Lower Lakes Carbon Project

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Lower Lakes Carbon Project

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LIST OF ABREVIATIONS

µagg - microaggregate fraction (53–250 µm)
µClay - microaggregate-derived clay-sized fraction (heavier than 1.85 g cm^{-3}, <2 µm)
µSilt - microaggregate-derived silt-sized fraction (heavier than 1.85 g cm^{-3} 2-53 µm)
CO_2 – carbon dioxide
cPOM - coarse non-protected particulate organic matter (>250 µm)
dClay - easily dispersed clay-sized fraction (acid-soluble <2 µm)
dSilt - easily dispersed silt-sized fraction (acid-soluble 2-53 µm)
EC – electrical conductivity
H-µClay - hydrolysable microaggregate-derived clay-sized fraction (acid-soluble <2 µm)
H-µSilt - hydrolysable microaggregate-derived silt-sized fraction (acid-soluble 2-53µm)
H-dClay - hydrolysable easily dispersed clay-sized fraction (acid-soluble <2 µm)
H-dSilt - hydrolysable easily dispersed silt-sized fraction (acid-soluble 2-53 µm)
iPOM - microaggregate-protected POM (heavier than 1.85 g cm^{-3}, >53 µm in size)
LF - fine non-protected POM (lighter than 1.85 g cm^{-3}, 53–250 µm)
NATA - National Association of Testing Authorities
NH-µClay – non-hydrolysable microaggregate-derived clay-sized fraction (acid-resistant <2 µm)
NH-µSilt - non-hydrolysable microaggregate-derived silt-sized fraction (acid-resistant 2-53 µm)
NH-dClay - non-hydrolysable easily dispersed clay-sized fraction (acid-resistant <2 µm)
NH-dSilt - non-hydrolysable easily dispersed silt-sized fraction (acid-resistant 2-53 µm)
OM – organic matter
SOC – soil organic carbon
TOC – total organic carbon

Executive Summary

Recent collaborative studies of sediments of the Lower Lakes highlighted the ecological importance of vegetation during the re-inundation of the acidified Lower Lakes' sediments that had been exposed during the drying event from 2007-2010. These studies indicated that bioremediation of the exposed acidified lake sediments by vegetation produced substantial environmental benefits from a combination of vegetation-associated processes including the provision of alkalinity from plant roots, as well as from the vegetation minimising soil erosion and hence preventing the exposure of severely acidic subsoils that occurred under unvegetated sites.

These studies also highlighted the large differences in organic input from different bioremediating vegetation. The ongoing supply of organic carbon to the sediments is a critical consideration as organic carbon is the critical energy source necessary to drive many of the likely ongoing remediation processes in these sediments such as sulfate reduction. This study was undertaken to gain a better understanding of the carbon production and cycling under different types of bioremediating vegetation to better gauge the likely effectiveness of such vegetation on long term bioremediation as well as on the effect of these vegetation types on carbon accumulation and sequestration in the sediments and soils in and around the Lower Lakes.

In particular this project monitored the changes in carbon status in the soils/sediments under three different vegetation types around the Lower Lakes including:

1) *Schoenoplectus valaidus* (under both high and low salinity conditions),
2) *Phragmites australis (a mature stand established ~ 4 years ago)*, and
3) *Melaleuca halmaturorum* (under two different growth stages).

For the *Schoenoplectus valaidus* and *Phragmites australis* this monitoring was at ~19 months after lake refilling. The carbon status was investigated by examining the chemical, physical, biochemical, and non-protected carbon pools of these soils consequent of the bioremediating vegetation. In addition, the metal content of these vegetation types at these sites were assessed.

The key findings of this study are:

1) At the three constantly inundated sites (i.e. the Waltowa, Meningie and the Hunters Creek *Schoenoplectus valaidus* sites*)* vegetation has increased the storage of organic carbon considerably within the surface layers after only a few years of growth. The initial rates of organic carbon increase in the three constantly inundated sites were 866 kg C ha^{-1} yr^{-1} for the *Phragmites* site at Waltowa, and 670 kg C ha^{-1} yr^{-1} and 903 kg C ha^{-1} yr^{-1} for the *Schoenoplectus valaidus* at Meningie and Hunters Creek, respectively. These rates of organic carbon increase are in accord with the rates typically found for such vegetated situations.

2) The rates of inorganic carbon (carbonate) accumulation due to the presence of vegetation at the three constantly inundated sites were very low to negligible compared to the rates of organic carbon accumulation.

3) These organic carbon increases at the three constantly inundated sites were almost totally in the relatively short-lived non-protected soil carbon pool with the main contributor being the cPOM (i.e. the coarse (> 250 µm) particulate organic matter). Thus the increase and maintenance of the additional stored carbon under the bioremediating vegetation is likely to be contingent on the maintenance of 1) the vegetation and the consequent supply of organic matter to this pool, and 2) of constantly inundating conditions.

4) The vegetation at the three constantly inundated sites and the size of the accumulation of the non-protected carbon pool (which is composed of relatively recent plant materials) in the sediment provide a food source to benthic and other biota. The elevated nickel concentrations in some of this vegetation needs to be a factor in any consideration of the ecological food web of the Lower Lakes.

5) There has been negligible organic carbon accumulation in the top 10 cm of these soil layers at the two upland sites (i.e. the Hunters Creek *Melaleuca halmaturorum* sites) indicating that the relatively slow growth of the *Melaleuca halmaturorum* may have not provided as much organic matter input as the agricultural crops grown or the *juncus* species growing at the control areas at these sites.

Recommendations

1) The data clearly shows that the different vegetation types, vegetating the lake sediments post lake re-filling at the three constantly inundated sites had similar and relatively high rates of organic carbon sequestration. The main carbon pool that was accumulating in these sediments during the early stages of vegetation establishment was the non-protected pool, a pool considered prone to removal via oxidation. In order to better understand the carbon sequestration processes under the lake vegetation it would be necessary to examine the residence (i.e. level of permanence) and oxidative behavior of the cPOM and microaggregate carbon pools in these sandy sediments in detail. Although the lability of these pools has been demonstrated in upland soil conditions this has not been examined previously for lake sediments either during inundation or after drying events.

   It is our recommendation that such a study be undertaken in order to predict firstly the potential of these sediments to continue to sequester carbon under the present lake conditions (i.e. high water levels), and 2) to be able to predict the fate of these sediments both under greater durations of inundation and also under exposure to the atmosphere during any repeat of the dry conditions of 2007-2010.

2) In a lake environment, including sites treated by bioremediation techniques, there are a number of scenarios where subsurface bio-available trace metals could enter the surface aquatic ecosystem. This includes ingestion by burrowing benthic organisms, translocation into plants via roots (this is an especially important consideration for lake sediment bioremediation via revegetation) and direct ingestion by foraging animals (e.g. insects, birds and fish). As such, the fate and possible mobility of subsurface pore-water nickel and zinc at these sites requires consideration from both a geochemical perspective (i.e. developing the knowledge required to predict how pore-water nickel and zinc will change into the future) and an ecological perspective (i.e. examining nickel and zinc uptake in potentially exposed organisms). The data on vegetation composition in this report clearly indicates that the contents of metals (especially nickel) in some of the vegetation are very high. This possibility was raised in an earlier report (Sullivan *et al.* 2011) and could have implications for the ecology of the Lower Lakes. In essence the data indicates that the *Phragmites* is likely acting as a pump of nickel from the subsoil layers into the lake waters.

   It is our recommendation that further detailed monitoring of the formerly severely acidic sediments and the overlying bioremediating vegetation be undertaken to assess the ongoing environmental risks posed by the presence, demonstrated here, of very high concentrations of potentially toxic trace metals in the vegetation growing on these sites.

1.0 Project Overview

Recent collaborative studies of sediments of the Lower Lakes and of the effects of bioremediation with the South Australian Environmental Protection Authority (EPA) and Department of Environment, Water and Natural Resources (DEWNR) (Sullivan *et al.* 2010, 2011) have highlighted the high ecological importance of sulfate reduction and associated processes during the re-inundation of the acidified Lower Lakes' sediments that had been exposed during the drying event from 2007-2010.

The most recent of these studies (Sullivan *et al.* 2011) examined several key locations around the Lower Lakes showing a range of revegetation treatments (in terms of both the vegetation species and timing of plantings), as well as unvegetated control sites.

The results of this study indicate that bioremediation of the exposed acidified lake sediments by vegetation produced substantial environmental benefits from a combination of vegetation-associated processes including the provision of alkalinity from plant roots as well as from the vegetation minimising soil erosion and hence preventing the exposure of severely acidic subsoils that occurred under unvegetated sites.

At the same time, the study by Sullivan *et al.* (2011) also highlighted the large differences in organic input from different bioremediating vegetation. Where perennial species that survived inundation (e.g. reeds such as *phragmites*) were used for bioremediation a continuation of the supply of organic carbon to the sediments is experienced for long times after lake refilling whereas where annual or relatively short vegetation (that was covered by the inundating waters) was used (e.g. Bevy rye, rushes, natural species like *cotula*) the supply of organic carbon to the sediment was limited to that produced prior to vegetative death caused by inundation. The ongoing supply of organic carbon to the sediments is a critical consideration as organic carbon is the critical energy source necessary to drive many of the likely ongoing remediation processes in these sediments such as sulfate reduction. It is thus critical to gain an adequate understanding of the carbon production and cycling under different types of bioremediating vegetation to better gauge the likely effectiveness of such vegetation on long term bioremediation as well as on the effect of these vegetation types on carbon accumulation and sequestration in the sediments and soils in and around the Lower Lakes.

2.0 Aim

This project aims to monitor the changes in carbon status in the soils/sediments under three different vegetation types around the Lower Lakes including:

1) *Schoenoplectus valaidus* (under both high and low salinity conditions),
2) *Phragmites australis (a mature stand established ~ 4 years ago)*, and
3) *Melaleuca halmaturorum* (under two different growth stages).

For the *Schoenoplectus valaidus* and *Phragmites australis* this monitoring will be at approximately 18 months after lake refilling. For *Phragmites australis* this study will build on the results of Sullivan *et al.* (2011). In addition, the metal content of these vegetation types at the sites they are growing in around the Lower Lakes will be assessed.

The carbon status was investigated by examining the chemical, physical, biochemical, and non-protected carbon pools of these soils consequent of the bioremediating vegetation.

3.0 Introduction

3.1 Background on soil organic carbon

3.1.1. General

Worldwide soils are an important store for carbon, storing approximately three times the amount of carbon found in plants (Schlesinger 1990). Soil organic carbon (SOC) constitutes a large pool in the global carbon cycle, and represents a dynamic balance between carbon inputs (through photosynthesis and deposition) and losses (via respiration, erosion and leaching) (Stewart *et al.* 2007). The preservation of organic carbon within the soil is vital as it improves soil structure, soil fertility, crop production, and ensures long-term sustainability of agriculture (Denef *et al.* 2004). Increasing SOC also has the added benefit of reducing carbon dioxide (CO_2) emissions into the atmosphere (Gulde *et al.* 2008).

In the early development of ecosystems, the accumulation of organic matter is essential to supply biota with a reliable supply of nutrients and water (Bechtold and Nainman 2009). As the plant communities develop, soils undergo a period of organic matter increase. This eventually levels off as organic debris production comes into equilibrium with its decomposition (Bechtold and Nainman 2009). The time scales over which these changes occur vary greatly among different ecosystems (Walker and del Moral 2003).

While it is well known that climate and the amounts and chemical composition of organic matter added to the soil strongly influence both carbon and nutrient cycling, the soil texture is also known to be an important controlling factor (e.g. Six *et al.* 2002; Bechtold and Nainman 2009). For example, organic matter is less prone to leaching and decomposition when adsorbed to silt and clay particles or when physically protected by aggregates (Six *et al.* 2002). These factors may significantly influence turnover times of organic carbon within the soil, which for organic matter encapsulated in aggregates may range from 10s to 100s of years and for clay-adsorbed organic matter in temperate ecosystems can range from 100s to 1000s years (Trumbore 1993; Gaudinski *et al.* 2000).

The following subsections outline the organic carbon fractions commonly observed within the soil (Section 3.1.2), the concept of SOC saturation (Section 3.1.3), modelling SOC dynamics (Section 3.1.4), and soil carbon pool dynamics in both restored wetlands (Section 3.1.5) and salt marshes (Section 3.1.6).

3.1.2. Soil organic carbon fractions

The organic carbon within the soil is commonly separated into two fractions known as *labile* (active/unprotected) and *stable* (passive/protected) pools (Parton *et al.* 1987; Six *et al.* 2002). The labile SOC pools are rapidly turned over in the soil and are sensitive to both land management and environmental conditions. Labile SOC pools play an important role in the short-term cycling of both carbon and nitrogen within the soil (Schlesinger 1990). The most commonly isolated labile pools are the light fraction (LF) and particulate organic matter (POM) (Gulde *et al.* 2008). These labile fractions consist mostly of mineral-free, partly-decomposed plant residues but also contain seeds and microbial debris such as fungal hyphae and spores (Six *et al.* 2002).

For soils to act as a carbon sink it is necessary for soil organic carbon to be stabilised in protected soil carbon pools. Organic carbon within the soil can be protected from decomposition and stabilised in soils by three potential mechanisms including: (i) physical protection by occlusion within aggregates, (ii) chemical protection by association with mineral surfaces, and (iii) biochemical protection by recalcitrance (Six *et al.* 2002; Plante *et al.* 2006b). A conceptual model showing SOC dynamics and the measurable organic carbon pools is presented in Figure 3-1; *silt- and clay-associated soil C* is also commonly referred to as the chemically protected carbon pool.

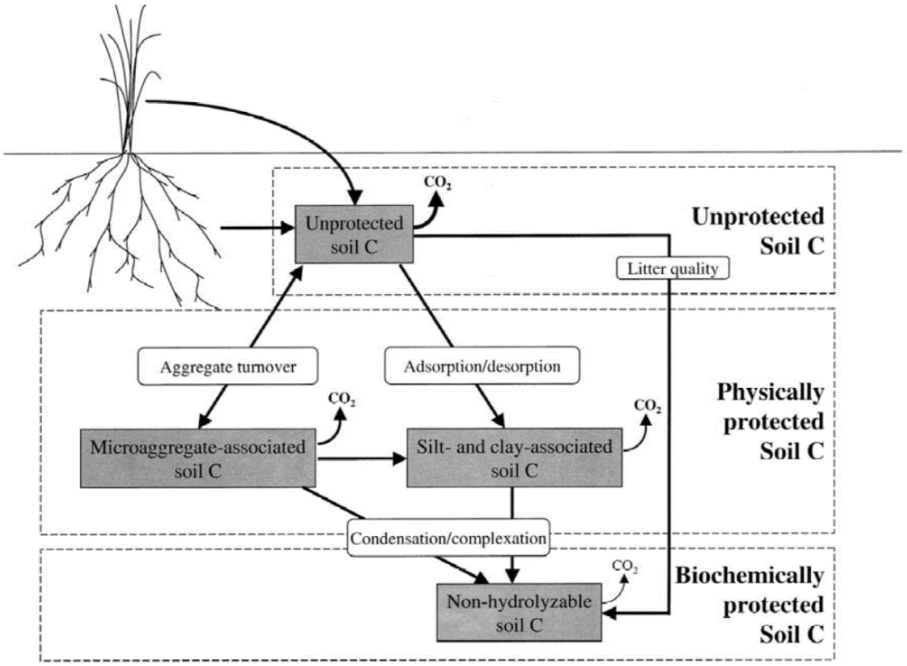

Figure 3-1. Conceptual model of soil organic carbon dynamics (Source: Six *et al.* 2002).

The inclusion of organic materials within soil aggregates is known to reduce their decomposition rate (Elliott and Coleman 1988). Aggregates physically protect organic matter within the soil by forming physical barriers between the microbes and enzymes and their substrates (Elliott and Coleman 1988). In addition, aggregates also physically protect organic matter by reducing oxygen diffusion into the aggregates (leading to reduced activity within the aggregates), and separate microbial biomass from microbial grazers (Six *et al.* 2002). The soil texture is widely known to influence aggregation and increased clay contents have been associated with increased aggregation or aggregate stability (Plante *et al.* 2006b).

The chemical protection of SOC results from the chemical or physicochemical binding between organic matter and minerals (i.e. clay and silt particles) within the soil (Six *et al.* 2002). The adsorption of organics to clay and silt particles is an important determinant of the stability of organic matter in soils (Hassink 1997). Finer soil particle-size fractions protect organic matter within the soil due to the reactivity of their surfaces (Plante *et al.* 2006a). Labile organic material that may have decomposed quickly may become protected from decomposition by close association with clay and silt particles (Sørensen 1972). In addition to the clay content, the type of clay (i.e. 2:1, 1:1 and allophonic clay minerals) may also influence the stabilisation of organic carbon (Sørensen 1972). Soils dominated by clays with a high specific surface area are expected to adsorb more humic substances than soils dominated by soils with low specific surface areas (Tate and Theng 1980), although this relationship is not always clear. For example, Hassink (1997) did not find a relationship between the dominant clay type and the amount of carbon associated with the clay and silt fraction.

The chemical composition of SOC (e.g. recalcitrant compounds such as lignin and polyphenols) provides biochemical protection, although this may also occur through chemical complexing processes within the soil (Six *et al.* 2002). Biochemically resistant carbon is defined as organic carbon that is resistant to acid hydrolysis (Leavitt *et al.* 1996). Previous research has shown that this non-hydrolysable biochemically protected carbon fraction may be substantially older (i.e. 1300 to 1800 years) than other carbon fractions within the soil (Leavitt *et al.* 1996; Paul *et al.* 1997, 2001). It has been assumed that as SOC decreases the proportion of biological resistant SOC increases, however, Plante *et al.* (2006a) have shown this is not always observed.

Studies indicate that while soil texture (particularly soil clay content) affects physical, chemical and biochemical protection of soil carbon, the non-protected carbon fraction is independent of soil texture (Plante *et al.* 2006b). Six *et al.* (2002) suggest that the physicochemical characteristics of a soil define the limit to the amount of carbon protection that may occur (see Figure 3-2). Details on the soil fractionation process that has recently been developed to isolate the unprotected and protected organic carbon pools, and used in this study, are given in Section 4.2.2.

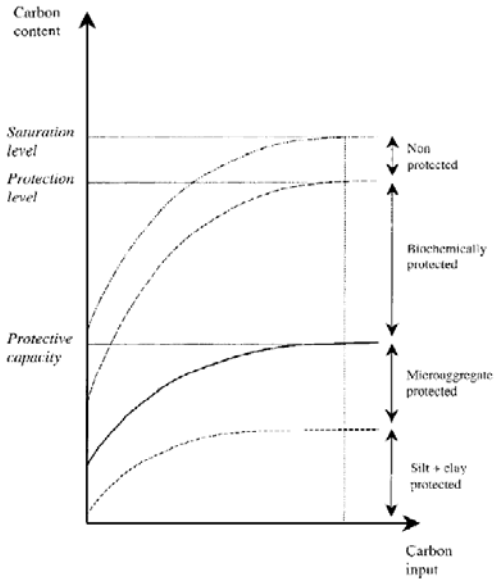

Figure 3-2. Conceptual protective and non-protective capacity to enhance storage of carbon in soil according to type of soil organic carbon (Source: Six *et al.* 2002).
The protective capacity of soil (which governs the silt and clay protected C and microaggregate protected C pools), the biochemically stabilized C pool and the unprotected C pool define a maximum C content for soils. The pool size of each fraction is determined by their unique stabilizing mechanisms.

3.1.3. Soil organic carbon saturation

Management practices that decrease soil disturbance and increase the amount of carbon added to the soil generally increase both the soil fertility and SOC content, however, the efficiency of these practices to store SOC may not only depend on the amount of carbon added but also how far a soil is from its saturation level (i.e. saturation deficit) (Stewart *et al.* 2009). The carbon saturation hypothesis suggests an ultimate soil carbon stabilisation capacity defined by the four SOC pools capable of carbon saturation (i.e. non-protected, physically protected, chemically protected and biochemically protected) (Stewart *et al.* 2009) (see Figure 3-2).

Previous studies have found that certain soils show little or no increase in stable (i.e. steady-state) SOC with increasing carbon input levels which suggests that SOC can become saturated with respect to carbon input (Stewart *et al.* 2007). Studies have also observed a direct relationship between the silt plus clay content of soil and the amount of silt and clay protected soil carbon, that indicates a saturation level for silt and clay associated carbon (Hassink 1997; Six *et al.* 2002). The theoretical relationship between input level and SOC contents at steady-state, with and without carbon saturation, is illustrated in Figure 3-3.

If it is assumed there is no carbon saturation, which previous studies have often observed, there is no limit to the soil carbon content as steady-state carbon rates increase (see Figure 3-3b). However, assuming carbon saturation there is a maximum equilibrium carbon level that will be reached when the carbon input is maximised (see Figure 3-3d). The potential for soil carbon saturation implies that the greatest efficiency in soil carbon sequestration would be in soils well below their soil saturation level (Stewart *et al.* 2007).

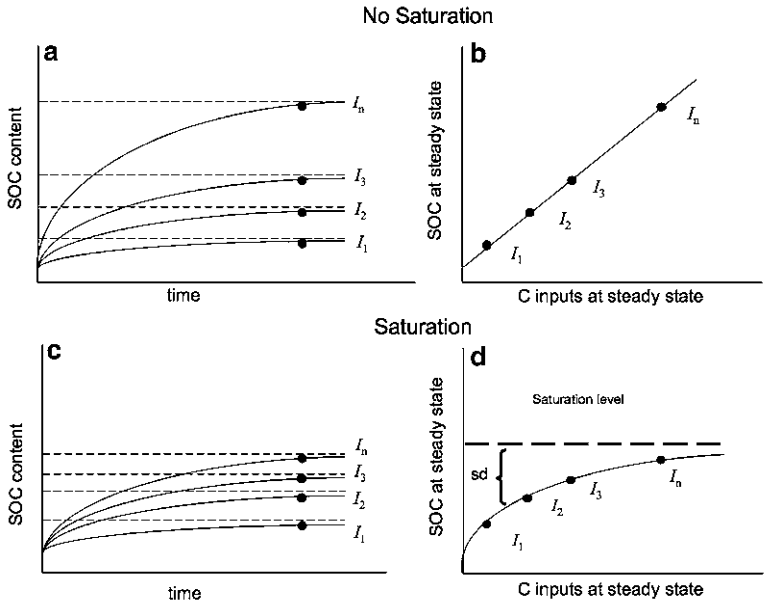

Figure 3-3. Theoretical relationship between input level (I, with I_1 being the lowest input level) and SOC contents at steady-state, with and without carbon saturation (Source: Stewart *et al.* 2007).

3.1.4. Modelling soil organic carbon dynamics

The current conceptual understanding of SOC dynamics in mineral soils has been encompassed within a plant-soil nutrient cycling model known as the CENTURY model (Parton *et al.* 1987). The CENTURY model has been applied to a variety of soils to predict changes in organic matter pools and fluxes in response to various scenarios including cropping practices, timber harvest and climate change (Bechtold and Naiman 2009).

Recently in a study by Bechtold and Naiman (2009) the soil component of the CENTURY model was combined with a simulation model of fluvial deposition and forest production to predict changes in soil carbon and nitrogen during primary succession on the floodplain and terraces of the Queets River, Washington, USA. The model simulated soil carbon and nitrogen cycling as bare sediments evolved to mature forests. The three interacting components of the organic matter simulation model including the soil, sedimentary and forest submodels as described by the CENTURY model are shown in Figure 3-4. The soil component of the CENTURY model uses soil texture (i.e. sand, silt and clay concentration) as a primary variable in the simulation of organic matter accumulation (Figure 3-4).

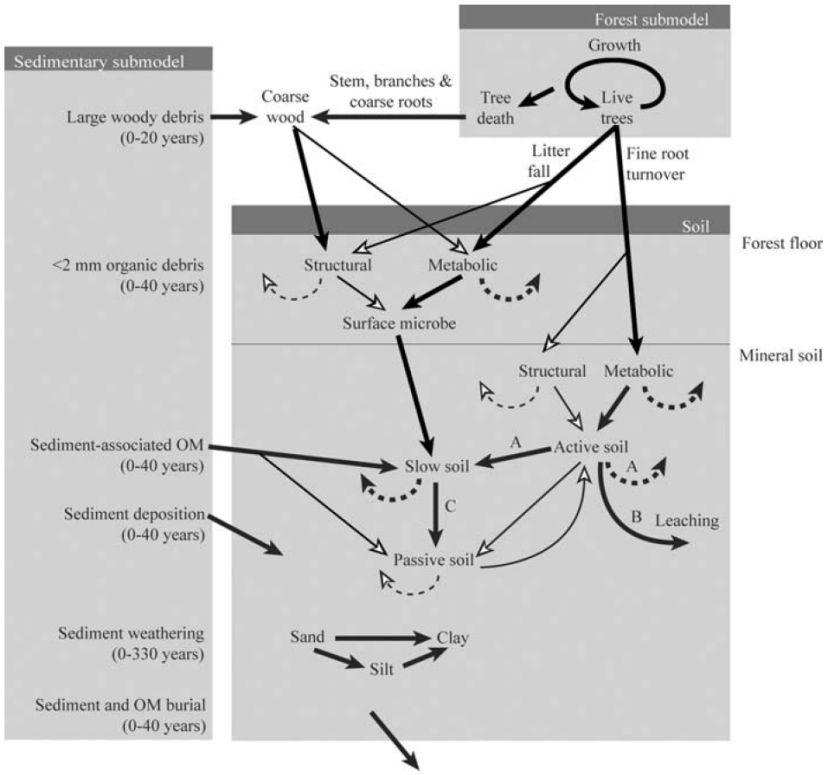

Figure 3-4. Organic matter simulation model as described by the CENTURY model (Source: Bechtold and Naiman 2009). *Arrow thickness* distinguishes major from minor fluxes. *Dashed arrows* indicate gaseous CO_2 outputs due to respiration. *Letters* indicate fluxes influenced by soil texture: *A*, silt and clay inhibit decomposition of active soil organic matter (OM); *B*, silt and clay reduce leaching by adsorbing OM and reducing hydrologic flux; and *C*, passive OM is formed by OM association with clays.

Bechtold and Naiman (2009) compared their model to soil data collected from 25 sites ranging in age from three to 330 years relative to initial plant colonisation. The simulated soil carbon accumulated rapidly to near-plateau concentrations of approximately 4,000 g/m^2 after about 100 years, and closely matched that observed in field studies (Figure 3-5). Their model was however observed to underestimate the soil nitrogen concentrations (see Figure 3-5), and this was thought to be due to failure of the model to account for nitrogen enrichment of an organic matter pool after its initial formation (Bechtold and Naiman 2009).

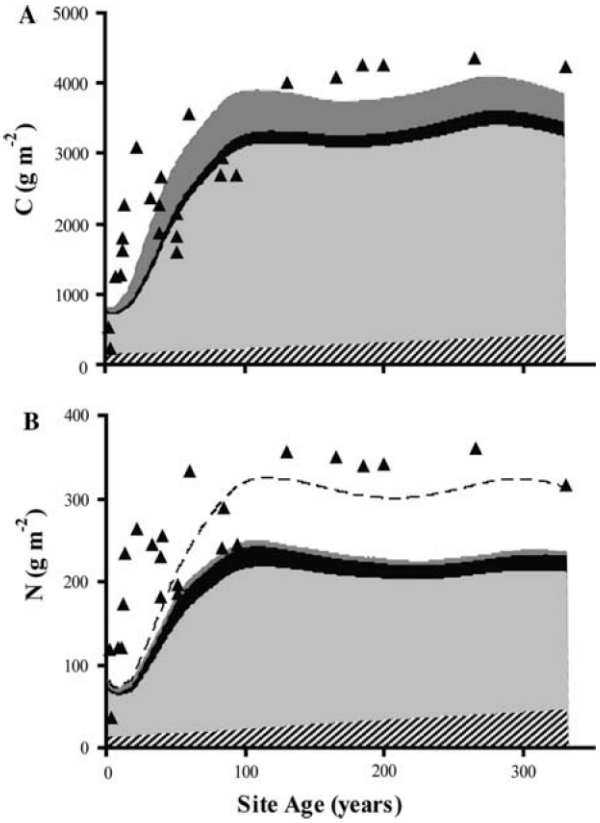

Figure 3-5. Soil carbon (A) and nitrogen (B) simulated over 330 years of floodplain development (Source: Bechtold and Naiman 2009).

Total C and N accumulation is indicated by sum of shaded areas. Shaded areas indicate sizes of individual soil pools: *dark gray* - surface and root litter; *black* - active pool; *light gray* - slow pool; *diagonal bars* - passive pool. *Triangles* indicate C and N measured in field studies. *Dashed line* in **B** indicates total simulated N when the model was altered to allow N-enrichment of structural litter and slow pool N after initial formation.

3.1.5. Soil carbon pool dynamics in restored marshes

There has been a widespread loss of marsh habitat as a consequence of development, particularly in coastal areas (Madrid *et al.* 2012). Although many wetlands have been restored or created over the past several decades, the degree of recovery of the ecosystem structure (driven mostly by plant assemblages) and functioning (driven primarily by the storage of carbon in wetland soils) has often been unclear (Moreno-Mateos *et al.* 2012).

A recent study by Moreno-Mateos *et al.* (2012) examined the degree of recovery of ecosystem structure and functioning following wetland restoration. The results indicated that the recovery of wetlands following restoration is often slow and incomplete. Moreno-Mateos *et al.* (2012) examined data from more than 600 wetland sites throughout the world, and showed that even a century after restoration biological structure and functioning remained on average 26% and 23% lower, respectively, than in reference sites.

The results of the study by Moreno-Mateos *et al.* (2012) clearly showed that the storage of both carbon and nitrogen were substantially reduced after degradation from preimpact levels, although phosphorus storage seemed unaffected (see Figure 3-6). Figure 3-6 shows that carbon storage initially increased slightly following restoration, but then plateaued below reference levels after 20 years following restoration. Nitrogen storage was observed to slowly but steadily increase (Figure 3-6).

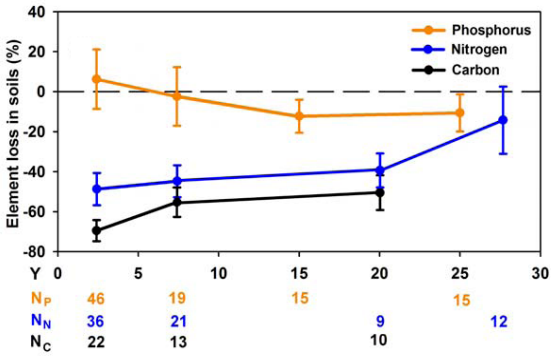

Figure 3-6. Recovery trajectories of created and restored wetlands (Source: Moreno-Mateos *et al.* 2012).
Chronosequences of the means (±SE) of the element loss in soils of restored or created wetlands. The zero value dashed line represents reference wetlands (N, number of data points used to calculate the mean per age class; Y, years after restoration).

Wetland degradation usually results in a reduction of stored carbon as the onset of aerobic conditions accelerates microbial respiration which oxidises accumulated organic carbon (Mitsch and Gosselink 2007). The presence of greater anaerobic conditions following restoration allow stores of organic carbon to slowly reaccumulate in the soil, however, Moreno-Mateos *et al.* (2012) results show that even 20 years following restoration carbon storage was 50% lower than in reference wetlands (Figure 3-6). The study also found the average organic matter concentrations remained only 62% of the concentration at the reference wetlands 20–30 years following restoration.

The storage of nitrogen was also found to be significantly lower 30 years after wetland restoration (Figure 3-6). The aerobic conditions observed in degraded wetlands are also known to disturb nitrogen storage and cycling, allowing mineralisation of organic nitrogen and transformation of ammonium to nitrate (Mitsch and Gosselink 2007). The nitrate formed is rapidly processed by both microorganisms and plants, consequently leaving the original pool of nitrogen in the soil depleted or unavailable (Moreno-Mateos *et al.* 2012). The depletion or unavailability of soil nitrogen can limit wetland productivity and can therefore slow down carbon storage (van Groenigen *et al.* 2006).

The data analysed by Moreno-Mateos *et al.* (2012) showed that even after 50 to 100 years restored wetlands recovered to an average of 74% of their biogeochemical functioning relative to reference wetlands. The results also suggested that the size of the ecosystem and the environmental setting affect the rate of recovery; wetland areas greater than 100 hectares and wetlands in warm (temperate and tropical) climates recovered more rapidly compared to smaller wetlands and those restored in cold climates.

Madrid *et al.* (2012) measured the net plant carbon capture in wetland vegetation and showed that the annual carbon production of constructed wetlands in a brackish marsh can be substantially less than that of surrounding reference wetlands. The study assessed the relative carbon capture by emergent and submerged vegetation in constructed marshes (2-3 years old) and a reference marsh. While the study found that submerged vegetation captured less carbon (0.1–0.3 kg/m^2) than emergent vegetation (0.2–1.7 kg/m^2), the constructed marshes were found to contain an order of magnitude less emergent habitat than the reference marsh. The lower emergent habitat in the constructed marshes meant the annual carbon production of entire constructed areas was less than half that of the reference area.

3.1.6. Soil carbon pool dynamics in salt marshes

Coast marshes are one of the most productive ecosystems on earth and are known to sequester large quantities of organic carbon (Madrid *et al.* 2012). Mangroves for example represent approximately 15% of carbon stored in marine sediments (Jennerjahn and Ittekkot 2002). Saline coastal marshes generally also have low emissions of the potent greenhouse gas methane compared to freshwater inland wetlands (Bartlett and Harris 1993), and therefore play a vital role in the global carbon cycle. While the carbon density of tidal saline wetland sediments is usually less than that in freshwater wetlands, previous studies have found that there is significant variation and uncertainty in carbon storage in tidal saline wetlands (Chmura *et al.* 2003).

A recent study by Liversley and Andrusiak (2012) examined carbon storage in temperate mangrove and salt marsh sediments along a natural transition from melaleuca woodland, salt marsh and into

mangroves along the Mornington Peninsula edge of Westernport Bay, Victoria. The study found the sediment carbon density was significantly greater in the salt marsh compared to the mangrove. The sediment carbon density in the salt marsh was approximately 168 Mg C/ha (16.9 kg C/m^2) which was comparable to that measured globally, whereas the mangrove sediment carbon density of 145 Mg C/ha (14.5 kg C/m^2) was amongst the lowest recorded. The sediment carbon density of tidal saline wetlands is expected to decrease as mean annual temperatures increases, in response to greater decomposition rates (Chmura *et al.* 2003). The findings by Liversley and Andrusiak (2012) indicate that mangrove sediments from cooler, drier temperate latitudes may store less carbon than mangroves in warmer and wetter tropical latitudes.

3.2 Introduction to this study

As a result of prolonged drought, combined with management practices upstream in the Murray-Darling catchment, the Lower Lakes of Lake Alexandrina and Lake Albert have recently experienced their first major drying phase since the introduction of barrages more than 50 years ago (Simpson *et al.* 2008; Sullivan *et al.* 2008). Concurrently, it was identified that the Lower Lakes were also being impacted by the presence of acid sulfate soil materials (Fitzpatrick *et al.* 2008). As a consequence of unprecedented low water levels, extensive areas of acid sulfate soils were exposed in the Lower Lakes which resulted in soil acidification (pH<4) over large areas and localised acidification of surface waters (DENR 2010).

To inform management decision making, a research program was undertaken to fill critical knowledge gaps related to the risks posed by exposure of acid sulfate soils in the Lower Lakes (DENR 2010). The research areas examined in this program included:

- an acid sulfate soil spatial heterogeneity/mapping survey;
- measurement of acid generation rates;
- assessment of the in-situ contaminant generation, transport and neutralisation processes;
- laboratory and field studies of the potential for mobilisation of contaminants following inundation with seawater compared to river water ; and
- geochemical modelling of lake water quality.

A study by Sullivan *et al.* (2010) examined the response of exposed Lower Lakes soil materials to wetting with seawater and river water. Among other key findings, Sullivan *et al.* (2010) identified that the major factor limiting sulfate reduction in the Lower Lakes sediments was the availability of organic carbon. Given the potential importance of sulfate reduction in relation to critical sediment/water aspects (e.g. the development of alkalinity in the sediments), Sullivan *et al.*'s (2010) research supported the practical options of enhancing the availability of organic carbon in the Lower Lakes environment being undertaken by the Department for Environment, Water and Natural Resources. The continuation of the bioremediation program of Lower Lakes sites through enhancing organic carbon availability was supported through scientific research as a feasible management option.

Sullivan *et al.* (2011) examined several key locations around the Lower Lakes showing a range of vegetation treatments (in terms of both the vegetation species and timing of plantings), as well as unvegetated control sites. The results of this study indicate that bioremediation of the exposed acidified lake sediments by vegetation produced substantial environmental benefits from a combination of vegetation-associated processes including the provision of alkalinity from plant roots as well as from the vegetation minimising soil erosion and hence preventing the exposure of severely acidic subsoils that often occurred under unvegetated sites.

At the same time, the study by Sullivan *et al.* (2011) also highlighted the large differences in organic input from different bioremediating vegetation. Where perennial species that survived inundation (e.g. reeds such as *phragmites*) were used for bioremediation a continuation of the supply of organic carbon to the sediments is experienced for long times after lake refilling whereas where annual or relatively short vegetation (that was covered by the inundating waters) was used (e.g. Bevy rye, rushes, natural species like *cotula*) the supply of organic carbon to the sediment was limited to that produced prior to vegetative death caused by inundation.

The ongoing supply of organic carbon to the sediments is thus a critical consideration as organic carbon is the critical energy source necessary to drive many of the likely ongoing remediation processes in these sediments such as sulfate reduction. It is thus critical to gain an adequate understanding of the carbon production and cycling under different types of bioremediating vegetation to better gauge the likely effectiveness of such vegetation on long term bioremediation as well as on the effect of these vegetation types on carbon accumulation and sequestration in these sediments and soils.

This project aims to monitor the changes in carbon status in the soils/sediments under three different vegetation types around the Lower Lakes in terms of their soil carbon pools. In addition, the metal content of these vegetation types at the sites they are growing in around the Lower Lakes will be assessed.

3.3 Sampling strategy

In this study sediments were collected from sites around the Lower Lakes in March 2012 including Meningie, (Lake Albert), Hunters Creek (Hindmarsh Island) and Waltowa (Lake Albert). The locations of the four sampling sites are shown below in Figure 3-7.

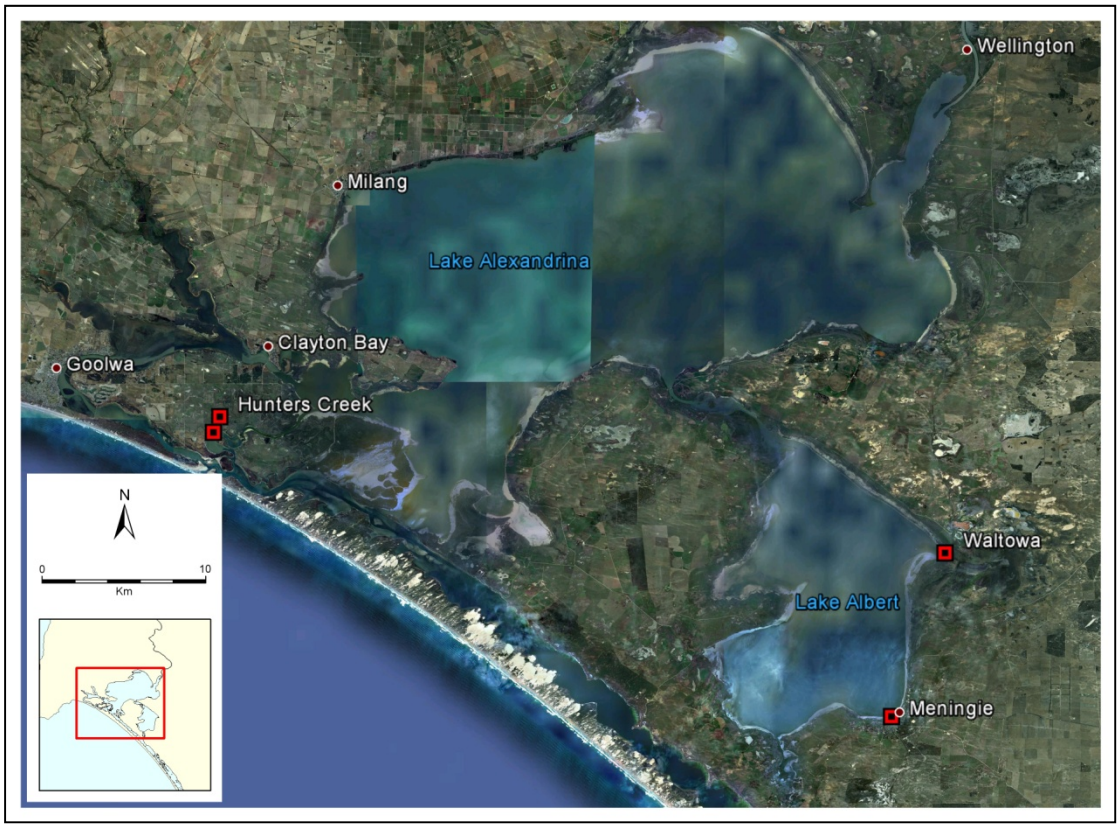

Figure 3-7. Map showing sampling sites around the Lower Lakes (Source: Google Maps).

The carbon status was examined at ten treatments across the four sites around the Lower Lakes between 26th and 29th March 2012. The carbon status was assessed in the soils/sediments under three different vegetation types including:

1) *Schoenoplectus valaidus* (under both high and low salinity conditions),
2) *Phragmites australis (a mature stand established ~ 4 years ago)*, and
3) *Melaleuca halmaturorum* (under two different growth stages).

In addition to the collection of soil/sediments, plant materials were collected from all sites containing vegetation at the time of sampling. A summary of the ten treatments at the sites examined in the Lower Lakes is presented below in Table 3-1. Please note that the Lower Lakes Phase 1 Sulfate Reduction Monitoring Project was also conducted at the Waltowa site in late March 2012 (refer to Sullivan *et al.* (2012) for further details).

Table 3-1. Summary of the treatments examined at each site in the Lower Lakes.

Site	Treatment
Meningie, Lake Albert	i. *Schoenoplectus valaidus* bed (vegetation, higher EC)
	ii. Control (no vegetation, higher EC)
Hunters Creek, Hindmarsh Island	i. *Schoenoplectus valaidus* bed (vegetation, low EC)
	ii. Control (no vegetation, low EC)
Waltowa, Lake Albert	i. *Phragmites australis* bed
	ii. Control (unplanted)
Hunters Creek, Hindmarsh Island	i. Remnant Stand *Melaleuca halmaturorum*
	ii. Control (for Remnant Stand)
	iii. 10 year Revegetation Site *Melaleuca halmaturorum*
	iv. Control (for 10 year Revegetation Site)

3.4 Lower Lakes site locations and characteristics

Maps showing the sampling locations and photographs of the landscape at each site are presented in Sections 3.4.1 to 3.4.3.

3.4.1 Meningie, Lake Albert site characteristics

Figure 3-8. Meningie sampling locations (Source: Google Maps).

Figure 3-9. View of Lake Albert from the Meningie site in March 2012.

Figure 3-10. Sediment sampling at the Meningie control site.

Figure 3-11. Meningie *Schoenoplectus valaidus* site (left) and sediment cores collected from the site (right).

3.4.2 Hunters Creek, Hindmarsh Island site characteristics

Figure 3-12. Hunters Creek *Schoenoplectus valaidus* sampling locations (Source: Google Maps).

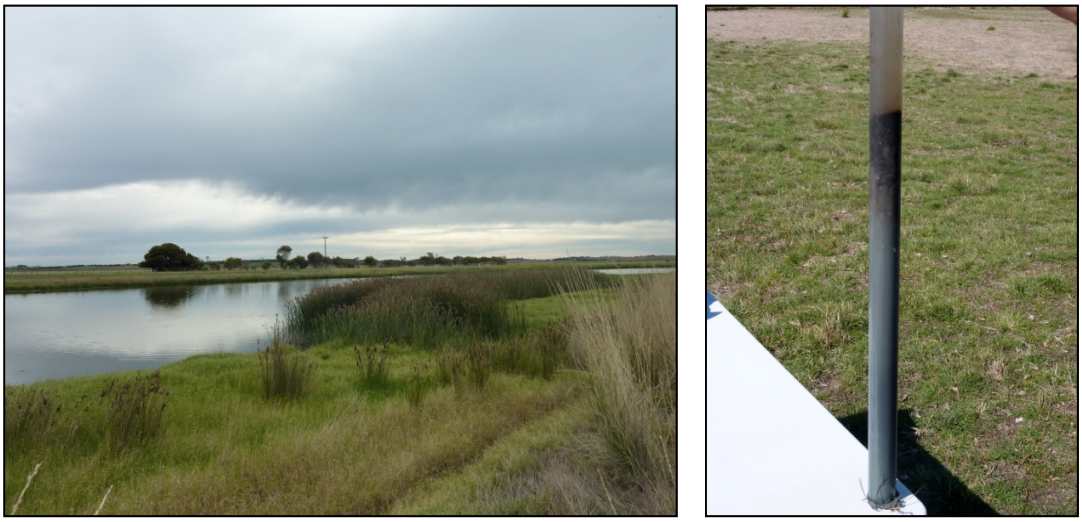

Figure 3-13. Hunters Creek *Schoenoplectus valaidus* site (left) and a sediment core collected from the control site (right).

Figure 3-14. Hunters Creek *Schoenoplectus valaidus* sampling site (left) and sediment cores collected from the site (right).

Figure 3-15. Hunters Creek *Melaleuca halmaturorum* sampling locations (Source: Google Maps).

Figure 3-16. Hunters Creek 10 year *Melaleuca halmaturorum* control and revegetation sites.

Figure 3-17. Hunters Creek 10 year *Melaleuca halmaturorum* control sampling site (left) and a representative soil profile (right).

Figure 3-18. Hunters Creek 10 year *Melaleuca halmaturorum* revegetated sampling site (left) and a representative soil profile (right).

Figure 3-19. Hunters Creek *Melaleuca halmaturorum* remnant stand site.

Figure 3-20. Hunters Creek *Melaleuca halmaturorum* remnant stand control sampling site (left) and a surface soil profile (right).

Figure 3-21. Hunters Creek *Melaleuca halmaturorum* remnant stand sampling site.

3.4.3 Waltowa, Lake Albert site characteristics

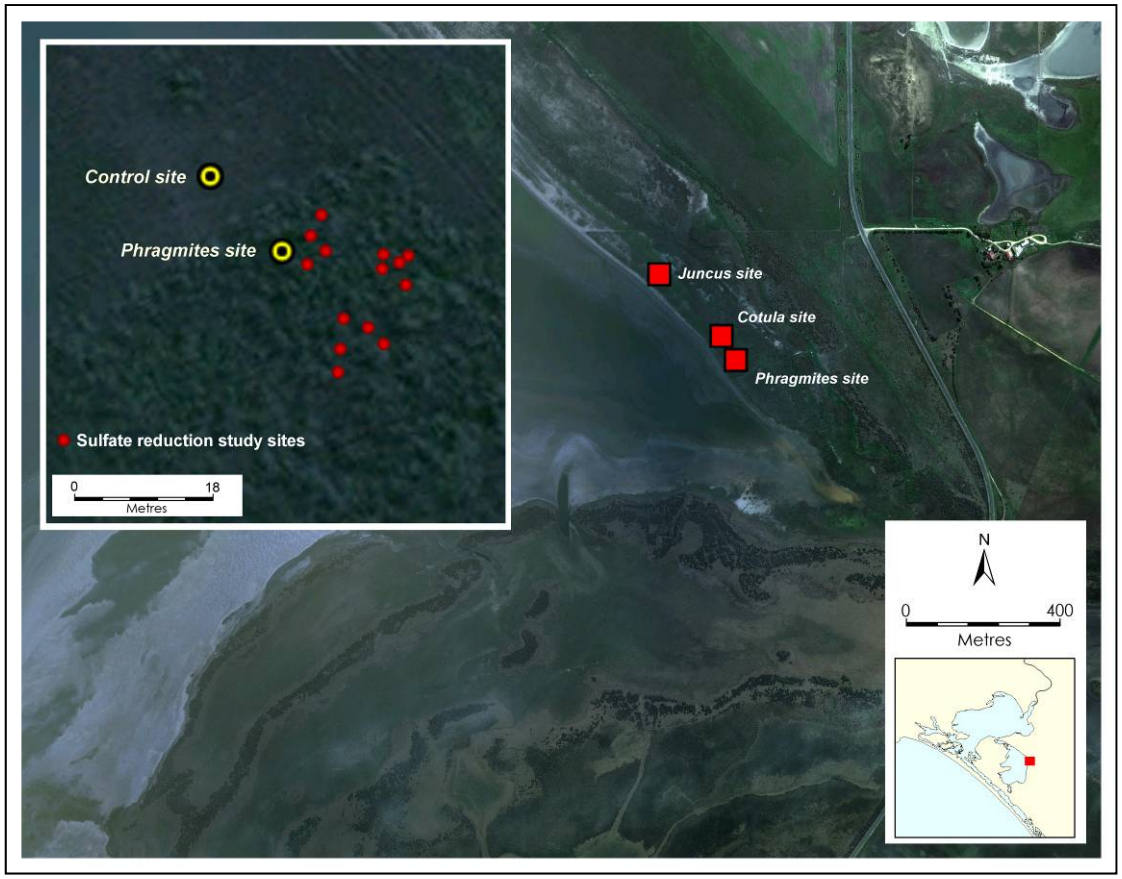

Figure 3-22. Waltowa sampling locations (Source: Google Maps).

Figure 3-23. View of Waltowa site in March 2012.

Figure 3-24. Sampling at the Waltowa control site (left) and sediment cores collected from the site (right).

Figure 3-25. Sediment cores collected from the Waltowa *Phragmites* site (left) and a *Phragmites* root (right).

4.0 Materials and methods

The methodology followed in this study allows the assessment of carbon in the various soil/sediment and above soil/sediment carbon pools. The experimental approach follows that of Stewart *et al.* (2009) and measured carbon changes in the sixteen pools most relevant to carbon turnover (including the chemical, physical, biochemical, and non-protected carbon pools in these soils and sediment).

4.1 Field sampling of soils/sediments and plant materials

Field sampling at the four sites around the Lower Lakes was undertaken between 26th and 29th March 2012. Soil/sediment profiles were collected from two replicate sampling sites from each treatment to a depth of 40 cm. Each soil profile was sub-divided into seven soil layers; the surface layers were divided into 2.5 cm increments (i.e. 0-2.5 cm, 2.5-5.0 cm), then in 5 cm increments to 20 cm, and 10 cm increments from 20 cm to 40 cm. All soil/sediment materials were refrigerated on return to the Southern Cross GeoScience laboratory.

As mentioned previously, plant materials were also collected from all sites containing vegetation at the time of sampling. Plant materials were collected for a comprehensive analysis of metals and nutrients in the plant tissues (including leaves, stems and roots).

Soil descriptions and global positioning system (GPS) coordinates for each site are presented in Appendix 1 (Table 9-1).

4.2 Laboratory analysis methods

4.2.1 General comments

All laboratory glassware and plastic-ware were cleaned by soaking in 5% (v/v) HCl for at least 24 hours, followed by repeated rinsing with deionised water. Reagents were analytical grade and all reagent solutions were prepared with deionised water (milliQ). All solid-phase results are presented on a dry weight basis (except where otherwise noted).

4.2.2 Soil/sediment analyses

The parameters measured on the sediment/soil layers collected from the ten sites included:

- Moisture content
- Bulk density
- pH (1:5 soil:water)
- Electrical conductivity (1:5 soil:water)
- Total C and N
- Total organic C
- Carbonate content
- Detailed organic carbon fractionation (16 carbon pools)

The moisture content was determined by weight loss due to drying at 105°C. The bulk density was calculated following weighing a known volume of each sediment/soil layer before and after oven-drying at 105°C. Soils/sediments for further analysis (with the exception of materials that underwent the detailed organic carbon fractionation analyses which were initially dried at 30°C) were oven-dried at 60°C and sieved (< 2 mm) prior to being ring mill ground. Soil total carbon and nitrogen determinations were performed on the bulk sampled material. The detailed organic carbon fractionation analyses were performed on the sample materials after sieving to < 2 mm.

Electrical conductivity (EC) and pH were determined by direct insertion of calibrated electrodes into a 1:5 soil:water extract linked to a TPS WP-81 meter. Total carbon (%C) and total nitrogen (%N) were measured on powdered oven-dried samples by combustion using a LECO-CNS 2000 analyser. The total organic carbon and carbonate contents were also determined by a LECO-CNS 2000 analyser following the treatment with 1.0 M HCl (Ahern *et al.* 2004). The carbonate content was determined from the difference between the total carbon fraction and the total organic carbon (TOC) fraction remaining after acid treatment.

Separation of the various carbon fractions was accomplished by a combination of physical and chemical fractionation techniques using a three-step process from Stewart *et al.* (2009) (see Figure 4-1). A summary of the sixteen carbon fractions analysed is given in Table 4-1.

Table 4-1. Summary of the carbon fractions analysed in the soils/sediments from the Lower Lakes (Source: Stewart *et al.* 2009).

Carbon Fraction	Description
cPOM	Coarse non-protected particulate organic matter (>250 µm)
LF	Fine non-protected POM (lighter than 1.85 g cm^{-3}, 53–250 µm)
iPOM	Microaggregate-protected POM (heavier than 1.85 g cm^{-3}, >53 µm in size)
µagg	Microaggregate fraction (53–250 µm)
µSilt	Microaggregate-derived silt-sized fraction (heavier than 1.85 g cm^{-3} 2-53 µm)
µClay	Microaggregate-derived clay-sized fraction (heavier than 1.85 g cm^{-3}, <2 µm)
NH-dSilt	Non-hydrolysable easily dispersed silt-sized fraction (acid-resistant 2-53 µm)
NH-dClay	Non-hydrolysable easily dispersed clay-sized fraction (acid-resistant <2 µm)
H-dSilt	Hydrolysable easily dispersed silt-sized fraction (acid-soluble 2-53 µm)
H-dClay	Hydrolysable easily dispersed clay-sized fraction (acid-soluble <2 µm)
NH-µSilt	Non-hydrolysable microaggregate-derived silt-sized fraction (acid-resistant 2-53 µm)
NH-µClay	Non-hydrolysable microaggregate-derived clay-sized fraction (acid-resistant <2 µm)
H-µSilt	Hydrolysable microaggregate-derived silt-sized fraction (acid-soluble 2-53µm)
H-µClay	Hydrolysable microaggregate-derived clay-sized fraction (acid-soluble <2 µm)
dSilt	Easily dispersed silt-sized fraction (acid-soluble 2-53 µm)
dClay	Easily dispersed clay-sized fraction (acid-soluble <2 µm)

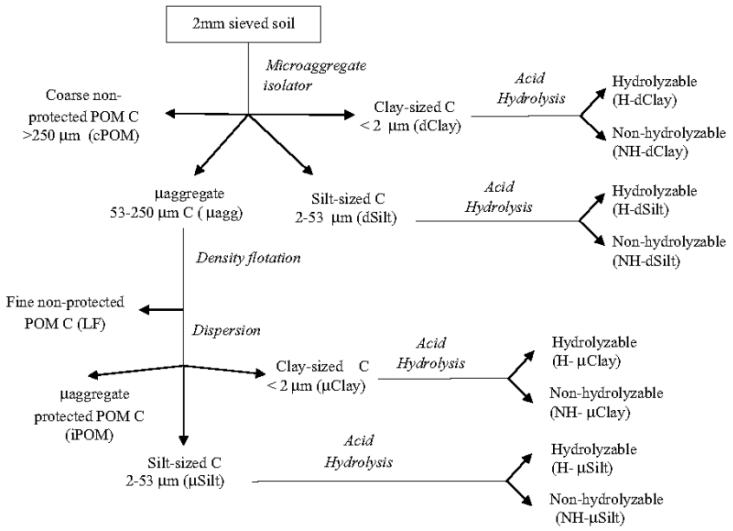

Figure 4-1. Soil fractionation scheme that isolates the four hypothesised C pools; non-protected, physically protected (microaggregate), the chemically protected (silt + clay) and biochemically protected pools (Source: Stewart *et al.* 2009).

The three-step process followed included: (i) the partial dispersion and physical fractionation of the soil to obtain the >250 µm (coarse non-protected particulate organic matter, cPOM), 53–250 µm (microaggregate fraction, µagg), and <53 µm (easily dispersed silt and clay, dSilt and dClay) fractions; (ii) further fractionation of the microaggregate fraction isolated in the first step; and (iii) acid hydrolysis of each of the isolated silt- and clay-sized fractions. While the three-step process followed isolates a total of sixteen fractions, some of the carbon fractions are composites of others (e.g. µagg is composed of LF, iPOM, µSilt and µClay, and the latter two are each composed of hydrolysable and non-hydrolysable portions) (Stewart *et al.* 2009).

A summary of the laboratory procedure followed in this study is presented in Appendix 2. The carbon fractions were quantified using a LECO-CNS 2000 analyser. The total organic carbon (TOC) content was determined following the removal of inorganic carbon by treatment with 1.0 M HCl.

The fractionation procedure followed isolates four hypothesized carbon pools (Stewart *et al.* 2009) including:

- ***Non-protected C pool***: consists of the cPOM fraction, isolated during the first dispersion step, and the LF fraction isolated during the second fractionation step.
- ***Physically protected C pool***: consists of the µagg fraction as a whole and the iPOM.
- ***Chemically protected pool***: corresponds to the hydrolysable portion of the silt- and clay-sized fractions isolated during the initial dispersion (H-dSilt and H-dClay).
- ***Biochemically protected pool***: corresponds to the non-hydrolysable C remaining in the silt and clay fractions after acid hydrolysis (NH-dSilt and NH-dClay).

Sediment data are presented in Appendix 3 (Tables 9-2 to 9-13).

4.2.3 Plant material analyses

A comprehensive analysis of metals and nutrients in the plant tissues (including leaves, stems and roots) was undertaken at all sites containing vegetation at the time of sampling. Plant materials were initially washed thoroughly in deionised water (milliQ) to remove any potential contamination (i.e. dust and soil materials). The plant materials were then dried at 70˚C for 24 hours prior to being ground. The metal and nutrient concentrations (except for carbon and nitrogen) were determined using ICP-MS (Inductively Coupled Plasma - Mass Spectrometry) following microwave digestion with nitric acid (HNO_3). Total carbon (%C) and total nitrogen (%N) were measured by combustion using a LECO-CNS 2000 analyser.

Plant material analysis data are presented in Appendix 4 (Table 9-14).

4.2.4 Quality assurance and quality control

For all tests and analyses, the Quality Assurance and Quality Control procedures were equivalent to those endorsed by NATA (National Association of Testing Authorities). The standard procedures followed included the monitoring of blanks, duplicate analysis of at least 1 in 10 samples, and the inclusion of standards in each batch.

Blanks were collected for laboratory or field samples to examine whether contaminants had been introduced to the sample. Reagent blanks and method blanks were prepared and analysed for each method. All blanks examined here were either at, or very close to, the limits of detection.

Duplicates were prepared for all experiments and analysed separately. Selected analytical duplicate samples were prepared by dividing a test sample into two, then analysing these sub-samples separately. On average, the frequencies of quality control samples processed were: 10% blanks, ≥ 10% laboratory duplicates and 5% laboratory controls. The analytical precision was acceptable for all analyses. For example, for values of sufficient magnitude the analytical precision was ±8% for EC, ±8% for total C and ±14% for TOC.

5.0 Results

5.1 General sediment condition

5.1.1 Meningie, Lake Albert

5.1.1.1 pH(1:5, soil:water)

The pHs of the sediments at the Meningie control and *Schoenoplectus valaidus* sites are similar with alkaline surface layers ~8.5 and an acidic sub-sediment of 4 between 25-40 cm depth (Figure 5-1). The offset in the pH-depth relationship would indicate that the control site, unprotected by vegetation, has suffered from erosion of ~5 cm depth compared to the vegetated site.

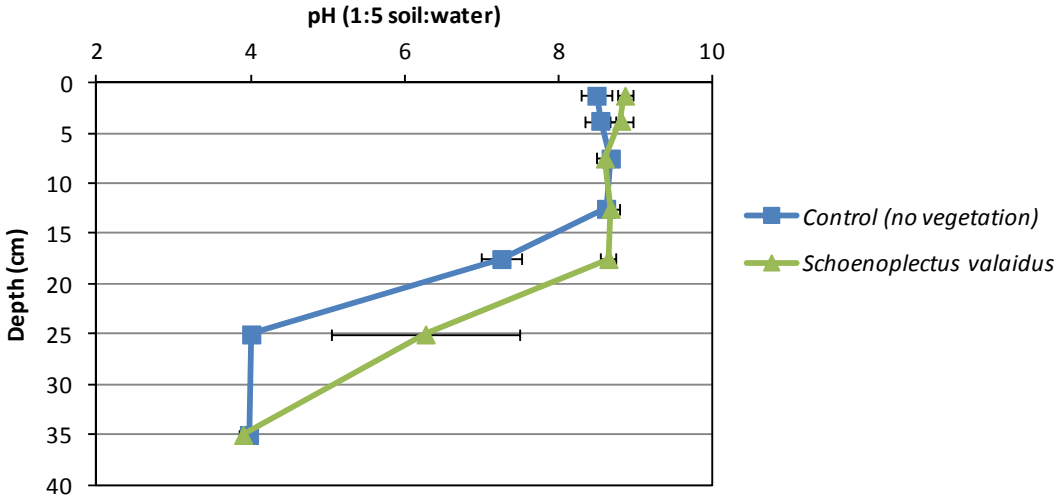

Figure 5-1. pH at the Meningie control (no vegetation) and *Schoenoplectus valaidus* sites.

5.1.1.2 Electrical conductivity (EC)

The ECs of the sediments at the two sites are similar with relatively fresh surface layers < 2,000 µS/cm down to 20 cm depth steadily increasing with depth to ~ 15,000 µS/cm (Figure 5-2). Again the offset in the EC-depth relationship would indicate that the control site, unprotected by vegetation, has suffered from erosion of ~5 cm depth compared to the vegetated site.

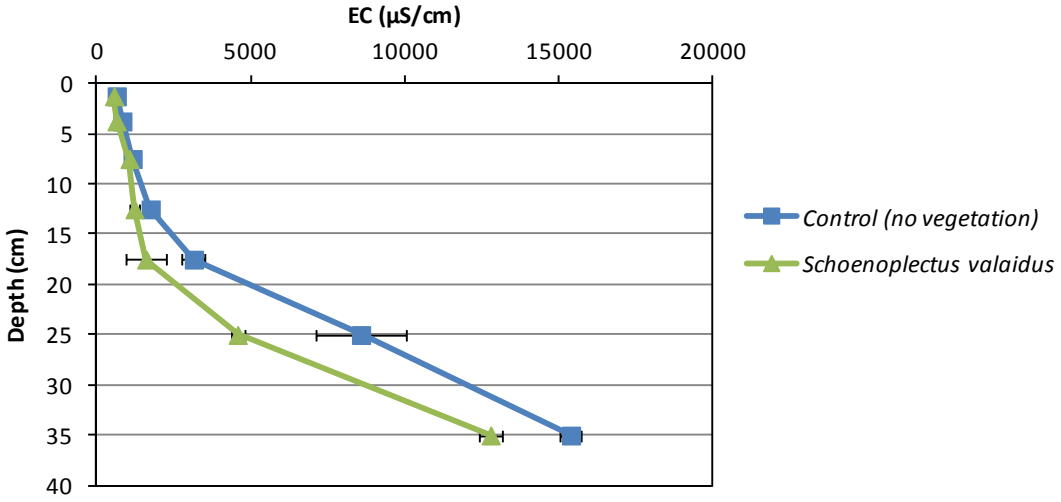

Figure 5-2. EC at the Meningie control (no vegetation) and *Schoenoplectus valaidus* sites.

5.1.1.3 Total carbon, organic and inorganic carbon

The total carbon, organic and inorganic carbon contents measured at the Meningie control and *Schoenoplectus valaidus* sites are shown below in Figures 5-3 – 5-5.

The total organic carbon contents indicate a higher concentration in the top 10 cm of the sediment under *Schoenoplectus valaidus* (Figure 5-4). After allowing for a depth of erosion of ~5 cm from the control site relative to the *Schoenoplectus valaidus* site, the concentrations of organic carbon in the sediments at depths below 20 cm are similar.

The data indicate that there was less carbonate in the top 10 cm of the sediments at the *Schoenoplectus valaidus* site indicating that, if anything, lower inorganic carbon accumulation under the bioremediating vegetation in this surficial layer (Figure 5-5).

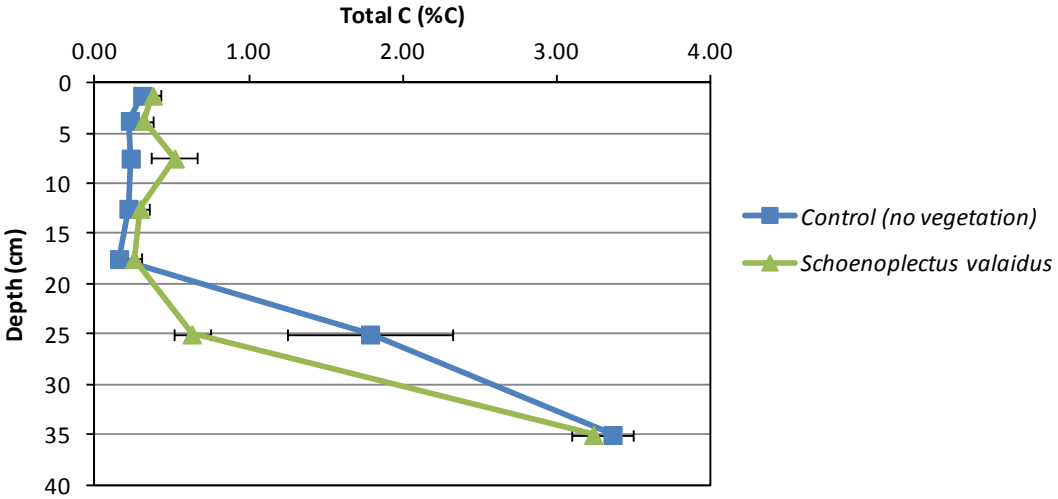

Figure 5-3. Total carbon at the Meningie control (no vegetation) and *Schoenoplectus valaidus* sites.

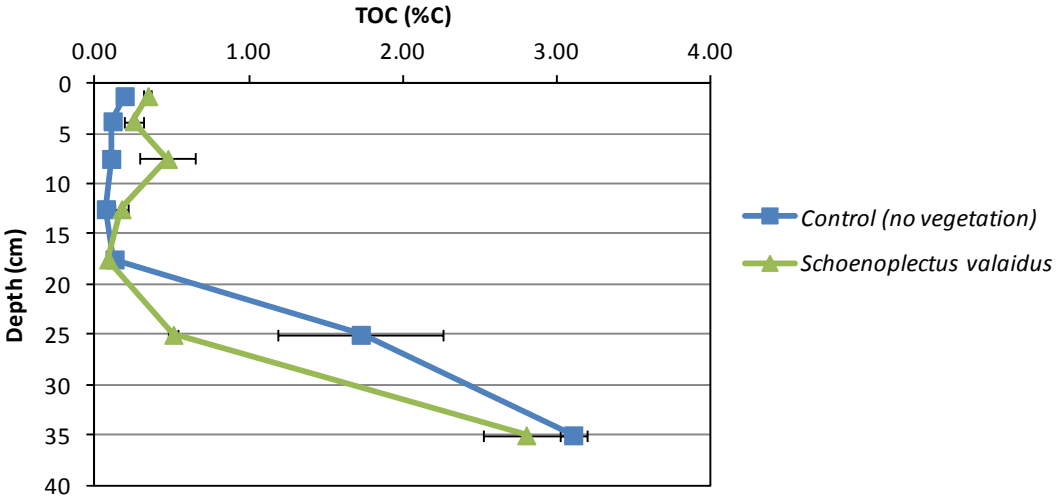

Figure 5-4. Total organic carbon at the Meningie control (no vegetation) and *Schoenoplectus valaidus* sites.

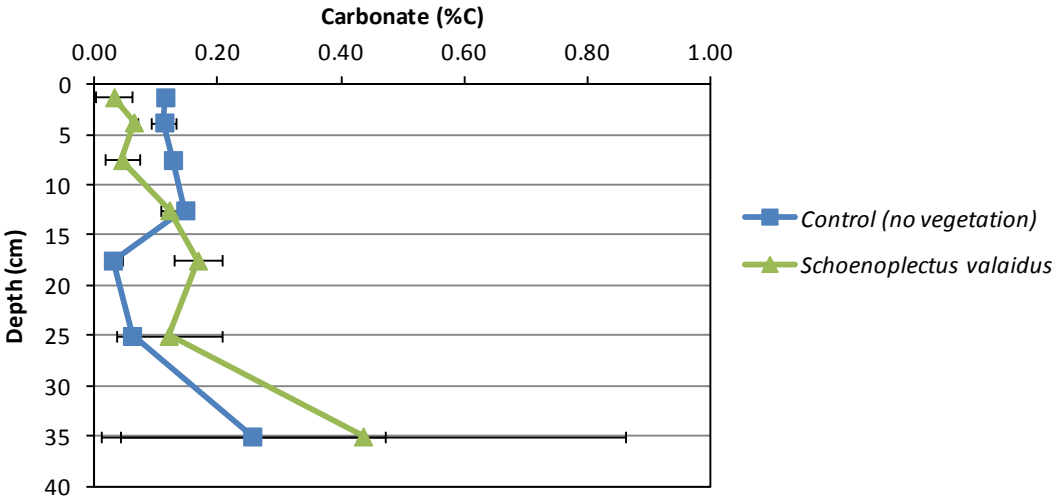

Figure 5-5. Carbonate (inorganic carbon) content at the Meningie control (no vegetation) and *Schoenoplectus valaidus* sites.

The quantity of carbon in the top 10 cm layer (where accumulation has been most likely) has been converted from the total organic carbon contents (in %) using the bulk densities of these surficial layers (Figure 5-6). In terms of carbon accumulation, this data shows that carbon has accumulated in the top 10 cm of these sediments at the *Schoenoplectus valaidus* site compared to the control site mainly in the Non-protected pool (i.e. 1.80 mg C cm^{-3} cf. 0.74 mg C cm^{-3}). The physically protected pool was identical at each site (i.e. 0.71 mg C cm^{-3}).

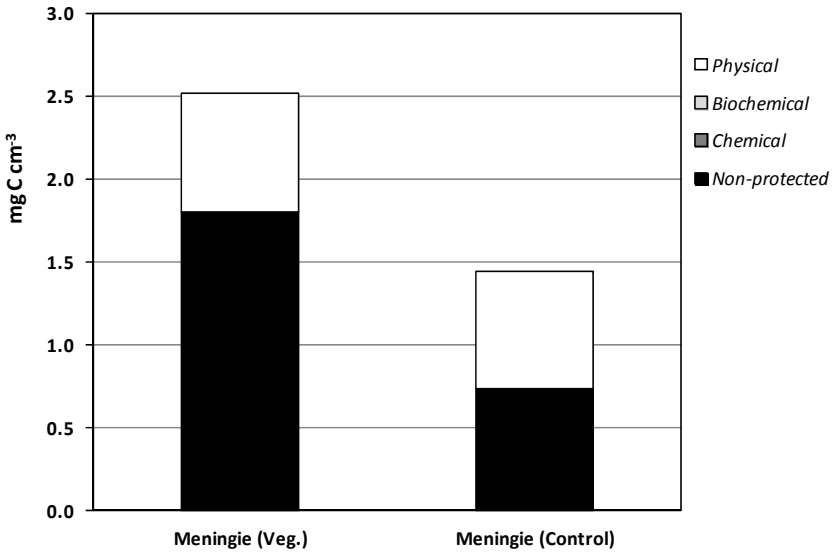

Figure 5-6. The carbon pools in the upper 10 cm of sediment at the Meningie control (no vegetation) and *Schoenoplectus valaidus* sites.

In terms of carbon accumulation, and assuming 19 months of growth of the *Schoenoplectus valaidus* since reinundation of the lake this represents a mean annual increase in total carbon of 670 kg C ha^{-1} yr^{-1} under the *Schoenoplectus valaidus*. All of this increase in carbon storage in the sediment is within the Non-protected (mainly the cPOM) pool indicating that this stored carbon is liable to decomposition within the short term.

5.1.1.4 Total nitrogen

The total nitrogen contents in the sediments were, after allowing for a depth of erosion of ~5 cm from the control site relative to the *Schoenoplectus valaidus* site, similar at all depths except that there was a higher concentration of total nitrogen in the 5-10 cm sediment layer beneath the *Schoenoplectus valaidus* site (Figure 5-7).

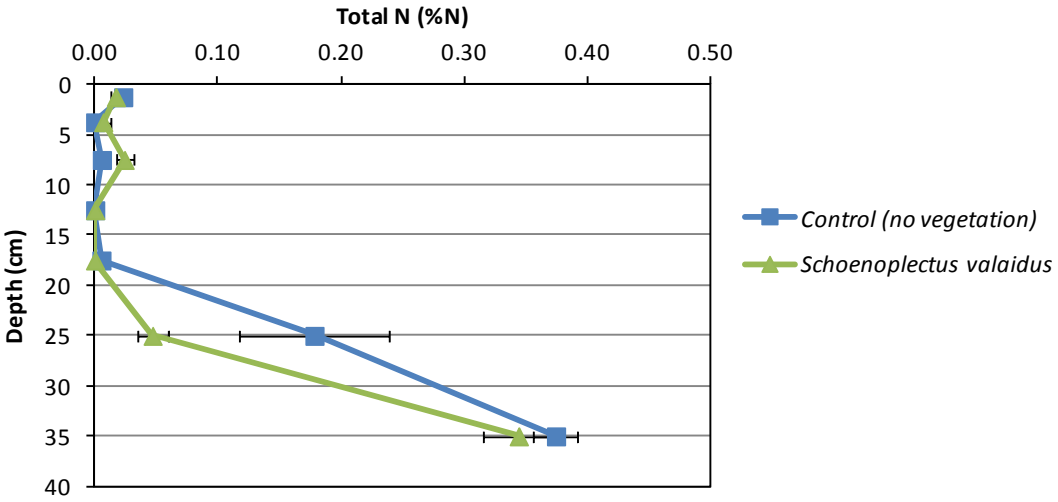

Figure 5-7. Total Nitrogen at the Meningie control (no vegetation) and *Schoenoplectus valaidus* sites.

5.1.2 Waltowa, Lake Albert

5.1.2.1 pH(1:5, soil:water)

The pHs of the sediments at the *Phragmites australis* site were slightly more alkaline than those of the control site, except in the top 0-2.5 cm layer which was slightly more acidic and in the 30-40 cm layer were the pHs were similar (Figure 5-8).

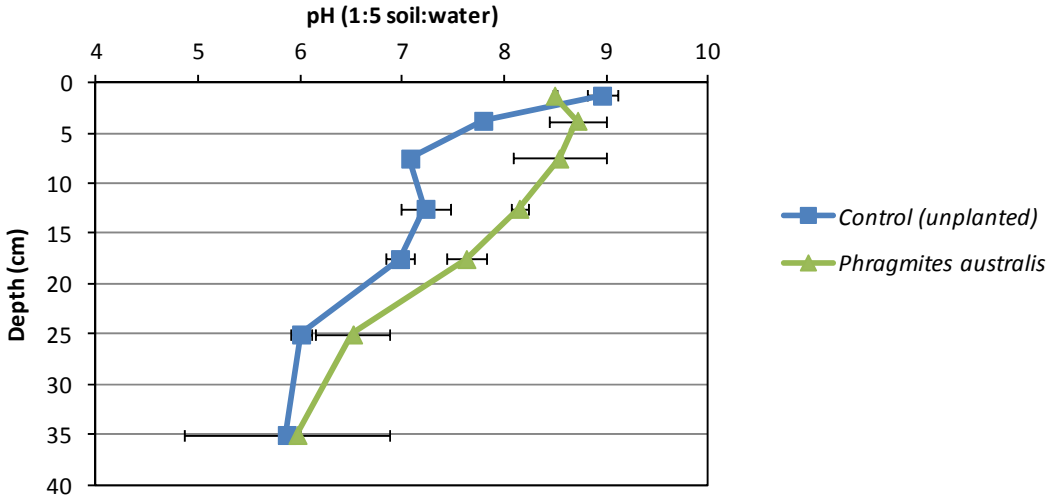

Figure 5-8. pH at the Waltowa control (unplanted) and *Phragmites australis* sites.

5.1.2.2 Electrical conductivity (EC)

The ECs of the sediments at the *Phragmites australis* site were slightly more saline than those of the control site except in the top 0-2.5 cm layer which was considerably more saline at *Phragmites australis* site (Figure 5-9).

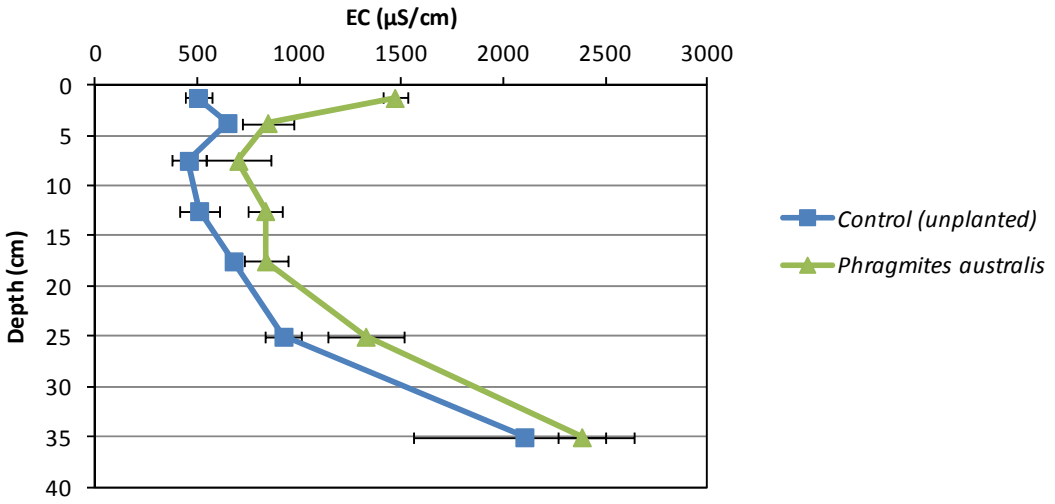

Figure 5-9. EC at the Waltowa control (unplanted) and *Phragmites australis* sites.

5.1.2.3 Total carbon, organic and inorganic carbon

The total carbon, organic and inorganic carbon contents measured at the Waltowa control (unplanted) and *Phragmites australis* sites are shown below in Figures 5-10 – 5-12.

The total organic carbon contents indicate a much higher concentration in the top 5 cm (and especially in the 0-2.5 cm layer) of the sediment under *Phragmites australis* (Figure 5-11). The data indicate that there was considerably more carbonate in the top 15 cm of the sediments at the *Phragmites australis* site (Figure 5-12). There was a surficial application of crushed limestone prior to planting at the *Phragmites australis* making estimations of the rates of inorganic carbon accumulation at this site due to bioremediating vegetation problematic.

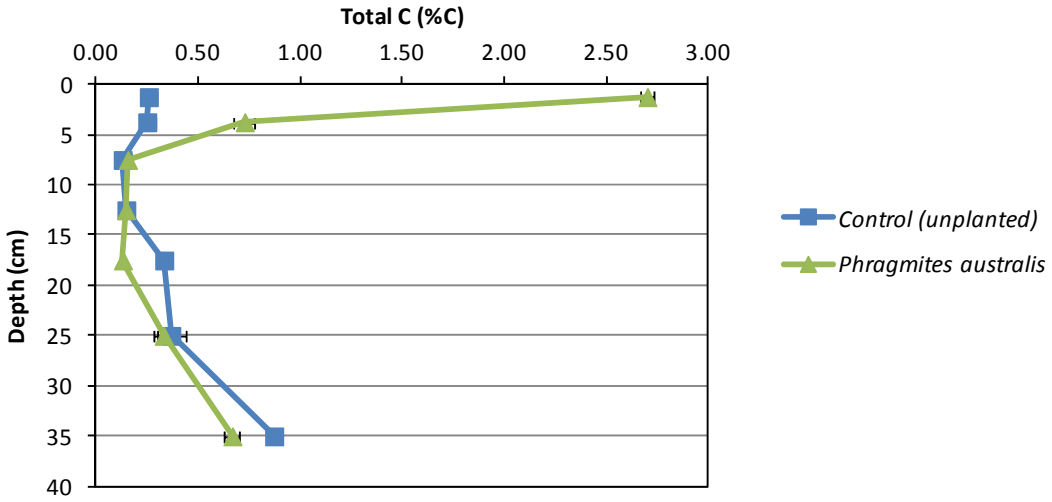

Figure 5-10. Total carbon at the Waltowa control (unplanted) and *Phragmites australis* sites.

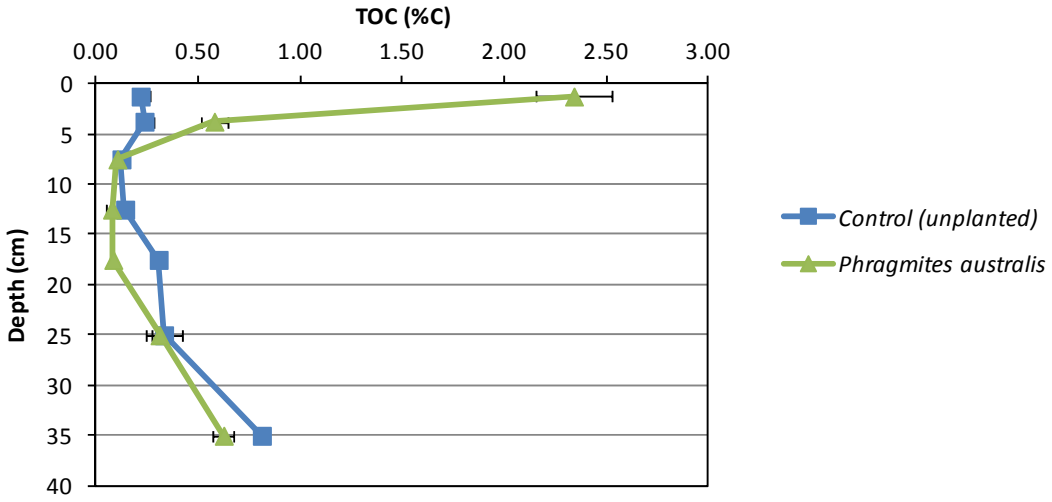

Figure 5-11. Total organic carbon at the Waltowa control (unplanted) and *Phragmites australis* sites.

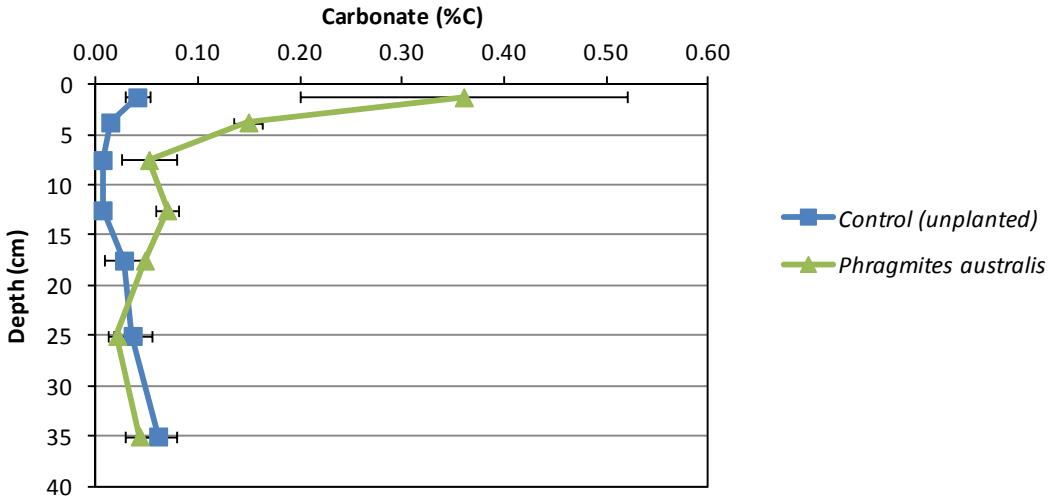

Figure 5-12. Carbonate (inorganic carbon) content at the Waltowa control (unplanted) and *Phragmites australis* sites.

The quantity of carbon in the top 10 cm layer (where accumulation has been most likely) has been converted from the total organic carbon contents (in %) using the bulk densities of these surficial layers (Figure 5-13). In terms of carbon accumulation, this data shows that carbon has accumulated in the top 10 cm of these sediments at the *Phragmites australis* site compared to the control site mainly in the Non-protected pool (i.e. 1.80 mg C cm^{-3} cf. 0.74 mg C cm^{-3}). The physically protected pools were similar at each site but appreciable (i.e. ~0.95 mg C cm^{-3}). Both the Chemical and Physically protected carbon pools at these sites were similar but minor (i.e. < 0.10 mg C cm^{-3}).

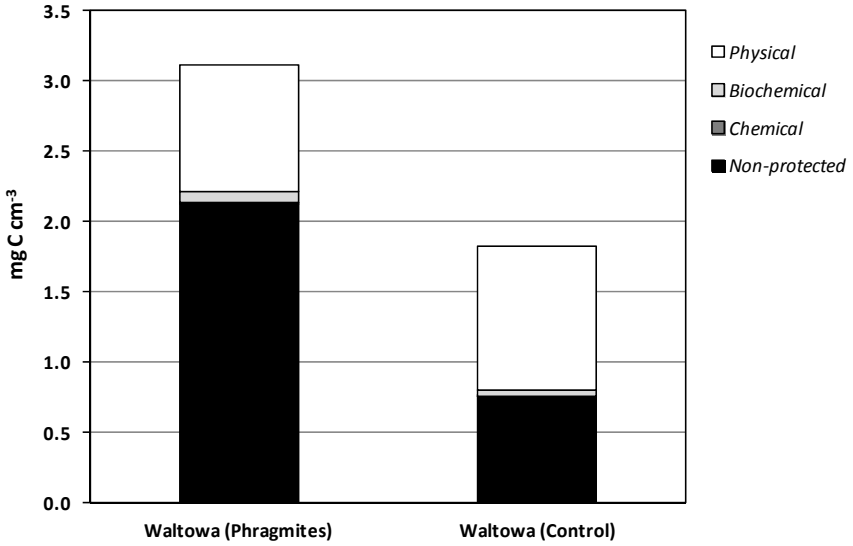

Figure 5-13. The carbon pools in the upper 10 cm of sediment at the Waltowa control (unplanted) and *Phragmites australis* sites.

In terms of carbon accumulation, this data shows that carbon has accumulated in the top 10 cm of these sediments at the *Phragmites australis* site compared to the control site mainly in the Non-protected pool (i.e. 2.12 mg C cm^{-3} cf. 0.75 mg C cm^{-3}). In terms of carbon accumulation, and assuming 19 months of growth of the *Phragmites australis* since reinundation of the lake this represents a mean annual increase in total carbon of 866 kg C ha^{-1} yr^{-1} under the *Phragmites australis*. All of this increase in carbon storage in the sediment is within the Non-protected (mainly the cPOM) pool indicating that this stored carbon is liable to decomposition within the short term.

5.1.2.4 Total nitrogen

The total nitrogen contents in the sediments under the *Phragmites australis* site were much higher than those in the control site in the upper 5 cm layer (Figure 5-14).

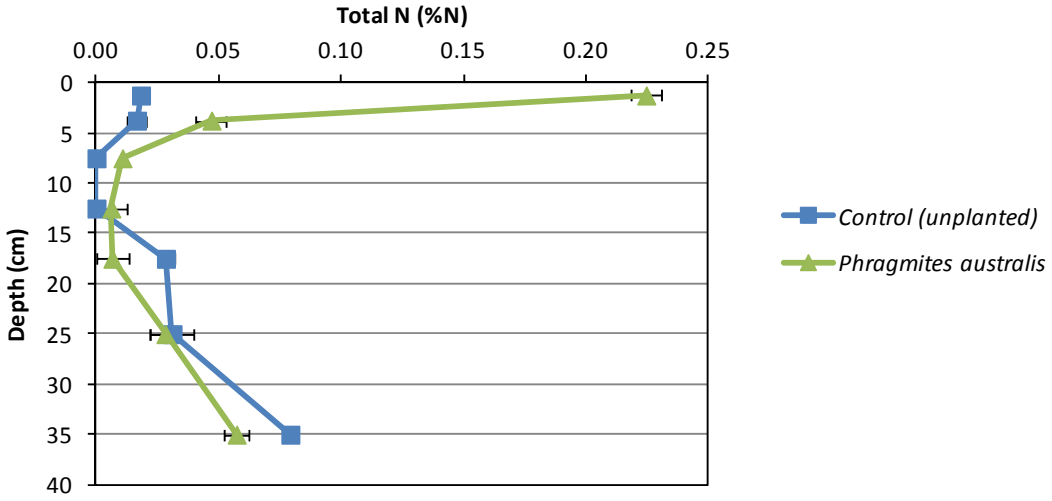

Figure 5-14. Total nitrogen at the Waltowa control (unplanted) and *Phragmites australis* sites.

5.1.3 Hunters Creek, Hindmarsh Island

5.1.3.1 Hunters Creek (*Schoenoplectus valaidus* site)

5.1.3.1.1 pH(1:5, soil:water)

The pHs of the sediments at the *Schoenoplectus valaidus* site were similar to those under the control (Figure 5-15).

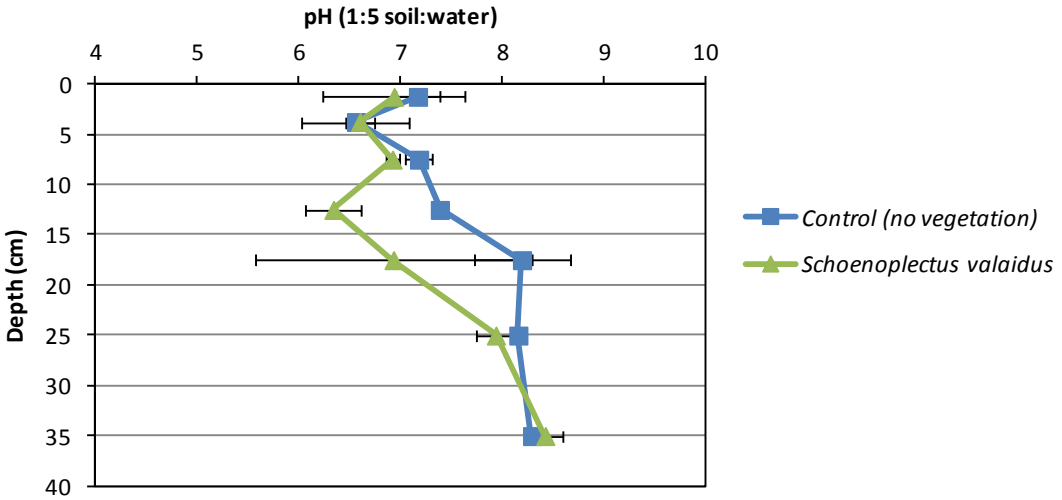

Figure 5-15. pH at the Hunters Creek control (no vegetation) and Schoenoplectus valaidus sites.

5.1.3.1.2 Electrical conductivity (EC)

The ECs of the sediments at the *Schoenoplectus valaidus* site were similar to those under the control (Figure 5-16).

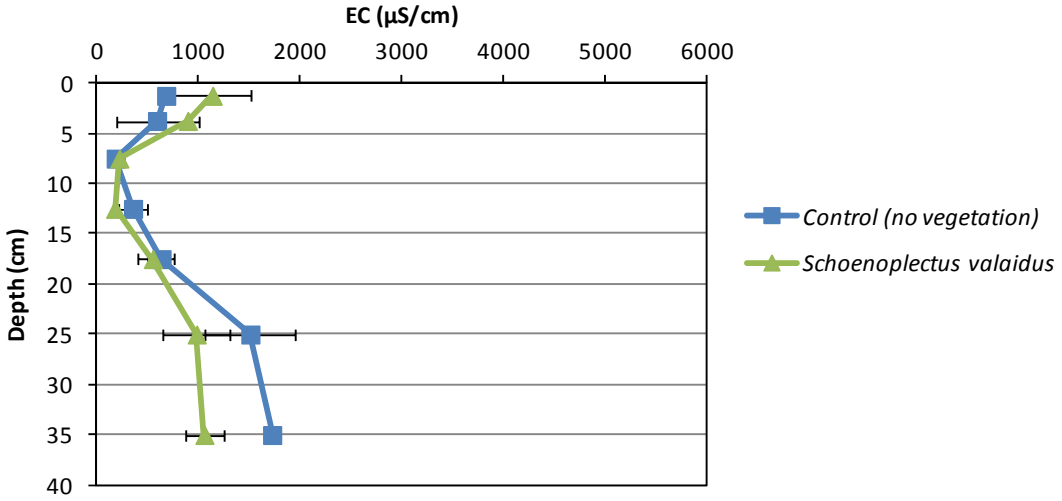

Figure 5-16. EC at the Hunters Creek control (no vegetation) and *Schoenoplectus valaidus* sites.

5.1.3.1.3 Total carbon, organic and inorganic carbon

The total carbon, organic and inorganic carbon contents measured at the Hunters Creek control (no vegetation) and *Schoenoplectus valaidus* sites are shown below in Figures 5-17 – 5-19.

The total organic carbon contents of the sediments at the *Schoenoplectus valaidus* site indicate a much higher concentration in the top 5 cm (and especially in the 0-2.5 cm layer) of the sediment than those in the control site (Figure 5-18).

The carbonate contents of the sediments at the *Schoenoplectus valaidus* were similar to those under the adjacent control except that they were slightly higher in the 0-2.5 cm layer than under the control. In any case inorganic carbon was only a small fraction of the total carbon at this site in the surficial layers (Figure 5-19).

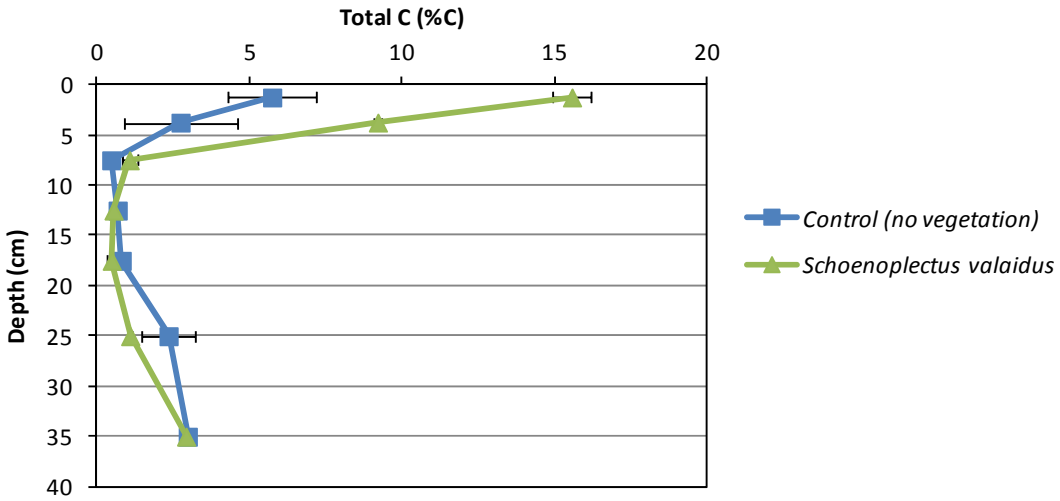

Figure 5-17. Total carbon at the Hunters Creek control (no vegetation) and *Schoenoplectus valaidus* sites.

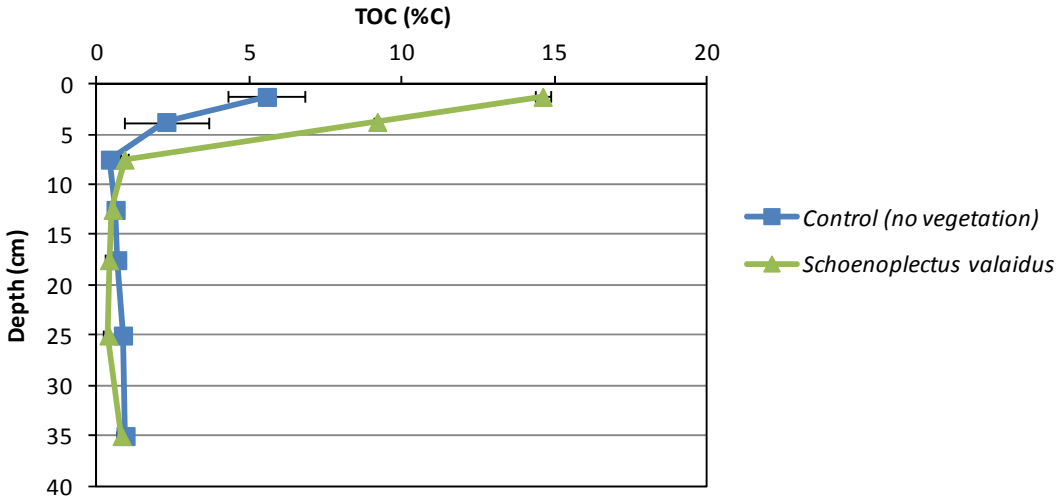

Figure 5-18. Total organic carbon at the Hunters Creek control (no vegetation) and *Schoenoplectus valaidus* sites.

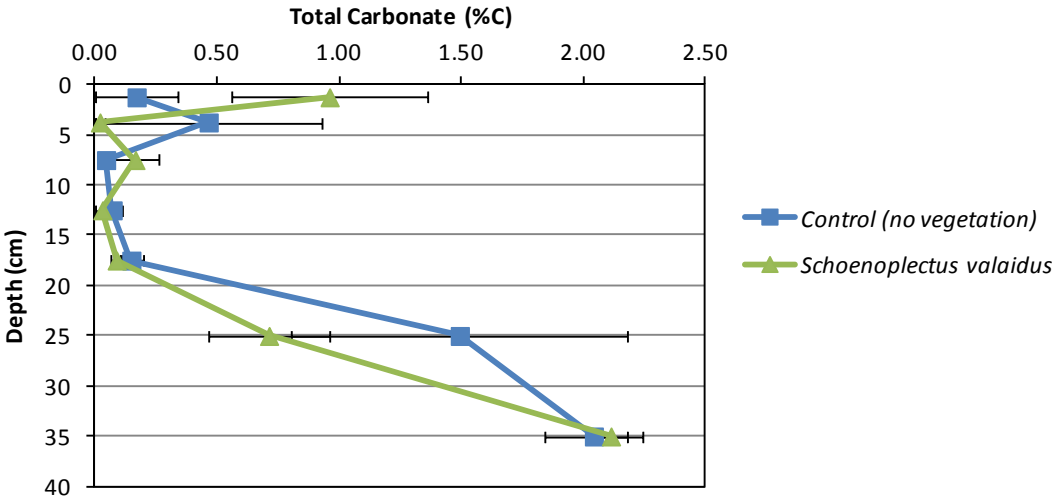

Figure 5-19. Carbonate (inorganic carbon) content at the Hunters Creek control (no vegetation) and *Schoenoplectus valaidus* sites.

The quantity of carbon in the top 10 cm layer (where accumulation has been most likely) at the *Schoenoplectus valaidus* site has been converted from the total organic carbon contents (in %) using the bulk densities of these surficial layers (Figure 5-20). In terms of carbon accumulation, this data shows that carbon has accumulated in the top 10 cm of these sediments at the *Schoenoplectus valaidus* site compared to the control site mainly in the Non-protected pool (i.e. 3.44 mg C cm^{-3} cf. 2.01 mg C cm^{-3}). The physically protected pools were similar at each site but appreciable (i.e. ~1.31 mg C cm^{-3}). Both the Chemical and Physically protected carbon pools were minimal (i.e. < 0.01 mg C cm^{-3}). In terms of carbon accumulation, and assuming 19 months of growth of the *Schoenoplectus valaidus* since reinundation of the lake this represents a mean annual increase in total carbon of 903 kg C ha^{-1} yr^{-1} under the *Schoenoplectus valaidus*. All of this increase in carbon storage in the sediment is within the Non-protected (mainly the cPOM) pool indicating that this stored carbon is liable to decomposition within the short term.

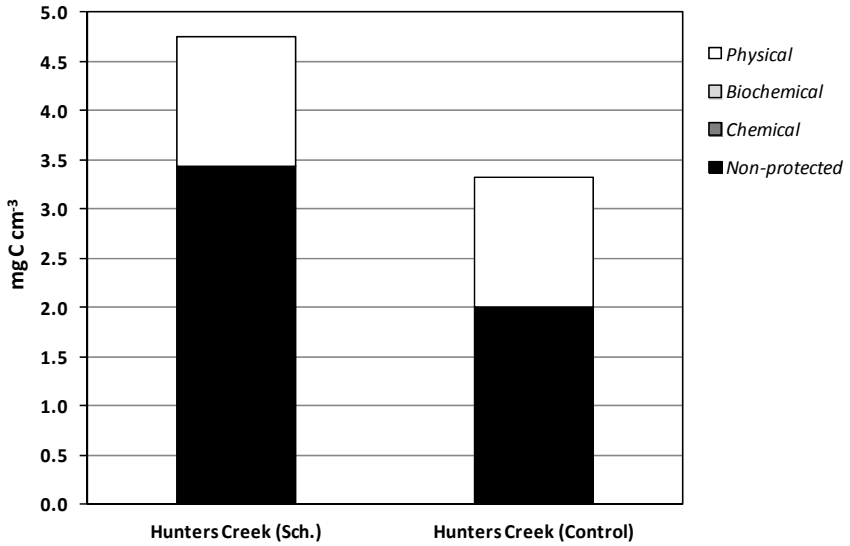

Figure 5-20. The carbon pools in the upper 10 cm of sediment at the Hunters Creek control (no vegetation) and *Schoenoplectus valaidus* sites.

5.1.3.1.4 Total nitrogen

The total nitrogen contents of the sediments at the *Schoenoplectus valaidus* were similar to those under the adjacent control except that they were considerably higher in the 0-5 cm layer under the *Schoenoplectus valaidus* (Figure 5-21).

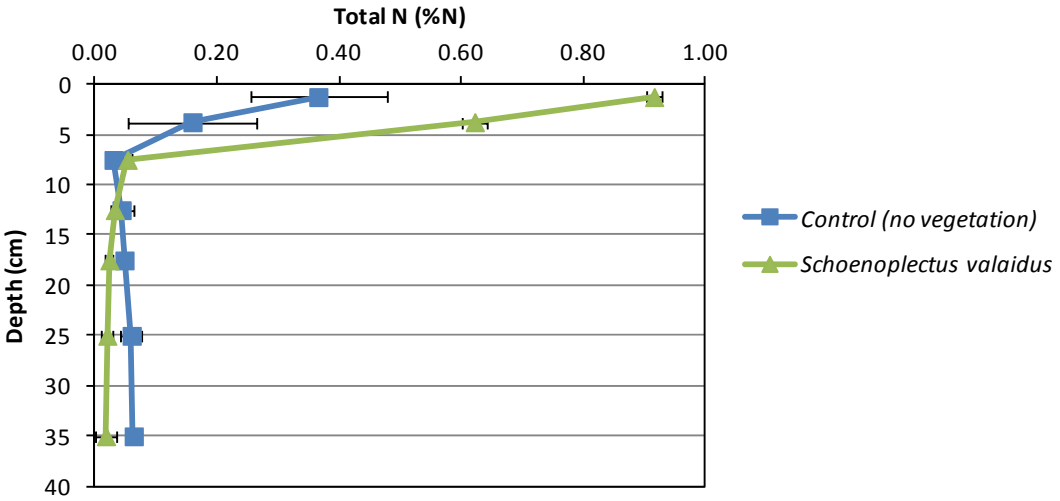

Figure 5-21. Total Nitrogen at the Hunters Creek control (no vegetation) and *Schoenoplectus valaidus* sites.

5.1.3.2 Hunters Creek (*Melaleuca halmaturorum* - 10 year revegetation site)

5.1.3.2.1 pH(1:5, soil:water)

The pHs of the sediments at the *Melaleuca halmaturorum* 10 year old revegetation site were similar to those under the adjacent control (Figure 5-22).

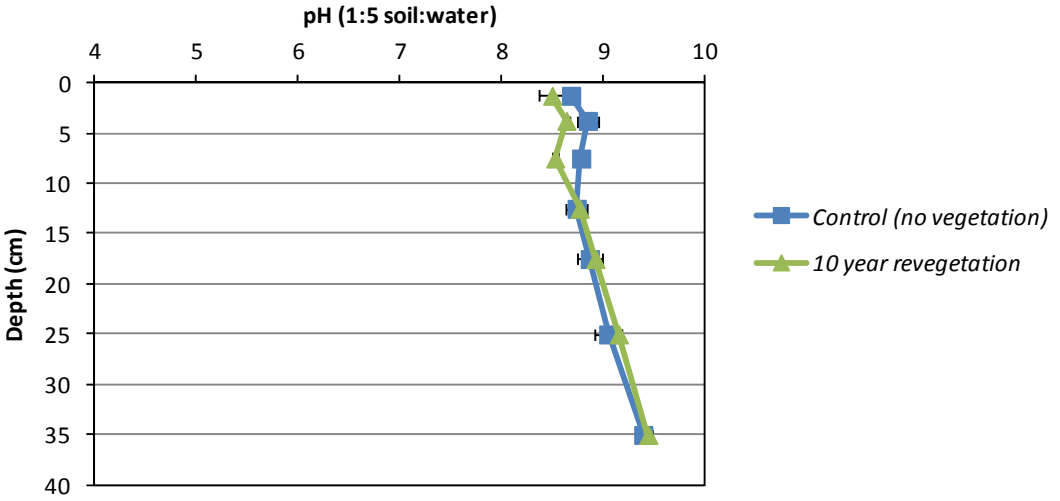

Figure 5-22. pH at the Hunters Creek control and *Melaleuca halmaturorum* sites (10 year revegetation).

5.1.3.2.2 Electrical conductivity (EC)

The ECs of the sediments at the *Melaleuca halmaturorum* 10 year old revegetation site were similar to those under the adjacent control. (Figure 5-23).

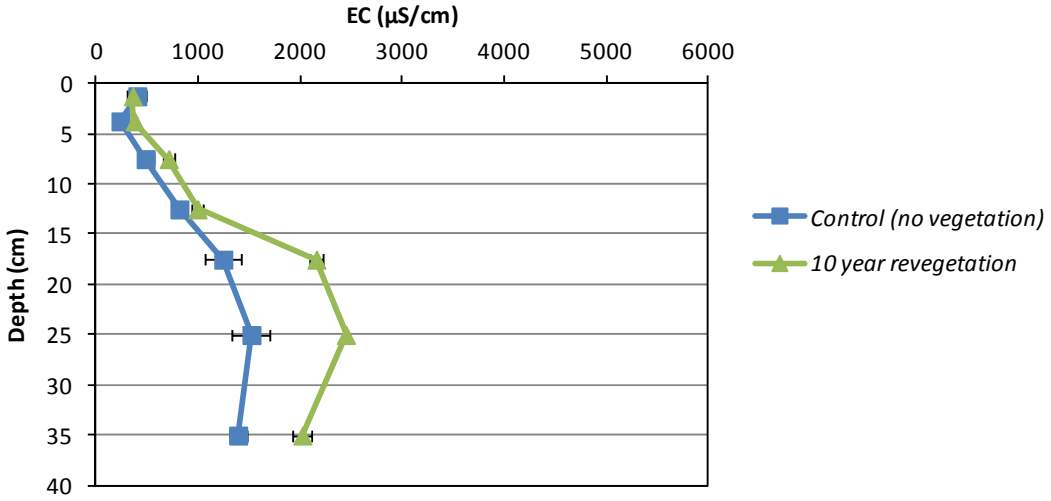

Figure 5-23. EC at the Hunters Creek control and *Melaleuca halmaturorum* sites (10 year revegetation).

5.1.3.2.3 Total carbon, organic and inorganic carbon

The total carbon, organic and inorganic carbon contents measured at the Hunters Creek control and the *Melaleuca halmaturorum* 10 year old revegetation sites are shown below in Figures 5-24 – 5-26.

The total organic carbon contents of the sediments at the *Melaleuca halmaturorum* 10 year old revegetation site were similar to those under the adjacent control except that they were slightly higher in the 0-2.5 cm layer under the *Melaleuca halmaturorum* 10 year old vegetation (Figure 5-25).

The carbonate contents of the sediments at the *Melaleuca halmaturorum* 10 year old revegetation site were higher than those under the adjacent control except that they were similar in the 0-2.5 cm layer (Figure 5-26).

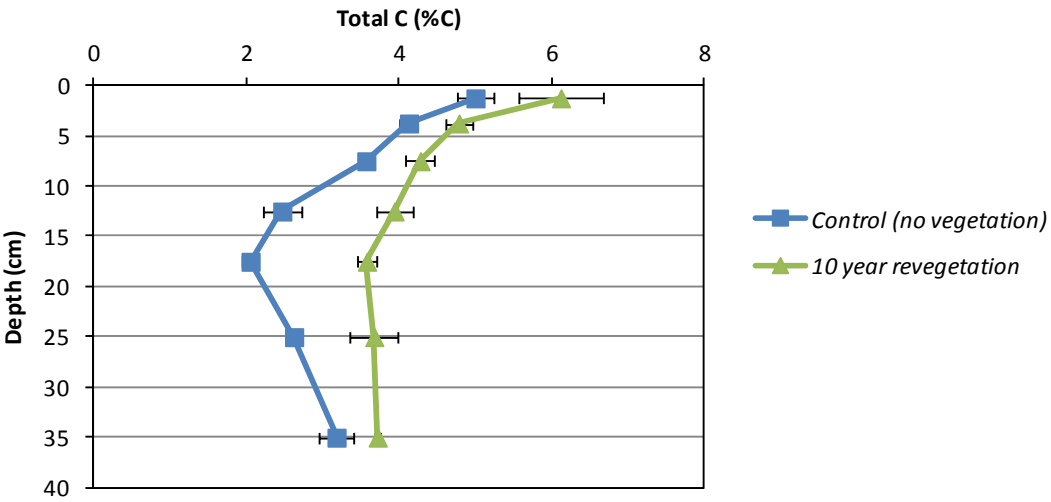

Figure 5-24. Total carbon at the Hunters Creek control and *Melaleuca halmaturorum* sites (10 year revegetation).

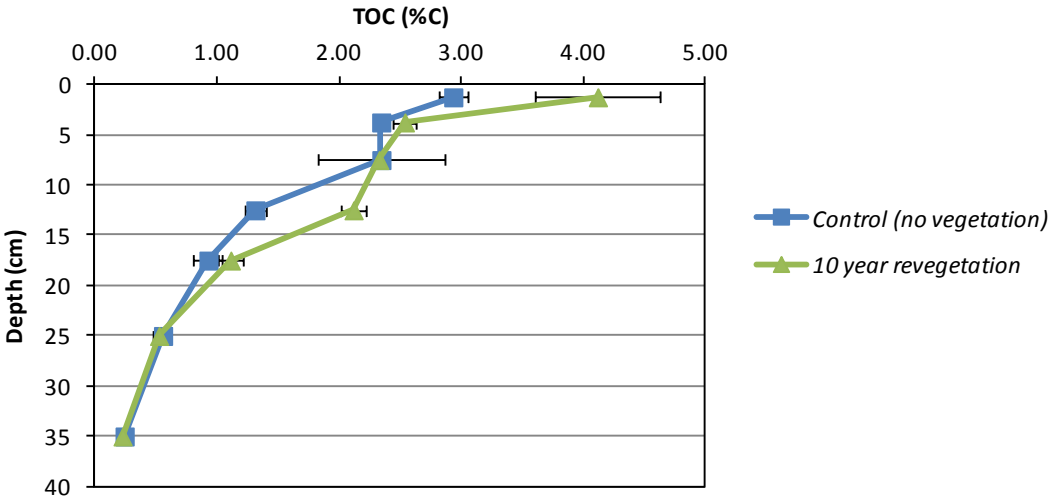

Figure 5-25. Total organic carbon at the Hunters Creek control and *Melaleuca halmaturorum* sites (10 year revegetation).

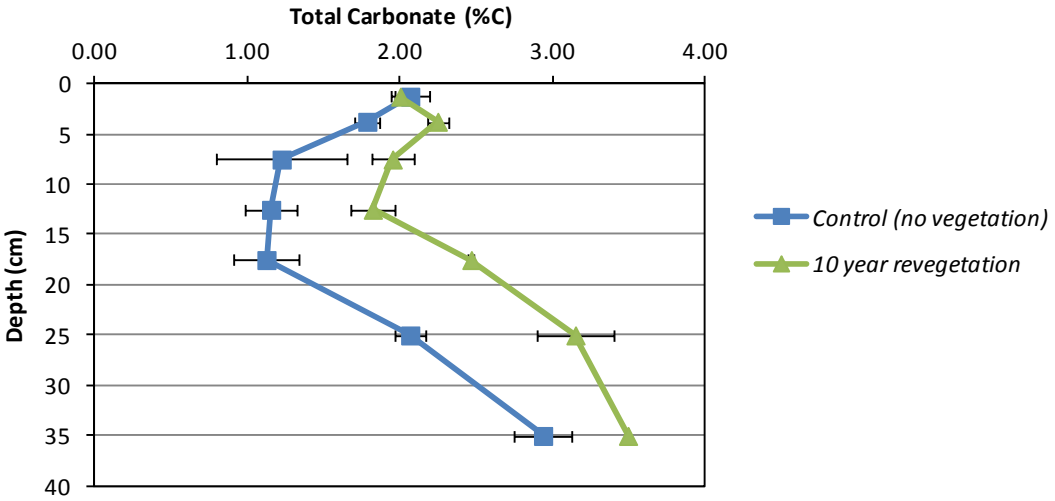

Figure 5-26. Carbonate (inorganic carbon) content at the Hunters Creek control and *Melaleuca halmaturorum* sites (10 year revegetation).

The quantity of carbon in the top 10 cm layer (where accumulation has been most likely) at the *Melaleuca halmaturorum* 10 year old site has been converted from the total organic carbon contents (in %) using the bulk densities of these surficial layers (Figure 5-27). In terms of carbon accumulation, this data shows that no carbon has accumulated in the top 10 cm of these soil layers compared to the control site albeit the data indicating a slight increase in carbon in the 0-2.5 cm surficial layer. This data indicates that, if anything, the relatively slow growth of the *Melaleuca halmaturorum* may not provide as much organic matter input as the agricultural crops grown at the control site.

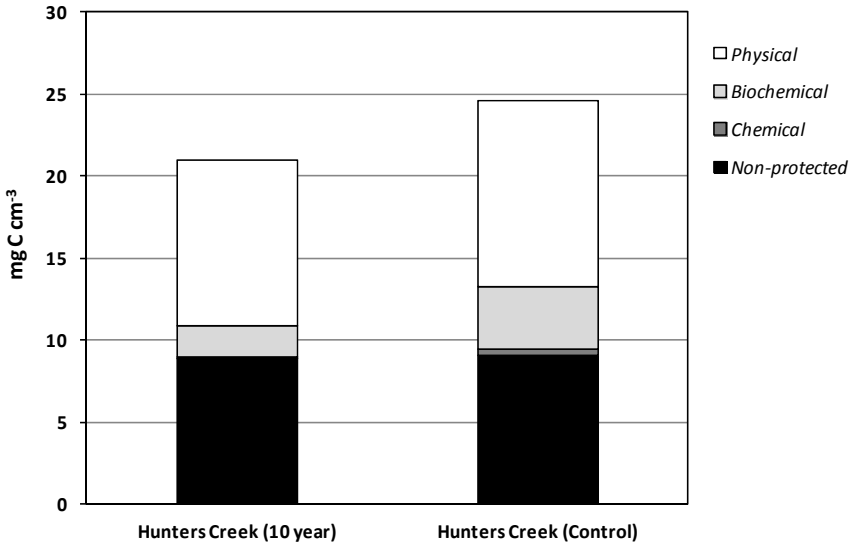

Figure 5-27. The carbon pools in the upper 10 cm of sediment at the Hunters Creek control and *Melaleuca halmaturorum* sites (10 year revegetation).

5.1.3.2.4 Total nitrogen

The total nitrogen contents of the sediments at the *Melaleuca halmaturorum* 10 year old revegetation site were similar to those under the adjacent control except that they were slightly higher in the 0-5 cm layer than under the control (Figure 5-28).

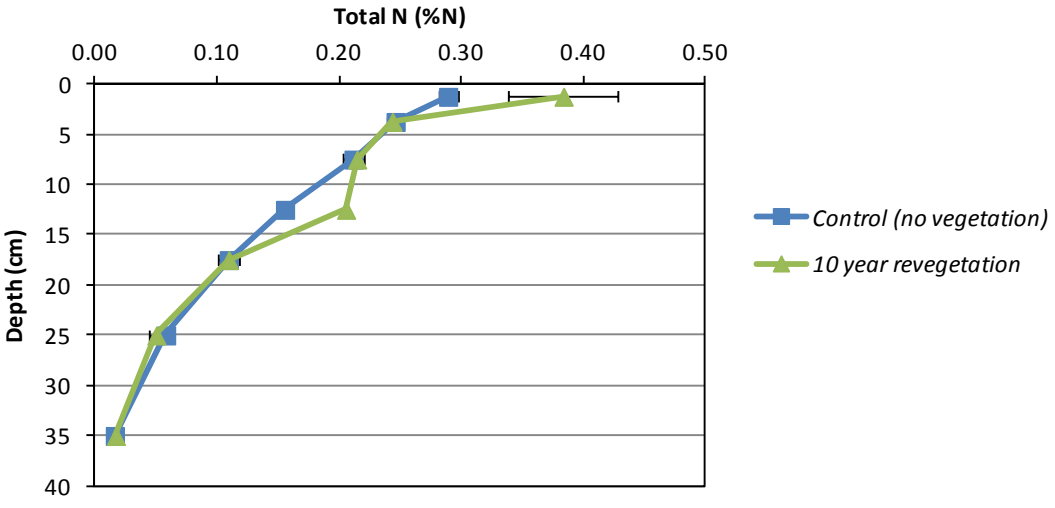

Figure 5-28. Total nitrogen at the Hunters Creek control and *Melaleuca halmaturorum* sites (10 year revegetation).

5.1.3.3 Hunters Creek (*Melaleuca halmaturorum* – Remnant stand site)

5.1.3.3.1 pH(1:5, soil:water)

The pHs of the sediments at the *Melaleuca halmaturorum* remnant site were similar to those under the adjacent control (Figure 5-29).

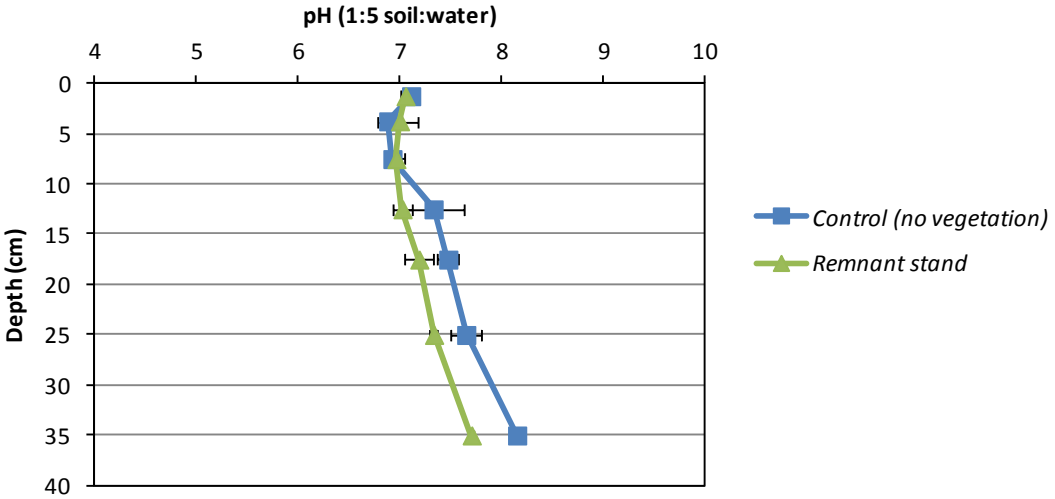

Figure 5-29. pH at the Hunters Creek control and *Melaleuca halmaturorum* sites (Remnant stand).

5.1.3.3.2 Electrical conductivity (EC)

The ECs of the sediments at the *Melaleuca halmaturorum* remnant site were similar to those under the adjacent control (Figure 5-30).

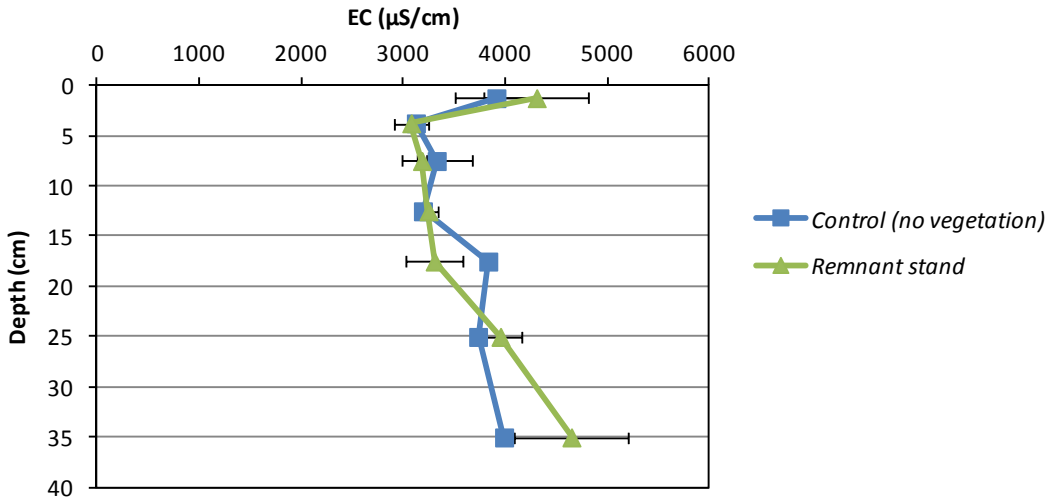

Figure 5-30. EC at the Hunters Creek control and *Melaleuca halmaturorum* sites (Remnant stand).

5.1.3.3.3 Total carbon, organic and inorganic carbon

The total carbon, organic and inorganic carbon contents measured at the Hunters Creek control and the *Melaleuca halmaturorum* remnant stand sites are shown below in Figures 5-31 – 5-33.

The Total Organic Carbon contents of the sediments at the *Melaleuca halmaturorum* remnant site were similar to those under the adjacent control except that they were considerably higher in the 0-2.5 cm layer under the *Melaleuca halmaturorum* remnant (Figure 5-32).

The carbonate contents of the sediments at the *Melaleuca halmaturorum* remnant site were higher than those under the adjacent control in the top 10 cm layer and lower in the 20-40 cm layer (Figure 5-33).

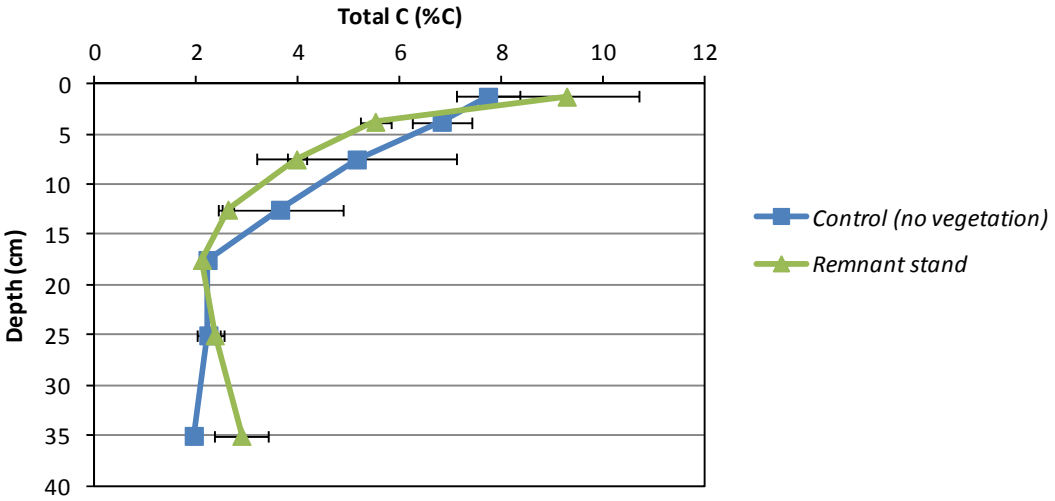

Figure 5-31. Total carbon at the Hunters Creek control and *Melaleuca halmaturorum* sites (Remnant stand).

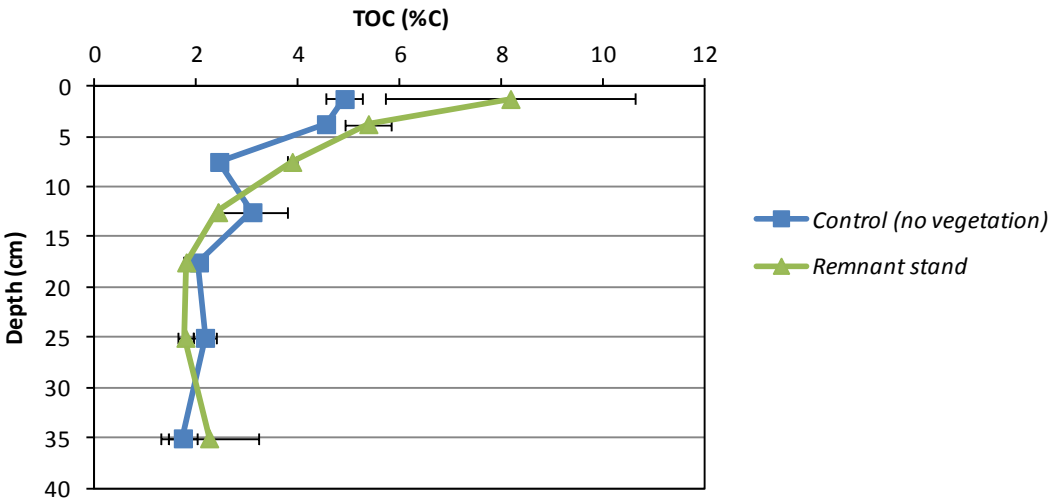

Figure 5-32. Total organic carbon at the Hunters Creek control and *Melaleuca halmaturorum* sites (Remnant stand).

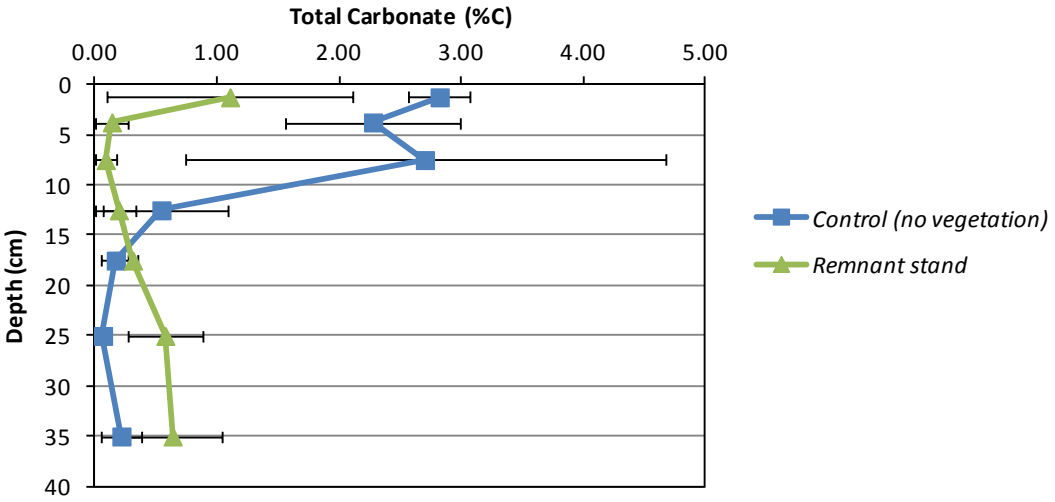

Figure 5-33. Carbonate (inorganic carbon) content at the Hunters Creek control and *Melaleuca halmaturorum* sites (Remnant stand).

The quantity of carbon in the top 10 cm layer (where accumulation has been most likely) at the *Melaleuca halmaturorum* remnant site has been converted from the total organic carbon contents (in %) using the bulk densities of these surficial layers (Figure 5-34). In terms of carbon accumulation, this data shows that no carbon has accumulated in the top 10 cm of these soil layers compared to the control site albeit the data indicating a slight increase in carbon in the 0-2.5 cm surficial layer. This data indicates that, if anything, the relatively slow growth of the *Melaleuca halmaturorum* may not provide as much organic matter input as the thick *juncus* species growing adjacent to the remnant.

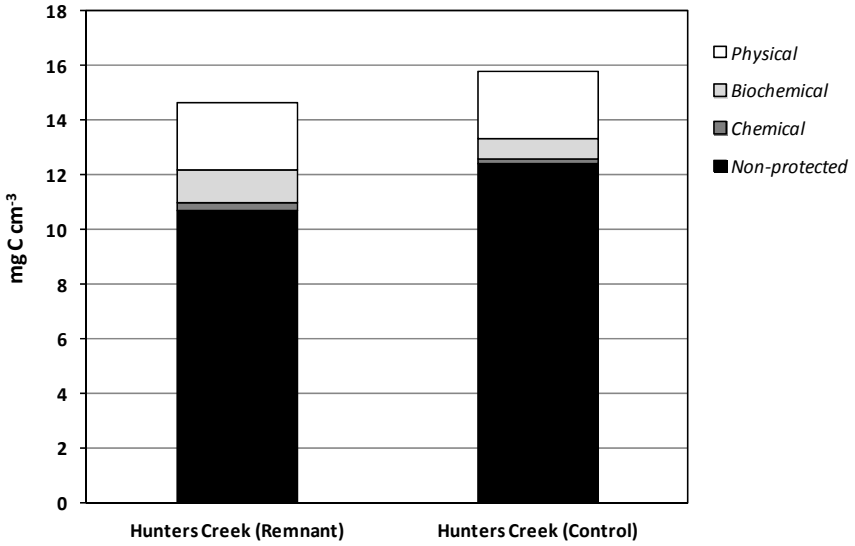

Figure 5-34. The carbon pools in the upper 10 cm of sediment at the Hunters Creek control and *Melaleuca halmaturorum* sites (Remnant stand).

5.1.3.3.4 Total nitrogen

The total nitrogen contents of the sediments at the *Melaleuca halmaturorum* remnant site were similar to those under the adjacent control in all sediment layers (Figure 5-35).

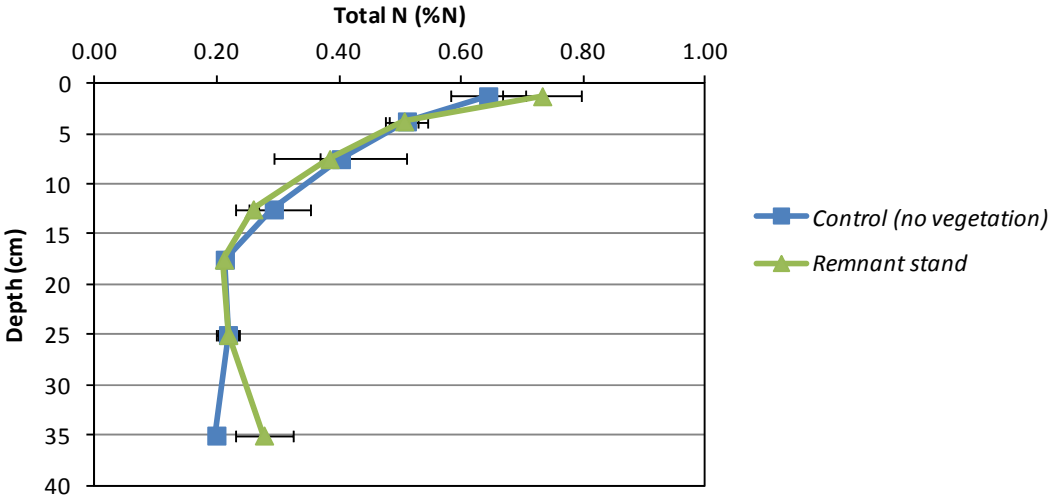

Figure 5-35. Total nitrogen at the Hunters Creek control and *Melaleuca halmaturorum* sites (Remnant stand).

5.2 Metals in bioremediating vegetation

This study also opportunistically sampled various parts of the bioremediation vegetation from the study sites for metal concentrations. The aim was to assess the uptake of some metals by the bioremediating vegetation especially from acidic sediment layers that previous studies (e.g. Sullivan *et al.* 2011) had shown to have nickel and zinc concentrations greatly exceed the respective Australian water quality guidelines for ecosystem protection. The translocation of such metals into plants via roots is an especially important consideration for lake sediment bioremediation via revegetation as direct ingestion by foraging animals of these materials is a viable transmission pathway from soil to animals.

Table 9-14 gives the metal concentrations of samples of the stem, leaf and roots of the vegetation at each site. The concentrations of zinc in all plants parts sampled were all at the low end of what is expected in agricultural products (e.g. Allaway 1968). The concentration of nickel was however, high in some of the vegetation samples. The roots and stems especially, but also the leaves of the *Phragmites* at the Waltowa site contained relatively high levels of nickel, as did the roots of the *Melaleuca* at the Hunters Creek 10 year remediation site and the roots of the *juncus* species adjacent the remnant melaleuca site at Hunters Creek, and the roots of the *Schoenoplectus valaidus* at Hunters Creek.

The concentrations of many of the metals (i.e. Cu, Co, Cd, Cr, As, Se, B and Mo) were generally low in the plant materials.

The concentrations of lead were all generally low apart from the stem material from the *Phragmites* at the Waltowa site, and the stem of the *Melaleuca* at the Hunters Creek 10 year remediation site (which was re-analysed and is likely to be despite the precautions taken, a result of contamination during sampling).

The concentrations of iron were all high in the root material at all sites likely indicating the formation of iron plaques around the roots. Such red/orange iron plaques were noted in the field around the roots of both the *Phragmites* and the *Schoenoplectus valaidus* sites. The formation of iron plaques around roots can protect plants from high levels of metals such as nickel, zinc and copper in soils (e.g. Greipsson 1995).

In particular the data indicates the importance to the surrounding ecology of vegetation taking up nickel from sediments that have high nickel concentrations as a result of processes such as acidification and redox cycling. This was especially evident for the *Phragmites* vegetation at the Waltowa site that prior to remediation was located on severely acidified acid sulfate soil.

5.3 Discussion

5.3.1 The three constantly inundated sites (i.e. the Waltowa, Meningie and the Hunters Creek *Schoenoplectus valaidus* sites)

The presence of vegetation at the three constantly inundated sites (Waltowa, Meningie and the Hunters Creek *Schoenoplectus valaidus site*) increased the storage of organic carbon considerably within the surface layers after only a few years of growth. The initial rates of organic carbon increase in the three constantly inundated sites were 866 kg C ha^{-1} yr^{-1} for the *Phragmites* site at Waltowa, and 670 kg C ha^{-1} yr^{-1} and 903 kg C ha^{-1} yr^{-1} for the *Schoenoplectus valaidus* at Meningie and Hunters Creek, respectively. The rates of inorganic carbon (carbonate) accumulation due to the presence of vegetation at the three constantly inundated sites were, where measurable, very low to negligible compared to the rates of organic carbon accumulation.

These organic carbon increases were almost totally in the non-protected soil carbon pool with the main contributor being the cPOM (i.e. the coarse (> 250 µm) particulate organic matter). The cPOM fraction is considered to be a relatively short-lived carbon pool (Six *et al.* 2002). Thus the increase and maintenance of the additional stored carbon under the bioremediating vegetation is likely to be contingent on the maintenance of the vegetation and the consequent supply of organic matter to this pool.

This non-protected carbon pool in the sediment is no doubt important in affecting the ecology of the lake sediments being a food source to benthic and other biota and being available to drive biochemically-driven processes in the sediment such as sulfate reduction. An important consideration here is the elevated concentrations of nickel in some of the vegetation, especially in the Waltowa site, and the effect of these concentrations of nickel on the food web of the Lower Lakes.

There was also a large (i.e. up to 50% of the total organic carbon) pool of physically-protected carbon at each of these sites. This carbon is protected physically from degradation by its inclusion in microaggregates (defined as 53–250 µm aggregates) in the sediment. The considerable size of this pool (relative to the total carbon pool) may seem surprising given the sandy texture of these sediments and the consequent lack of appreciable amounts of the clay and silt fractions necessary to form microaggregates (Plante *et al.* 2006b), but can be reconciled by the relatively very low total organic carbon contents of these sediments. This physically-protected carbon pool is considered to be a slow carbon pool with turnover rates of ~100 years (Six and Jastrow 2002). The presence of bioremediating vegetation had not increased this pool at the time of the sampling.

Given the sandy texture of the surface layers of the three constantly inundated sites (Waltowa, Meningie and the Hunters Creek *Schoenoplectus valaidus site*) it is not surprising that the biochemically- and chemically-protected carbon pools (i.e. the hydrolysable and non-hydrolysable carbon in the clay and silt fractions, respectively) were negligible in these sediments.

The recovery of mass at the three constantly inundated sites (as cPOM, microaggregates, d-silt, and d-clay) after the microaggregate isolation procedure was 98.0 % with a standard deviation of 2.3%.

The initial rates of organic carbon increase in the three constantly inundated sites were 866 kg C ha^{-1} yr^{-1} for the *Phragmites* site at Waltowa, and 670 kg C ha^{-1} yr^{-1} and 903 kg C ha^{-1} yr^{-1} for the *Schoenoplectus valaidus* at Meningie and Hunters Creek, respectively, are similar to those found by Craft (1997) of who, in an evaluation of four created estuarine marshes in North Carolina from 1–15 yrs old, found the mean accumulation of organic carbon to be 800 kg C ha^{-1} yr^{-1}. These rates are appreciably lower than the mean accumulation of organic carbon of 1,600 kg C ha^{-1} yr^{-1} observed over 10 years since reconstruction of two freshwater wetlands in Ohio by Anderson and Mitsch (2006). These rates are also appreciably higher than the mean accumulation of organic carbon of 360 kg C ha^{-1} yr^{-1} observed over 4,000 years in lake sediments by Dean and Gorham (1998). The mean organic carbon increase for small (<100 km^2) lakes are 270 kg C ha^{-1} yr^{-1} for oligotrophic lakes and 940 kg C ha^{-1} yr^{-1} for meso-eutrophic lakes (Mulholland and Elwood 1982). Thus the initial rates of organic carbon increase determined in this study for the three constantly inundated sites can be considered as in accord with the rates typically found for such situations.

The rates in the three constantly inundated sites are also appreciably higher than those measured for floodplains during the first 100 years of their revegetation (Bechtold and Naiman 2009), as well as for the average observed in forest soils following agricultural abandonment (Post and Kwon 2000), both

of which are ~340 kg C ha^{-1} yr^{-1}. The carbon accreting at these three permanently inundated sites is however, in the non-protected pool unlike for the floodplain soils where the increase was mainly in the 'slow' carbon pool with turnover rates of between 20–50 years (Bechtold and Naiman (2009). In comparison the non-protected carbon pool is a 'labile' pool that is relatively easily decomposable within years (Six and Jastrow 2002).

As long as the bioremediating vegetation in the in the three constantly inundated sites continue to grow and the sites themselves remain inundated then the organic carbon accumulation rates observed in this study are likely to continue for decades (e.g. Moreno-Mateos ***et al.*** 2012). However, if the Lower Lakes experience low water levels again as they did immediately prior to 2010 then this accumulated organic carbon, being almost exclusively in the non-protected (mainly cPOM) pool, would be expected to rapidly be consumed as the sediment biogeochemical regime changes from a reducing to a more oxidising condition. Unless the Lower Lakes can be assured to remain at near full levels then any carbon accumulated during full conditions is prone to loss as the lakes dry and the sediments become directly exposed to the atmosphere.

5.3.2 The two upland sites (i.e. the Hunters Creek *Melaleuca halmaturorum* sites)

The quantity of carbon in the top 10 cm layer (where accumulation has been most likely) at both of the *Melaleuca halmaturorum* comparison sites show negligible organic carbon accumulation in the top 10 cm of these soil layers, albeit a slight increase in organic carbon in the 0-2.5 cm surficial layer under the 10 year old *Melaleuca halmaturorum*. This data indicates that, if anything, the relatively slow growth of the *Melaleuca halmaturorum* at the 10 year old remediation site may have not provided as much organic matter input as the agricultural crops grown at the control site. Similarly the data indicates that, if anything, the relatively slow growth of the remnant *Melaleuca halmaturorum* may not provide as much organic matter input as the thick juncus species growing adjacent to the remnant.

The recovery of mass at the two upland sites (as cPOM, microaggregates, d-silt, and d-clay) after the microaggregate isolation procedure was 93.9 % with a standard deviation of 7.6%.

The physically protected pool represented the largest residue-C stabilized pool, averaging 45% of total stabilized C. Within the physically protected pool when sub-fractions amounts were large enough to measure we found that at the two upland sites 4–21% was associated with microaggregate-associated hydrolysable silt and clay fractions, the iPOM fraction comprised 12–56% and the non-hydrolysable fractions accounted for 7-59% of the carbon.

6.0 Conclusions

The key findings of this study are:

1) At the three constantly inundated sites (i.e. the Waltowa, Meningie and the Hunters Creek *Schoenoplectus valaidus* sites) vegetation has increased the storage of organic carbon considerably within the surface layers after only a few years of growth. The initial rates of organic carbon increase in the three constantly inundated sites were 866 kg C ha^{-1} yr^{-1} for the *Phragmites* site at Waltowa, and 670 kg C ha^{-1} yr^{-1} and 903 kg C ha^{-1} yr^{-1} for the *Schoenoplectus valaidus* at Meningie and Hunters Creek, respectively. These rates of organic carbon increase are in accord with the rates typically found for such situations.

2) The rates of inorganic carbon (carbonate) accumulation due to the presence of vegetation at the three constantly inundated sites were very low to negligible compared to the rates of organic carbon accumulation.

3) These organic carbon increases at the three constantly inundated sites were almost totally in the relatively short-lived non-protected soil carbon pool with the main contributor being the cPOM (i.e. the coarse (> 250 µm) particulate organic matter). Thus the increase and maintenance of the additional stored carbon under the bioremediating vegetation is likely to be contingent on the maintenance of 1) the vegetation and the consequent supply of organic matter to this pool, and 2) of constantly inundating conditions.

4) The vegetation at the three constantly inundated sites and the size of the accumulation of the non-protected carbon pool (which is composed of relatively recent plant materials) in the sediment provide a food source to benthic and other biota. The elevated nickel concentrations in some of this vegetation needs to be a factor in any consideration of the ecological food web of the Lower Lakes.

5) There has been negligible organic carbon accumulation in the top 10 cm of these soil layers at the two upland sites (i.e. the Hunters Creek *Melaleuca halmaturorum* sites) indicating that the relatively slow growth of the *Melaleuca halmaturorum* may have not provided as much organic matter input as the agricultural crops grown or the juncus species growing at the control areas at these sites.

7.0 Recommendations

1) The data clearly shows that the different vegetation types, established vegetation on the lake sediments post lake re-filling at the three constantly inundated sites had similar and relatively high rates of organic carbon sequestration. The main carbon pool that was accumulating in these sediments during the early stages of vegetation establishment was the non-protected pool, a pool considered prone to removal via oxidation. In order to better understand the carbon sequestration processes under the lake vegetation it would be necessary to examine the residence (i.e. level of permanence) and oxidative behavior of the cPOM and microaggregate carbon pools in these sandy sediments in detail. Although the lability of these pools has been demonstrated in upland soil conditions this has not been examined previously for lake sediments either during inundation or after drying events.

2) It is our recommendation that such a study be undertaken in order to predict firstly the potential of these sediments to sequester carbon under the present lake conditions (i.e. high water levels), and 2) to be able to predict the fate of these sediments both under greater durations of inundation and also if in the future these sediments are exposed to the atmosphere during any repeat of the dry conditions of 2007-2010.

3) In a lake environment, including sites treated by bioremediation techniques, there are a number of scenarios where subsurface bio-available trace metals could enter the surface aquatic ecosystem. This includes ingestion by burrowing benthic organisms, translocation into plants via roots (this is an especially important consideration for lake sediment bioremediation via revegetation) and direct ingestion by foraging animals (e.g. insects, birds and fish). As such, the fate and possible mobility of subsurface pore-water nickel and zinc at these sites requires consideration from both a geochemical perspective (i.e. developing the knowledge required to predict how pore-water nickel and zinc will change into the future) and an ecological perspective (i.e. examining nickel and zinc uptake in potentially exposed organisms). The data on vegetation composition in this report clearly indicates that the contents of metals (especially nickel) in some of the vegetation are very high. This possibility was raised in an earlier report (Sullivan *et al.* 2011) and could have implications for the ecology of the Lower Lakes.

4) It is our recommendation that further detailed monitoring of the formerly severely acidic sediments and the overlying bioremediating vegetation be undertaken to assess the ongoing environmental risks posed by the presence, demonstrated here, of very high concentrations of potentially toxic trace metals in the vegetation growing on these sites.

5) It is our recommendation that other vegetation types also be examined further (by studies along the lines of that provided in this report) for their effectiveness in bioremediation and carbon sequestration in the lake sediments. These species would include those likely to occupy significant areas of the lakes either naturally or after introduction, and would include other reed species and grasses/sedges (such as Gahnia).

6) It is our recommendation that further more detailed studies along the lines of that provided in this report be undertaken to develop a measure of 'eco-system' productivity of the different vegetation types. Simply, the non-stable carbon pools are a source of ecosystem energy and the rates of cycling of these pools and the rates of biomass production could, *inter alia*, be used for this purpose.

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9.0 Appendices

APPENDIX 1. Site and sample descriptions

Table 9-1. Site and profile descriptions.

Location	Treatment	Date	Profile	GPS Co-ordinates Zone East, North.	Location and Profile Remarks
Meningie, Lake Albert	*Schoenoplectus valaidus* bed (vegetation, higher EC)	27/03/12	P, Q	54H 0349262, 6049351	0-7 cm wave actioned clean sand. ~25 cm sharp change from sand to massive light marine clay containing thin grey/beige sand layers. Common living root knots down to 15 cm.
	Control (no vegetation, higher EC)	27/03/12	R, S	54H 0349265, 6049351	Site within 2-3 m of vegetated site. 0-8 cm wave actioned clean sand. ~20 cm sharp change from sand to massive light marine clay containing thin grey/beige sand layers. Some old root knots down to ~15 cm.
Waltowa, Lake Albert	*Phragmites australis* bed	29/03/12	Y, Z	54H 0352278, 6059119	Two type profiles: 1. 0-30 cm: beige sand with iron segregations. 30-40 cm: grey sand. 2. Overlying monosulfidic black ooze layer ~ 8 cm thick. 0-30 cm: beige sand with iron segregations. 30-40 cm: grey sand.
	Control (unplanted)	28/03/12	W, X	54H 0352268, 6059127	0-5 cm wave actioned clean sand. 5-30 cm: beige sand with iron segregations. 30-40 cm: grey sand.
Hunters Creek, Hindmarsh Island	*Schoenoplectus valaidus* bed (vegetation, low EC)	26/03/12	C, D	54H 0308834, 6066394	0-8 cm: dark grey organic matter layer with abundant roots. 8-15 cm: grey sandy layer, white zones around roots; abundant roots. 15-26 cm: dark grey clayey sand layer. 26-45 cm: grey sandy layer. Hunters Creek property, Wyndgate.
	Control (no vegetation, low EC)	26/03/12	A, B	54H 0308825, 6066388	0-8 cm: dark grey organic matter layer with common roots. 8-15 cm: grey sandy layer, white zones around roots; frequent roots. 15-26 cm: dark grey clayey sand layer. 26-45 cm: grey sandy layer.
	Remnant Stand *Melaleuca halmaturorum*	26/03/12	F, G	54H 0308380, 6065461 (sampling sites 3-4 m from this location)	Uniform grey clayey texture down to at least 50 cm Iron segregations frequent. Frequent chambers and channels. Occasional 20 mm diameter crab holes on surface. Water table at 25 cm at time of beginning of sampling but at 2 cm above surface at end of sampling due to tidal rise.
	Control for Remnant Stand	26/03/12	H, I	54H 0308380, 6065461 (Sampling sites 3-4 m from this location)	Under thick rush (*juncus*) vegetation. Uniform grey clayey texture down to at least 50 cm. Iron segregations frequent. Frequent chambers and channels.
	10 year Revegetation Site *Melaleuca halmaturorum*	26/03/12	L, M	54H 0308329, 6065480 (sampling sites 5-10 m from this location)	On surface a thin litter layer of melaleuca leaves. 0-15 cm: dark grey massive sandy clay. 15-40 cm: very pale coarsely structured (sub-angular blocky) beige clay.
	Control for 10 year Revegetation site	26/03/12	J, K	54H 0308329, 6065480 (sampling sites 5-10 m from this location)	0-15 cm: dark grey massive sandy clay. 15-40 cm: very pale coarsely structured (sub-angular blocky) beige clay.

APPENDIX 2. Laboratory procedure for carbon fractionation

SUMMARY OF LABORATORY PROCEDURE FOR CARBON FRACTIONATION

1. Soil is broken up to pass through an 8 mm sieve and air-dried at 60°C (Six *et al.* 2000; Plante *et al.* 2006b).

2. A 100g sample of soil is submerged in deionised water over a 2 mm sieve (Plante *et al.* 2006b) which is shaken up and down 3 cm 50 times over 2 mins (Six *et al.* 1998). The >2mm fraction is backwashed, oven dried at 60°C and weighed. The >2 mm floating material is discarded.

3. The water/soil sample is poured onto a 250 µm mesh screen above a 53 µm screen and gently shaken and flushed with water (Six *et al.* 2000).

4. The >250 µm material is collected (**cPOM**) and dried at 60°C.

5. Material on the 53 µm screen is wet sieved for 50 strokes over 2 mins.

6. The >53 µm fraction is collected (**µagg**) by gently backflushing the sieve, oven dried at 60°C and weighed.

7. The <53 µm suspension is centrifuged for 7 min at 127 x *g* to separate out silt-sized fraction (**dSilt**) and for 15 min at 1730 x *g* for the clay-sized fraction (**dClay**). The suspended clay fraction is flocculated with 0.25M $CaCl_2$–$MgCl_2$. Both fractions are then oven dried at 60°C and weighed.

8. From the **µagg** fraction (*from step 6*), a 5 g subsample is brought to room temperature and suspended in 35 mL of 1.85 g cm^{-3} sodium polytungstate (SPT) in a 50 mL graduated centrifuge tube. The tube is slowly reciprocally shaken 10 times (or more) to bring the sample into suspension (Six *et al.* 1998). Any material on the cap is washed into the sample with 10 mL SPT. The sample is then put under vacuum (100 kPa) for 10 mins and then allowed to equilibrate for 20 mins (Six *et al.* 1998).

9. The suspension is centrifuged for 1 hr at 1250 x *g*.

10. The floating material (**LF**) is aspirated onto a 20 µm nylon filter, rinsed thoroughly and transferred to an aluminium pan and dried at 50°C (Six *et al.* 1998).

11. The heavy fraction is rinsed twice with 50 mL deionised water and dispersed by shaking overnight with 12 glass beads (Stewart *et al.* 2009). After shaking, the sample is rinsed through a 53 µm sieve.

12. The >53 µm size fraction is flushed from the sieve, dried and weighed (**iPOM**).

13. The <53 µm size fraction is separated into **µSilt** and **µClay** by centrifugation.

14. A 0.5g sample of **dClay** and **dSilt** (*from step 7*) and **µSilt** and **µClay** (*from step 13*) is refluxed in 25 mL of 6M HCl for 16 hr. The suspensions are then washed and filtered with de-ionised water over a glass fibre filter, dried and weighed. This gives the non-hydrolysable C fractions (**NH-dSilt**, **NH-dClay**, **NH-µSilt** and **NH-µClay**) and hydrolysable C fractions (**H-dSilt**, **H-dClay**, **H-µSilt** and **H-µClay**).

APPENDIX 3. Characteristics of soil materials

Table 9-2. Soil characteristics of the Meningie, Lake Albert soil materials (March 2012).

Profile ID*	Depth Range (cm)	moisture content (%)	Bulk Density (g/cm^3)	Sediment Fractions (%)					pH 1:5 soil:water	EC 1:5 soil:water (µS/cm)	Total N (%N)	Total C (%C)	Total Organic C (%C)	Total Carbonate (%C)
				>2mm	2mm – 250µm	250 – 53µm	Silt	Clay						
P	0-2.5	32.59	0.81	12.50	47.76	38.96	0.00	0.10	8.96	484	0.01	0.32	0.32	0.00
P	2.5-5	29.24	0.98	3.61	46.42	49.54	0.01	0.05	8.96	566	<0.01	0.25	0.19	0.06
P	5-10	33.45	0.69	3.95	56.22	38.70	0.14	0.23	8.70	1,077	0.02	0.36	0.29	0.07
P	10-15	27.25	0.93	0.00	33.23	65.61	0.00	0.20	8.79	1,398	<0.01	0.23	0.13	0.11
P	15-20	22.64	0.95	2.77	33.26	62.59	0.00	0.14	8.55	2,279	<0.01	0.20	0.07	0.13
P	20-30	39.41	0.59	12.58	60.34	24.63	0.08	0.33	5.04	4,790	0.03	0.51	0.48	0.03
P	30-40	66.67	n.a.	31.40	33.91	23.07	2.50	0.72	3.95	13,190	0.31	3.09	3.08	0.01
Q	0-2.5	26.42	1.22	21.47	33.65	44.07	0.02	0.09	8.76	638	0.02	0.43	0.37	0.06
Q	2.5-5	23.14	1.02	8.80	59.52	26.35	0.04	0.13	8.66	722	0.01	0.38	0.31	0.07
Q	5-10	25.79	0.91	13.22	72.75	12.82	0.08	0.19	8.50	1,046	0.03	0.67	0.65	0.02
Q	10-15	21.58	0.98	2.22	41.27	55.64	0.05	0.05	8.56	1,048	<0.01	0.35	0.22	0.14
Q	15-20	21.08	1.09	0.82	42.79	55.42	0.13	0.18	8.74	931	<0.01	0.30	0.10	0.21
Q	20-30	26.89	0.90	8.73	74.76	14.08	0.27	0.85	7.50	4,360	0.06	0.75	0.54	0.21
Q	30-40	56.87	0.39	57.37	24.98	7.58	0.94	0.45	3.85	12,390	0.37	3.38	2.52	0.86
R	0-2.5	23.30	0.98	20.54	44.23	34.46	0.06	0.09	8.30	694	0.03	0.32	0.21	0.11
R	2.5-5	22.01	1.16	6.83	64.98	27.39	0.01	0.08	8.33	852	<0.01	0.22	0.13	0.09
R	5-10	18.86	1.15	1.34	37.38	61.13	0.05	0.11	8.58	1,106	<0.01	0.24	0.12	0.11
R	10-15	19.24	1.09	0.32	55.68	42.57	0.09	0.25	8.62	1,735	<0.01	0.25	0.09	0.16
R	15-20	18.59	1.19	0.73	36.20	61.61	0.44	0.06	7.51	3,520	0.01	0.20	0.16	0.04
R	20-30	42.98	0.55	10.87	47.18	37.73	0.62	0.70	3.97	7,120	0.12	1.25	1.19	0.06
R	30-40	59.24	0.36	38.56	34.61	16.85	1.25	0.72	3.95	15,750	0.39	3.49	3.02	0.47
S	0-2.5	21.16	1.11	24.70	46.14	28.32	0.06	0.07	8.68	594	0.02	0.29	0.17	0.12
S	2.5-5	21.72	1.06	0.86	34.15	64.17	0.08	0.11	8.75	809	<0.01	0.23	0.10	0.13
S	5-10	20.90	1.05	0.27	22.70	75.16	0.08	0.17	8.77	1,218	0.01	0.23	0.09	0.14
S	10-15	19.31	1.17	2.30	61.87	34.63	0.00	0.25	8.61	1,764	<0.01	0.19	0.05	0.14
S	15-20	20.10	1.14	1.92	51.50	44.12	0.31	0.44	7.00	2,780	<0.01	0.11	0.10	0.02
S	20-30	49.22	0.45	29.49	43.64	18.77	0.94	0.43	4.04	10,040	0.24	2.32	2.26	0.06
S	30-40	56.94	0.34	55.43	20.21	16.62	0.78	0.37	4.00	15,050	0.36	3.23	3.19	0.04

** See Table 9-1 in Appendix 1 for further details on the treatment.*

Table 9-3. Organic carbon fractionation (%C) of the Meningie, Lake Albert soil materials (March 2012).

Profile ID*	Depth Range (cm)	cPOM	LF	iPOM	µagg	µSilt	µClay	NH-dSilt	NH-dClay	H-dSilt	H-dClay	NH-µSilt	NH-µClay	H-µSilt	H-µClay	dSilt	dClay
P	0-2.5	0.1300	-	0.0213	0.0555	-	-	-	-	-	-	-	-	-	-	-	-
P	2.5-5	0.0766	-	0.0232	0.0680	-	-	-	-	-	-	-	-	-	-	-	-
P	5-10	0.1602	-	0.0127	0.0689	-	-	-	-	-	-	-	-	-	-	0.0031	-
P	10-15	0.0494	-	0.0226	0.0515	-	-	-	-	-	-	-	-	-	-	-	-
P	15-20	0.0226	-	0.0060	0.0657	-	-	-	-	-	-	-	-	-	-	-	-
P	20-30	0.1909	-	0.0203	0.0512	-	-	-	-	-	-	-	-	-	-	-	0.0071
P	30-40	1.2715	-	0.0466	0.3469	-	0.1157	0.0659	0.0177	0.0040	0.0040	-	-	-	-	0.0700	0.0217
Q	0-2.5	0.1497	-	0.0394	0.0895	-	-	-	-	-	-	-	-	-	-	-	-
Q	2.5-5	0.1744	-	0.0186	0.0456	-	-	-	-	-	-	-	-	-	-	-	-
Q	5-10	0.4045	-	0.0098	0.0376	-	-	-	-	-	-	-	-	-	-	-	-
Q	10-15	0.1048	-	0.0295	0.0511	-	-	-	-	-	-	-	-	-	-	-	-
Q	15-20	0.0535	-	0.0000	0.0275	-	-	-	-	-	-	-	-	-	-	-	-
Q	20-30	0.3543	-	0.0062	0.0445	-	-	0.0051	0.0152	0.0000	0.0046	-	-	-	-	0.0051	0.0198
Q	30-40	0.8067	-	0.0102	0.1200	0.0471	0.0440	0.0237	-	0.0010	-	-	0.0326	-	0.0114	0.0247	0.0135
R	0-2.5	0.0994	-	0.0156	0.0590	-	-	0.0035	0.0023	0.0001	0.0011	-	-	-	-	0.0036	0.0034
R	2.5-5	0.0564	-	0.0074	0.0376	-	-	-	-	-	-	-	-	-	-	-	-
R	5-10	0.0946	-	0.0198	0.0429	-	-	-	-	-	-	-	-	-	-	-	-
R	10-15	0.0262	-	0.0053	0.0242	-	-	-	-	-	-	-	-	-	-	-	0.0057
R	15-20	0.0239	-	0.0065	0.0223	-	-	-	-	-	-	-	-	-	-	0.0091	-
R	20-30	0.5502	-	0.0175	0.1674	-	-	0.0130	-	0.0004	-	-	-	-	-	0.0134	0.0257
R	30-40	1.1769	-	0.0270	0.1929	0.0837	0.0474	0.0304	0.0177	0.0000	0.0053	-	-	-	-	0.0304	0.0230
S	0-2.5	0.0646	-	0.0157	0.0331	-	-	-	-	-	-	-	-	-	-	0.0015	-
S	2.5-5	0.0482	-	0.0201	0.0783	-	-	-	-	-	-	-	-	-	-	0.0000	-
S	5-10	0.0426	-	0.0346	n.a.	-	-	-	0.0068	-	0.0001	-	-	-	-	0.0018	0.0069
S	10-15	0.0365	-	0.0075	0.0083	-	-	-	-	-	-	-	-	-	-	-	0.0057
S	15-20	0.0644	-	0.0098	0.0176	-	-	-	-	-	-	-	-	-	-	0.0046	0.0096
S	20-30	0.8554	-	0.0171	0.1126	-	-	0.0181	-	0.0000	-	-	-	-	-	0.0181	0.0107
S	30-40	0.5356	-	0.0264	0.1162	-	-	0.0153	-	0.0000	-	-	-	-	-	0.0153	0.0118

** See Table 9-1 in Appendix 1 for further details on the treatment.*

Table 9-4. Non-protected and protected organic carbon fractions (%C) of the Meningie, Lake Albert soil materials (March 2012).

Profile ID*	Depth Range (cm)	Chemical (H-dSilt + H-dClay)	Biochemical (NH-dSilt + NH-dClay)	Non-Protected (cPOM + LF)	Physical (µagg + iPOM)
P	0-2.5	-	-	0.1300	0.0767
P	2.5-5	-	-	0.0766	0.0912
P	5-10	-	-	0.1602	0.0816
P	10-15	-	-	0.0494	0.0741
P	15-20	-	-	0.0226	0.0717
P	20-30	-	-	0.1909	0.0715
P	30-40	0.0080	0.0837	1.2715	0.3935
Q	0-2.5	-	-	0.1497	0.1289
Q	2.5-5	-	-	0.1744	0.0642
Q	5-10	-	-	0.4045	0.0473
Q	10-15	-	-	0.1048	0.0806
Q	15-20	-	-	0.0535	0.0275
Q	20-30	0.0046	0.0203	0.3543	0.0507
Q	30-40	0.0010	0.0237	0.8067	0.1302
R	0-2.5	0.0012	0.0058	0.0994	0.0746
R	2.5-5	-	-	0.0564	0.0450
R	5-10	-	-	0.0946	0.0627
R	10-15	-	-	0.0262	0.0295
R	15-20	-	-	0.0239	0.0288
R	20-30	0.0004	0.0130	0.5502	0.1849
R	30-40	0.0053	0.0480	1.1769	0.2198
S	0-2.5	-	-	0.0646	0.0487
S	2.5-5	-	-	0.0482	0.0984
S	5-10	0.0001	0.0068	0.0426	n.a.
S	10-15	-	-	0.0365	0.0158
S	15-20	-	-	0.0644	0.0275
S	20-30	0.0000	0.0181	0.8554	0.1297
S	30-40	0.0000	0.0153	0.5356	0.1425

** See Table 9-1 in Appendix 1 for further details on the treatment.*

Table 9-5. Soil fraction masses and recoveries for the Meningie, Lake Albert soil materials (March 2012).

Profile ID*	Depth Range (cm)	Soil Mass Sieved (g)	Sieved Sediment Fractions					Recovery (%)
			>2mm (g)	cPOM (g)	µagg (g)	dSilt (g)	dClay (g)	
P	0-2.5	200.00	24.9941	95.5133	77.9177	0.0000	0.2073	99.3%
P	2.5-5	200.00	7.2167	92.8363	99.0765	0.0118	0.1088	99.6%
P	5-10	200.00	7.8952	112.4498	77.4034	0.2855	0.4696	99.3%
P	10-15	200.00	0.0000	66.4606	131.2234	0.0000	0.3976	99.0%
P	15-20	200.00	5.5455	66.5200	125.1797	0.0000	0.2841	98.8%
P	20-30	200.00	25.1630	120.6879	49.2677	0.1527	0.6505	98.0%
P	30-40	200.00	62.7994	67.8145	46.1307	4.9959	1.4481	91.6%
Q	0-2.5	200.00	42.9356	67.2971	88.1380	0.0366	0.1734	99.3%
Q	2.5-5	200.00	17.5977	119.0407	52.7072	0.0899	0.2665	94.9%
Q	5-10	200.00	26.4495	145.4904	25.6323	0.1605	0.3700	99.1%
Q	10-15	200.00	4.4370	82.5441	111.2804	0.0977	0.0967	99.2%
Q	15-20	200.00	1.6369	85.5772	110.8446	0.2604	0.3531	99.3%
Q	20-30	200.00	17.4504	149.5134	28.1632	0.5357	1.6960	98.7%
Q	30-40	200.00	114.7490	49.9530	15.1501	1.8774	0.8957	91.3%
R	0-2.5	200.00	41.0833	88.4636	68.9287	0.1229	0.1788	99.4%
R	2.5-5	200.00	13.6692	129.9548	54.7735	0.0282	0.1589	99.3%
R	5-10	200.00	2.7089	75.7815	123.9483	0.0934	0.2225	101.4%
R	10-15	200.00	0.6483	111.3533	85.1344	0.1898	0.4990	98.9%
R	15-20	200.00	1.4541	72.4044	123.2151	0.8817	0.1173	99.0%
R	20-30	200.00	21.7379	94.3662	75.4576	1.2332	1.4089	97.1%
R	30-40	200.00	77.1111	69.2283	33.6919	2.4970	1.4405	92.0%
S	0-2.5	200.00	49.4039	92.2827	56.6497	0.1103	0.1431	99.3%
S	2.5-5	200.00	1.7176	68.3004	128.3482	0.1581	0.2104	99.4%
S	5-10	200.00	0.5488	45.3939	150.3143	0.1556	0.3374	98.4%
S	10-15	200.00	4.6077	123.7309	69.2666	0.0000	0.5052	99.1%
S	15-20	200.00	3.8343	103.0073	88.2400	0.6243	0.8844	98.3%
S	20-30	200.00	58.9735	87.2858	37.5310	1.8847	0.8527	93.3%
S	30-40	200.00	110.8511	40.4193	33.2414	1.5642	0.7344	93.4%

** See Table 9-1 in Appendix 1 for further details on the treatment.*

Table 9-6. Soil characteristics of the Waltowa soil materials (March 2012).

Profile ID*	Depth Range (cm)	moisture content (%)	Bulk Density (g/cm³)	Sediment Fractions (%)					pH 1:5 soil:water	EC 1:5 soil:water (µS/cm)	Total N (%N)	Total C (%C)	Total Organic C (%C)	Total Carbonate (%C)
				>2mm	2mm – 250µm	250 – 53µm	Silt	Clay						
Y	0-2.5	50.09	0.62	9.83	64.29	23.39	0.24	0.26	8.51	1,405	0.22	2.67	2.15	0.52
Y	2.5-5	22.16	1.05	11.89	47.08	39.38	0.22	0.22	8.44	969	0.05	0.78	0.64	0.14
Y	5-10	21.32	1.07	0.19	14.07	84.44	0.28	0.25	8.08	858	0.01	0.17	0.09	0.08
Y	10-15	20.84	1.03	0.09	1.29	97.42	0.12	0.28	8.06	917	<0.01	0.13	0.05	0.08
Y	15-20	21.25	1.10	1.89	0.74	96.48	0.07	0.17	7.43	941	0.01	0.13	0.08	0.05
Y	20-30	22.48	1.07	4.25	6.19	87.94	0.44	0.30	6.15	1,511	0.03	0.38	0.35	0.03
Y	30-40	33.87	0.79	9.29	11.97	76.69	0.55	0.38	6.00	2,264	0.05	0.63	0.57	0.06
Z	0-2.5	35.87	0.67	44.61	34.76	17.74	0.42	0.55	8.47	1,526	0.23	2.73	2.53	0.20
Z	2.5-5	32.93	0.81	3.25	49.96	45.24	0.30	0.39	8.99	717	0.04	0.68	0.51	0.16
Z	5-10	22.05	1.08	1.48	30.92	66.80	0.16	0.23	8.99	541	0.01	0.14	0.12	0.03
Z	10-15	20.89	1.16	0.39	1.35	97.22	0.10	0.21	8.23	745	0.01	0.17	0.11	0.06
Z	15-20	21.47	1.14	0.23	1.70	97.06	0.18	0.16	7.82	728	<0.01	0.13	0.08	0.05
Z	20-30	24.33	0.93	1.25	6.74	90.05	0.64	0.42	6.88	1,135	0.02	0.29	0.27	0.01
Z	30-40	92.65	0.81	14.83	15.91	65.51	1.25	0.46	5.94	2,500	0.06	0.70	0.68	0.03
W	0-2.5	24.54	1.22	2.59	67.46	29.01	0.11	0.19	8.81	566	0.02	0.29	0.26	0.03
W	2.5-5	22.78	1.04	2.04	25.82	71.33	0.10	0.18	7.78	637	0.01	0.21	0.19	0.02
W	5-10	21.61	1.05	3.14	5.33	90.69	0.11	0.44	7.08	538	<0.01	0.13	0.12	0.01
W	10-15	21.50	1.07	0.05	1.04	98.33	0.09	0.35	6.98	603	<0.01	0.11	0.10	0.01
W	15-20	23.55	0.93	10.22	17.09	71.84	0.16	0.15	6.84	709	0.03	0.32	0.28	0.05
W	20-30	24.39	0.98	6.95	30.24	61.65	0.27	0.17	5.90	1,009	0.02	0.30	0.24	0.05
W	30-40	39.01	0.65	15.50	8.86	72.09	1.14	0.76	4.86	2,640	0.08	0.90	0.82	0.08
X	0-2.5	21.88	1.04	7.44	26.63	65.07	0.21	0.20	9.10	437	0.02	0.23	0.18	0.05
X	2.5-5	20.28	1.16	5.99	34.93	57.99	0.12	0.27	7.80	654	0.02	0.29	0.28	0.01
X	5-10	21.43	1.04	1.77	3.54	93.83	0.10	0.12	7.07	376	<0.01	0.13	0.13	0.00
X	10-15	21.20	1.06	0.17	1.29	98.09	0.13	0.31	7.47	411	<0.01	0.18	0.18	0.00
X	15-20	21.91	1.10	4.22	2.45	92.18	0.36	0.19	7.11	643	0.03	0.34	0.34	0.01
X	20-30	25.02	0.94	2.98	25.29	70.63	0.26	0.41	6.11	832	0.04	0.44	0.42	0.02
X	30-40	29.26	0.84	8.68	13.92	76.75	0.39	0.22	6.87	1,561	0.08	0.84	0.80	0.04

** See Table 9-1 in Appendix 1 for further details on the treatment.*

Table 9-7. Organic carbon fractionation (%C) of the Waltowa soil materials (March 2012).

Profile ID*	Depth Range (cm)	cPOM	LF	iPOM	µagg	µSilt	µClay	NH-dSilt	NH-dClay	H-dSilt	H-dClay	NH-µSilt	NH-µClay	H-µSilt	H-µClay	dSilt	dClay
Y	0-2.5	0.7046	-	0.0261	0.0926	-	-	0.0039	-	0.0007	-	-	-	-	-	0.0045	0.0079
Y	2.5-5	0.2797	-	0.0168	0.0814	-	-	0.0045	0.0059	0.0006	0.0005	-	-	-	-	0.0050	0.0064
Y	5-10	0.0445	-	0.0461	0.0506	-	-	0.0042	0.0059	0.0006	0.0000	-	-	-	-	0.0047	0.0059
Y	10-15	0.0090	-	0.0278	0.0423	-	-	0.0028	0.0066	0.0002	0.0004	-	-	-	-	0.0030	0.0070
Y	15-20	0.0225	-	0.0579	0.0741	-	-	-	0.0036	-	0.0000	-	-	-	-	0.0011	0.0036
Y	20-30	0.0811	-	0.0623	0.1273	-	-	0.0037	0.0059	0.0004	0.0001	-	-	-	-	0.0042	0.0060
Y	30-40	0.1607	-	0.0661	0.1434	-	-	0.0030	-	0.0013	-	-	-	-	-	0.0043	0.0070
Z	0-2.5	0.9407	-	0.0335	0.1526	-	-	0.0095	0.0110	0.0022	0.0050	-	-	-	-	0.0117	0.0160
Z	2.5-5	0.1983	-	0.0304	0.0611	-	-	0.0050	-	0.0005	-	-	-	-	-	0.0056	0.0107
Z	5-10	0.0458	-	0.0151	0.0513	-	-	-	0.0054	-	0.0000	-	-	-	-	0.0023	0.0055
Z	10-15	0.0095	-	0.0599	0.0640	-	-	-	0.0054	-	0.0000	-	-	-	-	0.0015	0.0054
Z	15-20	0.0231	-	0.0610	0.0600	-	-	0.0021	0.0036	0.0000	0.0000	-	-	-	-	0.0021	0.0036
Z	20-30	0.0728	-	0.0546	0.1395	-	-	0.0058	-	0.0011	-	-	-	-	-	0.0069	0.0097
Z	30-40	0.1987	-	0.0825	0.1592	-	-	0.0131	-	0.0017	-	-	-	-	-	0.0148	0.0112
W	0-2.5	0.1782	-	0.0199	0.0336	-	-	-	0.0044	-	0.0018	-	-	-	-	0.0018	0.0062
W	2.5-5	0.0728	-	0.0306	0.0762	-	-	0.0014	-	0.0000	-	-	-	-	-	0.0014	-
W	5-10	0.0227	-	0.0330	0.0524	-	-	-	-	-	-	-	-	-	-	0.0009	0.0109
W	10-15	0.0129	-	0.0349	0.0863	-	-	-	-	-	-	-	-	-	-	0.0012	-
W	15-20	0.0557	-	0.0316	0.0444	-	-	-	0.0035	-	0.0000	-	-	-	-	0.0018	0.0035
W	20-30	0.1455	-	0.0339	0.1004	-	-	0.0021	-	0.0000	-	-	-	-	-	0.0021	-
W	30-40	0.1504	-	0.0714	0.1531	-	-	0.0142	0.0153	0.0034	0.0005	-	-	-	-	0.0177	0.0158
X	0-2.5	0.0637	-	0.0316	0.0819	-	-	0.0034	0.0063	0.0007	0.0008	-	-	-	-	0.0041	0.0072
X	2.5-5	0.1380	-	0.0344	0.0799	-	-	-	0.0055	-	0.0004	-	-	-	-	0.0015	0.0059
X	5-10	0.0242	-	0.0285	0.0721	-	-	-	0.0025	-	0.0000	-	-	-	-	0.0017	0.0025
X	10-15	0.0112	-	0.0447	0.0802	-	-	-	0.0073	-	0.0002	-	-	-	-	0.0016	0.0074
X	15-20	0.0352	-	0.0456	0.1095	-	-	0.0034	-	0.0000	-	-	-	-	-	0.0034	-
X	20-30	0.1308	-	0.0620	0.1129	-	-	0.0026	0.0070	0.0002	0.0002	-	-	-	-	0.0028	0.0073
X	30-40	0.2375	-	0.0499	0.2055	-	-	0.0026	0.0042	0.0005	0.0001	-	-	-	-	0.0032	0.0043

** See Table 9-1 in Appendix 1 for further details on the treatment.*

Table 9-8. Non-protected and protected organic carbon fractions (%C) of the Waltowa soil materials (March 2012).

Profile ID*	Depth Range (cm)	Chemical (H-dSilt + H-dClay)	Biochemical (NH-dSilt + NH-dClay)	Non-Protected (cPOM + LF)	Physical (µagg + iPOM)
Y	0-2.5	0.0007	0.0039	0.7046	0.1187
Y	2.5-5	0.0011	0.0104	0.2797	0.0983
Y	5-10	0.0006	0.0101	0.0445	0.0967
Y	10-15	0.0005	0.0094	0.0090	0.0701
Y	15-20	0.0000	0.0036	0.0225	0.1320
Y	20-30	0.0005	0.0096	0.0811	0.1897
Y	30-40	0.0013	0.0030	0.1607	0.2095
Z	0-2.5	0.0072	0.0205	0.9407	0.1861
Z	2.5-5	0.0005	0.0050	0.1983	0.0915
Z	5-10	0.0000	0.0054	0.0458	0.0664
Z	10-15	0.0000	0.0054	0.0095	0.1239
Z	15-20	0.0000	0.0057	0.0231	0.1210
Z	20-30	0.0011	0.0058	0.0728	0.1941
Z	30-40	0.0017	0.0131	0.1987	0.2417
W	0-2.5	0.0018	0.0044	0.1782	0.0535
W	2.5-5	0.0000	0.0014	0.0728	0.1067
W	5-10	-	-	0.0227	0.0854
W	10-15	-	-	0.0129	0.1212
W	15-20	0.0000	0.0035	0.0557	0.0760
W	20-30	0.0000	0.0021	0.1455	0.1342
W	30-40	0.0040	0.0295	0.1504	0.2245
X	0-2.5	0.0015	0.0098	0.0637	0.1134
X	2.5-5	0.0004	0.0055	0.1380	0.1143
X	5-10	0.0000	0.0025	0.0242	0.1006
X	10-15	0.0002	0.0073	0.0112	0.1249
X	15-20	0.0000	0.0034	0.0352	0.1551
X	20-30	0.0004	0.0096	0.1308	0.1748
X	30-40	0.0007	0.0068	0.2375	0.2554

** See Table 9-1 in Appendix 1 for further details on the treatment.*

Table 9-9. Soil fraction masses and recoveries for the Waltowa soil materials (March 2012).

Profile ID*	Depth Range (cm)	Soil Mass Sieved (g)	Sieved Sediment Fractions >2mm (g)	cPOM (g)	µagg (g)	dSilt (g)	dClay (g)	Recovery (%)
Y	0-2.5	200.00	19.6550	128.5704	46.7812	0.4814	0.5161	98.0%
Y	2.5-5	200.00	23.7811	94.1576	78.7502	0.4444	0.4361	98.8%
Y	5-10	200.00	0.3708	28.1394	168.8765	0.5506	0.4977	99.2%
Y	10-15	200.00	0.1890	2.5793	194.8429	0.2457	0.5568	99.2%
Y	15-20	200.00	3.7869	1.4899	192.9631	0.1494	0.3463	99.4%
Y	20-30	200.00	8.4931	12.3742	175.8862	0.8861	0.6019	99.1%
Y	30-40	200.00	18.5792	23.9415	153.3877	1.0913	0.7550	98.9%
Z	0-2.5	200.00	89.2296	69.5209	35.4877	0.8364	1.0927	98.1%
Z	2.5-5	200.00	6.5036	99.9157	90.4742	0.5986	0.7892	99.1%
Z	5-10	200.00	2.9583	61.8478	133.6091	0.3104	0.4505	99.6%
Z	10-15	200.00	0.7806	2.7071	194.4473	0.2022	0.4263	99.3%
Z	15-20	200.00	0.4504	3.4099	194.1175	0.3660	0.3138	99.3%
Z	20-30	200.00	2.5039	13.4789	180.1018	1.2710	0.8361	99.1%
Z	30-40	200.00	29.6683	31.8168	131.0127	2.5009	0.9116	98.0%
W	0-2.5	200.00	5.1886	134.9289	58.0214	0.2204	0.3746	99.4%
W	2.5-5	200.00	4.0810	51.6414	142.6568	0.1967	0.3583	99.5%
W	5-10	200.00	6.2772	10.6663	181.3768	0.2148	0.8844	99.7%
W	10-15	200.00	0.0957	2.0703	196.6689	0.1763	0.7060	99.9%
W	15-20	200.00	20.4380	34.1770	143.6862	0.3204	0.3001	99.5%
W	20-30	200.00	13.9019	60.4725	123.3036	0.5378	0.3480	99.3%
W	30-40	200.00	31.0048	17.7289	144.1885	2.2781	1.5265	98.4%
X	0-2.5	200.00	14.8703	53.2591	130.1343	0.4205	0.4052	99.5%
X	2.5-5	200.00	11.9708	69.8556	115.9822	0.2305	0.5485	99.3%
X	5-10	200.00	3.5387	7.0857	187.6611	0.1940	0.2384	99.4%
X	10-15	200.00	0.3377	2.5937	196.5309	0.2660	0.6243	100.2%
X	15-20	200.00	8.4499	4.8995	184.3695	0.7179	0.3728	99.4%
X	20-30	200.00	5.9569	50.5836	141.2573	0.5211	0.8215	99.6%
X	30-40	200.00	17.3564	27.8449	153.4998	0.7771	0.4413	100.0%

** See Table 9-1 in Appendix 1 for further details on the treatment.*

Table 9-10. Soil characteristics of the Hunters Creek, Hindmarsh Island soil materials (March 2012).

Profile ID*	Depth Range (cm)	moisture content (%)	Bulk Density (g/cm^3)	Sediment Fractions (%)					pH 1:5 soil:water	EC 1:5 soil:water (µS/cm)	Total N (%N)	Total C (%C)	Total Organic C (%C)	Total Carbonate (%C)
				>2mm	2mm – 250µm	250 – 53µm	Silt	Clay						
A	0-2.5	48.70	0.61	42.93	27.56	25.25	0.00	0.19	6.95	670	0.25	4.31	4.31	0.00
A	2.5-5	45.94	0.62	10.12	14.00	73.58	0.38	0.47	7.08	183	0.05	0.89	0.89	0.00
A	5-10	37.22	0.72	0.45	4.06	88.71	2.90	1.15	7.31	166	0.02	0.38	0.34	0.03
A	10-15	39.60	0.66	3.27	2.98	78.81	5.95	1.14	7.32	214	0.02	0.45	0.42	0.03
A	15-20	45.29	0.56	1.43	8.49	81.06	5.16	1.43	8.66	499	0.04	0.81	0.62	0.19
A	20-30	56.90	0.38	1.78	27.56	62.12	3.59	1.26	8.21	1,056	0.04	1.46	0.65	0.81
A	30-40	54.09	0.42	8.35	36.89	46.70	3.47	0.63	8.22	1,773	0.07	2.88	1.04	1.84
B	0-2.5	71.72	0.19	82.71	5.09	8.11	0.42	0.21	7.38	687	0.48	7.15	6.81	0.34
B	2.5-5	60.73	0.31	40.48	13.41	39.52	1.31	0.61	6.03	996	0.27	4.57	3.64	0.93
B	5-10	38.39	0.67	6.19	5.62	83.11	2.73	1.13	7.04	201	0.04	0.56	0.50	0.06
B	10-15	27.57	0.83	1.99	7.18	81.65	5.91	1.35	7.44	492	0.06	0.90	0.79	0.11
B	15-20	46.57	0.56	1.06	11.42	80.81	3.11	0.63	7.71	766	0.06	0.80	0.70	0.10
B	20-30	27.93	0.88	20.29	36.90	39.10	0.60	1.01	8.09	1,955	0.08	3.22	1.04	2.18
B	30-40	26.28	0.89	0.80	27.59	63.98	4.20	0.23	8.35	1,667	0.06	3.06	0.82	2.24
C	0-2.5	78.11	0.19	83.02	4.93	1.00	0.19	0.10	6.23	1,510	0.93	14.90	14.34	0.56
C	2.5-5	58.61	0.41	46.05	18.89	28.99	0.17	0.67	6.46	901	0.60	9.30	9.26	0.04
C	5-10	25.48	1.02	17.94	19.08	60.05	0.74	1.28	6.85	188	0.05	0.83	0.76	0.07
C	10-15	21.77	0.96	3.79	11.02	80.26	0.66	1.18	6.06	166	0.03	0.51	0.45	0.06
C	15-20	21.14	1.09	5.16	16.40	75.50	0.66	1.08	5.56	691	0.02	0.35	0.28	0.07
C	20-30	23.15	0.96	5.33	43.43	48.72	0.54	0.74	7.73	1,314	0.01	1.14	0.18	0.96
C	30-40	26.35	0.91	0.19	0.76	97.41	0.51	0.57	8.59	870	<0.01	3.14	0.96	2.18
D	0-2.5	77.55	0.14	87.18	4.09	1.76	0.12	0.56	7.63	760	0.90	16.20	14.84	1.36
D	2.5-5	47.87	0.52	61.86	12.15	19.93	0.83	1.85	6.73	882	0.64	9.09	9.09	0.00
D	5-10	33.18	0.82	18.35	20.43	59.08	0.28	0.45	6.98	248	0.06	1.30	1.04	0.26
D	10-15	29.21	0.84	4.37	5.67	88.76	0.22	0.38	6.61	188	0.04	0.57	0.57	0.00
D	15-20	29.89	0.92	0.19	3.20	90.88	2.75	1.41	8.29	406	0.03	0.61	0.50	0.11
D	20-30	34.91	0.68	1.17	4.58	90.54	1.23	0.64	8.13	643	0.03	1.03	0.57	0.46
D	30-40	38.15	0.72	0.71	7.39	88.09	1.45	0.71	8.24	1,239	0.04	2.69	0.65	2.04

** See Table 9-1 in Appendix 1 for further details on the treatment.*

Table 9-10 (continued). Soil characteristics of the Hunters Creek, Hindmarsh Island soil materials (March 2012).

Profile ID*	Depth Range (cm)	moisture content (%)	Bulk Density (g/cm^3)	Sediment Fractions (%)					pH 1:5 soil:water	EC 1:5 soil:water (µS/cm)	Total N (%N)	Total C (%C)	Total Organic C (%C)	Total Carbonate (%C)
				>2mm	2mm – 250µm	250 – 53µm	Silt	Clay						
F	0-2.5	53.83	0.43	63.51	23.52	3.97	1.38	1.01	7.09	4,820	0.80	10.70	10.61	0.10
F	2.5-5	47.71	0.63	69.65	20.07	5.47	0.70	0.67	7.18	3,240	0.53	5.81	5.81	0.00
F	5-10	48.16	0.61	16.30	47.71	18.89	11.67	2.28	7.04	3,220	0.37	3.77	3.77	0.00
F	10-15	49.14	0.62	10.59	8.35	17.99	18.50	6.89	7.12	3,150	0.27	2.72	2.40	0.33
F	15-20	47.81	0.65	34.64	32.07	10.33	8.23	8.82	7.33	3,590	0.21	2.10	1.75	0.36
F	20-30	56.14	0.51	11.47	8.94	6.66	64.29	3.54	7.29	4,160	0.20	2.18	1.92	0.27
F	30-40	56.39	0.51	25.42	21.86	7.25	20.37	9.49	7.71	5,210	0.32	3.42	3.20	0.23
G	0-2.5	57.03	0.44	41.38	39.08	7.08	2.30	2.03	7.01	3,790	0.67	7.83	5.72	2.12
G	2.5-5	47.27	0.53	24.13	48.24	14.44	3.37	1.44	6.81	2,910	0.48	5.20	4.93	0.28
G	5-10	48.87	0.56	13.93	39.62	22.63	11.42	3.68	6.88	3,140	0.40	4.15	3.98	0.18
G	10-15	47.07	0.52	13.54	43.03	13.44	11.72	3.92	6.92	3,340	0.25	2.50	2.44	0.07
G	15-20	48.73	0.63	12.69	14.82	11.46	25.60	35.43	7.04	3,020	0.21	2.10	1.84	0.27
G	20-30	48.36	0.43	19.34	23.49	10.31	21.03	10.26	7.37	3,740	0.23	2.52	1.64	0.89
G	30-40	55.59	0.58	12.93	35.16	11.45	18.43	6.19	7.69	4,080	0.23	2.33	1.29	1.05
H	0-2.5	40.80	0.79	51.78	31.40	9.84	0.63	1.00	7.09	3,510	0.58	7.11	4.55	2.57
H	2.5-5	54.63	0.61	32.96	42.51	20.09	1.79	1.63	6.77	3,110	0.48	7.40	4.41	3.00
H	5-10	51.39	0.58	21.41	41.90	14.34	8.39	2.48	6.95	2,980	0.29	3.19	2.46	0.74
H	10-15	52.34	0.62	8.33	34.47	11.85	19.96	12.65	7.02	3,170	0.23	2.41	2.41	0.00
H	15-20	54.14	0.56	8.07	24.39	11.17	29.41	13.67	7.37	3,830	0.20	2.07	2.02	0.06
H	20-30	54.10	0.62	5.65	20.53	7.96	9.47	26.86	7.50	3,710	0.24	2.45	2.38	0.08
H	30-40	50.05	0.69	5.08	8.52	3.75	40.58	22.94	8.15	4,000	0.19	1.84	1.46	0.39
I	0-2.5	52.95	0.39	54.51	30.84	4.80	1.36	0.74	7.12	4,310	0.71	8.33	5.26	3.08
I	2.5-5	56.08	0.39	22.55	52.63	10.53	5.10	1.34	6.99	3,130	0.55	6.22	4.67	1.56
I	5-10	47.68	0.63	32.22	44.69	9.27	3.67	1.09	6.89	3,670	0.51	7.09	2.43	4.67
I	10-15	48.11	0.59	25.01	44.93	12.18	7.19	1.99	7.63	3,210	0.35	4.86	3.77	1.09
I	15-20	48.57	0.62	19.09	33.73	13.70	17.52	6.40	7.57	n.a.	0.22	2.35	2.07	0.29
I	20-30	45.56	0.73	19.10	27.59	11.71	18.23	7.75	7.79	3,750	0.20	2.00	1.95	0.05
I	30-40	51.82	0.64	11.77	25.28	14.42	22.69	12.61	8.14	3,970	0.21	2.04	2.00	0.05

** See Table 9-1 in Appendix 1 for further details on the treatment.*

Table 9-10 (continued). Soil characteristics of the Hunters Creek, Hindmarsh Island soil materials (March 2012).

Profile ID*	Depth Range (cm)	moisture content (%)	Bulk Density (g/cm³)	Sediment Fractions (%)					pH 1:5 soil:water	EC 1:5 soil:water (µS/cm)	Total N (%N)	Total C (%C)	Total Organic C (%C)	Total Carbonate (%C)
				>2mm	2mm – 250µm	250 – 53µm	Silt	Clay						
J	0-2.5	11.46	0.80	4.30	7.73	75.54	3.79	7.76	8.60	490	0.30	5.24	3.05	2.19
J	2.5-5	4.76	1.31	11.71	18.76	61.25	4.82	2.72	8.95	227	0.25	4.24	2.38	1.86
J	5-10	8.14	1.46	13.27	49.16	31.34	3.89	1.91	8.81	561	0.20	3.48	1.83	1.65
J	10-15	13.17	1.39	16.12	15.72	58.46	7.65	1.85	8.83	883	0.16	2.72	1.40	1.32
J	15-20	16.72	1.43	7.97	22.66	55.79	10.55	2.21	8.98	1,422	0.11	1.95	1.05	0.90
J	20-30	14.79	1.33	3.38	34.58	41.09	15.21	5.36	9.17	1,705	0.06	2.53	0.57	1.96
J	30-40	10.79	1.57	2.43	9.71	71.63	13.26	2.57	9.40	1,476	0.02	2.95	0.20	2.75
K	0-2.5	15.06	0.80	12.86	37.92	42.57	3.36	2.38	8.75	310	0.28	4.75	2.82	1.93
K	2.5-5	4.12	1.30	23.33	41.41	31.01	2.18	1.51	8.73	243	0.24	4.01	2.31	1.70
K	5-10	16.73	1.36	27.42	33.40	35.48	2.22	1.48	8.74	404	0.22	3.65	2.86	0.79
K	10-15	6.75	1.30	17.70	7.84	66.52	6.29	1.40	8.63	744	0.15	2.21	1.23	0.98
K	15-20	8.55	1.42	2.94	10.74	76.10	5.51	1.20	8.74	1,065	0.11	2.15	0.81	1.34
K	20-30	7.51	1.36	9.72	46.52	32.43	8.53	2.38	8.91	1,333	0.06	2.71	0.54	2.17
K	30-40	5.88	1.61	0.26	54.30	34.51	5.32	1.63	9.37	1,302	0.02	3.40	0.28	3.12
L	0-2.5	0.10	0.83	15.37	38.80	42.89	0.73	0.85	8.37	389	0.43	6.66	4.63	2.04
L	2.5-5	0.73	1.03	38.83	15.38	42.10	1.27	1.32	8.66	364	0.25	4.95	2.64	2.32
L	5-10	0.52	1.05	25.03	13.60	56.23	2.21	1.29	8.54	660	0.22	4.46	2.38	2.09
L	10-15	1.55	1.12	26.36	21.56	48.11	2.32	1.22	8.74	933	0.21	4.18	2.22	1.97
L	15-20	7.35	1.29	25.18	35.19	33.63	3.76	1.70	8.90	2,220	0.12	3.70	1.22	2.49
L	20-30	7.67	1.40	25.81	53.67	13.23	1.47	1.79	9.12	2,430	0.06	3.98	0.58	3.40
L	30-40	8.16	1.44	0.78	12.64	62.31	17.60	5.78	9.40	2,114	0.02	3.75	0.26	3.49
M	0-2.5	1.86	0.94	17.88	28.56	49.39	1.42	1.59	8.61	325	0.34	5.57	3.61	1.96
M	2.5-5	n.a.	1.12	30.92	16.57	49.42	1.14	1.29	8.60	386	0.24	4.61	2.44	2.17
M	5-10	3.78	1.02	27.48	20.97	47.34	1.95	2.05	8.50	758	0.21	4.09	2.28	1.81
M	10-15	5.13	1.26	9.53	20.52	63.83	2.95	0.79	8.78	1,050	0.21	3.69	2.02	1.67
M	15-20	12.46	1.41	17.95	17.25	50.99	10.83	2.32	8.93	2,091	0.10	3.45	1.01	2.44
M	20-30	17.86	1.45	9.62	23.71	40.19	13.56	12.05	9.17	2,460	0.04	3.36	0.47	2.89
M	30-40	14.93	1.40	0.88	8.71	67.86	14.22	6.11	9.47	1,923	0.01	3.68	0.19	3.49

** See Table 9-1 in Appendix 1 for further details on the treatment.*

Table 9-11. Organic carbon fractionation (%C) of the Hunters Creek, Hindmarsh Island soil materials (March 2012).

Profile ID*	Depth Range (cm)	cPOM	LF	iPOM	µagg	µSilt	µClay	NH-dSilt	NH-dClay	H-dSilt	H-dClay	NH-µSilt	NH-µClay	H-µSilt	H-µClay	dSilt	dClay
A	0-2.5	1.5488	-	0.1028	0.1792	-	-	-	-	-	-	-	-	-	-	-	0.0060
A	2.5-5	0.3395	-	0.0569	0.1354	-	-	0.0070	-	0.0006	-	-	-	-	-	0.0076	0.0141
A	5-10	0.0783	-	0.0432	0.1976	-	-	0.0310	0.0050	0.0000	0.0056	-	-	-	-	0.0310	0.0106
A	10-15	0.0539	-	0.0378	0.2025	-	0.0803	0.0648	0.0034	0.0058	0.0053	-	-	-	-	0.0706	0.0088
A	15-20	0.1485	-	0.0135	0.1501	-	-	0.0506	0.0076	0.0151	0.0068	-	-	-	-	0.0657	0.0144
A	20-30	0.4575	-	0.0214	0.2855	-	-	0.0377	0.0081	0.0069	0.0061	-	-	-	-	0.0446	0.0142
A	30-40	0.5275	-	0.0293	0.2191	-	-	0.0312	0.0055	0.0105	0.0023	-	-	-	-	0.0417	0.0078
B	0-2.5	0.4003	-	0.0229	0.1451	-	-	-	-	-	-	-	-	-	-	0.0216	-
B	2.5-5	0.8513	-	0.0492	0.2902	-	-	0.0330	0.0127	0.0083	0.0049	-	-	-	-	0.0413	0.0176
B	5-10	0.1251	-	0.0627	0.1488	-	-	0.0358	0.0079	0.0013	0.0061	-	-	-	-	0.0371	0.0140
B	10-15	0.1802	-	0.0183	0.1633	-	-	0.0933	0.0092	0.0018	0.0068	-	-	-	-	0.0951	0.0160
B	15-20	0.2455	-	0.0175	0.1948	-	-	0.0358	0.0048	0.0097	0.0029	-	-	-	-	0.0455	0.0077
B	20-30	0.3934	-	0.0344	0.1180	-	0.0743	0.0066	0.0127	0.0002	0.0000	-	-	-	-	0.0068	0.0127
B	30-40	0.3918	-	0.0682	0.2086	0.1364	0.1443	0.0474	-	0.0051	-	-	-	-	-	0.0525	-
C	0-2.5	1.1431	-	-	0.1060	-	-	-	-	-	-	-	-	-	-	0.0000	-
C	2.5-5	1.7527	-	0.1017	0.3055	-	-	-	-	-	-	-	-	-	-	0.0104	-
C	5-10	0.2072	-	0.0322	0.1436	-	-	0.0146	0.0231	0.0000	0.0076	-	-	-	-	0.0146	0.0306
C	10-15	0.1246	-	0.0363	0.2234	-	-	0.0124	0.0188	0.0001	0.0077	-	-	-	-	0.0125	0.0265
C	15-20	0.1013	-	0.0249	0.0815	-	-	0.0097	0.0196	0.0001	0.0069	-	-	-	-	0.0099	0.0265
C	20-30	0.1016	-	0.0310	0.0483	-	-	0.0049	0.0097	0.0000	0.0024	-	-	-	-	0.0049	0.0121
C	30-40	0.0098	-	0.8426	0.0680	-	-	0.0042	0.0119	0.0000	0.0000	-	-	-	-	0.0042	0.0119
D	0-2.5	0.7735	-	-	n.a.	-	-	-	-	-	-	-	-	-	-	0.0114	0.0552
D	2.5-5	1.3703	-	0.1711	0.5449	0.2180	-	0.0612	0.1196	0.0018	0.0179	-	-	-	-	0.0630	0.1375
D	5-10	0.3309	-	0.0322	0.0621	-	-	0.0046	-	0.0021	-	-	-	-	-	0.0067	0.0164
D	10-15	0.1013	-	0.0350	0.1658	-	-	0.0023	0.0078	0.0000	0.0001	-	-	-	-	0.0023	0.0079
D	15-20	0.1229	-	0.0322	0.1304	-	-	0.0341	0.0131	0.0083	0.0073	-	-	-	-	0.0424	0.0204
D	20-30	0.1909	-	0.0461	0.1909	-	-	0.0182	0.0073	0.0000	0.0028	-	-	-	-	0.0182	0.0101
D	30-40	0.1655	-	0.4271	0.1915	-	-	0.0166	0.0087	0.0000	0.0012	-	-	-	-	0.0166	0.0099

** See Table 9-1 in Appendix 1 for further details on the treatment.*

Table 9-11 (continued). Organic carbon fractionation (%C) of the Hunters Creek, Hindmarsh Island soil materials (March 2012).

Profile ID*	Depth Range (cm)	cPOM	LF	iPOM	µagg	µSilt	µClay	NH-dSilt	NH-dClay	H-dSilt	H-dClay	NH-µSilt	NH-µClay	H-µSilt	H-µClay	dSilt	dClay
F	0-2.5	1.9264	-	-	0.2219	-	-	0.0735	-	0.0056	-	-	-	-	-	0.0791	0.0489
F	2.5-5	1.1852	-	0.0394	0.1762	0.1063	0.0655	0.0270	-	0.0037	-	0.0873	0.0395	0.0191	0.0260	0.0307	0.0279
F	5-10	2.0515	-	0.0934	0.4108	0.1684	0.1301	0.3291	n.a.	0.0469	n.a.	-	0.0734	-	0.0567	0.3760	0.0482
F	10-15	0.2752	-	0.0909	0.2688	-	0.0798	0.3700	0.0785	0.0771	0.0115	-	0.0422	-	0.0375	0.4471	0.0887
F	15-20	0.7268	-	0.0339	0.1789	0.0520	0.0746	0.1111	0.0617	0.0165	0.0013	-	0.0348	-	0.0397	0.1276	0.0630
F	20-30	0.3799	-	-	0.2044	-	-	0.7972	0.0263	0.1360	0.0014	-	-	-	-	0.9332	0.0277
F	30-40	0.8755	-	0.0895	0.2678	0.0664	0.0621	0.4095	0.0883	0.0482	0.0063	-	0.0402	-	0.0219	0.4577	0.0946
G	0-2.5	2.8916	-	0.1503	0.3183	0.0954	0.0407	0.1025	0.0611	0.0131	0.0199	0.0746	0.0238	0.0207	0.0170	0.1156	0.0810
G	2.5-5	2.5360	-	0.0757	0.4366	0.1738	0.1195	0.1013	0.0355	0.0275	0.0142	-	0.0740	-	0.0455	0.1288	0.0497
G	5-10	1.6720	-	0.1532	0.4215	0.1819	0.1604	0.2867	0.0453	0.0573	0.0191	-	0.0888	-	0.0716	0.3440	0.0644
G	10-15	1.3206	-	0.0425	0.2720	-	0.0520	0.1700	0.0148	0.0395	0.0252	-	0.0264	-	0.0256	0.2095	0.0400
G	15-20	0.4446	-	0.0926	0.2841	0.0531	0.0703	0.2740	0.2013	0.0999	0.0503	-	0.0494	-	0.0209	0.3738	0.2516
G	20-30	0.5566	-	0.0851	0.1524	0.0510	0.0579	0.2440	0.0720	0.0571	0.0093	-	0.0282	-	0.0297	0.3011	0.0813
G	30-40	0.9247	-	0.0255	0.1939	-	0.0204	0.3778	0.0557	0.0261	0.0072	-	-	-	-	0.4039	0.0629
H	0-2.5	1.9767	-	0.0736	0.2559	0.1331	0.0755	0.0263	-	0.0026	-	-	0.0491	-	0.0264	0.0288	0.0474
H	2.5-5	2.4300	-	0.1546	0.5934	0.3285	0.2059	0.0600	0.0453	0.0151	0.0158	0.2683	0.1288	0.0602	0.0770	0.0752	0.0611
H	5-10	1.4456	-	0.0600	0.3103	0.1252	0.1181	0.1384	0.0138	0.0312	0.0170	-	0.0668	-	0.0513	0.1695	0.0308
H	10-15	0.7999	-	0.0310	0.2111	-	0.0523	0.2355	0.0962	0.0379	0.0001	-	0.0252	-	0.0271	0.2734	0.0963
H	15-20	0.6074	-	0.0496	0.2027	-	0.0344	0.3647	0.1008	0.0652	0.0124	-	0.0168	-	0.0176	0.4299	0.1133
H	20-30	0.5440	-	0.0614	0.1730	0.0758	0.0713	0.2424	0.2605	0.0191	0.0475	-	0.0394	-	0.0319	0.2615	0.3080
H	30-40	0.2189	-	0.0678	0.0535	-	0.0198	0.6778	0.1973	0.0696	0.0153	-	0.0112	-	0.0086	0.7474	0.2126
I	0-2.5	2.1309	-	0.0530	0.2288	0.0789	0.0425	0.0594	0.0202	0.0060	0.0078	-	0.0268	-	0.0157	0.0654	0.0280
I	2.5-5	3.1370	-	0.1035	0.4829	0.1491	0.0684	0.1959	0.0239	0.0348	0.0125	-	0.0422	-	0.0262	0.2307	0.0364
I	5-10	2.4579	-	0.0889	0.3260	0.1486	0.0977	0.1255	0.0192	0.0162	0.0122	0.1180	0.0605	0.0306	0.0372	0.1417	0.0314
I	10-15	1.7201	-	0.0647	0.2990	0.1136	0.0995	0.1639	0.0195	0.0353	0.0165	-	0.0590	-	0.0405	0.1992	0.0359
I	15-20	1.9283	-	0.0740	0.2813	0.0756	0.1092	0.1806	0.0283	0.1155	0.0401	0.0700	0.0543	0.0056	0.0549	0.2961	0.0685
I	20-30	0.6429	-	0.0526	0.1598	-	0.0758	0.2443	0.0574	0.0495	0.0123	-	0.0403	-	0.0355	0.2938	0.0697
I	30-40	0.5735	-	0.0664	0.1664	-	0.0851	0.4379	0.1097	0.0628	0.0135	-	0.0475	-	0.0376	0.5007	0.1232

** See Table 9-1 in Appendix 1 for further details on the treatment.*

Table 9-11 (continued). Organic carbon fractionation (%C) of the Hunters Creek, Hindmarsh Island soil materials (March 2012).

Profile ID*	Depth Range (cm)	cPOM	LF	iPOM	µagg	µSilt	µClay	NH-dSilt	NH-dClay	H-dSilt	H-dClay	NH-µSilt	NH-µClay	H-µSilt	H-µClay	dSilt	dClay
J	0-2.5	0.7213	-	0.4881	1.4030	0.4632	-	0.2656	0.4966	0.0004	0.0763	-	-	-	-	0.2659	0.5729
J	2.5-5	0.5282	-	0.2992	0.9799	0.4763	-	0.2771	0.1559	0.0179	0.0235	-	-	-	-	0.2949	0.1794
J	5-10	0.8258	-	0.1101	0.4513	0.2392	-	0.2072	0.0946	0.0097	0.0124	-	-	-	-	0.2169	0.1070
J	10-15	0.3107	-	0.1547	0.5963	0.4010	0.1645	0.2891	0.0596	0.0414	0.0127	-	-	-	-	0.3305	0.0723
J	15-20	0.3874	-	0.0605	0.3627	0.2106	0.1399	0.1898	0.0135	0.0232	0.0123	-	0.0629	-	0.0770	0.2130	0.0258
J	20-30	0.1931	-	0.0265	0.1487	-	0.0428	0.1643	0.0381	0.0291	0.0000	-	-	-	-	0.1934	0.0380
J	30-40	0.0315	-	0.0375	0.1086	-	0.0449	0.0886	0.0192	0.0199	0.0000	-	-	-	-	0.1084	0.0193
K	0-2.5	0.9025	-	0.4299	1.0131	-	-	0.1832	0.1438	0.0178	0.0208	-	-	-	-	0.2011	0.1646
K	2.5-5	0.8203	-	0.1826	0.6760	0.2895	-	0.1190	0.0850	0.0125	0.0109	-	-	-	-	0.1314	0.0960
K	5-10	0.6547	-	0.1527	0.5783	0.3229	-	0.1112	0.0729	0.0096	0.0116	-	-	-	-	0.1208	0.0844
K	10-15	0.2131	-	0.1319	0.7491	-	-	0.2207	0.0441	0.0296	0.0074	-	-	-	-	0.2504	0.0515
K	15-20	0.1998	-	0.0790	0.6045	0.3842	0.2829	0.1250	0.0222	0.0121	0.0022	-	0.1589	-	0.1240	0.1372	0.0244
K	20-30	0.2488	-	0.0386	0.1424	0.0775	0.0435	0.1220	0.0079	0.0026	0.0171	-	-	-	-	0.1246	0.0250
K	30-40	0.1418	-	0.0233	0.0766	-	0.0325	0.0500	0.0014	0.0000	0.0082	-	-	-	-	0.0500	0.0096
L	0-2.5	2.1221	-	0.5004	0.7524	-	-	0.0384	0.0587	0.0000	0.0088	-	-	-	-	0.0384	0.0676
L	2.5-5	0.5684	-	0.2010	0.6779	-	-	0.0761	0.0922	0.0000	0.0012	-	-	-	-	0.0761	0.0935
L	5-10	0.5285	-	0.2546	0.8300	-	-	0.1423	0.0893	0.0033	0.0027	-	-	-	-	0.1456	0.0921
L	10-15	0.5713	-	0.1510	0.7300	-	-	0.1428	0.0760	0.0000	0.0052	-	-	-	-	0.1428	0.0812
L	15-20	0.3871	-	0.0429	0.3198	0.1325	0.0960	0.0511	0.0174	0.0094	0.0114	-	0.0396	-	0.0563	0.0605	0.0289
L	20-30	0.3044	-	0.0162	0.0835	0.0322	0.0202	0.0159	0.0082	0.0000	0.0108	-	-	-	-	0.0159	0.0190
L	30-40	0.0303	-	0.0456	0.3255	-	-	0.0968	0.0012	0.0308	0.0259	-	-	-	-	0.1276	0.0271
M	0-2.5	1.8133	-	0.3484	0.7698	-	-	0.0653	0.0896	0.0060	0.0122	-	-	-	-	0.0713	0.1018
M	2.5-5	0.5930	-	0.2233	0.8263	-	-	0.0724	0.0864	0.0002	0.0051	-	-	-	-	0.0726	0.0914
M	5-10	0.6164	-	0.1618	0.6438	0.3572	-	0.1093	0.1230	0.0043	0.0112	-	-	-	-	0.1136	0.1341
M	10-15	0.6411	-	0.1395	0.8425	-	-	0.1450	0.0393	0.0068	0.0022	-	-	-	-	0.1519	0.0415
M	15-20	0.2369	-	0.0425	0.3053	0.1449	0.1055	0.1636	0.0091	0.0162	0.0138	-	-	-	-	0.1798	0.0229
M	20-30	0.1240	-	0.0213	0.1003	-	0.0353	0.1003	0.0469	0.0000	0.0241	-	-	-	-	0.1003	0.0710
M	30-40	0.0263	-	0.2118	0.0806	-	-	0.0682	0.0006	0.0006	0.0223	-	-	-	-	0.0688	0.0230

** See Table 9-1 in Appendix 1 for further details on the treatment.*

Table 9-12. Non-protected and protected organic carbon fractions (%C) of the Hunters Creek, Hindmarsh Island soil materials (March 2012).

Profile ID*	Depth Range (cm)	Chemical (H-dSilt + H-dClay)	Biochemical (NH-dSilt + NH-dClay)	Non-Protected (cPOM + LF)	Physical (µagg + iPOM)
A	0-2.5	-	-	1.5488	0.2821
A	2.5-5	0.0006	0.0070	0.3395	0.1923
A	5-10	0.0056	0.0360	0.0783	0.2408
A	10-15	0.0111	0.0682	0.0539	0.2404
A	15-20	0.0219	0.0582	0.1485	0.1636
A	20-30	0.0130	0.0458	0.4575	0.3069
A	30-40	0.0128	0.0368	0.5275	0.2484
B	0-2.5	-	-	0.4003	0.1680
B	2.5-5	0.0132	0.0457	0.8513	0.3394
B	5-10	0.0073	0.0437	0.1251	0.2115
B	10-15	0.0086	0.1025	0.1802	0.1816
B	15-20	0.0126	0.0406	0.2455	0.2123
B	20-30	0.0002	0.0193	0.3934	0.1524
B	30-40	0.0051	0.0474	0.3918	0.2768
C	0-2.5	-	-	1.1431	0.1060
C	2.5-5	-	-	1.7527	0.4072
C	5-10	0.0076	0.0377	0.2072	0.1758
C	10-15	0.0078	0.0312	0.1246	0.2597
C	15-20	0.0070	0.0293	0.1013	0.1064
C	20-30	0.0024	0.0147	0.1016	0.0793
C	30-40	0.0000	0.0161	0.0098	0.9106
D	0-2.5	-	-	0.7735	n.a.
D	2.5-5	0.0197	0.1808	1.3703	0.7160
D	5-10	0.0021	0.0046	0.3309	0.0943
D	10-15	0.0001	0.0101	0.1013	0.2008
D	15-20	0.0156	0.0473	0.1229	0.1626
D	20-30	0.0028	0.0255	0.1909	0.2369
D	30-40	0.0012	0.0254	0.1655	0.6186
F	0-2.5	0.0056	0.0735	1.9264	0.2219
F	2.5-5	0.0037	0.0270	1.1852	0.2156
F	5-10	-	-	2.0515	0.5043
F	10-15	0.0886	0.4486	0.2752	0.3596
F	15-20	0.0178	0.1728	0.7268	0.2128
F	20-30	0.1375	0.8234	0.3799	0.2044
F	30-40	0.0546	0.4977	0.8755	0.3573
G	0-2.5	0.0331	0.1636	2.8916	0.4686
G	2.5-5	0.0416	0.1368	2.5360	0.5122
G	5-10	0.0764	0.3320	1.6720	0.5748
G	10-15	0.0647	0.1848	1.3206	0.3145
G	15-20	0.1502	0.4752	0.4446	0.3767
G	20-30	0.0664	0.3160	0.5566	0.2375
G	30-40	0.0333	0.4334	0.9247	0.2194

** See Table 9-1 in Appendix 1 for further details on the treatment.*

Table 9-12 (continued). Non-protected and protected organic carbon fractions (%C) of the Hunters Creek, Hindmarsh Island soil materials (March 2012).

Profile ID*	Depth Range (cm)	Chemical (H-dSilt + H-dClay)	Biochemical (NH-dSilt + NH-dClay)	Non-Protected (cPOM + LF)	Physical (µagg + iPOM)
H	0-2.5	0.0026	0.0263	1.9767	0.3295
H	2.5-5	0.0310	0.1053	2.4300	0.7480
H	5-10	0.0482	0.1521	1.4456	0.3703
H	10-15	0.0380	0.3317	0.7999	0.2421
H	15-20	0.0776	0.4656	0.6074	0.2523
H	20-30	0.0666	0.5029	0.5440	0.2344
H	30-40	0.0850	0.8750	0.2189	0.1213
I	0-2.5	0.0138	0.0796	2.1309	0.2819
I	2.5-5	0.0472	0.2198	3.1370	0.5864
I	5-10	0.0284	0.1447	2.4579	0.4148
I	10-15	0.0518	0.1834	1.7201	0.3637
I	15-20	0.1556	0.2090	1.9283	0.3553
I	20-30	0.0618	0.3017	0.6429	0.2123
I	30-40	0.0763	0.5476	0.5735	0.2328
J	0-2.5	0.0767	0.7622	0.7213	1.8912
J	2.5-5	0.0414	0.4329	0.5282	1.2792
J	5-10	0.0222	0.3018	0.8258	0.5613
J	10-15	0.0541	0.3487	0.3107	0.7510
J	15-20	0.0355	0.2033	0.3874	0.4232
J	20-30	0.0291	0.2023	0.1931	0.1752
J	30-40	0.0199	0.1078	0.0315	0.1461
K	0-2.5	0.0387	0.3270	0.9025	1.4431
K	2.5-5	0.0234	0.2040	0.8203	0.8586
K	5-10	0.0211	0.1841	0.6547	0.7310
K	10-15	0.0371	0.2648	0.2131	0.8810
K	15-20	0.0143	0.1473	0.1998	0.6835
K	20-30	0.0197	0.1299	0.2488	0.1809
K	30-40	0.0082	0.0514	0.1418	0.0998
L	0-2.5	0.0088	0.0971	2.1221	1.2528
L	2.5-5	0.0012	0.1684	0.5684	0.8789
L	5-10	0.0061	0.2316	0.5285	1.0846
L	10-15	0.0052	0.2188	0.5713	0.8810
L	15-20	0.0208	0.0686	0.3871	0.3627
L	20-30	0.0108	0.0241	0.3044	0.0997
L	30-40	0.0567	0.0979	0.0303	0.3711
M	0-2.5	0.0181	0.1549	1.8133	1.1183
M	2.5-5	0.0053	0.1587	0.5930	1.0496
M	5-10	0.0155	0.2323	0.6164	0.8056
M	10-15	0.0090	0.1843	0.6411	0.9821
M	15-20	0.0301	0.1727	0.2369	0.3478
M	20-30	0.0241	0.1472	0.1240	0.1215
M	30-40	0.0229	0.0689	0.0263	0.2925

** See Table 9-1 in Appendix 1 for further details on the treatment.*

Table 9-13. Soil fraction masses and recoveries for the Hunters Creek, Hindmarsh Island soil materials (March 2012).

Profile ID*	Depth Range (cm)	Soil Mass Sieved (g)	Sieved Sediment Fractions					Recovery (%)
			>2mm (g)	cPOM (g)	µagg (g)	dSilt (g)	dClay (g)	
A	0-2.5	200.00	85.8542	55.1170	50.4908	0.0000	0.3784	95.9%
A	2.5-5	200.00	20.2406	28.0064	147.1580	0.7676	0.9351	98.6%
A	5-10	200.00	0.8930	8.1271	177.4133	5.7900	2.3037	97.3%
A	10-15	200.00	6.5490	5.9577	157.6177	11.8923	2.2752	92.1%
A	15-20	200.00	2.8520	16.9724	162.1222	10.3288	2.8536	97.6%
A	20-30	200.00	3.5647	55.1178	124.2386	7.1873	2.5135	96.3%
A	30-40	200.00	16.6902	73.7738	93.4048	6.9436	1.2573	96.0%
B	0-2.5	100.00	82.7112	5.0869	8.1141	0.4175	0.2128	96.5%
B	2.5-5	200.00	80.9616	26.8128	79.0435	2.6288	1.2162	95.3%
B	5-10	200.00	12.3805	11.2377	166.2291	5.4634	2.2509	98.8%
B	10-15	200.00	3.9827	14.3607	163.2994	11.8132	2.7084	98.1%
B	15-20	200.00	2.1190	22.8393	161.6204	6.2286	1.2691	97.0%
B	20-30	200.00	40.5868	73.7935	78.2071	1.2004	2.0267	97.9%
B	30-40	200.00	1.6024	55.1850	127.9690	8.3929	0.4593	96.8%
C	0-2.5	80.00	66.4126	3.9417	0.8037	0.1496	0.0835	89.2%
C	2.5-5	100.00	46.0519	18.8871	28.9879	0.1733	0.6720	94.8%
C	5-10	200.00	35.8890	38.1553	120.1060	1.4826	2.5640	99.1%
C	10-15	200.00	7.5846	22.0467	160.5139	1.3114	2.3658	96.9%
C	15-20	200.00	10.3271	32.7912	151.0056	1.3245	2.1605	98.8%
C	20-30	200.00	10.6574	86.8523	97.4460	1.0723	1.4801	98.8%
C	30-40	200.00	0.3790	1.5145	194.8270	1.0259	1.1423	99.4%
D	0-2.5	100.00	87.1824	4.0924	1.7584	0.1244	0.5606	93.7%
D	2.5-5	100.00	61.8642	12.1540	19.9302	0.8307	1.8500	96.6%
D	5-10	200.00	36.6978	40.8557	118.1516	0.5693	0.8993	98.6%
D	10-15	200.00	8.7386	11.3403	177.5227	0.4306	0.7644	99.4%
D	15-20	200.00	0.3758	6.4028	181.7616	5.5013	2.8146	98.4%
D	20-30	200.00	2.3396	9.1652	181.0877	2.4657	1.2726	98.2%
D	30-40	200.00	1.4159	14.7737	176.1843	2.8900	1.4232	98.3%
F	0-2.5	100.00	63.5070	23.5219	3.9729	1.3843	1.0056	93.4%
F	2.5-5	200.00	139.2928	40.1340	10.9358	1.4039	1.3337	96.6%
F	5-10	200.00	32.5987	95.4179	37.7843	23.3436	4.5616	96.9%
F	10-15	100.00	10.5912	8.3462	17.9897	18.5016	6.8896	62.3%
F	15-20	200.00	69.2784	64.1421	20.6565	16.4596	17.6323	94.1%
F	20-30	100.00	11.4677	8.9388	6.6594	64.2870	3.5417	94.9%
F	30-40	200.00	50.8486	43.7204	14.5011	40.7418	18.9850	84.4%
G	0-2.5	100.00	41.3848	39.0758	7.0836	2.2977	2.0307	91.9%
G	2.5-5	70.00	16.8910	33.7678	10.1056	2.3604	1.0107	91.6%
G	5-10	200.00	27.8551	79.2424	45.2633	22.8467	7.3617	91.3%
G	10-15	200.00	27.0705	86.0614	26.8737	23.4488	7.8472	85.7%
G	15-20	100.00	12.8814	15.0481	11.6329	25.9989	35.9800	101.5%
G	20-30	200.00	38.6867	46.9721	20.6224	42.0686	20.5129	84.4%
G	30-40	200.00	25.8657	70.3164	22.8982	36.8552	12.3702	84.2%

** See Table 9-1 in Appendix 1 for further details on the treatment.*

Table 9-13 (continued). Soil fraction masses and recoveries for the Hunters Creek, Hindmarsh Island soil materials (March 2012).

Profile ID*	Depth Range (cm)	Soil Mass Sieved (g)	Sieved Sediment Fractions					Recovery (%)
			>2mm (g)	cPOM (g)	µagg (g)	dSilt (g)	dClay (g)	
H	0-2.5	100.00	51.7756	31.3953	9.8354	0.6253	0.9959	94.6%
H	2.5-5	80.00	26.3676	34.0042	16.0702	1.4355	1.3072	99.0%
H	5-10	200.00	42.8285	83.8024	28.6895	16.7710	4.9653	88.5%
H	10-15	200.00	16.6585	68.9348	23.6924	39.9160	25.3090	87.3%
H	15-20	200.00	16.1417	48.7870	22.3430	58.8283	27.3303	86.7%
H	20-30	200.00	11.3022	41.0570	15.9102	18.9357	53.7158	70.5%
H	30-40	200.00	10.1606	17.0327	7.5039	81.1684	45.8763	80.9%
I	0-2.5	200.00	109.0246	61.6767	9.6064	2.7146	1.4733	92.2%
I	2.5-5	200.00	45.1001	105.2672	21.0535	10.2034	2.6873	92.2%
I	5-10	200.00	64.4318	89.3789	18.5406	7.3394	2.1881	90.9%
I	10-15	200.00	50.0132	89.8614	24.3549	14.3747	3.9712	91.3%
I	15-20	100.00	19.0865	33.7297	13.6960	17.5196	6.3997	90.4%
I	20-30	200.00	38.1912	55.1713	23.4259	36.4633	15.4999	84.4%
I	30-40	200.00	23.5380	50.5678	28.8414	45.3741	25.2268	86.8%
J	0-2.5	200.00	8.5929	15.4626	151.0844	7.5873	15.5271	99.1%
J	2.5-5	200.00	23.4133	37.5137	122.4900	9.6367	5.4431	99.2%
J	5-10	200.00	26.5384	98.3100	62.6739	7.7754	3.8285	99.6%
J	10-15	200.00	32.2342	31.4425	116.9196	15.2951	3.6988	99.8%
J	15-20	200.00	15.9463	45.3148	111.5877	21.0914	4.4106	99.2%
J	20-30	200.00	6.7614	69.1516	82.1726	30.4192	10.7278	99.6%
J	30-40	200.00	4.8677	19.4223	143.2500	26.5122	5.1342	99.6%
K	0-2.5	200.00	25.7226	75.8410	85.1366	6.7243	4.7505	99.1%
K	2.5-5	200.00	46.6508	82.8225	62.0200	4.3655	3.0176	99.4%
K	5-10	200.00	54.8760	66.8486	71.0000	4.4346	2.9594	100.1%
K	10-15	200.00	35.4093	15.6726	133.0489	12.5783	2.7923	99.8%
K	15-20	200.00	5.8709	21.4813	152.1954	11.0166	2.3908	96.5%
K	20-30	200.00	19.4312	93.0452	64.8587	17.0619	4.7685	99.6%
K	30-40	200.00	0.5264	108.5991	69.0288	10.6408	3.2693	96.0%
L	0-2.5	200.00	30.7417	77.5923	85.7734	1.4561	1.6933	98.6%
L	2.5-5	200.00	77.6555	30.7586	84.2098	2.5337	2.6362	98.9%
L	5-10	200.00	50.0583	27.1987	112.4553	4.4188	2.5751	98.4%
L	10-15	200.00	52.7148	43.1150	96.2199	4.6441	2.4389	99.6%
L	15-20	200.00	50.3553	70.3752	67.2627	7.5163	3.3972	99.5%
L	20-30	200.00	51.6186	107.3365	26.4654	2.9382	3.5842	96.0%
L	30-40	200.00	1.5527	25.2722	124.6106	35.1950	11.5557	99.1%
M	0-2.5	200.00	35.7638	57.1131	98.7831	2.8451	3.1805	98.8%
M	2.5-5	200.00	61.8320	33.1312	98.8432	2.2828	2.5788	99.3%
M	5-10	200.00	54.9651	41.9316	94.6800	3.9038	4.1015	99.8%
M	10-15	200.00	19.0624	41.0390	127.6569	5.8960	1.5785	97.6%
M	15-20	200.00	35.8906	34.5037	101.9883	21.6652	4.6300	99.3%
M	20-30	200.00	19.2468	47.4277	80.3857	27.1214	24.0951	99.1%
M	30-40	200.00	1.7623	17.4256	135.7281	28.4352	12.2131	97.8%

** See Table 9-1 in Appendix 1 for further details on the treatment.*

APPENDIX 3. Characteristics of plant materials

Table 9-14. Characteristics of plant materials (March 2012).

Site				Meningie		Hunters Creek		Waltowa			Hunters Creek (Remnant)			Hunters Creek (Remnant Control)		Hunters Creek (Control 10 yr)		
Vegetation				*Schoenoplectus* (stem)	*Schoenoplectus* (root)	*Schoenoplectus* (stem)	*Schoenoplectus* (root)	*Phragmites* (leaf)	*Phragmites* (stem)	*Phragmites* (root)	*Melaleuca* (branch)	*Melaleuca* (root)	*Melaleuca* (leaves)	*Melaleuca-Juncus* (shoots/stems)	*Melaleuca – Juncus* (roots)	*Melaleuca* (stem)	*Melaleuca* (leaves)	*Melaleuca* (root)
	Nutrient		**Units**															
Macronutrients	Nitrogen	(N)	%	0.80	0.57	0.69	0.42	3.14	0.76	0.76	0.42	0.51	1.47	1.24	0.38	0.37	1.18	0.61
	Phosphorus	(P)	%	0.08	0.06	0.14	0.10	0.20	0.08	0.12	0.02	0.03	0.22	0.14	0.21	0.05	0.32	0.07
	Potassium	(K)	%	1.16	1.36	1.49	0.91	0.93	0.67	1.71	0.10	0.15	0.59	0.76	0.55	0.29	0.92	0.34
	Sulfur	(S)	%	0.33	0.35	0.29	0.40	0.51	0.12	0.23	0.12	0.13	0.27	0.14	0.13	0.15	0.28	0.21
	Carbon	(C)	%	43.2	40.9	42.4	43.8	41.8	46.8	33.3	49.2	49.1	54.1	46.0	44.8	46.9	53.7	45.7
	Calcium	(Ca)	%	0.33	0.26	0.45	0.18	0.72	0.07	0.05	0.31	0.20	0.52	0.22	0.08	0.98	0.89	1.12
	Magnesium	(Mg)	%	0.18	0.24	0.20	0.14	0.29	0.06	0.09	0.08	0.11	0.34	0.26	0.12	0.13	0.36	0.22
	Sodium	(Na)	%	1.10	1.50	0.71	0.57	0.18	0.29	0.45	0.59	0.40	0.71	0.60	0.40	0.31	0.45	0.72
Micronutrients	Copper	(Cu)	mg/kg	3	20	2	4	7	4	6	5	4	3	7	10	8	7	7
	Zinc	(Zn)	mg/kg	9	18	7	30	15	8	10	5	4	17	15	18	9	32	8
	Manganese	(Mn)	mg/kg	84	154	339	78	211	48	23	32	25	29	172	80	19	47	28
	Iron	(Fe)	mg/kg	110	6,148	140	1,808	209	96	984	99	276	184	107	1,447	126	169	667
	Boron	(B)	mg/kg	11	10	14	7	12	2	4	14	9	70	31	9	6	49	26
	Molybdenum	(Mo)	mg/kg	0.3	0.4	0.3	0.3	0.8	0.1	0.2	0.7	0.8	0.3	0.7	0.5	0.2	0.8	0.5
	Cobalt	(Co)	mg/kg	<0.1	3.4	0.2	1.0	0.1	0.1	0.6	0.3	0.3	0.1	0.1	0.6	0.1	0.1	0.3
	Silicon	(Si)	mg/kg	701	460	540	345	300	388	422	388	414	934	747	758	272	573	381
Heavy Metals	Aluminium	(Al)	mg/kg	139	733	155	1,504	209	161	1,055	126	464	265	267	1,107	184	256	1,000
	Selenium	(Se)	mg/kg	0.5	0.8	0.7	0.3	0.3	0.1	0.2	0.2	0.1	0.3	0.4	0.4	0.1	0.3	0.5
	Cadmium	(Cd)	mg/kg	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.0	0.0	0.1	<0.1	<0.1	<0.1	<0.1	0.1
	Lead	(Pb)	mg/kg	0.3	2.1	1.0	2.0	0.5	47.2	3.4	1.6	3.1	0.3	0.2	2.3	3,404	7.9	1.2
	Arsenic	(As)	mg/kg	0.3	12.0	0.4	1.1	0.4	0.1	1.5	0.1	0.1	0.3	0.3	1.5	0.1	0.2	0.3
	Chromium	(Cr)	mg/kg	0.8	1.3	0.7	1.8	1.0	0.7	1.3	0.8	0.9	1.4	1.0	1.6	1.0	1.2	1.6
	Nickel	(Ni)	mg/kg	4.9	17.8	7.0	11.2	11.0	25.0	81.8	5.0	6.3	4.3	3.8	24.6	8.8	9.5	34.2
	Mercury	(Hg)	mg/kg	0.01	0.03	0.02	0.02	0.04	0.02	0.05	0.01	0.01	0.04	0.01	0.01	0.01	0.03	0.02
	Silver	(Ag)	mg/kg	0.01	0.03	0.01	0.02	0.04	0.03	0.03	0.05	0.07	0.02	0.02	0.03	0.05	0.01	0.03

APPENDIX 4. Additional carbon fractionation graphs

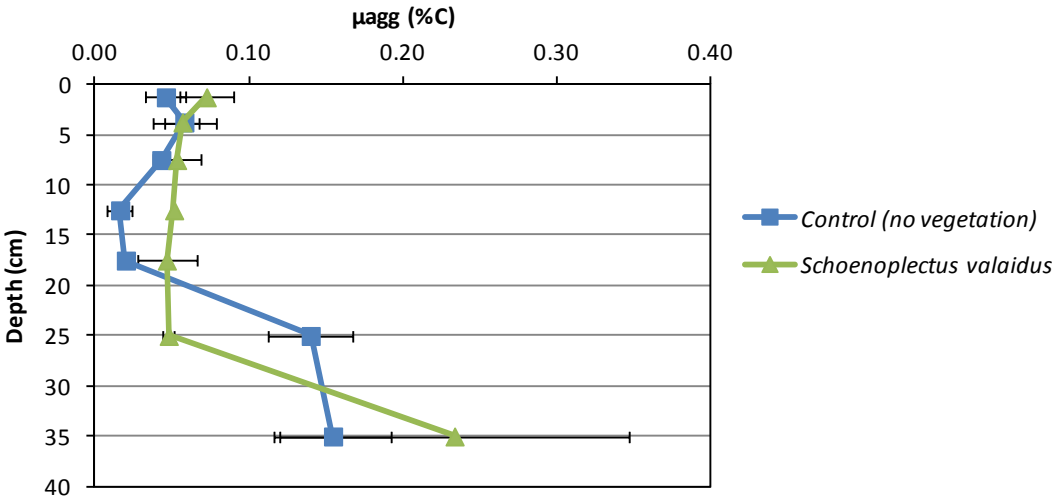

Figure 9-1. µaggregate carbon fraction at the Meningie control (no vegetation) and *Schoenoplectus valaidus* sites.

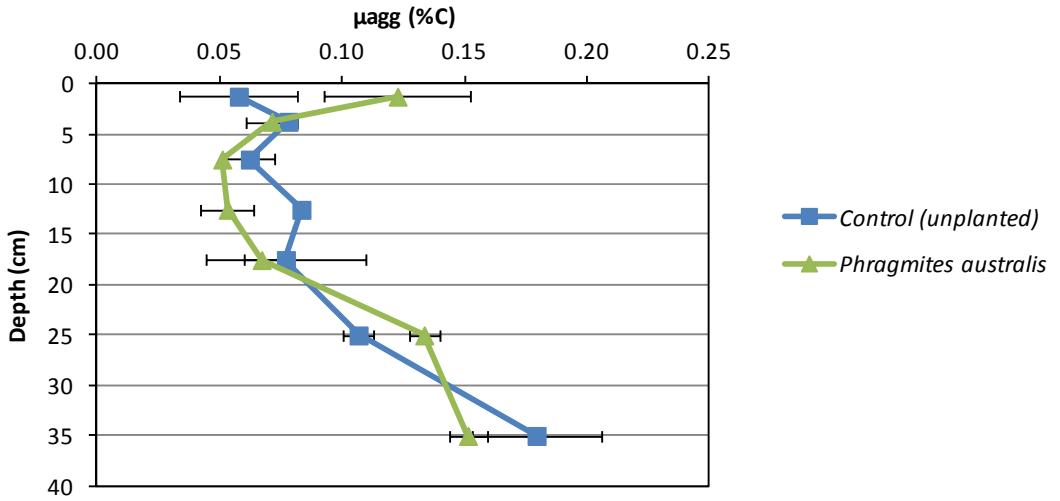

Figure 9-2. µaggregate carbon fraction at the Waltowa control (unplanted) and *Phragmites australis* sites.

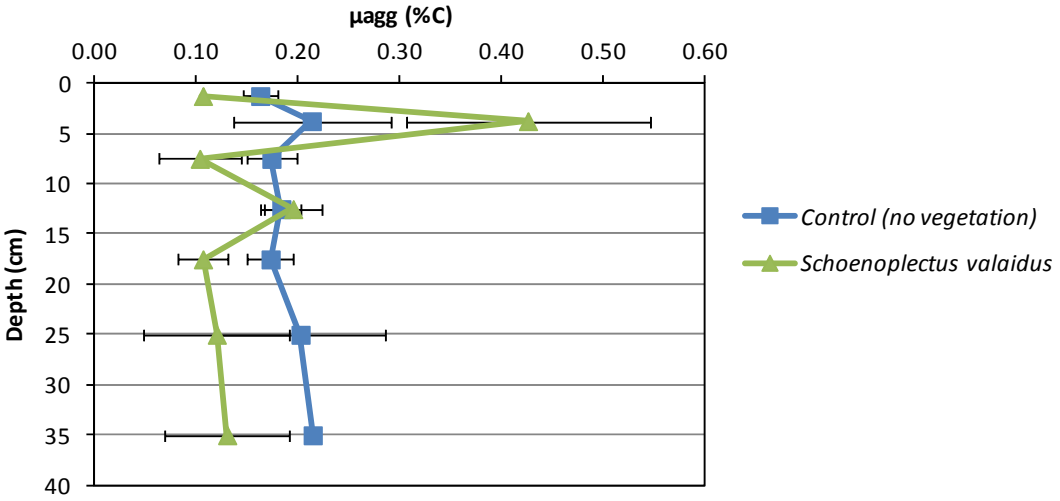

Figure 9-3. µaggregate carbon fraction at the Hunters Creek control (no vegetation) and Schoenoplectus valaidus sites.

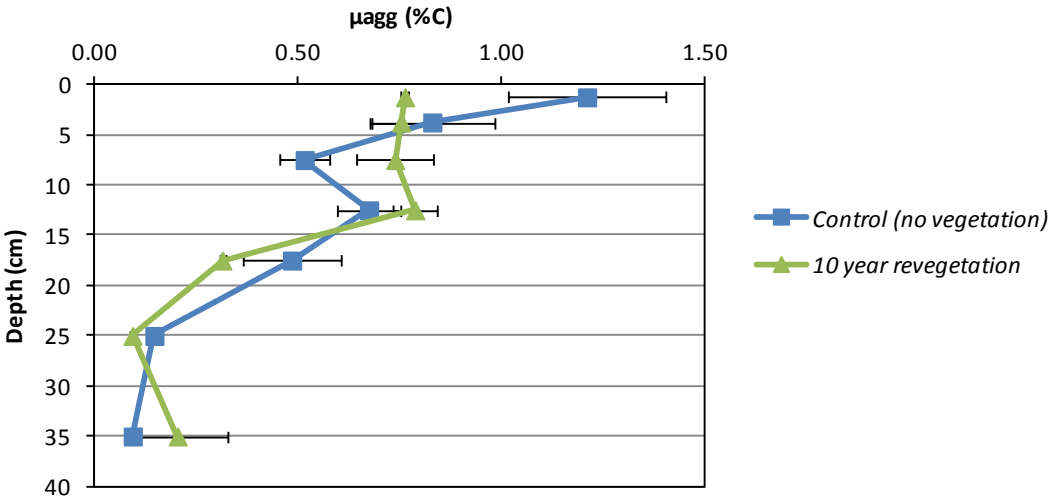

Figure 9-4. µaggregate carbon fraction at the Hunters Creek control and *Melaleuca halmaturorum* sites (10 year revegetation).

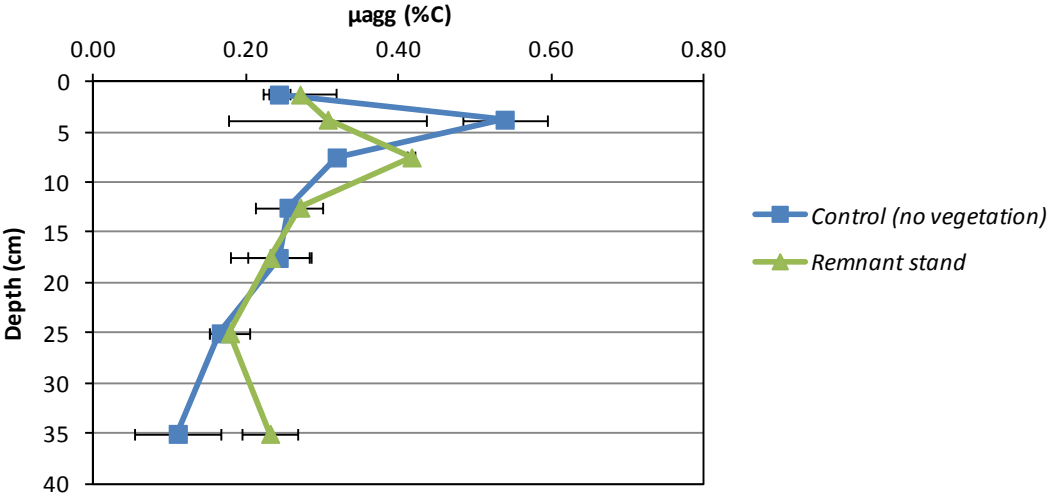

Figure 9-5. µaggregate carbon fraction at the Hunters Creek control and *Melaleuca halmaturorum* sites (Remnant stand).

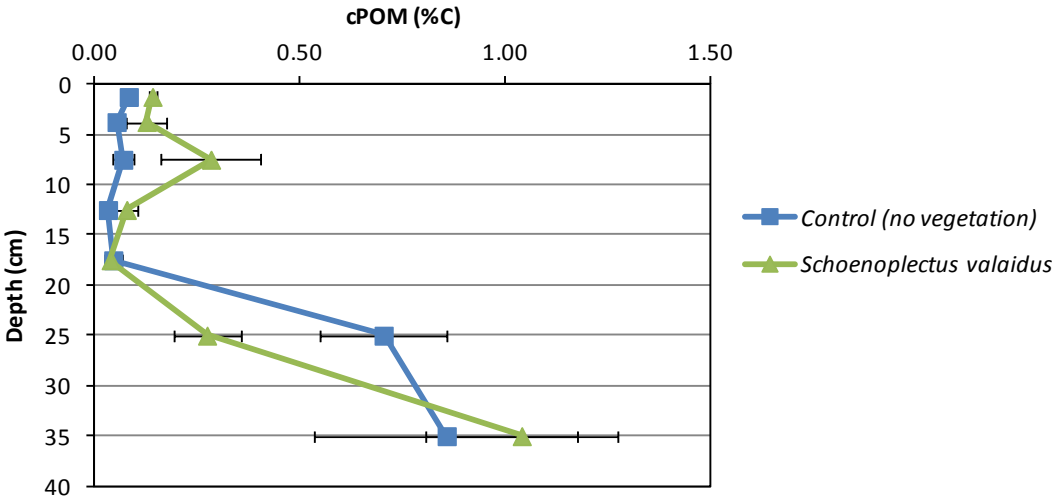

Figure 9-6. cPOM carbon fraction at the Meningie control (no vegetation) and *Schoenoplectus valaidus* sites.

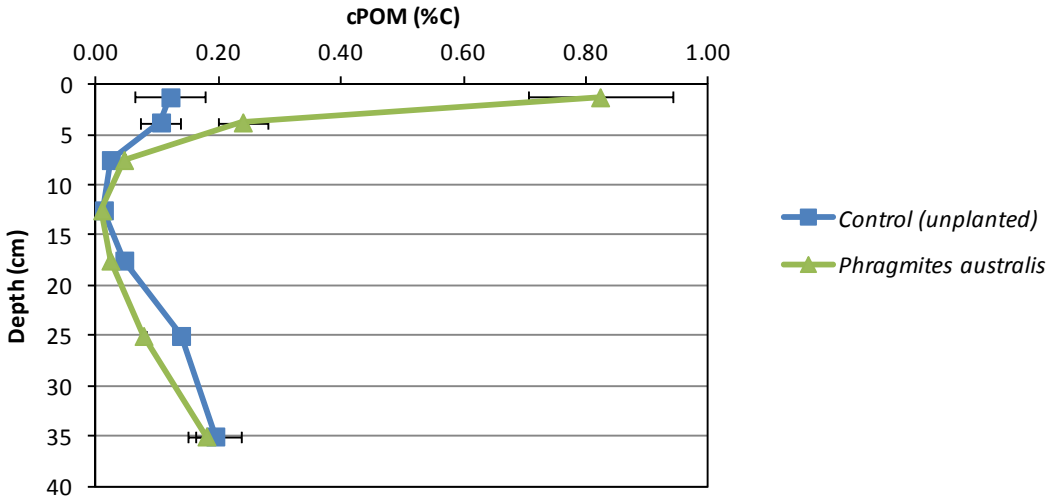

Figure 9-7. cPOM carbon fraction at the Waltowa control (unplanted) and *Phragmites australis* sites.

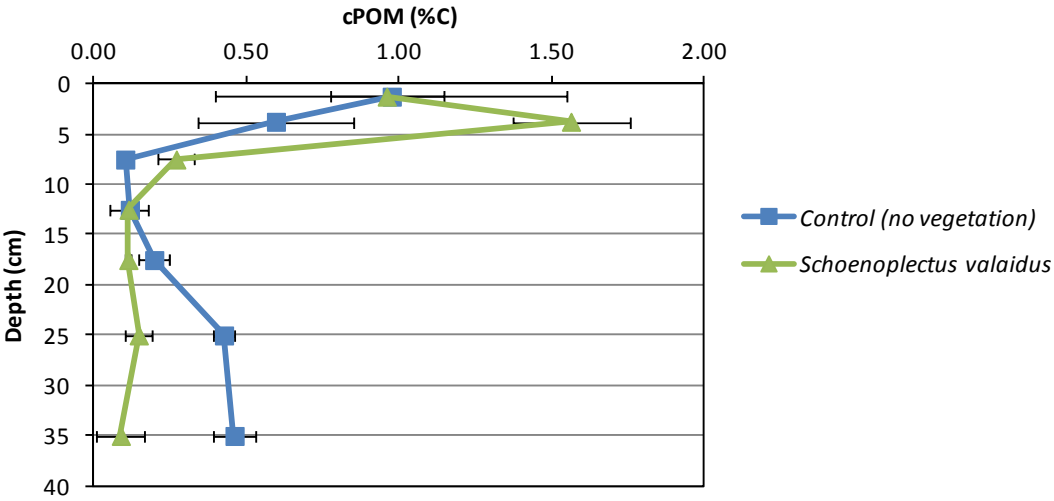

Figure 9-8. cPOM carbon fraction at the Hunters Creek control (no vegetation) and Schoenoplectus valaidus sites.

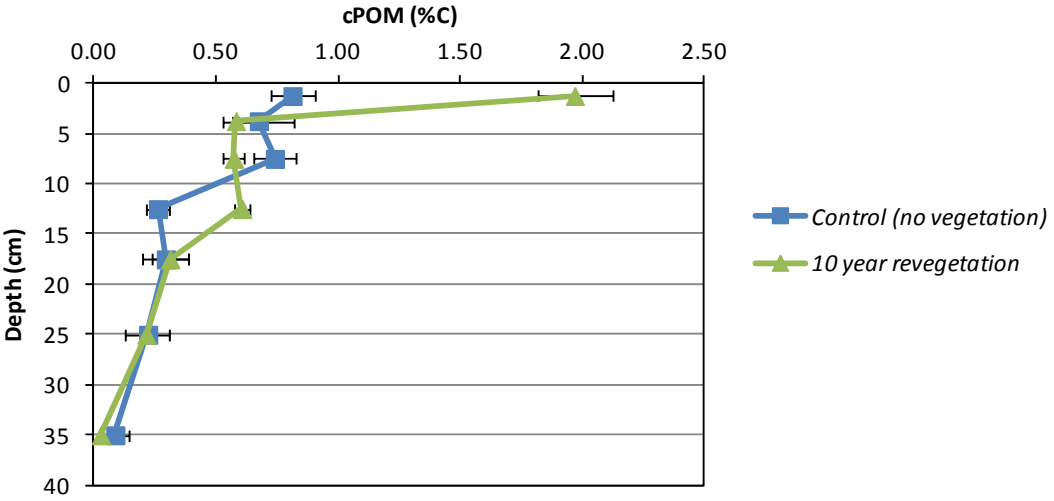

Figure 9-9. cPOM carbon fraction at the Hunters Creek control and *Melaleuca halmaturorum* sites (10 year revegetation).

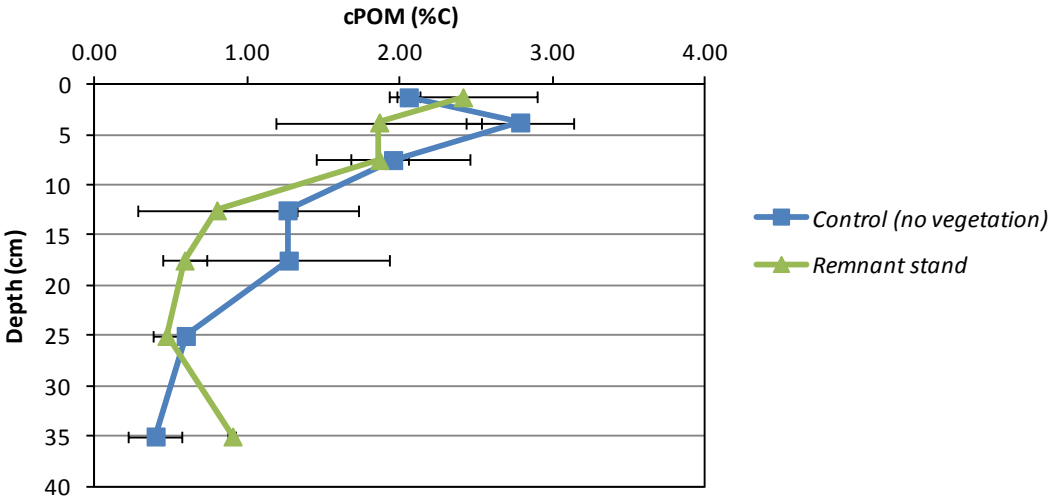

Figure 9-10. cPOM carbon fraction at the Hunters Creek control and *Melaleuca halmaturorum* sites (Remnant stand).

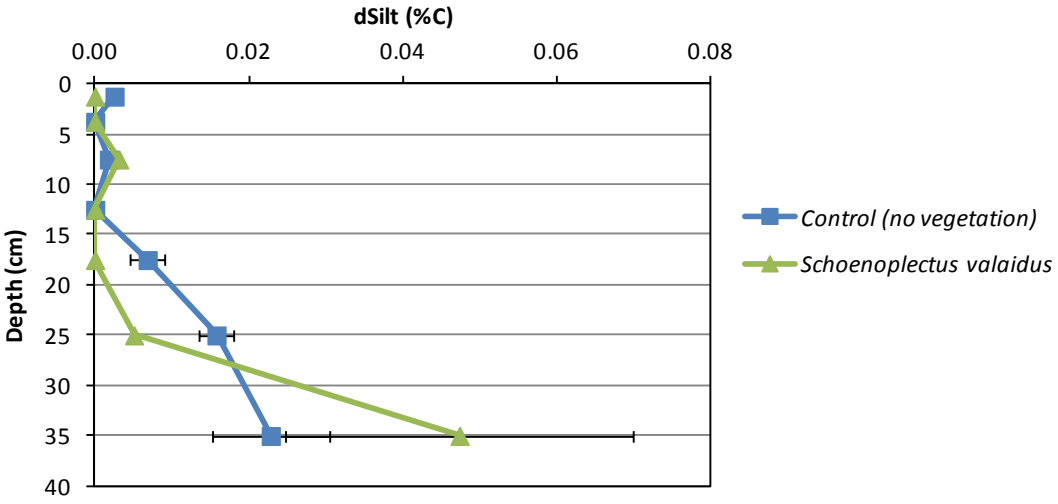

Figure 9-11. dSilt carbon fraction at the Meningie control (no vegetation) and *Schoenoplectus valaidus* sites.

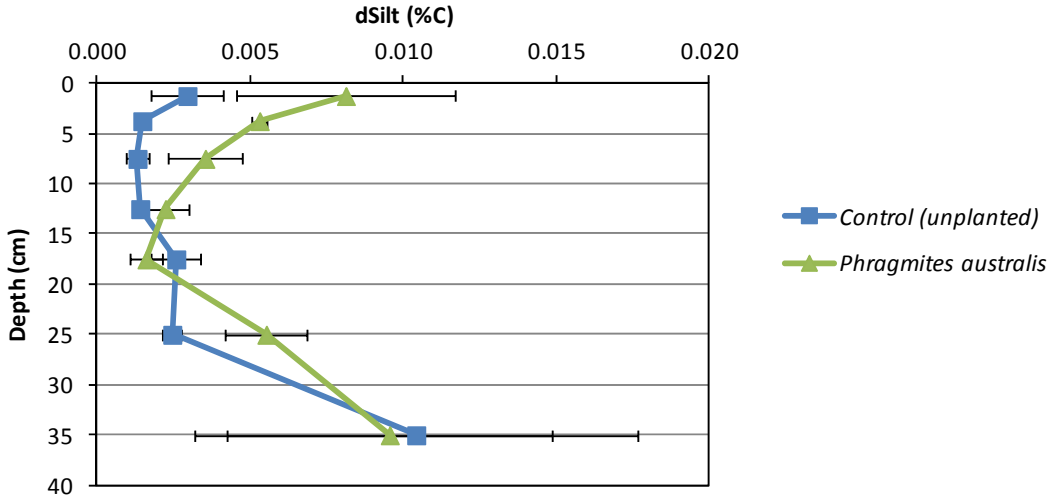

Figure 9-12. dSilt carbon fraction at the Waltowa control (unplanted) and *Phragmites australis* sites.

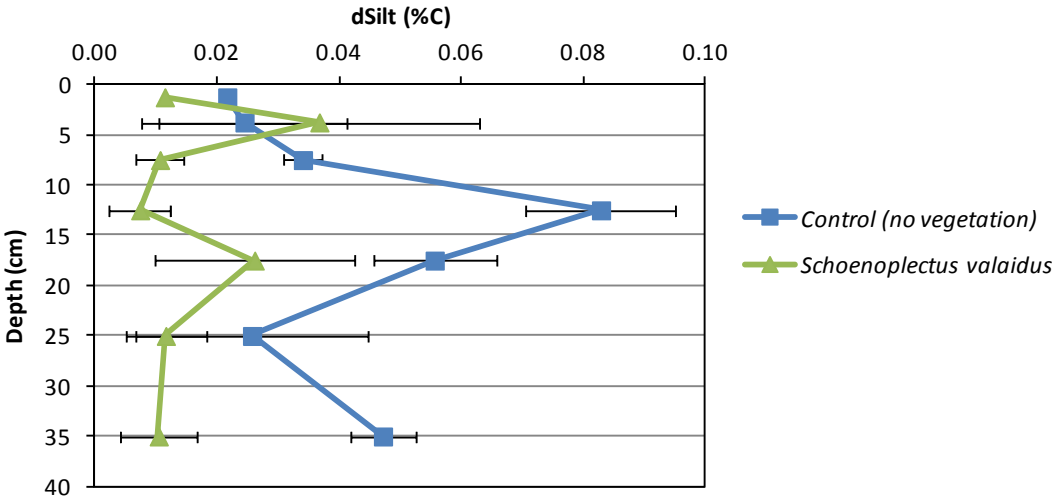

Figure 9-13. dSilt carbon fraction at the Hunters Creek control (no vegetation) and Schoenoplectus valaidus sites.

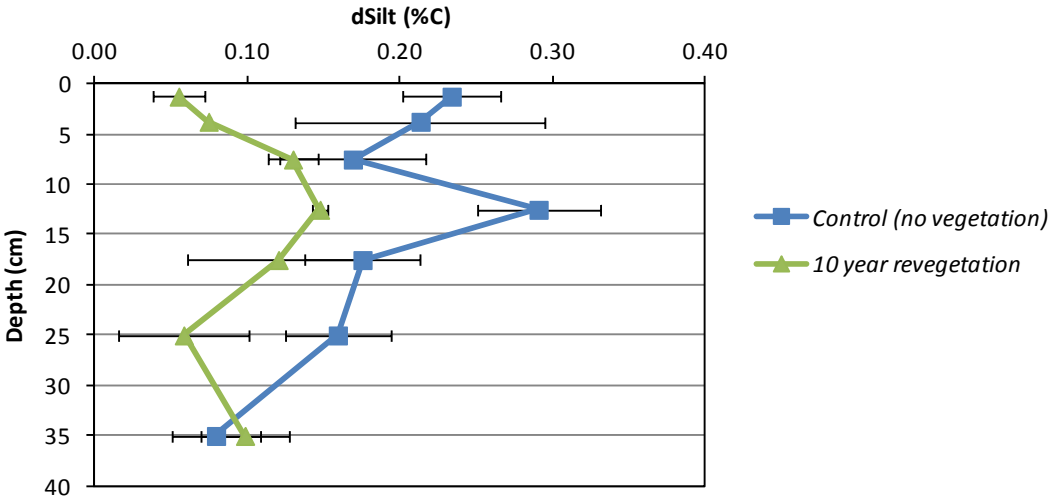

Figure 9-14. dSilt carbon fraction at the Hunters Creek control and *Melaleuca halmaturorum* sites (10 year revegetation).

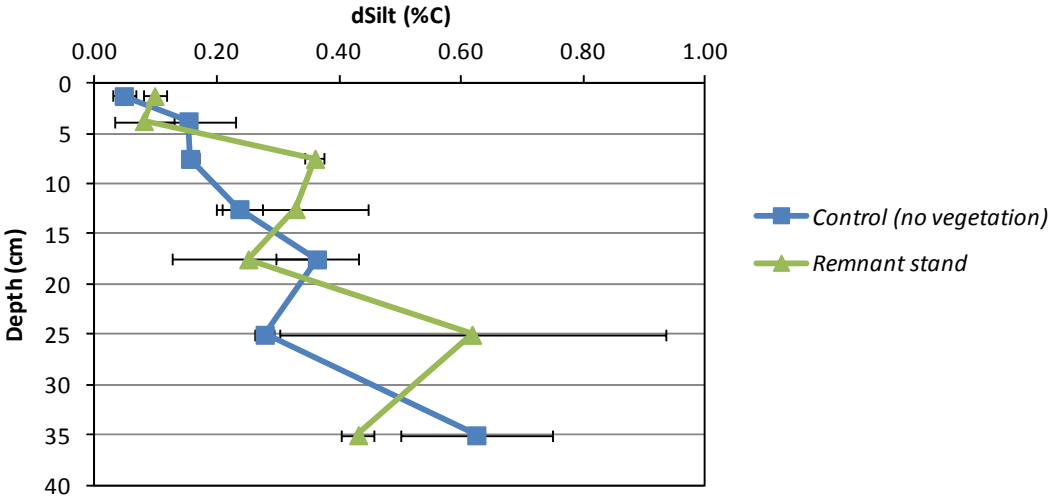

Figure 9-15. dSilt carbon fraction at the Hunters Creek control and *Melaleuca halmaturorum* sites (Remnant stand).

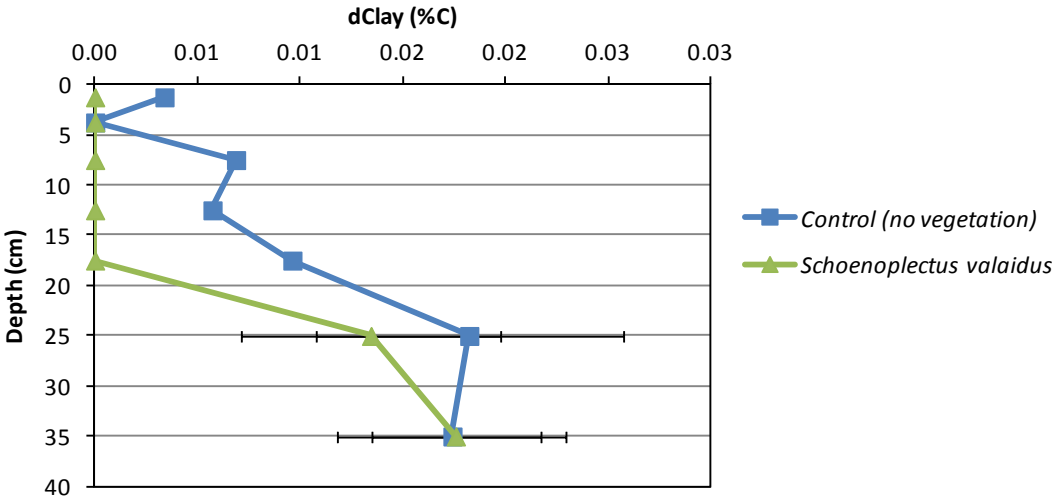

Figure 9-16. dClay carbon fraction at the Meningie control (no vegetation) and *Schoenoplectus valaidus* sites.

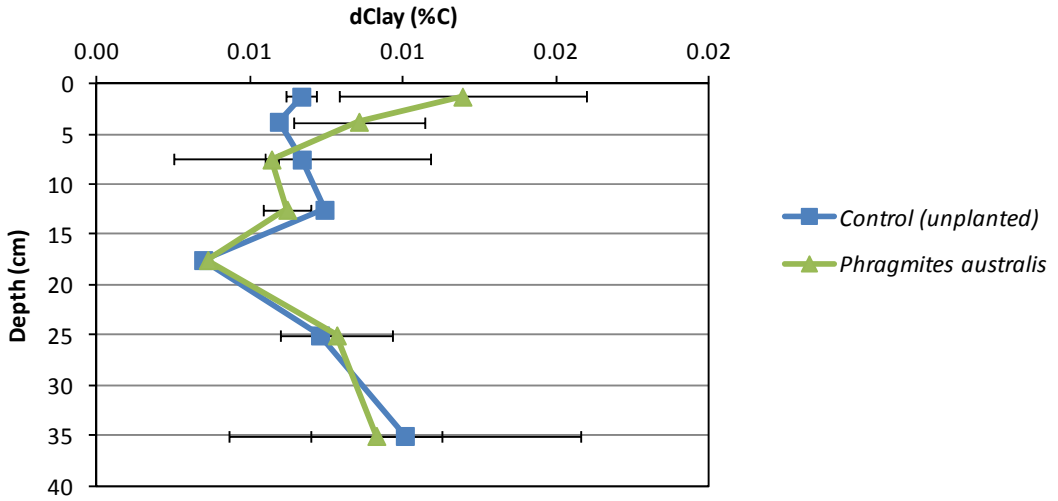

Figure 9-17. dClay carbon fraction at the Waltowa control (unplanted) and *Phragmites australis* sites.

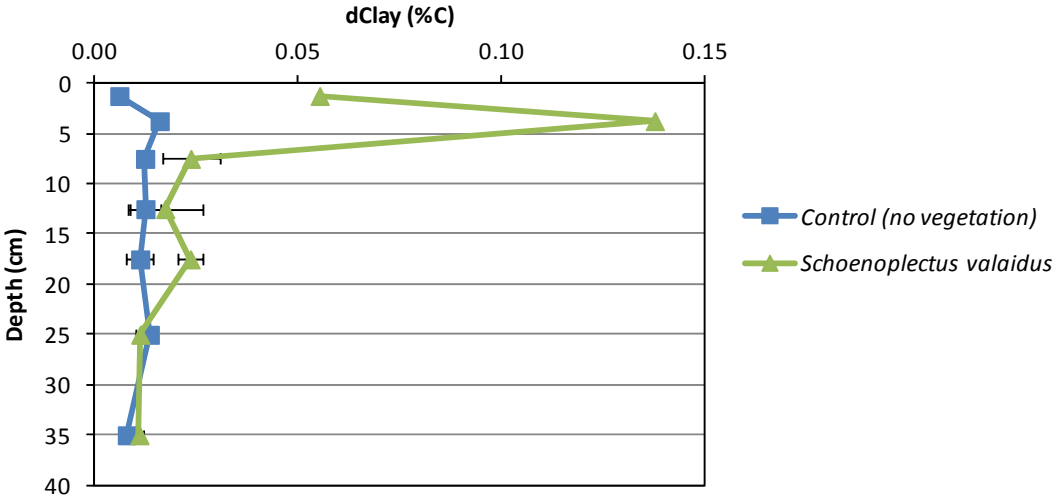

Figure 9-18. dClay carbon fraction at the Hunters Creek control (no vegetation) and Schoenoplectus valaidus sites.

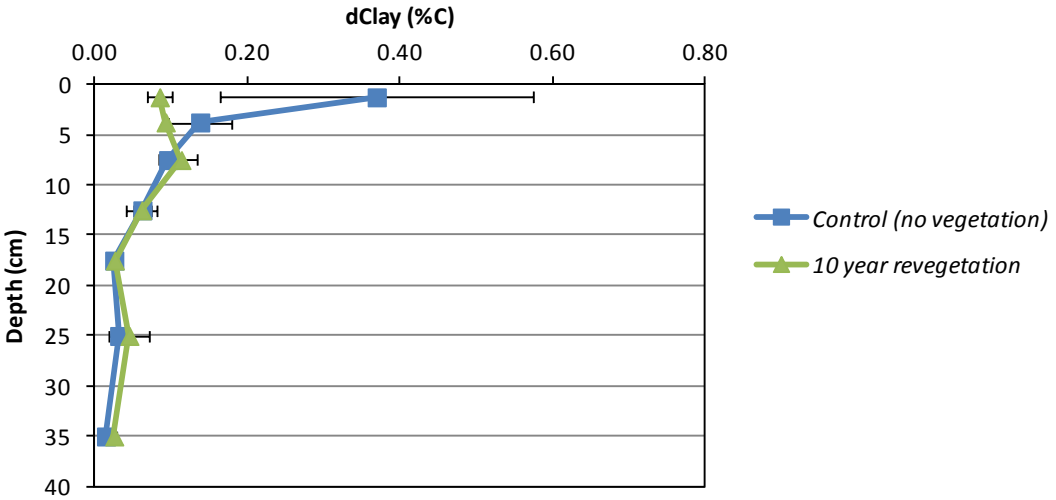

Figure 9-19. dClay carbon fraction at the Hunters Creek control and *Melaleuca halmaturorum* sites (10 year revegetation).

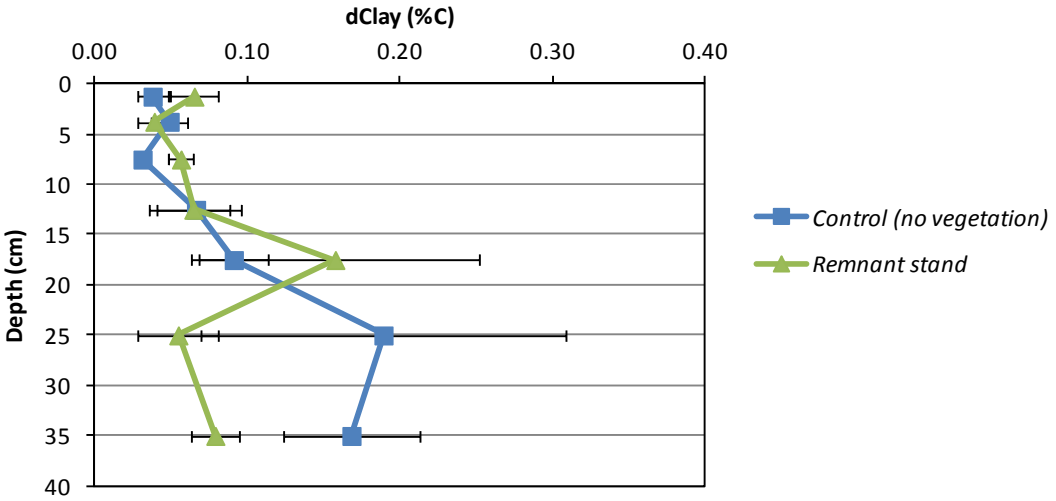

Figure 9-20. dClay carbon fraction at the Hunters Creek control and *Melaleuca halmaturorum* sites (Remnant stand).

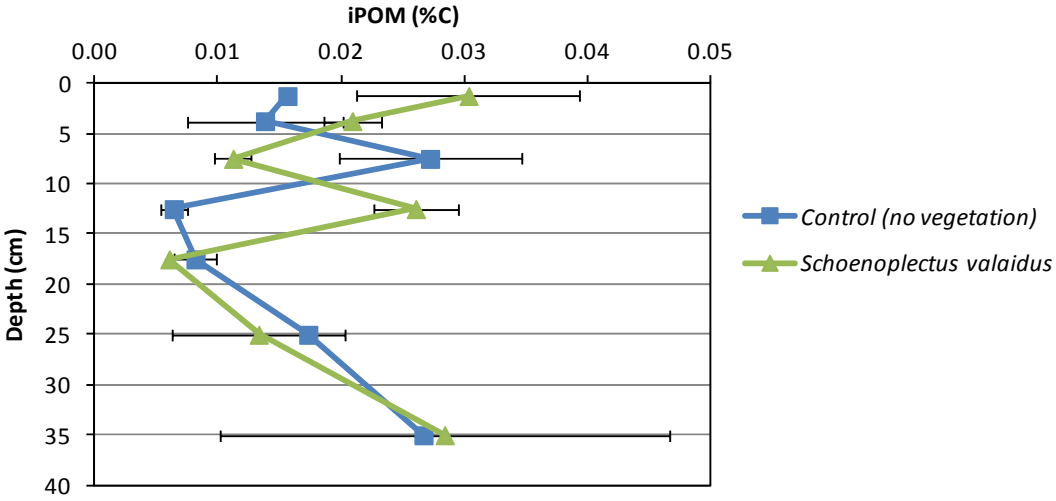

Figure 9-21. iPOM carbon fraction at the Meningie control (no vegetation) and *Schoenoplectus valaidus* sites.

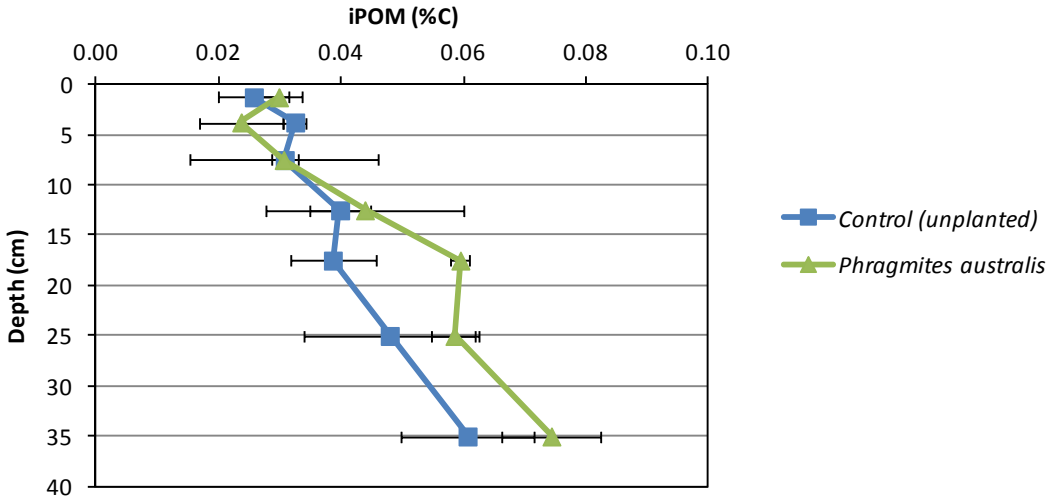

Figure 9-22. iPOM carbon fraction at the Waltowa control (unplanted) and *Phragmites australis* sites.

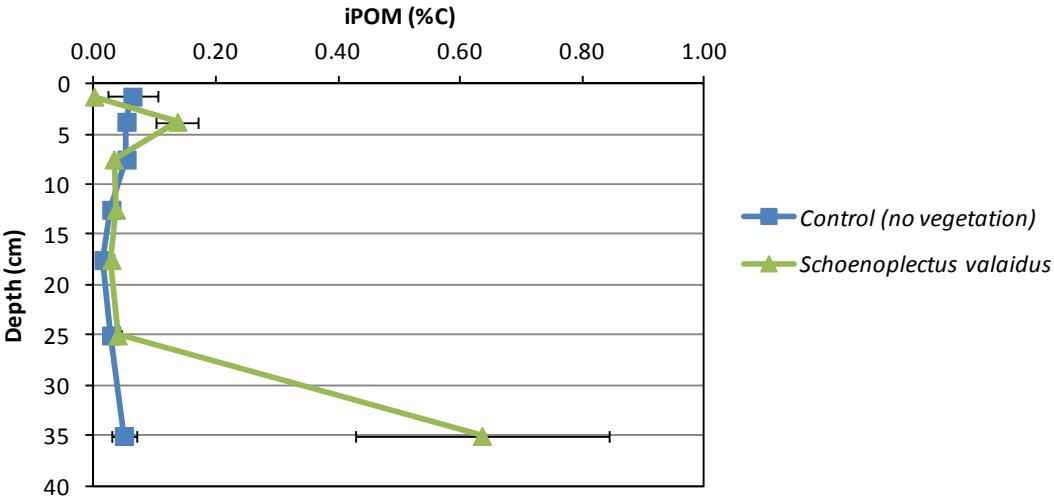

Figure 9-23. iPOM carbon fraction at the Hunters Creek control (no vegetation) and Schoenoplectus valaidus sites.

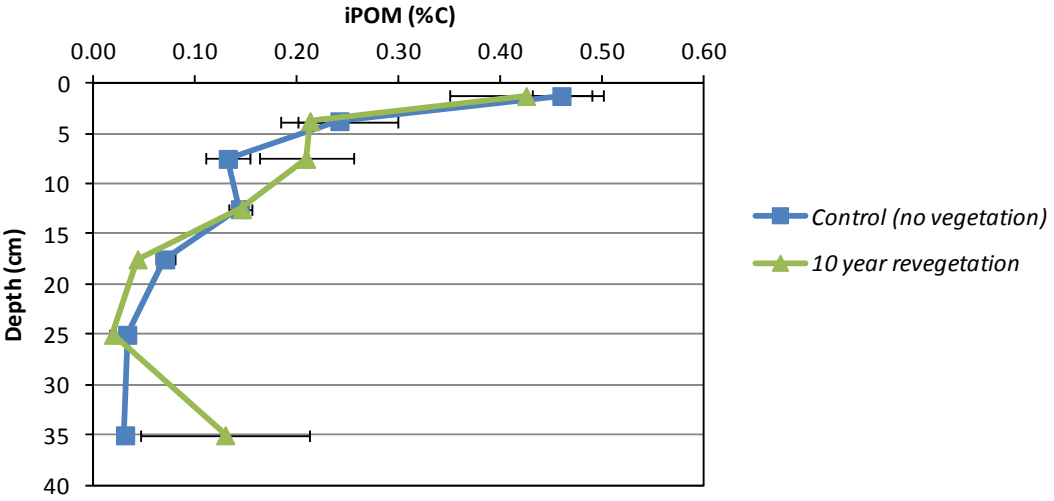

Figure 9-24. iPOM carbon fraction at the Hunters Creek control and *Melaleuca halmaturorum* sites (10 year revegetation).

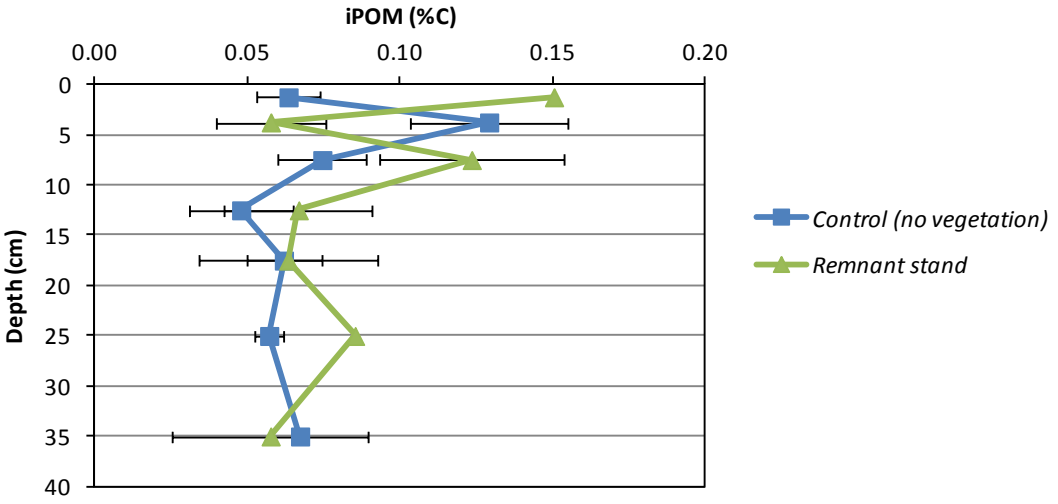

Figure 9-25. iPOM carbon fraction at the Hunters Creek control and *Melaleuca halmaturorum* sites (Remnant stand).

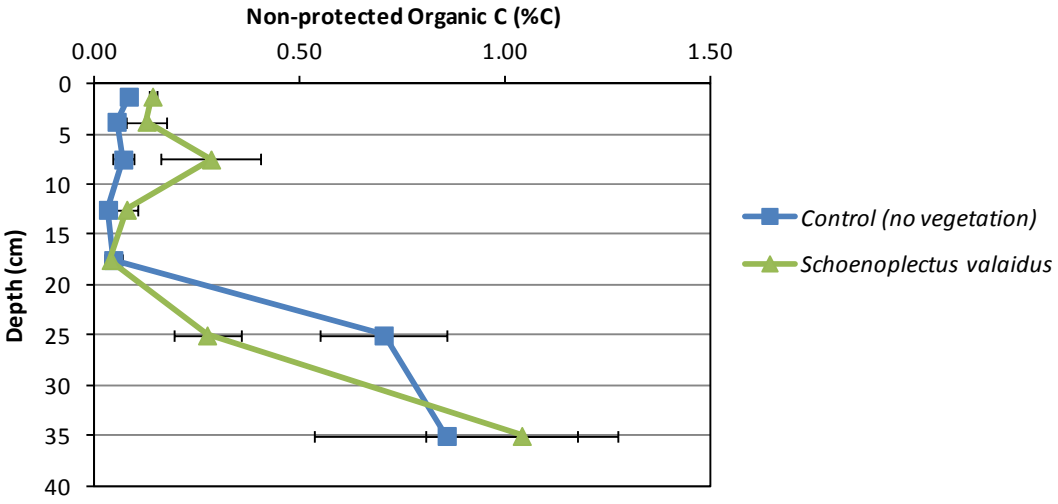

Figure 9-26. Non-protected organic carbon fraction at the Meningie control (no vegetation) and *Schoenoplectus valaidus* sites.

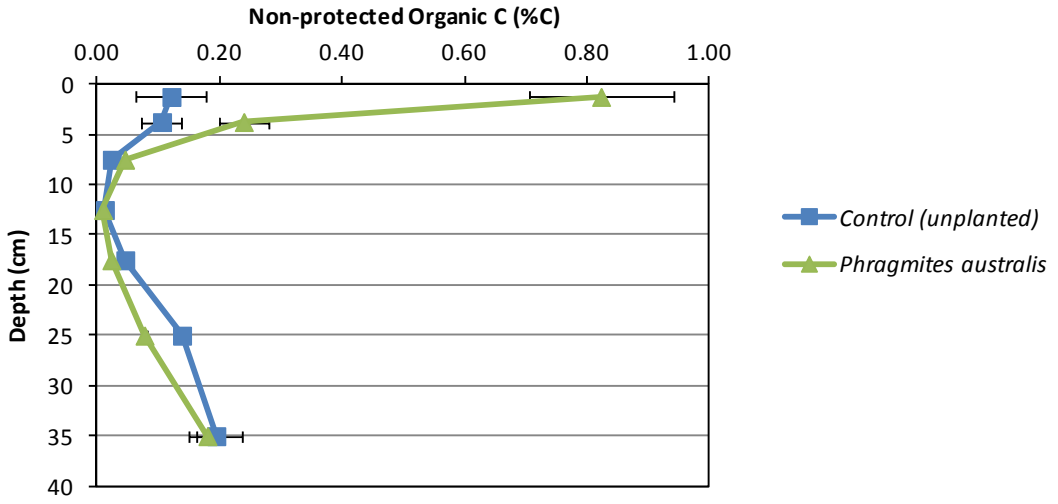

Figure 9-27. Non-protected organic carbon fraction at the Waltowa control (unplanted) and *Phragmites australis* sites.

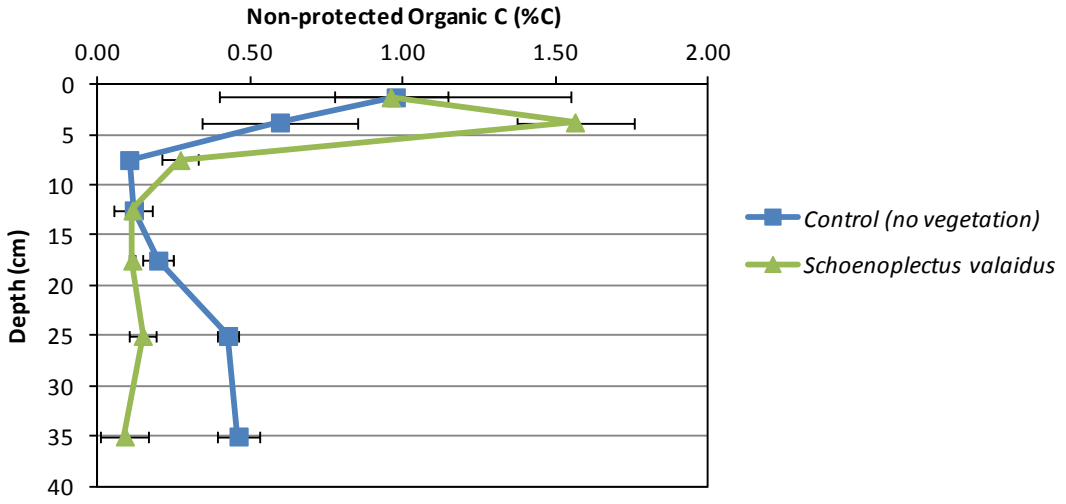

Figure 9-28. Non-protected organic carbon fraction at the Hunters Creek control (no vegetation) and Schoenoplectus valaidus sites.

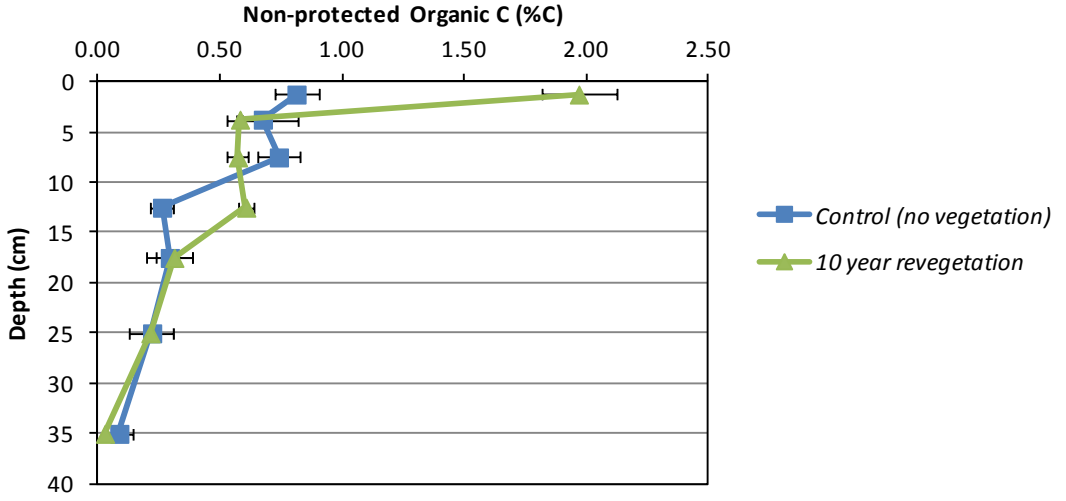

Figure 9-29. Non-protected organic carbon fraction at the Hunters Creek control and *Melaleuca halmaturorum* sites (10 year revegetation).

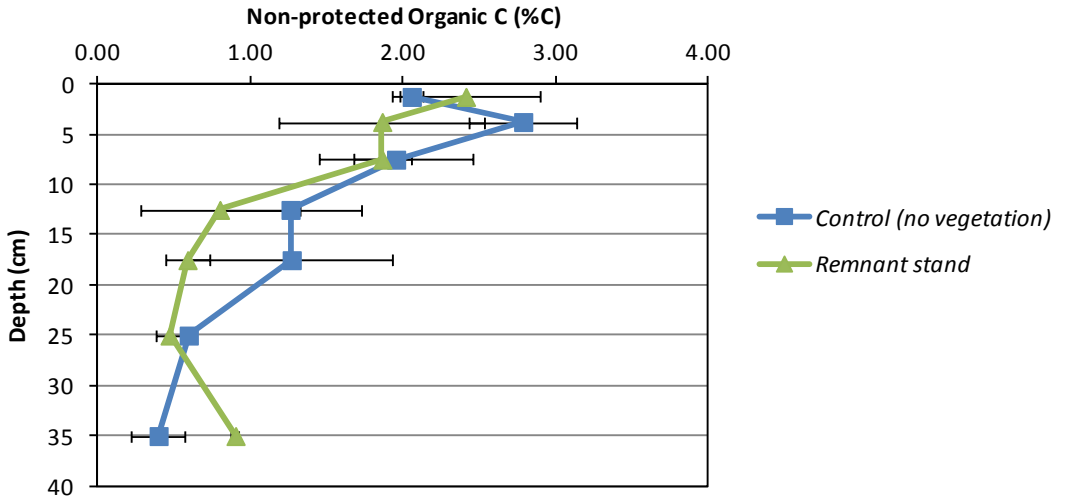

Figure 9-30. Non-protected organic carbon fraction at the Hunters Creek control and *Melaleuca halmaturorum* sites (Remnant stand).

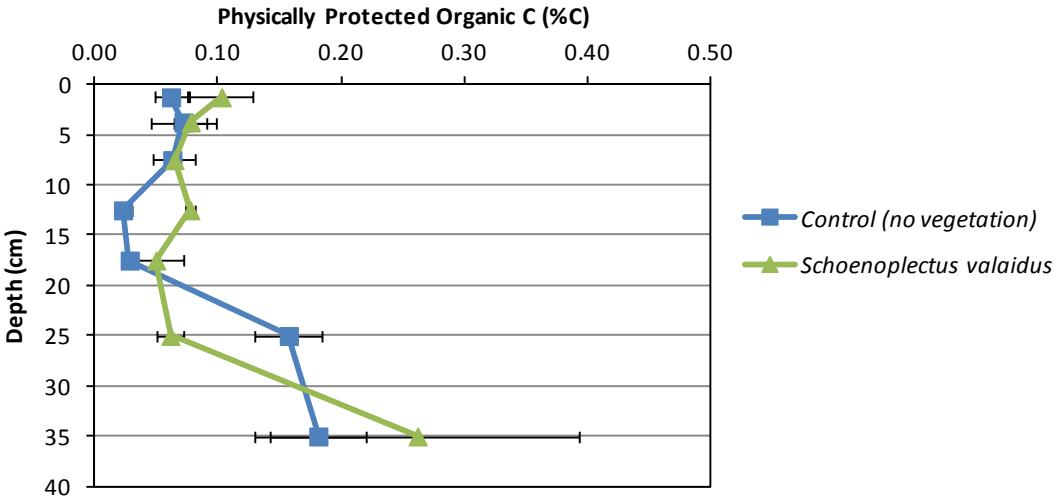

Figure 9-31. Physically protected organic carbon fraction at the Meningie control (no vegetation) and *Schoenoplectus valaidus* sites.

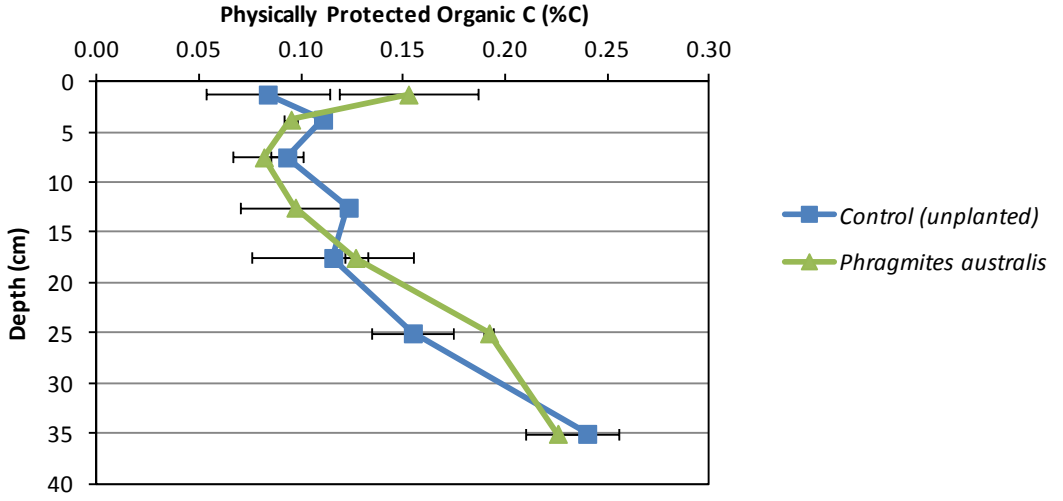

Figure 9-32. Physically protected organic carbon fraction at the Waltowa control (unplanted) and *Phragmites australis* sites.

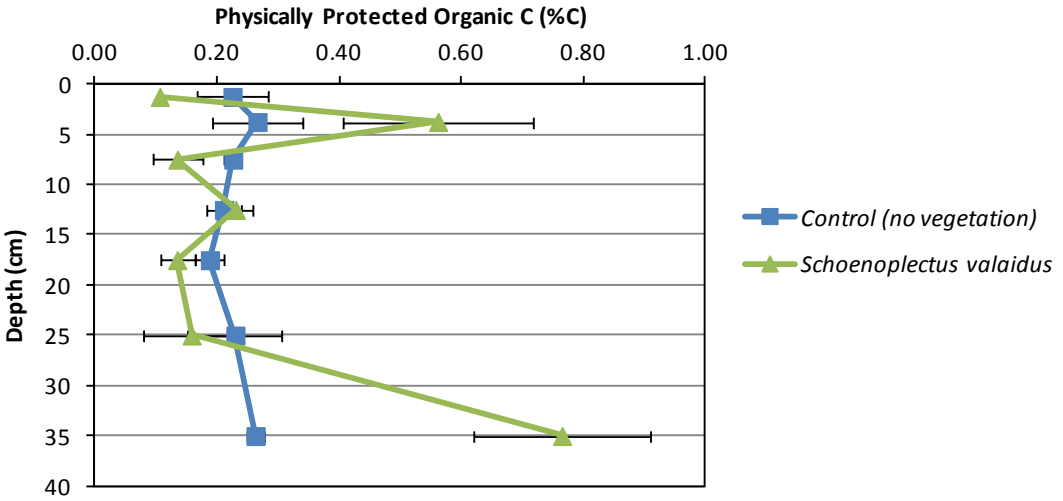

Figure 9-33. Physically protected organic carbon fraction at the Hunters Creek control (no vegetation) and Schoenoplectus valaidus sites.

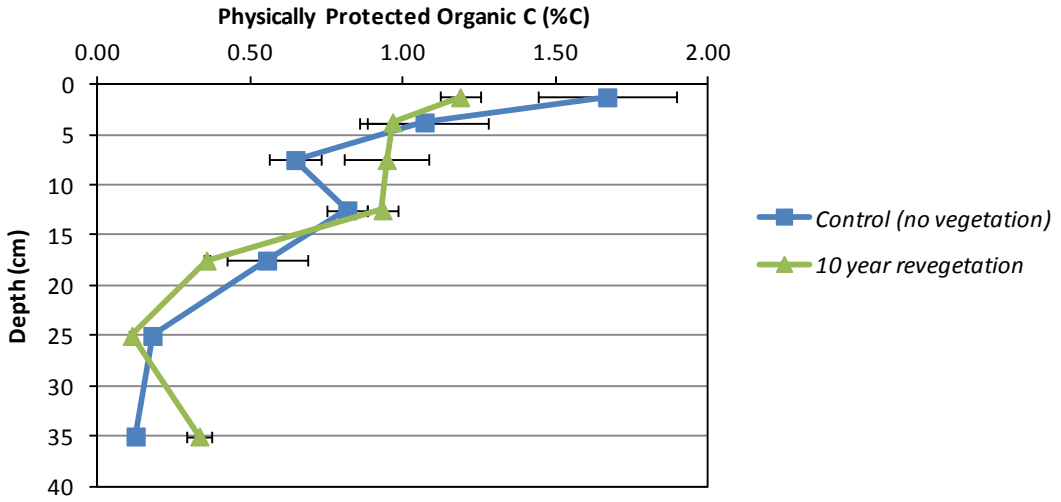

Figure 9-34. Physically protected organic carbon fraction at the Hunters Creek control and *Melaleuca halmaturorum* sites (10 year revegetation).

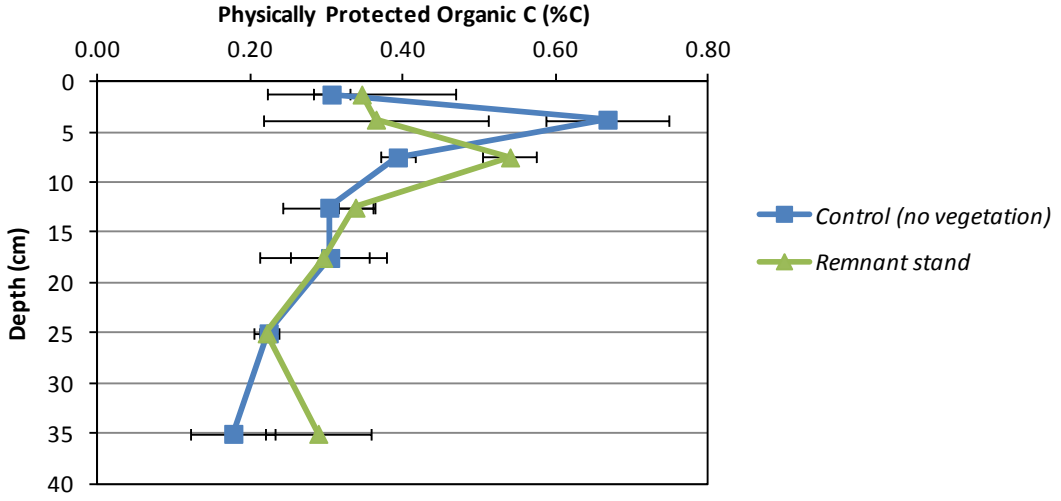

Figure 9-35. Physically protected organic carbon fraction at the Hunters Creek control and *Melaleuca halmaturorum* sites (Remnant stand).

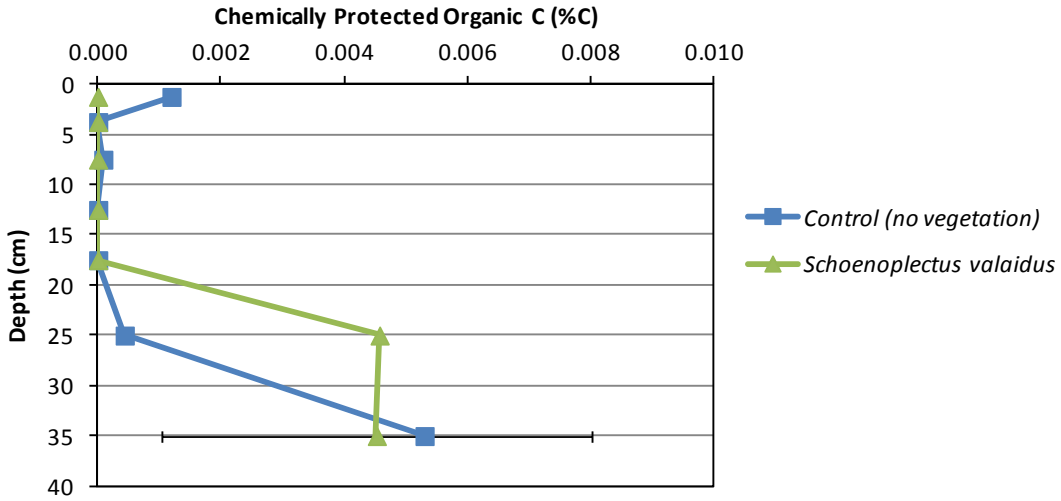

Figure 9-36. Chemically protected organic carbon fraction at the Meningie control (no vegetation) and *Schoenoplectus valaidus* sites.

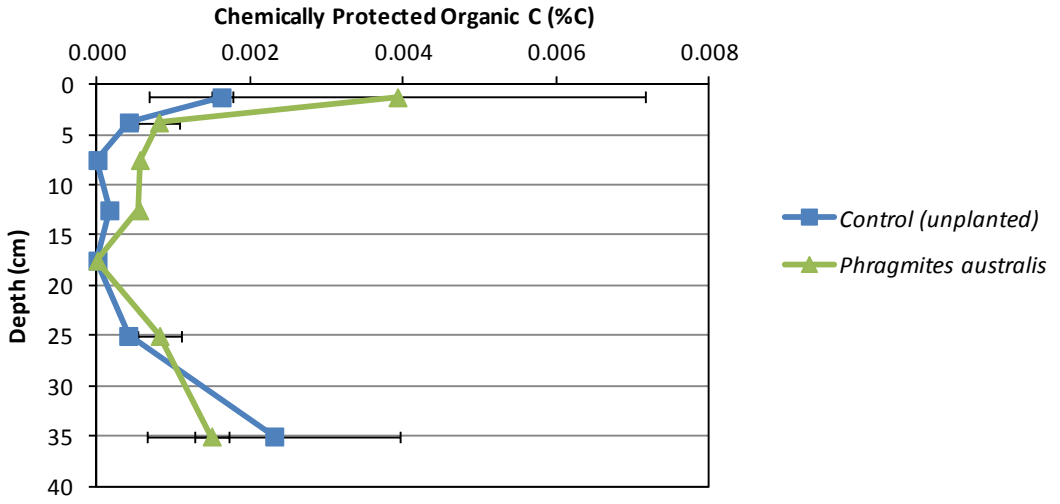

Figure 9-37. Chemically protected organic carbon fraction at the Waltowa control (unplanted) and *Phragmites australis* sites.

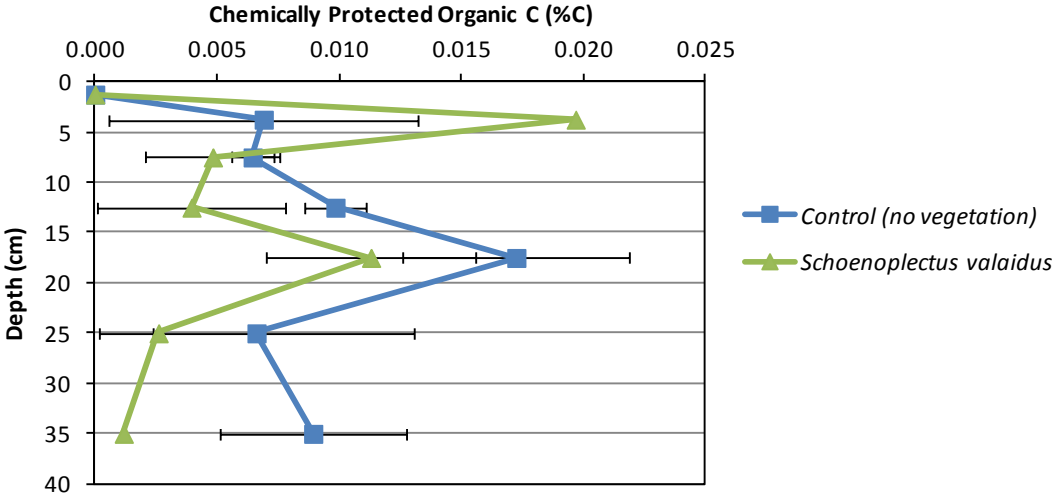

Figure 9-38. Chemically protected organic carbon fraction at the Hunters Creek control (no vegetation) and Schoenoplectus valaidus sites.

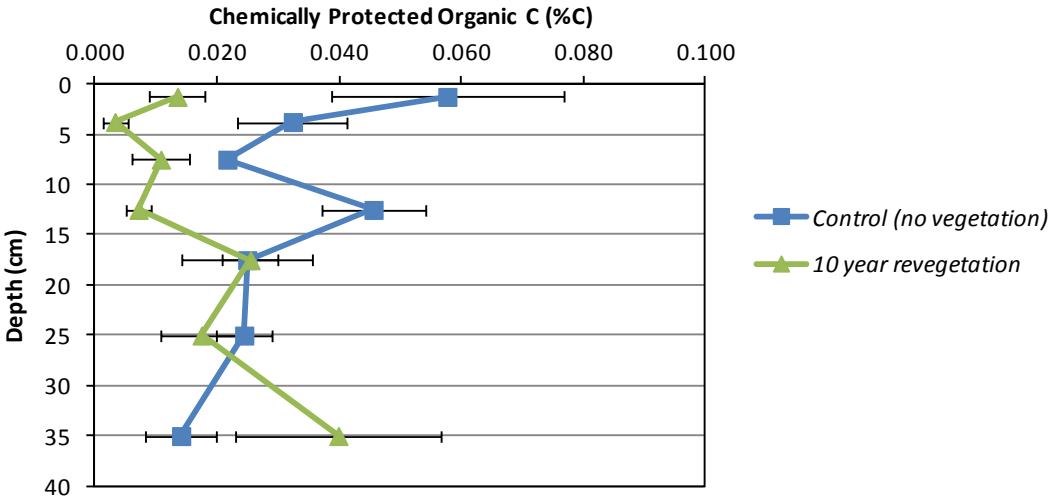

Figure 9-39. Chemically protected organic carbon fraction at the Hunters Creek control and *Melaleuca halmaturorum* sites (10 year revegetation).

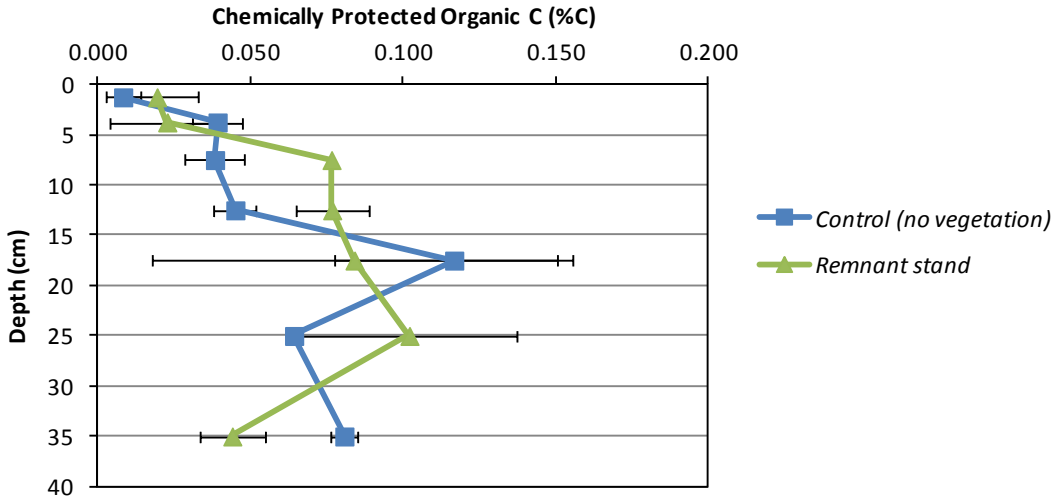

Figure 9-40. Chemically protected organic carbon fraction at the Hunters Creek control and *Melaleuca halmaturorum* sites (Remnant stand).

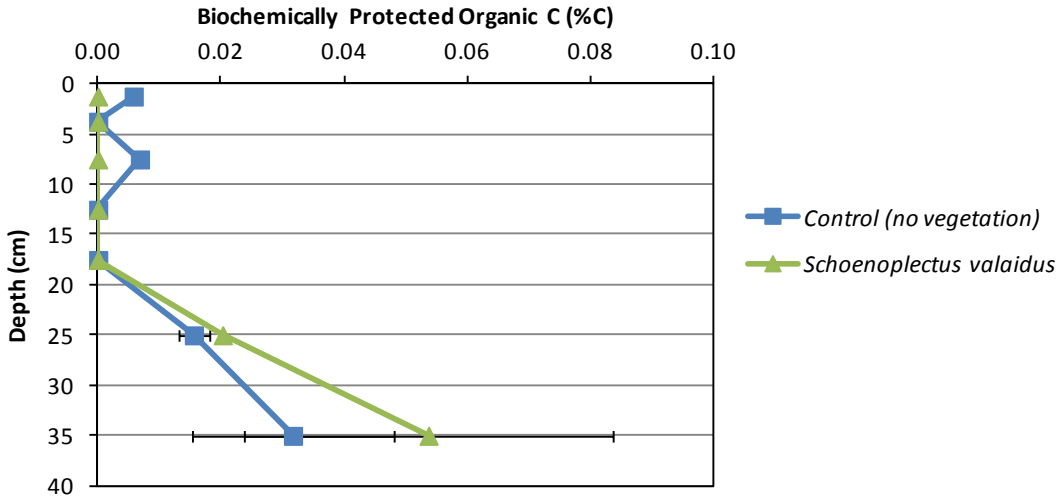

Figure 9-41. Biochemically protected organic carbon fraction at the Meningie control (no vegetation) and *Schoenoplectus valaidus* sites.

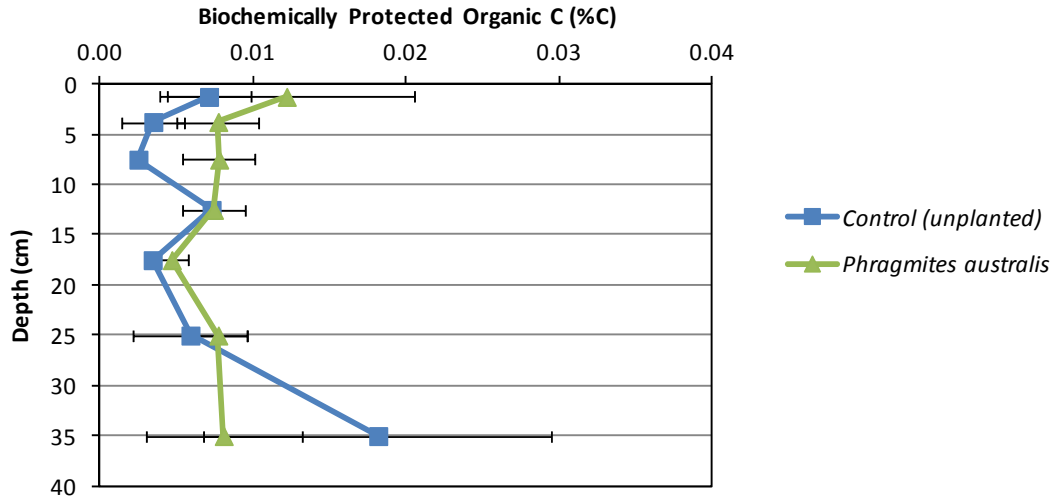

Figure 9-42. Biochemically protected organic carbon fraction at the Waltowa control (unplanted) and *Phragmites australis* sites.

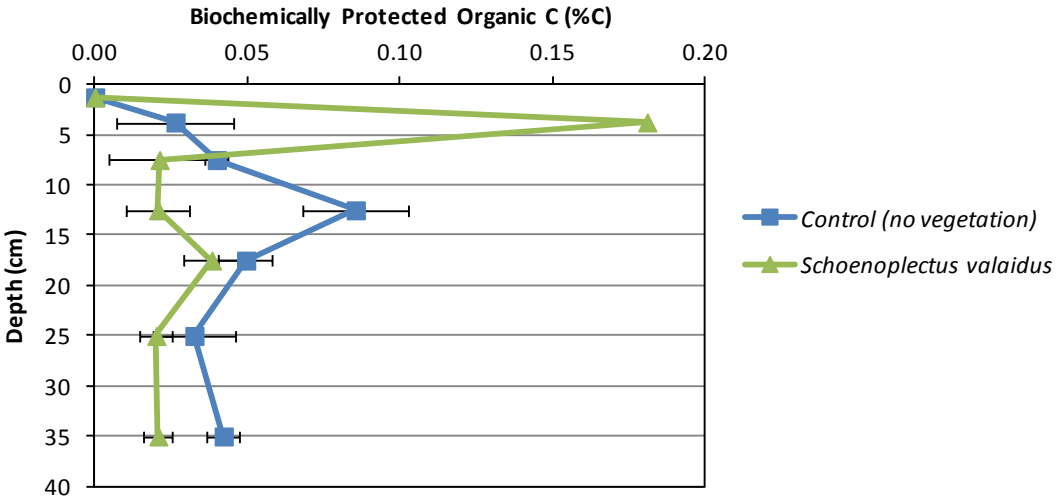

Figure 9-43. Biochemically protected organic carbon fraction at the Hunters Creek control (no vegetation) and Schoenoplectus valaidus sites.

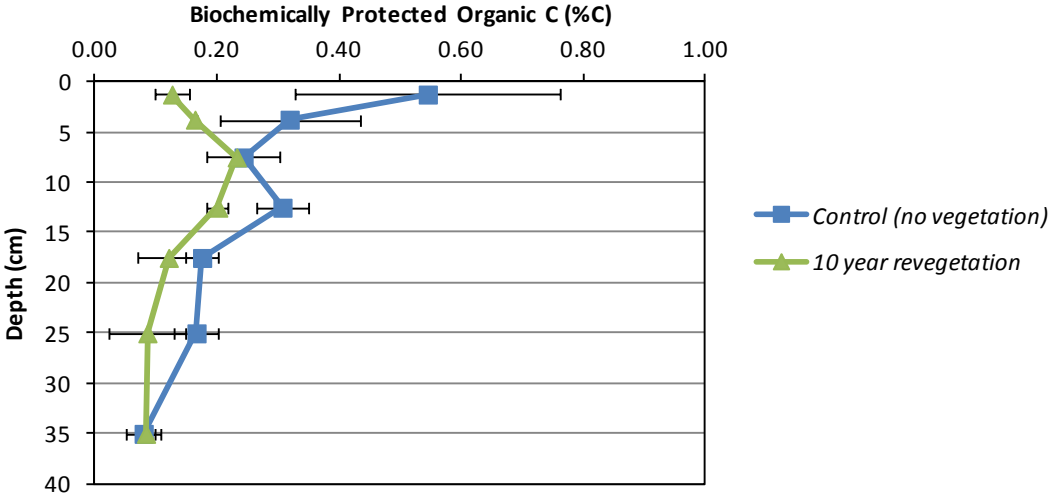

Figure 9-44. Biochemically protected organic carbon fraction at the Hunters Creek control and *Melaleuca halmaturorum* sites (10 year revegetation).

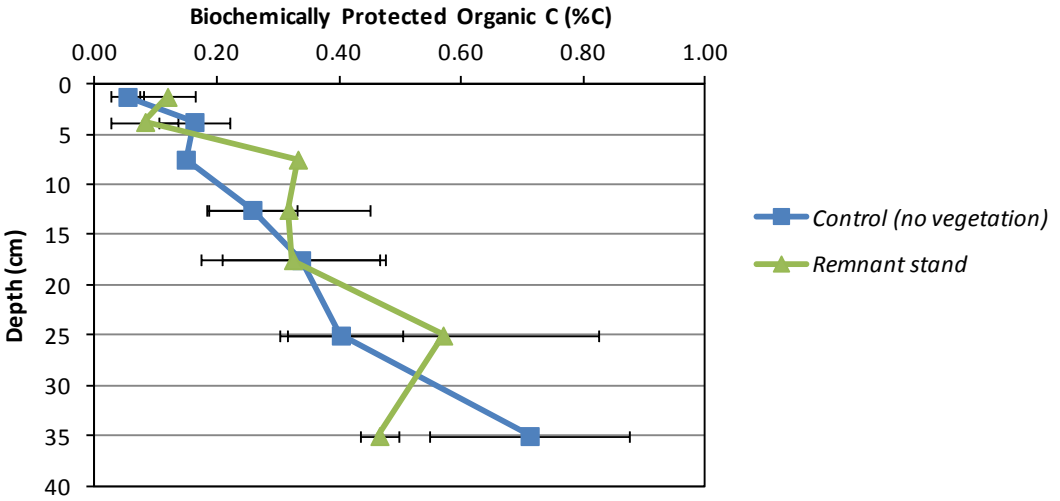

Figure 9-45. Biochemically protected organic carbon fraction at the Hunters Creek control and *Melaleuca halmaturorum* sites (Remnant stand).

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