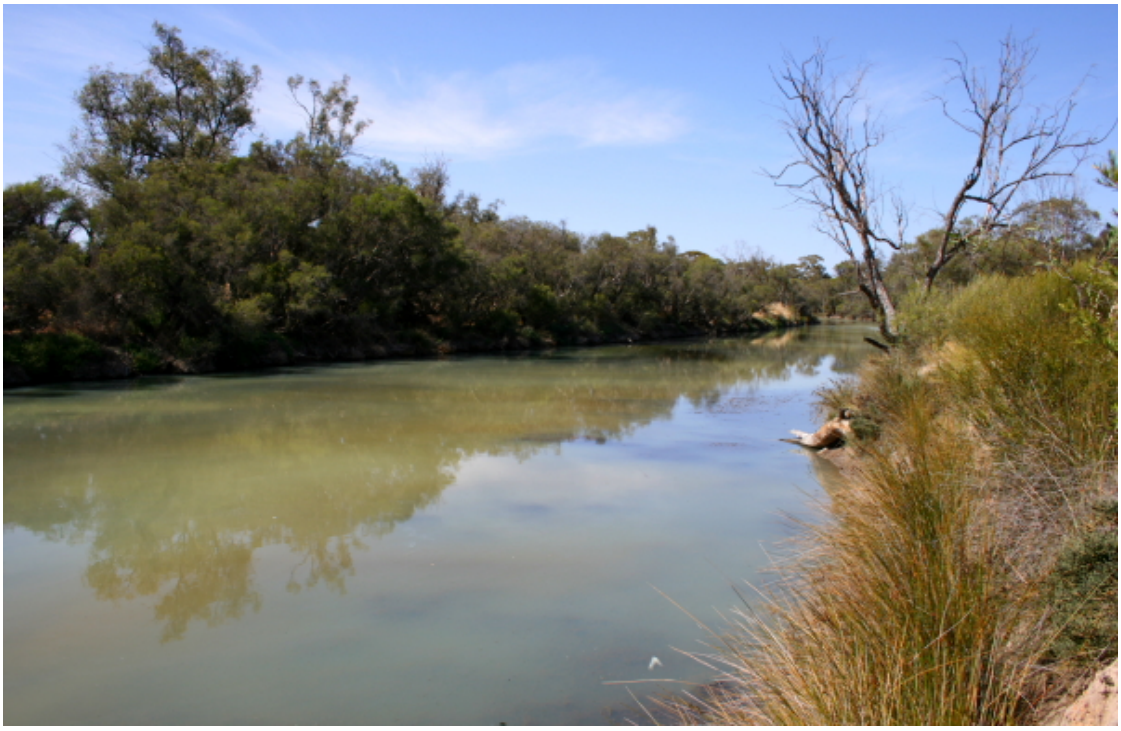
Review of the Economic Viability of Sediment Extraction from the Avon River Pools



Report prepared for the Department of Water and the Swan River Trust by *Advanced Choice Economics Pty Ltd* and *Viv Read & Associates*

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This project was jointly funded by Department of Water, Swan River Trust, Avon Catchment Council and the State and Australian Governments through the Natural Heritage Trust and the National Action Plan for Salinity and Water Quality.

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Cover photo: Boyagarra Pool (Photo taken by Michael Marriott, © Commonwealth of Australia)

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Acronyms

ACC	Avon Catchment Council
BCA	Benefit Cost Analysis
BCR	Benefit Cost Ratio
CEO	Chief Executive Officer
DoW	Department of Water
GST	Goods and Services Tax
NPV	Net Present Value
NRM	Natural Resource Management
PV	Present Value
SRT	Swan River Trust

Executive Summary

Major pools of the Avon River have filled with sediment as a result of alteration to the river channel during the 1950-70's to reduce flood risk, and by soil erosion from agricultural catchments. Some pools are completely filled with sediments and their environmental and social values are lost. Others are filling rapidly. There is further potential for significant sediment transport to the pools and channels in the upper reaches of the Swan River.

Sedimentation was identified as a significant threat to Avon river pools through the Avon NRM Strategy (ACC, 2005). The Avon Catchment Council and the State Government, through the Department of Water and the Swan River Trust, is seeking ways to recover the values of Avon River pools by sediment removal and maintenance. It is also assessing options to reduce the risk from sedimentation to the values of the Swan River. This study was commissioned to assess the economic feasibility of recovery and maintenance of the Avon River pools at little or no cost to the Council or Government.

The assessment provides:

- a description of the coarse river sand as a marketable resource,
- an analysis of feasibility opportunities and constraints for marketable sediment extraction,
- market opportunity analysis to identify and engage potential commercial users of the marketable sediment and
- benefit cost analysis of the extraction and transport of the sediment to form the basis of negotiations if cost-sharing arrangements between government and industry are required for extraction.

There is estimated to be approximately 2 million m^3 (3.2 million tonnes) of sediment in the 26 major river pools of the main channel of the Avon River. There is relatively little difference in distance from Perth between the major pools. This distance is approximately 100 km from Perth (or approximately 70 km from Midland) which is generally within acceptable transport distance for major extractive industries.

The market opportunity analysis presents strong interest for extraction of the marketable sand sediment by two commercial services (in addition to the existing commercial operation at Burlong Pool near Northam) and at least one Local Government Authority. There may be stronger interest if the different uses and values of the marketable sediments were better understood by the community.

Sediment extraction from Avon River pools is likely to provide a range of economic, environmental and social benefits. The marketable economic benefits are estimated in a benefit cost analysis (BCA). Although they are not quantified in this assessment, other likely benefits include the social and environmental benefits to local communities, personal and economic benefits to landholders adjacent to the river, a reduction in the risk of sedimentation impacting on the pools and channel of the upper Swan River and a reduction in costs, or a possible financial return, to the State Government from river pool recovery and maintenance.

The BCA is based on four scenarios:

- Recovery and maintenance of pools with coarse sand,
- Recovery and maintenance of locally valued pools with coarse sand,
- Sediment removal to provide Swan River protection, and
- Minimal pool recovery and maintenance.

Results of the BCR did not differ significantly across scenarios. The BCR was approximately unity (a value of 1.0, i.e. costs approximately equal benefits) for delivery to the metropolitan area, and approximately 3.0 for delivery to local sites (assumed to be 15 km from each pool). With growing scarcity of commercially-available sand in the metropolitan area, the economic feasibility of delivery to Perth is expected to improve in the medium-term. Volume demanded is also expected to be far greater in the metropolitan area than locally. The BCA was sensitive to the value of the sand, excavation, stockpiling and grading costs and transport costs.

From the report findings, seven recommendations are presented:

Recommendation 1: That the State Government (through its agencies) clarify ownership of the sediment where it occurs on private land title.

Recommendation 2: That the State Government (through its agencies) develop arrangements for commercial development of Avon River sand supplies.

Recommendation 3: That the State Government (through its agencies) create market opportunities by promoting the utility, commercial values and availability of the coarse Avon River sand for Perth metropolitan and local supply.

Recommendation 4: If commercial opportunities for excavation of pools with no cost to Government cannot be negotiated, that the State Government (through its agencies) negotiate cost-sharing arrangements with these commercial interests.

Recommendation 5: That negotiated cost-sharing arrangements for excavation of pools be short-term only.

Recommendation 6: That cost-sharing arrangements be negotiated on excavation, stockpiling and grading costs.

Recommendation 7: That cost-sharing arrangements be negotiated for the excavation of those pools that reduce the risk of sedimentation to the Swan River only.

It is acknowledged that the Avon River pools have significant value to indigenous populations and any recovery processes would need to be negotiated with them.

1 Introduction

1.1 Background

The biophysical condition of the Avon River has altered significantly since European settlement in the Avon River Basin. Sediments in the Avon River channel have been mobilised primarily due to the *River Training Scheme*, undertaken during the 1956-72 period for the purpose of flood mitigation, but also due to extensive clearing of native vegetation for agriculture causing soil loss due to the subsequent increased rainfall run-off. As a result, major river pools have filled, or are filling, with sediment. The loss of river pools is significant for social and environmental values.

Sedimentation processes have been documented as part of a comprehensive River Channel Condition Survey undertaken in 1996. An additional component to this survey was assessment of 26 major river pools. This assessment provides information about the volume of sediment fill in each pool (at the time of the survey), particle size analysis, nutrient and salt content and other river pool condition indicators (JDA, 1997).

Local community observations and measurements provide strong evidence that some pools have filled significantly since the time of these surveys. There is further concern by the Swan River Trust and within local communities that significant volumes of sediments have the potential to descent the Scarp and will affect the upper reaches of the Swan River. It is likely that some sediment deposition already exists in Boongarra Pool within Walyunga National Park.

There have been a range of initiatives to remove sediments from Avon River pools. These include excavation at Gwambygine Pool, Station (Cold Harbour) Pool, Burlong Pool, Blands Pool, Northam Town Pool, Katrine Pool, Boyagarra Pool and Long Pool. The arrangements for removal of sediments from Burlong Pool are continuing on an annual basis (P. Jones, *pers. comm*.).

River sediments have been used in the installation of septic tanks and leach drains, concrete aggregate, housing pads and nursery supplies. Local government (e.g. the Town of Northam) also find use for river sands for general municipal purposes.

With funding from the State and Australia Governments and through the Avon Catchment Council (ACC), Department of Water (DoW) has supported local communities in the preparation and on-going implementation of River Recovery Plans for all sections of the main Avon River from Yenyening Lakes in the Shire of Beverley to the Avon Valley National Park in the Shire of Toodyay. There were many small pools that previously existed in the main channel of the Avon River that are now de-valued or forgotten because they are filled with sediment. Through the River Recovery Planning process, a total of 26 major pools have been identified between Yenyening Lakes and Avon Valley National Park. These river pools are shown in Figure 1. Eight of these pools are completely filled with sediment and a further five are substantially filled (Table 2.1). The Recovery Plans identify the priority for recovery of these pools based on local values. It is acknowledged that the Avon River pools have significant value to indigenous populations and any recovery processes would need to be negotiated with them.

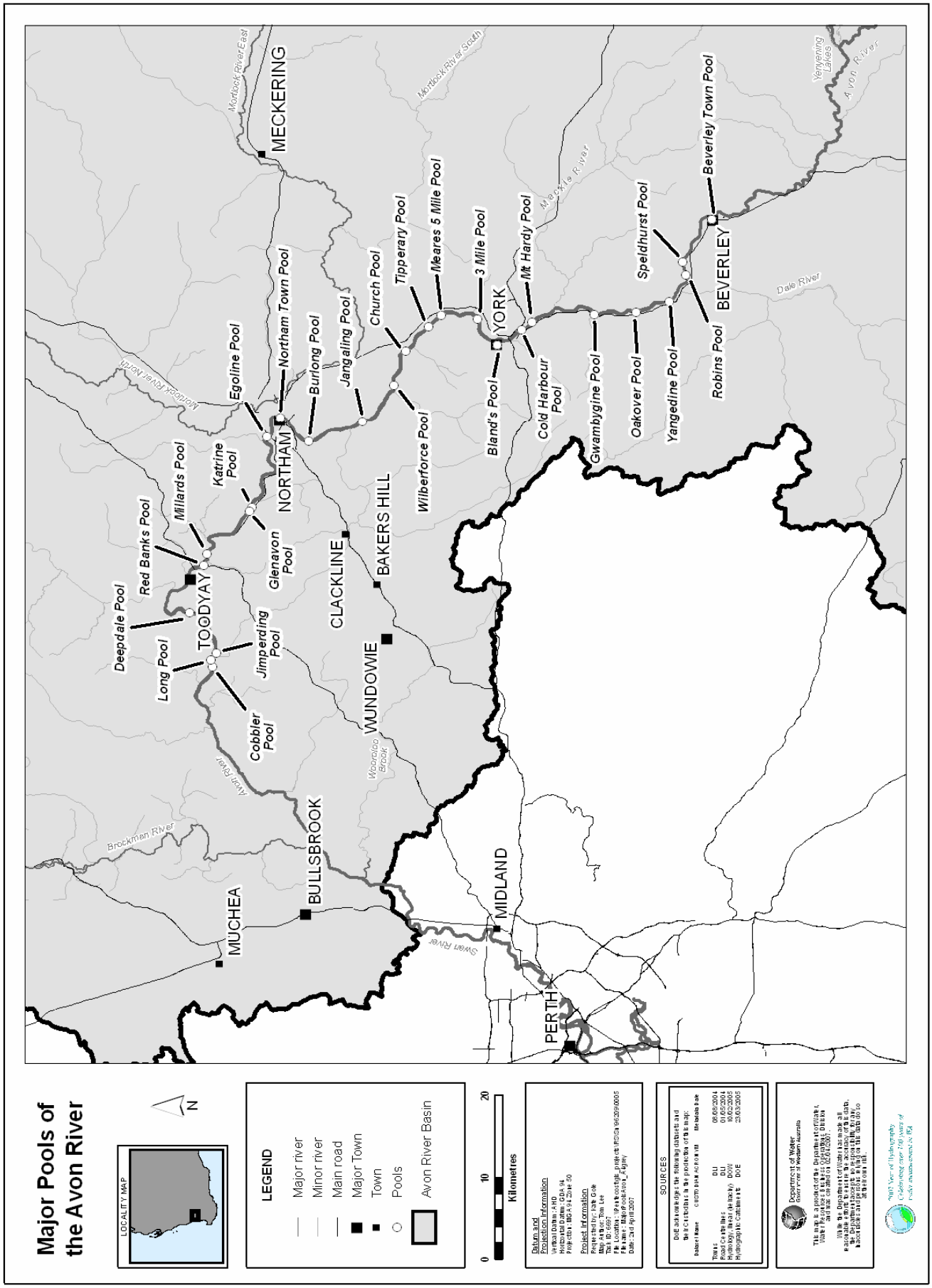


Figure 1: Major pools of the Avon River

Management of the Avon River pools is coordinated through the Department of Water in Northam with advice from the Avon Waterways Advisory Committee. The Avon Catchment Council provides broader coordination of regional natural resource management. The Swan River Trust has responsibility for management of the Swan-Canning Estuary, which is a significant receiving water body for sediment mobilised from the Avon River. The threat of sedimentation to the social and environmental values of the Swan River is recognised in this report.

1.2 Context of the study

The **purpose of the study** is to establish the least cost method to government of:

1. Clearing the Avon River pools of sediment, and
2. Providing on-going maintenance of the cleared pool condition.

The study is an economic feasibility assessment of achieving these outcomes.

The aim of the study is to assess the potential to achieve these outcomes free of cost to the State Government or at the lowest cost possible recognizing the possibility that these costs may be recurrent for many years to come.

The economic feasibility study is to be based on providing sediment as a raw material for industry or a range of other potential market options. It is not an analysis of the economic viability of the range of potential uses.

The **geographic scope of the study** is for the pools of the main channel of the Avon River from Beverley downstream to the Avon Valley National Park in the Shire of Toodyay. It does not include pools that occur on the South Branch of the river or on other tributaries to the river.

Sediment extraction from Avon River pools is likely to provide a **range of benefits**. Although not quantified, these benefits include:

- the social and environmental benefits to local communities
- personal and economic benefits to landholders adjacent to the river,
- a reduction in the sedimentation risk to pools and the channel of the upper Swan River, and
- a reduction in costs, or a possible financial return, to the State Government from river pool recovery and maintenance.

1.3 Study objectives and methodology

The objectives of the study **are to:**

1. Identify the Avon River pools with a suitable marketable sand resource and assess their economic potential as a supply source,
2. Identify market supply options for coarse river sand and determine the

criteria for market provision,

3. Identify and engage (where possible) potential market interest in coarse river sand,
4. Undertake a benefit-cost analysis (BCA) for the supply of river sand to potential market options (local and Perth metropolitan), and
5. Identify the cost to the State Government for the development of market supply options in both local and Perth metropolitan areas.

The **method of analysis** is based on a set of processes completed in sequence in the subsequent sections of this report:

1. *Marketable resource description* – a review of the available literature that describes the characteristics and potential ongoing supply of the marketable coarse river sand (Section 2),
2. *Feasibility opportunities and constraints* – an analysis of the range of opportunities and constraints that may affect the feasibility of sediment extraction (Section 3),
3. *Market opportunity analysis* – the identification and engagement with potential commercial users of the marketable coarse river sand with an interest in removing sediment at little or no cost to government (Section 4, not provided in this version of the report),
4. *Benefit cost analysis* of extraction and transportation by government – an analysis undertaken using the assumption that there is no commercial interest in extracting the sediments and that a government agent is required to pay for extraction (Section 5), and
5. *Conclusions and recommendations* – a discussion on the key report findings, development of recommendations and identification of the likely least cost method to government of recovering the major Avon River pools and maintaining them in the cleared pool condition by partial sediment extraction (Section 6).

The strategic context for recovery and maintenance of Avon River pools is recognised. At one extreme, full recovery and maintenance of all pools would not be an acceptable on-going public cost so a more feasible scenario would be for priority assets to be managed. Alternatively, if there is no action to recover and maintain river pools, there will be further loss of these assets which would be generally unacceptable to local communities and state and national conservation interests. Considering this, the BCA of Section 5 is based on a set of 'scenarios' for river recovery and maintenance.

A description and quantification of the marketable sediment resource for each of the 26 major Avon River pools is provided in the following section.

2 Marketable Resource Description

2.1 River pools and sediment

The major river pools are listed in the order they occur from Beverley downstream to the Avon Valley National Park in Table 2.1 and their locations shown in Figure 1. An estimate of the total sediment volume based primarily on the river pool survey information (JDA, 1997) is provided. Sediment volume information was not available for some pools in the Shire of Toodyay. For these, the volumes shown are based on field observations and local estimates (G. Donegan, *pers. comm.*).

The total estimated volume of sediment in the 26 major river pools is 2,065,000 m^3.

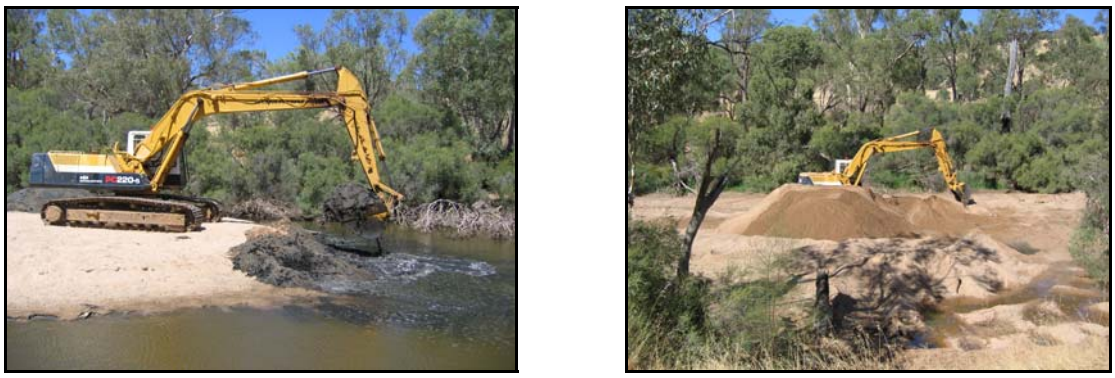
Table 2.1: Major pools of the Avon River

River pool	Estimated sediment volume (m^3)	Pool proportion full (%)	Sediment type
Beverley	50,000	70	Mixture with 55-70% medium sand in some sections, and 85-95% silt and clay in others.
Speldhurst	55,000	90	Generally coarse sand with 20-30% silt and clay. Downstream end is silt and clay
Robins (Seaton Ross Pool)	55,000	50	Silt and clay in the downstream section. Upstream section has higher medium sand content, but still greater than 40% silt and clay
Yangedine (Brouns)[2]	60,000	90	Generally dominated by coarse sand with low silt and clay content
Oakover (Fleays)	40,000	90	Silt and clay with some medium/coarse sand at the downstream end quickly becoming medium/coarse sand dominated with 2% silt/clay at the upstream end.
Gwambygine[2]	50,000 (10,000) [3]	30	Predominantly silt and clay throughout the pool except near the upstream end toward the sand slug where medium/coarse sand dominates
Mt Hardy [2]	75,000	100	Sand
Cold Harbour [2]	65,000	100	Sand
York (Blands)	10,000	15	Medium/coarse sand with 20% silt/clay at either end of the pool with higher silt/clay content (>90%) towards the centre of the pool
3-mile[2]	60,000	100	Sand
Mears (5-mile)[2]	30,000	70	Generally medium/coarse sand with less than 10% silt/clay
Tipperary	160,000	95	Generally silt and clay with an increasing sand content moving upstream
Church (Mackie, Chapel or Sermon)	100,000	65	Predominately clay and silt in the downstream section (>85%). Upstream section has higher sand content, increasing towards the upstream end.

River pool	Estimated sediment volume (m^3)	Pool proportion full (%)	Sediment type
Wilberforce	10,000	5	Generally silt and clay in the downstream section. Upstream section has higher sand content (still with up to 35% silt/clay) and 40% gravel at upstream end.
Jangaling (Muresk) [2]	70,000	100	Sand
Burlong[2]	65,000	100	Sand
Northam	230,000	70	Predominantly silt and clay (>60% content) with higher sand content near weir and upstream of Perth Road Bridge
Egoline[2]	160,000	100	Coarse sand
Katrine[2]	65,000	80	Generally medium/coarse sand with ~5% clay/silt
Glen Avon	30,000	15	Downstream samples high in silt and clay changing towards a high medium/coarse sand content (70%) at the upstream end
Millard[2]	310,000 (150,000) [3]	70	Upstream samples coarse or medium/coarse sand and downstream samples showing high(>90%) silt and clay content
Red Banks	NA	NA	Bed material has hard crust, samples could not be taken
Deepdale[2]	*~150,000*	100	Coarse sand
Jimperding[2]	*~100,000*	100	Dominated by medium/coarse sand with a few samples showing 35% clay/silt
Long[2]	*~60,000 (50,000)*[3]	*40*	Predominantly coarse sand with a few upstream samples showing 40-60% clay/silt
Cobblers	*~5,000*	*10*	Predominantly shallow medium/coarse sand over rock.
TOTAL	**2,065,000**		

Source: JDA (1997), Crilly (2000) and G. Donegan (*pers. comm.)*

Notes:
1. Figures in *italics* are estimates from field observations
2. Pools with potentially marketable coarse river sand.
3. Figures in parentheses are estimates of the volume of coarse sand if less than total volume.



Excavation of coarse sediment from Long Pool February 2005 (Photos courtesy of B. Kelly)

There are now 8 pools totally filled with sediment:

Mt Hardy Pool	Jangeling Pool	Jimperding
Cold Harbour Pool	Burlong Pool	Deepdale Pool
3-Mile Pool	Egoline Pool	

There are 5 pools that are almost filled with sediment:

Speldhurst Pool	Yangedine Pool	Oakover Pool
Tipperary Pool	Katrine Pool	

2.2 Sediment description

Sediments deposited in river pools range from coarse sands to silts and clays. An assessment of sediment fractions is provided in Table 2.1 based on the river pool survey information (JDA, 1997 and Crilly 2000). A brief description of the sediment type is shown in Table 2.1.

A visual classification and particle size distribution analysis is available for Burlong Pool (MP Rogers and Associates, 1996). Detailed sediment analysis was undertaken for Katrine Pool to evaluate sediments for use in road construction for the Great Eastern Highway Bypass near Northam (Golder and Associates, 1999). Detailed sediment analysis information is not available for other major Avon River pools.

There are 14 pools identified with a major proportion of sediments being coarse sand. The estimated total volume of these coarse sediments is 1,110,000 m^3.

2.3 Risk of further sedimentation to Avon River pools

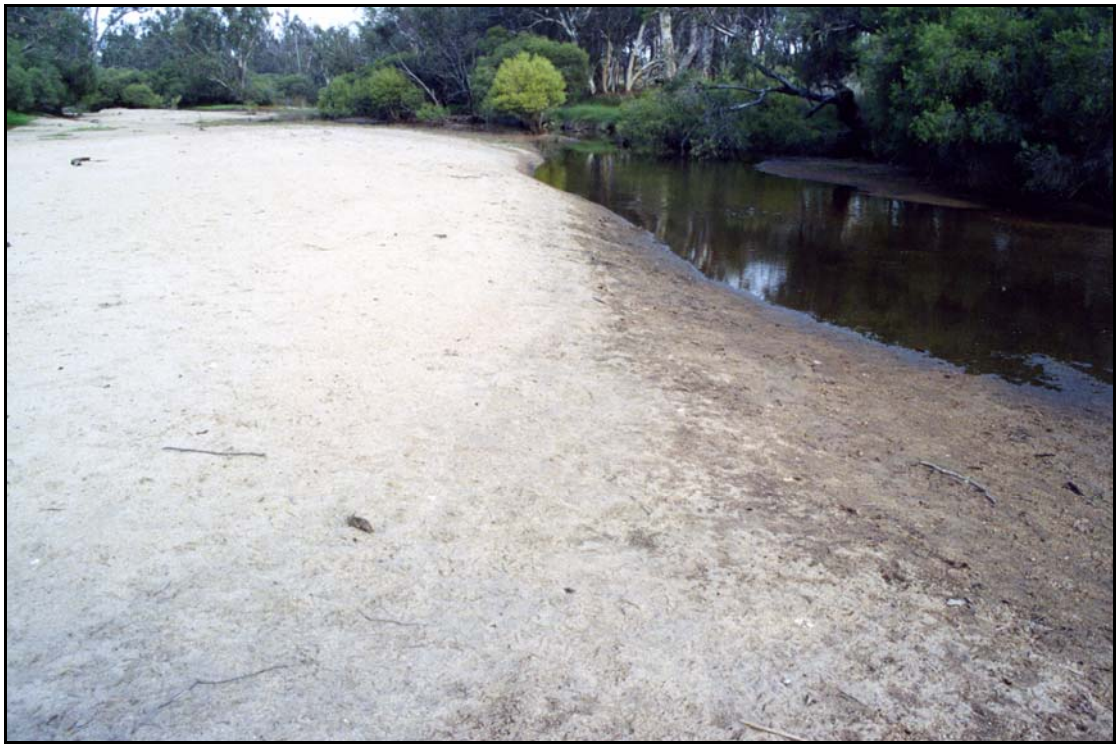
The risk of further sedimentation to Avon River pools is difficult to establish. The River Pool Survey (JDA, 1997) provides benchmark information about the volume, texture and content of sediments for the major river pools. A repeat survey recently commissioned by DoW will assess the changes to the pools within the Shire of Toodyay over the 10-year period since the initial survey. Local observations indicate that some pools are filling rapidly (e.g. Long Pool in the Shire of Toodyay). However, in some areas sediments within the river channel are being stabilized by vegetation.

Unstable river bedload sediments are mobilized by annual streamflow; however, most sediment is mobilized during flood events. It is these high-flow events that will further erode the river channel causing increased sedimentation. Flood events also mobilize sediments stored in the channel of some tributaries (e.g. from the Mackie River in the Shire of York during the January 2000 flood).

During the past 10 years, there has been just one significant flood event which occurred during 21-22nd January, 2000. This has been calculated to be a 1-in-7

year recurrence frequency event so is significantly smaller than previous Avon River flooding (e.g. in 1872, 1910, 1917, 1930, 1945, 1955, 1958 and 1963). While records show a significant decline in annual rainfall and climate predictions suggest further change, the potential for major flooding that causes massive mobilization of sediments can not be ignored.

For this study, risk is assessed on the basis of average annual increases in sediment volume within the pools. The sensitivity analysis, presented in Section 5, considers this range of annual sediment increment to be from 0.5% through to 5% of the 1996 pool sediment volume. The higher value is used in order to account for massive sediment mobilization that may occur in a 1-in-10 year flood event (i.e. 50% of the existing pool sediment volume is added at some time within the 10 year period).



Sediment slug in a river pool, Avon River catchment – photo courtesy K. Gole

3 Feasibility Opportunities and Constraints

The coarse sand sediments from the Avon River pools offer a number of opportunities to commercial enterprise:

- *Environmental and social value* – a business that is using or selling the sediments from the Avon River pools can promote the benefits of sediment extraction for the biophysical environment and the surrounding communities. This may have merit in improving the perceived environmental standing of the company by the public, and may lead to increased price or market share for their product,
- *Free draining and white-ant resistant* – the coarse sand sediments provide good quality fill for building as it is free draining and resistant to white-ants (P. Jones, *pers. comm.*),
- *The product is potentially free* – access to the sediments could be accessed free of government costs. This is becoming increasingly attractive to the building industry in Perth where, due to the recent building boom, sand of suitable quality is becoming a limited commodity.

A number of constraints to the feasibility of sediment extraction from the Avon River pools are identified:

- *Land for stockpiling* – a number of pools have adjacent crown land where extracted sediments can be stockpiled free of charge (e.g. Katrine Pool). However, other pools are surrounded by private land. Access to land for stockpiling and transport will need to be negotiated with landowners,
- *Road access* – access from a main road to some of the Avon River pools is limited. The excavation of sediments may require the construction of road infrastructure at these sites,
- *Railway crossings* – at some of the pools, the sediments need to be transported across a rail road to reach the main road. Where this is the case, access agreements will need to be arranged with *Westnet Rail,* the company which currently has long term lease agreements for management of the railways in the region. Where new road infrastructure is required, additional railway crossings may need to be constructed,
- *Water levels in the pools* – for those pools that are not completely filled with sediment, dredging equipment may be required to remove the sediments due to there being water in the pools. The filled pools still have water running over the surface of the sediments during most winters. However, during the summer months when water levels in the river are at a minimum, dredging equipment may not be needed, rather a lower-cost front-end loader can be used to extract the sand,
- *Distance to market* – the further the pool is from the market, the higher the transportation costs and the lower the economic feasibility of sediment extraction.
- *Sediment quantity and quality* – as shown in Table 2.1, the quantity and

quality of coarse sand sediments vary significantly across the pools. The feasibility of sediment extraction is analysed further in Section 5, and will be particularly constrained for those pools with relatively little coarse sand sediments, and

- *Obtaining disease-free certification for nursery suppliers* – if the sand is to be used by nursery suppliers, certification must be given to ensure the sediment is free of disease. This is difficult to obtain on a large scale across a number of pools.

Table 3.1 provides indicators of the above constraints for each of the Avon River pools.

Table 3.1: Indicators of feasibility for each of the Avon River pools

River pool	Availability of adjacent land (public/ private/ none)	Existing road access (good/ poor)	Additional railway crossings required (Yes/No)	Likely method of extraction (front-end loader/dredge)	Estimated road distance to Perth CBD (km)
Beverley	public and private	good	no	dredge	110
Speldhurst	private	good	no	front-end loader	106
Robins (Seaton Ross Pool)	private	poor	no	front-end loader	104
Yangedine (Brouns)	private	good	no	front-end loader	99
Oakover (Fleays)	private	good	no	front-end loader	95
Gwambygine	public	good	no	dredge	87
Mt Hardy	private	poor	no	front-end loader	82
Cold Harbour	private	poor	no	front-end loader	83
York (Blands)	none	good	no	dredge	75
3-mile	private	N/A	no	N/A	80
Mears (5-mile)	private	good	no	dredge	83
Tipperary	private	good	no	dredge	74
Church (Mackie, Chapel or Sermon)	private	poor	no	dredge	79
Wilberforce	private	poor	no	N/A	111
Jangaling (Muresk)	private	poor	no	front-end loader	105
Burlong	public and private	good	no	dredge	99

River pool	Availability of adjacent land (public/ private/ none)	Existing road access (good/ poor)	Additional railway crossings required (Yes/No)	Likely method of extraction (front-end loader/dredge)	Estimated road distance to Perth CBD (km)
Northam	public	good	no	dredge	97
Egoline	private	poor	no	front-end loader	103
Katrine	public	good	no	front-end loader	98
Glen Avon	private	good	no	dredge	97
Millard	public	good	no	dredge	91
Red Banks	private	poor	no	dredge	90
Deepdale	private	poor	yes	front-end loader	95
Jimperding	private	good	yes	front-end loader	90
Long	private	good	yes	front-end loader	85
Cobblers	private	good	no	N/A	80

Notes: (1) N/A – not applicable due to there being insufficient sediment

(2) The 'dredge' option includes 'long-line' excavators

(3) 'poor' road access indicates that road construction is required to gain access to the pool from an existing major road.

4 Market Opportunity Analysis

The purpose of this section is to report on processes used to engage potential market interest in coarse river sand, First, industries with potential commercial interest in the Avon River sediments were identified. Second, 28 companies representing these industries were contacted, and if amenable, some background information from Section 2 was provided to these companies. Decisions were made as to which companies would be contacted based on their size (generally the larger companies were targeted) and location (generally companies in close proximity to the Avon River pools were targeted).

Two commercial companies responded with interest. The first expressed an interest in the sediments for use in the construction of paving bricks and for concrete manufacturing. A reconnaissance trip to some of the Avon River pools was undertaken with representatives the company, the consultants and DoW.

The pools visited during the field trip included Long Pool, Deepdale Pool, Jimperding Pool and Katrine Pool. The company representatives indicated interest in the sediments although noted that the company is unlikely to be interested in extracting sediments from pools further upstream due to costly transportation.[1] At each of the pools, sediment samples were taken for and site specific opportunities and constraints were discussed. It was agreed that further action would be taken by the company to write a report on the feasibility of sediment extraction for internal circulation before reporting back to the consultants and DoW, Northam.

A second company that operates concrete batching and delivery services responded to the information with a request to take samples from Deepdale Pool. This request was granted by DoW (Northam) with the suggestion that they contact the local landowners for access rights. The results of the sample analysis were pending at the time this report was finalised. The company indicated that they expected to require a few thousand tonnes from the pool annually.

In addition to the 28 private companies, local government offices were also contacted to determine their interest in extracting sediments from the pools and if they were aware of any other private companies which may have an interest. One Shire indicated that they may have a use for the sediments. Further information was provided to the CEO, who agreed to respond early in 2007. It is expected that the Shire will require only small quantities intermittently. The Chief Executive Officer of another Shire indicated that many potential local users are concerned about the salt levels, and that a promotional campaign outlining the potential uses of the sand - including information that the salt leaches from the coarse sand easily - may create additional local interest. There may be a number of local contractors with interest in taking sand from the Avon River pools. However, it is expected that each contractor will require only small quantities.

[1] This response was made without information that all pools are approximately equidistant from Perth,.

5 Benefit Cost Analysis

The Benefit Cost Analysis (BCA) presented here is a study of the costs and benefits to government of excavating the marketable sand sediments from the Avon River pools. The analysis was conducted to aid decision making by government in the case that a commercial business does not conduct these activities. The analysis is presented in the following subsections:

Section 5.1 – Assumptions of the analysis,

Section 5.2 – Sediment extraction scenarios,

Section 5.3 - Calculating the costs,

Section 5.4 – Calculating the benefits,

Section 5.5 – Standard BCA results,

Section 5.6 – Sensitivity analysis, and

Section 5.7 – BCA conclusions.

5.1 Assumptions of the analysis

The BCA is based on a set of assumptions, which are listed below. These assumptions are established through consideration of economic principles and are significant to the outcomes of the analysis. Sensitivity analysis on the key analysis assumptions is provided in Section 5.5.

- Only marketable economic benefits are estimated. For a list of the other economic, environmental and social benefits, see Section 1.2,
- The period for costs and benefits is 30 years,
- The real discount rate is 7%. The costs and benefits are presented in 2006 dollars, hence there is no need to account for inflation. All future benefits and cost streams are converted to present values in the results section,
- Depreciation is not applied in the analysis. Rather, assets are assumed to be fully maintained as part of the excavation and machinery costs,
- Goods and services tax (GST) – all costs and benefits are shown exclusive of GST,
- 1 m^3 is equivalent to 1.6 tonnes of dry sand,
- The distance between all pools and a local buyer is assumed to be 15 km,
- Assumed road distances between each pool and the Perth metropolitan area are provided in Table 3.1,
- Quantities of marketable sand sediments in each pool are provided in Table 2.1 with a 1% annual increase in volume since 1996,
- Due to difficulties in extracting all the marketable sand sediments, it is

assumed that only 50% of the estimated volume is extracted from each pool

- Each pool is excavated once every 10 years (3 times over the 30 year analysis period).

5.2 Sediment Extraction Scenarios

The importance of considering a range of strategic scenarios for sediment extraction to recover and maintain Avon River pools has been identified (Section 1.2). A range of six scenarios is described. Some scenarios are included to take into account the relatively extreme range of management effort (i.e. from taking no action through to full recovery of all major river pools). One scenario specifically considers preventative action taken in Avon River pools to reduce the risk of sedimentation of Swan River assets.

The sediment extraction scenarios are:

Scenario 1: Full pool recovery and maintenance - Recovery of all major river pools and on-going maintenance.

Scenario 2: Recovery and maintenance of pools with coarse sand - Recovery of all major river pools with predominately coarse river sand and on-going maintenance.

Scenario 3: Recovery and maintenance of locally valued pools with coarse sand - Recovery of locally valued pools identified in River Recovery Plans and on-going maintenance.

Scenario 4: Swan River protection - Excavation and maintenance of major river pools downstream from Extracts Weir to provide capacity to significantly reduce or prevent transport of coarse river sediment from the Avon to the Swan River.

Scenario 5: Minimal pool recovery and maintenance - Current practice of occasional river pool sediment excavation as public funding opportunities arise and according to community interest. Existing arrangements for annual extraction of coarse river sand from Burlong Pool (Town of Northam) continues under this scenario.

Scenario 6: No Action - There is no extraction or maintenance of sediments from any of the major river pools.

Table 5.1 lists the river pools and their respective sediment loads for the sediment excavation scenarios. Based on information provided in Table 5.1, the analysis for evaluating the market potential for river pool sediments is based on Scenarios 2, 3, 4 and 5. The increased sediment volume estimates is used for analysis.

Table 5.1: Preliminary scenario evaluation

Excavation Scenario	Major River Pools	Estimated 50% Excavation Volume (m^3)	Evaluation Comment
1. Full pool recovery and maintenance	All	950,000 (1,020,000)	A high proportion of sediments in some pools are silty or clay texture with high salt content. As this is not a marketable resource, this scenario will not be considered further.
2. Recovery and maintenance of pools with coarse sand	Yangedine, Gwambygine, Cold Harbour, Mt Hardy, 3-Mile, Meares, Jangeling, Burlong, Egoline, Katrine, Millard, Deepdale, Jimperding, Long.	555,000 (610,000)	Scenario to be considered in the economic analysis.
3. Recovery and maintenance of locally valued pools with coarse sand	Yangedine, Gwambygine, Cold Harbour, Mt Hardy, Meares, Burlong, Katrine, Millard, Long.	260,000 (285,000)	Scenario to be considered in the economic analysis.
4. Swan River protection	Deepdale, Jimperding, Long.	150,000 (165,000)	Scenario to be considered in the economic analysis.
5. Minimal pool recovery and maintenance	Burlong, other occasional excavation	35,000 (35,000)	*Status quo* - opportunistic arrangements for excavation (other than for arrangements for Burlong Pool). Scenario considered as a benchmark situation for change.
6. No Action	None	None	This scenario was not considered in the economic analysis, however considering the risk of further sedimentation to valued Avon River pools and to the Swan River, it is considered for deriving the social and environmental benefits for other scenarios.

Note: The volume estimates provided in parentheses assumes a 1% annual increase in sediment load since the 1996 survey so is increased by 10%. The estimates are rounded to the nearest 5,000 m^3.

5.3 Calculating the costs

The schedule of costs for the standard analysis is presented in Table 5.2. The range of costs used for the sensitivity analysis is provided in Section 5.6.

Table 5.2: Schedule of costs

General assumptions	Standard costing
Site plans and approval ($/site) – only costed the first time a site is excavated	3,000
Capital costs (machinery) ($) – a one off up-front machinery cost Source: derived from contractor information	400,000
Cost to move machinery ($) – the cost to move the machinery from one pool to the next	5,000
Excavation, stockpile and grading costs ($/t)*	6.00
Stockpile preparation ($) – costed each time a pool is excavated	3,000
Stockpile restoration ($) – costed each time a pool is excavated	5,000
Transportation costs ($/t/km)	0.15

* Source: P. Jones, N. Blackwell, M. Rogers (*pers. comm.*), Crilly (2000)

** Source: P. Jones, N.Blackwell (*pers. comm.*), Crilly (2000)

5.4 Calculating the benefits

For the standard analysis, the value of sand sediment is estimated to be ***$32/t***. This is the retail value of yellow sand suitable for house pads and fill sourced from Rocla Pty Ltd and delivered anywhere within the metropolitan area (C. Bray, APG Homes, *pers comm.*). However, it is acknowledged that the marketable sand sediments have a range of uses and therefore values. Moreover, the value of the sand will be higher if a company intends to add value to it through using it as an input to production, such as the production of paving bricks. A sensitivity analysis on the value of the sand is provided in Section 5.6 to account for this variability.

5.5 Standard BCA results

The present value (PV) of the costs and benefits, the net present value (the difference between the present value of the benefits and the present value of the costs, NPV) and the benefit cost ratio (the present value of the benefits divided by the present value of the costs, BCR) for scenarios 2 to 5 are provided in Table 5.3.

Table 5.3: Present value of costs and benefits, net present value and benefit cost ratio – standard assumptions

	PV(Costs) ($million)	PV(Benefits) ($million)	NPV ($million)	BCR
Scenario 2 - metro	24.81	25.18	0.37	1.01
Scenario 3 - metro	12.75	13.48	0.73	1.06
Scenario 4 - metro	7.60	7.83	0.22	1.03
Scenario 5 - metro	2.14	1.84	-0.30	0.86
Scenario 2 - local	8.49	25.18	16.69	2.96
Scenario 3 - local	4.66	13.48	8.82	2.89
Scenario 4 - local	2.84	7.83	4.99	2.76
Scenario 5 - local	0.95	1.84	0.89	1.94

The present value of the costs and benefits are highest for Scenario 2 and decrease for each scenario. The net present value of each scenario is positive under all scenarios except for Scenario 5 (excavation of Burlong Pool only). Although this analysis is suggesting that extracting sand from Burlong Pool alone and transporting it to a buyer in the metropolitan area is not profitable, in reality it may be profitable if the sand is sold as a specialty product at a higher price than $32/t, or if cost savings are realised. The BCR is very close to unity (a value of one) for each scenario where sand is delivered to the metropolitan area (i.e. approximately one dollar is returned for each dollar spent). The BCR is between 2 and 3 (i.e. $2 - $3 is returned for each dollar spent) under current assumptions if the sand is transported to a local site, assuming the distance to be on average 15km from each pool. This suggests that a company who transports the sand to a Perth-based buyer is likely to break-even, but not generate a profit (before value-adding to the sand product), and a company who transports the sand to a local buyer is likely to generate a profit. Caution should be taken when interpreting these results for local supply. It is likely that lower cost alternative supplies are available locally, diminishing the cost-effectiveness of local supply from the Avon River pools. A sensitivity analysis of these assumptions is provided in the following sub-section.

5.6 Sensitivity analysis

The sensitivity analysis presented in this section shows the impact of changes to assumptions of the BCA analysis. A 50% increase or decrease in some analysis assumptions had little effect on the BCA results for the following assumptions, so individual results are not presented for these cost assumptions:

- Site planning and approval costs,
- Initial capital costs,
- The cost of moving machinery, and
- Stockpile costs – preparation and restoration,

Individual results of the sensitivity analysis are presented for the following key variables:

- The annual increase in sedimentation (Section 5.6.1),
- The proportion of sand sediment extracted from each pool (Section 5.6.2),
- Excavation, stockpile and grading costs (Section 5.6.3),
- Transportation costs (Section 5.6.4),
- The value of sand sediment (Section 5.6.5), and
- The discount rate (Section 5.6.6).

5.6.1 Sensitivity analysis – The annual increase in sedimentation

The annual increase in sedimentation used in the analysis is 1% of the 1996 sediment volume in each pool. Table 5.4 shows the analysis results if this is decreased to 0.5% or increased to 5%. The lower annual sedimentation rate has the effect of lowering the NPV and BCR, although the BCR is still very close to unity. Conversely, the higher annual sedimentation rate has the effect of improving the NPV and BCR. Depending on the scenario, transporting the sediment to the metropolitan area has a BCA of 1.1 – 1.3, and transporting it to a local buyer has a BCA of 2.5 - 3.4.

Table 5.4: Sensitivity analysis on the annual increase in sedimentation

	0.5%		Standard: 1%		5.0%	
	NPV ($million)	BCR	NPV ($million)	BCR	NPV ($million)	BCR
Scenario 2 - metro	-0.51	0.98	0.37	1.01	10.25	1.29
Scenario 3 - metro	0.28	1.02	0.73	1.06	5.72	1.31
Scenario 4 - metro	-0.04	0.99	0.22	1.03	3.15	1.29
Scenario 5 - metro	-0.35	0.83	-0.30	0.86	0.32	1.11
Scenario 2 - local	15.07	2.90	16.69	2.96	32.50	3.40
Scenario 3 - local	7.99	2.82	8.82	2.89	16.75	3.32
Scenario 4 - local	4.51	2.68	4.99	2.76	9.65	3.23
Scenario 5 - local	0.78	1.86	0.89	1.94	1.94	2.51

5.6.2 Sensitivity analysis – The proportion of sand extracted from each pool

The standard assumption for the proportion of sand extracted from each pool used in the analysis is 50%. Table 5.5 shows the analysis results if this is decreased to 25% or increased to 75%. Extracting lower or higher proportions of

sand from each pool has the effect of only marginally worsening or improving the NPV and BCR. This is because the variable costs of extraction and transportation significantly affect the profitability of the operations, both of which decrease or increase significantly as the proportion of sand extracted from each pool decreases or increases.

Table 5.5: Sensitivity analysis on the proportion of sand extracted from each pool

	25%		Standard: 50%		75%	
	NPV ($million)	BCR	NPV ($million)	BCR	NPV ($million)	BCR
Scenario 2 - metro	-0.14	0.99	0.37	1.01	0.88	1.02
Scenario 3 - metro	0.09	1.01	0.73	1.06	1.37	1.07
Scenario 4 - metro	-0.11	0.97	0.22	1.03	0.56	1.05
Scenario 5 - metro	-0.35	0.73	-0.30	0.86	-0.25	0.92
Scenario 2 - local	8.02	2.76	16.69	2.96	25.35	3.04
Scenario 3 - local	4.14	2.59	8.82	2.89	13.50	3.01
Scenario 4 - local	2.28	2.39	4.99	2.76	7.70	2.91
Scenario 5 - local	0.25	1.37	0.89	1.94	1.53	2.25

5.6.3 Sensitivity analysis – Excavation, stockpiling and grading costs

The standard assumption for the combined excavation, stockpiling and grading costs used in the analysis is $6/t. Table 5.6 shows the analysis results if this is decreased to $2/t (excavation is easy and the pool is dry) or increased to $10/t (excavation is difficult and the water level in the pool is high). Decreasing and increasing excavation, stockpiling and grading costs has the effect of slightly improving and worsening the NPV and BCR, respectively.

Table 5.6: Sensitivity analysis on excavation, stockpiling and grading costs

	$2/t		Standard: $6/t		$10/t	
	NPV ($million)	BCR	NPV ($million)	BCR	NPV ($million)	BCR
Scenario 2 - metro	3.52	1.16	0.37	1.01	-2.78	0.90
Scenario 3 - metro	2.41	1.22	0.73	1.06	-0.96	0.93
Scenario 4 - metro	1.20	1.18	0.22	1.03	-0.75	0.91
Scenario 5 - metro	-0.07	0.96	-0.30	0.86	-0.53	0.78
Scenario 2 - local	19.83	4.71	16.69	2.96	13.54	2.16
Scenario 3 - local	10.50	4.52	8.82	2.89	7.13	2.12
Scenario 4 - local	5.97	4.21	4.99	2.76	4.01	2.05
Scenario 5 - local	1.12	2.56	0.89	1.94	0.66	1.56

5.6.4 Sensitivity analysis – Transportation costs

The standard assumption for transportation costs is $0.15/t/km. Table 5.7 shows the analysis results if this is decreased to $0.10/t/km or increased to $0.20/t/km. Decreasing and increasing the transportation costs has the effect of significantly improving and worsening the NPV and BCR, respectively. At relatively high transport costs, it is not cost-effective to transport the sediment to the metropolitan area (BCA is approximately 0.80). At relatively low transport costs, transporting the sediment to the metropolitan area is profitable (BCA is approximately 1.3).

Table 5.7: Sensitivity analysis on transportation costs

	$0.10/t/km		Standard: $0.15/t/km		$0.20/t/km	
	NPV ($million)	BCR	NPV ($million)	BCR	NPV ($million)	BCR
Scenario 2 - metro	6.85	1.37	0.37	1.01	-6.11	0.80
Scenario 3 - metro	3.96	1.42	0.73	1.06	-2.50	0.84
Scenario 4 - metro	2.12	1.37	0.22	1.03	-1.67	0.82
Scenario 5 - metro	0.17	1.10	-0.30	0.86	-0.77	0.71
Scenario 2 - local	17.73	3.38	16.69	2.96	15.64	2.64
Scenario 3 - local	9.35	3.26	8.82	2.89	8.28	2.59
Scenario 4 - local	5.30	3.10	4.99	2.76	4.68	2.49
Scenario 5 - local	0.96	2.09	0.89	1.94	0.82	1.80

5.6.5 Sensitivity analysis – The value of sand sediment

The marketable sand from the Avon River pools has a range of uses, and hence a range of values. The standard assumption for the value of the sand is $32/t. Table 5.8 shows the analysis results if this is decreased to $10/t or increased to $50/t. Decreasing and increasing the value of sand has the effect of significantly worsening or improving the NPV and BCR, respectively. At a low value, it is not cost-effective to deliver the sand to the metropolitan area (BCA approximately 0.3) or to a local buyer (BCA approximately 0.9). At a very high value, it is very profitable to deliver the sand to the metropolitan area (BCA approximately 1.6) and to a local buyer (BCA approximately 4.5).

Table 5.8: Net present value and benefit cost ratios – sensitivity analysis on the value of sand sediment

	$10/t		Standard: $32/t		$50/t	
	NPV ($million)	BCR	NPV ($million)	BCR	NPV ($million)	BCR
Scenario 2 - metro	-16.94	0.32	0.37	1.01	14.53	1.59
Scenario 3 - metro	-8.54	0.33	0.73	1.06	8.31	1.65
Scenario 4 - metro	-5.16	0.32	0.22	1.03	4.63	1.61
Scenario 5 - metro	-1.57	0.27	-0.30	0.86	0.74	1.34
Scenario 2 - local	-0.62	0.93	16.69	2.96	30.85	4.63
Scenario 3 - local	-0.45	0.90	8.82	2.89	16.40	4.52
Scenario 4 - local	-0.39	0.86	4.99	2.76	9.39	4.31
Scenario 5 - local	-0.38	0.61	0.89	1.94	1.93	3.03

5.6.6 Sensitivity analysis –The discount rate

The discount rate used for the standard analysis is 7%. Table 5.9 shows the analysis results if this is decreased to 5% or increased to 9%. A lower and higher discount rate has the effect of slightly worsening or improving the BCR, respectively. This occurs as an increase in the discount rate causes the benefits to decrease by a relatively lesser amount than the costs, even though the value of the benefits and costs both decrease in absolute terms.

Table 5.9: Sensitivity analysis on the discount rate

	5%		Standard: 7%		9%	
	NPV ($million)	BCR	NPV ($million)	BCR	NPV ($million)	BCR
Scenario 2 - metro	-1.49	0.95	0.37	1.01	1.60	1.07
Scenario 3 - metro	-0.24	0.98	0.73	1.06	1.39	1.12
Scenario 4 - metro	-0.34	0.96	0.22	1.03	0.61	1.09
Scenario 5 - metro	-0.46	0.81	-0.30	0.86	-0.18	0.91
Scenario 2 - local	18.16	2.87	16.69	2.96	15.40	3.04
Scenario 3 - local	9.24	2.80	8.82	2.89	8.43	2.97
Scenario 4 - local	5.23	2.68	4.99	2.76	4.77	2.82
Scenario 5 - local	0.91	1.90	0.89	1.94	0.87	1.96

5.7 Benefit Cost Analysis Conclusions

The BCA was undertaken to assess the cost-effectiveness of accessing coarse sediments from Avon River pools as a supply of raw materials to potential local and Perth-based market options. Government-assisted supply may be required if a commercial enterprise is not found which is able to extract and transport sediments without assistance. A number of scenarios are considered:

Scenario 1: Full pool recovery and maintenance (not analysed in the BCA),

Scenario 2: Recovery and maintenance of pools with coarse sand,

Scenario 3: Recovery and maintenance of locally valued pools with coarse sand,

Scenario 4: Sediment removal to provide Swan River protection,

Scenario 5: Minimal pool recovery and maintenance, and

Scenario 6: No Action (not analysed in the BCA).

Analysis results indicate that the cost-effectiveness of extracting sand from all pools with coarse sand (Scenario 2), locally valued pools with coarse sand (Scenario 3) and for Swan River protection (Scenario 4) are very similar. This is because the pools are approximately equidistant from the Perth metropolitan area and the majority of the costs are variable costs (excavation and transport). Hence, the costs and benefits change at relatively the same rate for each scenario as the number of excavated pools, and therefore amount of excavated sand, changes.

If all this sand can be sold locally (within 15 km of each pool), and the price received is at least $12/t, then the BCR of these activities is likely to be at least unity (i.e. where at least $1 is received for every $1 spent). Transporting the sand to the Perth metropolitan area is likely to be cost-effective at current value of $32/t or greater.

The analysis results were sensitive to the price received for the sand, transport costs and, to a lesser extent, the annual increase in sedimentation, excavation, stockpiling and grading costs. The analysis results were not sensitive to site planning and approval costs, initial capital costs, the cost of moving machinery, stockpile preparation and restoration, the proportion of sand sediment extracted from each pool or the discount rate.

The analysis considers only the marketable economic benefits of sand extraction. Other economic, environmental and social benefits were not included in the analysis. If these other benefits were taken into account, they are likely to substantially improve the BCR.

6 Conclusion and Recommendations

Major pools of the Avon River have filled with sediment as a result of alteration to the river channel during the 1950-70's to reduce flood risk, and through soil erosion from agricultural catchments. Some pools are completely filled with sediments and their environmental and social values are lost. Others are filling rapidly. There is further potential for significant sediment transport to the pools and channel in the upper reaches of the Swan River.

The Avon Catchment Council and the State Government, through the Department of Water and the Swan River Trust, is seeking ways to recover the values of Avon River pools by sediment removal and maintenance. It is also assessing options to reduce the sedimentation risk to the values of the Swan River. This study was commissioned to assess the economic feasibility of river pool recovery and maintenance at little or no cost to the Council and Government.

The assessment provides a description of coarse sand as a marketable resource (Section 2). There is estimated to be approximately 2 million m^3 (3.2 million tonnes) of coarse sand in the 26 major river pools of the main channel of the Avon River. The feasibility for extraction of sediment from these pools is assessed (Section 3) on the basis of access to the pool, options for stock-piling and transport distance. Table 3.1 shows there to be relatively little difference between the major pools in the distance they are from Perth. This distance of approximately 100 km from Perth (or approximately 70 km from Midland) is generally within acceptable transport distance for major extractive industries.

The method of excavation is a major criterion for assessment of the suitability of each major pool. This study does not provide a technical feasibility assessment, however a preliminary assumption of the type of excavation method is provided in Table 3.1. Not all pools are suitable for sediment extraction.

The market supply options were assessed (Section 4) and there is strong interest by two commercial services (in addition to the existing commercial operation at Burlong Pool near Northam). At least one Local Government Authority has also expressed an interest. There may be stronger interest if the different uses and values of the marketable sediments were better understood by the community.

The economic assessment is based on BCA of six 'scenarios' (Section 5.2). The first scenario is for full pool recovery and the last is for 'no action'. Neither of these was considered to be realistic or acceptable options so were not analysed further. The accepted scenarios were:

Scenario 2: Recovery and maintenance of pools with coarse sand,

Scenario 3: Recovery and maintenance of locally valued pools with coarse sand,

Scenario 4: Sediment removal to provide Swan River protection, and

Scenario 5: Minimal pool recovery and maintenance.

The last of these (Scenario 5) represent the current arrangements which are generally not acceptable (i.e. not providing sufficient river pool recovery) however this does provide a benchmark assessment for the other three scenarios. The BCA is based on the marketable economic benefits of sand extraction, and does not

attempt to quantify the other economic, environmental and social benefits. These other benefits may include the social and environmental benefits to local communities, personal and economic benefits to landholders adjacent to the river, sediment risk reduction to pools and the channel of the upper Swan River, and reduction in costs or possible financial return to the State Government from river pool recovery and maintenance. The Benefit Cost results are likely to be higher if these benefits were to be included.

The value of the sand significantly affects the Benefit Cost results. In this analysis, it is valued at $32/t delivered (the market value for sand in the Perth metropolitan area). This value is important to the economic feasibility of supplying Avon River sand to the large metropolitan market, particularly for the building industry. While sand is not in short supply on the Swan Coastal Plain, the options for location of new or expanded extractive industries are restricted. It is expected that this value will increase with time.

The analysis is based on the assumption that commercial enterprises do not have to pay government fees or royalties for the resource. The State Government is not expecting to receive payment for the sand resource as there is major benefit through improved river values. However, there is a need to clarify if private landholders have a valid claim to royalty payments for sediment deposited on their land title area (which includes the river bed in some situations). Even a small private royalty would significantly alter the economic feasibility of sand extraction.

Recommendation 1: **That the State Government (through its agencies) clarify ownership of the sediment where it occurs on private land title.**

The costs and benefits for the four scenarios of the analysis with the standard assumptions are shown in Table 5.3. For scenarios 2, 3 and 4, the economic benefits (i.e. the cost savings by not having to pay for the sand resource from another supply) are slightly greater than the costs for supply to the metropolitan area (the BCRs are 1.01, 1.03 and 1.06 respectively). On this basis, it is marginally beneficial to source Avon River sands for Perth supply. The benefit does however increase if the travel distance is reduced (e.g. for supply to Midland).

Where the benefit is marginal, it may not be considered feasible if there is not value added to the coarse sand resource (e.g. if used as land fill for building site development). However, the resource would be more attractive to industries that add value to the raw material (e.g. manufacturing concrete products). This difference is demonstrated by the interest shown in the resource being from two value-adding commercial enterprises.

Table 5.3 shows the higher BCR's for local supply (i.e. assuming the transport distance is 15 km). This analysis is also based on alternative sand supplies costing $32/t delivered. It is likely that lower cost alternative supplies are available in local areas and the full benefit of using Avon River sands may not be realised. Considering this, and the larger potential volume of supply to the

metropolitan area, it is recommended that the State Government pursue contract arrangements with options to supply sand to the Perth area. However, the opportunity for local supply should be promoted and encouraged.

Recommendation 2: **That the State Government (through its agencies) develop arrangements for commercial development of Avon River sand supplies.**

Recommendation 3: **That the State Government (through its agencies) create market opportunities by promoting the utility, commercial values and availability of the coarse Avon River sand for Perth metropolitan and local supply.**

If arrangements cannot be negotiated for commercial development of Avon River sand supplies at no cost to the government, cost-sharing arrangements could be negotiated for the excavation of pools that reduce the risk of sedimentation to the Swan River.

Recommendation 4: **If commercial opportunities for excavation of pools with no cost to government cannot be negotiated, that the State Government (through its agencies) negotiate cost-sharing arrangements with these commercial interests.**

Given that the BCR of delivery of sediments to the metropolitan area is approximately equal to unity at current prices and costs, and given that the supply of sand in Perth is likely to be constrained in the future, the feasibility of supply is likely to increase in the short to medium-term. Hence, any negotiated cost sharing arrangements should be short-term only.

Recommendation 5: **That negotiated cost-sharing arrangements for excavation of pools should be short-term only.**

Also shown in Table 5.3 is that all scenarios for metropolitan and local supply are more feasible than the current arrangements (Scenario 5). This indicates that there will be greater public benefits by the State Government agencies actively arranging for a higher volume of extraction of Avon River sand than occurs now.

The BCA sensitivity analysis shows that economic feasibility is strongly influenced by the value of the sand (Table 5.8) however this is a value that is established through market processes. Government could not effectively influence the market value of the resource.

The sensitivity analysis shows some cost variations result in little difference to the

economic feasibility while others cause significant difference. The two major costs to which the economic feasibility responds are the excavation, stockpiling and grading costs (Table 5.6) and the transport costs (Table 5.7). These are the costs that are most likely to influence the commercial decisions for Avon River sand extraction. In situations where negotiated arrangements are required, it is recommended that the focus of negotiation is on these two costs. Moreover, the excavation, stockpiling and grading costs are dependent on the volume of sediment removed, whereas transport costs are also dependent on transportation distance. It is likely to be easier to audit cost-sharing negotiations, and predict their cost, if they are associated with excavation, stockpiling and grading costs, rather than transport costs.

Recommendation 6: **That cost-sharing arrangements be negotiated on excavation, stockpiling and grading costs.**

Scenario 4 is based on extraction of sediments in pools that will reduce the risk of sedimentation to the Swan River. The State Government may consider this to be a priority for public benefit and seek to encourage extraction from these pools in favour of other river pools. Negotiated arrangements for cost-sharing under this management scenario may be required to ensure adequate volume is removed and the potential environmental risk is reduced. Protection of locally-valued pools is likely to occur in the medium term as the feasibility of sediment excavation improves.

Recommendation 7: **That cost-sharing arrangements be negotiated for the excavation of those pools that reduce the risk of sedimentation to the Swan River only.**

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