Stream rehabilitation – impact on water quality and long-term effectiveness in an urban environment

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Abstract

Shrimptons Creek is a small catchment in the suburban-commercial area of North Ryde, New South Wales, Australia. The original channel system was significantly modified by firstly agricultural, then suburban, and finally commercial development in its catchment and along the channel. Sewer lines, uncontrolled stormwater outlets, major road systems with culverts and significant weed infestation occurred over a period of more than 150 years. The opportunity was provided to rehabilitate a section of the channel and monitor the effectiveness of the rehabilitation. It is concluded that the rehabilitation impacted on the aesthetic amenity of the channel and had some limited effects on water quality. However, the failure to maintain the system, a problem identified elsewhere by the authors, has reduced the effectiveness of the rehabilitation
Keywords: urban stormwater pollution, channel rehabilitation, water quality.

1 Introduction

The transition of watersheds from the natural to the urban condition encompasses the removal of vegetation and canopy, compaction of soils, creation of impervious surfaces, and alteration of natural drainage networks. These actions result in increased surface runoff and a change in the hydrologic regime of the receiving water and also cause change to sediment budgets (Herricks and Osborne [1]; Henshaw and Booth [2]). Urbanisation also has many damaging impacts on the chemical and biological systems of the stream.

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Restoration and rehabilitation projects on small streams have been undertaken for many years. The primary elements of stream restoration are isolation, removal, transfer and dilution through space and time (Herricks and Osborne [1]). Isolation requires the permanent limitation on movement and transfer of a substance within a stream and is often a restoration technique of limited value. Removal of a substance or cessation of an activity that may be detrimental to stream health eliminates the potential for future degradation. Preferably removal should occur at the source rather than in the waterway. Transfer relies on the stream itself to remove the substance from an area and is a poor rehabilitation tool as it only solves the problem in a particular area and may subject a section further downstream to increased environmental stress. Dilution through space and time may be achieved through transfer (Herricks and Osborne [1]).

Gore [5] suggests that river and stream rehabilitation should be viewed as a "process of recovery enhancement" in which management efforts strive to help the waterway adjust naturally to disturbance. The recovery potential and success of rehabilitation works should therefore be measured by the capacity of the stream reach to attain a sustainable structure and function for the position it occupies in the catchment, and the boundary conditions under which it operates (Fryirs and Brierley [3]). Once this is achieved, sustainable physical and ecological functioning can occur (Fryirs and Brierley [3]).

River rehabilitation strategies require post project maintenance, monitoring and auditing for ongoing success (Fryirs and Brierley [3]). Projects require clear objectives, baseline data, good study design, long-term commitment and adaptability (Fryirs and Brierley [3]).

There are significant quantities of research regarding the benefits of individual rehabilitation measures such as gross pollutant traps, riffles and large woody debris. However there is little information available on systematic studies evaluating the success of restoration projects (Kondalf [4]). This paper tries to fill this gap by evaluating the success of a stream rehabilitation project located in the Ryde City Council area of News South Wales in Australia. Suggestions are made to improve sustainability of such rehabilitation.

2 Shrimptons Creek

Ryde City Council is located in the North-West of Sydney (Figure 1). It received a grant for the rehabilitation of Shrimptons Creek under the New South Wales Stormwater Trust Stage 2 Grants Scheme. The objective of the Stormwater Trust is to encourage and support improved urban stormwater quality management practices and to improve the condition of the State's waterways. Stage 2 of the Stormwater Trust Grant Scheme is for stormwater projects that will have a significant and long-term benefit to the health of urban waterways. The strategy for rehabilitation of the channel was as outlined in Figure 2.

Shrimptons Creek is located in suburban Sydney. It is a perennial creek flowing in a North easterly direction into the Lane Cove River and forms part of the Central Ryde sub-catchment that drains into the Lane Cove River. The catchment, of approximately 555 hectares (EGIS Consulting Environmental and

AWT [7]), encompasses the suburbs of North Ryde, Marsfield and Macquarie Park within the Local government area of Ryde City Council. In the reach of interest two minor tributaries enter the creek immediately downstream of Kent Road, while many stormwater drains flow into Shrimptons Creek from the local urban areas.

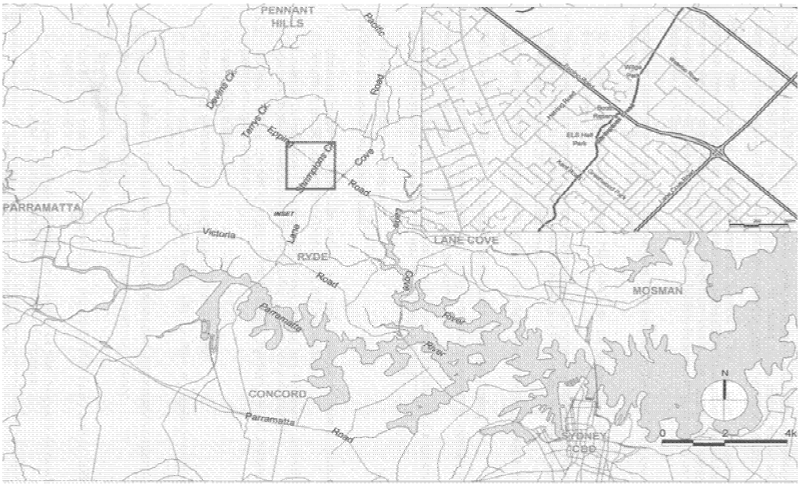


Figure 1: Shrimptons Creek (Source UBMC [6]).

The catchment area consists of a number of zonings including land which is zoned Open Space 6(a), Recreation Existing, Open Space 6(c), Recreation Proposed, Roads (a), Country Road Proposed, Industrial 4(d) Industrial Special University and Residential 2 (c1) and (a).

The section of stream in which rehabilitation was undertaken extends from Kent Road to Waterloo Road, passing underneath Epping Highway (Figure 1).

Sampling took place at 6 sites, which included a control. Physical, chemical and biological parameters were monitored, to have a detailed knowledge of the water quality in the stream. In addition, hydrological and meteorological characteristics, namely rainfall, streamflow and air temperature, were also monitored. The sampling strategy including the parameters assessed as part of this study is outlined in Table 1. There was an initial period of monitoring prior to the rehabilitation works, then monitoring during construction and for 6 months following the completion of rehabilitation works. A year later the site was monitored for another year. Six years latter the site was inspected to assess the sustainability of the rehabilitation.

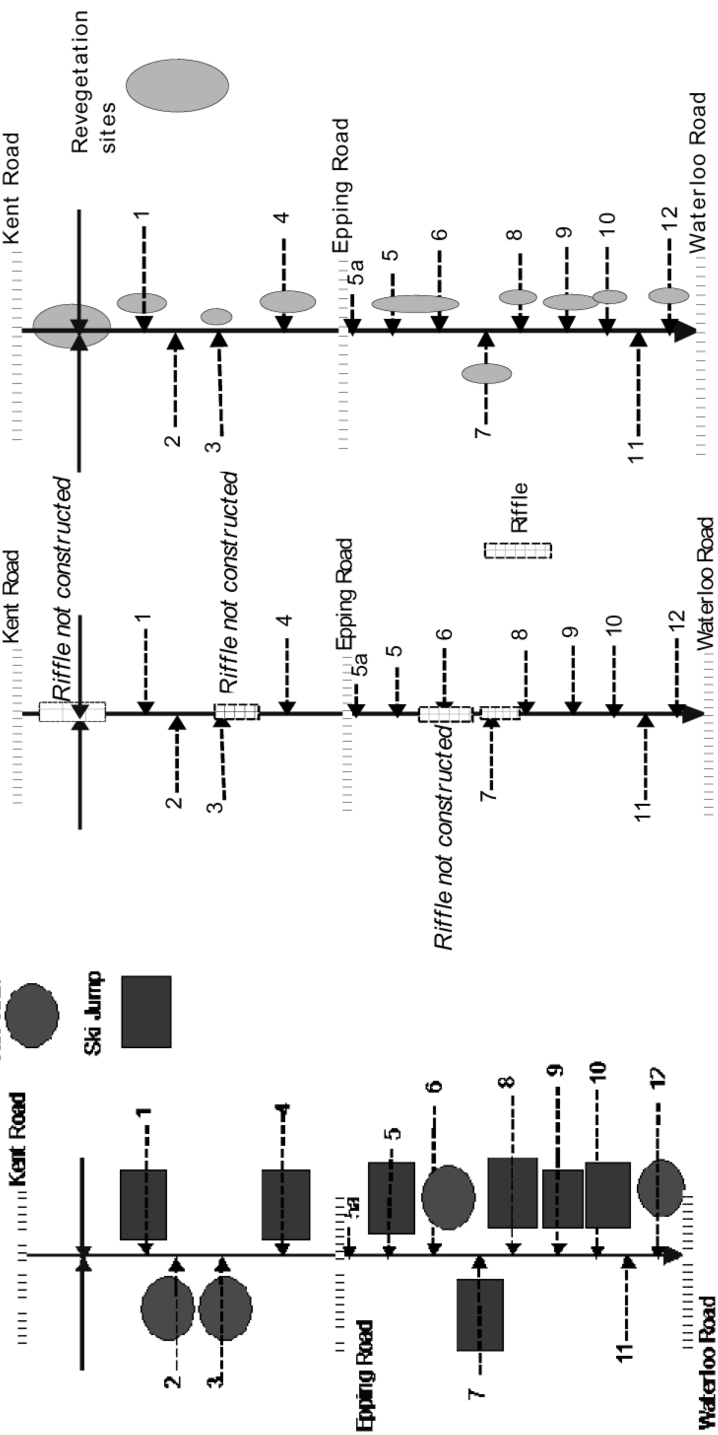


Figure 2: Schematic diagram of gross pollutant trap and riffle structures, and revegetation.

Table 1: Summary table of stream monitoring program.

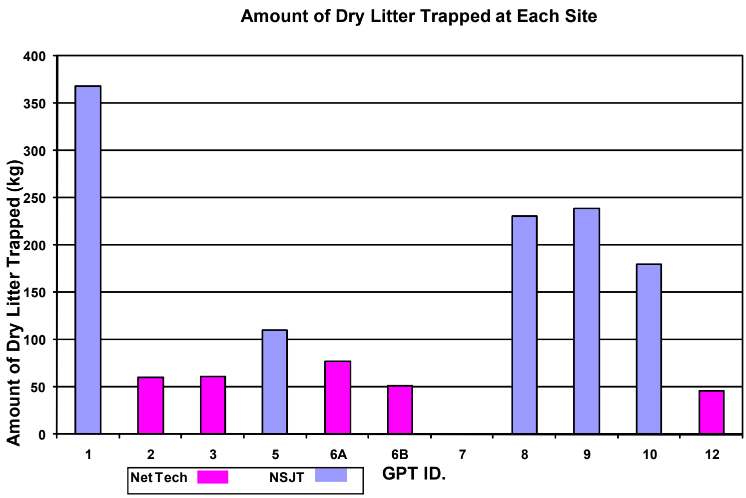
PARAMETER	SAMPLING FREQUENCY	SAMPLING LOCATION	ANALYSIS METHOD
Temperature	Weekly	All	Hydrolab M/D
pH	Weekly	All	Hydrolab M/D
Percent Dissolved Oxygen	Weekly	All	Hydrolab M/D
Specific Conductivity	Weekly	All	Hydrolab M/D
Oxygen Reduction Potential	Weekly	All	Hydrolab M/D
Turbidity	Weekly	All	Hydrolab M/D HACH Turbidimeter
Faecal Coliform	Weekly/monthly	1 and 6	UWSH APHA (1995) section 9222D.
Total Nitrogen	Weekly	1 and 6	UWSN
Total Phosphorus	Weekly	1 and 6	UWSN
Anions	Weekly	1 and 6	Ion Chromatography
Cations	Weekly	1 and 6	Ion Chromatography
Nitrate	Weekly	All	Hydrolab M/D
Chloride	Weekly	All	Hydrolab M/D
Total Suspended Solids	Weekly	1 and 6	UWSN APHA (1995) section 2540D.
Rainfall	Fifteen minutes	MU	MU AWS
Stream flow	Ten minutes	Near Site 6	Starflow depth-velocity recorder
Air Temperature	Fifteen minutes	MU	MU AWS
Storm Sampling	Event Based	Sites 1 and 6	AWT
Gross pollutants	As required	All GPTs.	UWSN

Hydrolab M/D- Hydrolab Minisonde/Datasonde
UWSH - University of Western Sydney Hawkesbury
MU AWS - Macquarie University Automatic Weather Station
UWSN - University of Western Sydney Nepean

3 Results

A large amount of data was collected during this study. The following presents an analysis of some of the gross pollutant data and the discussion summarises some of the results of the water quality sampling.

The collected material was sampled for content, as illustrated for in Table 2. A total of 3 tonnes of gross pollutant (wet weight) or 1.4 tonnes of dry material weight was collected from the traps over a 12-month period (Fig 3). This is a conservative figure however as the cleanout procedures reverted to mechanical procedures, due to increased maintenance efficiency and worker safety concerns, where the trapped material weights were not ascertained. The Net Tech bags collected more material than indicated but due to their inability to retain material during high flow periods much material was lost and released back into Shrimptons Creek.



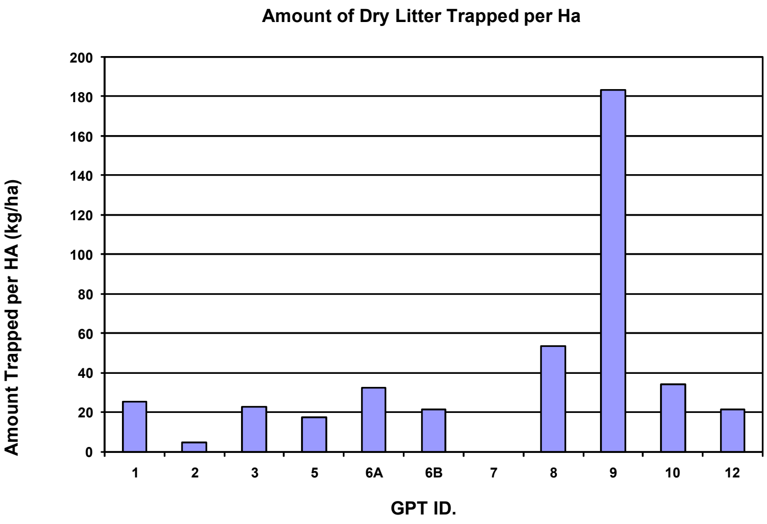


Figure 3: Amount of dry litter trapped in GPTS and corrected for catchment area.

Table 2: Content analysis for clean out on the 21/11/00.

Material Class	GPT ID									
	1	2	3	5	6A	6B	8	9	10	12
Aluminium Cans (kg)					0.03		0.28			
Glass (kg)			0.13	0.26	0.03		0.04			
Organic Materials (kg)	94.81	2.89	6.47	15.78	4.26	3.47	29.81	49.14	29.72	30.38
Plastics (kg)	0.85	0.49	0.1	0.92	0.19	0.06	0.54	0.27	16.45	0.15
PET (kg)		0.19			0.07					
Paper/Cardboard (kg)		0.04		0.02	0.06	0.05	0.04	0.27	7.61	0.15
Other Materials (kg)		1.09	0.07	0.03		0.02	1.06	0.02	9.08	0.02
Other (kg)	0.85		0.03	0.07	0.13	0.16	1.37			
< 2mm (kg)	23.7	0.25	0.23	10.17						1.73
Amount of Wet Litter Trapped (kg)	298	11	18	56	10	8	71	145	84	36
Amount of Dry Litter Trapped (kg)	120.22	3.86	7.02	27.25	4.758	3.77	33.14	49.7	62.87	13.12
Percent of Dry Litter (%)	40.34	35.12	38.99	48.67	47.84	47.13	46.68	34.27	74.85	36.44
Dry Litter/Day (kg/d)	4.29	0.14	0.25	0.97	0.17	0.13	1.18	1.775	2.24	0.47
Dry Litter/ha (kg/ha)	8.35	0.3	2.6	4.4	1.98	1.57	7.71	38.2	12.09	6.25

4 Discussion and conclusions

When discharge is compared to water quality parameters several trends emerge. During low discharge periods spatial differences, between sites, are highest. There is no clear seasonality, with most changes detected due to rain events with seasonal variations confined almost exclusively to temperature and oxygen concentration. In some cases, it is the hydrological conditions that often regulate the water chemistry. However, when some parameters were compared to the creeks discharge, the low level of correlation between flow and these parameters suggests that other processes are occurring, that were not measured, which are significant to water quality.

There were few examples in the observed chemical and physical data monitoring where definite conclusions could be drawn as to weather the rehabilitation works had a negative or positive effect on stream health. This may be due to the variability of data and effect of activities that were not monitored. Preston et al. [8] found that there is a high variability of water quality over time in catchments of the Lane Cove River. In studies by Sim and Webster [9] of sites upstream and downstream of a trash rack little improvement in water quality was observed. The removal of substantial quantities of gross pollutants by the GPTs placed along the stormwater outlets discharging into Shrimptons Creek and the improved visual and, therefore, recreational amenity of the stream corridor through bank stabilisation and regeneration works are clear signs of improvement. This suggests that for the short-term benefit of the stream, the installation of gross pollutant traps and regeneration of the riparian corridor are successful strategies to improve the quality of the aquatic environment.

In future studies, the use of more accurate equipment that enables better and improved data capture and obtain more reliable results will be required. A consistent approach to the assessment of Total Nitrogen and Total Phosphorus is also needed. Also, if a larger data bank is built up over several years, future analysis could include adjustments for storage behaviour, climatic variables, seasonality and stream flow that would further reduce fluctuations in water quality that confound the detection of real trends.

Streams have considerable powers of natural recovery. However adjustment, either towards a new equilibrium or recovery to pre-condition is a long-term process and depends upon the removal of the original disturbance or stressor (Swales [10]). Therefore the future health of similar streams and creeks in suburban catchments cannot depend solely on the successful implementation of one-off initiatives but need to be built into the wider urban planning process with the removal of major sources of effects on urban streams being ameliorated.

Upstream and downstream of the rehabilitated stretch is still degraded and the rehabilitation measures may therefore not be sustainable in the long-term. Practical maintenance for a number of years is therefore necessary for performance consistency and is also required to ensure the financial, intellectual and labour inputs were not in vane (ASCE [11]; Morris and Moses [12]).

Committing to a long-term program of monitoring is the most practical and effective way to assess a restoration program and document the recovery of ecosystems (Frissell and Ralph [13]). Reference data is especially important because it provides a measure of site potential, or a sense of what level of recovery is reasonable and desirable (Frissell and Ralph [13]). Assessing the unrestored condition of a creek will allow the gauging of the effects of restoration efforts as will measurements of pre-treatment baseline data (Frissell and Ralph [13]). The data collected as part of this project could be viewed as baseline or reference data, as it documents the early stages of rehabilitation, to be used as part of a wider and longer term monitoring strategy. Brown et al. [14], along with others, have pointed out the need for long-term maintenance if the rehabilitation and pollution control systems are to be effective and sustainable. A site inspection in 2007 showed that the revegetation was failing, although the structural works, namely the pools and riffles, had maintained their integrity. The gross pollutant traps were in place but the required cleaning may not have been as frequent as possible. A prolonged drought in Sydney reduced the number of sizeable runoff events, and street sweeping may have been more effective in reducing the amount of material washed into the traps.

Rehabilitation, to be effective, has to be sustained. Volunteer groups cannot be relied upon in the long term, and rate payers often see alternative uses for their taxes and levies that may not be aligned with the aspirations that enabled the rehabilitation works.

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