Baseline study of the soil composition of the degraded marsh, known as Campgrounds, based on soil depths of at least two meters.

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Abstract:

The Los Cerritos Wetlands Complex incorporates some of the last remaining coastal wetlands in Southern California. Soil quality is an important aspect of how a wetland functions. For this study, soil cores were taken from an area called the Campgrounds, a degraded coastal salt marsh located within the Los Cerritos Wetlands Complex in Long Beach, CA. Two long cores where taken, and soil was analyzed by testing grain size, bulk density, heavy metal concentration and organic carbon concentration. When compared to Steam Shovel Slough, a nearby functioning wetland, the Campgrounds showed similar grain size percentages, but carbon content was much lower. The Campgrounds were also observed to have high levels of the heavy metal zinc. We attribute these results, in part, to the urban development surrounding the property. Based on our findings we believe, that with proper remediation, the Campgrounds can be restored to a functioning wetland.

Introduction:

Of the ecological systems in the world wetlands are among the most important. Not only because they are biologically diverse, but also because they provide important environmental and economic benefits. Californians, in particular, need wetlands as a retreat away from the hustle and bustle of the day to day life. Visitors of a restored Los Cerritos Wetlands would enjoy the true tranquility of connecting with one of nature's most peaceful environments. Even in their degraded state, the Los Cerritos Wetlands house some of the most exciting and majestic animals. Between the wildlife and the unique vegetation the Los Cerritos Wetlands have the potential of drawing all kinds of nature lovers. Recreational value is only one of the many benefits that the Los Cerritos Wetlands provide to the community. The wetlands are also capable of providing flood and storm protection, water purification, breeding grounds for fish and shellfish, habitat for endangered species, and a resting ground for migratory birds. The value of wetlands is clear, even so, these gems of the California coast have been lost at an alarming rate. California has lost an estimated 90 – 95% of its historic coastal wetlands (Pednekar et al., 2005). This huge loss creates an urgent need to preserve the last of our restorable wetlands. The Los Cerritos Wetlands is the largest tidal estuarine salt marsh in Los Angeles County. Portions of the Wetlands are still fully functioning, but other areas are degraded. Currently there is an effort to acquire privately owned portions of the wetlands for a large scale restoration project.

Healthy coastal wetlands are typified by soil with clay to clay loam textures (Zedler, 2001). These soils are composed of small grain size particles, and ideally for wetlands, anaerobic conditions of hydric soils (Zedler, 2001). Soils are also expected to have higher concentrations of organic matter which provide nutrients for wetland plant species. These distinctive qualities, in part, determine the composition and diversity of plants found throughout the marsh.(Davidson et al.,2008). Sediment can be deposited on wetlands both naturally and from anthropogenic sources. These accumulated sediments can play a considerable role in how a wetland functions. In particular grain size affects the sorption of heavy metals, organic material, and water content, as well as, playing a role in bulk density. (Yang et al., 2008) Soils with higher percentages of fine grains retain more water, nutrients and heavy metals, while coarser grain sediments allow these items to travel easily through the sediment.

Determining the quality of the soil is an important part of wetland restoration because it provides valuable information for creating the basic structure of a successful restoration plan. The purpose of this study was to determine the feasibility of restoration for the Campgrounds, a degraded marsh located in Long Beach at 2nd Street and Studebaker. The 2009 Hydro/Chem team evaluated the quality of the soil at depths up to 360 cm, and made these results available to the 2009 Ecology team for their wetlands restoration plan. The 2009 H/C team chose to core to a minimum of 2 meters to ensure that information attained would include analysis of original wetland soil as well as top fill. Evaluating the soil to this depth insured our data provided accurate values for grain size percentages, organic carbon content, and heavy metals. The location of our cores where chosen based on their location within the campgrounds. One core was taken at a location near 2nd Street at N33°45.494' W118°6.126' and one was taken near the rivers edge at N33°45.458'W118°6.094'.

The tests performed on the soils of the Campgrounds included: grain size analysis, bulk density, organic carbon content, and heavy mental content. These tests were preformed to determine if the Campgrounds were, in fact, a wetland, determine the quality of the soil, and provide important information for restoration planning. Grain size was tested to determine the ability of the soil to retain water and support plant life. Results for grain size analysis were compared with the results, taken by the 2007 Hydro/Chem team, from intertidal zone of Steam Shovel Slough a nearby, fully functioning wetland. Soils were tested for organic carbon content to determine where the healthiest soils are, and therefore, guide the 2009 Ecology team in their restoration planning efforts. Soils with high organic carbons are considered healthier, and are better able to support vegetation. The soil was also tested for heavy metal content. Heavy metals dramatically affect the health of wetlands. Metals that were tested for include lead, zinc, and arsenic. These metals were chosen based on the results from previous Hydro/Chem teams, and the negative affects they can have on the beneficial uses of wetlands and the species that live within them. By doing this study we hope to determine that the soils of the Campgrounds are characteristic of wetlands and conducive for establishing a successful wetland habitat. We also hope that our results will guide the 2009 – and future - Ecology teams in creating a successful restoration plan that will benefit the surrounding community.

Methods:

Sample Collection & Location

Within the Los Cerritos Wetlands Complex (LCW) two sites in the Degraded Marsh, also known as the Campgrounds, will be used for this study to evaluate the conditions of the soil at depths greater than 45cm. Locations chosen and located via GPS are seen in the included Google Earth image of our area of study in the section of the LCW. Two 2 meter soil core samples were collected with a modified hydraulic sediment corer. Collected cores were stored in oriented protective plastic sleeves until lab analysis. In the lab, samples will be dissected into halves, described visually in terms of geologic strata and soil type, and then cut into 3 cm sections.

Table 1. Coordinates of Core Samples from the Campgrounds

	latitude	**longitude**
CG1	N33°45.458’	W118°6.094’
CG2	N33°45.494’	W118°6.126’

P1 is location of CG1
P2 is location of CG2

Figure 1. Map of study location, the Campgrounds.

Grain Size

Grain size analysis will follow the protocol method outline by Lewis and McChonchie 1994. The process will involve wet sieving a 20 gram homogenized sample through a 0.0625 mm sieve to separate coarse sand grains from finer sediments. Separated sand grains will represent 2φ grain sizes particles. Sediment that flows through the sieve will then be diluted to 1000ml with nano-pure water. The column will be agitated to ensure a homogenous mixture. At 20 seconds post agitation, a 20ml pipetted sample will be taken at a depth of 20 cm within the column. This sample will represent 4φ grain size particles. At 2 hours post agitation, another 20 ml sample will be taken, this time at 10 cm. This sample will represent 8φ grain sizes particles. The 20-ml samples, as well as the separated coarse sand grains, will then be dried, weighed, and numbers will be adjusted for 1000mL content. With equations outlined in Boggs 2000, weights will be used to calculate median grain size, and percent silt, mud, and sand. Grain size analysis will be used to determine if soils are characteristic of wetlands and to determine the health of the soils at different depths and proximities to development.

Bulk Density

Soil will be loosely packed to fill 1.5 mL pre-weighed vials. Once full, vials will be re-weighed and data will be recorded. Samples will then be placed in a vacuum drier for 24 hours to eliminate all moisture within the sample. Once dried the vial with sediment will be weighed. Dried weight will be subtracted from wet weight, and *in situ* bulk density and porosity will be calculated. Bulk density will be used to determine if root penetration is possible, and porosity will be used to determine the soil's water holding abilities. Healthy wetlands soils will have relatively lower bulk densities and be able to retain water.

Total Carbon

Samples were selected for total carbon testing based on sample depth. At least one sample was chosen from each core so that as broad an understanding of how carbon content relates to depth in the Campground could be formed. Percent total carbon was measured using loss on ignition methods such as those used by the 2008 hydro/chem. team. First samples were dried in a freeze dryer to remove any water that might inflate the sample weight prior to ignition. After freezing samples were homogenized using a mortar and pestle. Next, 10-17mg of sample was weighed into a ceramic boat. The boat was then run through the CM5300 Total Carbon Apparatus, located in the IIRMES laboratory, which combusted the sample at a temperature of 950^oC. A CM5014 CO_2 Coulometer, calibrated using known $CaCO_3$ samples, then measured the CO_2 released by the sample combustion and printed a percent total carbon value on a data sheet. The Coulometer was allowed to run for 15 min, or until it was finished, whichever came first.

Heavy Metals

Analysis for heavy metals present in soil samples will be performed according to EPA Method 3052. The samples will be digested in concentrated acids and analyzed by inductively coupled plasma mass spectrometry (ICP-MS). The ICP-MS decomposes targeted elements into ions; detecting and separating them by mass to charge ratios to yield recoveries of metals such as Lead and Zinc. Heavy metals are some of the most highly regulated pollutants because of the dangers some of them pose to human and environmental health. Many of these metals are necessary in small concentrations but dangerous in high concentrations. One of the arguments for restoring wetland habitat is the beneficial aspects they bring as a nursery for marine species. However, if heavy metals are present in the Los Cerritos wetlands then restoring them without proper mitigation could contribute to greater bio-accumulation of heavy metals in the food chain. This test will verify or deny the presence of heavy metals in the samples tested. The Perkin-Elmer 6100 ICP-MS that will be used is located in IIRMES and will be operated as directed by Chris Mull.

Software/Statistics

Programs used in facilitating with our research included statistical software, computer software like Microsoft and various geographic systems. A handheld GPS system was used to identify coordinates of the locations chosen for the soil cores that will be extracted and analyzed. Google Earth helped locate the GPS coordinates to provide the map included in the report. Analyzed data and results are represented on MS Excel or Origin graphs and tables.

Results:

Grain Size

To calculate the cumulative dry weight of the dehydrated sand, silt, and clay the cumulative % of mud range formula was used:

$$\textbf{\% Mud} = 100 - \frac{((50-1) * \text{Pipetted Sample Weight})}{S + F}$$

S = Weight of Sand Fraction
F = Weight of Mud

Results for each sample can be located in the Appendix. Sand percentages for drive 1 where much higher than drive 2, and amounts of sand varied widely with depth. Sand percentages remained relatively consistent throughout drive 2 typically staying at or under 10%. Silt and clay percentages also varied widely in drive 1. Variation was independent of depth. Throughout drive 2 silt and clay percentages typically exceeded 90%. On average, silt percentages where the highest and made up for more than half of each soil sample with an average of 64%. Soil classifications for drive 1 fall into the loam, clay, and clay loam textures. Soil classifications for drive 2 fall into silty clay loam and silt loam textures. The data for drive 1 is consistent with the results of the 2007 Hydro/Chem team. The data for drive 2 varies from the data collected by the 2007 team which found higher concentration in sand overall.

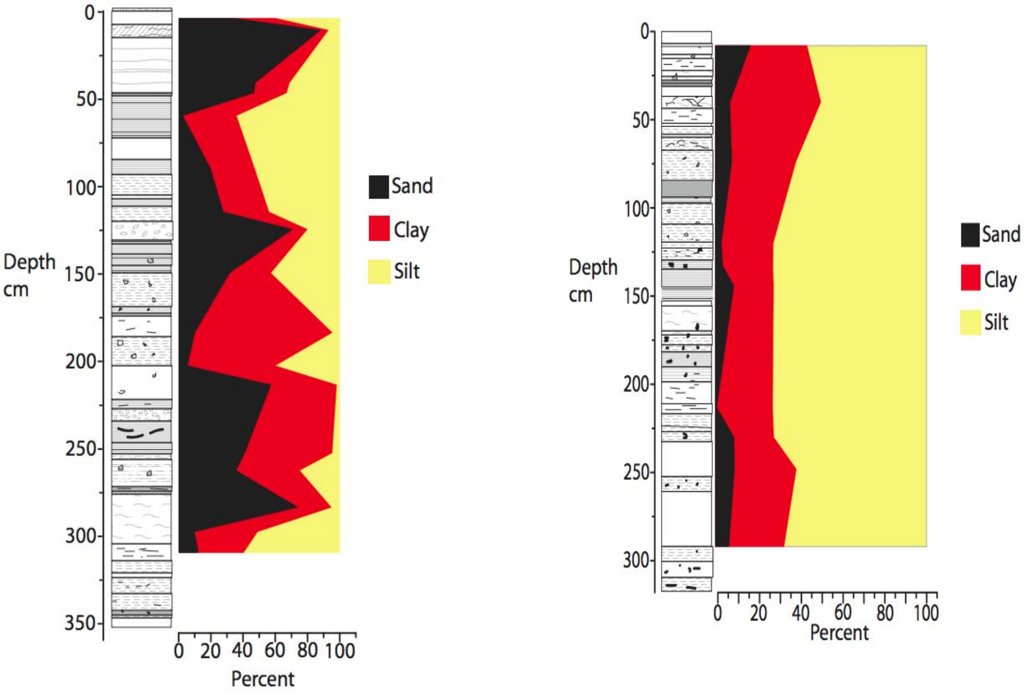

Figure 2. Grain size percentages of sand, silt, and clay for drive 1 (left) and drive 2 (right) in the Campgrounds, a degraded marsh within the Los Cerritos Wetland Complex.

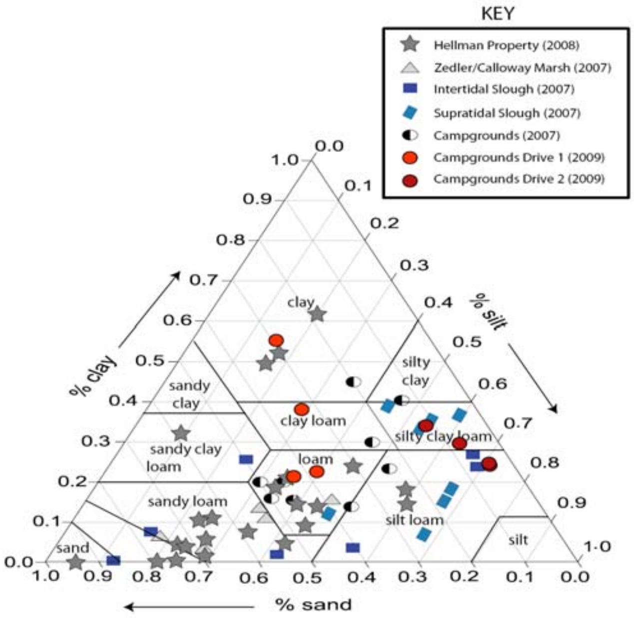

Figure 3. Ternary plot for showing average grain size results for 2007, 2008, and 2009 Hydro/Chem Teams. Point are based on percentages of sand, silt and clay.

Bulk density and porosity

Bulk density and porosity was calculated to determine the soil's capabilities to hold water and allow for root penetration of wetland plants. To calculate bulk density the following formula was used:

Soil bulk density (g/cm$_3$) = $\frac{\text{oven dry weight of soil}}{\text{volume of soil}}$

To calculate porosity the following formula was used:

Soil porosity (%) = 1 – (soil bulk density/2.65) x 100

Results for both bulk density and porosity for each sample can be located in the Appendix. The calculated bulk densities were compared to the texture of the soil to determine the relationship of bulk density to root penetration (Table 2). For both drives the bulk density of the soil was at levels low enough for ideal plant root penetration. In the top 100 cm, drive 1 had an overall lower bulk density then drive 2 by about 15%. Bulk density for both drives increased with depth inversely to porosity which decreased with depth. Porosity for drive 2 remained above 50% until about 240 cm at which time it started dropping off reaching levels as low as 28%. Porosity in drive 1 started at around

50-60% for the first 125 cm, and then decreased; at 300 cm porosity levels where reduced to approximately 44%.

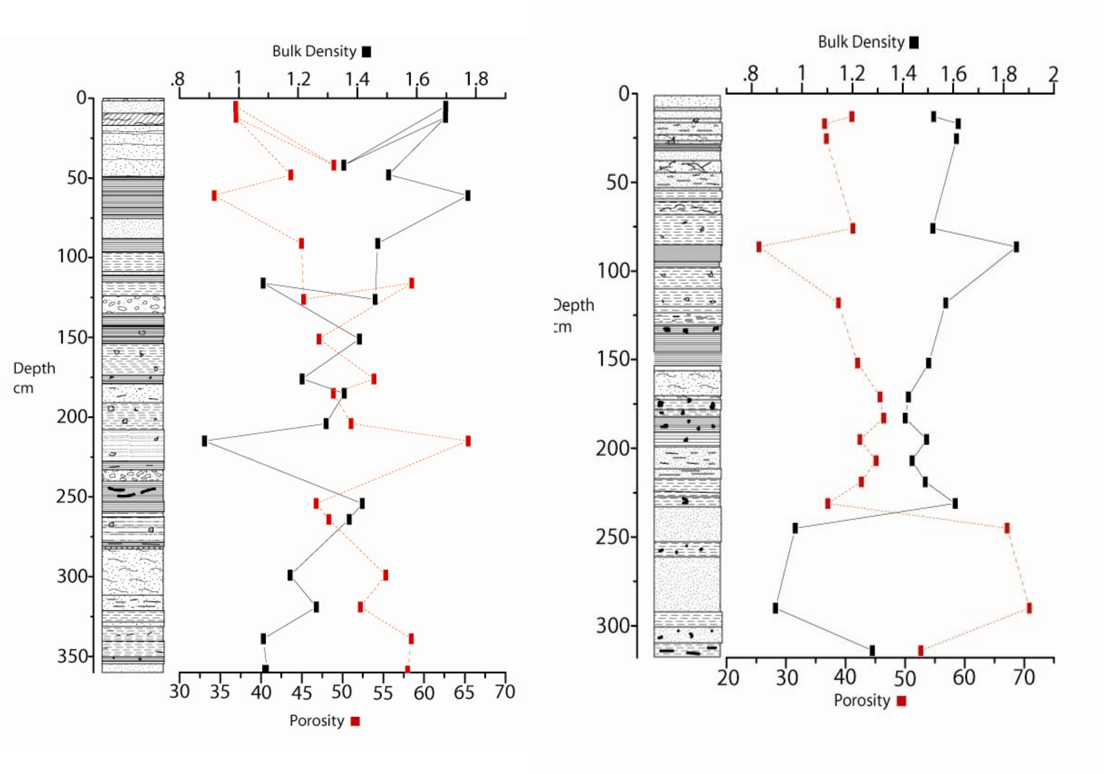

Figure 4. Bulk density and porosity for drive 1 (left) and drive 2 (right) in the Campgrounds, a degraded marsh in the Los Cerritos Wetland Complex.

Table 2. General relationship between bulk density and root growth based on soil texture.

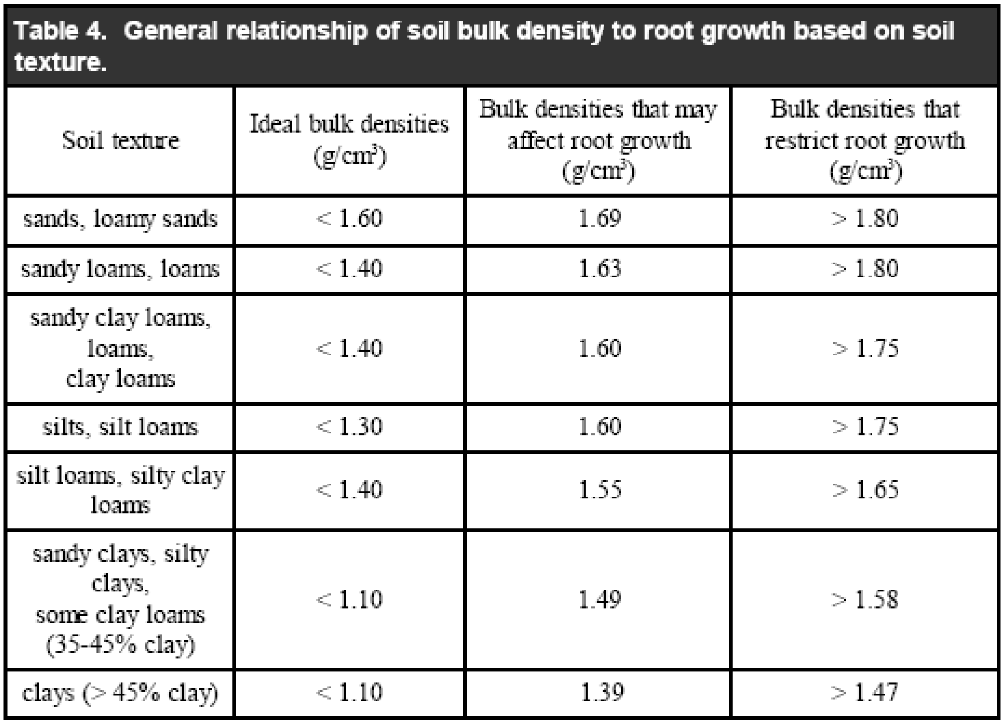

Table 4. General relationship of soil bulk density to root growth based on soil texture.

Soil texture	Ideal bulk densities (g/cm³)	Bulk densities that may affect root growth (g/cm³)	Bulk densities that restrict root growth (g/cm³)
sands, loamy sands	< 1.60	1.69	> 1.80
sandy loams, loams	< 1.40	1.63	> 1.80
sandy clay loams, loams, clay loams	< 1.40	1.60	> 1.75
silts, silt loams	< 1.30	1.60	> 1.75
silt loams, silty clay loams	< 1.40	1.55	> 1.65
sandy clays, silty clays, some clay loams (35-45% clay)	< 1.10	1.49	> 1.58
clays (> 45% clay)	< 1.10	1.39	> 1.47

Total Carbon

The maximum total carbon content for drive 1 was 4.8098% while the minimum value was .0051%. The median sample value for total carbon content in drive 1 was .6212%. The maximum total carbon content for drive 2 was 1.9942% while the minimum value was .4315%. The median total carbon content value for drive 2 was .9126%. There was no discernable relationship between TC values and depth. There was also little discernable relationship between soil texture and carbon content.

Table 3. Drive 1 TC measurements

Depth cm	Percent Total Carbon
49	.8923
95	4.8098
101.5	.0051
153.5	.9407
182	1.3354
203	.3007
243	.5085
299	.5754
339	.6212

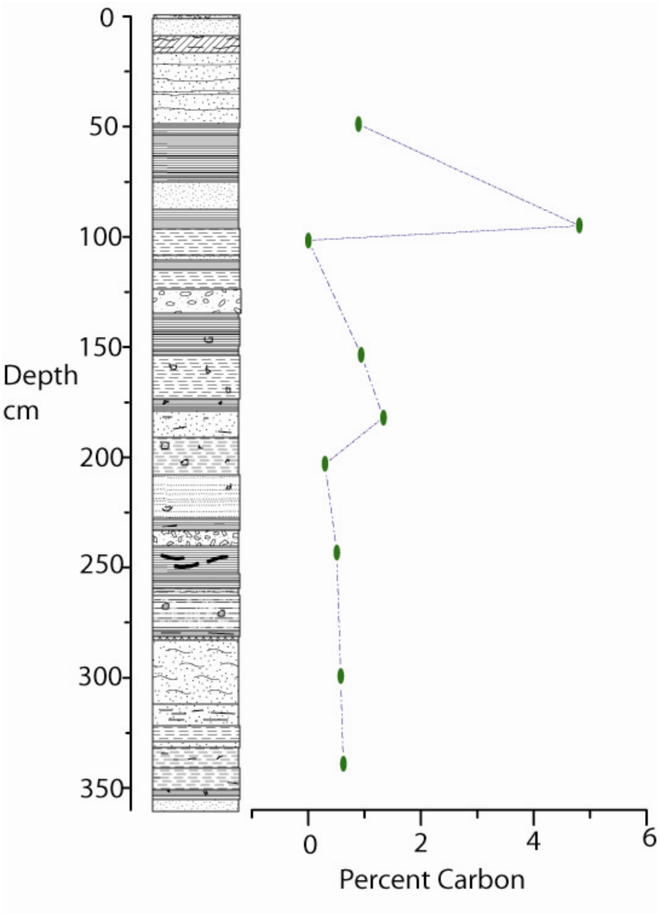

Figure 5. Drive 1, depth vs. percent total carbon.

Table 4. Drive 2 TC measurements

Depth cm	Percent Total Carbon
11	.8254
26.75	1.9942
126	1.0338
143	.9997
183	.6815
219	1.7522
247.5	.4315
292.5	.7049

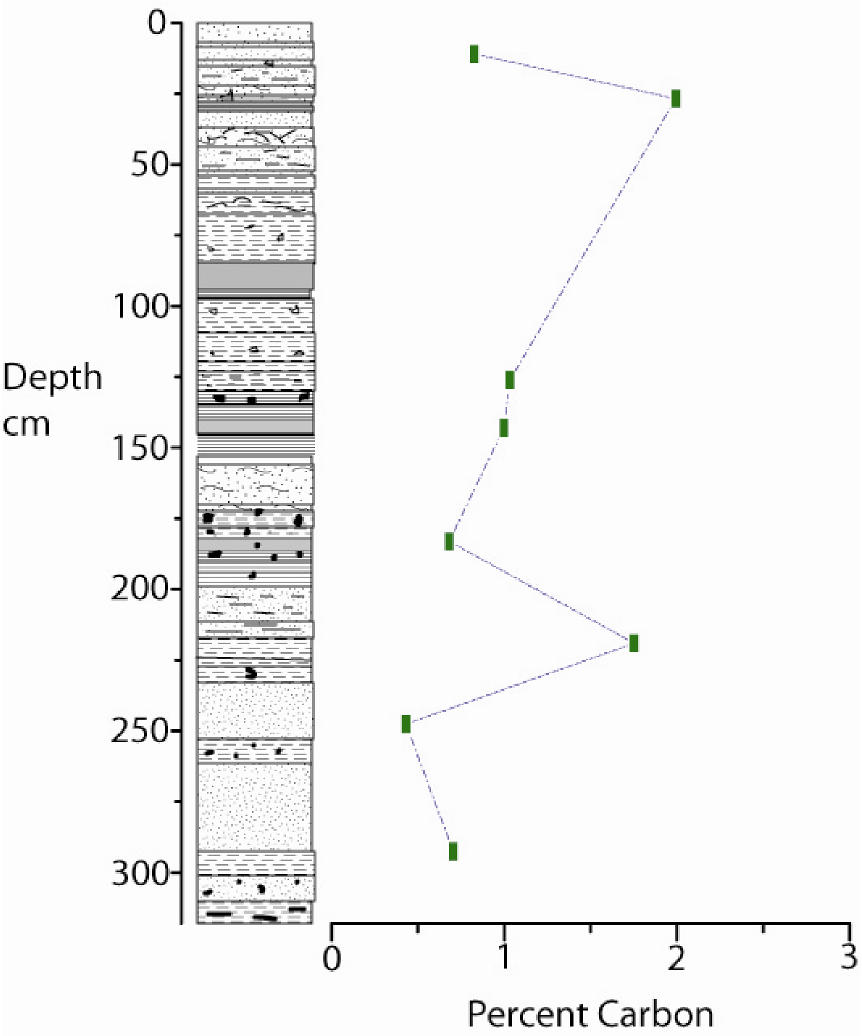

Figure 6. Drive 2, depth vs. percent total carbon.

Heavy Metals

The heavy metals chosen for analysis in the soil samples were zinc (Zn), arsenic (As) and lead (Pb); of theses metals, none exceeded regulatory limits applied to soils. Raw data can be seen in Appendix A. Soil pollution control standards set in accordance to Article 5 of the Soil and Groundwater Pollution Remediation Act, state that soils must contain less than 200,000 ppb for Zn, 200,000 ppb for Pb and 60,000 ppb for As. The concentration for zinc was found to be relatively high in comparison to other heavy metals present but it still remains below the 200,000 ppb control standard, averaging a mere 81,187 ppb for both cores extracted. At the surface of location CG1, large amounts of Zn concentration was found, steadily decreasing with depth. Location CG2 had a more homogenous Zn concentration throughout its entirety with one abrupt increase in concentration at a depth of 225cm. Metal concentrations for lead and arsenic are very similar for both cores, having the characteristic of higher concentrations near the surface then decreasing slightly but having no change with depth. There appears to be no trend with neither with grain size and heavy metal percolation nor with total carbon content and heavy meal absorption.

Table 5. Heavy metal averages

	Zinc	**Arsenic**	**Lead**
CG1	85,083.0 ppb	12,999.5 ppb	16,139.1 ppb
CG2	77,291.5 ppb	10,425.2 ppb	13,728.0 ppb

Note: ppb = ng/g

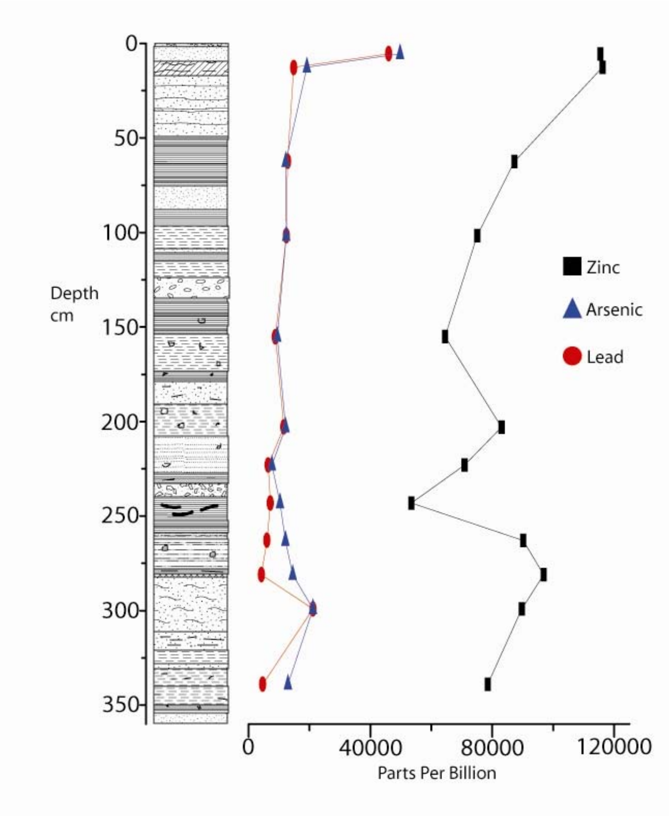

Figure 7. Heavy metal concentration for CG1.

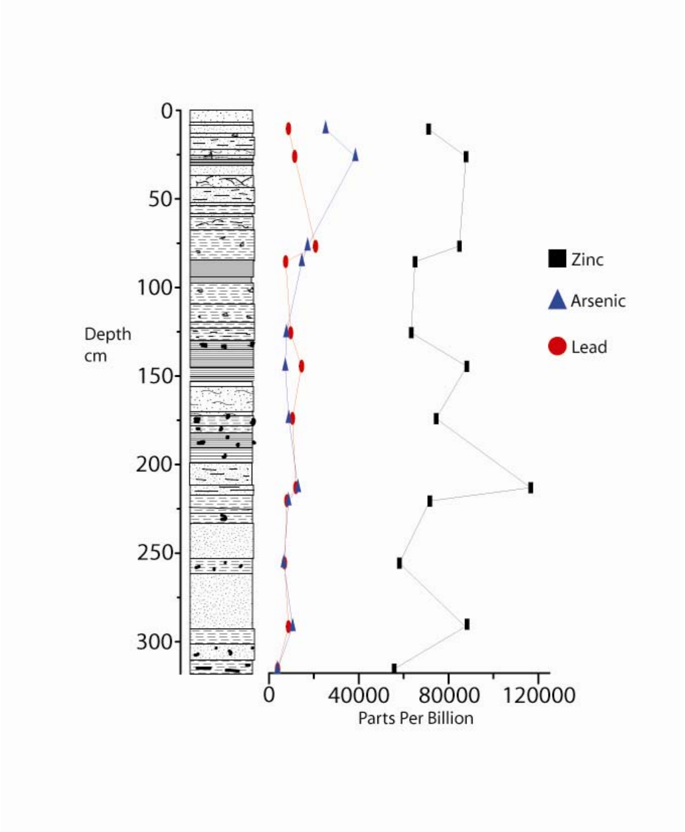

Figure 8. Heavy metal concentration for CG2.

Disscussion:

Grain Size:

The grain size analyses for the 2 cores taken from the Campgrounds had little in common other then the fact that they have little organic matter and are not hydric soils. Drive 1 varied widely in its percentages of sand, clay and silt, and consisted of loam, clay, and clay loam textures. This is encouraging because natural salt marshes typically fall into clay and clay loam textures (Zedler, 2001). The variation of grain sizes within the soil was found to be independent of depth for the first 250 cm (at which point we hit a gleyed layer and our first indication of original wetland soil). Sand percentages varied from 10% - 88% throughout the entire depth of the core. These numbers hit above and below the standard range (20 – 75%) of sand percentages found in a properly functioning wetland (Davidson et al., 2008).

Clay percentages were found to be above the minimum 20% required for a functioning wetland. The clay found in our sediment samples are responsible for forming several clay lenses throughout the depth of the profile. These lenses allow for temporary pools of water to form on the surface, and may also be responsible for blocking groundwater from moving up through the soil. During drive 1 the water table was not hit until depths surpassing 2 meters. Because the water table is located at these depths and soils are not inundated long enough to create anaerobic conditions hydric soils have not formed at the Campgrounds.

Given that soil levels are located well above the water table and there is very little organic carbon within our samples we have concluded that the sediment from drive 1 consists mainly of fill from nearby projects. These might include dredging of the San Gabriel River and/or left over soil from nearby developments. Results from the 2008 Hydro/Chem suggested that high levels of sand could be partially due to platform build up from oil sumps (Davidson et al., 2008). Due to drive 1's close proximity to an oil sump, build up from the sump may have played a roll in the high percentage of sand and the variation in grain size found within the drive. In any case, we have determined that with the proper remediation, as discussed below, restoration is possible in this portion of the campgrounds.

Unlike drive 1, the percentages of sand, clay, and silt for drive 2 were consistent throughout the depth of the drive, and fell into the categories of silty clay loam and silt loam textures. Sand percentages for drive 2, which were about 10% throughout the depth of the drive, fell well below the standard range typical of wetland soils. Drive 2 consisted mainly of silt particles with an average 64% for the drive. High percentages of these coarser grains would allow for heavy metals, water, and nutrients to move more freely through the soil. While drive 2 contained higher percentages of coarser grains, not typical of a healthy wetland, the numbers are consistent with values found by the 2007 Hydro/Chem team in the intertidal zone of the slough. The slough is considered a functioning wetland, and therefore, we have determined that with an increase of organic matter and proper remediation restoration of this area is possible.

Bulk Density and Porosity

Bulk density is the measure of the weight of dry soil per unit volume. It is associated with the texture and organic content of the soil, and is a good indicator of soil compaction. Bulk densities, for both drives, were found to be in the ideal range for plant root penetration. Porosity levels were also found to be at good levels for supporting viable wetland vegetation. This data supports our beliefs that restoration of the Campgrounds is possible with proper remediation.

Total Carbon

Total carbon content is a value describing carbon originating from a number of sources. Most important for this experiment is carbon originating from decaying organic matter, inorganic carbonates and petroleum hydrocarbons. Decaying organic matter is desirable in wetland soils because it improves soil structure and buffers soil pH. Decaying organic matter is also important to wetland soil development because it supports important microbial communities including those that fix nitrogen (Zedler 104-105. 109-110).

Natural salt marsh soils are expected to have anywhere from 10-40% organic matter (Zedler 104-105. 109-110). In a Southern California salt marsh organic matter content is expected to fall into a much lower range of 5-10% (Langis et al.). The median total carbon content values for drive 1 and drive 2 in the campgrounds were .4315% and .9126% respectively. Of this, only a portion is expected to originate from desirable decaying organic matter. The rest is probably petroleum hydrocarbons originating from urban runoff, onsite oil operations or natural oil seeps. While oil pollution can cause significant damage to salt marsh ecosystems the total carbon content values of the samples tested indicate that petroleum hydrocarbon levels are not present in high enough concentrations to inhibit salt marsh restoration (Cowell). At temperatures above 400^{o}C carbonate combusts adding another source of total carbon besides petroleum hydrocarbons and decaying organic matter (Zedler 104-105. 109-110). Further testing will need to be done to discern how much of the present carbon originates from decaying organic matter and how much is from petroleum hydrocarbons and inorganic carbonates.

Given the multiple sources of carbon it can be assumed that percent carbon content from decaying organic matter is much lower than the recorded total carbon values. This would not be out of the ordinary for a restored wetland. It has been widely observed that soil organic matter is significantly lower in a restored wetland than in a natural wetland (Bruland and Richardson). This can be problematic because low levels of organic carbon create an energy limitation for nitrogen fixing microbes (Langis et al.). This can in turn effect ecosystem development by limiting the amount of nitrogen available in sediment for use by the plant community. To prevent this limitation soil organic matter at the Campgrounds should be supplemented before any wetland restoration takes place. Further experiments regarding organic matter content should also be carried out to examine in detail the organic matter content of the top 100 cm of sediment; an area of topsoil which is immediately available for use by the plant and microbial communities.

Heavy Metals

Heavy metals are found in the natural environment and some are essential trace elements (Eisler, 1993). It is in wetland soils that heavy metals accumulate since water and runoff is transient through these delicate systems. The presence of heavy metals like zinc, arsenic and lead are not inherently bad for wetlands, but it is the amount and accumulation of these toxins that can pose threat to the health of the wetland and its inhabitants.

Sediment characteristics like grain size influences the amount of metals that accumulates and disperse throughout the system. It was found in wetland systems that sediments with less clay content contained lower metal concentrations (Li et al, 2007) due to less surface area than those soils that contained more sand. Analysis of grain size on the Campgrounds showed the opposite correlation. Results from grain size showed that CG1 contained more sandy percent than CG2. The average of heavy metals as seen in Table 5, show that CG1 contained overall higher concentrations. Another sediment characteristic that has been observed to affect the mobilization of heavy metals is the salinity of soils. Increased saline soils can increase the uptake and movement of heavy metals (Hatje et al). Salinity of soils in the campgrounds was not tested this year but according to Hydro Chem's research in 2007, the campgrounds were found to be highly saline, with 10.93 dS/m (Conterno at al, Unpublished data). It had been observed that increases saline soils can increase heavy metal mobilization and uptake (Hatje et al).

Because sediments can accumulate heavy metals, vegetation is affected but is not obvious on how it is impacted (Zedler, 2001). Amount of metal concentrations in soils is found to influence the level and variation of metal uptake and translocation in a plant and its different components (Suntornvongsagul, 2007). A specific species of cord grass was found to have accumulated a moderate amount of heavy metals in the roots when growing in contaminated soils (Suntornvongsagul, 2007). Due to the accumulated heavy metals in roots, stems and leaves, it has been observed of a reduction of photosynthesis' photochemical and enzymatic activity in plant tissues (Suntornvongsagul, 2007).

Along with possible affects on a plant's physiology marsh plants are speculated to act as conduits for movement of toxic metals into marsh food web (Suntornvongsagul, 2007). The passage of nutrients and energy is passed through a community of species from primary consumers, in wetlands species such as marsh plants, to secondary and tertiary consumers like inverts and birds. It is probable that through this link of species, bioaccumulation can occur from lower trophic organisms through higher trophic levels (Xiangyang et al, 2007). Although definite results have not concluded that this passage of heavy metals is dangerous to wetland inhabitants it is still an issue that should not be disregarded.

The results of the heavy metal analysis can be correlated to human activities such as highway pollution and vehicle wear; two of many major sources responsible for the following principal pollutants: suspended solids, heavy metals, hydrocarbons and deicing salts (Sriyaraj, 2001). The heavy metals of zinc, arsenic and lead have made their way into the wetland through various means. For example the presence of zinc in the campgrounds can be attributed to the on site oil drilling operations as zinc is a by-product of such activities (USDHHS, 2003). Zinc toxicity targets not only organs in birds and mammals but aquatic organisms that ingest zinc-contaminated particulates (Eisler, 1993). Another heavy metal, selenium, is added to the environment by being deposited from coal burning and is also a common by-product discharged by electricity-generating power plants (USDHHS, 2003). Selenium bioaccumulation is dangerous because it known to have effects on bird reproduction and a possible cause of birth defects (Roberts, 1996), a real issue since the campgrounds is home to species of endangered birds.

Even though the levels of heavy metals in the campgrounds do not exceed standards they are still a hazard to organisms because of bioaccumulation of zinc, arsenic, lead and other metals and the possibility of having those metals enter the food web.

Restoration Suggestions:

The proper restoration of the Los Cerritos wetlands which had formerly been owned by Tom Dean will require a significant sum of money due in large part to the fact that the appropriate wetlands soil is covered by about 2.5 meters of fill. Unfortunately this problem is compounded by the identification of the heavy metals zinc, lead and copper being present within the fill a wetland soil. The removal of the fill cover will decrease the land elevation of the respective wetlands parcel and increase the potential for natural pooling of water from rains and tides.

Optimally most of the fill within the property can be used to construct platforms that will allow visitors to observe the restoration efforts and enjoy the beauty of the Los Cerritos wetlands. Unfortunately however there is still the issue that contaminated fill could be leached out, reintroducing the heavy metals into the wetlands and potentially harming the environment through bioaccumulation. Phytoremediation, the process of using plants to collect heavy metals through adsorption and absorption, could be used on the platform to manage the contamination within the fill material. These plants should be drought tolerant and will need to be replaced consistently until future studies determine that heavy metal concentrations are sufficiently low that there will be no foreseeable negative impact on the wetlands.

Once the fill has been removed and the appropriate wetlands soil exposed for vegetation to be reintroduced, the issue of oil rigs must be addressed. It would be impractical to expect the oil companies to cease their oil extractions, however the methods used to get onto the property and extract the oil should be evaluated so that any respective oil company's activities will have the least negative impact on the wetlands as possible.

Appropriate channels must be developed to allow for tidal flows to recharge wetlands with fresh and salt water. Ideally, both the Los Cerritos Channel and the San Gabriel River will be used to supply the wetlands with water and bring back some resemblance of a natural ecosystem to Los Cerritos wetlands. Dependant upon extended water quality testing of both water sources the determination to use both the channel and river or utilizing only one source may be exercised. The organic carbon content of the soil in the Los Cerritos wetlands was found to be very low and must be increased for the land to be considered a true functioning wetland. This can be achieved through the use of kelp as mentioned in the discussion section.

Another issue is the roads surrounding the respective wetlands property. Streets and automobiles can be significant sources of pollutants due to storm runoff collecting heavy metals on the street surfaces and introducing them into the wetlands where they seep into the soil and mix in with the water bodies. To insure that motor vehicles and other urban activities have the least possible impact there should be swales along the perimeter that will filter out the contaminants that would otherwise accumulate in the wetlands. Bioswells could also be utilized within the Los Cerritos wetlands to mitigate the pollutants coming from the urban surroundings. These bioswells are primarily small man made ponds designed to trap pollutants from local sources entering the ecosystem in the form of runoff.

Soil organic carbon is used as a partial indicator of soil health. The soils located in the campgrounds have low soil organic matter content that require supplementing. This will be possible onsite because test samples indicate that the proper clay and silt soil textures are in place to retain organic carbon amendments (Homann and Kapchinske). Ideally transplanted salt marsh sediment from a local salt marsh would be used to supplement soil organic carbon at the same time providing a stock of important microbes. Since this is unlikely to be plausible given the lack of available donor marshes kelp should be used to supplement organic matter content (Zedler 104-105. 109-110). Even with these amendments it is unlikely that soil organic carbon levels will match those of a natural salt marsh before a time period of 15-30 years, if they ever do (Langis et al.). Whether or not this is an issue of concern is a matter of debate. It has been shown that percent organic matter relates directly to species richness and that organic matter amendments do not increase soil organic matter content (Alsfeld et al.). However, it has also been shown that organic carbon amendments have a positive relationship with soil nitrogen fixation which has a direct effect on the health of a salt marsh ecosystem (Langis et al.). For these reason it is suggested that the campground soils be amended with organic matter in the form of kelp and that continued monitoring of soil organic carbon levels, nitrogen fixation, species richness and productivity take place in order to assess the results of this amendment

Literature:

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Appendix:

depth	sand %	fines	clay%	silt%
5	33.900841	66.099159	25.816888	40.282271
42	47.72696	52.27304	21.080804	31.192236
12	88.213049	11.786951	4.6974892	7.0894623
48	46.727613	53.272387	20.219961	33.052425
61	2.5983027	97.401697	33.218455	64.183242
91	19.762534	80.237466	27.336672	52.900793
126	70.83002	29.16998	9.0738679	20.096112
116	27.735683	72.264317	28.353284	43.911032
151	31.673691	68.326309	25.554812	42.771497
185	10.057347	89.942653	85.360312	4.5823415
204	5.5229565	94.477043	54.505987	39.971057
215	57.354385	42.645615	40.758641	1.8869741
254	41.121242	58.878758	54.128556	4.7502024
264	35.665145	64.334855	39.45265	24.882205
285	74.000859	25.999141	20.79218	5.2069611
299	9.9705677	90.029432	39.053211	50.976221
311	12.174364	87.825636	28.108624	59.717012

Grain size drive 1.

depth	sand %	fines	clay%	silt%
8	17.636939	82.363061	28.065226	54.297835
40	7.3452827	92.654717	45.230354	47.424363
74	8.3053206	91.694679	31.85883	59.835849
120	3.1281505	96.87185	25.76557	71.10628
133	3.8336966	96.166303	24.86711	71.299193
144	9.3271555	90.672844	19.742143	70.930701
213	0.8125604	99.18744	27.763611	71.423829
230	9.3923446	90.607655	19.72795	70.879706
	5.1024525		23.74578	71.151767
248	9.6635428	90.336457	30.721565	59.614892
292	6.8714575	93.128542	27.350018	65.778524

Grain size drive 2.

cm	bulk density	porosity
5	0.9894	62.664151
42	1.3210667	50.148428
12	0.9904667	62.623899
48	1.1752667	55.650314
61	0.9174667	65.378616
91	1.211	54.301887
126	1.2188667	54.005031
116	1.5835333	40.244025
151	1.2704667	52.057862
176	1.4562	45.049057
	1.2642	52.29434
185	1.3192667	50.216352
204	1.3788	47.969811
215	1.7738	33.064151
254	1.2608667	52.420126
264	1.3035333	50.810063
299	1.4954667	43.567296
319	1.4102	46.784906
339	1.5822	40.29434
359	1.5696	40.769811

Bulk density drive 1.

cm	bulk density	porosity
76	1.2016667	54.654088
25.5	1.0968	58.611321
17	1.0890667	58.903145
13	1.1976	54.807547
86.5	0.8294667	68.699371
118	1.1442667	56.820126
152	1.2202667	53.952201
171	1.3100667	50.563522
183	1.3242	50.030189
195	1.2295333	53.602516
207	1.2935333	51.187421
219	1.2354	53.381132
231	1.1023333	58.402516
314	1.4709333	44.493082
290	1.9023333	28.213836
245	1.8140667	31.544654

Bulk density drive 2.

	52	59	63	65	66	75	77	82	111	112	118	120	208
	Cr	Co	Cu	Cu	Zn	As	Se	Se	Cd	Cd	Sn	Sn	Pb
CRM	7024.254137	3576.840178	7234.714579	7308.180987	30747.4471	4351.311547	2713.524386	346.4933743	138.2750496	153.8363744	571.6107324	569.3678576	8021.238488
CG 1-1 4-7CM	72812.67644	4053.449717	13453.8457	13840.19687	49931.93408	19884.45637	1860.134584	261.0823948	220.489101	216.8782703	540.6089035	537.4131467	21515.801
CG 1-1 11-14CM	11876.283	5064.464653	11263.16358	11763.77671	50453.93571	6426.444498	1381.787096	123.434652	116.7976322	116.5069773	336.5940248	331.6963595	8324.44454
CG1-1 61-64CM	17930.63076	6891.837478	20553.85615	21164.95715	34473.52998	5048.327681	2196.065054	216.9190406	97.70461447	99.18464047	221.2940719	217.4004429	4815.98145
CG1-2 51	18093.65663	6665.927508	15426.84204	16054.60017	37463.59509	6173.558068	2284.660806	229.2495449	110.6003297	113.5121647	385.5272892	376.7993867	6176.594126
cg1-3 39-49cm	15488.22597	4982.984167	11299.24308	11771.80589	32273.23217	4423.700085	1261.821841	1882.988133	89.82519095	78.49945386	532.1894462	520.1405639	4731.583848
CG1-4 40CM	17078.56517	5795.432468	10964.65877	11679.72473	35431.45192	3217.794506	2060.437295	125.0008789	20.77297204	16.9137151	636.320709	624.8765689	3828.831078
CG1-4 60CM	18493.90604	4303.463084	8376.281165	8803.734961	26677.71003	3585.962478	1585.625314	85.71576395	47.30701137	41.82521085	931.2757376	925.9197537	5140.56573
CG1-4 80CM	21582.70032	7245.549713	21745.19382	22357.31474	45007.07836	3007.722214	2469.52414	408.6124937	26.37158354	26.78706924	453.3654544	452.27534	6033.244868
CG1-4 98CM	24131.34901	9471.612344	18134.87973	18899.80777	48342.79697	2074.752676	2634.485653	333.0012139	31.42095258	34.73024573	375.4692687	377.8041786	7219.573332
CG1-4 200CM	20748.30767	7064.704832	15504.12599	16174.15043	41457.36295	5778.372625	3295.424515	214.2975601	33.98280886	30.43033177	727.49027	719.5778526	6055.815727
CG1-5 20CM	23916.50075	7053.018367	16977.68979	17603.18723	44937.6402	10606.79112	2573.95025	254.9120079	83.82853078	80.34800145	483.9274921	470.6804921	10597.29793
CG1-5 60CM	17069.79547	6584.208288	16799.56647	17592.73473	39093.72291	2331.162887	3146.400611	364.2589991	85.08088458	86.66245086	448.0825099	434.9663044	6443.499675
CG2-1 9-13CM	11399.84762	5339.450801	12015.82847	12356.73906	31402.5687	3926.463152	2288.894871	318.0293215	79.05335201	78.71663958	311.1964122	302.9374651	11226.39376
CG2-1 25-28CM	12727.90777	5447.859231	20918.80388	21484.24661	36704.58011	4881.499315	3957.215034	353.7967034	116.8500711	113.3390047	339.2366485	323.5375137	16162.24009
CG2-1 76-78CM	18451.15517	9315.501371	24443.14832	24879.37698	34719.34221	8553.361077	3728.177421	280.0398074	399.3663195	409.2349094	168.6494742	162.8781106	7108.182967
CG2-2 4-8CM	13446.34337	5371.959517	11119.28565	11419.47628	29130.30467	3434.939604	1500.222086	297.8519882	49.37217531	48.58861466	248.6427573	246.9651289	6631.112628
CG2-2 45-47CM	15494.06363	6325.373073	19312.50539	19579.79902	31959.27908	4965.494014	2331.667288	241.1410517	56.84752246	58.70638802	194.3483204	190.4923892	4002.675594
CG2-2 63-67CM	17905.00352	6657.233755	17496.45324	18014.84878	34263.7067	5703.736582	2640.809507	149.3381968	156.0716257	159.8562034	250.9953467	246.0664802	2908.104072
CG2-3 7-10CM	14965.16958	5749.866862	12646.21295	13047.75327	29647.71969	4223.042684	1996.878916	400.2544607	293.4536547	290.803262	622.6188302	612.1655038	3598.313202
CG2-3 46-49CM	17587.75448	6910.804568	13895.66728	14431.78574	39433.39936	4111.547859	2727.830554	173.3662373	126.4132783	128.6145629	462.8178069	458.9772108	4442.675638
CG2-3 53-57CM	10219.17251	5317.055805	8563.929787	9041.352557	25930.19253	2960.201503	3681.375873	149.5223727	334.1868025	334.3457188	252.7641183	252.5020808	3205.977706
CG2-4 9-13CM	12003.98525	4412.231033	9115.249467	9575.582793	24526.97584	3003.732099	1652.464951	126.8061118	47.97004492	52.3710237	190.2405704	183.9848117	2862.95051
CG2-4 45-49CM	12790.0474	4840.597837	9151.798739	9538.998337	28241.75833	2882.621202	2442.560791	153.107272	90.83301734	93.39662698	270.1157303	265.0476445	3470.722358
CG2-4 69-73CM	10342.72868	3907.364917	5536.106157	5980.604884	22034.1692	1595.132753	1711.276458	87.84865378	87.82987225	87.57356279	174.3972235	170.7401731	1568.994314