INTRODUCTION TO STORMWATER ISSUES

4. *Stormwater contaminants*

4.1. Sediment

Polluted (black) sediment deposit at a stormwater outfall
Source: Rouge Watershed, Ontario

Flash flood through a stormwater outfall
Source: Rouge Watershed, Ontario

In simple terms, road generated stormwater quality effects can be divided into construction and subsequent use effects, each with their own suite of typical **contaminants** and issues. Construction related effects relate to **sediment** (as a contaminant) almost exclusively, whereas over the longer term, **heavy metals**, **hydrocarbons** (e.g. diesel, oils), and **litter** are the major contaminants of concern. As always, this division is not always so cleanly cut. For example:

- **Sediment** can remain the major **contaminant** of concern on unsealed, or metalled, roads;
- Increases in **impervious surfaces** (such as road widening) may result in increased **channel scour** and **erosion**; continuing the discharge of sediment until a stable channel re-establishes.
- Construction related discharges of sediment frequently leave residual deposits within stormwater systems. These can reduce capacity, causing **flooding** and the delayed discharge of 'stored' sediment from within the stormwater system.
- Other contaminants (such as oils, solvents, emulsions, and litter) can also be discharged as part of the construction process.

Erosion, the presence of **suspended sediments** within waterbodies, and **sediment deposition** are all natural processes. Flood events in undisturbed or developed catchments can give rise to large amounts of sediment being transported into waterways and to the coast. The extent of sediment build-up or **accretion** in the receiving environment is affected by attributes such as water velocity and the energy of the coastal receiving environment. The effect of sediment on natural ecosystems has therefore been studied widely and is well understood; being, irrespective of the cause, as follows:

- Suspended sediment:
  - Scouring of **periphyton** (aquatic plants) from substrates;
  - Increases in water **temperature**;
  - Possible increases in **nutrients** (if eroded material has a high **organic content** for example);
  - Reduction in light (affecting plant growth and animal feeding habits);
  - Changes in predator / prey relationships (i.e. the ability to detect a predator or to feed);
  - Physical damage to **fauna** (e.g. **abrasion** or clogging of gills, abrasion of skin) thereby increasing the risk of secondary infection and disease;
  - Changes in ecosystems and natural communities (e.g. loss of an age **cohort** / year group, changes in diversity and abundance, and / or changes in species composition;
  - Impacts upon aquatic insects;

- Reduced aesthetics, recreational (e.g. swimming, fishing) amenity, and value;
- Increased abrasion on infrastructure and equipment (e.g. jet boat units, hydrogenation equipment, or farm irrigation systems);

Inanga
Source: Fishbase

- Deposited sediment:
  - **Habitat** loss and the physical smothering of plants, insects, and aquatic **fauna**;
  - Smothering of eggs (complete loss or reduced survival rates);
  - Change in **substrate** type (leading to changes in community type / composition);
  - Changes to water velocity, pool and riffle systems, reduced stream capacity (increasing flooding and other related effects further down gradient);
  - Impoundment of water and stagnation (exacerbated if coupled with a high oxygen demand which may deplete **dissolved oxygen**);
  - Increased maintenance of infrastructure (e.g. on-line stormwater treatment devices, storage dams, culverts, navigation channels, port basins);
  - Reduced aesthetic appeal and recreational use of waterways, lakes, and affected coastal areas (most noticeably on sandy beaches);
  - Impacts on coastal **aquaculture** and fishing.

A detailed overview of some of the above sediment related effects for New Zealand was provided in the paper entitled *Environmental Effects of Sediment on New Zealand Streams: A Review* (Ryan, 1991). Sediment **deposition** and **accretion** are particular risks within soft shore communities, which are lower energy environments and therefore tend to accumulate sediment naturally. There is a perception that such environments are limited to northern coastal reaches, associated mainly with areas between Tauranga and the Hokianga harbour[1], and therefore sediment as a contaminant is 'not a problem' for most of New Zealand. This overlooks the sensitivity and existing quality of streams, rivers, and lakes, as well as the presence of other soft shore coastal environments that do exist, in other parts of New Zealand.

These lower energy coastal environments were described for New Zealand through a comprehensive overview produced in the 1960s (Morton and Miller, 1968). More recently a quantitative classification system has been developed by Biodiversity New Zealand in the *Marine Protected Areas: Classification and Protection Standard and Implementation Guidelines* (Biodiversity New Zealand, February 2008). This document establishes a consistent approach to classification of marine habitats and an inventory to identify where marine protection is required. The classification uses a hierarchy of five layers, beginning with one of fourteen biogeographical regions, whether estuarine or marine, tidal or subtidal, exposure level and finally substrate type – whether mud, sand, gravel, cobble, boulder or rock – and aspect. This produces a potential for up to forty four different habitats to be considered within any biogeographical region.

[1] Indeed in some of these areas, a recent indicator of accelerated erosion and coastal sedimentation has been the establishment of mangroves along coastal fringes.

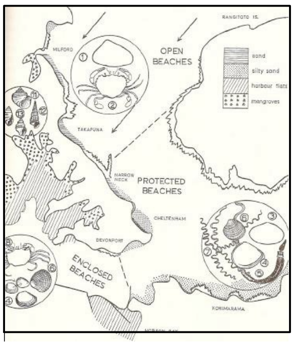
There is a perception that lower energy marine receiving environments are not sensitive and have little ecological complexity or value. Indeed, in 1968, Morton and Miller observed that:

> *"Beaches and flats are undoubtedly simpler habitats than rocky shores. Their species list is invariably shorter."*

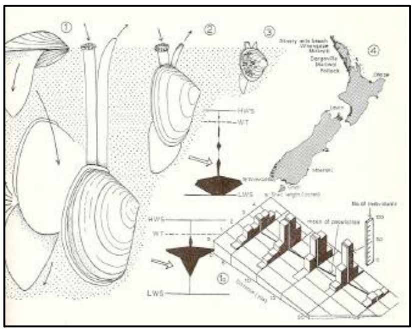
Such environments can be underestimated. Morton and Miller give some clues as to why this may be so:

> *"By far the richest life is withheld until ...low water springs, and sometimes inaccessible even then...for most animals it is necessary to dig and sieve."*

The complexity of these environments may not always be apparent to a casual observer. Their value can be underestimated, too. **Mangal** (or stands of mangroves) are one of the most productive environments on the globe. Mangal generate large quantities of organic material which provides a ready food source, and act as **refuges** and nurseries for many fish species. Snapper, piper, inanga, kingfish, and eel (amongst many others) use the resources provided by mangal and the soft shoreenvironment (Crisp et al., 1990). Other plants in these lower energy systems are also important, but less obvious. Zostera (eel grass) can be visible within the intertidal zone; algae and **phytoplankton** may not be visible at all.



Soft shore fauna
Source: Morton and Miller, 1968.



Sandy beach fauna
Source: Morton and Miller, 1968.

Mangal - Whangamata
Source: Environment Waikato.

Zostera (eel grass)
Source: Environment BOP

Because these environments are generally already muddy, it is often assumed that they can cope with added sediment. Although estuarine ecosystems have adapted to their environment, and can therefore adjust to periodic events of high sediment deposition, sustained and accelerated sediment deposition can have wide-spread and significant effects. These can extend beyond the immediately affected area and, as indicated by the following statement (Morton and Miller, 1968), may have long-term consequences:

> *"The low tidal flat at Hobson Bay, Auckland, for example, lost its Zostera* [eel grass] *cover when deep muds accumulated after a road viaduct cut it off from the main harbour."*

In the United States, sediment has been found to be the number one water pollutant by volume; its effects often overlooked as a consequence of the relative attention given in research to heavy metals and other industrial pollutants. In New Zealand, land uses which disturb soils (e.g. agriculture and forestry) have been found to generate high yields of sediment, but these yields are dwarfed when compared with the yields from construction, or **earthworks** (refer to Figure 4.1.1).

The **sediment yield** from an earthworks site depends on many factors. These include, but are not limited to:

- Rainfall characteristics;
- Soil type and cohesiveness;
- Slope of the area worked and the length of the slope before discharging from the site;
- Area opened and the duration that the area remains unstabilised; and
- Type of cover and the roughness of the surface.

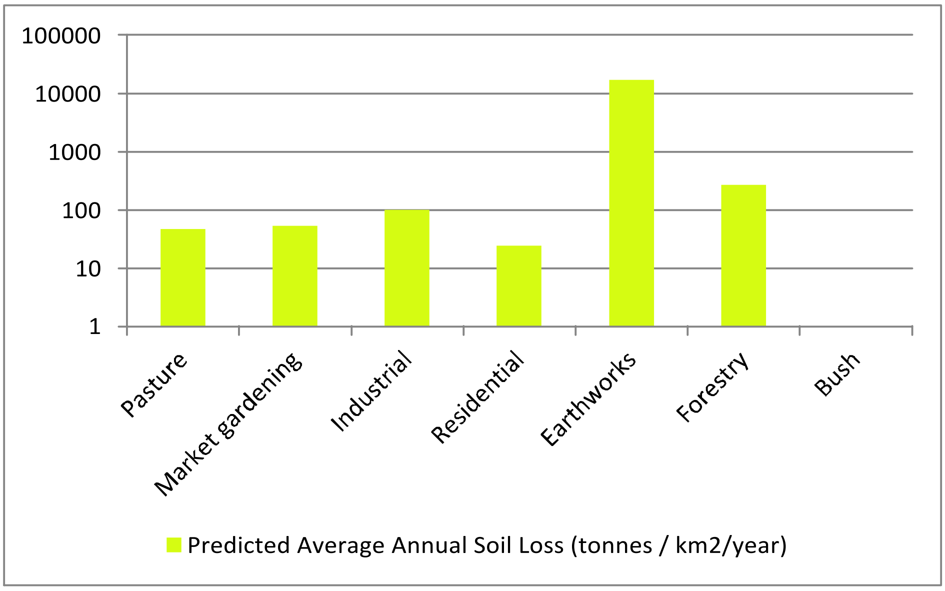


Figure 4.1.1: Sediment Loss by Land Use
Source: Auckland Council *Auckland Regional Plan: Sediment Control* and O'Loughlin et al., 1980.

The universal soil loss equation (**USLE**) uses these factors to predict sediment generation and yield from earthworks sites. Its applicability to New Zealand has been considered (Winter, 1998) and, while there are some limitations and some modification is necessary, it is a reasonable approach for predictive assessments of the relative magnitude of likely discharges arising during construction. A review of erosion indicators from throughout New Zealand was undertaken by MfE in 2000 and released as *Soil intactness/erosion monitoring techniques: a literature review* in Technical Publication 62: Land (Lambrechtsen and Hicks, 2001). National rainfall data can be found in NIWAs High Intensity Rainfall Design System (**HIRDS**).

The exact yield of sediment during construction will be variable by site, year, season, and location. Research undertaken both in New Zealand and in the United States shows that discharges of sediment arising from construction activities can contain high concentrations of suspended sediment in individual storm events. For example, up to 56,000ppm of suspended solids were measured off a 5ha construction site (Winter, 1998), and although treatment systems such as ponds can be implemented and may be highly efficient (Winter estimated this could be as much as 90%), this still leaves concentrations that are sufficiently elevated to result in adverse effects upon the environment[2].

Construction of a stream crossing
Source: Environment Waikato

This is a significant consideration when assessing requirements relative to defined discharge concentrations. This is discussed in **Section 5**. Even if a pond is appropriately designed, constructed, and operating efficiently and effectively, discharges may not be able to meet a discharge standard for construction (e.g. in the example provided, discharges would still be in the order of 5,600ppm and might compare with a statutory discharge standard of 80 - 100ppm in some regions). Additional treatment (e.g. flocculation), and / or mitigation may be required.

The relative potential discharge fom different land uses is significant and will be orders of magnitude greater for an earthwork site than for other land uses. As road construction is invariably linear, this usually involves works within several **sub-catchments**, and can involve multiple stream works, or the disturbance of culverts or reticulated systems (with a greater risk of direct discharges of sediment). This typically holds true even in urban environments. Consequently, whether a new road is being constructed, or the works involve widening or minor improvements, an RCA has an important role in managing sediment discharges effectively. The means of mitigating such effects are discussed further in **Section 6.**

Flood Discharge from the Eel River, California
Source: L Leithold (1974)