Paper written by: **Paul Duncan**- Managing Director

BTL Environmental Services Australia PTY LTD Trading as **BTL Australia**

Soft Engineering

The Sustainable alternative for improving water quality and achieving environmental outcomes.

Turf Reinforcement Mats

2010

Paul Duncan has been involved in the Australian construction industry for over 20 years. He has had employment history with some major civil contracting companies such as Thiess, Leightons and Abigroup, working in the areas of survey and on all aspects of road construction. He has also filled roles with the NSW RTA and within road construction for his local council.
Paul and his wife Jenny, created the business of BTL Albury after discovering, through his road construction experience, the relatively unknown environmental and economic benefits of using 'soft engineering' in place of 'hard armour'. BTL Environmental Services Australia PTY LTD emerged from the original business of BTL Albury, which began in 2002.The company has grown from purely the supply and installation of erosion control products such as TRM's, to consulting and providing contractors with a complete package for the implementation of erosion and sediment control minimization measures for their projects.

Those close to Paul know that his greatest motivation for bringing about change comes from the loss of his five year old daughter Jessica to cancer. It was suggested to Paul that it was possibly caused by environmental influences but no one could be certain. That was enough for Paul to decide to do something to improve and protect the environment. He has found not only a vehicle to improve water quality by promoting soft engineering but also a way to honour his daughters' short life.

BTL has had articles published in the Australian Contractor Magazine, The NSW Farm Guide and had a hand in the TRM information presented in the updated version of the Soils and Construction Volume Two, Blue Book. BTL has been a member of the International Erosion Control Association since 2004.

Jenny Duncan

BTL Australia's mission statement is: **To assist with making environmentally sensitive judgements for the prevention of erosion and to minimise the adverse effects of sedimentation for sustainable management of land and water resources.**

Some of the organizations and projects BTL has been involved with include:

- The Southern Alliance, Hume Highway, Abigroup
- The Northern Alliance, Hume Highway, Leightons
- Woomargama Bypass, Hume Highway, Abigroup
- Goulburn Murray Water
- NSW Road Traffic Authority
- Lake Macquarie City Council-Civilake

- Albury City Council, NSW
- Launceston City Council, Tasmania
- West Tamar City Council, Tasmania
- NSW Department of Natural Resources

Abstract

Effective measures for the improvement of water quality

The shortage of water Australia wide has become a major issue facing every state. The purpose of this paper is to highlight an equally major threat to our present and future water supplies- sedimentation and the subsequent pollutants that are carried or ˜ piggybacked˜ within sediment, ending up contaminating our waterways.

This paper presents much needed information regarding innovative and effective ˜ soft engineering˜ techniques that can be adopted to reduce the damaging effects of erosion and polluted sedimentation, at a fraction of the cost, with improved environmental outcomes, not presently achievable with the application of traditional measures. We aim to share with readers a sustainable method for achieving an effective approach to erosion control and stormwater management and the easiest, most effective method we presently have for improving water quality.

Our vision is to share with readers the examples of ˜ soft engineered˜ initiatives that have been undertaken throughout the Eastern states with our goal being to reach a common understanding on the most effective way of achieving an efficient national approach to water improvement, which could lead to the development of consistently applied water management strategies Australia wide.

The methods we use now to manage our water are critical to Australia's future water health. For example, our current stormwater systems are designed to take rainwater from our streets

into the closest waterway. The stormwater is not treated before it enters our waterways, in most cases it flows directly from our streets and gutters into our rivers, creeks, bays and the ocean. When stormwater flows over our constructed impervious surfaces it readily accumulates pollutants from many different sources, ranging from litter and petrochemicals, to sedimentation from building sites, soil erosion and land degradation.

By using vegetation enhancing Turf Reinforcement Mats in place of hard engineering practices we are able, in part to address the stormwater pollution issue by filtering water runoff through vegetation. This is our most viable option for achieving sustainable management of our polluted water runoff. There are multiple environmental benefits to using these vegetated water systems and because these technologies are less costly than traditional hard engineered or piped solutions, we are able to increase the quantity of water improving projects possible within budget constraints .

This paper would fall under a Learning and Development theme and we are grateful to be able to share successful project case studies and subsequently demonstrate the evolving behavioural change that is occurring with regards to present day water management techniques.

Kind regards,

Paul Duncan

The purpose of this paper is to highlight the use of Turf Reinforcement Mats (TRM's) as a method for achieving a sustainable approach to erosion control and stormwater management and to improve water quality, thus reducing our environmental footprint.

Our second purpose, is to address the slow uptake of 'soft engineering' alternatives in Australia and to highlight the necessity for current research into these applications to ensure these practices become Australian standard in future construction projects and as a subsequent erosion and sediment control measure.

Background:

For many years we have been using synthetic materials to help hold on to land when it is exposed to water running over it. "In erosion control terms, the geotextile protects soil surfaces from the tractive forces of moving water or wind and rainfall erosion." (Engineering Use of Geotextiles" Technical Manual. Departments of the Army TM 5-818-8 and the Airforce AFJMAN 32-1030 20 July 2005.p8) This manual is referring to types of geotextiles that on their own cannot reinforce and prevent further degradation or erosion. These types of geotextiles would require stakes along with rock and/or gravel to hold them in place and shield them from ultraviolet light. When talking about geotextiles in Australia, most would think of these types of geotextile materials. However, there are many types of geotextiles available, with a wide variance in their specifications and performance capabilities.
For the purpose of this paper our area of focus pertains to 'stand alone' geotextile material, known as Turf Reinforcement Mats (TRM's). In the specific field of TRM's there is a wide variance in qualities and capabilities amongst the many mats on the market. The use of synthetic, woven and non-woven mats (TRM's) to reinforce and strengthen disturbed soil areas, allows us to apply such techniques even when water flow velocities are in the higher range, without losing the structure of the system to the erosive forces of flowing water.
In fact, the newer ‘High Performance’ TRM's (HPTRM's) can maintain their strength and integrity with flows comparable to those experienced during cyclonic weather, and still hold vegetation in place.

Existing need/necessity:

The provision of clean water is one of the most pressing challenges facing Australia and the rest of the world in the 21st century. The methods we use now to manage our water are critical to Australia's future water health. For example, our current stormwater systems are designed to take rainwater from our streets into the closest waterway. The stormwater is not treated before it enters our waterways and in most cases it flows directly from our streets and gutters into our rivers, creeks, bays and the ocean. As our population continues to grow and urbanisation increases, we must be mindful of the direct link between the present stormwater systems and the future outcomes for our rivers, creeks and oceans.

When stormwater flows over the ever increasing amount of constructed impervious surfaces like roads, driveways, car parks, roofs and paving, it readily accumulates pollutants from many different sources and including litter, fuels and oils, hydrocarbons, excess fertiliser and soaps, as well as sediment from building sites, soil erosion and land degradation.

It is known that, "Improving stormwater quality in the long term will require effective prevention and management of these pollutants at their source as well as treatment of stormwater before it enters our waterways". (From: EPA Victoria-Victoria's Water Environment-Stormwater issues.)

Projects that reduce stormwater runoff volumes and address stormwater pollution are essential and long overdue in Australia and should be seen as viable options for achieving sustainable management of our water.
The US Environmental Services and the US EPA currently fund projects that encourage the implementation of innovative approaches to stormwater management.

The goals of the US EPA's funded projects include:

- Filtering stormwater to **remove pollutants** before the runoff enters groundwater, streams, or wetlands;
- Using and promoting methods that provide **multiple environmental benefits**;
- **Capturing and detaining stormwater** runoff as close to the source as possible; and
- Using **technologies that are less costly** than traditional hard engineered or piped solutions.

All of these goals can be achieved using TRM's to reinforce and strengthen the capabilities of vegetated water carrying systems.

Some of the long known benefits of vegetated stormwater drains and sustainable stormwater systems include:

- the ability to improve water quality by **reducing sediments and pollutant** loads;
- the ability to **slow runoff** velocities and **promote infiltration**:
- more **cost effective** and **easier to maintain** than curb and gutter and other traditional hard engineering practices.

(From: Stormwater library- Resources for Stormwater Professionals. Jan.25, 2009- filed under Design Resources, Green St. Series, Low Impact Design.)

Open drain (before)

Open drain (after)

Section1: '<u>Soft Engineering' technologies</u>

TRM's -Applicability/Capability

TRM's have been widely used and adopted in the US for over 20 years and have become a Best Management Practice(BMP) as a most effective method for managing water flows and preventing the effects on land of water erosion. Some regions and cities in the United States have actually retro-fitted outdated concrete drainage systems with vegetated stormwater drains. The City of Chattanooga has become known for their innovation with ‘soft engineering’ in place of traditional engineering. Many other US cities have implemented 'Green Stormwater Initiatives' and 'Low Impact Designs' over the last decade including the City of Portland, Oregon and the City of Seattle, Washington.

Structural stormwater management practices (using TRM's to reinforce as necessary) can be used to achieve four broad resource management goals.

These include:

- **Flood control;**
- **Channel protection;**
- **Ground water recharge;**
- **Pollutant removal** goals

TRM's can be used to help permanently reinforce vegetated land in low-moderate intermittent flow conditions and are considered a Best Management Practice for dealing with storm water runoff from urban, suburban and developing areas in US cities.
('Protecting Water Quality in Urban areas.' Minnesota Pollution Control Agency. March 2000)
Fortunately, we now have access to High Performance Turf Reinforcement Mats (HPTRM's) which are capable of maintaining and reinforcing vegetation even in very high flow conditions, up to 8 m/second for a peak flow event.
The storms and hurricanes such as Katrina, experienced in South Florida in 2004-2005 clogged waterways with debris, damaged water control structures and caused severe erosion along canal banks. One such canal C-51, which runs parallel to State Road 98/441 was identified as a critical bank to protect from further erosion. Although articulated concrete block and rock rip rap were considered for the project, they wanted the finished project to look natural, using reinforced vegetation to stabilise the shoreline so as not to inhibit the natural ecosystem and wildlife that make the canal their home. They chose a high performance TRM for the 55 000 square yards of shoreline requiring reinforcement.
The combination of high tensile strength and superior UV stability were key considerations for acceptable design life, as were the long term maintenance requirements. The TRM chosen was composed of X3 extruded fibre technology which creates ridges and valleys to trap more water, soil and seed for faster vegetation establishment.(from: Propex Geosynthetics. Project Spotlight 2006 -133-FLA LL300)

The benefits for society, of using soft engineering, fall into three key areas:

- **cost** effectiveness- to install and maintain
- **environmental impact**-improvement in water quality, land degredation
- **public acceptance**/ aesthetics/ safety.

Over the years TRM's have been used for a multitude of applications in the United States from stormwater management, streambank stabilisation, coastal protection through to reinforcing golf courses, grass carparks and walking tracks. The US EPA published a fact sheet in1999 regarding the uses of and benefits of using TRM's. This document states that in addition to providing scour protection, the mesh netting of TRM's is designed to enhance vegetative root and stem development.
"By protecting the soil from scouring forces and enhancing vegetative growth, TRM's can raise the threshold of natural vegetation to withstand higher hydraulic forces on stabilization slopes, streambanks and channels."

Software is now available from many of the manufacturers of TRM's to help engineers with the selection of the most appropriate mat for each specific project.

Cost:

Little data is available in Australia to estimate the difference in cost between the various types of channels designed, hard or soft engineering for reinforcement. One US study (SWRPC, 1991) estimated the construction cost of grassed channels at approximately $0.75 per m2. This price does not include design costs or contingencies such as reinforcement. Additionally, Brown and Schueler (1997) estimate these costs at approximately 32% of construction costs for most stormwater management practices. For swales, however, these costs could be significantly less given that the construction costs are so low compared with other practices. A more realistic estimate for a reinforced channel would be between $15 -$30 per m2 installed. Which still compares favourably with other hard engineering stormwater practices.
The Californina Department of Transportation commissioned Caltrans to investigate and report on new technologies for erosion control in 2003. This report tested one manufacturers TRM's that would now days be considered lower grade, compared to the HPTRM's that are now available. The study rated the TRM's performance and cost effectiveness, compared to the construction costs of using hydromulch with seeding, as the standard of comparison. This study rated these TRM's as being a 'permanent' erosion control method with their use identified as appropriate for rural and urban situations. Effectiveness was found to be 'High' with a confidence level of effectiveness also rating 'High'. To Caltrans standards these TRM's met the set effectiveness criteria. Appropriately, the report graded the construction complexity as 'low' however they did note that 'correct installation is critical to meet effectiveness criteria'.
Compared on a cost per hectare basis to hydromulch seeding (which is a temporary or semi-permanent method at best) they were considered as 'medium' cost with a maintenance level of effort also 'medium'.

These higher ratings would probably be due to the capabilities of the particular products tested, with relatively low tensile strengths for these tested mats and a lack of UV stability, meaning maintenance and re-seeding to maintain vegetative cover may become necessary after significant rain events. (Caltrans- Erosion Control New Technology Report. June 2003.p.350-353)

With TRM's, as with most things, you get what you pay for!

Selection of appropriate TRM should be governed by project specifications to prevent the likelihood of failure and washouts following solid rain events.

The construction and maintenance of grassed swales is less expensive than concrete ditches or drains. Hence, the use of grass swales, even those reinforced with TRM's, is often a less expensive alternative than traditional hard engineered design approaches. Considering that in any one application, a TRM may be performing several functions, from filtration, erosion control, reinforcement, sediment control and aiding valuable ground water recharge, even if they did not come in cheaper than concrete and other harder alternatives, they still provide too many environmental benefits to be discounted purely on the basis of cost.

Maintenance of grassed channels is minimal and mostly involves litter control or the removal of trash and debris. Maintaining the vegetative cover is essential and is easy to achieve when reinforcing with TRM's because the synthetic fibre matrix of higher grade TRM's locks and protects soil and seed, so the emergence of vegetation is enhanced and the lockability of the roots fosters a more even coverage.

For example, in the 4 years since completing the installation of this HPTRM channel in a continuous flow stormwater channel which runs directly into the Murray River in Albury,NSW there has been no need for re-seeding or top soiling and it has been un-necessary to cut or mow the established grasses as it provides a greater degree of filtration and entrapment of sedimentation.

<u>Environmental impact</u>:

What we know is that when it rains stormwater runoff flows over impervious surfaces picking up pollutants along the way and if not properly managed, washes the pollutants into rivers and streams. According to Chapter 4 of the Minnesota Stormwater Manual-Better Site Design Techniques,p.2
"….every ten acres of impervious surface removal will result in an annual reduction of runoff of 8 million gallons."

Aside from contributing pollution of the waterways, stormwater runoff can also cause flooding and erosion, destroy flora and fauna habitat and contributes a significant amount of sedimentation, which over time will reduce the volume capacity of affected water storage areas.
Stormwater management systems that mimic nature by integrating stormwater into building and site development can reduce the damaging effects of urbanisation on rivers and streams. Directing runoff to natural systems like vegetated swales reduces and filters stormwater runoff.

The term swales(wet and dry) refers to a vegetated, open grassed channel, designed specifically to treat and manage runoff for a specified water volume. As stormwater runoff flows along these channels, it is treated through natural vegetation, slowing the water to allow capture of sediment, filtering through the subsoil or infiltration into the underlying soils.
It is important to stabilise any channel while the vegetation becomes established. This can be done quickly with the use of synthetic erosion control products such as TRM's that allow vegetation to become anchored and established quickly.

TRM's can be applied in arid and semi-arid climates with the design incorporating drought tolerant vegetation. The specific design features will differ for each project, but all are improvements on the traditional concrete or hard engineered drainage ditch, and can bring the prospect of improved water quality outcomes.
Few studies are available on the effectiveness and pollutant removal capabilities of TRM reinforced systems and to date none have been undertaken in Australia. The available data from around the world on grassed channels suggests relatively high removal rates for pollutants, some bacteria and phosphorus.

One study of available performance data (Brown & Schueler, 1997) estimates the removal rates for grassed channels as:

- Total suspended solids: 81%
- Total phosphorus 29%
- Nitrate nitrogen 38%
- Metals: 14% to 55%
- Bacteria: -50%

Colorado State University perform Erosion Control performance testing in their specially designed research centre for studies testing in the fields of open channel and closed conduit hydraulics. They test embankment erosion protection and have done much testing on vegetative systems. Hydraulic testing has been performed on channels vegetated and reinforced with Rolled Erosion Control Products (RECP's) but to date have not been charged with testing a High Performance Turf Reinforcement Mat.
Even though testing has not yet been conducted, these HPTRM's have continued to be specified and used due to their capabilities, with on-going success.
The value of these practices should be weighed against the problems that can occur without them.
Grassed channels are a good treatment option within watersheds that drain to cold water streams. These practices do not pond water for long periods and often induce infiltration. Without an abundance of commonly used rock, the water would not typically be subjected to solar warming or thermal pollution and therefore would not adversely affect the natural spawning process of fish within the cold water streams.
Grassed channels and swales can be used on most soils and also on sites with steep slopes to prevent erosion and establish vegetation, with the application of the appropriate TRM's to reinforce slopes as necessary. The establishment of dense vegetation helps reduce velocities, protects the channel from erosion, and acts as a filter to treat water runoff.

4 weeks after installation- There is no chance to filter such a turbid flow except through vegetation.

Some TRM's, consisting of 3 dimensions have a matrix of continuous stitch fibres, which provide a greater degree of seed protection and a greater percentage of soil can also be retained within the mat.

Cleaner, filtered stormwater could also provide us with new opportunities for stormwater harvesting and re-use, helping to protect our precious water reserves for future generations.

Public acceptance/aesthetics/safety

Vegetated systems are an endorsed Best Management Practice in some countries, usually where a high priority is given to the implementation of innovative water management projects which have the potential to improve water quality and watershed health, in both the short and long term. Grassed swales are considered well suited for the treatment of highway or residential road runoff as they are linear practices and can become part of a treatment train, for instance, conveying water to a detention pond and receiving water from filter strips. (from: Portland, USA. Sustainable practices-Stormwater Management).

Furthermore, swales are highly recommended proponents of Low Impact Design and better site design, as well as being more aesthetically pleasing and safe for use in public areas. Grassed swales can be applied in every region of Australia, even in arid and semi-arid climates with the designs incorporating drought tolerant vegetation.

An additional benefit is that grassed, reinforced areas are far more accessible to people and vehicle traffic with much less risk of damage or injury.

The United States has experienced a significant shift in the priorities placed on urban infrastructure, with the environment and energy moving ahead of mobility and economic growth. This shift is well documented, for example the Centre for American Progress found from the 2005 Gallup poll that American's continue to favour the environment when asked to choose between environmental protection and economic growth with 53% saying that 'protecting the environment should be given priority when environmental protection conflicts with economic growth.'

The following is an extract from an e-mailed response calling for information/confirmation on the use of soft engineering techniques, particularly the use of TRM's in the United States.

"The City of Chattanooga has taken an initiative few years back on recommending green infrastructures stormwater BMPs (Low Impact Development) on new and retrofitted sites. We have revised our BMP manual http://www.hamiltontn.gov/waterquality/BMP.aspx) and provided special emphasis on LID (Low Impact Design) practices. Our stormwater operations (public projects) have for the last few years exclusively used TRMs and other similar 'green' products to stabilize channels. Also, our staff has been encouraging the private sector to adopt such techniques on new and retrofitted sites."

Mounir (Mo) Minkara, Ph.D., P.E. (Water Quality Manager- Water Quality Program)

City of Chattanooga (423) 643-5877 phone (423) 643-5862 fax

Section2: **TRM application in Australia**

If ever there were ever a time to step forward and contribute to our understanding of what sustainability in urban infrastructure means, it is now. Yet despite an abundance of literature endorsing TRM's from other parts of the world, they remain the least used application in Australia, even though they are included and have been recently listed as the leading application for preventing erosion in the Soil and Construction Volume Two, (The Blue Book). Having contacted and sent relevant information pertaining to this TRM technology to numerous engineers, developers, councils, catchment and water authorities, and municipal leaders, all charged with finding solutions to our water crisis, we have been astounded by the lack of interest and are left believing that until such time as these agencies and departments are actually mandated to use better alternatives, they will resist.
The Hon. Phillip Costa MP - Minister for Water, Minister for Rural Affairs and the Minister for Regional Development has stated in correspondence with us dated November 2008, that;

"*The Department of Water and Energy recommends the use of vegetated systems, such as turf matting, where it provides a suitable option to improve water quality and prevent land degradation."*

The Minister goes on to say that the Department does not always have an approval role in rehabilitation works as some organisations are exempt from gaining approval under the Water Management Act 2000. However, The Department does not recommend the use of hard engineering such as concrete and rock in waterways, *"….at all and supports its removal to increase the interaction between aquatic and terrestrial environments."*

Our company BTL Environmental Services Australia, began contact with water authorities, councils, engineers and designers in 2003 to inform them of the capabilities and environmental benefits that could be achieved by using reinforced, vegetated systems instead of continuing to use 'hard engineering' methods such as rock and concrete.
Since then, we have had numerous conversations, personally travelled to meet with engineers and water authorities. We have shared product samples, information, specification information and case studies of both first and second generation TRM's. If we are serious about improving water related outcomes in Australia, for present and future generations, why aren't we actively looking into and practicing what our own objectives state?.

An example of what could be considered ‘environmental vandalism’ was documented by Michael Frankcombe President of the International Erosion Control Association (Australia) in the July 2008 newsletter. He found that whilst he was travelling through the Jilliby State Conservation Area located at the southern end of the Watagan Mountains, an area managed by the National Parks and Wildlife Service (NPWS), road maintenance/improvement works had been undertaken on the unsealed Watagan Forest Drive that traverses the area.
" Being NSW's lead environmental agency it would be reasonable to expect the highest possible environmental standards on these roadworks. Unfortunately the opposite was the case. Over a number of kilometers of the road works I observed maximum disturbance to highly erodible soils, steep unlined "v" drains, no stabilisation or rehabilitation of any kind and absolutely no sediment control."

Mr Frankcombe states that this could be considered "material harm to the environment" as defined by S.147 of the Protection of the Environment Operation Act (POEO Act). He goes on to express his annoyance that if a mining company or other private company were responsible they could expect fines or some other legislative intervention from the EPA and he was in doubt as to whether the NPWS would receive the same fate, considering that the NPWS are part of the lead agency for environmental management in NSW

"Setting the high standard that all others aspire to.....They have no excuses for not doing the right thing."

We in Australia need to open our eyes and embrace and implement innovative environmental management, now. There is no need to wait another 10 or more years to see how much more damage urbanisation can do to our country.

Almost everywhere in the US they are attempting to transition from "fast conveyance" systems to more closed loop, self sufficient systems. A viewpoint shared by visionary companies like CDM, a consulting, engineering, construction and operations firm which conducts business all over the world. Their vision is striving for a more holistic approach to environmental and infrastructure improvement. Within this organisation they place great importance on collaboration to achieve true and lasting environmental outcomes."

It would seem that we in Australia could achieve some true water improving outcomes if only we could accept the need for "better inter-jurisdictional collaboration that facilitates integrated planning efforts and a sustained commitment to joint project planning, implementation and accountability, for results." Paul R. Brown, 'Blue Water in Green Cities' -President of CDM.

It is conceivable, and even essential, that this is exactly what we (Australians) should be aiming to achieve.

Sooner rather than later !

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