Trash Accumulation at the Colorado Lagoon:
Employing the Clean Water Act

May 11, 2009

Policy Team

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Abstract:

As of the 2006, the list of impaired water bodies, dictated by sect. 303(d) of the Clean Water Act (CWA), for the State of California identified the Colorado Lagoon (the Lagoon) as one of the most heavily impaired water bodies in the state. Heavy metals, PCBs, dieldrin, and DDT are a few of the several officially recognized impairments (1). Policy makers and the community alike have accepted that the Lagoon is impaired and are working to restore it. For example, Total Maximum Daily Loads (TMDLs) are in the processes of being developed for all of the officially recognized pollutants within the water body.

The issue is that while these TMDLs will cover many dangerous pollutants within the Lagoon, one very obvious pollutant is being overlooked. Trash, a prominent and pervasive pollutant within the Lagoon, has not been included as a pollutant of concern to be listed on the 303(d) impairment list.. Currently, the State Water Board is preparing the listings for the 2008 version of the 303(d) list, which by CWA mandate must be updated every two years. However, trash has again escaped the radar as a pollutant for the impairment list. Through personal communications with State Water Board employee, Eric Wu, it was determined that trash has been overlooked as a pollutant of concern not because of a lack of significant threat to the ecosystem of the Lagoon, but because insufficient evidence has been provided to the Water Board regarding its prevalence. In other words, the community has not pushed for regulation of trash through the implementation of a trash TMDL.

The collection of quantitative and qualitative data on trash at the Lagoon can be tied to negative impacts on the six beneficial uses assigned to the Lagoon (REC-1, REC-2, COMM, WILD, WET, RARE, SHELL, SPWN) as defined in chapter two of the LA Basin Plan. This project will provide evidence to the Water Board to support the inclusion of trash as a pollutant to be regulated by TMDLs for the 2010 revision of the 303(d) list. In addition, the data collected by this project will have a secondary by-product as a use for baseline trash data for two projects, the Termino Avenue Drain Project and the Colorado Lagoon Restoration Plan, which are expected to reduce the trash pollution levels within the Lagoon.

I. Introduction

As of the 2006, the list of impaired water bodies, dictated by sect. 303(d) of the Clean Water Act (CWA), for the State of California identified the Colorado Lagoon (the Lagoon) as one of the most heavily impaired water bodies in the state. Heavy metals, PCBs, dieldrin, and DDT are a few of the several officially recognized impairments (1). There have been frequent beach closures at the Colorado Lagoon, for example in 2003 the Colorado Lagoon was closed for 19 days making it the "worst water quality swimming area in the City of Long Beach" (2). Policy makers and the community alike have accepted that the Lagoon is impaired and are working to restore it. For example, Total Maximum Daily Loads (TMDLs) are in the processes of being developed for all of the officially recognized pollutants within the water body.

The issue is that while these TMDLs will cover many dangerous pollutants within the Lagoon, one very obvious pollutant is being overlooked. Trash, a prominent and pervasive pollutant within the Lagoon, has not been included as a pollutant of concern to be listed on the 303(d) impairment list.. Currently, the State Water Board is preparing the listings for the 2008 version of the 303(d) list, which by CWA mandate must be updated every two years. However, trash has again escaped the radar as a pollutant for the impairment list. Through personal communications with State Water Board employee, Eric Wu, it was determined that trash has been overlooked as a pollutant of concern not because of a lack of significant threat to the ecosystem of the Lagoon, but because insufficient evidence has been provided to the Water Board regarding its prevalence. In other words, the community has not pushed for regulation of trash through the implementation of a trash TMDL.

The collection of quantitative and qualitative data on trash at the Lagoon can be tied to negative impacts on the six beneficial uses assigned to the Lagoon (REC-1, REC-2, COMM, WET, RARE, WILD, SHELL, SPWN) as defined in chapter two of the LA Basin Plan. This project will provide evidence to the Water Board to support the inclusion of trash as a pollutant to be regulated by TMDLs for the 2010 revision of the 303(d) list. In addition, the data collected by this project will have a secondary by-product as a use for baseline trash data for two projects, the Termino Avenue Drain Project and the Colorado Lagoon Restoration Plan, which are expected to reduce the trash pollution levels within the Lagoon.

1.1 Site History:

The Colorado Lagoon was historically part of the Los Cerritos Wetlands (LCW) complex. At one point, the LCW Complex encompassed most of East Long Beach, totaling 2,400 acres. Though highly degraded, the LCW complex is one of a few remaining coastal salt marshes in California. The Los Cerritos Wetlands Trust (LCW Trust) estimated that the original span of the LCW has been reduced by 98.3% as a result of development. Additional estimates by the Trust state that the whole of California has seen a 95% drop in its wetland habitat, leaving approximately 30 coastal salt marshes in the state. On the national level, wetlands have been reduced by 70%. The Los Cerritos Wetlands Stewards claim that with 776 acres having the potential for restoration the LCW complex is the largest restorable estuary-salt marsh remaining in Los Angeles County.

The Los Cerritos Wetlands is at the terminus of the San Gabriel River Watershed, which covers an area of 640sq. miles and contains 37 cities. The LCW complex crosses county lines, which raises management issues, as there are several administrative bodies that are stakeholders in the wetlands. This management setback has been partially addressed via the LA Regional Water Quality Control's Board (LARWQCB) Basin Plan, which sets comprehensive water quality goals for the entire Los Angeles Basin.

All of the land within the complex is privately owned except for the Colorado Lagoon (managed by the City of Long Beach) and two parcels, a 5-acre and a 66-acre plot, purchased by the Los Cerritos Wetlands Authority (LCWA). The LCWA is a joint powers agreement set up between two conservation groups (The Rivers and Mountains Conservancy and the Coastal Conservancy) and two municipalities (the Cities of Long Beach and Seal Beach). The LCWA is the driving force in land acquisition and restoration efforts for the wetlands. Once the land acquisition process is complete, the LCWA will implement a comprehensive restoration plan for the wetlands. The land acquisition is currently underway. Recent developments included a land swap, which has been approved by the City of Long Beach. This land swap involves Tom Dean, a private landowner within LCW, trading part of his wetland property for city land in west Long Beach.

The Lagoon itself is a 13-acre wetland area situated within a moderately affluent residential community. The tides to the Lagoon have been muted through urbanization and development, however it still experiences some tidal influence via a 1000-foot underground channel connecting to Alamitos Bay. Because of muted tidal flow and urban run-off dumped into the water from 11 different storm drains, the Lagoon is highly polluted. Fish and birds still use the Lagoon as a refuge, in addition to human use for recreation, despite the pollution and reduced tidal influence (16).

II. Methods

Between February 3, 2009 and April 27, 2009 the Colorado Lagoon was assessed for trash using the format of San Francisco Regional Water Quality Control Board's (SFRWQCB) *Citizens Water Quality Monitoring Program*. Collection protocols were aligned with the *Water Quality Control Policy for Developing for the Clean Water Act Sect. 303(d)*, which delineates parameters such as sample size and frequency the pollutant of interest must be exceedence in order to be listed.

Upon an initial assessment of the Lagoon, three 500-feet intervals were designated for sampling. The three designated areas were: the north-west side of the Lagoon near the Termino drain storm-water outfall and adjacent to the golf course (CL1), the west-side of the lagoon near the Marine Education Center (CL2), and the north-east side next to the storm-water outfall near the homes (CL3) (Figure 1).

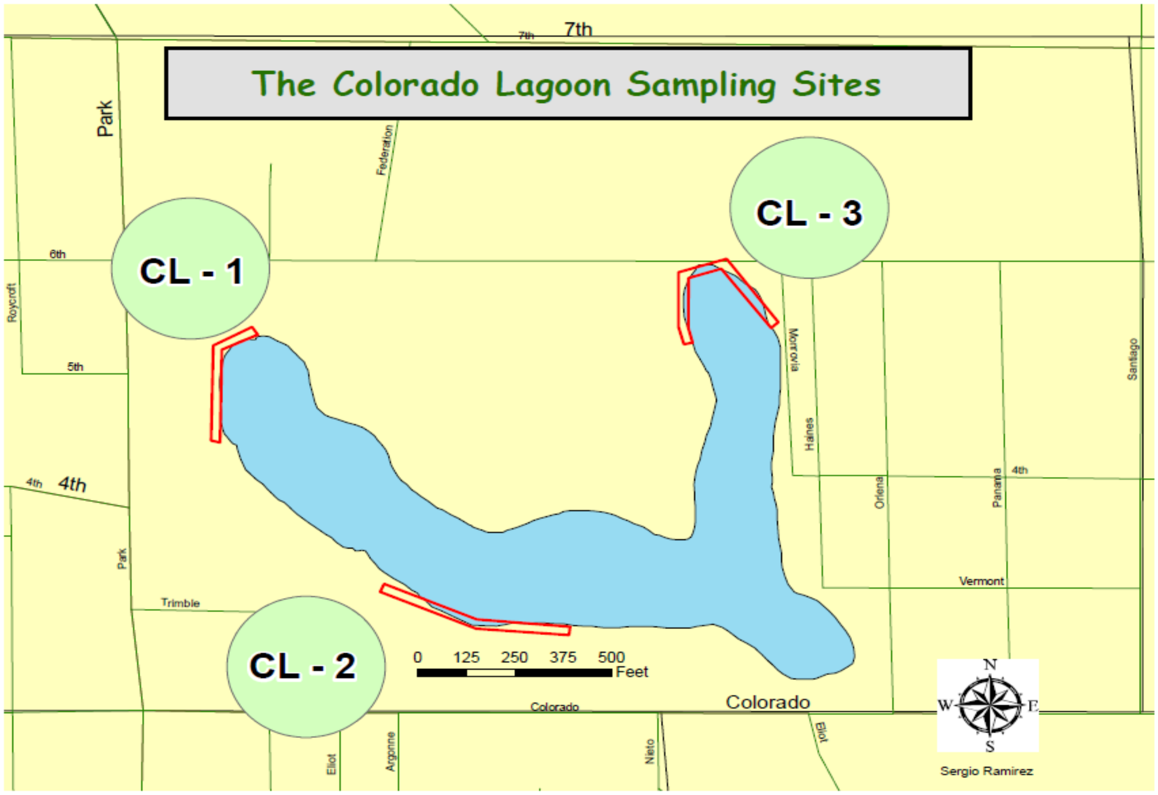

Figure 1: Map of sampling sites at the Colorado Lagoon

Within each of these 500-foot intervals, 100-ft of shoreline (taking into account natural shoreline curves) were randomly selected for sampling) and delineated by a transect tape. The start and end locations of the transect were documented with a GPS unit, however the GPS units were not accurate enough to provide useful data.

The area along the transect between the low tide and the high tide water line was surveyed for trash. During the survey the trash was collected using a "trash picker" and deposited in a trash bag. The individual collecting trash verbally relayed details of the trash items to the data recorder. Appendix B provides a summary of team member duties and a sampling schedule.

On the *Rapid Trash Assessment* sheet (Appendix A) there were seven initial criteria, which provided an overall characterization of the trash and hazard level. They were: 1) level of trash, 2) actual number of trash items found, 3) threat to aquatic life, 4) threat to human health, 5) illegal dumping and littering, 6) accumulation of trash, and 7) weather conditions (including the day prior to the sample day). Each category was ranked along the following scale: optimal, sub-optimal, marginal and poor. Each category within the scale (optimal, sub-optimal etc.) was divided into a sub-scale of 0-20, 0 being the worst quality (Appendix A). This initial assessment was conducted upon arrival for each visit at all three sample sites.

The *Rapid Trash Assessment Sheet (Appendix A)* divided the trash into 10 categories, which are then further broken down into sub-categories. The 10 main categories were 1) plastic, 2) biohazard, 3) miscellaneous, 4) metal, 5) toxic, 6) biodegradable, 7) glass, 8) fabric and cloth, 9) construction debris, and 10) large objects (Appendix A). The trash collected was categorized into one of these classes, including the specific sub-category (Appendix A) by trash collector during the survey process. Appendix B provides a summary of team member duties and a sampling schedule.

After collecting the trash the data was analyzed to look for trends in trash accumulation. Specifically, an ANOVA was completed for 8 of the 10 main categories in order to compare the mean trash count for each category between the two sites near storm drains (CL-1 and CL-3) and the control site along the beach seemingly affected more by non-point source trash pollution, such as wind-blown debris from the street or trash cans (CL-2). The "construction debris" and "large object" categories were omitted due to the fact that little or no data was observed in the field. Prior to each ANOVA a Test of Variance was completed to verify that the variances of the data from each sample site were equal.

A total waste characterization was completed in order to determine the dominant trash types (i.e. plastic bags, aluminum cans etc.). Six of the seven initial observations (level of trash, threat to aquatic life, etc.) were analyzed in order to infer how often each category was ranked as sub-optimal (rank level 15 on the 20-0 scale) or lower.

III. Results

3.1 Initial Observations

Each site was characterized with six initial categories: 1) level of trash at first glance, 2) actual number of trash items found, 3) threat to aquatic life, 4) threat to human health, 5) illegal dumping and littering, 6) accumulation of trash and rated on a scale of optimal (levels 20 through16), sub-optimal (levels 15 through 11), marginal (levels 10 through 6), or poor (levels 5 through 0). The following results show the frequency of impairment level ratings as well as percentage of site visits for which each category was rated as impaired to some degree (receiving a score of 15 or less). The level of trash at first glance was rated impaired 65.38% of the time for level of trash at first glance (Figure 2), 96.15% of the time for actual number of trash items found (Figure 3). 88.46% of the time for threat to aquatic life (Figure 4), 76.92% of the time for human health threat (Figure 5), 46.15% of the time for dumping and littering (Figure 6), and 96.15% of the time for trash accumulation (Figure 7).

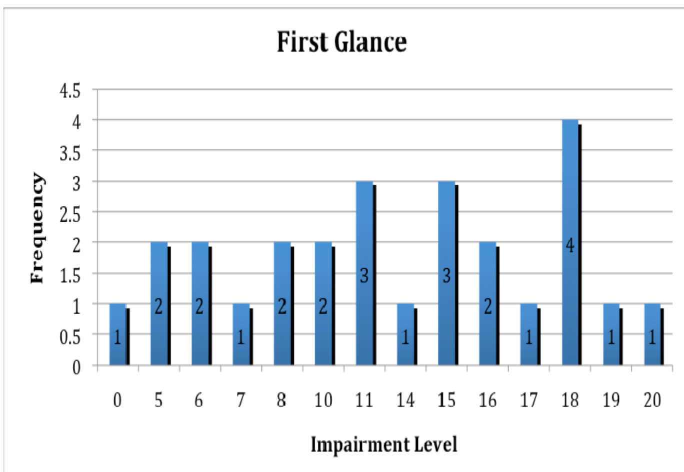

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Figure 2: Impairment level for trash level at first glance

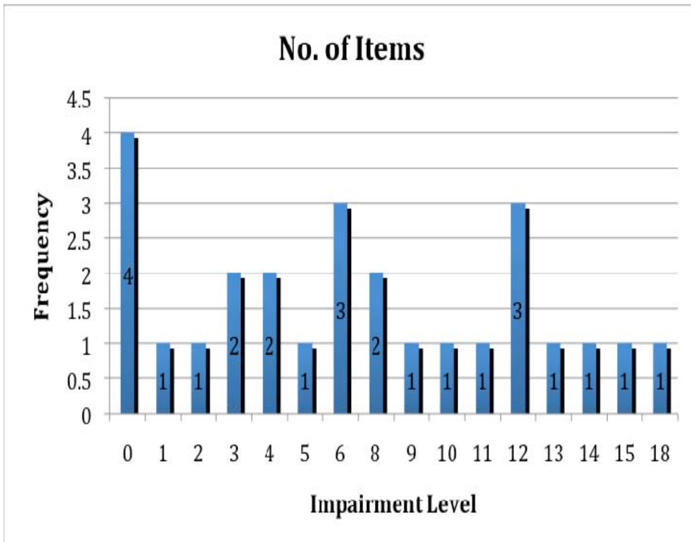


Figure 3: Impairment level for number of trash items

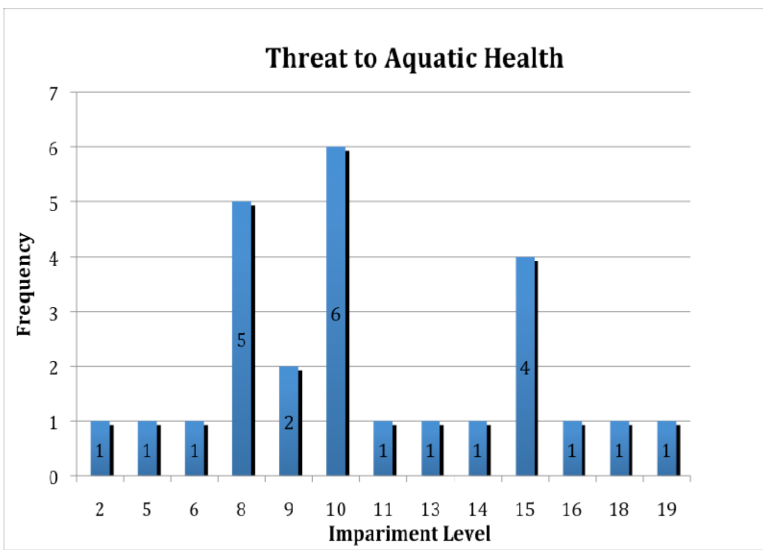


Figure 4: Impairment level for threat to aquatic life

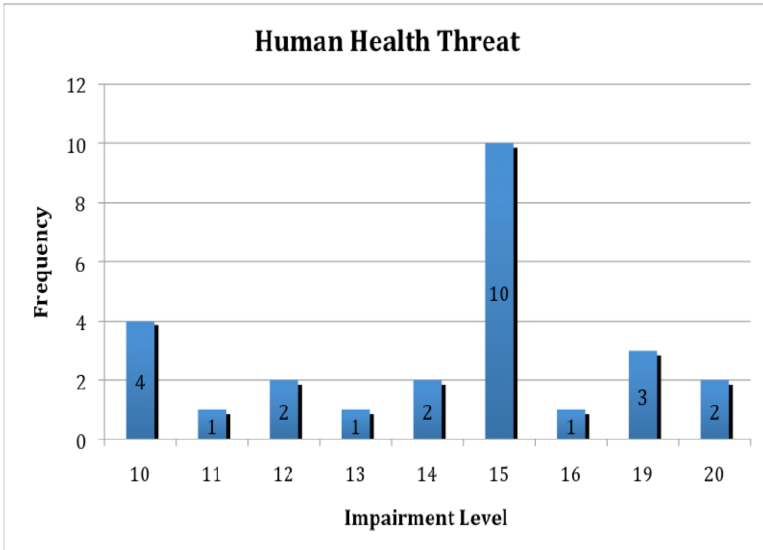


Figure 5: Impairment Level for human health threat

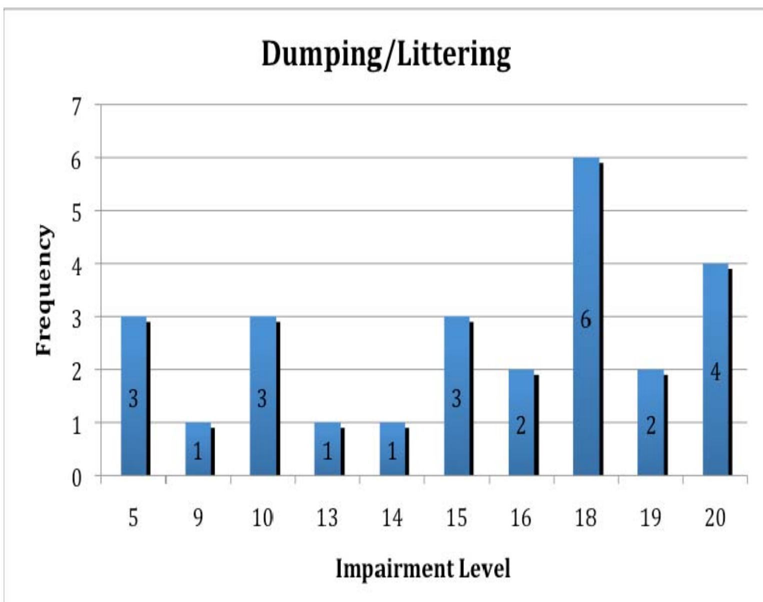


Figure 6: Impairment levels for illegal dumping/litering

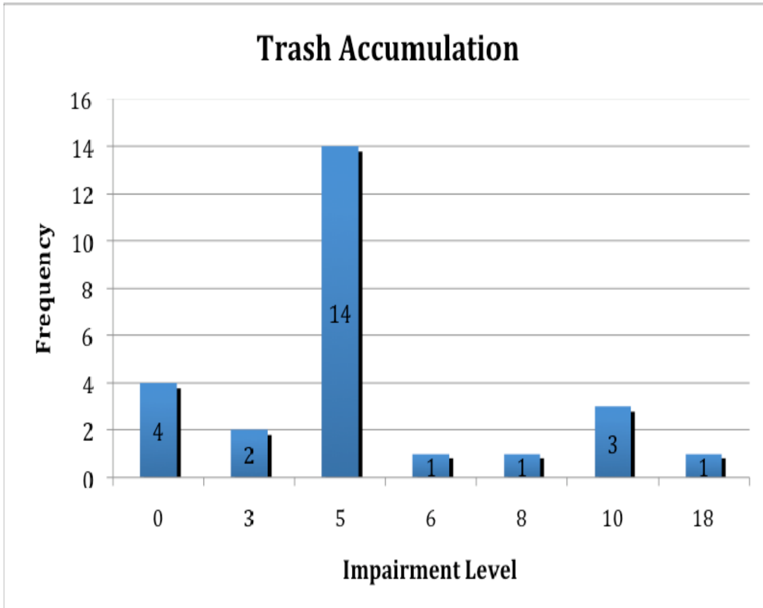


Figure 7: Impairment levels for trash accumulation

3.2 Overall Trash Characterization

In total, 1401 individual items of trash were collected. Of this 787 pieces were plastic, comprising 56.17% of the total number of trash items. Of the plastics the two largest categories were Styrofoam comprising 22.10% of total plastics (174 individual pieces collected) and plastic wrappers 36.21% (285 pieces collected). Cigarette butts, comprised 23% of the debris, for a total of 324 butts collected (see Figure 8). (Categorical breakdown for each site is included in Appendix C).

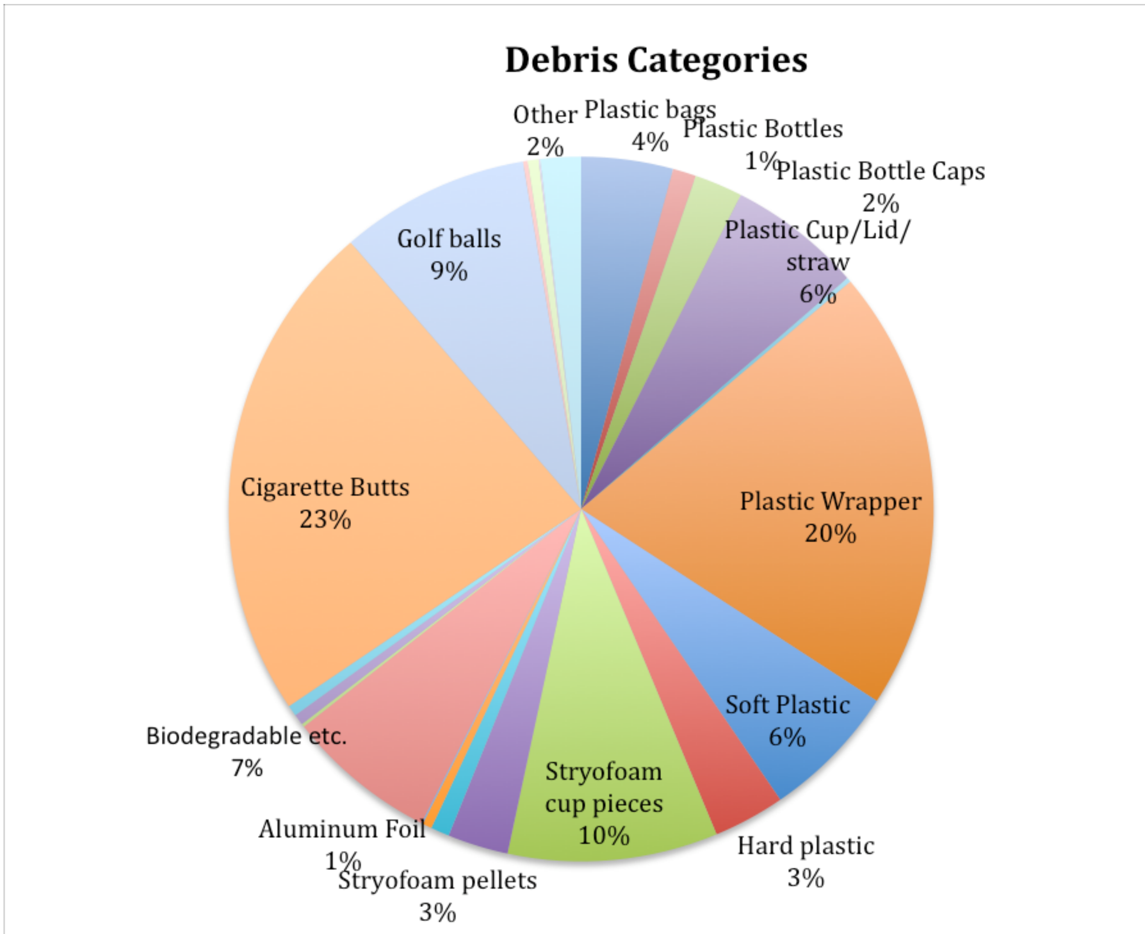


Figure 8: Debris characterization

3.3 Trash-type dispersion between sites

In addition to an overall characterization of the using the initial observation categories, 6 of the main trash categories (plastic, metal, biodegradable, biohazards, glass, miscellaneous, toxic, and fabric and cloth) were analyzed to see if they were distributed evenly throughout each of the three sample sites. No statistically significant difference was found in the mean trash level between the sites for any of the analyzed trash categories.

The plastic trash level between the three sites (Table 1) [F (2.53), P (0.0101), α=.05] showed two outliers. One was on February 10th, 2009, at CL-1, where 92 plastic items were found. The weather records indicated that it had rained the previous day. On the same date, at the CL-2, 71 pieces of plastic were cleaned from the beach. This is a higher number of plastics collected than the mean for each of these sites. The overall mean for CL-3 is higher than CL-1 or CL-2, but is not significantly different.

Table 1: Mean plastic amount at each site

Site	**Mean**
CL-1- Golf course	26.89
CL-2 -Control	19.89
CL-3 – Roadway	45.75

The metals category (Table 2) also showed two outliers in the data collected [F (0.48), P (.627), α=.05]. One outlier was on February 10th when three aluminum cans were collected from CL-1 and the other on February 20th, when two aluminum cans and piece of foil was collected from CL-3.

Table 2: Mean metal amount at each site

Site	**Mean**
CL-1-Golf course	1.00
CL-2-Control	0.667
CL-3- Roadway	0.625

As observed in both the metals and plastics category, the biodegradables (Table 3) displayed two outliers. The outlier was at CL-2 on February 20th, 2009, twelve pieces of biodegradable trash were found. This is higher than normal and is significant due to the fact that the tractor rake was used the day before in this area. The other outlier was found at the CL-3. The mean for this site is higher than normal (6.375). On March 7th, 2009 there was only one piece of biodegradable material found at this site. The overall mean for CL-3 at the roadway is higher than either of the two other sites.

Table 3: Mean biodegradable amount at each site

Site	Mean
CL-1- Golf course	3.111

CL-2 Control	2.889
CL-3 – Roadway	6.375

Biohazardous material (Table 4) was not very prevalent within any of the three sites and was evenly distributed, except for at CL-3 where no biohazardous material was found [F (1.18), P (.325), α=.05] . One outlier persisted at the CL-2 on March 7th, 2009. Here used band-aids (considered medical waste) were found.

Table 4: Mean biohazard amount at each site

Site	Mean
CL-1- Golf course	0.3333
CL-2 Control	0.3333
CL-3 - Roadway	0.000

Glass (Table 5), like biohazards, was not very prevalent at any of the sites. Glass was evenly distributed between Sites 1&2, with slightly more being found at the roadway [F (.30), P (.745), α=.05] .

Table 5: Mean glass amount at each site

Site	Mean
CL-1- Golf course	0.2222
CL-2 Control	0.2222
CL-3 - Roadway	0.3750

The miscellaneous category (Table 6) was fairly even between Sites 1 and 2, with roughly half the amount being present at CL-3 [F (.38), P (.690), α=.05] . One outlier was obtained on February the 20th, 2009 at CL-1, when sixty-six miscellaneous items were obtained.

Table 6: Mean misc. amount at each site

Site	Mean
CL-1- Golf course	20.00
CL-2 Control	21.22
CL-3 – Roadway	11.63

The level of toxic materials (Table 7)was low within all of the sites, with none being found at CL-1. There was an outlier at CL-2, here a bone was collected on March 19th, 2009.

Table 7: mean toxic material amounts at each site

Site	Mean
CL-1- Golf course	0.000
CL-2 Control	0.111

Fabrics and materials were not found at high levels at any of the sites (Table 8) [F (.33), P (.724), α=.05].. One outlier persisted at CL-2 on February 10th, 2009. Two pieces were found.

Table 8: mean fabric and materials amounts at each site

Site	Mean
CL-1- Golf course	.2222
CL-2 Control	.3333
CL-3 - Roadway	.5000

IV. Conclusions:

Our results show that the Colorado Lagoon suffers from chronic trash pollution and steps should be taken to implement a trash TMDL for the Lagoon. At every sampling site, on all days sampled trash was found. The scores from the initial observation on *the Rapid Trash Assessment Sheet (Appendix A)* reinforced the visual observations of trash impairment. The largest categories of trash were plastics, comprising 56.13% of the total amount of trash collected, indicating that consumer waste, in the form of packaging and shopping bags, plays a significant role in the trash impairment of the lagoon. Analysis of the trash prevalence between the sites indicated that there is not a significant difference in the amount of each trash-type accumulating at each site. CL-2 (the control) did not appear to have a different accumulation pattern than CL-1 and CL-3, making it difficult to attribute trash accumulation at CL-1 and CL-3 to the storm drain and CL-2 to non-point source pollution.

V: Discussion:

5.1 Impairment of Beneficial Uses

As mentioned, the Basin Plan assigns six beneficial uses to the Colorado Lagoon, which the TMDLs are designed to protect. By capping pollutant levels regulators aim to ensure that the diverse spectrum of use within a water body are preserved. The first beneficial use designated at the Lagoon is Water Contact Recreation (REC-1). REC-1 is characterized as "Uses of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and scuba diving, surfing, white water activities, fishing, or use of natural hot springs"(1). Specifically for the Colorado Lagoon is used for swimming (observed during the sample period on March 19th, 2009), fishing and church baptisms.

The second beneficial use characterized by the Los Angeles Basin Plan is Non-Contact Water Recreation (REC-2), which is defined as "Uses of water for recreational activities involving proximity to water, but not normally involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tide pool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities"(1). Bird watching can be included within REC-2 as the Colorado Lagoon provides a refuge for several species of birds including the Snowy Egret (*Egreta thula*), the California Brown Pelican (*Pelecanus occidentalis*), Ring Billed Gulls (*Larus delawarensis*), Ruddy Ducks (*Oxyura jamaicensis*) and Red Shouldered Hawks (*Buteo jamaicensis*) (10).

Commercial and Sport Fishing (COMM) is the third beneficial use assigned to the Lagoon and is described as "Uses of water for commercial or recreational collection of fish, shellfish, or other organisms including, but not limited to, uses involving organisms intended for human consumption or bait purposes"(1). The California Halibut (*Paralichthys californicus)*, for instance, can be found within in the Lagoon." (1). This category is encompassing of all the life found in the lagoon, which includes vegetation invertebrates, fish and birds. As mentioned, California Halibut is found at the Lagoon and two of the other fish most commonly found at the Colorado Lagoon are topsmelt (*Atherinops affinis*) and jacksmelt (*Atherinops californiensis)* (9). Shovelnose Guitarfish (*Rhinobatus productus*), Electric Ray (*Torpedo californica*) are two of the (9). Warm freshwater habitat (WARM), Wildlife Habitat (WILD), Shellfish (SHELL) are the last three beneficial uses assigned to the Lagoon and all serve to protect the habitat of the species living within and dependant on the water.

While not officially recognized within the Basin Plan as a beneficial use, fourth on the list of beneficial uses is that of **Wetland Habitat (WET)**, which is defined as "Uses of water that support wetland ecosystems, including, but not limited to, preservation or enhancement of wetland habitats, vegetation, fish, shellfish, or wildlife, and other unique wetland functions which enhance water quality, such as providing flood and erosion control, stream bank stabilization, and filtration and purification of naturally occurring contaminants" (1). This category is encompassing of all the life found in the lagoon, which includes vegetation invertebrates, fish and birds. The Colorado Lagoon is also home to some endangered species like the California Brown Pelican (*Pelecanus occidentalis)* and the Least Tern (*Sternula antillarum browni*) (10) (11). **Rare, Threatened, or Endangered Species (RARE)** is another beneficial use and is characterized as "uses of water that support habitats necessary, at least in part, for the survival and successful maintenance of plant or animal species established under state or federal law as rare, threatened, or endangered" (1). The final beneficial use of the lagoon that we observed was **Spawning, Reproduction, and/or Early Development (SPWN)** shown as "Uses of water that support high quality aquatic habitats suitable for reproduction and early development of fish" (1). Wetlands are seen as spawning grounds for juvenile fish and one in particular is the economically important California Halibut (*Paralichthys californicus*) (9).

The data that we collected in the three sampling sites clearly demonstrates that trash is present at the Lagoon, and the presence of any amount of trash as the potential to compromise all of the aforementioned beneficial uses. For example, just the presence of trash is enough to impair REC-1 and REC-2 uses, as trash is aesthetically displeasing. The World Health Organization states, “a clean beach is one of the most important characteristics sought by visitors” (7). They also stated that trash causes a “loss of tourist days and resultant damage to leisure/tourism infrastructure” (7). People do not want to swim in or even carry out recreational activities on water or a beach that is laden with trash.

Over the nine sampling days that we collected trash in total for these three sites we found a total of seven pieces of glass, two syringes, one dead bird, oil containers and lighters. These types of trash pollutants can impair all six of the beneficial uses as they are considered biohazards (syringes and a dead bird), toxics (oil containers and lighters), and physical hazards (glass) (6). All of these pollutants have detrimental health effects to the biology that uses the lagoon. Glass “can cause puncture or laceration injuries” (6) and when exposed to the water can expose the person’s (or other organisms) blood stream to microbes like fecal coliform bacteria (6). Syringes are also a significant health hazard because it can transmit diseases to swimmers, anglers and the many people being baptized over the weekends. Dead animals especially birds are a specific concern recently because dead birds have been found to have the West Nile Virus. This can effect the people who come into contact with the lagoon under REC-1 uses as well as the birds that frequent the area especially the endangered ones, like the California Brown Pelican (*Pelecanus occidentalis*) and the Least Tern (*Sternula antillarum browni*) and can violate the RARE beneficial use.

There has been evidence of illegal dumping of yard waste near CL-3 on the northeast arm of the Lagoon. An excess of this kind of organic waste in the lagoon it can cause oxygen depletion in the water of the Lagoon. Respiration processes of microbes that break down the organic material require a lot of oxygen to digest the debris (6). The anoxic environment arising from such a scenario would be detrimental to the WILD, SHELL, and WARM uses of the Lagoon.

In total 1402 individual items of trash were collected. Of this 781 pieces were plastic, comprising 56.13% of the total number of trash items. Cigarette butts, comprised 23% of of the debris, with a total of 324 butts collected. This was significant but not surprising, globally the proportion of plastics among marine debris ranges from 60-80% and in some places it reaches over 90% (5). Plastics are primarily synthetic organic polymers derived from petroleum (8). The persistence of plastics in the environment can be attributed to the low cost of production as well as its light weight and the varied properties of plastics (8). In the last two decades of the 20^{th} century the deposition rate of plastics has accelerated past the rate of production (7). During each year data is collected and analyzed by the International Coastal Cleanup (ICC) by volunteers and it has been shown that 60% of the debris items retrieved from beaches on the Coastal Cleanup Days (CCD) in the U.S. have been plastic (5).

There are three concerns that are associated with plastics, ingestion, entanglement and organic pollutants that are associated with plastics. Ingestion of plastics is common for almost all marine and aquatic organisms as well as terrestrial organisms especially birds. 90% of all floatable debris is plastic (5) and when exposed to UV light plastics break down into smaller and smaller pieces making it easy for ingestion by the biota (8) (7). Organisms ingest plastics that appear to be food (or as an object of curiosity) because the plastics have been broken down, when ingested it fills their stomachs and as this builds up in their bodies it gives them the impression that they are full and they can eventually die from starvation (6) (8). Studies have shown that Entanglement is also a major issue of plastics because the very definition of plastics is that is easily molded, so it is very easy for fishing line, six pack holders and plastic bags to wrap around organisms which can lead to wounds that can lead to infection, loss of limbs, strangulation, suffocation and inhibition of an animals ability to swim (7) (6). One of the most disturbing attributes of plastics is its ability to absorb persistent organic pollutants (POP) (8). Some of these POPs including dichlorodiphenyltrichloroethane (DDT), polychlorinated biphenyls (PCB) and polycyclic aromatic hydrocarbons (PAH). PAHs and PCBs are found in post production plastics but the environmental protection agency (EPA) has greatly reduced how much can be in plastics. PCBs for instances can only have a concentration of 10 parts/million in plastics that contain food (13). These 3 organic chemicals are considered highly toxic and have a wide range of chronic effects, including endocrine disruption (developmental, reproductive and neurological problems), mutagenicity (capacity to induce mutations) and carcinogenicity (causes cancer) (8) (3) (4). Studies have shown that that post consumer plastics have the capacity to absorb these three chemicals in greater concentrations then were in post production pre-consumer plastics (8). This is thought to be because of the of plastics lipophilic nature (ability to combine and dissolve in fats) (8). High concentrations of these persistent organic pollutants have been found in high concentrations in fish and birds. The Colorado Lagoon is on the EPA's 303(d) list for impairments for PHAs, PCBs and DDT and is found in considerable concentrations in the sediments (12) (2). "The migrations of these chemicals from sediments that are known to contain high concentrations of PCBs to water provide an ongoing supply of the materials to the water phase" (8). So there is a significant probability that the high concentrations of plastics that we found on the shoreline and the persistent supply of organic chemicals in the lagoon will mix and over time DDT, PCB and PAHs will concentrate on the plastics. As the organisms ingest the plastics they will absorb the chemicals and it will accumulate in their fatty tissue. These chemicals bioaccumulate up the food chain, which means as you go up the food chain the concentrations will become higher and higher. The negative components of plastic, ingestion, entanglement and the chemicals associated with plastics impair all the beneficial uses of the lagoon REC-1 (fishing), REC-2(bird watching), COMM, WET, RARE and SPWN because all the organisms are affected by the contaminants.

Smokers toss at least 4.5 trillion cigarette butts each year While the paper and tobacco of cigarette butts are biodegradable, their cellulose acetate filters are not, according to the report. `for the past 8 years, cigarette butts have been the leading item found during the (CMC's) International Coastal Cleanup Project," accounting for nearly one in every five items collected.

<u>5.2 Colorado Lagoon Clean-ups</u>

There are two significant entities that work to remove the load of debris, which accumulates at the Lagoon. Friends of the Colorado Lagoon holds weekly clean up around the perimeter of the water body. Throughout the sampling period 173lbs. of trash were collected from the Colorado Lagoon during FOCL clean-ups (pers. Comm., Erick Zahn). In addition, the City of Long Beach rakes the beach for trash on a semi-regular basis, which is seemingly dependant on the season. This effort his headed by Lester Thompson, Long Beach's Supervisor of Beach Maintenance. While beach raking removes significant amounts of debris (~), this effort is not inclusive to the entire perimeter of the Lagoon. For instance, CL-1 and CL-3 are both located within the vegetated intertidal zone of the Lagoon. These areas accumulate a significant amount of trash that cannot be addressed by the City's beach raking efforts, as they are not composed of sand sediments and are largely inaccessible to the large raking vehicles. Furthermore, neither the comprehensive efforts of FOCL or the City are tailored to remove or handle the debris that may accumulate and settle on the Lagoon bottom.

Table : Weight of trash collected by FOCL during sampling dates

DATE	Wt. of Trash (lbs)
March 16th	20
March 23rd	30
April 6th	10
April 13th	50
April 15th	36
April 20th	17
April 27th	10

These constant cleaning efforts further reinforce the need for the implementation of TMDLs. Even with these organized clean-ups occurring once or twice per week, the rapid trash assessments showed that 96.15% the Colorado Lagoon was impaired (either sub-optimal, marginal, or poor) for actual number of trash items. Furthermore, levels of trash were still abundant enough to rate as impaired "at first glance" over 65% of the time. It is apparent achieving the Lagoon's water quality standards set forth by the Federal Environmental Protection Agency. Bi-weekly scheduled beach combings occur and yet trash can be seen within and on the shores of the Lagoon. Initial trash assessments implemented by the Policy Team reflects a chronic problem with local trash runoff abatement measures. After major rain events in February, the shore of the Lagoon was observed to be littered with trash items such as tennis balls, plastics, rubber materials, Styrofoam, and organic debris. The influx of trash is to great to be controlled solely by clean-up measures. This points to the need to cap the level of trash entering the Lagoon in the first place, which can be achieved through the implementation of a trash TMDL.

5.3 Current Restoration Efforts

The lagoon is referred to by the City of Long Beach as the "Little Lagoon That Could". Separate from the TMDL implementation, the City is carrying out a restoration initiative at the Lagoon.

As stated in the restoration feasibility study created by Moffat and Nichols, the goal of the plan is to "restore the marine ecosystem and support safe recreation while improving water quality and managing storm water in the Colorado Lagoon."

In order to restore the Lagoon, funding has come from the CA State Water Resources Control Board State Coastal Conservancy ($500, 000), Rivers and Mountains Conservancy ($150,000), the Port of Long Beach ($325,000), and the Army Corps of Engineers ($900,000). Using this money, the City has entered into two contracts. One is with LSA Consultants, who completed the EIR which was adopted by the LB City Council in October 2008 (pers. Comm., Zahn). The other is with Moffatt and Nichols Consultants to develop a monitoring program for the restoration.

Storm drain upgrades are one of the major mitigation measures that will improve the trash level of the Lagoon. The Colorado Restoration Rroject is projected to upgrade 7 storm drains at the lagoon 3 of which are major storm drains and the other 4 are local storm drains. Two of the three major storm drains are at CL-1 and CL-3 of our sampling sites. These three major drains will be redirected to a wet well area (water storage area) that will discharge the low flows to the sanitary sewer system for treatment (14). The wet well and pump station would be located on the golf course at the corner of East 6th Street and Park Avenue. The size of this well would be 40x40 feet and 12 feet deep. Trash separation devices on the same three major storm drains would be installed up stream of the diversion devices to capture trash before it reaches the diversion station. Implementing these improvements to the storm sewer system and put into practice trash separation devices would reduce the amount of trash entering the Lagoon.

Another mitigation measure to be applied to the Colorado Lagoon Restoration Project is the removal of contaminated sediments located in the western arm of the Lagoon and in the center of the Lagoon (14). At the western arm of the Lagoon 6 feet of sediment will be removed. The sediments are contaminated with organic chemicals like DDT, PCBs, Dieldrin and Chlordane. These organic chemicals tend to accumulate on plastics that enter the lagoon due to disturbances in the soil that kick up the chemicals into the water column. When these chemicals adhere to the plastics and as UV light break down the plastics it becomes easier to become ingested by the local wild life. This can cause developmental, reproductive and neurological problems. With the sediment gone these problems would be greatly reduced.

The Termino Avenue Drain Project (TADP) is set to redirect one of the 4 major drains, the Termino Avenue Drain (TAD) (which is located at the western most portion of the Lagoon). This drain would redirect low dry weather flows to the diversion structure while discharging storm water flows to Marine Stadium. The TADP is also set to redirect 3 local drains located at the southern portion of the Lagoon to Marine Stadium as well. This project would divert about 139.4 acre feet of water to Marine Stadium which is approximately 55% of the storm water volume entering the Lagoon (14).

Flows from the four local storm drains that are not diverted to the wet well would flow into vegetative bioswales. Bioswales are storm water runoff conveyance systems that are an alternative to storm sewers. These bioswales would successfully lessen the amount of trash that would be able to enter the Colorado Lagoon during light or heavy storm events. Both efforts will serve to reduce trash introduction. However this plan does not provide any legal "teeth" in terms accountability for the trash. There is no mandate that trash must be kept of the Lagoon waters through the implementation of these projects. Therefore it remains that in addition to all Colorado Lagoon remediation efforts, trash must be added as on of the Lagoon's impairments on the 303d list. This will hold the City of Long Beach responsible for ensuring that trash flow into the Lagoon ceases. As has been the case with other water bodies considered impaired for trash, we suggest that the acceptable trash level be set at 0.

5.4 Existing Trash TMDL Policy

The whole purpose of the Clean Water Act (CWA) section 303(d) is to "fill in the gaps" where the CWA section 402 is insufficient in meeting water quality standards. The CWA section 402 is the National Pollution Discharge Elimination System (NPDES) and regulates all point sources, more specifically the Municipal Separate Storm Sewer System (MS4) or storm drains and Publically Owned Treatment Works (POTWs). Essentially, controls the source of pollution. CWA section 303(d) on the other end sets a cap on pollution levels in the water body itself. This covers point sources as well as non-point sources, which include discarded litter and wind blown debris. Both these sections of the CWA work in conjunction with one another to maximize the effectiveness of the law to improve water quality.

The LA Regional Water Quality Control Board provides public information on Basin Plan Amendments to the Water Quality Control Plan for the Los Angeles Region. These amendments provide a framework for the policy development in terms of the implementation process for trash TMDLs in the Colorado Lagoon.

While trash TMDLs are a relatively new pollutant recognized under the CWA, there is a strong history of the trash TMDLS set at a level of 0 for water bodies with a wide range of beneficial uses. This means, according to the Los Angeles Regional Water Quality Control Board (LARWQCB), any presence of trash impairs any beneficial use of a water body. Personal communication with Eric Wu (March 12, 2009), a State Water Board employee, further reinforced the tendency of the Sate to set the TMDL levels at 0.

The feasibility of a trash TMDL at a level of 0 may not be entirely feasible and should be heavily considered. What is the cost to a polluter (i.e. municipalities or Cal Trans) to remediate trash pollution? The case of the LA River demonstrated the opposition encountered by the implementation of a 0 trash TMDL, as 22 cities filled a suit against the SWRCB citing that a goal of 0 trash is unattainable.

There are thirteen (13) Basin Plan Amendments that have passed in the Los Angeles region since April 2001 and have served as vital actions to further assist members of the public concerned with trash abatement in specific water bodies. For each trash TMDL amendment that exists a detailed summary of their findings is provided. These findings document the beneficial uses that are specific to the area in question and define the Regional Board Basin Plan Water Quality Objectives (Table 10):

Table 10

Water Quality Objective	Definition

Floating Material	*Waters shall not contain floating materials, including solids, liquids, foams, and scum, in concentrations that cause nuisance or adversely affect beneficial uses.*
Solid, Suspended, or Settled Material	*Waters shall not contain suspended or settled material in concentrations that cause nuisance or adversely affect beneficial uses.*

Regional Board Basin Plan Water Quality Objectives. East Fork Trash TMDL amended on May 25, 2000. P.11

<u>5.5 Sampling and analysis errors:</u>

Regarding the initial observations categories of the *Rapid Trash Assessment* sheet (Appendix A), the "trash level at first glance" may not accurately represent the expanse of trash on the Lagoon shores. Small pieces of debris, such as weathered plastics, cannot always be readily seen during a quick, initial visual scan. The small size of trash items does not diminish their importance; in fact it may increase their potential to comprise beneficial uses such as WILD or WET in that they are easily ingested.

Furthermore qualitative observations translated onto numerical scales leave room for personal biases to enter analyses. Throughout the sampling process the individuals acting as the "trash collector" and "recorder" positions changed. Each individual likely responded to trash levels somewhat differently when using a rating system, creating a minor inconsistency in rating accuracy. Individuals may have also sub-categorized trash differently, for instance calling a "plastic wrapper" "soft plastic" instead. This may have affected the accuracy of the total percentage of trash assigned to each sub-category.

Regarding the parameters of the *Rapid Trash Assesment (Appendix A),* the focus for debris characterization is on beach and intertidal areas. Trash existing on the benthos of the water body is not evaluated. This can provide an underestimation of the scope of the trash issue as the submerged and water born trash is of more concern to wildlife and human health than the beached debris.

Weather conditions and equipment failure inhibited the scope of analysis. Rainfall was frequent prior to the commencement of sampling but infrequent throughout the sampling process. Originally intentions were to attempt to demonstrate the difference in trash present at the Lagoon during wet and dry periods. This would be significant as trash increases during wet periods would imply contributions from the storms drains vs. non-point source contributions, such as the presence of windblown debris. The GPS units provided for this analysis were not accurate enough to locate the start and end of all transects implemented, making it difficult to monitor one exact location.

APPENDICES

APPENDIX A

RAPID TRASH ASSESSMENT WORKSHEET

Surface Water Ambient Monitoring Program, San Francisco Bay Regional Water Quality Control Board

WATERSHED/STREAM: ___________________________ DATE/TIME: ______________________

MONITORING GROUP, STAFF: ____________________ SAMPLE ID NO. ___________________

SITE DESCRIPTION (Station Name, No., etc.): ____

	CONDITION CATEGORY			
Trash Assessment Parameter	**Optimal**	**Sub optimal**	**Marginal**	**Poor**
1. Level of Trash	On first glance, no trash visible; little or no trash evident when streambed and streambanks are closely examined for litter and debris, for instance by looking under leaves.	On first glance, little or no trash visible; after close inspection small levels of trash evident in streambank and streambed.	Trash is evident in low to medium levels on first glance. Stream-bank surfaces and immediate riparian zone contain litter and debris. Evidence of site being used by people: scattered cans, bottles, blankets, and/or clothing.	Trash distracts the eye on first glance. Streambank surfaces and immediate riparian zone contain substantial levels of litter and debris. Evidence of site being used frequently by people: many cans & bottles, food wrappers, manmade shelters, blankets, and/or piles of clothing.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Actual Number of Trash Items Found	0 to 5 trash items based on a rapid survey of a 100-foot stream reach.	6 to 25 trash items based on a rapid survey of a 100-foot stream reach.	26 to 50 trash items based on a rapid survey of a 100-foot stream reach.	Over 50 trash items based on a rapid survey of a 100-foot stream reach.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Threat to Aquatic Life	Trash, if any, is mostly paper or wood products or other biodegradable materials. Note: A large amount of rapidly biodegradable material like food waste creates high oxygen demand, and should not be scored as optimal.	Little or no persistent, buoyant, and small litter or debris. Presence of settleable, degradable, and non-toxic debris such as wood, glass, metal, and degradable plastics such as foamed plastics.	Medium prevalence of persistent (plastic, synthetic rubber or cloth), toxic, buoyant, and small litter such as: plastic bags; pellets; cigarette butts; large deposits of settleable debris such as glass or metal; and any evidence of small clumps of deposited yard waste or leaf litter.	Large amount of persistent (plastic, synthetic rubber or cloth), toxic, buoyant, and small (transportable) trash such as: cigarette butts; plastic bags; plastic pellets; batteries or other toxic substances; and large clumps of yard waste or dumped leaf litter.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Threat to Human Health	Observable trash contains no evidence of bacteria or virus hazards such as medical waste, diapers, pet or human waste, no evidence of toxic substances such as pesticides or batteries, no ponded water for mosquito production & no evidence of puncture or laceration hazards associated with the observed litter or debris.	No medical waste or sources of toxic substances, but any presence of puncture or laceration hazards such as broken glass and metal debris. Or presence of ponded water in trash items such as tires or containers that could facilitate mosquito production.	Presence of **one** of the following: hypodermic needles, pipettes, or other medical waste ; any used diapers or pet waste within the stream channel or where runoff could carry materials to waterbody; any toxic substance such as pesticides, batteries, or fluorescent light bulbs (mercury).	Presence of **more than one** of the following: any hypodermic needles, pipettes, or other medical waste; used diapers or pet waste within the stream channel or where runoff could carry materials to waterbody; any toxic substances such as pesticides, batteries, or fluorescent light bulbs (mercury); ponded water in trash items.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

RAPID TRASH ASSESSMENT WORKSHEET

Surface Water Ambient Monitoring Program, San Francisco Bay Regional Water Quality Control Board

	CONDITION CATEGORY			
Trash Assessment Parameter	**Optimal**	**Sub optimal**	**Marginal**	**Poor**
5. Illegal Dumping and Littering	Any observed trash is incidental litter (less than 5 items) or carried downstream from another location. No evidence of illegal dumping.	Some evidence of in-stream or shoreline littering; and/or some evidence of illegal dumping, such as a sign prohibiting dumping along with observed garbage bags of material. Limited vehicular access limits the amount of potential dumping, or material dumped is diffuse paper-based debris (e.g., convenience stores or fast food).	Prevalent in-stream or shoreline littering; and/or the presence of **one** of the following: furniture, appliances, or bags of garbage or yard waste, coupled with vehicular access that facilitates in-and-out dumping of materials to avoid landfill costs.	Significant litter on shoreline or stream banks and streambed; and/or evidence of chronic dumping, with **more than one** of the following items: furniture, appliances, shopping carts, garbage bags, or yard waste. Easy vehicular access for in-and-out dumping of materials to avoid landfill costs.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
6. Accumulation of Trash	There does not appear to be a problem with trash accumulation from downstream transport. Observable trash, if any, appears to have been directly deposited at the stream location.	Some evidence that litter and debris have been transported from upstream areas to the location. Less than 5 trash items have been transported from upstream locations, based on evidence such as silt marks, faded colors or location near high water marks.	5 to 20 items of observable trash are carried to the location from upstream, as evidenced by its location near high water marks and siltation marks on the debris.	Trash appears to have accumulated in substantial quantities at the location based on delivery from upstream areas, and is in various states of degradation based on its persistence in the waterbody. Over 20 items of observable trash have been carried to the location from upstream.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Total Score ______________

SITE DEFINITION:
UPPER/LOWER BOUNDARIES OF REACH: ____
HIGH WATER LINE: ____
UPPER EXTENT OF BANKS OR SHORE: ____
____

NOTES:
____
____
____
____

RAPID TRASH ASSESSMENT WORKSHEET

Surface Water Ambient Monitoring Program, San Francisco Bay Regional Water Quality Control Board

TRASH ITEM TALLY (Tally with (|) if found below high water line, and (•) if above)

PLASTIC	**METAL**
Plastic Bags	Aluminum Foil
Plastic Bottles	Aluminum or Steel Cans
Plastic Bottle Caps	Bottle Caps
Plastic Cup Lid/Straw	Metal Pipe Segments
Plastic Pipe Segments	Auto Parts (specify below)
Plastic Six-Pack Rings	Wire (barb, chicken wire etc.)
Plastic Wrapper	Metal Object
Soft Plastic Pieces	**LARGE (specify below)**
Hard Plastic Pieces	Appliances
Styrofoam cups pieces	Furniture
Styrofoam Pellets	Garbage Bags of Trash
Fishing Line	Tires
Tarp	Shopping Carts
Other (write-in)	Other (write-in)
BIOHAZARD	**TOXIC**
Human Waste/Diapers	Chemical Containers
Pet Waste	Oil/Surfactant on Water
Syringes or Pipettes	Spray Paint Cans
Dead Animals	Lighters
Other (write-in)	Small Batteries
CONSTRUCTION DEBRIS	Vehicle Batteries
Concrete (not placed)	Other (write-in)
Rebar	**BIODEGRADABLE**
Bricks	Paper
Wood Debris	Cardboard
Other (write-in)	Food Waste
MISCELLANEOUS	Yard Waste (incl. trees)
Synthetic Rubber	Leaf Litter Piles
Foam Rubber	Other (write-in)
Balloons	**GLASS**
Ceramic pots/shards	Glass bottles
Hose Pieces	Glass pieces
Cigarette Butts	**FABRIC AND CLOTH**
Golf Balls	Synthetic Fabric
Tennis Balls	Natural Fabric (cotton, wool)
Other (write-in)	Other (write-in)

SPECIFIC DESCRIPTION OF ITEMS FOUND (if any):

____

____

____

____

APPENDIX B

Field Research Schedule

February

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1	**2**	**3**	**4**	**5**	**6**	**7**
8	**9**	**10** Allyson: SP/SV Nicole: SP/SV Sergio: SP	**11**	**12**	**13**	**14**
15	**16**	**17**	**18**	**19**	**20** Dan: SP/SV Allyson: SP/SV	**21**
22	**23**	**24**	**25**	**26**	**27**	**28**

March

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1	**2**	**3**	**4**	**5**	**6**	**7** Allyson: SP Sergio: SV Dan: SV Ricardo: SP
8	**9**	**10**	**11**	**12**	**13**	**14**
15	**16** Dan: SV Allyson: SP Sergio: SV Nicole: SP	**17**	**18**	**19** Dan: SP/SV Ricardo: SP/SV Nicole: SV	**20**	**21**
22	**23**	**24**	**25**	**26**	**27**	**28**
29 Allyson: SP Sergio: SV Dan: SV	**30**	**31**				

April

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
			1	2	3	4
5	6	7	8	9 Dan: SV Allyson: SP Sergio: SV Ricardo: SP	10	11
12	13	14	15	16	17	18
19 Dan: SV Allyson: SP Sergio: SV Nicole: SP Ricardo: SV	20	21	22	23	24	25
26	27 Dan: SP Allyson: SV	28	29	30		

Work delineations for each team member:

Nicole Chatterson: Sampler & Surveyor

Sergio Ramirez: Sampler & Surveyor

Allyson Clark: Sampler & Surveyor

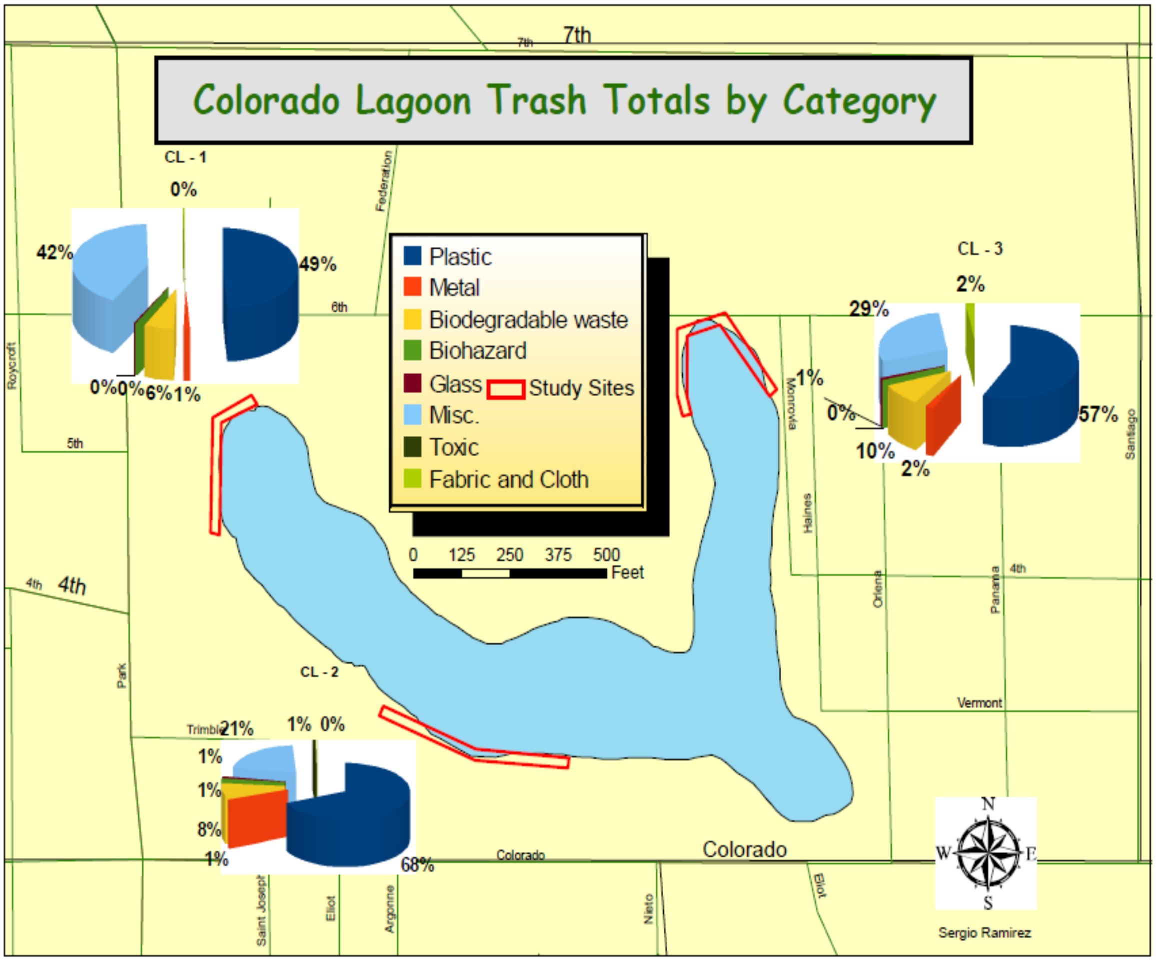
Daniel DeCurtins: Sampler & Surveyor

Ricardo Magallanes: Sampler & Surveyor

Sampler (SP): collects samples while communicating with the surveyor

Surveyor (SV): collects data from the sampler

Appendix C


Colorado Lagoon Trash Totals by Category
CL - 1
0%
42%
49%
0%0%6%1%
Plastic
Metal
Biodegradable waste
Biohazard
Glass
Study Sites
Misc.
Toxic
Fabric and Cloth
0 125 250 375 500
Feet
CL - 3
2%
29%
1%
0%
57%
10%
2%
CL - 2
21%
1% 0%
1%
1%
8%
1%
68%
7th
6th
5th
4th
Federation
Roycroft
Park
Trimble
Monrovia
Haines
Orlena
Panama
Santiago
Vermont
Colorado
Saint Joseph
Eliot
Argonne
Nieto
N
W
E
S
Sergio Ramirez

WORKS CITED

1. Los Angeles Regional Basin Plan; Section 2 Beneficial Uses; Los Angeles Regional Water Quality Control Board Basin Plan- June 13, 1994
2. Colorado Lagoon: Water Quality Assesment Report; Kinnetic Laboratories, Inc. Carlsbad, Ca and Moffatt & Nichol; Long Beach, Ca; August, 2004
3. Polycyclic Aromatic Hydrocarbons (PAH): U.S. Department of Health and Human Services, Public Health Service Agency for Toxic Substances and Disease Registry. September 1996
4. Polychlorinated Biphenyls (PCB): U.S. Department of Health and Human Services, Public Health Service Agency for Toxic Substances and Disease Registry. Febuary 2001
5. Eliminating Land-Based Discharges of Marine Debris in California: A Plan of Action From The Plastic Debris Project; Algalita Marine Research Foundation and California Coastal Commission; June 2006
6. Rapid Trash Assessment Protocol: Surface water Ambient Monitoring Program; California Regional Water Quality Control Board, San Francisco Bay Region, November 15th 2004
7. Synthetic Polymers in the Marine Environment: A Rapidly Increasing Long-Term Treat; Charles James Moore. Algalita Marine Research Foundation, 148 N. Marina Drive, Long Beach, Ca 90803. 2008
8. Persistent Organic Pollutants Carried By Synthetic Polymers in the Ocean Environment: Lorena M. Rios et. al. Marine Science Bulletin 54 (2007) 1230-1237
9. Something's Fishy, Eric Zahn; Friends of Colorado Lagoon Newsletter No. 10. March 2009
10. A Salt Marsh Unseen, Eric Zahn; Friends of Colorado Lagoon Newsletter No. 6; April 2007
11. Terns at the Lagoon. Rich Sonnenberg**;** Friends of Colorado Lagoon Newsletter No. 9; September 2008
12. http://oaspub.epa.gov/tmdl/enviro.control?p_list_id=CA408.0260T%20COLORADO%20LAGO&p_cycle=2002
13. http://www.atsdr.cdc.gov/csem/pcb/standards_regulations.html

14. Cigarette butts cause environmental pollution. Monday, May, 24 2009. http://web.vtc.edu/mt/102/Projects/ElectronicNotebooks/SectionA/JoshCross/cig4_1.html

15. *Final Termino Avenue Drain Project Environmental Impact Report,* State Clearinghouse No. 2000111022, by EDAW, inc.

16. *Friends of the Colorado Lagoon* . http://www.coloradolagoon.org/focl/history.html, visited 3/24/09

17. *City of Long Beach Restoration Project.* http://www.waterboards.ca.gov/water_issues/programs/beaches/cbi_projects/docs/summaries/310_colorado_lagoon.pdf, visited 3/23/09

18. Los Cerritos Wetlands Trust. http://www.lcwlandtrust.org/TheLosCerritosWetlands.htm

19. Los Cerritos Wetlands Stewards. http://lcwstewards.org/lcws/index.html

20. CA SWRCB. http://www.waterboards.ca.gov/tmdl/docs/ffed_303d_listingpolicy093004.pdf

21. *US EPA.* http://www.epa.gov/owow/tmdl/

22. Lovanna, Richard and Griffiths, Charlie. *Clean water, ecological benefits, and benefits transfer: A work in progress at the U.S. EPA* (2006). Ecological economics, 60(2), 473.

23. Davis, B.S. *Catchment-wide assessment of the cost-effectiveness of stormwater remediation measures in urban areas.* Ecological economics 60.2 (2006):473.