The Case for Best Practice Erosion and Sediment Control Compliance

A South East Queensland Perspective

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Executive Summary

Sediment runoff from urban construction sites is a major source of pollution and potentially the greatest contemporary risk to the environmental health and economic productivity of Moreton Bay. Studies undertaken by Healthy Waterways and other stakeholders have identified low levels of compliance (~5%) with erosion and sediment control requirements on large scale urban land development sites during construction. Based on current rates of urban land development, construction activities in SEQ are estimated to generate ~114,000 tonnes of mobilised sediment annually. This represents approximately 40% of the total sediment load entering SEQ waterways each year.

These outcomes persist in SEQ despite the clear legislative requirements that are supported by a range of cost-effective regulatory compliance tools and the availability of simple, affordable, and effective Erosion and Sediment Control (ESC) practices.

This study sought to identify, and where possible quantify the range of impacts and costs caused by sediment pollution from construction sites, and to identify the key economic, social and environmental benefits, including avoidable costs, that can be achieved by improving ESC performance on urban construction sites as a result of increased regulatory compliance activities.

Key findings

The key findings of the study were that:

- Cost-benefit Analysis (CBA) identified that there is a clear economic case for ESC regulation and enforcement with a conservative economic benefit of $1.20 for every $1 invested in current best practice ESC
- Sustained and consistent ESC compliance and enforcement activities have been shown to result in high levels of effective onsite ESC performance within the land development industry, capable of achieving sediment load reductions of 60 – 80%
- Implementation of current best practice ESC on urban construction sites within SEQ could conservatively reduce annual construction-phase sediment loads by 68,000 – 91,000 tonnes per year)
- There are significant benefits of ESC implementation from the perspective of developers (through reduced operational risks) and governments (through lower waterway management costs). For example, the present value of savings of avoided waterway management to local government over the next 20 years is estimated at around $160 million

Recommendations

The primary recommendations from this report are for:

1. The Queensland Government and the Council of Mayors SEQ to oversee the establishment and long-term support for regionally consistent best practice ESC compliance programs within each SEQ Council. This program should support local Councils to create a strong economic incentive for industry to comply with ESC requirements, and be underpinned by a proactive compliance monitoring approach that substantially increases the likelihood of non-compliant sites being subject to substantial enforcement action and penalties.

2. The Queensland government and all local SEQ Councils to make a long-term funding commitment to implement the regional ESC Strategy for SEQ (currently under development by Healthy Waterways) that takes a holistic approach to improving ESC compliance on building and construction sites in SEQ. The ESC Strategy will consist of a range of prioritised actions and reforms relating to ESC policy, proactive compliance auditing, enforcement, capacity building activities and industry incentives necessary to substantially improve ESC compliance and protect water quality.

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Definitions

Best Practice – management of an activity to achieve an ongoing minimisation of the activity's environmental harm through cost-effective measures assessed against the measures currently used nationally and internationally for the activity.

Construction sites – a generic classification used within this document that encompasses all types and scale of construction, earthworks and building activities associated with typical urban land uses. This includes land development types such as single house building sites, multi-unit dwellings (such as townhouses), commercial buildings, and large scale land subdivisions.

Council(s) – used within this document to describe a South East Queensland local government authority unless noted otherwise.

Erosion and Sediment Control (ESC) – the application of structural and non-structural measures to control stormwater drainage, soil erosion and sediment runoff during the construction and building phases of land development.

ESC compliance – conformance by a person or company with ESC-related laws, regulations, standards and referenced guidelines relating to best practice Erosion and Sediment Control. May also be used to describe the activities of a regulatory authority (e.g. a local Council) to ensure industry achieves best practice ESC outcomes on building and construction sites.

General environmental duty (as defined under s.319 of the *Queensland Environmental Protection Act 1994*) – A person must not carry out any activity that causes, or is likely to cause, environmental harm unless the person takes all reasonable and practicable measures to prevent or minimise that harm.

Sediment - soil particles detached and mobilised by soil erosion processes (typically by water and/or wind erosion). For the purposes of this report 'sediment' encompasses other common descriptors including earth, soil, dirt, mud, gravel, sand, silt and clay.

Urban land use – includes all land uses within a typical urban footprint, such as high and low density residential, urban parks and other recreational areas, roads and other infrastructure, and industrial and commercial land uses.

1. Introduction

This document was prepared by Healthy Waterways in response to the need to better understand and communicate to government and industry the costs and benefits of implementing best practice Erosion and Sediment Control (ESC) on construction sites in South East Queensland (SEQ).

The purpose of this document is to:

- provide contextual information on why there is a need to better understand the costs and benefits associated with implementing best practice ESC on construction sites (Section 2)
- describe, and where possible, quantify, the wide-ranging costs and benefits that are distributed to the community (Section 5) and the construction industry (Section 6) as a result of implementing best practice ESC on construction sites (e.g. new residential subdivisions, industrial and commercial developments) in SEQ
- describe, and where possible, quantify, the costs and benefits of effective regulatory compliance and enforcement activities that are required in order to achieve best practice ESC (Section 7).

This document forms part of a body of work by Healthy Waterways that improves not only our understanding of the problem, including the costs and benefits of effective ESC compliance and enforcement activities, but is also informing a range of future priorities and actions via the *ESC Strategy* (that Healthy Waterways is currently developing) to help local Councils and industry improve ESC outcomes on building and construction sites.

Where the land development market has resulted in excessive runoff of pollutants into stormwater assets and waterways, an externality has occurred. This provides a rationale for some form of intervention such as regulation, and to the extent that the benefits of the regulations exceed the costs, there is a strong business case for that intervention. Furthermore, regulating practice to address loads at the source is consistent with the risk mitigation hierarchy (avoid, reduce and mitigate risks at source before off-site actions or compensation are considered).

For further information refer to the Healthy Land and Water website at www.hlw.org.au.

2. Why we need to better understand the costs and benefits

Sediment is threatening our waterways and is compounded by population growth

The increasing amount of sediment entering SEQ's waterways is the greatest issue currently affecting the health of SEQ's waterways (Healthy Waterways, 2014), including the regionally and internationally significant Moreton Bay Marine Park. With these waterways estimated to provide over $10 billion per year to the region's economy through tourism, recreation, drinking water supply and fishing (Healthy Waterways, 2015a).

Erosion is the primary source of sediment in our waterways and most commonly comes from farming/rural land, worn away river and creek banks and urban construction sites which, unmanaged, expose large amounts of soil that can be easily eroded during rainfall events.

However, the dominant driver of growth in loads is urban development, as land that has historically been uses for low intensity uses is gradually developed to cater for population growth. Figure 1shows the Queensland Government's forecasts for growth in the number of private dwellings in SEQ out to 2036. The number of dwellings is expected to increase from around 1.29 million in 2016 to between 1.78 million (up 38%) and 1.99 million (up 54%) over the next 20 years.

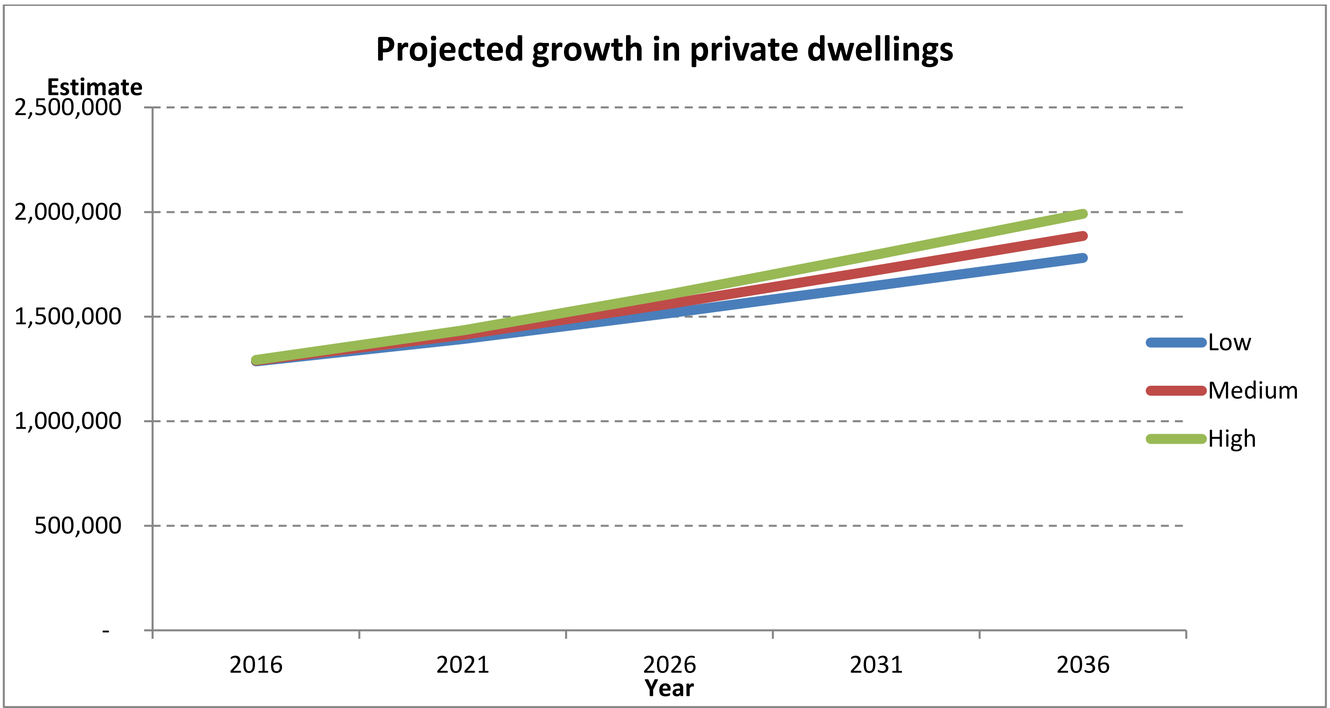

Figure 1 Estimated growth in private dwelling numbers for SEQ (Source: Queensland Government household and dwelling projections, 2015 edition, Queensland Treasury)

With SEQ's urban footprint projected to grow by around 45,000 ha during 2009-2031, which is equivalent to approximately 2,300 ha/yr of residential construction activity (Queensland Government, 2009), sediment from unmanaged urban construction sites poses a continuous and growing threat to waterway health and the benefits accrued by the community from waterways. However, the magnitude of this threat is not well understood. The information gathered as part of this study will help to improve our understanding of the issue and help to inform future actions.

Based on our current understanding we estimate annual unmitigated loads to be around 114,000 – 202,000 tonnes per annum. Using this current range of estimates and possible urban growth scenarios for SEQ, unmitigated loads could be as high as 310,000 tonnes per annum by 2036. This is shown in Figure 2.

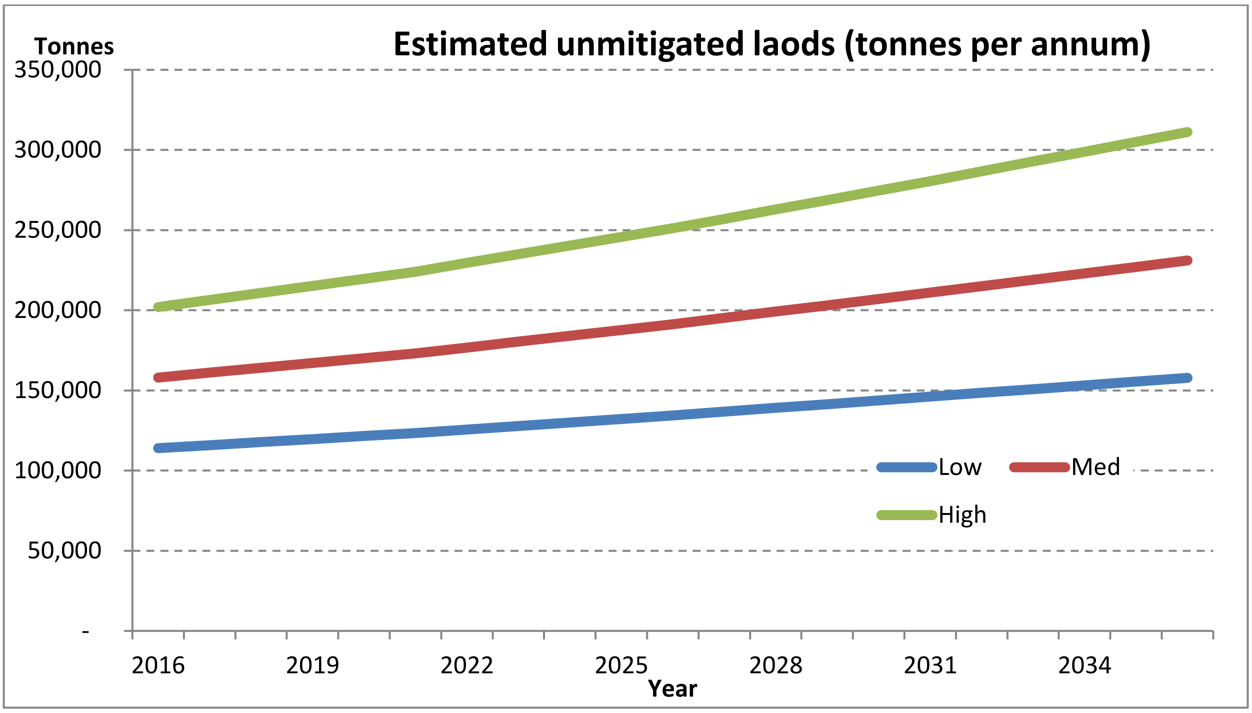

Figure 2 Potential growth in unmitigated sediment loads (Source: HWL modelled estimates)

The continuation and increase in loads creates a number of risks to several objectives including:

- Local government stormwater management. Negative impacts on the performance of drainage systems and increased maintenance costs.
- Tourism and recreation. Declining condition of waterways and Moreton Bay and associated negative impacts on tourism and recreation amenity.
- Declining waterways condition and associated environmental values.

These risks predominantly occur downstream of construction sites, where the risks are diffuse across downstream communities.

Legislative requirements designed to mitigate threats

To help mitigate the threat on our highly valuable waterways, organisations and individuals undertaking land disturbing activities in Queensland are legally obliged to prevent or minimise sediment from entering stormwater and waterways, for example as prescribed under section 440ZG of the *Environmental Protection Act 1994* (the 'EP Act'). Effective erosion and sediment controls (ESC) are the accepted practices to help fulfil this legislative obligation, the principles of which are well-established and documented in industry standards and guidelines such as the International Erosion Control Association (Australasia) *Best Practice Erosion & Sediment Control* documents (IECA, 2008).

In addition, the current Queensland legislative framework provides a suite of effective regulatory tools to enable State and local Council regulators to cost-effectively enforce ESC performance standards within their jurisdictions. In recent years, the Queensland Department of Environment and Heritage Protection has refocussed its regulatory strategy and resources towards greater onsite, outcome-focussed, compliance and enforcement activities. The Queensland Government has also recently increased the range of ESC-related offences and penalties for non-compliance to provide a stronger incentive for organisations to comply with legislative ESC requirements in recognition of community expectations concerning environmental protection and stormwater pollution.

Despite the legislative framework requirements and availability of accepted practices to achieve compliance, only 5% of construction sites in SEQ have been found to be substantially compliant with current ESC-related legislative requirements, with 21% partially compliant and 74% non-compliant (Healthy Waterways, 2015b).

To the extent that on-ground actions are poorly implemented, costs will still be borne by developers, but the benefits (the objective of the interventions) will not accrue. This reinforces the need for substantive compliance to ensure societal objective are achieved.

Why compliance is low

Whilst the costs of compliance are borne directly by developers and subsequently passed onto purchasers of new dwellings, the benefits tend to be more diffuse (and less obvious to developers). The direct feedback loop between ESC expenditures and financial benefits for developers is not clear. Therefore, there is a very strong financial incentive for developers/civil contractors not to fully implement ESC measures (IUW SEP, 2015). The lack of enforcement and/or inconsistent enforcement across the region is reducing the likelihood of land developers and construction site operators getting 'caught', fined, or prosecuted for non-compliance (Healthy Waterways, 2015c). A recent study has identified that, on average, there is only a 2.2% likelihood (risk) of a SEQ construction site facing significant enforcement action by a local Council for ESC non-compliance (e.g. Environmental Protection Order, 'stop work notice', prosecution) while the cost of complying with existing ESC-related legislation to developers/civil contractors (based on 2013 data) far outweighs the cost of not complying by a factor of 14 (IUW SEP, 2015).

As a consequence, some industry members are willing to risk the chance of getting caught rather than budgeting for the full cost of proper ESC implementation in their construction and building projects or implementing and/or adequately maintaining their ESC measures (Healthy Waterways, 2015c). These factors contribute to a commercial operating environment where ESC compliance is generally considered a low priority, or where staff do want to comply, but are constrained by insufficient ESC budgets. Industry feedback suggests that current tendering practices often favour the 'lowest price' ahead of those companies who believe in best practice ESC (Healthy Waterways, 2015c).

Key lever to improve compliance

Both the public and private sector generally feel that this situation could be corrected by government regulators increasing compliance inspection frequency and the enforcement of ESC requirements (Healthy Waterways, 2015c). This would provide a more 'level playing field' across the land development sector and create a strong incentive for companies and operators to properly plan, budget and implement effective and compliant erosion and sediment controls on their projects (Healthy Waterways, 2015c).

The literature and experience of leading international and local stormwater managers and ESC practitioners supports the view that a proactive ESC compliance program is necessary in order to get industry to comply with ESC requirements. For example:

- Taylor (2003) explains that '...there is strong evidence from the literature and case studies to suggest a well-designed, vigorous and ongoing enforcement program is essential in substantially increasing the performance of erosion and sediment control on construction sites.' (p. 3)
- Lehner *et al.* (1999) concluded from a review of 100 stormwater-related case studies in the US that "programs with high accountability [e.g. enforcement elements] often reduce pollutant loadings by 50% or greater."
- Fritz (2002) states "...that education and awareness [alone] does not lead to compliance. There must be an incentive for compliance to work. This can be either positive (monetary savings, awards) or negative (regulatory intervention)."

Some local SEQ Councils, such as Brisbane City Council (BCC), have been implementing and refining their ESC Program since the late 1990s. Supported by strong and sustained political leadership, this multifaceted program includes a strong emphasis on firm but fair enforcement of environmental laws to improve industry ESC performance. The program has reported average ESC compliance levels in excess of 80%.

The community supports shifting the cost of sediment pollution back to those persons causing the problem. For example, a survey of over 920 SEQ households found that the majority of people (80% of respondents) would rather the polluter pay for the 'externalities' (pollution) and compensate for any environmental impacts caused by new housing developments (MJA, 2010). Shifting this cost back would allow the savings to be invested into other services and infrastructure that support economic prosperity and improve the quality of life for the broader community.

As a result, this document not only presents the costs and benefits of ESC compliance that accrue to industry, the community and the environment, but also the costs and benefits to local Councils of implementing effective compliance programs.

3. Method

3.1 Overview

Simplified cost–benefit frameworks have been used to bring together quantitative and qualitative values of the costs and benefits to industry, local Councils, the community and environment associated with implementing best practice ESC on construction sites. The frameworks allow:

- a broad assessment of whether the benefits are likely to outweigh the costs
- stakeholders to easily evaluate the best available data to draw their own conclusions.

To populate the frameworks:

- data was collected from literature, industry and councils via literature reviews, informal interviews, confidential discussions, forums, surveys and data requests (Section 3.2)
- sediment loads representative of SEQ construction sites were calculated (Section 3.3)
- case studies (representing typical land development types, and scales of development in SEQ) were undertaken to provide more detailed assessments of ESC compliance costs and benefits (Section 3.4)
- the costs and benefits of an effective ESC compliance program were calculated (Section 7).

3.2 Data collection

As set out in Table 1, data was collected from literature, industry and councils via literature reviews, interviews, forums, surveys and data requests.

Table 1 Data sources

Data	Source
Typical sediment generation rates from construction sites	Literature
Efficacy of current ESC practices in reducing sediment runoff concentrations	Literature
Sediment export rates from SEQ construction sites (unmitigated and mitigated scenarios)	Literature
Economic data on the likely impact costs of sediment (including avoided costs) upon economic, social and environmental values	Literature
Current Council economic expenditure on sediment-related asset maintenance and operational ESC-related activities, sediment-related cost data (e.g. the cost of removing sediment from Council infrastructure)	Data was requested from 12 Councils in SEQ and one Council in North Queensland. 9 Councils responded with information.

Direct and indirect costs, and avoided costs, of onsite ESC implementation	Private sector companies
Cause and effect' relationships between modern construction project and site management practices and the current state of ESC compliance in SEQ	Stakeholder meetings, informal interviews, industry forums and stakeholder surveys.
ESC unit rates for the supply, installation and maintenance of the most common and effective best practice ESC measures considered necessary to comply with the requirements of the *Environmental Protection Act 1994*, including both traditional Type F/D 'batch' sediment basins and the more recent high-efficiency sediment (HES) basins	Civil contractors, building companies and specialist ESC consultants
Typical staff costs (including overheads) and officer 'productivity' data	Several local SEQ Council officers directly involved in ESC regulation of building and construction sites

Limitations with the data include:

- Some of the data is from geographic locations outside of SEQ, which makes it difficult to directly translate factors such as soil type, rainfall patterns, regulatory requirements and also economic considerations to the SEQ environment
- There is a paucity of locally available economic data to undertake a robust economic assessment of the benefits and costs of ESC at typical development scales. This is because either the data is not collected (particularly by local Councils) or stakeholders are not willing to share the data publically (particularly industry)
- Actual costs and benefits may vary considerably across the region based on site-specific conditions (e.g. in high rainfall jurisdictions) and 'end-user' cost structures
- Where cost data was either sparse or incomplete, assumptions were established in consultation with relevant experts.

3.3 Calculating sediment loads

The unmitigated *total* sediment export potential for urban construction sites in SEQ was calculated as a function of the rate of sediment exported from a given land area and the amount of development that is expected to occur over a given time interval. The estimates are of total sediment load, including both coarse sediment (typically sands and gravels) and fine sediment (typically silts and clays), which is important when considering where, and how, the impact costs of sediment and the benefits of sediment load reductions are distributed.

The adopted methodology took into consideration a broad range of factors including:

- annual dwelling construction volumes (projected and actual)

- typical lot yields (i.e. dwellings per hectare)
- average annual rainfall (i.e. nominal 'low' and 'high' rainfall zones)
- the area and duration of soil exposure during the construction period
- estimated mean annual sediment export rates (t/ha/yr)
- estimates of new industrial and commercial land development rates (ha/yr).

Amount of development

To predict the amount of land that will be developed in the coming years, we compared two scenarios. Scenario 1 adopted the population growth and urban land use projections defined within the SEQ Regional Plan (2009 – 2031) (Queensland Government, 2009) (Table 2). Average land development rates in SEQ over the past nine years (ABS, 2006-2015) have been approximately 40% lower than the development rates projected by the SEQ Regional Plan (2009 – 2031), which is equivalent to approximately 980 hectares less land being developed each year across the region than predicted (Scenario 2).

While Scenario 2 is more conservative, it was used to estimate the annual sediment load likely to be generated from construction activities in SEQ so that the load estimates are reflective of recent land development trends.

Table 2 Potential unmitigated sediment runoff from SEQ construction sites

Scenario 1 (Projected Land Development rates – SEQ Regional Plan 2009 – 2031)	Scenario 2 (Actual Land Development rates – ABS building approval data 2006 – 2015)
202,000 tonnes per year	**114,000 tonnes per year**

Sediment exported from a given land area

While research into sediment export rates from SEQ construction sites is needed to refine current load estimates, the relative contribution of sediment loads from construction sites compared to other land uses, such as agriculture and grazing, is well represented in the literature and current SEQ data.

On-site monitoring of sediment-laden runoff from urban construction sites in SEQ has recorded very high concentrations of up to 23,730 mg/L Total Suspended Sediment (TSS) discharging from unmitigated construction sites (i.e. sites with no effective ESC measures present), with an average of 3,842 mg/L TSS coming from a mixture of partially mitigated and unmitigated sites (Davis, 2014).

The estimated areal sediment loading rate for the region's construction sites (representing total sediment load) are shown in Figure 3. In the absence of more accurate data the total sediment load was calculated by applying a 33% weighting (O'Neill, 2015) to the TSS loading rates generated from the catchment load ('Source') modelling (BMT WBM, 2014b).

Anecdotal evidence indicates that sediment loads generated from SEQ construction sites can be highly variable given the range and effects of key erosion factors such as slope, soil type, surface cover, soil exposure duration and in particular, rainfall intensity and distribution across SEQ. Given this variability the rates in Figure 3 are considered conservative.

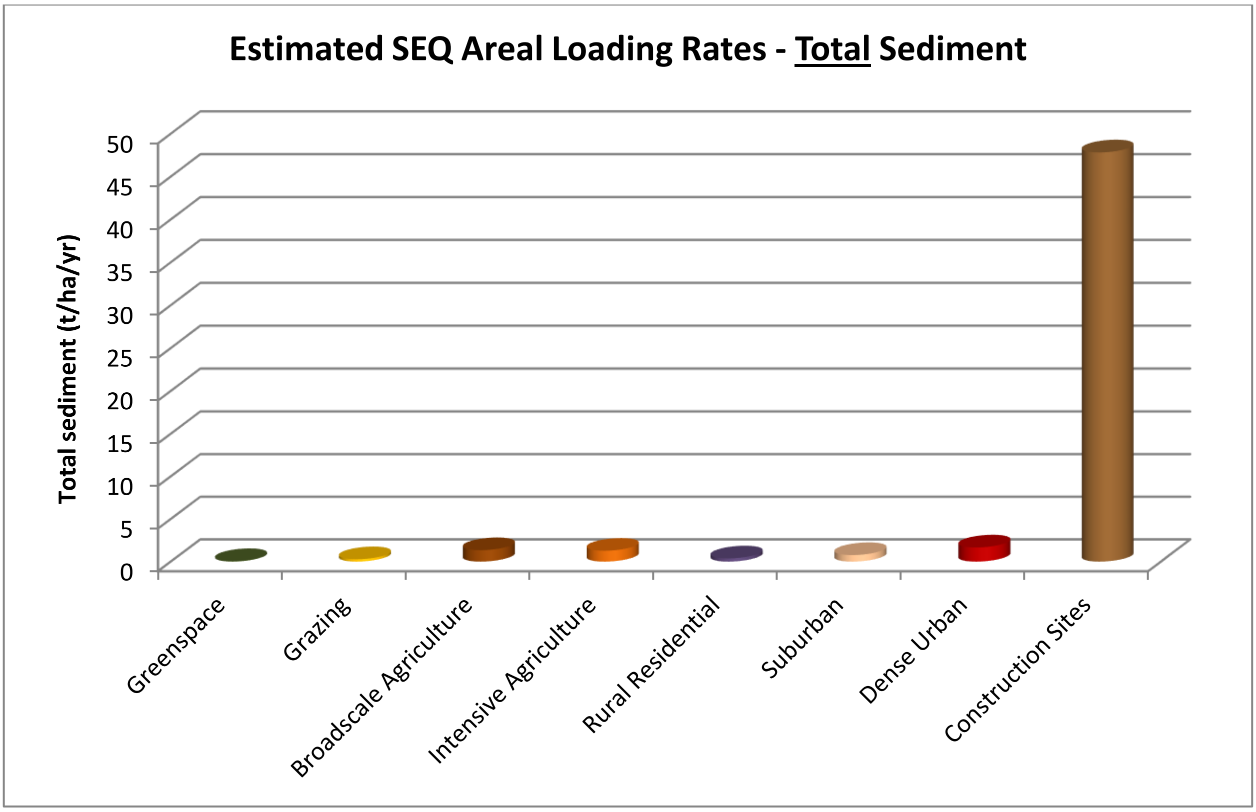

Figure 3 Estimated SEQ areal sediment loads by land use type (total sediment t/ha/yr) (Source: BMT WBM (2014b), adapted by Healthy Waterways Ltd)

Based on the SEQ-based data above, the estimated mean sediment export rates for unmitigated sites[1] adopted in this study were:

- **48 t/ha/yr** (low rainfall zones)
- **151 t/ha/yr** (high rainfall zones)

In addition to their higher erosion potential, urban construction activities offer minimal infiltration of rainfall due to their relatively hard, compacted surfaces. As a result they can produce large

[1] I.e. sites where best practice erosion and sediment control measures are *not* implemented on new urban developments in SEQ or implemented but with very limited effectiveness.

cumulative volumes of sediment-laden runoff, including from those more frequent, low intensity rainfall events that are less likely to generate runoff from typical agricultural and grazing land uses.

Limitations

The sediment load estimates do not include:

- major new public infrastructure, such as major roads, rail lines, pipelines, large-scale community facilities and State projects
- construction and maintenance activities (both public and private) occurring within the existing urban footprint (e.g. road upgrades, drainage upgrades, building extensions)
- instream erosion and sediment loads generated downstream of land development sites due to changes in hydrological conditions (i.e. increased runoff frequency and volume).

Therefore the calculated sediment loads from 'construction sites' is considered conservative.

3.4 Assessing case studies

Three case studies were assessed to provide a quantitative understanding of the likely costs of implementing typical best practice ESC measures to comply with current legislative requirements[2] across typical urban land development scenarios in SEQ.

The following case studies from the Healthy Waterways '*A Business Case for Best Practice Urban Stormwater Management: Case Studies* (version 1.1, 2010) were used and adapted:

- Case study 1: large scale residential greenfield subdivision during the bulk earth works and civil construction phase. 76 ha under development, assuming 4 – 5% average slope, producing 951 detached house lots, with a typical lot size of between 400 – 700 m^2
- Case study 2: medium scale residential greenfield subdivision during the bulk earth works and civil construction phase. 7.4 ha under development, average slope less than 1%, producing 84 detached house lots with a typical lot size of between 400 – 500 m^2
- Case study 3: large scale residential infill (urban renewal) development during the construction phase. 7.4 ha under development, average slope less than 1%, producing 25 separate buildings within the site.

Using desktop assessment tools (e.g. satellite imagery) and discussions with other industry practitioners, case study 2 was adopted as a representative 'scale' of short to medium term detached residential land development that is most likely to occur in SEQ. Therefore, case study 2 was used for further investigation into site variables including site erosion 'risk', slope and construction duration (i.e. staging).

[2] Under the *Environmental Protection Act* 1994 ('the EP Act')

While these case studies are considered to represent 'typical' construction site scenarios, there is variability in both development scale and site conditions (slope, soil type, site area, rainfall etc) across SEQ, which will affect *likely* ESC costs.

Best practice ESC measures were applied to the case studies in accordance with well established guidelines for designing and implementing best practice ESC measures, such as within the *IECA Best Practice Erosion and Sediment Control* documents (IECA, 2008). Guidelines such as these emphasise that erosion prevention/reduction measures should be used as the primary control principle where possible, followed by drainage management and sediment control measures when soil exposure is unavoidable. This is particularly relevant to SEQ, where the region's fine-grained, clay based soils are both difficult to capture and have a high potential to cause environmental harm.

Hydromulch was adopted as the primary stabilisation method for these scenarios (excluding single house blocks), reflecting its common use as an effective long-term ground stabilisation method to minimise soil erosion. However alternative erosion control methods and technologies are also available including mulching, direct seeding without the use of mulch, and polymer-based soil binders.

The costs include installing, maintaining, and decommissioning the various ESC practices, such as temporary earth drains, sediment fences, sediment basins, and the effective stabilisation of the site against erosion.

3.5 Regional aggregate economic estimates

Using State Government forecasts for future development patterns, costs from the major case studies, and benefit estimates from the literature, it is possible to undertake a simplified CBA for implementing enhanced ESC compliance in SEQ from the perspective of society. Under this approach:

- Costs are primarily the financial costs and transaction costs (e.g. design costs) attributable to on-ground ESC actions undertaken by developers and passed onto new owners of dwellings and relevant infrastructure owners.
- There are a number of benefits largely in the form of costs avoided that accrue to different sections of society:
  - The development industry in the form of any operation costs savings, or avoided costs etc.
  - Councils and the State Government in the form of avoided stormwater management, waterway rehabilitation, and potentially water supply.
  - Society via avoided costs and risks to recreation, tourism, and non-use values such as protecting waterway health and ecological outcomes (e.g. maintenance of seagrass for dugongs).

From a societal perspective, all of these benefits should be within the scope of the assessment including non-market values. This requires an assessment of both the physical relationships between ESC actions and the marginal changes to benefit streams attributable to those actions within a CBA model.

Furthermore, because of the likely growth in loads into the future and the changes in values attributable, a 20-year timeframe has been used for the analysis.

Given the uncertainty in the modelling (both physical relationships between ESC actions and changes in benefit streams and the value of those benefits); significant sensitivity analysis was also undertaken. This analysis was undertaken from the perspective of SEQ (a societal perspective) including as many market and non-market values as possible.

3.6 Calculating costs and benefits of an effective ESC compliance program

The *likely* costs and benefits of implementing an effective ESC compliance program were calculated based on typical staff costs (including overheads) and officer 'productivity' data.

The *likely* benefits to Councils and the community for each Full Time Equivalent (FTE) ESC compliance officer were calculated based on known work capacity/'site coverage' per officer per year, expressed as the average number of individual sites inspected per year, the total site inspection capacity per year, and the total effective area (in hectares) inspected per year.

Officer work capacity was then applied at two typical land development types (scales): 'small scale' land development representing domestic house building sites and 'large scale' land development representing development projects typically requiring Council planning approval, including compliance with the Queensland *State Planning Policy* construction phase design objectives (typically sites >2,500m^2 in area).

The *likely* benefit (i.e. sediment load reduction) was estimated based on the following criteria:

- a simplified rainfall 'zone' allocation, defined as:-
  - high rainfall zone – Council areas with >1200mm average rainfall per year (includes Gold Coast, Redland, Sunshine Coast and Noosa); and
  - low rainfall zone - Council areas with <1200mm average rainfall per year (includes Logan, Brisbane, Moreton Bay and western SEQ councils, such as Ipswich)
- annual sediment export rate in t/ha/yr. Adopted values:
  - high rainfall zone – 151 t/ha/yr; and
  - low rainfall zone – 48 t/ha/yr
- the annual inspection capacity of one FTE ESC compliance officer for 'small scale' house sites and 'large scale' urban construction sites (as total effective area in hectares)
- 'typical' construction site disturbance area and duration and average percentage disturbance over the construction period for 'small scale' and 'large scale' developments
- average coarse and fine sediment percentage load reductions achievable due to effectively implementing and maintaining best practice ESC throughout the construction period (as cited in the literature)
- applying the estimated average sediment impact costs for coarse and fine sediment (where available) to quantify the potential benefits.

4. Identified costs and benefits relevant to ESC

Table 3 qualitatively lists the likely costs and benefits of improved ESC compliance.

Table 3 Regional ESC compliance costs and benefits

Likely costs of improved ESC compliance	Likely benefits of improved ESC compliance
to Councils • Costs of monitoring and enforcing private sector compliance on construction sites • Implementing and maintaining best practice ESC on Council owned/operated construction sites • Staff awareness and training • ESC policy development • Industry awareness and capacity building • Development assessment costs • Internal quality assurance/ reporting systems	***to Councils*** • Avoided costs associated with rehabilitating and maintaining downstream waterways • Reduced costs to maintain open drains and creeks • Reduced costs to maintain closed stormwater drainage infrastructure (including pipes and Stormwater Quality Improvement Devices) • Reduced sediment on roads (street sweeping costs, public safety and amenity) • Reduced costs of managing aquatic weeds, enhanced algal blooms and fish kills • Avoided cost of rectification work and construction downtime on council projects • Less public complaints • Economic benefits to primary industries, such as agriculture and commercial fishing, seafood industry, recreational fishing, tourism, local recreation opportunities and property values nearby waterways • Social benefits, such as recreational opportunities, human health, scenic amenity and bequest values to future generations • Demonstrates Council's commitment to environmental protection in the eyes of ratepayers • Avoided impacts of nuisance flooding, including insurance claims against Council
to Industry • Implementing and maintaining best practice ESC during construction and building work • ESC design and project management costs • Internal quality assurance/ reporting systems • Staff and sub-contractor awareness and training	***to Industry*** • Reduced downtime after rain events • Reduced onsite sediment clean-up costs • Reduced offsite sediment clean-up costs • Reduced subsoil and topsoil erosion losses • Reduced risk of fines and regulatory enforcement • Avoided damage and failure of ESC measures • Avoided damage to new, on-site infrastructure (stormwater infrastructure, retaining walls, landscaped areas) • Reduced sediment impacts on neighbouring properties (homes and businesses) • Avoided litigation costs • Reduced financial risk and liability (e.g. cost over-runs, disputes, compensation) • Better public image/brand association/social licence to operate Better environmental track record • Less public complaints • Better working relationship with ESC regulators • Improved visual 'presentation' of developments (i.e. 'clean and green' place to live)

Likely costs of improved ESC compliance	Likely benefits of improved ESC compliance
to SEQ Region and community • State ESC-related policy, regulations, research and developing and maintaining guidelines • LGA and industry capacity building in ESC • Community awareness about sediment and ESC	***to SEQ Region and community*** • Avoided nutrient transport by sediment, such as nitrogen enrichment in waterways • Avoided seagrass productivity loss due to impacts caused by sediment • Reduced dredging costs of navigable channels • Reduced costs of nuisance flooding, including rising insurance costs • Economic benefits to primary industries, such as agriculture and commercial fishing, seafood industry, recreational fishing, tourism, local recreation opportunities and property values nearby waterways • Social benefits, such as recreational opportunities, human health, scenic amenity and bequest values to future generations • Environmental benefits, such as the health of fish stocks sensitive to turbidity and protecting biodiversity and habitats

While there is not sufficient information and data to quantify many of these costs and benefits, Sections 5 to 7 evaluative as many of these costs and benefits as practicable within data and resource constraints.

5. ESC – the rationale for the construction industry

This Section considers the costs and benefits of ESC from the perspective of the construction industry. This will differ from the societal CBA presented in Section 7 as issues such as regulatory penalties (i.e. fines) are relevant.[3]

5.1 Costs

From the case studies outlined in Section 3.4, the *likely* cost of implementing best practice ESC on 'typical' SEQ construction sites in order to achieve compliance has been calculated to range from $1,500 - $1,700 (average $1,600) per lot for a single house block and $24,000 - $44,000 per hectare (average $34,000 per hectare) for a typical medium to large scale development (Table 4).

Table 4 Likely cost to implement best practice ESC in SEQ across different development types

Development Scenario	Size	Likely cost to implement Best Practice ESC
Large scale residential greenfield (bulk earthworks & civil phase)	76 ha	$40,500 / ha
Medium scale residential greenfield (bulk earthworks & civil phase)	7.4 ha	$44,000 / ha
Large scale residential Infill (bulk earthworks & civil phase)	14 ha	$24,000 / ha
Single house block[4] (during house building phase)	480 m^2	$1,600[5] / lot (dependent upon site conditions)

Examples of some typical best practice ESC measures are shown in Figure 4, including (from left to right) progressive stabilisation, a high efficiency sediment (HES) basin and effective site stabilisation upon completion of construction works to minimise soil erosion.

5.2 Benefits

Best practice ESC provides a range of benefits to the construction industry in the form of avoided impact costs.

If adequate ESC measures have not been properly implemented and maintained, the construction industry can be significantly impacted by erosion and sediment mobilisation on, and from, their construction sites[6]. The diverse range of risks and costs include:

[3] In a formal societal CBA, these values re excluded as they simply represent a transfer from one sector to another.

[4] Median lot size in SEQ (HIA Economics, 2015)

[5] Typical range $1,500 - $1,700 per lot (Healthy Waterways, 2015c)

[6] Based on literature review, industry case studies, and consultation with various industry and government ESC specialists and waterway management stakeholders.

- clean-up costs
- construction delays
- regulatory enforcement costs
- litigation costs
- third-party damages and compensation
- staff resource time
- reputational damage to both persons and company brands.

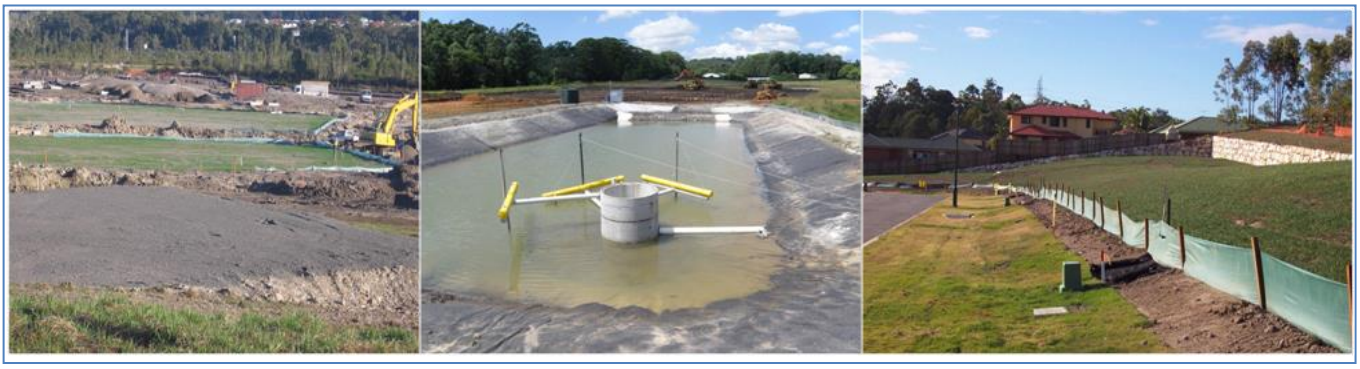

Figure 4 Examples of highly effective erosion and sediment control management practices

Onsite impacts

If ESC measures are not well positioned, constructed, or maintained, rainfall can easily lead to problems such as earth bunds bursting, sediment fences collapsing and drains overtopping. Inadequate ESC measures can also lead to severe erosion on newly topsoiled lots, retaining walls becoming undermined, and major structural failures occurring, such as a sediment basin embankment, often with significant consequences (Figure 5).

New infrastructure assets such as roads, earth embankments and drainage infrastructure can also be severely damaged, requiring the diversion of labour and equipment to undertake costly repairs and clean-up operations. In addition to this, the physical state of a poorly managed construction site after a rainfall event may make the site less trafficable due to poor drainage and create 'boggy', unsafe ground conditions, all of which can increase construction downtime, lost productivity and cost/schedule over-runs.

Figure 5 Examples of on-site impacts due to poor erosion and sediment control

While many of these impact costs cannot be quantified, they are largely avoidable through ESC compliance. Table 5 presents the potential avoidable impact costs that can be quantified. These are discussed in more detail in the following sections.

Table 5 Potential impact costs that can be avoided through best practice ESC compliance

Item	Cost	Comments
On-site Impacts: Burst earth bund/drain Sediment fence collapse Sediment basin failure	Estimated repair cost : $10 - $20+ per metre $10+ per metre $1,000 - $12,000+ for repair of embankment/outflow, and removal of sediment deposits	Source: (BMT WBM, 2014a) (Taylor & Wong, 2002) (SEEC Consulting, 2015)
Resource costs: Loss of soil/fill/sand stockpiles from construction site	$50 - $80 per tonne (not including transport costs)	(BMT WBM, 2014b) Commercial landscape supply prices, 2015
Impacts on neighbouring properties: Sediment removal (e.g. from pool, back yard, house) and repair of damaged assets Relocation of affected property owners – temporary accommodation etc.	$1,000 - $5,000 + $180 + per night	Estimated cost range to remove and transport sediment, clean and/or replace damaged items Average daily temporary accommodation costs
Regulatory penalties: (e.g. Infringement Notices and court penalties)	$8,835 - $736,250 (or 5 years imprisonment)	*Environmental Protection Act 1994,* (as at 01 July 2015).
Legal costs: (e.g. Solicitor, Barrister, expert witnesses)	$1,000 - >$100,000	Confidential interviews

The potential impact costs that can be avoided from effective ESC planning and onsite ESC practices can easily range from tens of thousands to many hundreds of thousands of dollars depending on the scale and particular circumstances of the site. For example, Beaupeurt and Wright (1999) state that *'extended downtime as a result of poorly controlled stormwater runoff [ESC] on a site can become very costly in a very short period of time.'* (p. 38). They identify that the cost of implementing temporary ESC measures would be 20 - 25% of clean-up costs at the end of the project and conclude that the cost of progressively implementing ESC pays for itself four-to-fivefold throughout the life of a project.

Across three cases[7], the direct avoidable impact costs resulting from poorly implementing ESC ranged from between $12,000 - $700,000 (in 2015 AU$). The costs vary considerably depending on the project size, site characteristics and the severity of the impacts. These examples may be conservative as they do not include potential environmental costs, construction delays, regulatory enforcement costs or potential litigation costs.

In the two case studies by Frankcombe (2000), the direct costs to rectify the failures and damage to new road infrastructure as a result of poor ESC practices ranged from 14% to 38% of the total project cost. In contrast, "*...on most road construction projects, properly designed and integrated erosion and sediment control measures represent a maximum 4% cost to the total value of the project (usually less than 1%)*" (Frankcombe, 2000).

Resource costs

As a building and construction resource, the replacement value of the soil (e.g. earth fill, sand, topsoil) lost from building and construction sites is an important consideration. For example, the commercial replacement cost of lost 'Brickies Loam' (not including transport) can range from $50 per tonne (BMT WBM, 2014a) to $80 per tonne[8]. Therefore, soil and sediment lost from building and construction sites can literally represent money flowing down the drain (Figure 6).

Figure 6 Erosion and sediment loss due to poor on-site ESC management

[7] Two by Frankcombe (2000) and Case Study 1 (Appendix 1)

[8] Online search of commercial sand and gravel suppliers conducted on 18 October 2015

Impacts on neighbouring properties

Private properties located adjacent to, and down-slope of, construction sites are at risk from poorly managed ESC. The damage caused to private properties and the subsequent emotional stress to affected residents and their families can be severe and long-lasting. For example, there have been several instances within Queensland of swimming pools, yards and even homes being inundated with sediment originating from neighbouring construction sites during typical seasonal rain events (Figure 7). In some cases, residents needed to be relocated into temporary accommodation for many weeks while repairs were undertaken.

Similarly, there have been instances of downstream business premises, warehouse floor stock, equipment and production capacity impacted by sediment runoff prom poorly managed construction sites and failed ESC measures. The lost productivity, clean-up and repair costs and, in particular, the potential legal liability to land developers and construction contractors can be considerable, especially if development approval conditions and legislative ESC requirements have not been complied with.

Figure 7 Impacts to neighbouring properties due to poor construction erosion and sediment control management

Regulatory penalties and legal costs

Within jurisdictions where ESC requirements are actively enforced, there are additional risks and potential costs to developers and site operators who are not compliant being subject to regulatory enforcement action for breaches of environmental and planning legislation, including fines, statutory notices and prosecution through a court of law.

As of July 2015, Penalty Infringement Notices (PINS), i.e. 'on-the-spot fines', issued for offences prescribed under section 440ZG of the *Environmental Protection Act 1994* (the 'EP Act') have increased to $1,767[9] for an individual and $8,835[9] for a corporation. The offender (including corporations and company directors) faces a maximum penalty of $196,137[9] if successfully prosecuted under this section of the EP Act.

More serious ESC-related offences under the EP Act, such as the wilful contravention of an Environmental Protection Order (section 361), attract penalties in excess of $730,000[9] or five years imprisonment[9].

[9] Penalties as at 01 July 2015.

ESC-related court matters are often complex and technical in nature, meaning that legal proceedings can be both time consuming and costly. For example, the legal costs for a typical 3-day trial (excluding penalties if found guilty) may be in the order of $50,000.

5.3 Summary

The costs and benefits to the land development industry of adopting best practice ESC on construction sites are summarised in Table 6.

Table 6 Likely costs and benefits to industry from effective on-site ESC compliance

<table>
<tr><th>Likely costs of ESC compliance</th><th>Likely benefits of ESC compliance</th></tr>
<tr><td>Major quantifiable costs (estimates)</td><td>Major quantifiable potential benefits (estimates)</td></tr>
<tr><td rowspan="3">1. Civil construction phase
Implementation and maintenance of a best practice ESC Plan/ Program onsite
- $24,000 - $44,000 per ha
(average = $34,000 per ha)

2. House building phase
Implementation and maintenance of best practice ESC measures onsite
- $1,500 - $1,700 per site
(average = $1,600 per site)</td><td>1. Reduced risk of fines (PINs)
(based on penalty unit value as at 01 July 2015)
- $8,835 per offence

2. Avoided offsite sediment clean-up costs
(e.g. sediment discharge into council drainage system)
- $375 per tonne</td></tr>
<tr><td>Major unquantifiable potential benefits</td></tr>
<tr><td>- Reduced rectification works and construction downtime
- Better public image/social licence to operate
- Reduced financial risk and liability (e.g. cost over-runs, disputes)
- Reduced topsoil loss
- Reduced damage to new buildings, on-site stormwater drainage and other infrastructure susceptible to erosion and/or sediment (e.g. pipes, pits, bio-retention systems, undermining of retaining walls, newly landscaped areas)</td></tr>
<tr><td>Minor potential costs</td><td>Minor potential benefits</td></tr>
<tr><td>- Staff and sub-contractor awareness and training
- Internal quality assurance/ management reporting systems</td><td>- Client satisfaction
- Better working relationship with Regulator
- Better environmental track record
- Improved visual 'presentation' of developments (i.e. 'clean and green' place to live)
- Contribution to protecting economic, social and environmental values associated with waterway health (e.g. recreational and commercial fishing, tourism, seafood industry and bequest values to future generations)</td></tr>
<tr><td colspan="2">Conclusions regarding the relative magnitude of likely costs and benefits:</td></tr>
<tr><td colspan="2">While many of the potential costs and benefits are difficult to quantify (due to them being site-and circumstance-dependent), considering all the identified potential costs and benefits of improved ESC practices on construction sites, the benefits are likely to outweigh the costs for typical construction sites.</td></tr>
</table>

6. ESC – the rationale for Councils

This section describes the costs and benefits to Councils of implementing effective compliance programs.

6.1 Costs

Collectively across SEQ, local Councils are estimated to be investing approximately $2.2 million per year in efforts to improve ESC compliance on building and construction sites[10]. The likely cost of one dedicated Full Time Equivalent (FTE) ESC compliance officer resource is estimated at $100,000 per year[10].

However, the direct operational costs of running an ESC compliance program may be at least partially, if not fully, offset by:

- the revenue generated through issuing of Infringement notices to those companies found to be causing or allowing sediment pollution to occur
- savings in other Council expenditure (e.g. stormwater asset maintenance costs) due to lower volumes of sediment entering Council's drainage network.

6.2 Benefits

The majority of benefits to Councils from improved ESC compliance are costs that can potentially be avoided as a result of less sediment. These include the costs to maintain assets (8), rectify stormwater infrastructure, rehabilitate and maintain waterways, and reduce the overall cost of meeting regional loads abatement targets.

Figure 8 Sediment accumulated within Council infrastructure

Table 7 summarises the range of typical maintenance costs that potentially can be avoided, or at least reduced, by Councils as a result of ESC compliance reducing sediment loads. This indicates that SEQ Councils are collectively spending approximately $31 million per annum[10] on managing the direct impacts of sediment upon Council infrastructure assets. The table below provides an overview of the potential costs borne by councils that could be avoided / reduced if ESC was more widely adopted.

[10] Figures derived from annual costs (2014 calendar year) and supporting data provided by participating Councils and Healthy Waterways analysis. Urban footprint data was used to extrapolate expenditure estimates across all SEQ Councils where specific data was unavailable.

Table 7 Summary of sediment-related costs that can potentially be avoided by local Councils

Item	Unit	Estimated Cost (per year)
Cleaning and maintaining stormwater infrastructure (closed stormwater infrastructure and stormwater quality treatment devices)[10]	SEQ Wide	$8.2 Million p.a
Removing sediment from open drains and creeks[10]	SEQ Wide	$14.6 Million p.a
Street sweeping activities[10]	SEQ Wide	$6.6 Million p.a
Managing other flow-on impacts such as aquatic weeds, algal blooms and fish kills[10]	SEQ Wide	$1.2 Million p.a
Rectifying vegetated stormwater assets (e.g. reinstating bioretention systems[10])	Per device	$10,000 - $100,000
Waterway rehabilitation and maintenance[11]	Per stream metre	$200 - $3,000
Average sediment removal from stormwater infrastructure (estimated from Council supplied data – range $250 - $500 /tonne)[10].	$/tonne	$375
Community complaints relating to water and/or wind erosion (sediment and dust)[12]	Per complaint	$800 - $4,100

The degree to which these benefits would accrue to local governments will be determined by locally-specific circumstances. While not all of the sediment-related maintenance costs incurred by Councils can be solely attributed to new urban construction sites, sediment from construction sites represents a significant portion of the total sediment runoff in developing catchments due to their high erosion potential and low average compliance.

In addition, the current funding allocated for sediment-related asset management (e.g. desilting) may be considerably less than what is required to maintain stormwater infrastructure assets in a fully serviceable condition. For instance, some Council staff indicated they would require at least a 100% increase in their annual sediment-related maintenance budget to help ensure that stormwater infrastructure remains fully serviceable and uncompromised by sediment accumulation.

[11] Refer to Water by Design (2010)

[12] Based on a typical ESC-related complaint breakdown and analysis by Healthy Waterways with input from local government stakeholders (Healthy Waterways, 2015c)

Rectifying stormwater assets

An avoided cost regularly cited by Councils was the cost to rectify vegetated stormwater assets in new housing subdivisions. After a vegetated stormwater asset (particularly a bio-retention system) has been installed during the land development phase and then transferred to Council as a Council-owned asset, it can quickly become inundated with sediment during the subsequent house building phase.

While these assets are installed to help capture and remove sediment and nutrients from newly developed sites, they are not designed to cater for the large sediment loads that flow from house building sites with little, or often ineffective, onsite ESC measures in place.

When large amounts of sediment fill these vegetated stormwater assets they can become dysfunctional, pond water for extended periods of time and can become weed infested. Some Councils have spent between $10,000 to $100,000 per asset to repair or reinstate them[10]. The cost of unnecessary rectification works can be avoided and subsequent maintenance costs minimised, by improving ESC compliance by house builders, as well as by closely scrutinising vegetated stormwater assets at the time of handover to Council (Water by Design, 2012).

Complaints

Increased public complaints and unwanted negative media attention may result from issues that are exacerbated by increased sediment pollution e.g. algal blooms and fish kills.

Complaints relating to sediment pollution from construction sites can produce often unseen and unquantified costs for Councils. In consultation with experienced Council regulatory staff, the typical cost of managing ESC complaints is estimated to range from approximately $800 - $4,100 per complaint[12]. Stakeholder consultation indicates that some larger Councils may receive hundreds of such complaints each year[10].

In addition to sediment-related complaints due to erosion by water, dust complaints (typically caused by wind erosion and/or construction traffic movement) can also be very expensive for Councils to respond to, often more so than from water erosion. This is due to the larger number of neighbouring properties potentially affected by airborne dust and public health concerns raised by people with respiratory conditions. Although effective dust control technologies are readily available in SEQ, their use is currently limited.

6.3 Summary

Table 7.2 summarises the *likely* ESC compliance costs and benefits to local Councils in SEQ from implementing an effective ESC compliance program.

7. ESC – the societal public policy rationale

The broader community and the natural environment bear a significant cost burden for the sediment released from poorly managed, and often non-compliant, construction sites, instead of the polluter.

7.1 Costs

The community does not incur any direct costs associated with ESC compliance. However, indirectly they would incur the cost of Council compliance programs through their rates and is addressed within Section 7 of this report.

7.2 Benefits

Sediment reductions

Using the method described in Section 3.3, the total annual unmitigated sediment load from urban construction sites in SEQ has been calculated to be between **114,000 - 202,000 tonnes per year**, with an average of 158,000 tonnes per year[13] (Table 2).

The current annual 'construction footprint' of new land development in SEQ represents only approximately 1% of the total urban footprint, yet generates approximately 40% of the total annual urban sediment load (based on BMT WBM (2014b) modelling and further Healthy Waterways analysis). This is fundamentally the case for improving ESC compliance on construction sites – very high sediment loads generated from a relatively small land area (compared to other land uses) and across most rainfall scenarios (i.e. not just during major events and floods).

Figure 9 shows the relative proportions of total areal sediment load as a function of land use type. This estimates that construction sites currently contribute approximately 13% of the SEQ

[13] These figures represent total sediment load estimates, including both coarse sediment (typically sands and gravels) and fine sediment (typically silts and clays).

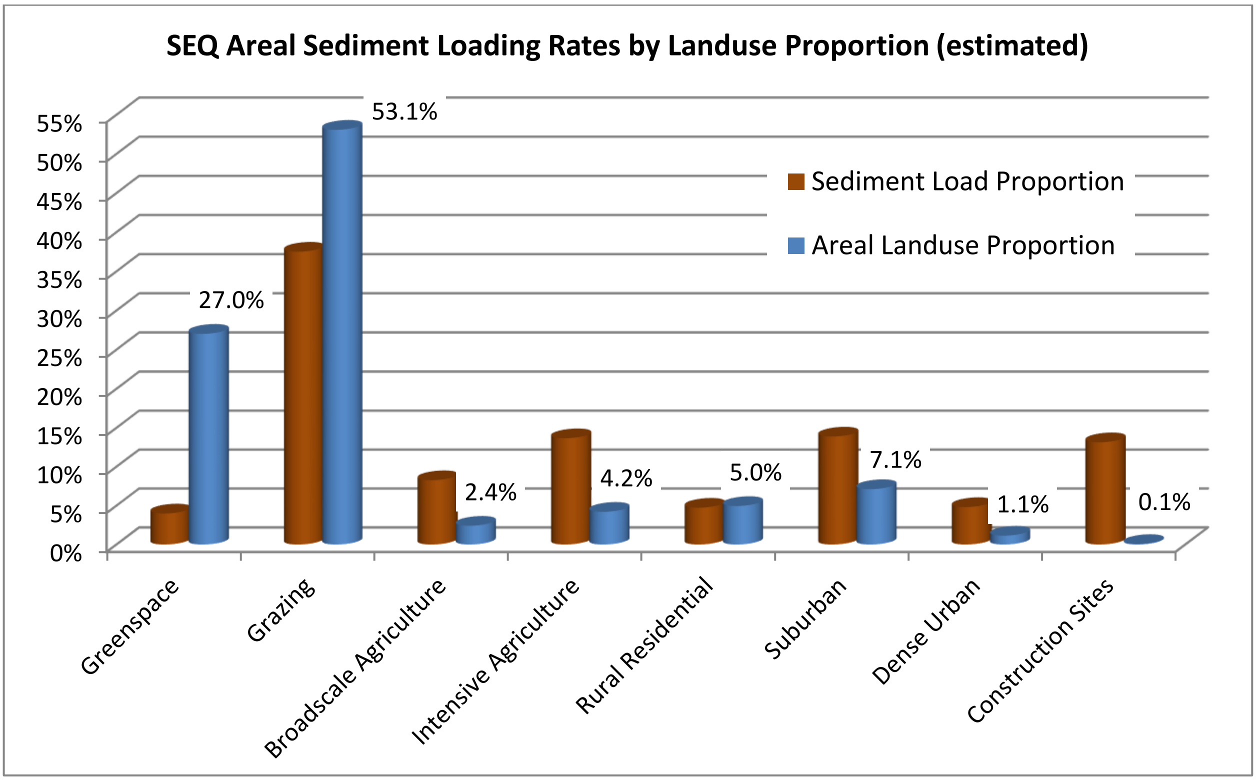

Figure 9 Estimated SEQ areal sediment loads by land use type (Total Sediment t/ha/yr) (Source: BMT WBM (2014b), adapted by Healthy Waterways Ltd

Less sediment entering our waterways is a key outcome sought through increased ESC compliance. Best practice erosion control measures are capable of reducing sediment loads from construction sites by between 60 - 90% (Taylor & Wong, 2002), with high efficiency sediment (HES) basins capable of load reductions of between 90 - 99% (BMT WBM, 2014a).

To understand how much sediment runoff from SEQ construction sites would be avoided through improved ESC compliance, the potential reduction in sediment from an effective ESC compliance program that results in high levels of industry compliance is presented in Table 8. This assumes, as described in Section 2, that an effective compliance program is essential to improve industry ESC performance and therefore sediment load reductions from construction sites.

Table 8 Likely productivity outcomes to Councils from an effective ESC compliance program

Item (based on 1 FTE) ESC compliance officer	Development Type	
	Domestic house site (average size 480 m^2)	Large scale development (average site/stage area 2.5 ha)
Total inspection capacity[14] *(per officer, per year)*	625	300
Total number of separate sites/projects inspected[14] *(per officer, per year)*	312 (~2 inspections per site)	100 (~3 inspections per site)
Average total disturbance area inspected per year[15] *(per officer, per year)*	15 hectares	250 hectares
Average percentage disturbance over the construction period[16]	70%	70%
Average construction duration[16]	16 weeks (~3.7 months)	8.5 months (~5 months construction + 3.5 months for effective ground cover establishment)
Average annual sediment load reduction across all sites as percentage of total load[17] *(by implementing best practice ESC)*	80% of coarse sediment 30% of fine sediment	80% - 90% of coarse sediment 40% - 50% of fine sediment
Total sediment reduction (range is for 'low' and 'high' rainfall zones)[18] *(per officer, per year)*	73 – 229 t/yr	3,580 – 11,250 t/yr

Quantitative data has been used in Table 5.2 where available. However, where data was not available a number of assumptions were necessary. These assumptions are based on the collective experience of the authors and contributors to this document.

Avoided environmental costs

It is difficult to assign an economic benefit to environmental impacts that can be avoided by reducing sediment entering our waterways, such as those listed below in Table 9 and shown in Figure 10. However, the absence of a specific economic valuation does not reduce the significance of these impacts, as they can be extensive and often cumulative in effect.

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[14] Based on Brisbane City Council annual site inspection capacity data using dedicated ESC compliance officer resources

[15] Calculated using annual number of individual sites inspected and an estimated average site area of 2.5 hectares

[16] Preliminary estimates of typical disturbance area and duration on SEQ building and construction sites based on satellite photos and industry consultation

[17] Based on cited literature such as Taylor & Wong (2002), BMT WBM (2014a)

[18] Outputs of modelling by Healthy Waterways Ltd (2015)

Table 9 Examples of sediment-related environmental impacts

Impact	Description
Direct impacts to fish health	Sediment abrades and damages fish gills, increasing risk of infection and disease.
Decreases in primary production	Increased turbidity levels limit light penetration and photosynthesis, resulting in reductions in plankton and aquatic plant growth. Physical smothering by sediment of submerged macrophytes and benthic zone.
Changes to aquatic communities and biodiversity	Loss of species sensitive to sediment. Shifts in fish communities to more sediment tolerant species such as carp. Reduced number of aquatic macro invertebrates, which then impacts through the food chain. Destruction of fish spawning areas.
Alteration of aquatic habitats	Increased loads of particle-bound toxicants and nutrients leading to eutrophication, algal blooms and aquatic weed infestations. Siltation and smothering of habitats. Loss of habitat diversity in small streams (e.g. dry weather pools in ephemeral streams displaced by sediment). Changes in size and distribution of habitats, such as mangroves, salt marshes and sea grass meadows, including shallowing of estuaries and smothering and reduction of seagrass beds. Increased bank erosion and changes to channel morphology.

Figure 10 Examples of freshwater environmental impacts related to sediment pollution

Environmental impacts can have flow-on consequences for human use of waterways and the local economy, such as commercial and local fishing, tourism and local recreation. Some studies have been undertaken to try and quantify environmental services for human use in SEQ. For example Marsden Jacob Associates (MJA, 2011) estimated the economic benefit derived from SEQ waterways and Moreton Bay to be greater than $5.1 billion per annum (refer to Table 10).

Table 10 SEQ waterways & marine environment key economic values. Source: MJA (2011)

Sector	Annual Value (2011) $Million
Primary Industries (inc. agriculture and commercial fishing)	$1,390M
Nature-based Tourism	$2,850M
Local Recreation	$660M
Recreational Fishing	$210M
Total	**$5,110M**

In a similar study Marsden Jacob Associates (MJA, 2010) considered the impact of a decline in natural resource condition on these industries. Such a decline could arise due to:

- increases in sediment and nutrient loss from agricultural areas
- reductions in fishing catch rates due to increases in turbidity in estuaries and Moreton Bay
- reductions in nature-based tourism and recreational expenditure due to reductions in amenity (perceived or actual) and fewer opportunities for swimming and water-based recreation.

A more recent analysis of the economic values of SEQ waterways has revised this estimate to greater than $10 billion per year (Healthy Waterways, 2015a). However, it should be noted that these values are *total* benefits derived from waterways. To undertake a simplified CBA of ESC it is important to assess the *marginal* benefits attributable to ESC compliance.

Table 11 provides an example of abatement that could be achieved through improved ESC compliance. These are based on:

- estimated unmitigated sediment load of 114,000 tonnes per year from construction sites, which is considered appropriate given the low compliance rates recorded on urban land development sites in 2013 (Healthy Waterways, 2015b)
- assuming one-third of the load is coarse material (i.e. sands and gravels) and two-thirds of the load is fine material (i.e. silts and clays).

Table 11 Broad abatement efficacy

Benefit type	Potential load reduction (per year)
Avoided impact costs from coarse sediment, typically associated with improved creek stability and reduced stormwater infrastructure maintenance (e.g. desilting and instream weed removal)	60 – 85% (23,000 – 32,000 tonnes)

Benefit type	Potential load reduction (per year)
Avoided impact costs from fine sediment associated with sediment nitrogen enrichment in receiving waters[19] (i.e. lower river estuaries and Moreton Bay)	30 – 50% (23,000 - 38,000 tonnes)

Environmental impacts also have economic values. Table 12 summarises the key estimates of the value of environmental attributes used in this business case. These have been derived from meta-analysis of the literature and previous studies. Where necessary, economic estimates have been modelled with physical data (e.g. recreational fishing activity) to establish economic values, and all values have been updated to 2016 values.

Table 12 Estimates of unit values for benefits used in analysis

Environmental value	Unit	Low	Med	High	Comments and key source(s)
Waterway management					
Avoided stream management	$ / tonne	$300	$375	$450	Avoided impact costs from coarse sediment, typically associated with improved creek stability and reduced stormwater infrastructure maintenance (e.g. desilting and instream weed removal).
Avoided impact costs from fine sediment associated with sediment nitrogen enrichment in receiving waters[20] (i.e. lower river estuaries and Moreton Bay)	$ / tonne	$960	$1,200	$1,400	Runoff from future construction adds to legacy loads that already need to be reduced. Therefore, the benefits of ESC relate to the additional costs of abatement beyond that is already incorporated into existing targets. Analysis of targets and marginal costs (Binney and James 2012) indicates the marginal costs of additional abatement effort required are very high.

[19] See BMT WBM (2014a)

[20] See BMT WBM (2014a)

Avoided dredging costs – Port of Brisbane[21]	Avoided cost ($/m³)	$8.69	$11.59	$14.49	SKM (2013). Based on study by SKM across several ports (noting Port of Brisbane can dredge up to 1 million m³ a year).
Recreation					
Recreational fishing (number of trips)	Number of trips	850,000	875,000	900,000	Data is derived from the 2013-14 DAF survey of recreational fishing. These estimates are based on the Moreton and Brisbane Regions from that study which also includes the Gold and Sunshine Coasts.
Recreational fishing (value per trip)	Consumer surplus per trip ($/trip)	$60	$62	$64	Based on estimates from a major travel cost study Pascoe et al (2014). Note these values represent the marginal values[22] as this better represents values attributable to changes in waterway health induced change.
Beach visits	Annual household value for a 1% improvement	$4.19	$4.81	$5.20	Water quality is an important feature for beach visitors in SEQ, and particularly to residents of the Gold and Sunshine Coasts. Estimates presented here are modelled on a travel cost study by Windle and Rolfe (2013).
Environmental values					
Improvement in waterway health	Annual household value for a 1% improvement	$3.60	$4.58	$5.36	Results from a major willingness to pay (choice modelling) study in SEQ ((MJA (2010)). The range presented here represents the results of statistical analysis of the range of

[21] Note: This benefit stream relates to avoided costs of *moving* sediment deposits from shipping lanes. This benefit is likely to become more valuable as the 2nd Brisbane runway project comes to an end and dredged materials are no longer a resource for land reclamation.

[22] These values exclude the costs of fixed inputs for fishing such as boat ownership and registration etc.

					survey responses.
Improvement in seagrass (extent and condition)	Annual household value for a 1% improvement	$0.62	$0.73	$0.84	Results from a major willingness to pay (choice modelling) study in SEQ ((MJA (2010)). The range presented here represents the results of statistical analysis of the range of survey responses.

Other social and economic benefits not included in our quantitative estimates

Other social and economic costs that may be avoided by reducing sediment from construction sites include:

- **Water service provision costs.** Increased pollution loads increase the cost (chemical and energy) of treating potable water to appropriate standards (up to $90+ per ML provided). While data on costs to water treatment attributable to water quality is available, the bulk of development is accruing downstream of dams and ESC actions are less likely to deliver these benefits. Therefore we have not included these values in our quantitative analysis.
- **Recreation at dams.** Whilst these values have been estimated (MJA 2013), the bulk of development is accruing downstream of dams and ESC actions are less likely to deliver benefits for this category of recreation.
- **Recreation at other freshwater waterways (e.g. wetlands or creeks).** There are no reliable and directly relevant travel cost studies to utilise within this study. The HWL Social Survey (HWL, 2015b) indicates that these waterways are not preferred waterways for recreation (rivers = 8.9%, wetlands = 1.8% of respondents).
- **Property values:** Several studies have quantified the decline in property values due to increases in turbidity of nearby waterways/water bodies ((Steinnes, 1992), (Poor, Pessagno, & Paul, 2007), and (Bin & Czajkowski, 2013)).
- **Human health:** Turbidity has been linked to the occurrence of waterborne diseases, as demonstrated by Lawrence (2012) and Gregory (1998). Nutrients bound to colloidal sediments (i.e. fine, turbidity-producing sediments such as clay) can increase floating aquatic weeds such as *Salvinia molesta*, which can attract mosquitoes carrying diseases such as Ross River virus and Barmah Forest virus (Webb CE, 2012). Poor water quality has also been shown to reduce the ability of natural areas to lower the stress levels of human visitors and ultimately reduce their enjoyment of that area (Hipp & Ogunseitan, 2011).

Given these omissions, the estimates of benefits accruing from ESC compliance should be considered conservative (i.e. underestimates).

While further work is needed to more accurately quantify the cost of sediment run-off to the environment, society and the economy, these studies identify some of the potential costs of sediment pollution and highlight the cumulative benefits of reducing sediment within our waterways.

7.3 Aggregate CBA assessment

Based on forecast dwelling development patterns, estimates of efficacy, and available information on the benefits and costs of ESC outlined above, a CBA was conducted to determine the costs and benefits of ESC compliance over a period of 20 years.[23] Given the variability in input parameters, three separate CBA scenarios were undertaken:

- **More likely.** This CBA used the mid points of all input parameters (abatement efficacy, costs and benefits).
- **Pessimistic.** This CBA is based on the lowest expected efficacy, the highest costs and the lowest unit values for benefits. This provides an indication of the worst-case scenario.
- **Optimistic.** This CBA is based on the highest expected efficacy, the lowest costs and the highest unit values for benefits. This provides an indication of the best-case scenario.

There are a number of decision rules used in a CBA. Firstly, a policy or project is only economically viable where the net present value (NPV) is >$0. Secondly, the ratio of benefits to costs (called the benefit-cost ratio or BCR) should be >1.

Table 13 shows the summary findings from the CBA, including:

- The aggregate estimates of benefits, costs and net benefits over the 20-year period.
- The benefit-cost ratio (BCR).
- An analysis of the distributional consequences for both costs and benefits.
  - For costs this assumes that all additional ESC compliance officer costs will be borne by councils. Ultimately these costs are either recovered via development application fees, or passed onto ratepayers. All on-ground ESC implementation costs will be initially borne by developers and then passed onto the purchasers of new dwellings.
  - For benefits, we have assumed that all benefits in the form of avoided costs for waterway management (e.g. avoided dredging) will accrue to Governments or Government-owned entities, with benefits accruing the community and consumers. Social benefits such as enhanced recreational amenity will accrue to society.

The key points to note from the CBA are:

- The CBA does not include all potential benefits due to limitations in data availability, and therefore, the findings presented here should be considered conservative.
- Under the more likely and optimistic assumptions, there is a clear economic case for ESC as the benefits exceed the costs.
  - Under the more likely suite of assumptions, the BCR for ESC is around 1.2 (i.e. for every $ of expenditure on ESC, an economic benefit of $1.20 accrues).
  - Under the optimistic suite of assumptions, the BCR increases significantly to around 2.0.
  - Where pessimistic input assumptions are adopted (low levels of efficacy, low unit values for benefits and high costs), the economic case is not evident.
  - The overall results of the CBA are most sensitive to the assumptions regarding the efficacy of ESC (i.e. what is the level of abatement achieved?). This reinforces the rationale for industry capacity building as part of any package of ESC interventions to ensure benefits are actually realised.

[23] A real discount rate of 5% was used for the analysis.

Table 13 Summary of results from cost-benefit analysis (CBA)

Item	Pessimistic	More likely	Optimistic
CBA			
Present value benefits over 20 years	$476,000,000	$721,000,000	$1,174,000,000
Present value costs over 20 years	$1,123,000,000	$621,000,000	$578,000,000
Net present value over 20 years	-$647,000,000	$100,000,000	$596,000,000
Benefit cost ratio	0.4	1.2	2.0
Distribution of costs and benefits by entity			
Costs			
Council	6%	5%	5%
Developers - new homeowners	94%	95%	95%
Benefits			
Avoided financial costs	91%	92%	92%
Social benefits	9%	8%	8%

- Under all scenarios, around 95% of the costs are initially borne by developers and then incorporated into land prices.
- Less than 10% of the benefits of ESC are likely to accrue directly to the community in the form of social benefits (recreation, ecological function etc.).
- The bulk of the benefits are likely to accrue initially to governments (Table 14).
    - Avoided waterway management, both to local governments (avoided local stream management and drainage management). The present value of savings over the next 20 years is estimated at around $160 million (more likely scenario).
    - The largest benefit stream is the potential to avoid future catchments management expenditures required to meet sediment targets in SEQ waterways and Moreton Bay. Under the Resilient Rivers Initiative councils, the State Government, and the broader community are committed to reducing loads into Moreton Bay to sustainable levels. This will require significant region-wide investments. To the extent that loads from urban development are not managed, the abatement required under the Resilient Rivers Initiative to achieve the targets will be significantly higher. Furthermore, opportunities for low-cost on-ground abatement actions to offset the growth in urban loads will not be available. The bottom line is that the cost of achieving the Resilient Rivers Initiative targets could be almost $500 higher over the next 20 years if ESC loads are not addressed.

There are also a number of policy implications evident from the analysis. These include:

- The implementation of ESC regulations should be considered as part of a broader suite of interventions to achieve waterway management targets. Different policies would be required to efficiently manage legacy sources of loads and future sources of loads. This should include capacity building to ensure benefits of ESC accrue.

- The impact of implementing ESC on total building costs is similar to the cost of an additional 1m^2 on a typical 240m^2 new home, or equivalent to two months capital gains under current house price trends. The cost impost is not significant and shouldn't have any material impact on building activity.
- Imposing a minor additional cost on new dwellings is entirely consistent with community views, where surveying indicates 91% of SEQ households believe taking preventative actions to prevent environmental decline in SEQ is preferable to more costly remediation at a later date (Binney and James (2012)).
- Given the uncertainties in physical and economic data, it would be prudent to embed monitoring and evaluation within the suite of ESC actions to underpin continuous improvement of ESC design and implementation.

The distribution of benefits by type for the medium scenario is shown in Figure 11.

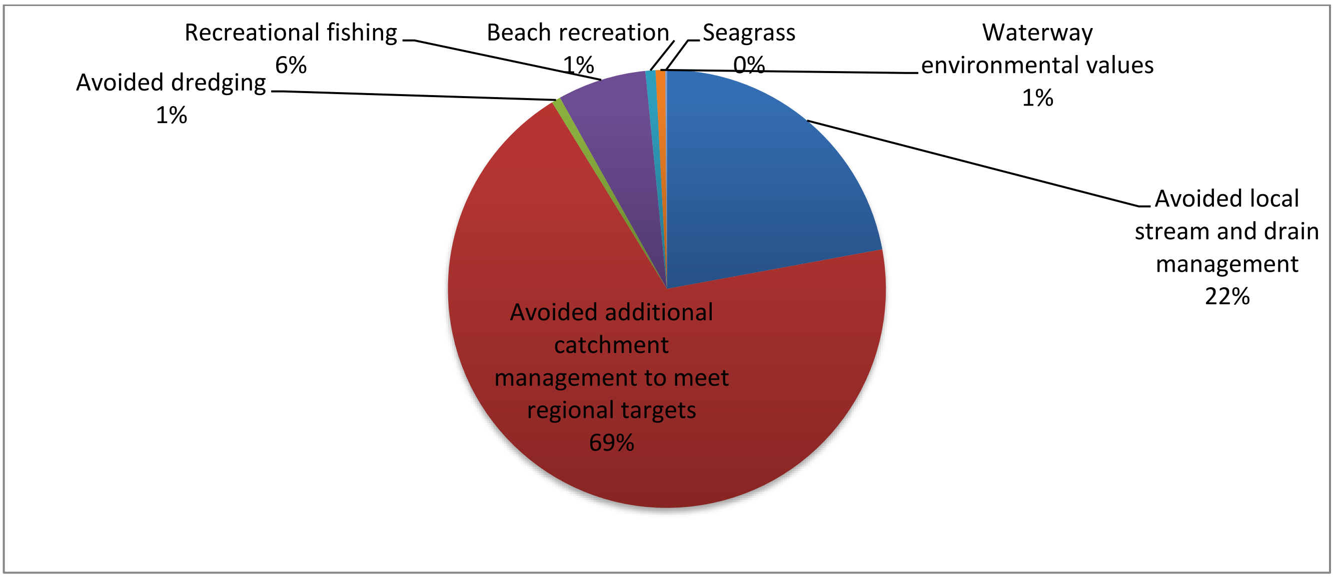

Figure 11 Distribution of benefits by type

Table 14 Likely costs and benefits to Councils from an effective ESC compliance program

<table>
<tr><th>Likely costs of improved ESC compliance</th><th>Likely benefits of improved ESC compliance</th></tr>
<tr><td>Major quantifiable costs (estimates)</td><td>Major quantifiable potential benefits (estimates)</td></tr>
<tr><td rowspan="3">1. Implementation and maintenance of a best Practice ESC Compliance Program

- $100,000 per officer per year (average) for every:
➢ 100 x large scale development sites (i.e. site area > 2,500 m^2); or
➢ 300 x domestic house sites (i.e. site area ~480 m^2)

Notes:
- Includes staff operational costs and administrative overheads for each Full time Equivalent (FTE) officer.
- Council ESC compliance program operating costs are likely to be cost-neutral as a result of revenue generated from enforcement activities.</td><td>1. Value of the reduction in sediment to stormwater
Equivalent <u>coarse</u> sediment removal cost of $375 per tonne (see Table 7.1)
- Large scale development sites: 1,715 - 5,395 t/yr (~$640,000 - $2M per year)[24]
- Domestic house sites: 42 – 131 t/year (~$16,000 - $49,000 per year)[24]
2. Potential avoided costs associated with downstream waterway rehabilitation and maintenance
Coarse sediment deposits causing instream instability (e.g. stream bank erosion, instream weed growth)
- $200 - $3,000 per metre of stream per annum[11]
3. Potential avoided costs associated with damage to Water Sensitive Urban Design (WSUD) infrastructure
Increased rate of sediment deposition and clogging of filter media in bio-retention systems
- $10,000 - $100,000 per device[10]
4. Reduced number of ESC-related complaints
(reduces over time as voluntary compliance increases)
- $800 - $4,100 per complaint[12]</td></tr>
<tr><td>Major unquantifiable potential benefits</td></tr>
<tr><td>- Contribution to the protection of economic, social and environmental values associated with waterway health (e.g. recreational and commercial fishing, tourism, seafood industry, bequest values to future generations).
- Community amenity at local and regional scale (i.e. connection to water cycle) - see Table 5.4.</td></tr>
<tr><td>Minor potential costs</td><td>Minor potential benefits</td></tr>
<tr><td>- Initial program establishment, management and councillor briefings, staff procurement and training
- Additional development assessment costs
- Industry awareness and engagement</td><td>- Demonstration of Council's commitment to environmental protection in the eyes of ratepayers
- Demonstration of Council's commitment to the 'polluter pays' principle in the eyes of ratepayers – see Section 2 and Section 6.1</td></tr>
<tr><td colspan="2">Conclusions regarding the relative magnitude of likely costs and benefits:</td></tr>
<tr><td colspan="2">While the magnitude of the potential benefits will vary based on a number of factors (such as erosion risk, annual rainfall, site inspection frequency, improvements in industry ESC performance and the assumptions around benefits), considering all the identified potential costs and benefits of improved ESC compliance on construction sites, the benefits are likely to outweigh the costs for typical construction sites.</td></tr>
</table>

[24] The benefit value (i.e. avoided cost) calculation method is summarised in Table 5.2 of this document. The potential cost savings are proportional to the calculated sediment export rate. Therefore, higher rainfall zones will have a higher potential benefit (in dollar terms) for the same input cost (i.e. FTE ESC compliance officer).

8. Conclusions and recommendations

The land development market is failing to deliver socially optimal outcomes by increasing the cost to the community to meet waterway health objectives with subsequent negative impacts on recreation, tourism and other social values. But managing this water pollution problem at its source is both logical, achievable, and will not have a detrimental impact on the development sector.

Urban construction sites in SEQ currently generate sediment runoff of approximately 114,000 tonnes per year, with the potential to generate significantly more than 200,000 tonnes per year if future land development rates were to increase in line with the SEQ Regional Plan (2009 – 2031) growth projections. SEQ construction sites are estimated to generate more than 40% of the total urban sediment load per year, but represent only around 1% of the total urban footprint.

Low levels of ESC compliance on urban construction sites is the most significant cause of these sediment loads, with only around 5% of land development sites (based on 2013 data) being substantially compliant with ESC requirements. With the consistent implementation and maintenance of simple, effective and affordable ESC practices on urban construction sites in SEQ it is estimated that sediment loads could potentially be reduced by, on average, at least 60 – 80% (approximately 68,000 – 91,000 tonnes per year).

This document assesses the rational for ESC:

- Firstly from the perspective of the whole of society in SEQ using a CBA framework. This analysis found that the benefits of ESC compliance exceed the costs, particularly where the efficiency of ESC action is assured. While the bulk of the costs will initially be borne by developers, these costs will be passed onto purchasers of new dwellings. The benefits include social benefits (less risk to recreation etc.) and reduce costs to local governments and the State to meet waterway targets.
- Secondly from the perspective of the construction sector, where significant operational efficiencies and operational risks can be mitigated though robust implementation of ESC. We estimate the cost of compliance is around $1,600 per new dwelling.
- Finally, from the perspective of the local government sector where significant reductions in stormwater management assets and waterway rehabilitation could be achieved where ESC is implemented well. This would require a relatively small investment in additional compliance staff for many Councils (Table 14).

There is a clear public policy rationale for ESC, the economic analysis indicated that the policy is economically viable, and implementation of ESC is consistent with the view of the majority of practitioners and the broader community.

The absence of an <u>effective and regionally consistent</u> regulatory ESC compliance and enforcement program across all SEQ Councils is viewed by many experienced ESC stakeholders from both government and industry as the major barrier to improved compliance, but also a major part of the solution. Implementation of such a program in SEQ that is supported by strong political leadership, education and collaboration between government and industry, will ultimately help to change current attitudes and behaviours, increase the implementation of best practice ESC, and reduce the costs and impacts of sediment pollution in SEQ.

The information contained in this report forms a key component of a broader project being undertaken by Healthy Waterways and its partners to develop a long-term regional ESC strategy in SEQ to substantially improve onsite ESC compliance and reduce sediment pollution from building and construction sites into the region's waterways over the next 10 years.

The primary recommendations from this report are for:

1. The Queensland government and the Council of Mayors SEQ to oversee the establishment and long-term support for a regionally consistent best practice ESC compliance program within each SEQ Council. This program should support local Councils to create a strong economic incentive for industry to comply with ESC requirements, and be underpinned by a proactive compliance monitoring approach that substantially increases the likelihood of non-compliant sites being subject to substantial enforcement action and penalties
2. The Queensland government and all local SEQ Councils to make a long-term funding commitment to implement the regional ESC Strategy for SEQ (currently under development by Healthy Waterways) that takes a holistic approach to improving ESC compliance on building and construction sites in SEQ. The ESC Strategy will consist of a range of prioritised actions and reforms relating to ESC policy, proactive compliance auditing, enforcement, capacity building activities and industry incentives necessary to substantially improve ESC compliance and protect water quality.

Furthermore, interested stakeholders and practitioners committed to the protection of SEQ's waterways should utilise the information in this report to help raise awareness and encourage constructive discussion within their organisations and local communities about the impacts and costs of sediment, and the cost-effective solutions available.

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Appendix 1: ESC Case Study
Case Study 1: Road Upgrade Project – batter chutes failure

Prepared by SEEC Consulting, 2015 for Healthy Waterways Ltd

Location:	South-eastern NSW.
Project:	Road upgrade project. Undertaken during 2012.
Climate:	Warm temperate. Average rainfall approximately 800mm/year.
ESC issue:	Erosion and sediment control measures not installed correctly as per the approved ESCP.
Causes:	Lined batter chutes not installed as per the ESCP prior to rainfall on semi-completed fill batters. Water accumulated on the fill at the sag point (see Figure 1), then overtopped the windrows along the hinge point of the fill in an uncontrolled manner.

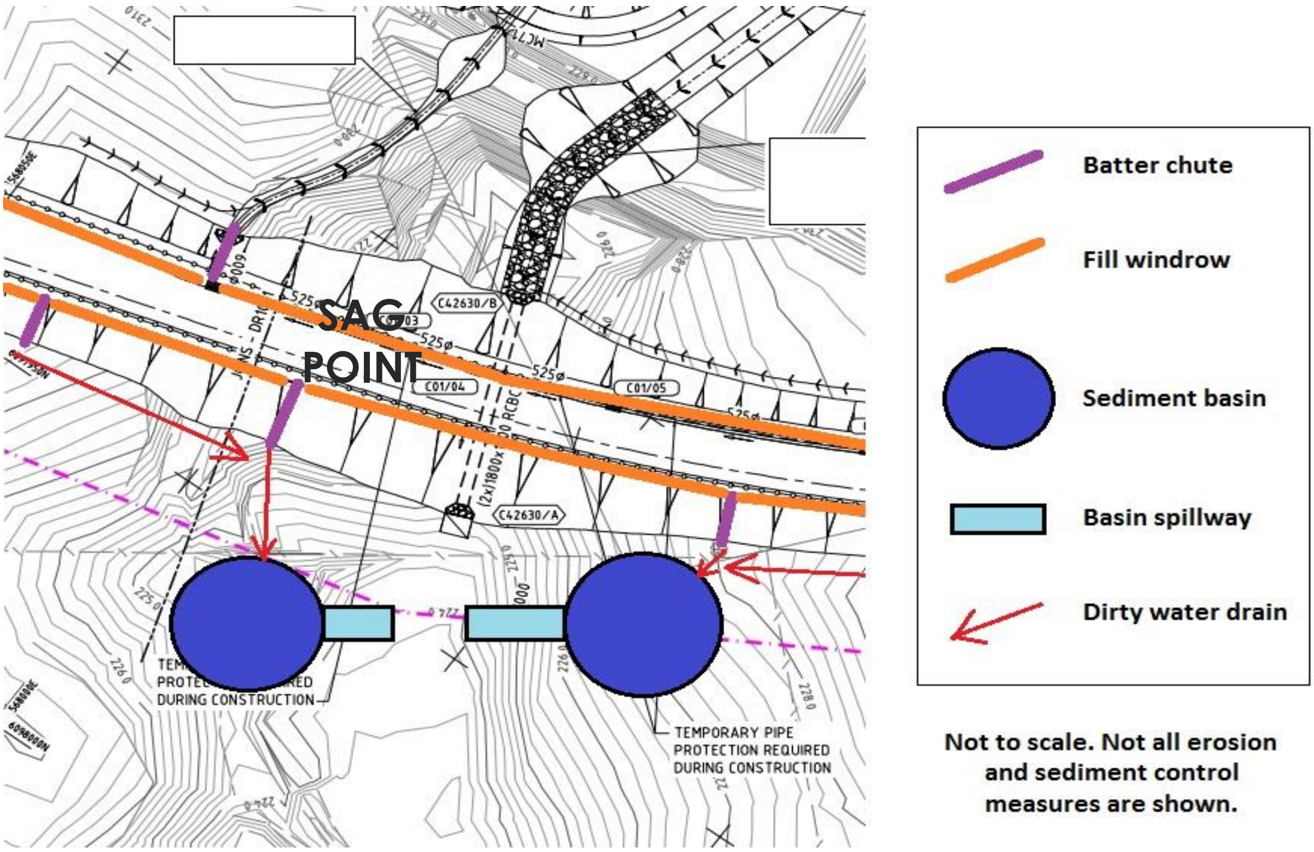

Figure 1 Portion of the ESCP for this location, showing the windrows and lined batter chutes required to control the flow of water off the fill, down the embankments and into sediment basins.

Impacts:	Numerous impacts including: - Significant scour of the fill embankment (approx. 15 tonnes of sediment eroded) necessitating re-work and repair (Figure 2); - Scouring below the fill embankment eventually led to a large volume of dirty water missing the adjacent sediment basin (Figure 3); - Dirty water instead flowed untreated directly into the natural "clean" water flowing through the nearby culvert; - Significant sediment accumulation (approx. 2 tonnes) on the newly-placed rock dissipater at the culvert outlet, necessitating clean-out and replacement of rock; - Sediment deposition (approx. 3 tonnes) on private property necessitated clean-up; - Non-compliance reporting; - Additional regulatory attention and client scrutiny.
Estimated cost:	Estimated direct cost of the incident is $12,000 which covers: - Plant and labour; - Engineer's and environment manager's time spent liaising with client, regulator and landholder; - Non-compliance reporting; - Replacement materials (e.g. fresh rock). The cost associated with additional regulatory and client scrutiny is not included in this estimate. No enforcement action was taken as a result of this incident.
Cost to avoid:	Estimated cost to correctly install plastic-lined batter chutes in addition to earthen windrows along batter hinge points at this location is $800 which covers plant, labour and materials.

Figure 2 Scour of the fill embankment caused by lack of drainage control. Lined batter chutes as shown on the ESCP (Figure 1) had not been installed prior to rainfall.

Figure 3 The scour extended down the batter and created a channel which diverted dirty water away from the sandbag-lined berm which should have taken dirty water to the sediment basin (visible in the distance). As a result, dirty water missed the basin and flowed directly offsite.

Appendix 2: Summary of stakeholders

Over the course of this study and concurrent ESC projects Healthy Waterways has sought data, input and informed opinions from a range of public and private sector stakeholders regarding the current barriers and opportunities to significantly improve ESC compliance on urban construction sites in SEQ. This information has been collected from a range of stakeholder meetings, one-on-one interviews (many confidential), formal data requests to Councils, industry forums and surveys.

A summary of the organisations (and staff where appropriate) that have contributed to this process are provided below in alphabetical order:

Andre Taylor Consulting (Andre Taylor)

A.R Volders Environmental Consulting (Adrian Volders)

BMT WBM (Tony Weber)

Brisbane City Council

City of Gold Coast

Civil Contractors Federation (Qld)

Healthy Waterways Integrated Urban Water Scientific Expert Panel (IUWSEP)

Housing Industry Association (Qld)

Ipswich City Council

Logan City Council

Mainstream Economics and Policy (Jim Binney)

Moreton Bay Regional Council

Noosa Council

O2 Environment + Engineering (Terry Clark and Ben Starr)

Queensland Government

Queensland Master Builders Association

Redland City Council

SEEC Consulting (Andrew Macleod)

Toowoomba Regional Council

Townsville City Council