were only tested in the muscle tissue to determine whether or not the parts eaten by humans contained levels of metals higher than the levels permitted by the Tasmanian food regulations of the time (Public Health [Food and Drug Standards Regulations] [1971]). The fish were found to contain levels of zinc, cadmium, and copper well below the maximum levels permitted. Manganese was also low. There were some small differences in levels of zinc and copper between the species of finfish which was attributed to feeding habits. For instance, pelagic feeders had slightly lower levels than those that fed on the bottom. The food of the latter group is more likely to be enriched with heavy metals than the former, particularly those species that ingest sediment.

The results of the study were presented in two tables. The first table contained finfish of the classes Elasmobranchii, Teleostomi and Holocephali, which were caught at three or more sites. Most of these were commercial species, such as flounder, trevalley and Australian salmon. The second table contained the species of finfish of which only one or two were caught during sampling, and the mollusc and crustacean samples. Because the metal concentrations were not normally distributed it was decided to use the median value as an estimate of the central tendency as calculation of a mean would have given an estimate considerably higher than the concentrations found in the majority of the samples (Eustace 1974). The highest value in Table 2 (Eustace 1974) for zinc (146.7 ppm) relates to a non-edible species where the whole fish was homogenised because of the impractibility of filleting it. The National standard for zinc in fish is 150 ppm wet weight but this applies only to the part to be eaten. Most species were well below this standard.

Two mollusc species commonly eaten, the native oyster (*Ostrea angasi*) and the common mussel (*Mytilus edulis*), both contained much higher levels of all four metals. The levels of zinc (5657 ppm and 45.8 ppm respectively) and cadmium (10.7 ppm and 5.5 ppm) exceeded the maximum levels specified by the food regulations at that time, which were : zinc 40 ppm, cadmium 5.5 ppm. Due to further research into the toxic effects of zinc and cadmium on humans, the NH&MRC recommended that the maximum permissible level for zinc in oysters be increased to 1000 ppm and reduced for cadmium to 2 ppm (Eustace 1974,). The average levels of zinc in oysters were found to be around 1000 ppm in areas around Tasmania where there was very little human impact on the environment. It was considered that this was the natural background level needed by oysters to balance the effects of calcium in their tissues (Thomson 1979).

Bloom (1975) also found very high levels of zinc and cadmium in shellfish. The results from the two studies shown in Table 2 vary widely because they represent different ranges. The figures given from Eustace's survey (1974) are ranges of median values for the families of finfish and species of shellfish. The results from Bloom's survey are ranges from the lowest to the highest value taken from his original data, hence the dramatic differences. The two lots of figures together give a relatively clear picture of the degree of heavy metal contamination in shellfish.

In the study by Ratkowsky, Dix and Wilson (1974) it was found that position in the food chain was an important factor in the concentrations of mercury in the fish sampled. Approximately 51% of individuals of species whose diets consisted of other fish had mercury contents over 0.5 mg/kg. (This was the National Food Standard at the time. The Tasmanian standard was 1.0 mg/kg. Tasmania now uses the NHMRC Food Standards Code 1987. The standard for mercury content is still 0.5 mg/kg). By contrast 24% of invertebrate predators and only 7% of individuals of herbivorous species had mercury concentrations higher than 0.5 mg/kg.

These studies showed that shellfish throughout the estuary were unfit for human consumption, while finfish were within standards but to be treated with caution. Davies and Kalish (1989) found that fish in the upper estuary consistently exceeded the" safe" level for mercury, causing a potential risk to 5% of the fisherfolk fishing that part of the estuary, as fish made up a large percentage of their diet. 85 kg of mercury was still released from ANM per year. Seventy-five percent of fish sampled had a mercury content >0.5 mg/kg. Significant bioaccumulation was occurring. The high sludge sediment bacterial activity generated methylmercury, which was mobilised under low oxygen and high sulphide conditions into the water column and became available for uptake. The distribution of mercury residues in "sludge" indicated that material released in the past from the Risdon zinc works and ANM Boyer continued to be a problem.

There is little specific information on the sub-lethal effects of metals on the fish or the effects on populations and species diversity in the Derwent estuary, although there are studies that have been done in other parts of the world that supply general information. Connell (1981) provides an overview of the toxic effects of heavy metals on aquatic biota. In general the invertebrate groups Crustacea, Mollusca and Annelida are sensitive to heavy metal pollution, whereas Hemiptera, Arachnida and leptocerid trichopteran larvae seem to be highly tolerant. Population levels change and a drop in species diversity and abundance can occur.

The examples given by Connell (1981) most relevant to the Derwent estuary are : zinc salts are toxic to the larvae of a variety of Australian aquatic animals in concentrations of 0.1 ppm to 11.0 ppm. Copper salts can kill fish at 2 ppm. Sublethal effects caused by cadmium include gill damage in the shrimp *Paratya tasmaniensis,* In a species of freshwater amphipod reproductive success and population viability was harmed at 1 µg/L , somatic growth and a decrease in food consumption occurred at 5-6 µg/L and generally low concentrations of cadmium caused a significant decrease in locomotory activity. Low levels of cadmiumaffects the feeding behaviour of Galaxiids, a native fish species and seemed to prevent them forming into schools which makes them vulnerable to predation.

The highest levels of heavy metals were found world wide in the early 1970's as the extent and nature of the health risks of pollution became known. For example after the cause of Minimata disease became known, the Great Lakes in the USA and Canada, were checked for heavy metal levels and several closed for fishing because of the mercury content of the fish. Since then efforts have been made (at least in developed countries) to reduce heavy metal emissions from industry and mining (Connell 1981).

EZ have installed various pollution control and efficiency measures that have significantly reduced heavy metal inputs into the Derwent estuary. These measures have included a contaminated water system, which recycles the water to different parts of the plant after heavy metals and suspended solids are settled out. The solids are siphoned off and returned to the plant. An effluent treatment plant to treat material that cannot be recycled has also been installed. "From all these endeavours the losses to the Derwent have been reduced by approximately 95%" (EZ 1985:31). Further modernisation projects are taking place to increase production, but also to maintain and improve pollution control measures. Part of this is a new effluent treatment plant , which "will bring levels of all contaminants in effluents to the Derwent River from the Risdon Plant below the limits specified in the

Tasmanian Environment Protection (Water Pollution) Regulations. Thus the current Ministerial Exemptions, under which the plant , (along with other industries and Local Government) is operating, will no longer be required" (Pasminco Metals-EZ Information Brochure 1989).

2.2.2 Sewage

Sewage effluent has caused problems in many estuaries around Australia and in other parts of the world for many years. Sewage has also been utilised by many peoples throughout the world as fertiliser and to generate energy. In Australia sewage is largely a wasted resource, although in South Australia and Victoria primary treated wastewater is being used to irrigate tree plantations. Waste water can also be used to water parks and sports fields, fodder crops, pasture and turf farms (Scott and Furphy 1990) It can be used in industry for various processes that normally use potable water. For example, EZ Risdon were negotiating with the Hobart City Council to use some of the wastewater from Selfs Pt STP and a news report recently about the development of a process to reuse slag from steel works at Port Kembla claimed the process would use wastewater from sewage treatment plants.

However using wastewater in the manner described above is currently the exception. In Australia, as in much of the western world, waste from domestic and industrial sources is mixed with potable water, pumped to a sewerage treatment plant, where it undergoes some form of treatment before the liquid waste is expelled into a natural water body. Sludge, a by-product of the treatment is disposed of elsewhere. In Hobart sludge is dried and used as landfill or is dumped on the tips (Scott and Furphy 1990). In light of the potential usefulness of much of the waste and the increasing demands on potable water resources, it seems a very wasteful operation, especially as approximately 10 L of water is used with every toilet flush (Crennan 1991). Apart from this aspect, the effluent emitted into lakes, bays, estuaries and oceans can contain excessive nutrients, high BOD levels, high NFR levels, high concentrations of faecal coliforms and, depending on the application and type of disinfectant, the possible formation of organochlorine compounds. Ecological and economic damage has occurred on the Great Barrier Reef in Queensland, where excess nutrients from sewage are killing coral and in the Georges River in NSW oyster farmers have on occasions been unable to harvest and sell their oysters due to contamination by sewage. There are hundreds of examples like those above of ecological damage, economic loss and human health risks relating to sewage effluent. Currently in the Derwent the most obvious result of sewage effluent is the risk posed to human health during swimming and other forms of recreation..

Over the years as the population inhabiting the banks of the estuary has grown, the capacity of the existing sewerage works has been stretched and in some cases exceeded. The focus of most Councils, has been to provide sewerage services to new subdivisions and to patch up the older works to cope with increasing demands. The newer plants, usually small ones built to secondary treatment level also need upgrading to cope with increased suburban development. Councils argue that their small capital base makes it impossible for them to provide adequate sewage treatment without help from the State Government.

In 1977 the Derwent River received effluent from 17 sewerage treatment plants. Four of those were to secondary level, the rest were primary treatment or no treatment at all. Most sludge was disposed of on land, although sludge from Sandy Bay (no treatment), Rosny (primary treatment), and Taroona (secondary treatment) was disposed of in the estuary. Primary treatment was considered unsatisfactory because of the high grease content which was aesthetically unpleasing and the high bacteriological concentrations would need heavy chlorination, which would add to the toxic load (Scott and Furphy 1977).

Many small industries were connected to wastewater treatment plants which were exempted from limits at that time. This was considered to be an unsatisfactory situation, as industry could use the treatment works as a means to dispose of untreated toxic waste, upsetting both the biological treatment process and the quality of the receiving waters. All industrial waste in the Hobart municipality was found to be connected to sewerage treatment facilities. However in the Glenorchy municipality some of the smaller industries were connected, some not, and none of the large industries were connected (Scott and Furphy 1977).

Three new treatment plants were considered at this time. Some other treatment plants discharging into the estuary at Rokeby, Rosny, and Kingston would be phased out, and raw sewage from Sandy Bay would be pumped to Taroona and treated there. Sludge from all plants was to be taken to a Regional Plant at Prince of Wales Bay for dewatering. Treated effluent in all instances was to be discharged "into estuaries, bays, and rivers". It was considered that the emission limits could be "easily achieved" using current technology, and that there would be a need for more stringent emission controls in the future so that existing limits should be regarded as an interim measure. The small capital base of the municipalities meant that secondary treatment could not be attained in all treatment plants until 1988-1990 (Scott and Furphy 1977).

There are now 14 STPs discharging waste into the estuary. In 1989 Ministerial exemptions were current for 7 STPs . Scott and Furphy completed another study in 1990 (Scott and Furphy 1990). They found much the same situation that they had found in 1977. The focus of the second report was each plants compliance to Tasmanian standards for BOD, NFR, and faecal coliform emissions in sewage effluent. The standard for BOD emissions is 20 mg/L ; for NFR the standard is 30 mg/L (or 60 mg/L where the lowest flow rate of the receiving waters is at least 50 times greater than the rate of flow of the emission) and for faecal coliforms being discharged in emissions into bays and estuaries the standard is 1000/100mL (*Environment Protection (Water Pollution) Regulations 1974*).

The total BOD load for the estuary from the combined sources of industrial and domestic waste has been calculated as 32 257 kg/d . The amount from sewage outfalls totalled is 9057 kg/d. This amounts to approximately 19% of the BOD entering the estuary from industry and domestic waste per day. The greatest contributor of BOD is ANM which contributes 73% (Scott and Furphy 1990).

Similarly the total NFR load from domestic and industrial wastewater is 52 855 kg/d. ANM Boyer contributes 48 000 kg/d NFR which is about 91%. The total NFR from STPs is 4455 kg/d, which is about 8% of the total from these sources (Scott and Furphy 1990).

Put in this context the STPs combined do not appear to be much of a problem. However they cause localised pollution in many bays and high faecal coliform counts have rendered many areas unfit for primary contact recreation and in some cases secondary contact recreation.

Scott and Furphy (1990) checked all STPs for compliance to standards. They found plants at New Norfolk and Bridgewater had vastly improved since 1977, although the Bridgewater plant was overloaded and could not comply to standards all the time. In the Hobart municipality, Selfs Pt complied to standards most of the time, but could not handle shock loads or a large input of industrial waste which it was required to do. Macquarie Pt had a ministerial exemption, but was about to complete secondary treatment facilities. Sandy Bay was still untreated and had a ministerial exemption for all standards.

In the Clarence municipality, three sites had ministerial exemptions, but Rosny was in the process of upgrading to full secondary treatment. The other sites were Tranmere, a relatively new subdivision with septic tanks draining into the estuary, and South Arm, another septic tank area. Risdon fully complied with standards for BOD and NFR, but was exempt from standards for faecal coliforms. Rokeby complied most of the time to BOD and NFR standards.

In the Glenorchy municipality, Cameron Bay complied with the standards for BOD and NFR, but were exempt from standards for faecal coliforms. Prince of Wales Bay, one of the largest plants on the estuary, discharging 10 ML/d was exempt on all counts.

In the Kingborough municipality Taroona, a small plant with secondary treatment with disinfectant, did not fully comply to BOD and NFR standards and was found to have a high faecal coliform count despite disinfectant. Blackmans Bay was in a similar situation to Taroona, having secondary treatment with disinfection, but a low compliance rate for BOD and NFR and a very high faecal coliform count (Scott and Furphy 1990).

As one of his first actions in office, the last Minister for Environment and Planning placed a sunset clause on exemptions which allowed Councils to exceed standards with regard to sewage treatment. This was in retrospect an unfortunate move, in the sense that the time limit of 5 years was not derived from any understanding of the amount of work that might be required to comply. The upgrading that needs to be carried out is extensive and costly. The proposals subsequently put forward by the Councils are not necessarily the best, as in some cases they were hastily prepared. If the Minister had worked with the Councils towards planning the best available, cost effective sewage treament then the enormous burden on the ratepayers that will be required to pay for the improvements would be justified and the extra rates payments could be confidently seen as an investment in a future clean environment. If however the plans now in place, are carried out over the next few years still at enormous cost to the ratepayers, such confidence cannot be felt. There is a strong chance that large sums of money will be required again in the not too distant future.

There *was* a need to push Councils to do something. However in this instance the time limit was inappropriate. The time it would take to do the job thoroughly and properly would ultimately pay off, rather than a rush to meet standards that may well be found to be inappropriate in the longer term. Research is needed into ways of using effluent rather than discharging it into the river. In the short term the water quality may deteriorate, but the long term benefits of no sewage effluent entering the estuary must surely outweigh short term temporary gain.

The State Government is reluctant to assist with funds as they think it is a Local Government responsibility. The problem is unresolved, even though the current upgrading underway is partly State funded. The Councils have argued that the funding is inadequate and that the requirement to complete projects by 1994, unrealistic.

All the Councils involved are required to provide full secondary treatment with disinfectant by 1994. The Councils have been given a grant of $10M to share by the State Government. Their proposed expenditure is as follows:
Glenorchy - $10.6M;
Hobart - $16M;
Clarence - $13.6M;
Kingborough - $0.5M (DEP undated).

2.2.2.1 <u>Bacteriological monitoring by DOE</u>

Bacteriological monitoring of coliforms, *E. coli,* and faecal streptococci has been undertaken in the estuary by the DOE since 1974. Ranges of values from the results of this monitoring are shown in Table 3.
It is interesting to note that until 1987 the DOE surveys used their fixed monitoring sites (see Figure 6) which do not cover the most popular primary recreation sites in the estuary, namely beaches near Taroona, Kingston Beach, Blackmans Bay, Opossum Bay, and South Arm. In 1987, a comprehensive bacteriological survey was undertaken by the DOE.

For primary contact recreation the recommendation is that in receiving waters a median value not exceeding 150 faecal coliforms/100mL for a minimum of 5 samples taken at regular intervals not exceeding a month with 4 out of the 5 samples containining less than 600 faecal coliforms/100 mL should be obtained (NH&MRC 1990: Schedule 1).

It can be seen from the ranges given in Table 3 for coliforms, that in some years (1976 and 1985) no part of the estuary monitored was suitable for primary contact recreation with the lower end of the range (570/100 mL and 330/100 mL respectively) exceeding the limit. Many of the other values recorded in the receiving waters during those years exceeded the levels permissible for emission limits. However in other years (1974, 1975, 1977, 1979) the lower end of the range has been well below the limit. This again may be a reflection of the sampling technique as there are no obvious reasons for such wide fluctuations of bacteria counts in the same sites. DOE reports shed no light on the matter, merely noting that the counts are high. High levels are consistently found in the upper estuary near ANM Boyer, Bridgewater and as far down as the Tasman Bridge.

Although counts for *E. coli* and faecal streptococci have been taken and results recorded there is no mention of these bacteria in DOE reports, in the *Environment Protection (Water Pollution) Regulations 1974* or in the NHMRC guidelines (1990).

DOE's bacteriological monitoring programme for 1988-89 showed Prince of Wales Bay and Newtown Bay to be heavily contaminated. Prince of Wales Bay had a median value of 6650 faecal coliforms/100mL of water. Newtown Bay had a median value of 885/100mL.

Table 3. Bacterial levels measured in the Derwent estuary

Author	Year	Medium	Coliforms /100mL	*E. coli* /100mL	Faecal strept. /100mL	Klebsiella
DOE	1974	water	40 - 1800	34 - 1536	20 - 1040	
	1975		60 - 9800	20 - 3800	15 - 115	
	1976		570 - 13 100	150 - 10 500	60 - 960	
	1977		30 - 1500	20 - 1200	2 - 150	
	1978					
	1979		10 - 3700	3 - 1305	2 - 864	
	1980		71 - 3955	4 - 18 500	24 - 231	
	1981		108 - 179 000	5 - 3679	7 - 498	
	1982		91 - 4064	62 - 2292	25 - 308	
	1983		163 - 15 020	40 - 2172	6 - 1528	
	1984					
	1985		330 - 9800	20 - 7480	30-480	
	1986		<100-6000		<10 -2735	
	1987					
	1988					
	1989			<5 - 280		
HECEC/ TASUNI	1989	sediment	<100 - 300 000/g	<5 - 150 000/g		<5 -171.000/g

The sources of DOE scientific data are from the averaged results of water monitoring surveys tabled in their Annual Reports 1974 - 1989.

Other areas to fail the primary contact standard were Elwick Bay, Lindisfarne Bay, Howrah Beach, New Norfolk, Geilston Bay, Kangaroo Pt, Sullivans Cove and Battery Pt. Most of these areas have been accepted by the community as non-swimming areas for years. It has not been publicly questioned whether it is acceptable to have so many potential primary contact recreation areas unavailable. Howrah Beach is the exception. The state of Howrah Beach has been one of the main centres of public concern, along with Nutgrove Beach and Blackmans Bay, the latter areas having failed to reach standards for primary contact in 1987. All have been popular swimming beaches for many years and have only just come under threat. In most cases the high bacterial levels have been related directly to sewage effluent. It is regarded as one of the main problems affecting the recreational value of the Derwent estuary. It may also pose a serious threat to the ecology of the river, although little work has been done in this area in relation to the

Derwent estuary to date. One of the potential threats , mentioned by Scott and Furphy (1977) and by Prof. Harry Bloom (lecture 1990), is the formation and release of organochlorines in sewage effluent due to the use of chlorine as a disinfectant in the treatment process. This practise is increasing in the Hobart area as more plants are upgraded.

2.2.3 Nutrients

Nutrients from sewage, untreated sewerage and from effluent from factories such as ANM Boyer, Cadbury Schweppes and Cascade Brewery are also to be considered. Very few nutrient measurements have been taken in the Derwent estuary to date (DOE 1988). Scott and Furphy (1977) claimed the nutrient levels in the Dewent estuary were very low and that an increase in nutrients may be an improvement.

The DOE carried out two nutrient surveys during the 1987-88 period. This was to test the nutrient levels against the preliminary AEC guidelines which had recently been developed for nutrient levels in ambient waters (DOE 1988). The surveys showed that most sites had nutrient levels below those recommended for recreational waters. Total phosphates at Battery Point and Prince of Wales Bay were above the suggested guidelines to protect recreational waters from nuisance weed growth, and the sum of total nitrogen (nitrate, nitrite and ammonia) in Prince of Wales Bay also exceeded suggested levels (DOE 1988).

The survey was repeated in 1989 and similar results were found. Twelve sites were surveyed. The levels for reactive phosphorous ranged from <5 μg/L to 37 μg/L. For nitrate and nitrite the levels ranged from <5 μg/L to >130 μg/L. The areas with highest nutrient levels were New Norfolk and the two areas mentioned above.

The DOE report states: "Nutrient dynamics in estuaries are complex and there is some difficulty in interpreting these data" (DOE 1989). It was considered that the levels were likely to be low enough to avoid eutrophication. It is evident that more work needs to be done to understand the nutrient dynamics in the Derwent.

2.2.4 General water quality parameters

General water quality is an indicator of the presence and impact of pollutants, hence its inclusion in this section. A number of physicochemical parameters have been measured on an ongoing basis by the DOE and also as part of many other studies (see Table 4) to determine water quality degradation. Those studies relating to the upper estuary found effluent from the ANM Boyer factory to be responsible for the poor water quality in that area. In other parts of the estuary the links have not been made so clearly. DOE reports have not enlightened the readers on reasons for fluctuations in these water quality parameters, nor, in fact, of the significance of their data.

Temperature

Temperature has only been measured in studies of the upper estuary and has been related to dissolved oxygen and salinity. The seasonal temperature varies by about 15°C.

pH

The DOE measured pH for 5 years, then stopped. In the *Guidelines on Minimum Desirable Ambient Water Quality for Receiving Waters in Tasmania* (1986), published to supplement the *Environment Protection (Water Pollution) Regulations (1974)*, the recommended pH level was 5-9 for primary contact recreation and between 6.5 -8.5 for aquaculture in saline waters (DOE 1986: 17&23). In all cases of DOE monitoring pH levels in the estuary the levels were between these limits. Davies Fulton and Kalish (1988) found levels in the water column in the upper estuary of 9.3.

Table 4. Physicochemical parameters measured in the Derwent estuary

Author(s) of study	Year	Medium	Temp.deg C.	pH	DO	Salinity $^0/_{00}$	Conductivity	Secchi disc metres	Turbidity silica scale	Redox	NFR mg/L	BOD
DOE	1972	water column		7.-7.9	62 - 102%			0.9 - 5.0			4.1-32.8	
	1973			7.2 - 7.9	41 - 97%			0.1 - 4.4	2.1 - 71.1		4.5-164	
	1974			7.1 - 8.0	84 - 96%			0.7 - 4.6	3 - 16		6.5 - 50	
	1975			7.2 - 8.0	78 - 109%			1.25 - 4.3	1.2 - 3.6		4.5 - 52.5	
	1976			7.1 - 7.8	94 - 103%			0.55 - 3.6	2.2 - 15.2		15.7 - 38.7	
	1977			6.5 - 7.8	81 - 105%			0.5 - 4.0			3 - 24	
	1978											
	1979				84 - 104%			1.5 - 3.6			1.5 - 9.5	
	1980				74 - 99%			0.5 - 4.0			1.8 - 53	
	1981				88 - 111%			0.4 - 3.2			2.4 - 133	
	1982				79 - 99%			<0.1 - 4.1			2.9 - 92	
	1983				88 - 108%			0.5 - 4.1			2.9 - 88.1	
	1984											
	1985				87 - 110%			0.5 - 3.0			1.8 - 24	
	1986				62.4 - 108.5%			1.0 - 4.0			0.9 - 32.4	
	1987											
	1988											
	1989				6 - 97%							
Bloom & Ayling	1977	surface water		7.1 - 8.0	84 - 96%							
Matthews	1979	water column	4 - 20.5	6.8 - 7.5	0.4 - 13.2 mg/L	0.00 - 30.7					2.5-25	
Davies, Fulton & Kalish	1988	water column		6 - 9.3	5.5 - 12.4 mg/L	0.2 -3.7	415-7400 µS/cm				<5-305	
Davies & Kalish	1989	water column	8 - 18 (saline) 5 - 22 (fresh)		0.1-12 ppm	2-30					<0.5-100	300-400mg/L
HECEC/ TASUNI	1989	sediment	14 - 20	5.6 - 7.4			10.9 - 42.5 mS/cm			- 40 - + 150 mV		

Water column refers to the sampling of surface, mid and bottom waters. These were not done in standard fashion, so each study has taken water from different depths. The source of DOE data is again from Annual Reports 1972 -1989.

This may be as a result of ANM effluent which is known to be alkaline (Davies and Kalish 1989), although the pH for the effluent is not given. It is likely that such a high pH level causes stress to the benthic community at least, as it probably represents close to a hundredfold change from background hydrogen ion levels in the estuary. All DOE pH readings from the upper estuary were within one or two points of 7.

Dissolved oxygen

Dissolved oxygen levels were greater than 75% saturation in most of the estuary, but were low in the upper estuary. The first indication of low levels in the upper estuary was an average level of 41% saturation at East Boyer in the DOE's 1972-73 monitoring.

Matthews (1979) found levels as low as 0.4 mg/L dissolved oxygen in waters in the toe of the salt wedge.

Davies and Kalish (1989), working in the upper estuary found oxygen levels were high in surface waters, decreasing downstream as salinity increased. Oxygen levels in the upstream zone of the salt wedge were low, below 10% saturation at salinities above 20 parts per thousand for around 6 months of the year. Low oxygen conditions were apparent in the upper salt wedge. After major flooding in October 1988 high oxygen levels were temporarily restored in the salt wedge, but decreased over a period of 4 months to extreme minima.

Using these figures from Davies and Kalish(1989) and according to the oxygen level criterion suggested in Alabaster and Lloyd (1982) for most fish populations, the upper estuary for the 25 kms from New Norfolk to Dogshear Pt was suitable for fish life for 8 months of the year, but only above 2m in depth. Oxygen levels were too low to support benthic life from New Norfolk to Bridgewater for most of the year.

Davies and Kalish (1989) suggested that there was strong evidence to continue an arbitrary separation of the upper estuary from the lower estuary (Dogshear Pt and below). The upper estuary was reliant on flows of freshwater for oxygen, whereas the lower estuary gains its oxygen supply from wind-wave action and tidal mixing.

They found that since 1977/78 there had been a significant decrease in DO levels. The oxygen sags at that time were less intense and less extensive, and there had been an increase in estuarine respiration over the 10 years. The isolation of upper estuarine waters under low flow caused a severe oxygen debt in the salt wedge toe from organic sediments. The BOD input from ANM and the estuarine respiratory demand were principal factors controlling the oxygen deficit in the upper estuary, taking 50% of the total oxygen input (Davies and Kalish 1989).

Non-filterable residue (NFR)

DOE monitoring of the estuary for NFR levels has shown them to be over the limit of 30 mg/L (or 60 mg/L where the lowest flow rate of the receiving waters is at least 50 times greater than the rate of flow of the emission) (*Environment Protection (Water Pollution) Regulations 1974*:Regulation 3, Schedule II Part II. 1). Of the 16 readings in Table 4, seven of the higher concentrations considerably exceed 60 mg/L and 12 are above 30 mg/L. These results are from samples taken from receiving waters, so they probably severely underestimate point source emissions. Between 1972 and 1979 the highest concentrations given in the ranges were spread over the estuary and NFR levels were much higher overall.

All of the higher concentrations, after 1980 are in the vicinity of ANM Boyer. The NFR concentration permitted for pulp and paper mill effluent is 200mg/L, hence the higher levels in receiving waters, adjacent to the mill. After 1980, levels throughout the rest of the estuary dropped to consistently low levels more in line with the lower concentrations given in the ranges in Table 4.

Some of the results indicate that dispersal of NFR in the receiving waters of the upper estuary is not very efficient or that the levels being emitted from the mill are higher than those recommended. Both scenarios are likely. Davies, Kalish and Fulton (1988) found that NFR levels were too high for fish populations. The tentative criterion for NFR levels for fresh water fish taken from Alabaster and Lloyd (1982) was 25 mg/L. NFR was found to be high on the northern side of the channel in surface waters. Mid and bottom waters showed higher NFR levels at other locations with channel NFR levels unacceptable for fish populations in most areas of bottom waters below the Boyer outfall.

Secchi disc and turbidity

For primary contact recreation the secchi disc reading must not be lower than 1.2 metres. Twice, in 1975 and 1979 all readings in the DOE monitoring program of the estuary fulfil the primary contact recreation requirement. However only a relatively small proportion of the estuary is now used for swimming and many of the areas fail primary contact recreation on other criteria as water quality in many of the bays is poor due to a variety of reasons Sewage effluent, high nutrients, poor flushing capacity, and stormwater are a few of the most obvious possible causes, but as yet are poorly documented. Work is in progress for Elwick Bay and Prince of Wales Bay, two of the most affected areas. Most of the Secchi disc readings showing low visbility correspond to areas where primary contact recreation does not occur. Most of the lower values were again found in the upper estuary near the ANM mill.

2.2.5 ANM effluent

As can be seen from the discussion on water quality above, one of the most severely affected areas has been the upper estuary. ANM effluent has been the major cause of this degradation (Matthews 1979, Davies, Fulton and Kalish 1988, Davies and Kalish 1989, HECEC/TASUNI 1989).

Biological data was collected in 1976 relating to benthic invertebrate populations in the upper estuary (Matthews 1979). Bioassays to determine the lethal toxicity concentrations and sub-lethal effects of the ANM effluent were carried out on the species *Xenostrobus securis* (a mussel), *Paratya australiensis* (a shrimp), *Potamopyrgus nigra* (a snail), and *Prionospio sp.* (a sandworm). The tests indicated that concentrations of effluent required to kill test animals were much higher than occurred in field conditions. The sand worm was found to be the most abundant organism and was the only one to be found throughout the the study area. Whilst recognising the data were limited, Matthews (1979) claims "this initial aggregate picture of the benthic data suggests a very unbalanced and stressed community with very low species diversity". Wood fibre from ANM Boyer's effluent was considered to have a considerable impact on benthic fauna and to be a major factor causing low DO levels.

Matthews (1979) concluded that the assimilative capacity of the upper estuary may have been reached, if not exceeded and that there was an urgent need to manage and monitor the pulpmill effluent quality. There were also recommendations for further studies, especially those directed towards understanding the mixing and exchange mechanisms, and tidal influences which would allow more accurate assessments of flushing and exchange rates to be obtained.

In 1987 the Inland Fisheries Commission (IFC) undertook a study (Davies Fulton and Kalish 1988) in the upper estuary The aims were to examine the toxicity of the effluent, especially resin acids, to fish residing in, or passing through the effluent outfall with the ultimate goal of providing recommendations for "safe" concentrations of resin acids to protect the fish populations in the long term.

As ANM were to start operation of a new thermo-chemical pulp plant (TMP

No.2) in July 1987 the opportunity was provided to observe any changes that occurred in fish populations after the beginning of operations when the resin acid input into the estuary would increase by 100%.

Fish species in the vicinity of ANM

Davies et al (1988) provided background information about finfish communities in the study area. The area in the vicinity of Boyer had resident finfish and was also described as important for the passage of all migratory fish species in the Derwent which moved through the effluent at various times of the year,

Fish moving through the area included: Sea trout (*Salmo trutta*), Tasmanian whitebait (*Lovettia sealii*), Common jollytail (*Galaxias maculatus*), Tasmanian mudfish (*Galaxias cleaveri*), Spotted Galaxias (*Galaxias truttaceus*), Black bream (*Acanthopagrus butcheri*), Yellow-eyed mullet (*Aldrichetta forsteri*), Short-finned eel (*Anguilla australis*), Pouched lamprey (*Geotria australis*), and Short-headed lamprey (*Mordacia mordax*).

Whitebait (which includes *Lovettia sealii* and galaxiid species) migrated into the estuary for different reasons. The galaxiids came in as young to live in fresh water as adults. *Lovettia sealii* came in as adults in order to spawn. The Common jollytail migrated out of fresh water to spawn on the edges of the marshes in the estuary. Mudfish lived in the marshes below the outfall and probably spawned there. The sea trout fishery depended on populations of whitebait, as whitebait runs stimulated feeding migrations of sea trout during spring.

Frequently, exposure to effluent (which occurred for all mentioned species) occurred at a crucial life stage, such as larvae or spawning adults.

Resin acids

Sampling of ANM effluent before the start of the TMP No. 2 showed resin acid concentrations in the effluent to be 3-4 mg/L. After TMP No.2 started operating resin acid levels rose as expected to 6-7 mg/L. It was found that surface concentrations of resin acids on the northern side of the river were high under all conditions. Only very low incoming tide caused the levels to be high on the southern side. Under all other conditions resin acid levels on the southern side were of little concern to fish. Concentrations were found to be less in the lower part of the water column. Consequently surface resin acid levels were of the greatest concern to fish.

The tentative maximum concentration for resin acids in the water column taken from Alabaster and Lloyd (1982) was 0.05 mg /L. However it was deemed important that toxicity testing for resin acids be carried out on local fish populations rather than relying on safe concentrations from overseas data, as many species in the Derwent estuary were unique to Tasmania or Australia. It was found that the effluent from ANM had considerable toxicity to fish with resin acids being the principal toxic component. Juvenile trout proved to be the most sensitive species tested.

The usual process of determining LC50 values for 96 hours was considered to be inappropriate; rather time independent LC50 values were used in establishing maximum concentrations for the ANM mill because there were no data regarding the exact time various species spent in the effluent plume. Some species may spend a considerable part of their lives there. The recommended maximum concentration was based on a time independent LC50 value for the most sensitive species multiplied by a safety factor of 0.1., and for resin acid in the Derwent River deemed to be 0.02 mg/L. This method is regarded as a fairly crude measure of resin acid toxicity. Richardson (1982) has developed more accurate and reproducible analytical methods, which have been accepted in NSW as the official indicator of purity testing for the Albury ANM plant (Bloom pers. comm. 1991)

Effects of effluent on fish

Fish were netted over a 26 month period, between New Norfolk and Dogshear Pt. Seven species were caught in the vicinity of the Boyer mill with 15 species caught at Dogshear Pt.

Trout showed a distinct avoidance response to the effluent outfall. Feeding was thought to be restricted as a result. Of the trout resident in the area 86% showed fin discoloration and erosion, and 7% carried ulcers or tumours. Sea trout showed a much lower incidence. Ninety-seven trout were caught at Dogshear Point and none had similar pathological conditions.

Whitebait seemed able to cope with effluent conditions. Most were caught on the more polluted northern side of the river downstream of the effluent. Catches in the effluent plume were variable.

No effects of increase in resin acids were observed on larger finfish (trout and bream). Below the point of general mixing both resin acid levels and NFR levels appear to be acceptable for fish passage. Fish avoided the effluent plume using the "clear" southern side of the channel to pass.

The possible effects of effluent were considered to be the pathological conditions of fin erosion. Trout also relied on forage fish as their principal food item. A large proportion of the trout caught had empty stomachs which could indicate a lack of diversity of food caused by poor water quality.

Another study on the upper estuary by Davies and Kalish (1989) picked up on their own recommendations to thoroughly investigate the poor water quality of the upper estuary and to continue monitoring large finfish. During their previous study they had observed low DO levels close to minimum acceptable levels for salmonids, and large quantities of floating organic matter, especially at low tide. These were comprised of masses of fine and coarse decaying wood fibre. They were anoxic and had a high

hydrogen sulphide content. They were accompanied by copious releases of gas from bottom sediments (Davies, Fulton and Kalish 1988). This seemed to correspond with some of Matthews' findings (Matthews 1979).
The report took into consideration the earlier studies in a critical way, building on those areas that were seen to be relevant and questioning the validity of some of the conclusions reached from previous data collected.

The study had five aims, which covered working out the current water quality, looking at previous data, examining historical and current hydrological data to determine changes that had occurred through different uses and providing initial data to construct a simple model for examining the relationship between "water quality, estuarine mixing, the estuarine oxygen budget, and river flows." The report also made recommendations on management directions that would improve the water quality of the upper estuary.

The background information documented the impacts of human activity on the river. The upper estuary being narrow and highly stratified, with limited tidal movement, had poor flushing capability and a long turn over time. This had been exacerbated by modifications to the flood hydrology due to regulation of river flow by hydro-electric storages throughout the period of major organic input from the ANM mill. Thus the flushing flows necessary to shift the organic load had been limited, resulting in a build up of organic matter on the bottom of the river. This incurred a high oxygen demand which exceeded the river's capacity to supply.

<u>Waste water</u>

Davies and Kalish (1989) determined that waste water inputs into the upper estuary were from ANM and two sewage treatment plants located at New Norfolk and Bridgewater. The principal source was ANM which, until late 1988, discharged 100-120 ML/ day of liquid waste containing 80-140 tonnes of wood fibre with typical biological oxygen demand (BOD) levels of 300-400 mg/L. The total oxygen demand on the upper estuary was in the order of

35-40 tonnes/day.

The waste water contained resin acids, chlorine, chlorinated organic compounds, slimicides, dyes, and mercury as well as secondary treated sewage and coke residues. The effluent was hot (up to 65°C) and alkaline. A major proportion of BOD discharged was caused by non-fibrous organic extractive material comprised of various by-products of wood processing such as cellulose, sugars, tannins, lignins, and phenolics. There had been a significant change in emissions since 1988 when a primary treatment plant was installed reducing discharge of suspended material by around 50%. Despite this drop in the discharge of NFR there had been little change in the BOD levels, which had remained about 35 tonnes/day.

The 5 day BOD measurement taken for the Department of Environment and Planning to satisfy water regulations took into account only a part of the total BOD of the effluent stream. The 5 day test is based on the assumption that after 5 days the organic material in the effluent released into the receiving waters will no longer demand oxygen from the system. However wood fibre decomposes more slowly than the organic extractives. The implications of this are that the total oxygen demand of ANM effluent had been seriously underestimated as the wood fibre component had virtually been left out of the equation.

A measure of long term BOD which would incorporate total oxygen demand of all waste components had not been taken because there was no legal requirement to do so. It was plain from this that for ANM the 5 day BOD in the form of "maximum theoretical BOD" was unsuitable because the test was inappropriate for the type of waste, and excessive loadings were being permitted in relation to the assimilative capacity of the receiving waters.

Wood fibre is now recycled in the papermaking process instead of being released into the estuary. However 100 000 m^3 wood fibre is still close to the

ANM outfall and around Green Is, so BOD is still high in the area. (HECEC/Aquahealth 1990).

Sulphide

Sulphide levels were high especially in deeper saline water. The levels showed distribution compatible with low oxygen levels.

Recommended maximum levels of sulphide for maintenance of fish and invertebrates were in the order of 0.002 ppm (USEPA). The upper Derwent estuary was characterised by sulphide concentrations over this maximum recommended level at all times.

Levels of > 0.1 ppm caused severe chronic physiological effects in fish, even for short exposure. Levels > 0.5 ppm caused apnea and respiratory arrest; 0.2 and 0.6 ppm had been observed in surface waters during flood times, causing odour problems and a fish kill in the Bridgewater area.

Distinct sulphide odours were noted during the period of maximum flood flows in 1988. Surface water levels at this time were 0.4-0.6 ppm despite >90% oxygen saturation. Testing in the laboratory showed that it took several hours of vigorous aeration to break sulphide down.

Lower levels, likely to cause physiological damage to fish, were widespread throughout the upstream section of the salt wedge for 6 months of the year.

Critical flow events

It was found that there were three critical flow events for the upper estuary. The first, which displaced the salt wedge was a flow above 70 cumec. The second, which was observed by Matthews (1979) and corroborated by this study was that 150 cumec provided a flushing flow which displaced the salt wedge and moved it rapidly downstream within the vicinity of Bridgewater. The third, which was the most important and the one that had been most restricted by river regulation, was a 5 day flood event of 200-300 cumec which completely flushed the upper estuary and removed its oxygen debt. This type of event improved water quality for about 30 days.

The oxygen consumption rate of the organically enriched sediment within the Boyer area due to the 1.5 million tonnes of wood fibre that had been discharged into the river over the past 40- 45 years had to be satisfied before flushing flows were effective. It was estimated that without this benthic demand, 5 day flows of 150 cumec may be sufficient to effectively flush the upper estuary and improve water quality. These events occurred more frequently and were not affected to the same extent by the dams upstream.

Comparison with 1977/78 findings (Matthews 1979)

Contrary to Matthews' idea that wood fibre was settling upstream of Boyer in the toe of the salt wedge, Davies and Kalish found that the velocities of the main channel, even in worst case conditions were strong enough to carry effluent downstream from the mill. Sludge was found in two areas. One was near the Boyer outfall, an area characterised by sluggish backwater flow with low velocity at high tide. The other was in the estuary below Bridgewater, where the channel widened rapidly, and surface velocities decreased to 5-10 cm/sec, as opposed to at least 10-30 cm/sec near Boyer. The bulk of surface transported material moved to below Bridgewater and settled in areas of low velocity out of the main channel.

This scenario does not diminish Matthews' claim that the salt wedge toe was under great impact from the effluent load. It was, but for a different reason.

Sludge

In 1988 after public complaints a limited river bed sampling survey by the DOE found sludge in most of the bays of the mid estuary area. This was followed by a more detailed study (HECEC/TASUNI 1989). This sludge appeared to resemble the floating matter, being "black in colour, fibre rich and gelatinous in texture, and smelt strongly of sulphur."

The types of sediment found were graded into three categories, sludge, intermediate sludge, and non-sludge. The characteristics of sludge were that they had a close to neutral pH, a low solids content, and a high organic content (as noted it was largely composed of decomposing wood fibres). They had no animal life and minimal plant life. The range of microbial life was limited. There were no living diatoms or protozoa, but bacteria were abundant.

The problems of the upper estuary are almost entirely as a result of ANM effluent. In the past few years pollution control equipment has been installed, which enables the plant to be the first large industry on the Derwent estuary to comply with the *Environment Protection (Water Pollution) Regulations (1974)* standards.

2.2.6 Urban runoff

Little work has been done on the impact of urban development on the estuary, although Wood's study of Lindisfarne Bay (Wood 1988) indicates that sedimentation caused by urban runoff is considerable.

He found that Lindisfarne Bay had been changed considerably since European settlement. Within living memory the bay had changed from one "well known for its excellent beaches and clear water" to one that had "become polluted and due to a massive accumulation of sediment the beaches have virtually disappeared." This was due to a number of factors, the most significant being clearing of land for agriculture and subsequent urban development. The original beach areas of the bay are now either reclaimed and turned into a park or covered in a layer of silt and mud about 2m thick.

Agricultural, and later urban, development meant wholesale clearing of land throughout the bay's catchment area. The hilltops which were left as bushland were considered to be a fire hazard so that from 1940 onwards the vegetation was burnt regularly, to avoid wildfire. The practice was replaced in the 1970s by small area controlled burns every few years depending on climatic conditions. The frequent burning exposed fragile soils which were prone to erosion.

It was found that much of the sediment in the bay was composed of run-off from exposed soils, road gravel and garden loam. Other sources of sedimentation were heavy metals from the Pasminco EZ works and sewage effluent which was released into the bay untreated between the early 1940's and 1982, as well as sediment in the river from the whole Derwent catchment.

The study deals with only a fraction of the estuarine system, but indicates the need to include assessment of the impact of urban development in any baseline study of the estuary.

Coleman (1983) also expresses concern that urban runoff is a source of pollutants that are left out in consideration of the management of the estuary. Stormwater was rarely monitored. Types of pollutants were generally similar to those resulting from sanitary wastes. It had been estimated that the run-off from the Hobart Rivulet catchment was equivalent to effluent from a medium sized sewerage treatment plant. After a storm, it was considered that there was an initial high stress period on the receiving waters of the estuary lasting about 30 minutes. The impact of this on the estuary was almost totally unknown. There was a real need for the effect of urban and rural run-off on the water quality of the Derwent estuary to be studied.

Thorp considered the protection of fish breeding grounds to be of major importance (Thorp 1981). These habitats are located in shallow bays (5-10 fathoms) such as Sandy Bay, Kangaroo Bay, and Lindisfarne Bay. As shown in Wood's report (1988) the nature of Lindisfarne Bay has changed considerably due to sedimentation. It is clear from observation of other bays in the estuary where mud has replaced sand on the foreshore that similar change is occurring elsewhere. The effect this has on breeding grounds has not been fully assessed, although it is recognised as a potential threat.

The problems of urban runoff and erosion from urban development and the chemical constituents of stormwater are, by and large, an area of study that has been neglected in relation to the Derwent estuary. The impact of stormwater and increased sedimentation on the estuary is virtually unknown. From observation, stormwater outlets are numerous. Many of the beaches have two or three. These are often small creeks that have been turned into open drains for suburban waste. Fitzpatrick (1982) found 369 effluent outlets along the banks of the eastern and western shores of the estuary between Bridgewater and Howrah Pt on the eastern shore and Blinking Billy Pt on the western shore. There are many more below these points.

Quality characteristics of stormwater in other parts of Australia and the world show that the concentrations and total load of pollutants carried by stormwater is greater than effluent from secondary sewage treatment plants (Cordery 1977). Although the pollution characteristics of urban runoff vary widely there are some common trends: the biochemical oxygen demand (BOD) levels are of the same order of magnitude as treated sewage; levels of suspended solids frequently exceed those found in treated sewage; and many organic and inorganic pollutants found in industrial and domestic sewage are also found in urban runoff (Jenkins 1991).

These general principles are borne out by Cordery's study (1977) of three catchment areas in Sydney. He compared the results of his data with both raw sewage effluent and secondary treated sewage effluent. The mean levels of suspended solids found in the stormwater for the three catchment areas all equated with levels found in raw sewage effluent (about 270mg/L). Mean

BOD levels in the stormwater equated with (18mg/L) or were double (30 and 28 mg/L) those found in secondary treated sewage (16 mg/L) (Cordery 1977).

Nutrient levels in stormwater are generally much lower than those found in sewage, although rainfall events have been found to cause a significant increase in nutrient levels in unpolluted estuaries in South Africa (Emmerson 1989), suggesting that nutrient increases with rainfall are the norm in undisturbed natural systems. It has been found that nutrient export from undisturbed forest appeared to be equal to that entering the catchment during rainfall events (Rosich and Cullen 1982).

Scheaffer (1982) provides a list of pollutants to be found in stormwater, which contains 29 categories broken down into smaller chemical components. Some of the categories which most likely relate specifically to stormwater entering the the Derwent estuary are : Bulk cellulosic matter, eg paper, and tree limbs; natural processed animal fibres; basic soil constituents and inorganic dust falls from air pollutants; phosphate based detergents; roadway and vehicular hydrocarbons, water based paint solutions; animal excretions, human excretions, dead animals, vegetation and some pesticides.

Personal observations show that it is relatively common practice in Hobart for people to wash cars in the street, to empty ash, paint waste, soapy water, dyes, and many other substances into the gutters. A recent survey of small industry adjacent to Prince of Wales Bay found that many were dumping liquid waste into the stormwater drains and were unaware of the regulations governing these practices.

2.2.7 Pesticides

Pesticides are also potential pollutants that have not been monitored or documented to any great extent, although Wood (1988) tested 65 species found in the sediments of Lindisfarne Bay for traces of organochlorine pesticides Dieldrin, Lindane, Aldrin and DDT. These are known to be persistent in the environment, and were used on orchards in the study area before World War II. It was found that the specimens contained less than 0.1 ppm of the pesticides mentioned above. Having concluded from this preliminary study that the sediments in the bay were not polluted with pesticides, no further testing was undertaken (Wood 1988).

There are a number of market gardens close to the riverbanks in the upper estuary and slightly upstream of New Norfolk. There are also other market gardens in the catchment area. The runoff from these gardens and suburban gardens either goes straight into the river or into feeder streams. Gardening is one of Australia's most popular leisure activities supporting a garden product industry worth $1500 million per year (Boughton 1984) which implies that the use of fertilisers and pesticides in the suburban garden is widespread. It seems that more work could be done in this area.

2.3 Conclusion

From the results presented in Tables 2-5 it can be seen that the information concerning the Derwent estuary is scattered. There are areas which have remained virtually unexplored. For example the sublethal effects of the various toxic pollutants on fish populations are largely unknown, as are sedimentation rates and transport around the estuary; nutrient dynamics; the impact of urban runoff and stormwater; the conditions under which release of heavy metals into the water column from sediments is likely to occur; and an inventory of aquatic flora and fauna is needed. Many of the synergistic effects of the various pollutants and their interaction with the aquatic ecosystem also remain to be assessed. Although much information can be gained from literature concerning studies on other water bodies and their ecology and inferences made, there is still a need to understand the Derwent and its ecology more fully.

The limited nature of the data available is illustrated. They are impossible to integrate at any other than the most simple level of description such as is contained above. Chapter 4 shows that the Thames received systematic scientific study to provide the evidence required for prioritisation of contaminants and to determine what action was needed. Certainly, in Tasmania, nothing has motivated the initiation of the type of ecological study that would be required to make decisions about the overall state of the River Derwent. Point source emission standards may have been responsible for some of the changes identified in this chapter, but no one knows because of lack of information. Industry responses with new technology may have had a similar result, but no one can be sure. Nothing that has been done to understand the importance of various kinds of pollutants or to ascertain the quality of the receiving water gives an accurate assessment of the state of the estuary as a whole.

The DOE have been aware of the need for a sophisticated model of assessment since late 1986. In 1988 a firm of consultants was employed to provide guidelines for a baseline monitoring survey (National Environmental Consultancy 1989). However the implementation of this study has not been a Government priority and to date little has occurred. The DEP is now undertaking more specific surveys of the estuary (Bartle pers. comm. 1992), rather than the broad water quality surveys undertaken until 1987, which is a move towards a cumulative database that is of more use than that available to date.

There is enough evidence to show that the Derwent estuary is polluted and that in general the water quality is deteriorating to the detriment of the human population and the life in and around the river. The major sources of pollutants, the types of pollutants, and some of the impacts of those pollutants are known. Many of the areas where more work needs to be done have been identified. Some studies have shown that measures taken by the EZ company to dramatically reduce the output of heavy metals have already had a positive impact on the heavy metal levels found in fish (Cooper et al 1982). Others disagree, having found evidence to the contrary which shows that the influence of heavy metals released into the estuary in the past are still having an effect (Davies and Kalish 1989). There is evidence to show that the health of the fish populations, at least in the upper estuary, is being affected quite significantly (Davies et al. 1988). It would be interesting to know if the abundance and diversity of fish in the estuary has been affected by the pollution levels and to further monitor the health of fish populations.

Invertebrate communities are a valuable source of information. Some work has been done on invertebrate communities in the upper estuary as part of an EIS for a lightweight coated paper mill at ANM Boyer. Unfortunately that information was not available to me as ANM did not reply to a letter the author sent asking for permission for access. However, as the author was involved in the field work, personal observation of the samples of macroinvertebrates showed a very depauperate fauna, the main species being polychaetes, chironomids and snails. Abundance was low and at many sites there was no invertebrate life present. Further invertebrate sampling has been done as part of the Sludge (Phase II) project.

It is possible that invertebrates will be used as indicators of water and habitat quality in the estuary (Horwitz pers.comm.October 1991) and in the event of a rehabilitation programme being implemented could provide a measure of improvement.

Water quality is publicly perceived as being poor, as Winter's survey of fishers showed (Winter 1985). All who tackle the issue (Scott and Furphy 1977, Thorp 1981, Coleman 1983, Hepper and Marriott 1985, DOE 1988, Davies and Kalish 1989), agree that the existing regulatory procedures are inadequate and that they need reviewing and updating in light of evidence that fixed standards applied to point source emissions do not necessarily lead to improvement of water quality, because they do not take into consideration the conditions already existing in the receiving waters. All have blamed this focus on fixed emission standards as the primary tool of management as a major cause of continuing degradation. Davies and Kalish (1989) provide strong evidence to support this showing that although ANM were complying to standards, the water quality of the upper estuary was still deteriorating.

A pattern of interconnections has developed, creating a tangled that is difficult to penetrate. Lack of commitment has led to weakened environment protection legislation with significant loopholes, and institutional arrangements for the management of the estuary that have resulted in a fragmented use of the scientific process. The lack of information and uncoordinated management has created an incapacity for prioritisation for action to occur. Consequently progress is difficult to measure which reinforces the lack of commitment and the whole process recurs. Efforts by single government departments, such as the DEP, to break out of this pattern have been hamstrung by lack of support from other parties involved. These interrelationships are more fully explored in the next chapter.

3. Management issues

3.1 Introduction

There are 4 major issues to be discussed in relation to the management of the Derwent estuary. These are: the plethora of management authorities for the river; the loopholes in the Environment Protection Act 1973; the emphasis on fixed emission standards as the basis of regulation and the poor use of the scientific process. The combined effect is a scattered database and ineffective, haphazard management. Management of the estuary has been about coping with what is already there and trying to work out how to fit all the uses together without affecting existing practices.

Although industry are putting in pollution control mechanisms, they are still disposing of waste into the estuary. This approach seems to rest on the assumption that the current use of the estuary is all right despite the presence of conflicting interests. Visions of a different use of the river in the future are almost nonexistent, or are ignored by those dealing with management. Large amounts of money are to be spent on new infrastructure, but there is no attempt by Councils or the Government to look seriously at alternative technologies designed to remove effluent from the system completely. The notion of aiming for zero impact is not considered, even as a long term goal.

Hepper Marriott and Associates (1985) suggested that all relevant agencies should identify and clarify their goals and objectives for management of the estuary and that there should be more emphasis placed on educating the community with the aim of greater community involvement in management decisions. They suggested that the river and foreshore should be regarded as one interrelated system and that it should be managed in a systematic and coordinated way as a multiple-use resource. Due to its size and nature, and the division of the estuary between various management bodies, it is difficult to view the system as a whole. However there are indications (such as the accumulation of heavy metals in oysters in an oyster farm far from EZ) that this is necessary if the quality of the estuary is to be improved and if uses of the estuary are not to be in conflict. The existing institutional arrangements for the estuary make the coordination of management activities very difficult.

3.2 Management authorities

The current uses of the estuary are as a drain for domestic and industrial pollutants, a port, a recreational and commercial fishery, a tourist attraction, a wildlife sanctuary, a place for family outings and picnics and foreshore bushwalks, for swimming, sailing , canoeing, waterskiing, power boat racing, para-sailing, windsurfing, and rowing. Each of these has a different standard for water quality to allow the pursuit of their use of the Derwent. In any case there seems to have been a strong emphasis on protecting interests which tend to regard the estuary as providing a convenient place to dump waste.

As noted above there are many authorities responsible for aspects of the river, without any of them having the river as the focus of their operations. There are five municipal councils who have responsibility for land management and development around the estuary, including infrastructure, such as stormwater and sewerage treatment facilities. They also have responsibility to monitor bays and beach areas in their municipalities to determine their beneficial use status and to try and maintain primary contact recreation areas by quick detection of problems. The results of this monitoring are passed onto the Department of Environment and Planning and the Department of Health.

Apart from the abovementioned authorities there is the Marine Board of Hobart, which has jurisdiction over all activities on the estuary from low water mark; the Inland Fisheries Commission which is responsible for the aquatic faunal resource above Dogshear Pt. They have particular interest in the water quality of the upper estuary and in recreational activities that take place in that area. The Department of Sea Fisheries is interested in the nurseries for commercial species of fish, the scallop beds (although few are left) and the potential for aquaculture. They are also responsible for conservation of habitat for fish species unique to the estuary. The Department of Primary Industry is also interested in the status of commercial fish stock and nurseries in the estuary, and the potential for aquaculture.

The Department of Parks, Wildlife and Heritage, deals with areas set aside as wildlife sanctuaries and conservation areas and is also concerned with wildlife outside any specified conservation area. They are also responsible for sites of historical interest on the foreshore and for the protection of the aboriginal middens.

There are other government bodies involved as well in a minor capacity, such as the Town and Country Planning Commission, which approves municipal planning schemes; the Department of Mines which has expertise in landslip and erosion problems, which are evident in many areas along the foreshore. Interest in sand mining also arises occasionally. The Department of Sport and Recreation has a direct interest in promoting sporting and recreational activities in and around the estuary, as it is regarded as a prime recreational resource.

The major industries, ANM, Pasminco EZ, and Cadburys, obviously have a vested interest in the estuary , but their main focus is naturally on maintaining efficient and economically viable plants, while attempting to control pollution *as the law demands;* and finally the community groups, such as Friends of the Derwent, sailing clubs, sea scout groups, and progress associations, who all want the estuary available for use.

Policies from federal agencies such as the Department of Arts, Sports, Environment, Tourism and Territories (DASETT) and the Department of Primary Industry can have an impact too. An example is the Resource Assessment Commission's investigation of coastal management currently underway nationally. Guidelines developed from that study, will influence management strategies adopted in Tasmania.

The networking required to coordinate all the responsible authorities and those who have interests in the estuary is complex and time consuming. It does not happen, yet.

Hepper Marriott and Associates (1985) considered that the disadvantages of the system of management as it was in 1985 were seen to be that a large number of agencies were involved in managing bits of the river in isolation from each other, leading to either duplication of effort or single issue management which did not take into consideration the system as a whole. Much of this was caused by lack of communication between groups. There was a lack of political will, demonstrated by a lack of resources, of ongoing monitoring programmes and evaluation of past management decisions. There was little if any public consultation. This was seen to lead to confusion and frustration.

The positive aspects of the situation were "a common desire and willingness to improve the Derwent River." This was considered to be enhanced by the fact that there were no laws stopping better management occurring, and that the expertise and skills already exist within the community. Some work was already being undertaken to improve the situation. This is borne out by the DOE discussion paper entitiled, *Regional Strategy for Environmental Quality Assurance Lower Derwent* (DOE 1988). In the introduction the difficulties spoken of in Coleman's critique (1983) and referred to again in Hepper, Marriott and Associates report (1985) were acknowledged. The report then goes on to suggest that there is no emphasis on ambient environment in the *Environment Protection Act (1973)* and that compliance to standards by single industries does not protect the environment due to the combined effect of effluent entering the water body.

> Unless we in the environmental management business recognise this anomaly in control strategy, we risk condemning future generations to unnecessarily restricted choices in using the natural resources of our State (DOE 1988).

3.3 Legislation

Part of the process of change in the DOE has been a review of the legislation which in its current form is acknowledged to contain serious flaws.

The *Environment Protection Act (1973)* superseded all other Acts which until then had powers to prevent pollution, except the Oil Pollution Act 1961 and the Public Health Act 1962. In 1974 the regulations were set for water pollution control. In theory this should have indicated the beginning of change with regard to environmental damage and pollution control in the Derwent estuary as the Department of Environment had the power to control emissions from the industries polluting the estuary.

The Act contained specific instructions for the municipalities

> It is also the duty of the municipalities to use their powers to prevent or mitigate, so far as is reasonable or practicable, pollution of the environment within their respective municipal districts, to prosecute offenders against any law that assists such prevention or mitigation

> and to proceed by way of action, suit, or other proceeding against persons who so pollute the environment as to become liable to such proceedings.
> (EPA 1973: Part III **12** (5))

This shows the potential strength of the Act, but there are one or two clauses which provide loopholes that have been used consistently to allow the continuation of pollution. In the clause quoted above, the words " so far as is reasonable and practicable" provide a way out of action or prosecution by Councils. Thorp (1981), in looking at management issues concerning pollution and coastal zones and the implication for planning at the local government level, brought attention to relevant sections of legislation, indicating that local government did have power to assist in the prevention of pollution and loss of habitat. He criticised the overlap which occurs between state government and local government responsibilities claiming this had the effect of diffusing the power available but suggested that the Councils have more power than they use.

However the most damaging clause, as far as the Derwent estuary is concerned is the ministerial exemption.

> The Minister may by writing under his hand or official seal exempt any person from the operation of this section in respect of any specified act or course of action (EPA 1973: Part III **15** (7), **16** (5), **17** (2)).

Until recently, this has rendered substantial sections of the Act meaningless for those industries in Tasmania that were perceived to be the backbone of the Tasmanian economy in terms of direct employment and multiplier effects. The cost to the industries to install pollution control equipment would have been substantial, but not impossible, as the present industry efforts in a time of economic recession show.

Coleman (1983) suggested that the *Environment Protection Act (1973)* had failed to have any significant effect on levels of pollution in the estuary.

Sewage related pollution had increased and any improvement was slow. He feared that a real danger existed that the population of Tasmania will be conditioned to accept an estuary which is still very polluted to a level severe enough to endanger human health and cause undesirable changes in the more delicate biological equilibrium.

The ability of the minister to exempt industries from complying to standards and the relatively low profile of the Department of the Environment, due to lack of finance, implied a lack of commitment to serious pollution control by the Tasmanian State Government. The impact of this lack of commitment is clearly illustrated by the comparisons made in Chapter 2 between levels of pollutants in the water column and the standards in point source emissions.

3.4 Fixed point source emission standards

Another major weakness in the legislation is the use of point source fixed emission standards as the major form of regulation.

> The Act has been interpreted as only dealing with point source emission standards and is silent about diffuse sources of pollution. Consideration of the assimilative capacity of the environment has not featured in regulations (Department of Environment and Planning 1991:14).

The practice of standards being set by law was considered too inflexible. The standards provided a minimum level of pollution control that must be reached rather than indicating a maximum level for pollutants that could be released into the system. Once the standard had been reached efforts to further minimise pollution stopped. There was no incentive to lower the concentration of pollutants below the standard even when there was the capacity to do so. This limits the use of policy tools available to the estuarine manager. There can be no negotiation of standards based on the quality of the receiving environment; no pollution budget can be implemented; there can be no incentive for polluters to lower their emissions, as in the polluter pays system; there can be no consensus about necessary action, because all the polluters need to focus on is complying with standards fixed in legislation. They have the legal right to refuse to cooperate beyond the demands of the legislation.

Also point source standards for water quality implied a linear model for water movement. For example metals deposited into the estuary supposedly flow to the sea and are dispersed in the ocean. Estuarine water movement was much more complex and did not fit the linear model at all. Standards for pollutants were even less realistic as there was no mention of the volume of effluent allowed into the system. Thus a small highly concentrated emission was rigidly controlled by the Act, but a large emission using a lot of water for dilution was protected. The latter had the higher pollution load (Coleman 1983). Other criticisms relate to the emphasis placed on point source, rather than the ambient environment (Scott and Furphy 1977).

Point source emission standards are used to control the amount and type of effluent entering the river system. To do this standards have been devised that determine "safe concentrations" of chemical substances. Safe concentrations are determined once the risk of a chemical is assessed.

> Risk is the probability of harm from an actual or predicted concentration of a chemical in the environment. Safe concentrations are those for which the risk is acceptable to society (Cairns 1980: 101).

Currently "risk" generally relates to direct or indirect effects on human health. Much damage can occur to the ecosystem of an estuary before humans are at risk from pollutants. The impact of pollution on the biotic community of the river can be affected by the environmental quality parameters, such as, water hardness, temperature, pH, and dissolved oxygen concentrations which mediate the toxic response. There is also the consideration that some chemicals produce adverse biological effects at concentrations below the present analytical capabilities and toxic chemicals may act differently in combination than they do individually (Cairns 1983).

3.4.1 Toxicity tests - criteria for standards

Safe concentrations of a toxic substance are determined through a series of laboratory tests on living matter. Toxicity of chemical substances can only be tested on living matter.

> This immediately produces both scientific and regulatory difficulties because living material is complex, regionally (and temporally) differentiated, often highly variable, and may act differently in laboratory test containers than in natural systems (Cairns 1983:2).

One of the most debated aspects of toxicity testing is that tests are carried out in a laboratory in carefully controlled conditions on a single species of laboratory animal or plant. The results of these tests are then extrapolated to apply to higher levels of biological organisation such as communities or ecosystems or to the human population. Tests are carried out over a time span of 2-3 years which makes the process of testing enormously expensive and very slow. Wynne (1981) puts the problem in perspective documenting the following details.

1. There are about 7 000 000 known chemicals.
2. Approximately 80 000 are in commercial circulation.
3. Approximately 1 000 new chemicals enter commercial use per year.
4. Using the total of world laboratory resources about 500 chemicals per year could be testable for toxicity (at colossal expense).

The shortcomings of toxicity tests as criteria for setting standards is readily recognised by scientists. Standards are regarded as a tool to be used in conjunction with monitoring of the ambient environment and reassessment of the standard if the need arises.

3.4.2 Implementing standards

Unfortunately, once a standard becomes regulation and is bound in legislation there is no guarantee that monitoring will occur, or that the monitoring that does take place will identify the problems. Much of the monitoring in the Derwent to date have been broad water quality surveys. Coles and Sutherland (1983) describe the characteristics of this type of sampling. It is generally broad-scale; covers a wide range of indicators; involves fixed sites sampled at regular, infrequent intervals, and are generally ongoing. The resulting data is usually subject to minimal data processing (Coles and Sutherland 1983: 132). They criticise the lack of clear and specific objectives in this type of sampling.

> The objectives are far too general and in effect suggest that water quality data should be collected in case they are needed (Coles and Sutherland 1983: 132).

This is an excellent description of the sampling programme conducted by the DOE from 1972-1986; in 1986 it was recognised by the DOE that the programme was, in fact, not of great value.

Enforcement of the standard is frequently regarded as the endpoint of the process. The view of both scientists and policy analysts is that standards are a tool to be used, but should not be perceived as an endpoint, rather an aim within the ongoing process of protection and restoration of water quality. No matter how good the information base, "in the final analysis a major judgemental or subjective component still exists" (Gore 1980: 13).

All scientific literature concerned with setting standards concedes that there is some margin for error. The adoption of an absolute standard for a substance entering a waterway is a throwback to the rational model of policy making. In this formulation problems are diagnosed, information about the problem is collected, various alternative solutions are provided and assessed on some cost benefit criteria and a choice is made.

This does not allow for the flexible approach advocated by some scientists and policy analysts. However the focus on the direction of flexibility is slightly different. Policy analysts suggest that too much notice is taken of scientific information and that this emphasis on "objective", empirical data acts as a barrier to discussion of the wider issues. Scientists argue that the emphasis on numbers is damaging and that if all the information presented (including the limitations of their data) was taken into account then the numbers presented as criteria for standards would assume their rightful place in the broader context of the study. In this sort of scenario, toxicity testing would be one step towards an understanding of the impact of a chemical substance on an ecosystem. Other steps would involve testing using local species, and monitoring the system continuously to determine any long term impacts or synergistic effects.

> Problems arise when a "number that may once have been an effusion of a tentative model evolves into an immutable constraint. Apparently the need to have precision in the rules of the game is so desperate that administrators seize on numbers - and then conveniently forget where they come from (Socolow in Tribe Schelling and Voss 1976:7).

Between the scientific assessment of a safe concentration for a toxic substance and the enforcement by a regulatory authority of a standard based on those assessments it appears that a lot of information is misconstrued or lost.

> Managers often misunderstand science and expect it to deliver a truth that is non-arguable. They fail to understand the very process of science demands no such truths, so that assumptions methods and conclusions can always be challenged (Cullen 1990: 201).

The expectation that science has delivered "a truth" is especially evident when standards are transported across geographical boundaries, with the accompanying false impression that a substance will have the same impact in any receiving environment. This has occurred in Tasmania, where the standards have been based on those formulated in other States in Australia or as part of the USEPA (DOE 1988).

The use of a fixed standard has the advantage of making pollution control easier for the bureaucracy. Either a company is complying to the standards or it is not. It also makes it easier for controlling authorities and the politicians associated with them to relate to the public as compliance with the standard forms a tangible point at which things become safe. Thus they continue to perpetuate the myth of scientific certainty.

The major disadvantage in management being based on the use of point source emissions, which is strongly evident in the context of the Derwent estuary, is that management has been able to occur and continue with little knowledge of the receiving environment. When problems occurred with pollutants there were no baseline data available to assess the extent of the damage, or to inform decisions about management options. The result of this approach is described below.

> By 1988, after 15 years of the existence of the Tasmanian legislation for environmental protection, the quality of the Tasmanian environment is not well known for those environments receiving industrial effluent and being used for other purposes by the community and by nature. Furthermore, the criteria for judging whether those environments were healthy or not and fit for intended use were not available and understood by the community (DOE 1988).

The scientists contracted by government agencies in relation to the Derwent estuary have been used to respond to problems, doing relatively short term studies with little chance to follow up their findings with more research. Hence a fragmented, incomplete database has accumulated that is of limited use. Management agencies need to make decisions relatively quickly and scientific information is often used to legitimise a stand already taken (Cullen 1990). However the commissioning of a scientific study can also be used as a tactic to evade making decisions which require a value-based judgement.

The result is poor use of the scientific process and poorly informed management. Part of the problem is lack of understanding on both sides and a lack of communication. Scientists are often unable to communicate their results in terms that lay people can understand, often because they have an expectation that lay people will not be capable of understanding anyway. Scientific information is only one aspect to be taken into account when a decision has to be made. Consequently managers often don't want to be bothered with a lot of technical jargon that will take hours to decipher and that they quite often consider superfluous to decision making. It is clear that if science and management are going to be partners in the future there are a lot of barriers to be broken down and myths to be debunked. However it is beyond the scope of this work to enter further into this debate.

3.5 Basing management on the receiving environment

If the estuary management were based on the receiving environment a longer term view would necessarily be taken. Scientific information would play a more basic role in informing decisions and there would be more opportunity to do research over a long term. There are various strategies available which are concerned with the receiving environment. They are: creating beneficial use zones, determining the assimilative capacity of the receiving environment and using biological indicators as a base measure of the quality of the environment.

3.5.1 Beneficial use zones

This is a human-centred approach to the receiving environment and relies on water quality data and standards applicable to the receiving environment as well as at point source. Beneficial uses are uses "of the environment or any part thereof that is conducive to human benefit, welfare, safety or health" (DOE 1988:2). This approach was favoured by the Department of Environment in Tasmania in the late 1980s.

Some of the areas of a river may be zoned for primary recreation, some for secondary recreation, some for industrial waste , some for aquaculture, and so on. The types of activities will be determined by the water quality in different parts of the estuary, and the water quality conversely, determined by the type of activity for which the area is zoned.

There are problems with this type of approach. Firstly, this seems to be a planner's solution, adopting the concept of zoning of land to the river. Zones are static boundaries placed on a fluid dynamic system. Water flows from one beneficial use zone to another carrying with it effluent and waste from other zones. This has been superbly illustrated in the Derwent estuary by the extent of sludge and distance from its source that it has travelled, and by the presence of high concentrations of zinc and cadmium in oysters grown in Ralphs Bay far from the EZ works.

Secondly, there is a tendency to accept the existing uses of the estuary without assessing whether the type of activity is appropriate for that area of the estuary or to evaluate any other alternatives. So if an area is suitable for secondary contact recreation, for example, that automatically becomes its zoning, without an attempt to see if it can be improved.

Thirdly, this system does not necessarily protect the aquatic ecosystem, as it is more concerned with the human uses of the water body.

3.5.2 Assimilative capacity

The principle of assimilative capacity is based on the assumption that the receiving environment has "some capacity, albeit limited to disperse dilute and absorb certain types of pollutants without incurring long-term damage to the biological functioning of the marine (and freshwater) communities in question" (Pearce 1991: 567). This principle needs to be based on a sound knowledge of the receiving environment. It is also necessary to know the types and amounts of wastes being discharged, their combined load and the synergistic effects that occur in relation to each other and to the receiving environment. This principle was one of the strategies used in the Thames. The "pollution budget" takes into account the whole river; its dynamics, physical characteristics, biota, and human use. Industry and domestic users have to comply to standards that relate to the sensitivity of the section of the river into which they are emitting effluent, also taking into consideration the way the effluent disperses, and its impact on other factors. This is discussed in more detail in Chapter 4, which deals with the Thames clean-up. There is also a safety factor that ensures that the tidal Thames does not become offensive. In the case of the Thames the safety factor is that at all places and at all times there is a minimum of 10% dissolved oxygen. Overall most of the river has a much higher dissolved oxygen content, but those areas most at risk must have the minimum level.

The principle of assimilative capacity has as its primary objective the protection of the biological integrity of the receiving environment and in this respect it goes a step further in protection than the use of beneficial use zones.

3.5.3 Biological monitoring

However Mackay and Hillman (1983) argue that assimilative capacity is of little ecological value, only ensuring acceptable water quality for human use of the surface waters. They argue that most pollutants are not assimilated, but undergo biological transformation which may increase their toxicity or deleterious effects.

> The cumulative effects of an increasing number of minor insults, occurring over several human generations, have slowly destroyed many aquatic resources..........As long as rivers are assumed to have some sort of excess capacity to accomodate wastes, we can be sure that this process of slow deterioration will continue (Mackay and Hillman 1983: 149).

The suggestion arising from this is that there should be a policy of no waste discharge into aquatic environments, but failing that possibility, due to economic and social factors, biological monitoring should be undertaken to assist in determining the impact of pollutants as reliance on water quality data and standards is insufficient. Benthic invertebrate populations have been studied as an indicator of changes in water quality, however it is not always clear that changes have occurred due to the presence of a pollutant. There are hundreds of variables which make the less obvious effects difficult to quantify (Mackay and Hillman 1983).

3.6 Conclusion

One realisation that comes from the ongoing debate between scientists about the best way to approach pollution problems is that the knowledge of Australian aquatic biota and their environments is still very limited. The move from point source emission standards to beneficial use zones in the receiving environment, to assimilative capacity and pollution budgets for the receiving environment and finally to biological monitoring show a shift from a purely human-centred approach to environmental problems to a recognition of the importance of the aquatic ecosystems. While this may still be confined mainly to scientists, there are an increasing number of management strategies that require protection of the aquatic biota as their fundamental objective.

It seems that a combination of all these pollution control strategies are necessary to provide as much protection as possible for a waterway. The ideal, which is almost impossible considering the extent of human impact on estuarine environments, is to have no waste entering the system. Despite its apparent impossibility there is value in having zero discharge as a long term goal.

In relation to the Derwent it is clear that before any pollution control strategy can be effectively implemented much more needs to be known and understood about the estuary. Scientists have an important role to play preparing a baseline database about the estuary and informing managers and the community at large about their findings. Other research also needs to be undertaken concerning social, economic and political factors impacting on the management of the estuary. All parties will have to work closely together if an effective strategy is to be worked out for the future of the Derwent, which protects what is left of the aquatic ecosystem as well as continuing to be a valuable resource for the human population that inhabits its banks.

It appears as if we are poised on the brink. The degree of commitment by governments, industry and community and the decisions of the next few years will determine the long term future of the estuary. Unfortunately the Tasmanian Government (no matter which party is in power) has trodden a fairly narrow, conservative path. The policies and actions of all governments have favoured the status quo, especially the business sector. Economic growth is still the major criterion considered in decision making in Tasmania, so that hard decisions affecting industry and in favour of the environment are very unlikely.

It is also necessary to attempt to broaden the thinking of the professionals in the field of waste management who, it seems, have been loath to consider alternative strategies for effluent other than cleaning it up as much as possible and discharging it into the estuary. Waste is something waiting to be reused, not a necessary evil that has to be endured. The latter opinion seems to dominate the thinking of professionals dealing with waste management. It would be of great benefit to the community if money was channelled into research into the reuse of current waste products. The Councils with municipalities bordering the estuary have known for 15 years that upgrading of sewerage treatment facilities was necessary (Scott and Furphy 1977). Action has only recently been taken, since the Councils have had sunset clauses placed on the ministerial exemptions allowing sewage effluent discharging into the estuary to exceed standards.

Despite this somewhat gloomy assessment of the Government's attitude to environmental issues, all is not lost. Over the last twenty years there has been a shift in attitude and approach to the problems in the estuary, due in part to an increase in the knowledge base. Another major factor influencing the change in approach is the increasing interest in environmental problems world wide. This is reflected in the Tasmanian community where there is a general lack of willingness to continue tolerating industrial pollution. There is a feeling in the community that industry does not do enough to care for the environment. (These sentiments were expressed by Grahame Ogilve, managing director of ANM, at the end of 1990 when he was opening the new. facilities at the ANM Boyer plant. This was an historic moment as ANM became the first major industry on the Derwent estuary to comply to Department of Environment and Planning standards).

The desire to see industry act more responsibly is a general attitude pervading the community, rather than any specific comment or action over the state of the Derwent estuary, although the media are very swift to react to news concerning the state of the Derwent. Due to the changing expectations of the world community and more specifically of the local population, industry seems to be aiming for a "greener" image. Consequently it is a good time to pressure both industry and government to put the necessary structures into place to cope with a rehabilitation programme.

At a similar point in the history of the tidal Thames, the decision was made to commit resources and energy into cleaning up the river. It has been regarded as one of the most successful river clean-ups in the world. For that reason it seems possible that there are things to learn from it. Consequently the next chapter provides an overview of the Thames clean-up.

4. An overview of the rehabilitation of the tidal Thames, England

4.1 Introduction

The most notably publicised successful river clean-up to occur in the Western world in the past few decades is that of the River Thames in the UK. The rehabilitation process took 15 years and about 500 million dollars. The success of the project has been credited to the very thorough scientific evaluation of the state of the Thames, leading to a comprehensive understanding of the physical characteristics of the river, enabling a mathematical model to be constructed which became the backbone for predictions of pollution impacts and measures taken to counteract those impacts. There was also a series of management objectives decided upon that provided the basis for the river quality desired.

The Thames has been chosen as a case study because of the success of the clean-up, rather than any similarities it has to the Derwent. They are two quite distinct estuarine systems.

4.2 Physical characteristics of the Thames River, England.

There are two parts to the Thames that are clearly demarcated in all the literature about the clean-up. These are the non-tidal Thames and the tidal Thames. The former refers to the freshwater section of the river which has been under rigid controls since 1857 when the Thames Conservancy was established to ensure a constant supply of potable water to the Greater London area and other settlements within the Thames catchment. The latter refers to the estuarine Thames which extends from Teddington 30 kms west of London Bridge to the sea at Southend (see Figure 6). The section of the tidal Thames that flows through London (see Plates 4.1 to 4.3) has been spasmodically subject to severe pollution from

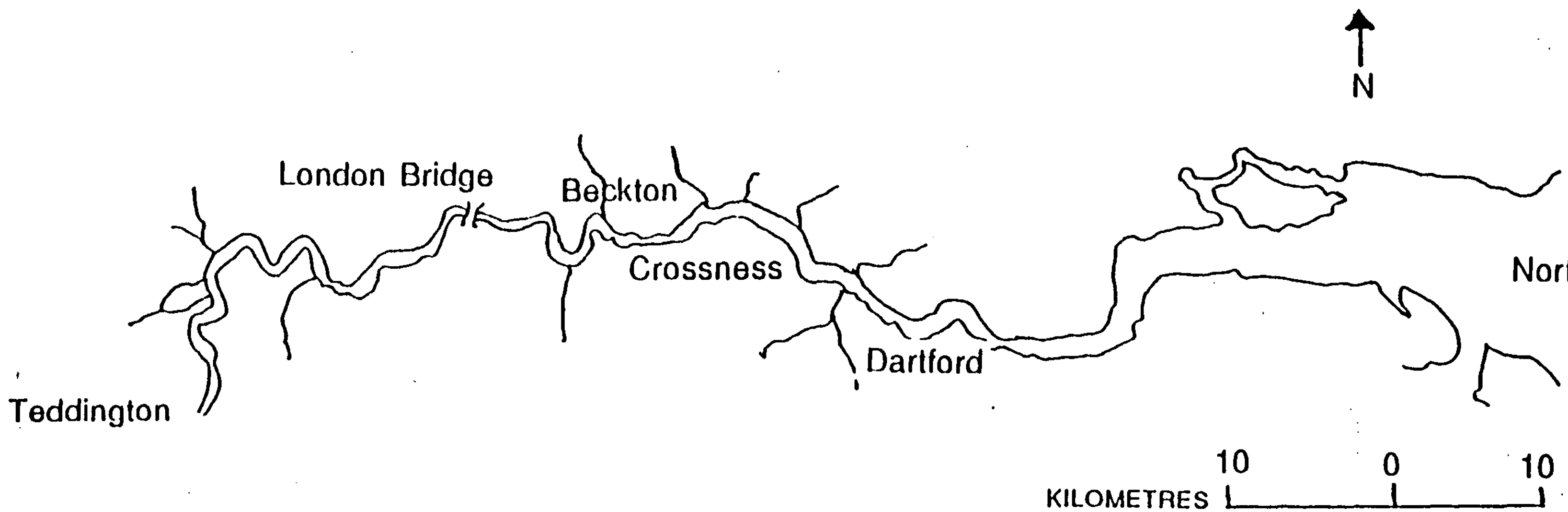


Figure 7. The tidal Thames, England

Plate 4.1: The City of London taken from the South Bank across the Thames

Plate 4.2 Tower Bridge on the tidal Thames in the City of London

Photographs: Bob King

Plate 4.3 Views of the Thames at Dartford
Photographs: Bob King

a variety of sources for the past two thousand years.

The Thames rises in the Cotswold Hills and flows 250 km to Teddington weir where tidal influences begin (Wood 1980). It then flows as a tidal river through the City of London to the North Sea a distance of approximately 140 km. The tidal Thames is "virtually an enclosed system affected only to a very limited degree by upland flows." Rubbish thrown into the Thames off London Bridge moves 10 miles downstream on an ebb tide and returns $9^1/_2$ miles on the flood tide. Thus it can take from 6 weeks to 3 months for debris to be flushed out of the tideway into the North Sea (Potter 1971: 3). The average freshwater input is 66 cumec. The range is from 9 to 400 cumec. The upper end of the range is considered to occur under exceptional circumstances. Tidal variation is up to 7m and is the major influencing factor in the tideway.

4.3 History of the Thames

In order to understand the political will behind the clean-up of the Thames it is necessary to give a brief history of pollution in the river.

The first effort at cleaning up the river was a Royal Order issued by Edward III in 1357 when he noticed that "dung and other filth" had accumulated along the river banks giving rise to an "abominable stench" (Morrison 1974). The City authorities were aware of the problem of fouling the waters of the Thames from the earliest times. There were many regulations enacted over the thirteenth and fourteenth centuries to prevent debris entering the river, none of them very successful as the deteriorating state of the river and the outbreaks of plague and cholera among the citizens of London testified. The great fire of London in 1666 was of benefit to the health of the city because it burnt away the accumulated filth of centuries and set in train the first serious efforts to provide sanitation in the rebuilding of the city. However the benefit of this system was soon overturned by the growing population and the increase in industry as the impact of the Industrial Revolution was felt.

By the mid nineteenth century the river was becoming seriously polluted both in its upper reaches and in London. The government of the day had the foresight to establish the Thames Conservancy in 1857 to protect the freshwater resource. Their duty was to keep the upper Thames clean. Using the powers conferred on them by Parliament they served " notice on various towns requiring them to stop putting sewage and other debris into the river. People who had been accustomed to polluting with impunity were vigorously prosecuted and many were convicted in the courts" (Morrison 1974: 48).

The rigid controls laid down by this body kept the freshwater section of the Thames clean. Every use for this part of the river has had to be cleared by the Thames Conservancy for the past hundred years. The body has now been superseded by the National Rivers Authority, which has control of the whole Thames catchment.

The tidal Thames was under no such control despite efforts to clean it up in the mid 19th century, after the Great Stink of 1858, when sheets soaked in disinfectant were hung in the windows of Westminster to combat the smell. Joseph Bazalgette redesigned the sewers for London, upgrading them to cope with the increased load. The main sewerage treatment plants were located at Beckton and Crossness, respectively 11 and 13 miles downstream of London Bridge. The sewage effluent was released from large holding reservoirs on the ebb tide. The initial effect was an improvement of the water quality of the tidal Thames, especially around Westminster. However the pressure of population and industrial waste soon overwhelmed the system and the only lasting effect had been to move the problem further downstream.

In the 1880's sewage was treated with lime and six ships were built to carry the sludge out to sea. These efforts to improve the condition of the river were to no avail. The population of the metropolis grew from 2.25 million in 1840 to 4.75 million in 1880 to 8.5 million in 1939. By 1934 there were 180 disposal works discharging to the Thames and its tributaries within 25 miles of central London.

In 1936 the Middlesex County Council to the north and west of London rationalised 28 small and overloaded sewerage works. A recommendation for a regional drainage board for the whole of west Middlesex was adopted. The 28 small works were to be replaced by one site for treatment of a high standard. This was the first serious attempt to rationalise since Bazalgette's work a century before, and the first large-scale application of the activated sludge process, where bacteria were used to purify organic waste. Sludge digestion was also used decreasing the pollution load entering the river from that plant by about 90%. Other refinements were incorporated, methane gas was used to generate electricity; waste heat from the gas engines used to heat the sludge in the digestion tanks. These were important innovations in 1936 and paved the way for upgrading of other plants later (Morrison 1974).

After the second World War the tidal Thames was described as the most "overworked stretch of water in the world" (Bates 1977: 35). During the war there had been little attention paid to the plight of the river. Despite by-laws industrial waste poured into the Thames.

> Silver in ship's saloons and buttons on uniform jackets were tarnished by sulphurous fumes from the filthy water. Suicides from London Bridge were not so much drowned as poisoned....
>
> As far up the river as Teddington I once saw shoals of dace dimpling the surface of the water, but, the River Purification Officer grimly told me, these fish were not rising to flies but gasping for oxygen which was no longer available in the polluted water (Bates 1977: 35)

The river was not only black and evil smelling from many inadequate sewerage treatment plants, but was undergoing increasing siltation, so much so that dredges working to keep the channels open for shipping were inadequate. It was known that pollution and siltation were linked, largely due to the 500 million gallons per day of partly treated sewage that entered the water robbing it of oxygen causing the silt to drop instead of carrying to the sea (Bates 1977). Combined with the dumping of industrial waste, the amount of fresh water taken from the non-tidal Thames for London's domestic and commercial use and the discharge of hot water from the growing number of riverside generating stations, raising the temperature of the water all added up to a very sick river.

The Port of London Authority (PLA) under the guidance of the chairman Lord Waverley set up a committee to study the problems. Scientific investigations were carried out by the Government Department of Scientific and Industrial Research. A team of scientists, engineers, and seamen worked for several years to discover the ways the river flowed. Minute quantities of radioactive mud were fed into the tides and traced. A large working model of the river bed and its tides was set up in a cargo shed, where the tidal cycle was electronically reproduced, complete with model silt.

When the inquiry had reached a sufficiently advanced stage to prove the full impact of pollution and siltation, Lord Waverley called a conference "at which were represented the Ministries of Health, Housing and Local Government, Transport and Civil Aviation; the London, Middlesex and Surrey County Councils; the Metropolitan Water Board, the Thames Conservancy, the British Electricity Authority and many other riparian councils and bodies" (Bates 1977: 35).

The findings of the group were later reiterated by the Government committee report under Professor A.J.S. Pippard, which was commissioned in 1951 and published its findings ten years later in 1961.

> The Committee concluded that there were two states of the estuary that could be acceptable; firstly and most importantly, the estuary must be prevented from becoming offensive and to ensure this there must be a safety margin; and secondly, to raise the dissolved oxygen to such a level as would allow the passage of salmon" (Cockburn 1981: 151).

This Committee concluded that the objective of keeping the tidal Thames from being offensive was the more realistic of its two main objectives and that it should be achieved. The safety margin was worked out to be a minimum dissolved oxygen level of 10% in any part of the estuary at any time. This was adopted as a standard.

Following the Pippard report, the major sources of pollution in the tideway (the works at Crossness and Beckton) were overhauled and upgraded. An entirely new treatment plant was commissioned for Crossness in 1964. Beckton was completed in 1976 and since that time, following an almost 90% reduction in polluting load the river has met the requirement of the Pippard standard (Cockburn 1981).

The Greater London Council (GLC) was formed in 1965, and the sewage disposal undertakings of the Middlesex and London County Councils were combined. The result was a single main drainage authority for an area of 500 square miles serving a population of over 7 million. The GLC decided to reduce the 20 sewerage works in its area to 8.

In conjunction with the upgrading and rationalisation of sewage treatment works the pollution control body at the time (PLA) also made sure that industrial effluents were improved. Almost all trade effluent is discharged to sewers and not directly to the Thames. Industry pay for the conveyance and treatment of their effluents in proportion to their volume and strength. Hence there is a financial incentive to reduce the pollution load discharged (Morrison 1974).

Over the intervening years between the initial decision to aim for 10% dissolved oxygen at all times in all places as a means of achieving the goal of preventing the estuary from becoming offensive, the tidal Thames has turned from an anoxic, silted up, stinking river into a highly managed and controlled waterway that is once more capable of supporting fish and bird life. The state of the river has improved so dramatically that the second aim of the Pippard Committee which seemed unrealistic and unattainable in the first instance, ie to support migrating salmon is now an achievable goal and steps have been taken to re-establish the fish in the upper reaches of the river.

4.4 Controlling authorities

The first controlling authority was the Thames Conservancy. This was the major authority , especially for the non- tidal Thames, although its jurisdiction was increased in 1894 to cover parts of the tidal Thames (Freeman 1977). The Conservancy was eventually absorbed into the new water authority in 1974.

In 1909, when the Port of London Authority was formed, pollution control powers for an area "extending from a point below Teddington Lock to a new seaward boundary 50 miles below London Bridge" were transferred from the Conservancy to the new authority (Potter 1971: 3). The PLA were unique in their role, being the only Port Authority to have full pollution control powers. The Authority also had the advantage of owning nearly all the bed and foreshore of the river between Teddington and Southend, allowing them to impose licence conditions restricting the use of the land, thus reducing pollution risks (Potter 1971).

In 1974 the Thames Water Authority was established, which took over the role of the Thames Conservancy. It was responsible for pollution control over the whole of the Thames apart from the tidal Thames which was still under the jurisdiction of the PLA, which was also responsible for navigation and dredging. The GLC was responsible for flood prevention in the tidal Thames. The main responsibility of the Thames Water Authority in the tidal zone was fisheries. In the freshwater zone they were responsible for everything (Freeman 1977).

The ongoing process of keeping the Thames and surrounding tributaries clean is now the responsibility of the National Rivers Authority Thames Region. This body was set up in 1989, one of ten regional units.

> Established by the 1989 Waters Act, the NRA is a major environmental protection agency responsible for safeguarding and improving the natural water environment (NRA Thames Region undated.)

The NRA Thames Region is responsible for an area of 5 000 square miles supporting a population of over 11 million people. It deals with pollution control, flood defences, water resources, fisheries and conservation, and recreation. It handles 8 000 planning applications and development enquiries per annum and monitors 9 321 discharge consents granted under the Pollution Act. To carry out this work the NRA Thames Region has 1 300 employees and an operating expenditure of 35 million pounds. Twenty million pounds per year is to be invested on capital projects. These activities are financed from a combination of Local Government precepts, direct charges and Government grant aid (NRA Thames Region undated).

The rivers and streams are monitored constantly, to ensure that the standards that have been set are maintained. Some monitoring is done automatically on a daily basis and the results sent back to the laboratory. There is also a vessel that contains laboratory facilities so that on site testing can be carried out. In order to counteract any trouble spots where the dissolved oxygen level falls below the required standard, the Thames Bubbler has been devised. This is a vessel that injects pure oxygen into the water at the appropriate place continuing until the crisis has passed and the oxygen level has been raised. There are also special vessels to clear the river of surface debris.

4.5 Discussion

The limitations of this description of the tidal Thames are that the literature available is written in the main after the event has taken place and describes in glowing terms the successes of the project. There is very little information about the processes that took place in decision-making and cooperative effort, apart from references to decisions being made and cooperation achieved. There is no overt explanation of the reasons behind the clean-up being set in motion with such single-mindedness at that particular point in history. It appears that the driving force behind the process being set in motion was the PLA. The problem of siltation was so severe that the commercial capabilities of London as a port were at risk, particularly with the advent of bigger cargo vessels. The need to dredge deeper channels to cope with these vessels was beyond the dredging facilities available and it would have been (I suspect) economically unviable to deal with the result rather than tackle the source of the problem, which was an anoxic river, dropping its heavy sediment load in the wrong place.

There is also a cultural aspect to the clean-up. People have been living in London for two thousand years since it was first built by the Romans. The Thames has long been regarded as synonomous with London. Old Father Thames has been woven into the fabric of peoples' lives for centuries. The banks of the Thames house some of the most famous historic buildings in the world, such as the Tower of London and Tower Bridge, Westminster, and Big Ben. As Morrison writes in the introduction to his paper "It's not much of a river". By the standards of such rivers as the Nile or the Zambesi "the Thames is a mere trickle," but it has been charged with symbolism by the people who inhabit its banks and is thought of with pride and affection. Morrison describes it as "our little river" in an otherwise factual description (Morrison 1974: 48).

The tourism value, arising from the strong heritage value of the Thames, is also a strong reason for an attempt to have an inoffensive river. Visitors and residents are much more likely to be attracted to recreational and tourist activities related to the river if it is clean and aesthetically pleasing.

4.5.1 Environmental awareness

The early 60s produced the first dire warnings of the impacts of pollution on the health and well being of the planet and its inhabitants. Rachel Carson's book *Silent Spring* was first released to the world in this period. The effects of pollution on the rivers of the world used as drains for industrial waste were all too obvious. Attempts were being made in other parts of the world to reverse the effects of waste on waterways, especially in the U.S.A. without a great deal of success (Gross 1976).

Britain's confidence in its ability to overcome any obstacle put in its path was still at a level that would have regarded the Thames clean-up as a challenge that could be solved with the application of the appropriate scientific research and technology. The process of setting up the study resulting in the model of the river bed and the interventionist approach to management of the waterway illustrates the confidence with which the task was approached. There may also have been an element of competition with other countries trying to come up with a solution to pollution problems that could be applied world wide.

Gross uses the Thames as an example of a successful estuarine clean-up in his paper presented to the Third International Estuarine Research Conference in 1975. At this point in time it appears that success stories equivalent to the achievements with the Thames were few and far between, but not for lack of trying, or capital investment. Efforts to clean up estuaries in the USA met with little success despite large investments into improvement of sewerage treatment works. What appears to be missing in these approaches is an holistic approach to the problem.

> Successful clean-up of the Thames Estuary required well-defined objectives and a regional plan based on a comprehensive scientific study. Capital expenditures exceeded 500 million (1974) dollars, about half of that since 1950. At least 15 years were required to achieve the clean-up objectives; including delays caused by World War II, planning and implementation required several decades (Gross 1976: 3)

The things that are outstanding in the Thames example are the amount of accumulated data on the state of the river. London County Councils had been conducting weekly surveys since the early 1900's giving the pollution control arm of the PLA a lot of background information to use when they started their studies in 1949. Historical references build up an accurate picture of the fate of the Thames and the influence it has had on the lives of Londoners and the impact they have had on it. For example one record of apprentices, working near the river, complaining about their monotonous diet of salmon caught from the Thames, plus numerous records kept by various authorities responsible for the running of London's everyday affairs.

There is a strong undercurrent in the literature of a feeling of ownership and therefore responsibility for the Thames which translates into a commitment to clean up the river, but in a very strongly interventionist management role. The Thames has been manipulated over the years to service London in many ways. This clean-up operation is no less a manipulation of the river than any other use to which it has been put. The objectives expressed in the Pippard report recognises the value of having a river that does not become offensive because in the long term it is more expensive, and harmful to the health of the people and to the reputation and attractiveness of the city.

The use of a healthy diverse aquatic biota as an indicator of success in balancing the impact of pollution with the natural state of the river has been invaluable in the Thames situation. There was a very clearcut distinction between the river before pollution that had life (which in large part had been recorded) and the river after severe polluting that had none. Thus the return of any life to the tidal Thames was an indicator that the operation was being successful, which fuelled the enthusiasm of those committed to the clean-up and dampened the criticisms of those sceptical. The ongoing return of fish and birdlife to the river has been a source of inspiration to all concerned and clear evidence to the people of London paying for the clean-up that the money was well spent.

One of the most important features of the Thames clean-up is the very thorough monitoring programme of the river. Samples are taken daily in some high risk areas and weekly elsewhere. Over 3 000 water samples are collected and analysed yearly, apart from the automatic daily monitoring that occurs, where the information is telemetred back to the central laboratory. This monitoring programme is the means by which the relevant authorities could determine whether their strategies and pollution control measures were meeting the required objectives.

As there were a large number of authorities originally involved in the Thames clean-up the need for cooperation and consultation was paramount. The number of bodies with responsibility for the Thames has dwindled over the years with centralisation of authority into one major body, created in 1989. However the intervening years were marked by a spirit of commitment, cooperation and goodwill, if many of those writing in hindsight are to be believed (Morrison 1974, Bates 1977, Cockburn 1981).

4.5.2 Public participation

Although there are no explicit references to public input into the Thames clean-up, it appears that the general public were concerned by the state of the Thames and other waterways in Britain and that their degree of environmental awareness was quite high and being fostered through educational programmes, such as the Clean Stream survey run by the

Sunday Times, the Advisory Centre for Education (ACE), and the Nature Conservancy. This was a programme designed for children and their families to take part in a nationwide survey of the waterways. The Sunday Times advertised Clean Stream kits which were to be sent out to families wishing to participate. Over 10 000 kits were sent out in the week following the advertisement. Five thousand surveys were completed and returned to the ACE. The idea was basically to sample macro-invertebrates. The various species of invertebrates found were used as an indication of the degree of pollution likely in the waterway. Observations about the surrounding environment were also encouraged.

One major commitment made by the people of the Greater London area was their willingness to pay for the upgrading of the system to provide a clean river.

Those pushing the clean-up had the advantage that the Thames looked and smelt disgusting, thus not even the most hardheaded opposition could have a case against the clean-up operation. It made economic sense on at least three fronts. Shipping lanes were threatened by the silt overload. Health was threatened by the putrid state of the river. Cholera outbreaks in London in the late 19th century were testimony to the dangers. The aesthetic appeal of the river was nil and as such had an effect on the appeal of London, both to the tourist and to the Londoner who may have used the river as a source of recreation.

4.5.3 Pollution budget

A British Royal Commission on Environmental Pollution (1972) proposed a policy for control of pollution in estuaries

> suggesting that they might be managed to allow reception of *biodegradable wastes* (my italics), provided that the water quality could be maintained at a standard which would allow the amenities for which the public were prepared to pay, to be achieved (Wood and Cockburn 1980: 83).

This requires two factors to be considered; the potential ecological quality of the estuary and the public's ablility and willingness to pay for the upgrading. These two factors determine the level of upgrading that occurs.

The process required is to determine environmental quality objectives for the estuary in question, then to work out a pollution budget for that estuary according to the state of the estuary and the desired environmental quality. The next step is to share out the budget to the various dischargers. The share of each is determined by the quality required of each discharge. This is a different approach to the one used in Australia and Europe and parts of the USA, where fixed emission standards are set and similar effluent discharges are required to be of the same standard. In these cases the state of the receiving waters is not necessarily even considered.

> The United Kingdom approach is, however, to consider river or environmental quality objectives as the prime concern and to adjust the required quality of discharges to achieve these objectives. The Royal Commission Third Report suggested two simple criteria for estuarine quality:
> (i) that the estuary should be capable of supporting the passage of migratory fish at all states of the tide,
> (ii) that the estuary should be capable of supporting on the mud bottom those organisms required to sustain sea fisheries"
> (Wood and Cockburn 1980: 85).

4.5.4 Non-biodegradable waste

The most obvious and damaging substance in the 1950's was detergent which in sewerage works and locks caused clouds of suds. It also effectively blocked the interface between the air and the water causing severe oxygen depletion in the water.

Heavy metals, in the quantities such as those released into the Derwent have never been a problem. Cockburn states quite clearly that effluent released into a river should be biodegradable, as does the report of the Royal Commission. This has been adopted as a standard for U.K. waters. It is expected that non biodegradable waste either doesn't enter the system at all, or that during treatment it is broken down chemically (Wood and Cockburn 1980, Cockburn 1981).

However, Johnston and Feil (1987) in their study of fish disease in the inner Thames estuary, determined that despite sludge adsorbing up to 70% of metal content from the influent stream at a treatment works, it is possible that 5 tonnes of cadmium and 1.5 tonnes of mercury are released into the river per year. Samples taken below the two major treatment works at Beckton and Crossness showed a high incidence of fish disease (Johnston and Feil 1987). They used flatfish (flounder, plaice, dab, and sole) as these are all "sediment sifters". The types of visible disease were similar to those found on finfish studied by Davies, Fulton, and Kalish (1988) in their study of the upper Derwent estuary (see Chapter 2).

4.5.5 Biodegradable waste.

The main problems in the Thames were the interrelated ones of lack of oxygen in the water and the sheer volume of pollution entering the system. The extension of the sewerage works to cope with the volume of sewerage and trade waste that was entering the system, decreased the pollution load by up to 90%, thus partially solving the problem of excessive BOD. One factory, Thames Board Mills of Purfleet, could not meet the standards required before discharge, so the company paid for the research and development of an aerator which oxygenates the river and compensates for the oxygen depletion their effluent caused (Freeman 1977). The other factor relating to BOD was the temperature of the water. There were quite a few power stations along the banks of the Thames that drew water from the river for cooling, then put it back in the river as hot or warm water.

The dissolved oxygen content of the water was a convenient and effective measure of the state of the river and was thus used as the basis for standards of water quality.

4.5.6 Comparisons to the Derwent estuary

The Derwent situation is both more and less complex. There is the heavy metal content of the river which far exceeds standards in some areas. This problem has not really been addressed in any systematic way. Although recovery of heavy metals from the effluent has improved and there is significantly less heavy metal in the water column, there is the long term unknown impact of the metals that are currently bound in the sediments. As the river bottom is scoured, these sediments may release the metals into the water column in a volatile form. The rest of the effluent entering the river is biodegradable and there is far less than that entering the Thames as the population and the number of discharges are smaller. Relatively, the problem of cleaning up the biodegradable effluent is not so great.

The real dilemma with the Derwent is that there have been no objectives defined about the desired water quality and there is no information base that has been collected in a systematic way that allows judgements to be made about the "potential ecological quality of the estuary." Until the former has been established, any action taken to clean up the river is patching up the problem in the ad hoc manner so typical of Tasmanian endeavours. This argument will be taken up and expanded in the final chapter.

5. Alternatives for future management of the Derwent estuary, Tasmania.

5.1 Introduction

Addressing the problems of the Derwent estuary has been deferred for years for a variety of reasons. The most obvious reason has been the lack of political will of any Government to enforce regulations, or to gain funding from all authorities and industries contributing to the problems to initiate a baseline study of the estuary.

In recent years there has been a move to cooperative measures, where industries and Councils share the monitoring responsibilities with DOE. This has been an attempt by the state government to encourage polluters to 'own' their effluent and assist with assessing its impact on the receiving environment. This has had limited success. There is still an underlying expectation that the State Government bears ultimate responsibilty. This is evident from the funding arguments for sewage treatment plants between the State Government and Councils described in Chapter 2.

At present none of the agencies dealing with the estuary have its care as their primary concern. The day to day tasks of administration and management in Councils, State government departments, and other authorities diffuse the issues related to the estuary, so that it is dealt with either in a haphazard way with long delays, or not at all.

An attempt to coordinate the diverse interests saw the formation of the Derwent Estuary Advisory Group, which was set up during 1990. This is a voluntary cooperative body of professionals and a community representative set up to assist/ advise all persons involved in making decisions which influence the management of the Derwent estuary for its use by present and future generations (DOE 1990).

The structure consists of a number of special focus groups which report to a coordinating body which acts as a go-between for the Minister and the special focus groups and the community. It was suggested at one of the meetings that the main function of the advisory group would be to provide a buffer for the Minister.

There is a genuine concern amongst the various members of this group about the estuary, but the underlying issues are power and responsibility. Everyone is willing to be part of such a body, because they want to improve the state of the estuary, but also because they fear that they will lose jurisdiction over their own affairs if they are not present. There is also a fear that they will be asked to take responsibility for more than they have agreed to already and worse still to spend money. This appears to be the bottom line. Everyone agrees that something must be done, but no-one is willing to change the power structures that currently operate.

Anyway without a firm commitment from the State Government in the form of a decision-making body to consider proposals put forward by the advisory group and *make decisions* about the Derwent estuary, then the value of the advisory committee is limited.

If the current use of the estuary continues unchanged it will eventually lose its value to the people of Tasmania. It already appears that the social and economic significance of the Derwent estuary is underrated by the present and preceding State Governments. It is particularly noticeable at the moment in light of the image of Tasmania which is currently being promoted.

In a submission to the State Government in 1988 the Hobart Municipal Councils Association (HMCA) summed up the economic potential of the Derwent that would be lost if no action was taken.

The Derwent is recognised as one of the great waterways of the nation.

> It is under utilised by both residents of the region and visitors, as a unique recreation and tourism asset......
>
> The desire for a pollution-free environment in which to live and raise families is becoming an increasingly important factor in immigration and in the location of advanced technology activities......
>
> The major attribute which both this State and region have to promote is the environment which it can offer to the short term visitor and the potential resident/investor.
>
> It is fundamental that if the credibility of such a claim is not to be eroded the river which forms such a major focus must also reflect this environment. Sadly in many instances it does not (HMCA 1988).

As demonstrated in Chapter 2 there is enough scientific evidence available to substantiate the concerns expressed by the HMCA report. The Derwent estuary is severely degraded in parts and action is necessary. Community concern which is expressed in a variety of ways is being defused by politicians and management agencies. This will be dealt with later in the chapter.
So how do we deal with the 'tragedy of the commons' (Hardin 1968).

5.2 The Thames experience

There are lessons to be learnt from the Thames experience that can guide future directions for the management of the Derwent estuary.
There are 3 major aspects of the Thames clean-up that the author considers most important in relation to the Derwent estuary.

1. A full scientific investigation of the river and the associated problems was carried out before any management objectives were proposed.

2. Fundamental broad aims were established upon which all other management goals and strategies were based.

3. The use of a centralised body of authority to control pollution in the tidal Thames was one of the strengths of the clean-up operation. Although there were other authorities involved there was one authority to coordinate the whole operation. This meant there was always a focal point for any group or interest to go to if they needed advice or if they had grievances. The spirit of cooperation that is lauded by commentators on the Thames clean-up may well have arisen due to the presence of a central body which was obliged by statute to deal exclusively with issues concerning the Thames River.

The first two points are essential to a successful management strategy. However the institutional arrangement through which this can be achieved in Tasmania needs further examination. The rehabilitation of the tidal Thames has been strongly interventionist, manipulating the river to fit it to the needs of the human population while "balancing" the water quality so that the aquatic flora and fauna can survive in a waterway designed to serve 11 million people. The water in the tidal Thames is a cocktail created by humans that needs constant attention and intervention to maintain the right mix. There is no attempt to rid the Thames of effluent altogether. With so many people and such a volume of effluent, it has not been considered.
Tasmania may not need such heavy-handed methods.

5.3 Institutional arrangements

Ostrom (1987) puts forward two possible institutional arrangements for dealing with commons. The first is the idea to allocate full private ownership rights to a set of participants. While this may be a practical solution for land it is difficult to own sections of a river and maintain your activities within boundaries, without them impacting on a neighbouring section. It also denies access to the resource for the general public, which is socially inequitable.

The second is to allocate full authority to regulate the commons to an external authority. The National Rivers Authorities in Britain (described in 4.4) are an example of this type of arrangement. The Port of London Authority also had this type of authority for the tidal Thames when the Thames clean up project was initiated. It had the power and resources to instigate the necessary scientific investigations, because it had full responsibility for the estuarine area (Potter 1971).

It is essential that such a body is given full powers, otherwise there is a danger that it could be a drain on resources or a cumbersome bureaucracy that achieves very little.

The Port Phillip Authority was an example of this kind of body The PPA overlapped the responsibilities of other bodies without any form of overall command and it had no means to enforce decisions. It could not raise any independent funds or spend any money except on administration (PPA 1977: 115). In effect it had little real power.

It is possible that such a body does not work until the state of the environment is so catastrophic that it is recognised that drastic, even draconian, measures need to be taken. In the Australian context, there are very few examples of such severe environmental degradation, with corresponding serious economic and social impacts. A case can be argued that the Murray-Darling Basin is one such example and the response was to set up a central authority to tackle the problems.

A third view also presented by Ostrom (1987) is that

> left to themselves individuals who are dependent on common-pool resources for essential inputs to their economic activities will work out a system that achieves regulation over the commons
> (Ostrom 1987: 251).

It appears that this type of arrangement would only work where primary industry depending on the immediate environment was the major source of economic activity. Most of the use of the estuary is not directly related to economic activity. However there is a certain appeal in the idea of evolving institutional arrangements, and communal ownership of a resource.

Another alternative is to decentralise power to local authorities, making each community responsible for the industrial and domestic effluent entering the river and for solving local problems. Decentralization is supposed to be an effective way of meeting local needs. It is designed to provide greater access to administrative agencies which could lead to greater local participation in the decision-making process and community involvement in development plans for their local region. It is also expected that people through their interest and participation will come to understand the specific problems and advantages of their local area. In practice it tends to fall short of expectations as most institutional arrangements sound better in theory than they work in practice (Smith 1985). At this point in time it would seem that decentralization may be good for the community, but not necessarily good for the river. However it seems essential that any future management strategy for the Derwent estuary should involve community education and encourage community responsibility.

Whatever institutional arrangement is adopted a top priority for the estuary is a baseline study. This would provide a basis on which to decide priorities for action and strategies. A long term monitoring programme also would need to be established which should be informed by social, economic and political values as well as by scientific information. These relate to the values the estuary has to the human population, what they want from it, what they hope to pass onto future generations, the value attributed to the aquatic ecosystem and how much they are willing to contribute to the cost and care of the river.

Unfortunately these types of issues are not addressed. The community is marginalised and given token public participation by decision making bodies

(Coleman 1983). Managers and politicians often use science to stifle debate about issues such as these by attaching too much significance to the numbers implemented as standards, limiting the possibilty of open discussion about the nature of the risks involved. No matter how much risk assessment is done, the actual process of protecting the resource and monitoring the effectiveness of the management programme falls to the bureaucracy, and politicians. The assessment of how much risk and to what type of risk the public can be exposed, rests in the lap of this group of people. The spokespersons for this group are often the politicians, who wish to convey reassurance.

> The larger the issue of public accountability (as opposed to professional accountability alone) looms in an official's mind, the less willing he becomes even to formulate a problem in terms of acceptable risk. These reflexes persist even when there are no lives at stake (Socolow in Tribe, Schelling and Voss 1976:9).

Parading standards as an endpoint is a classic example of this. An expectation has been fostered in the Hobart area that when all industries and sewage treatment plants comply to the standards the pollution, problems in the estuary will be solved. This is a false expectation created largely by political point scoring exercises on a number of occasions, when Ministers have perceived some gain from it. One of the difficulties with long term projects such as caring for the Derwent catchment is that governments only retain power for a relatively short term.

Compliance with standards as they stand may, in fact, cause serious ecological damage, in the case of sewage treatment, because of the widespread use of chlorine as a disinfectant and the potential for a significant increase in organochlorines (Scott and Furphy 1977, Bloom 1990). Heavy metals are still bound in the sediments, and little is yet known about the conditions that will release them as toxins into the environment. More precise analytical capabilities in the future could prove all the standards are useless. This has already been shown to be the case to some extent with the upper estuary. ANM are complying to point source standards, which permits continuing discharge, but the ambient environment has dissolved oxygen levels well below 6 mg/L. It has been recommended in the draft Australia and New Zealand Environment and Conservation Council (ANZECC) water quality guidelines that water bodies with DO levels below 6mg/L should not receive any discharge which further lowers DO level (ANZECC 1991). The public are in the main unaware of these problems and little effort is made by public authorities to enlighten them. This is because:

> Science is widely promoted as the ideal of intellectual inquiry. It is supposedly rational and empirical in that it is based on observations rather than faith. Governments see science as the provider of new technologies and of economic recoveries. Non-scientists rarely understand that scientists accept and reject hypothesesas working assumptions on the basis of the probability of evidence rather than on the basis of 'truth' (Cullen 1990: 204).

Science needs to be demystified, so that politicians cannot use it as a panacea any longer. David Suzuki (1988) in a public lecture at the University of Tasmania, called for scientific literacy to be an essential aspect of education, so that people understand the culture of science and cease to expect it to come up with 'the truth'.

The public have become less accepting of scientific 'truth' than in the recent past. There is a tendency to question science more as scientists are played off against each other in the increasing number of conflicts over environmental issues that are battled out in the media. This type of journalism encourages opposing expert opinion to be tossed into the arena, all quoting objective scientific data, which conflicts. This leaves the public confused, highly sceptical of the credibility of numbers and increasingly wary about claims of definite answers and certainty. In the resulting confusion, the conclusion to be drawn is that few have faith in the myth, yet the public framework of regulation is still based upon fundamental tenets of rational knowledge that bureaucracy, politicians and the media still attempt to perpetuate. The result is equivalent to collective hypocrisy.

This is a phenomenon that Douglas and Wildavsky (1982) would attribute to the belief of the established hierarchy that ways of operating that have worked in the past will continue to work in the future, despite individuals recognising the problems and inconsistencies in the system. The coping mechanism within the system to overcome failure is to call for more technical information, as if lack of information is always the cause and more information the only cure. This has the function of deflecting from the real issue, which is failure of the system to cope with changing demands.

5.4 Conclusion

If these problems, all of which are relevant to the problems of the Derwent, are to be overcome the current power structures should be broken, science should be used properly and the public involved in the decision making process in a comprehensive meaningful way. To achieve this the following steps should be taken, in sequence.

1. Baseline data on the estuary must be compiled to determine the hydrology, provide an inventory of the biota, to determine the ecological damage and physical degradation that has occurred and is occurring, to examine relationships, to assess the assimilative capacity of the estuary and to provide suggestions for future management and monitoring programmes.

2. This information and all other relevant social, economic and political data should be interpreted in a manner accessible to the public and disseminated, so that an opportunity is provided for an informed debate to define the values of the estuary, which will in turn inform the future uses and care of the estuary.

3. Fundamental broad aims can then be established for management based on the definition of the estuary's values.

This would be a lengthy and difficult process at the best of times, but with the current diversity of authorities it is an impossible task. The most practical institutional arrangement for this type of activity would be the formation of a body, whose primary tasks are those set out above.

Any such undertaking would require a commitment by the Parliament that it would support the project with sufficient funding and infrastucture support. The body would need to be given full authority to carry out the tasks necessary, even if entrenched interests felt threatened by the process. Power is rarely given away, so sometimes it must be taken. As it would need the cooperation of all relevant government departments, Councils and industries in the early stages it must have the power to insist that information and resources be forthcoming.

Conversely, the body must be accountable to the Parliament and the community, and must be open about its operations.

Once the conditions outlined above have been met and a strategy designed to achieve the aims, it may be unnecessary to continue such a body or it may take on the role currently played by DEAG of an advisor to the Government. It may even be possible to decentralise, putting responsibility onto the community to find ways of implementing strategies to suit local conditions. Maybe , over a period of years the estuary will be regarded as a communal resource, with all attendant rules and regulations developed to support a culture based on caring for the environment.

It would be necessary to keep a central information base intact. If long term scientific research is to be undertaken and a monitoring programme designed to determine if the broad aims were being achieved there needs to be a central location to store the information generated. The results of studies would naturally be for peer review, but a requirement would also be that a presentation be made in a manner accessible to community groups and that the general public have access to the information base.

There are a number of issues that need to be addressed before a Tasmanian government could adopt change of this nature. These are: a recognition that continued lack of action with regard to the estuary will have a detrimental economic impact on Tasmania; that action needs to be taken beyond short term political point scoring; that a structure in which action can take place needs to be established; that legislation needs to be changed, so that standards can be negotiated in line with management objectives; and that the community, not big industry should guide the actions of government.

There is of course a danger in allowing the public to determine the future uses of the estuary. People are currently locked in a mode of thinking that permits them to exploit the environment around them. Environmental groups, often with very limited resources are attempting to inform, educate and encourage people to know and respect their immediate local environment or to understand the consequences of their actions on the environment around them.

There are many simple actions that can be taken either as an individual or as a member of a community that would have a significant effect on minimising the human impact on the local environment. The process of disseminating information and discussing issues of concern allows the educative process to begin.

There is clearly a concern about the environment in Tasmania and people have always acted with a great deal of enthusiasm when given the chance to defend the places they regard as their own. There are many people in the greater Hobart area who have special places relating to the estuary, who would welcome a chance to have some input into the management process.

There are indications already that the Derwent estuary is becoming cleaner. However there is no room for complacency. A clean-up undertaken in the "muddle along" haphazard manner employed so far, will ultimately cost more in time and money than is necessary. The stage is almost set for a coordinated, cooperative, high quality, holistic strategy to be worked out and implemented. The Government (no matter which Party) needs a push in the right direction. The general community, with the help of scientists and professionals, must provide that push. Ultimately, the rehabilitation of the Derwent estuary, Tasmania is a community responsibility.

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