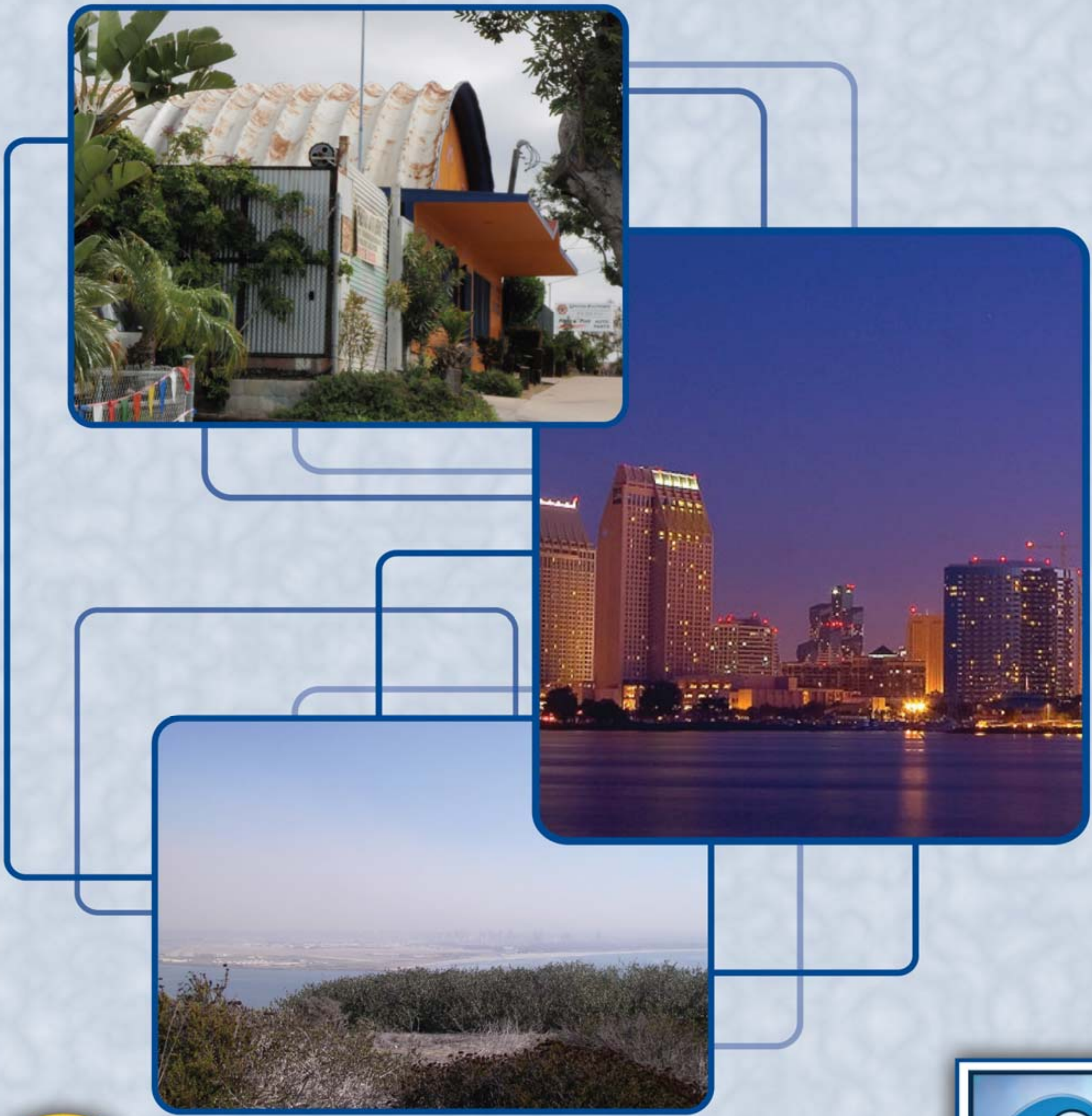
City of San Diego Aerial Deposition Study, Phase III

Source Evaluation of TMDL Metals in the Chollas Creek Watershed

June 17, 2009

Final Report



City of San Diego

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Aerial Deposition Study, Phase III
Source Evaluation of TMDL Metals in the Chollas Creek Watershed

Final Report

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June 17, 2009

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LIST OF ACRONYMS

Acronym	Definition
ANOVA	Analysis of Variance
APN	Assessor's Parcel Number
ARB	Air Resources Control Board
BMP	best management practice
BPP	Brake Pad Partnership
CARB	California Air Resources Board
CTR	California Toxics Rule
EPA	United States Environmental Protection Agency
GIS	geographic information system
SDAPCD	San Diego Air Pollution Control District
TMDL	total maximum daily load
WESTON®	Weston Solutions, Inc.
WLA	waste load allocation
WQO	water quality objective

LIST OF UNITS

Unit	Definition
µg/L	microgram per liter
ppb	part per billion
$\mu g/m^2$/day	microgram per square meter per day
mg/m^2/day	milligram per square meter per day
mg/L	milligram per liter
µm	micrometer
mg/kg	milligram per kilogram
%	percent
km	kilometer
mph	miles per hour
mm	millimeter
cm^2	square centimeter
m^2	square meter

EXECUTIVE SUMMARY

This *City of San Diego Aerial Deposition Phase III Report* presents the results and data analyses from this multi-media program and builds on the results of previous study phases. The study was conducted throughout the Chollas Creek Watershed to investigate the sources of copper, lead, and zinc that may contribute to receiving water quality impairments.

This Phase III Study was conducted from January 2009 to May 2009 and represents a Tier II source identification activity in relation to the Chollas Creek Dissolved Metals Total Maximum Daily Load (TMDL) Implementation Plan and the City of San Diego Storm Water Department's Strategic Plan (WESTON, 2007). This project also qualifies as a watershed activity under the National Pollutant Discharge Elimination System (NPDES) Permit.

The objectives for this Phase III Study were as follows

1. Create a geographic information system (GIS) database of existing watershed inspection, enforcement, and monitoring data.
2. Assess annual emissions data reported to the San Diego Air Pollution Control District (SDAPCD) from stationary emission sources near the mouth of Chollas Creek.
3. Identify potential sources of metals in the watershed based on facility characteristics and land use from the developed GIS database.
4. Verify potential sources of metals identified in the GIS database with field reconnaissance and dry weather surveys. Parcel-based evaluations included documenting facility construction type, outdoor metals storage, evidence of emissions sources, pavement staining indicating runoff of pollutants, and drainage direction and proximity to the nearest storm drain inputs.
5. Conduct wet weather first flush sampling at targeted storm drains from industrial and commercial land uses to verify if they are a high threat to water quality.
6. Compare aerial deposition results to runoff concentrations from residential drains in different priority sectors to determine if effects from facility emissions are evident.

Results and Key Findings

- Average annual aerial emissions of copper from four stationary facilities near the mouth of Chollas Creek are roughly five times higher than the average annual load discharged via storm water runoff. In contrast, lead and zinc emissions were only 1% and 24% of average annual discharge load.
- Aerial deposition of copper, lead, and zinc accounts for 100%, 29%, and 74%, respectively, of the average annual load discharged via storm water runoff. This suggests that mobile emissions sources (e.g., automobiles and resuspended dust) and localized parcel-based sources also play a role in metals deposition of lead and zinc in the watershed.
- Conservative estimates of street sweeping effectiveness in relation to the annual loads deposited from aerial deposition were less than 10% for copper and zinc, and less than 40% for lead. Street sweeping may be more effective for industrial and commercial areas in Priority Sector 1, but may have limited effectiveness for watershed wide metals loading from aerial deposition. Additionally, lead in soils from historical leaded gasoline use may continue to be a source of this metal from erosive soils in canyon areas.
- Samples collected from metal rooftops in poor condition (e.g. deteriorating or rust evident), identified through the GIS desktop exercise, were found to be significantly higher in concentrations of total and dissolved zinc compared with the street level runoff

concentrations. Concentrations of copper and lead were relatively low from metal rooftop runoff, but increased in street level runoff suggesting aerial deposition or other parcel-based sources of copper and lead.

- Total and dissolved copper concentrations were positively correlated (higher) with higher percent impervious surface area.
- Copper, lead, and zinc concentrations were higher in commercial and industrial land uses compared with residential land uses.
- Copper and zinc concentrations were significantly higher in Priority Sector 1 compared with other priority sectors. This supports the conclusion that emissions of copper and zinc from stationary facilities near the mouth of Chollas Creek likely contribute to aerial deposition and subsequent runoff of these metals.
- Industrial and commercial activities with uncovered outdoor metal storage and outdoor operations were positively correlated to high levels of copper, lead, and zinc.
- Field surveys suggested that several areas identified within the Chollas Creek Watershed actually drain to other watersheds in Priority Sector 1 and Priority Sector 2. Additionally, several storm drains were observed to have excessive amounts of dirt and debris and were in need of maintenance.

Relevance to Current City of San Diego Efforts

This study supports other Stormwater Department programs and cost-reduction efforts, including the following:

- The Chollas Creek Dissolved Metals TMDL Implementation Plan.
- Development of TMDLs for the mouths of Chollas, Switzer, and Paleta creeks.
- City of San Diego Street Sweeping Best Management Practice (BMP) Effectiveness Assessment Study.
- La Jolla Areas of Special Biological Significance (ASBS).

Key Recommendations

The following recommendations are presented based on the results of this study:

- Initiate staff meetings with the Regional Water Quality Control Board (Regional Board), SDAPCD, and Air Resources Control Board (ARB) to discuss existing emissions sources in the watershed.
- Continue supporting the California Stormwater Quality Association (CASQA) Brake Pad Partnership (BPP) efforts to implement and pass SB346.
- Consider public-private partnership programs to replace or maintain metal rooftops in poor condition.
- Update the City of San Diego's storm drain layers, and redefine the Chollas Creek Watershed based on updated drainage area maps.
- Prioritize the catchbasin cleaning programs in areas identified to be in need of maintenance.
- Enforce City of San Diego codes in the industrial and commercial runoff inspections program with regard to exposed metals storage and outdoor facility operations.

Benefits to the City of San Diego

This City of San Diego Aerial Deposition Phase III Study provides the following benefits to the City of San Diego:

- The study complies with regulatory requirements laid out under the San Diego County Municipal Storm Water Permit (Permit) (Final Order R9-2007-0001, 2007).
- The study provides important data for the Chollas Creek Dissolved Metals TMDL Implementation Plan.

1.0 INTRODUCTION

This *City of San Diego Aerial Deposition Phase III Report* presents the results and data analyses from this multi-media program that builds on the results of previous study phases. This multi-media assessment includes: review of existing emissions and inspections data; storm drain pollutant source investigations of dry weather runoff; laboratory analysis of wet weather storm water samples collected in areas identified as a high threat to water quality; and analysis of dust wipe samples to characterize the spatial deposition of particles in the watershed. Analyzed together, these data sets provide the basis to identify the sources of metals that contribute to the pollutant loading to receiving waters. Aerial deposition is an important mechanism in the overall pollutant loading that impacts water quality.

This Phase III study was conducted from January 2009 to May 2009 and represents a Tier II source identification activity in relation to the Chollas Creek Dissolved Metals Total Maximum Daily Load (TMDL) Implementation Plan and the City of San Diego Storm Water Department's (City) Strategic Plan. This study also provides valuable information for other City projects as shown on Figure 1-1. For example, this aerial deposition study directly links to the Aggressive Street Sweeping Study by comparing the aerial deposition rate and subsequent loads to the efficiency and load removed via street sweeping. The metals source identification provided by this study provides key data in developing Tier I source control and pollution prevention activities to meet the loading reduction goals under the Chollas Creek Dissolved Metals TMDL, the pending TMDLs at the mouth of Chollas, Switzer, and Paleta Creeks, and the exception permit under the Ocean Plan for the La Jolla Area of Special Biological Significance (ASBS).

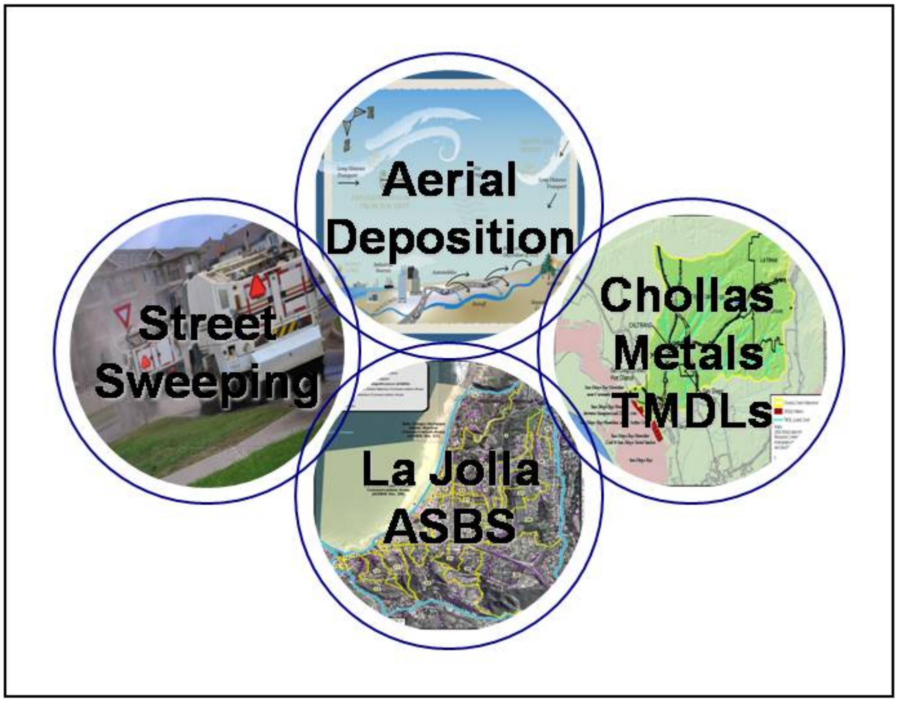


Figure 1-1. Relation of Aerial Deposition to Other City of San Diego Projects

This report is organized by the following sections:

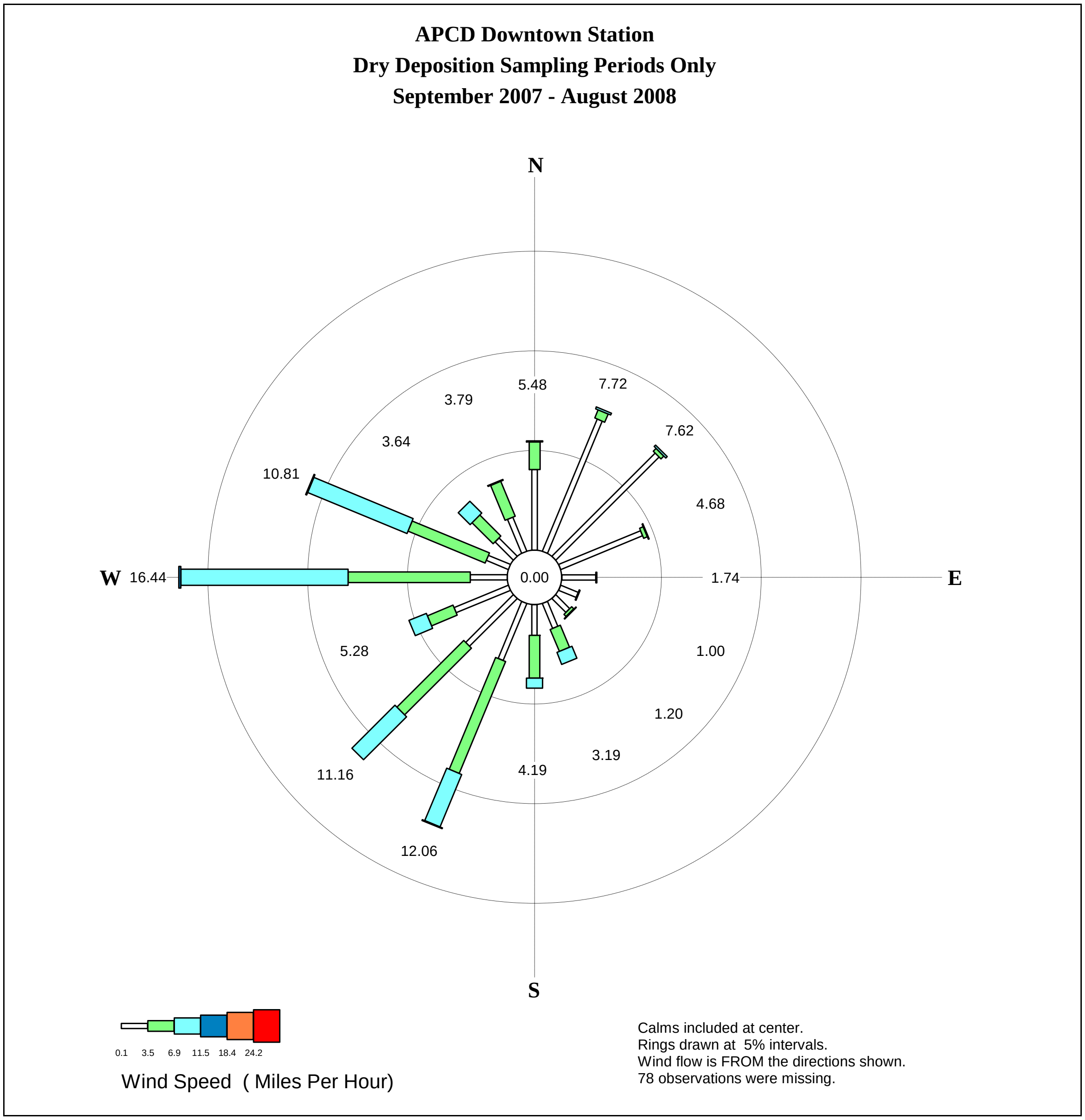
- Section 1 – Introduction.
- Section 2 – Methods.
- Section 3 – Results.
- Section 4 – Findings.
- Section 5 – Conclusions and Recommendations.
- Section 6 – References.

1.1 Problem Statement

The City of San Diego encompasses a land area of approximately 342 square miles and includes highly urbanized and developed land uses. Several areas within the City of San Diego experience detections of specific metals (e.g., copper, lead, and zinc) above wet weather water quality objectives (WQOs) in storm water runoff related to land uses and activities conducted in these areas. The Chollas Creek Watershed, the Tecolote Creek Watershed, the Shelter Island Drainage Area, and the La Jolla Area of Special Biological Significance (ASBS) are examples of specific study areas where metals are a concern in wet weather and dry weather runoff.

Many studies relating to TMDLs and WQO exceedances are based on methods that have been developed since the inception of the Clean Water Act in 1972. These methods have focused on a single media assessment that specifically measures the concentrations of pollutants in water. The methods have been standardized and are typically performed by laboratories certified to perform the tests, as required by federal and state regulations. Well over a thousand analytical tests of water quality have been performed in San Diego County over the past decade. These data have shown that some waterbodies contain concentrations of pollutants that pose potential threats to the beneficial uses listed in the San Diego Basin Plan. These data are also used to list impaired waters and develop the TMDLs. Once pollutants are identified as exceeding WQOs, municipalities will often perform investigations (e.g., bacterial source tracking, illegal connection and illicit discharge (ICID) studies, and other general water quality tracking studies) to determine the source of the pollutants. In many of these cases, the root cause of pollution sources can be identified, since the flow of water is often continual and can be traced using deductive reasoning if it is associated with a point source discharge. However, sources associated with trace metals concentrations just above the WQO are considerably more difficult to determine when associated with non-point source pollution.

A potential source of water quality pollutants is atmospheric deposition from point and non-point sources (i.e., stationary and mobile area wide emission sources). The City of San Diego Phase I and Phase II aerial deposition studies demonstrated that area wide emission sources (e.g., cars, trucks, and other activities) and stationary emission sources near the mouth of Chollas Creek (e.g., heavy industrial facilities, welding, and painting activities) likely contribute to metals deposition rates and subsequently metals loading to receiving waters through storm water migration via indirect deposition. In the Chollas Creek Watershed, it was concluded that aerial deposition could account for up to 100% of the copper and zinc loading that results in concentrations in storm water and receiving waters above the WQO. Several areas with deposition rates greater than average measured deposition rates were associated with specific land uses or activities and often had results correlated with defined areas of influence (e.g., sites downwind of freeways or industrial facilities). Additionally, some stationary facilities near the mouth of Chollas Creek report annually to the San Diego County Air Pollution Control District (SDAPCD) on the amounts and types of emissions of specific pollutants (e.g., copper, lead, and zinc). With the prevailing winds from the west, as shown in Figure 1-2, the potential for these emissions to influence indirect deposition loads for the Chollas Creek Watershed is apparent.



Calms included at center.
Rings drawn at 5% intervals.
Wind flow is FROM the directions shown.
78 observations were missing.

Figure 1-2. Annual Wind Rose for Downtown San Diego

The primary focus of this Phase III study is answer specific questions relating to sources of metals in relation to the Chollas Creek Dissolved Metals TMDL and in relation to TMDLs being developed for sediment impairments at the mouths of Chollas, Switzer, and Paleta creeks. The Chollas Creek Dissolved Metals TMDL was adopted on October 22, 2008, by the State Office of Administrative Law and was approved by the United States Environmental Protection Agency (EPA) on December 18, 2008.

1.1.1.1 Dissolved Metals Waste Load Allocations

The Chollas Creek Dissolved Metals TMDL WQOs are based on the California Toxics Rule (CTR) water quality criteria. The EPA established numeric criteria for toxic pollutants, which, through promulgation of the CTR, form applicable WQOs for dissolved copper, lead, and zinc. These WQOs are the basis for the Dissolved Metals TMDL for the Chollas Creek Watershed (Table 1-1). The waste load allocations (WLAs) of the Dissolved Metals TMDL are concentration-based and include an explicit 10% margin of safety that takes into account any uncertainties in the TMDL calculation. The WLAs for dissolved copper, lead, and zinc are equal to 90% of the CTR chronic and acute criteria. The TMDL also includes an implicit margin of safety due to the conservative assumptions used in development of the criteria for the CTR (Stephan et al., 1985). As a concentration-based TMDL, compliance is not driven by total loads (flow based), but rather by a measured concentration in the waterbody to which the TMDL applies. Unlike loads, which typically apply in the downstream portions of the watershed, these concentration-based WLAs apply to the entire receiving water of the Chollas Creek Watershed.

Table 1-1. Water Quality Objectives for Specified Metals in the Chollas Creek Watershed

Metal	Numeric Target for Acute Conditions	Numeric Target for Chronic Conditions
Copper (dissolved)	(0.96) * {e^ [0.9422 * ln (hardness) -1.700]	(0.96) * {e^[0.8545 * ln (hardness) - 1.702]
Lead (dissolved)	{1.46203 – [0.145712 * ln (hardness)]} * {e^ [1.273 * ln (hardness) - 1.460]}	{1.46203 – [0.145712 * ln (hardness)]} * {e^[1.273 * ln (hardness) - 4.705]}
Zinc (dissolved)	(0.978) * {e^ [0.8473 * ln (hardness) + 0.884]}	(0.986) * {e^[0.8473 * ln (hardness) + 0.884]}

Hardness is expressed as mg/L.
The natural log and exponential functions are represented as “ln” and “e,” respectively.

The CTR equations are based on hardness (e.g., calcium and magnesium carbonate). As shown on Figure 1-3, there is an inverse relationship between hardness and toxicity. The water toxicity threshold (and WLA) increases with increased hardness. As hardness increases, charged constituents such as dissolved metals complex (or adhere) with the greater concentration of minerals making them less bioavailable to aquatic organisms and less toxic. Therefore, increased hardness results in a decrease in bioavailability and thus a higher WLA. Due to the urbanized nature of the Chollas Creek Watershed and the channelization of a large portion of the creek, natural buffering mechanisms that would increase hardness are not present in many segments of the creek. The lower hardness generally observed in wet weather storm flows decreases the WLA, and therefore, very low concentrations of dissolved metals have a higher probability of exceeding the WLA. The observations for dry weather flows have indicated that hardness is generally higher in these flows and is less likely to exceed the WLA. Additionally, dry weather flows are relatively infrequent and are typically a result of municipal water over irrigation, which has considerably higher hardness. This is likely the result of the higher mineral content in imported water used for irrigation and other activities that result in dry weather urban runoff.

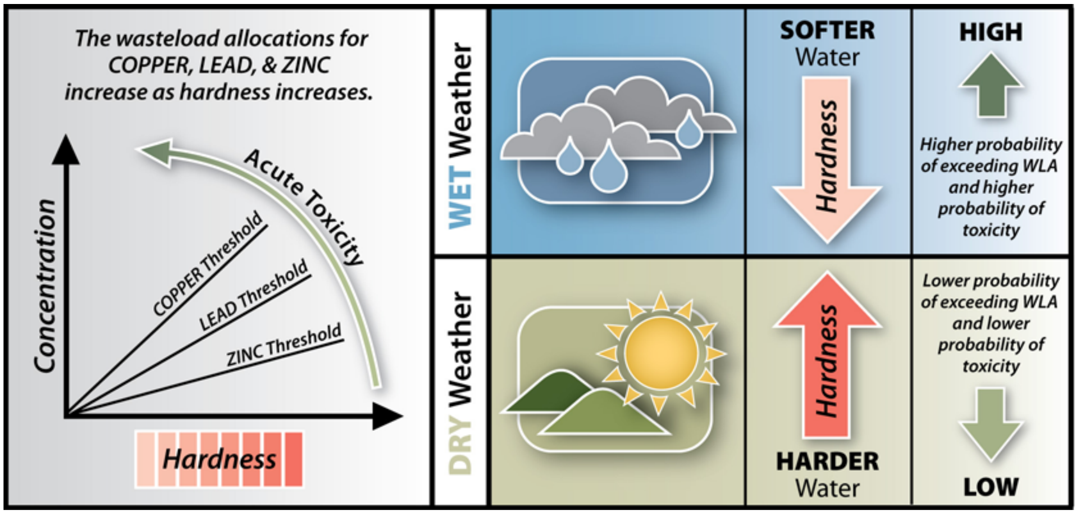


Figure 1-3. Impact of Hardness as a Dominant Variable in the Dissolved Metals Total Maximum Daily Load

1.2 Summary of Previous Projects and Regulatory Developments

To better understand the sources of metals WQO exceedances in Chollas Creek., which is the basis for the Section 303(d) Listing and the Dissolved Metals TMDL, the City of San Diego implemented the City of San Diego Dry Weather Aerial Deposition Study. The study occurred the during Summer 2006 and Fall 2006 (WESTON, 2007) to assess the contribution of aerially deposited particulate matter on surfaces subject to runoff during storm events. A second study, the City of San Diego Aerial Deposition Study, Phase II (WESTON, 2009a), was conducted from August 2007 to September 2008 to assess the annual variability of dry deposition in targeted areas. Wet weather deposition rates and the solubility of deposited particulates were also evaluated. Based on the results of the Phase I and Phase II studies, it was evident that specific areas in the Chollas Creek Watershed experience deposition rates greater than average deposition rates of copper, lead, and zinc and were correlated with industrial and commercial land uses. In response to the Phase II findings, a source identification study was conducted as Phase III that focused on linking the relationship between aerial deposition and storm water runoff in the Chollas Creek Watershed.

The Phase I Dry Weather Aerial Deposition Study found freeways and major roadway land uses demonstrated a link between tire-wear particles and zinc concentrations. The Phase I and Phase II aerial deposition studies demonstrated that aerially deposited particulates can account for the majority of the concentration of copper and zinc and, to a lesser degree, lead in storm water runoff found in Chollas Creek. Sites with elevated deposition rates were often correlated to the major land uses or in close proximity to likely sources. Additionally, the Southern California Coastal Water Research Project (SCCWRP) conducted a dry deposition study along the Southern California Bight and identified that San Diego Bay at the Mouth of Chollas Creek had the highest mean deposition rate for copper (29 $\mu g/m^2/day$) out of eight sites along the Southern California Bight. San Diego Bay also had the second highest lead and zinc deposition rates (3.3 $\mu g/m^2/day$ and 63 $\mu g/m^2/day$, respectively) (SCCWRP, 2007). The site monitored was directly adjacent to significant industrial operations near the mouth of Chollas Creek. The Phase I Dry Weather Aerial Deposition Study also demonstrated that significant emissions of copper and zinc were reported to the SDAPCD from several facilities near the mouth of Chollas Creek.

As a result of the findings of Phase I study and the requests from the City of San Diego, the Chollas Creek Dissolved Metals TMDL Basin Plan amendment was revised to require the San Diego Regional Water Quality Control Board and the local Air Resources Control Board (ARB) to review regulatory gaps that may impact water quality in the Chollas Creek Watershed (State Water Resources Control Board Resolution No. 2008-00054) (Appendix A-1).

Items 5–7 of Resolution No. 2008-00054 read as follows:

5. Pollutant loadings from atmospheric deposition onto land, which are being conveyed into stormwater discharges, are included in the stormwater waste load allocations. One study has shown that atmospheric deposition of particulates containing trace metals in the urban areas is an important source of metals contaminants on land surfaces (Sabin et al., 2005). It appears from studies in other areas that larger particulates are responsible for the highest loadings of metals in atmospheric deposition, and therefore pose the greatest risk to water quality. The Water Boards, the California Air Resources Board (CARB), and some of the Air Districts have identified the need to (1) expand monitoring of larger particulates in atmospheric deposition to better gauge the impact to water quality, and (2) investigate the sources of these metals in order to design a control strategy. The San Diego Water Board and the State Water Board should meet with the San Diego County Air Pollution Control District (SDAPCD) and CARB to pursue further studies and to assist in developing appropriate controls.

6. The State Water Board encourages local municipalities within the urban watersheds in the San Diego Region and San Diego County to work with the SDAPCD and CARB to further identify and control sources of trace metals in atmospheric deposition. If necessary, the State Water Board and San Diego Water Board shall enforce compliance with the adopted plans by the SDAPCD and CARB as appropriate under Water Code sections 13146 and 13247, and all other relevant statutes and regulations.

7. The San Diego Water Board will work with municipalities and San Diego County to encourage building designs and best management practices that will retain pollutants on site. This will help prevent the conveyance of pollutants from atmospheric deposition and other sources from being washed into stormwater and discharged to Chollas Creek, and other urban watersheds.

The ARB is the lead air agency in the state responsible for enforcing the Federal CAA. Industrial and commercial emissions are controlled by 35 local districts, including the SDAPCD. Air quality regulations are primarily based on threats to human health and do not consider impacts to aquatic ecological health. Many of the toxic air compounds monitored by the SDAPCD (e.g., ozone, nitrogen dioxide, carbon monoxide, and sulfur dioxide) are not considered to impact the water quality of San Diego County. However, particulate matter is monitored by the SDAPCD. Elevated concentrations of particulate matter can cause both health and water quality impairments.

As a recommendation from the Phase I Aerial Deposition Study, the City became involved with the Brake Pad Partnership (BPP). The BPP is an organization of government regulators, brake pad manufacturers, storm water management agencies, and environmentalists that have been active for over the past ten years. Because copper is toxic to aquatic organisms, the brake pad manufacturers have agreed to change their product formulations "if brake pad wear debris is found to impair water quality" (Sustainable Conservation, 2006). The BPP has a technical library of over 197 studies related to the fate and transport of copper associated with brake wear debris. Based on this recommendation, the City actively participated with the California Stormwater Quality Association (CASQA) who formed a BPP Subcommittee to implement a legislative bill to remove copper from brake pads. The legislative bill (SB 346, Kehoe) was authored by Senator Christine Kehoe and is currently in the legislative approval process. SB 346 recently passed out of the Senate Appropriations Committee on May 26, 2009 and the California State Senate floor on June 4, 2009. The next steps in the approval process occur in the California Assembly. A fact sheet for SB 346 is provided in Appendix A-2.

1.3 Study Design

The study design for this Phase III study was directed to answer specific questions related to identifying sources of metals in the Chollas Creek Watershed. A secondary focus was to further investigate and characterize the emissions data reported to the SDAPCD in relation to the Chollas Creek TMDL and the reported pollutant loads discharged on an annual basis. The key questions that are addressed in this report are as follows:

1. **Do high deposition rate areas identified in the Phase II Aerial Deposition Study coincide with high runoff concentrations for copper, lead, and zinc?**
2. **How do metals concentrations from residential runoff areas compare to industrial/commercial runoff areas in the same relative aerial deposition area?**
3. **Are some facilities/sites contributing greater runoff concentration of copper, lead, and zinc compared to other facilities/sites?**

To answer the questions above, a multiple-phased and multi-media approach was used for evaluating the potential sources of metals throughout the watershed. A focused desktop exercise was conducted using geographic information systems (GIS) to assess the industrial and commercial land use sectors of Chollas Creek. Sites were assessed and categorized by the potential to contribute metals loadings (e.g., metal rooftops, evidence of emissions, facility operations, and metals storage). These observational data were combined with industrial inspection data, reported code compliance violations, and dry weather action level exceedances for metals to determine if specific patterns were evident. The GIS desktop review data were then overlaid on the City of San Diego's storm drain layer to identify potential sample locations that drained the potential industrial/commercial source site in question. Residential sites were also identified to ensure they were separate and distinct from a commercial/industrial facility. Field reconnaissance was then conducted to develop a list of sites for sampling in each priority sector of Chollas Creek (Figure 1-4).

The Chollas Creek Watershed was divided into five priority sectors as part of the City of San Diego Strategic Plan and was subsequently redefined (i.e., priority sectors 4 and 5 were changed) by the Chollas Creek Dischargers as part of the Draft Chollas Creek TMDL Implementation Plan (WESTON, 2009b). The priority sectors were to be the focus of the sampling effort to determine if concentrations of metals differed by sector and by land use (commercial/industrial versus residential within the same sector). Land use for the watershed is shown on Figure 1-5.

Following the field reconnaissance, sample locations were then identified, and wet weather samples were collected and analyzed for metals and conventional analytes. Additionally, dust wipe samples were collected and analyzed for spatial characterization. The methods, results, and discussion are provided in the subsequent sections of this report.

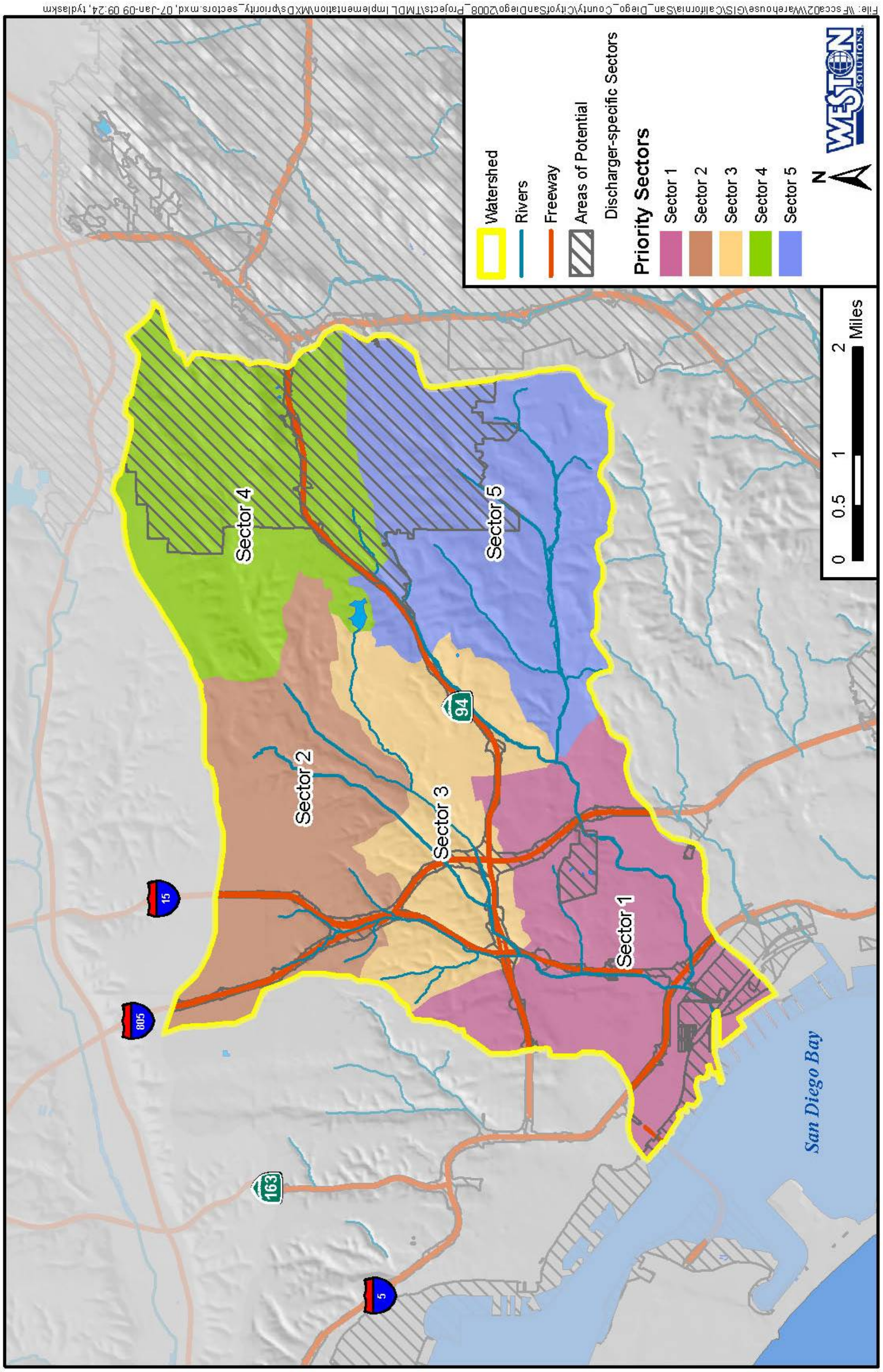


Figure 1-4. Chollas Creek Priority Sector Map

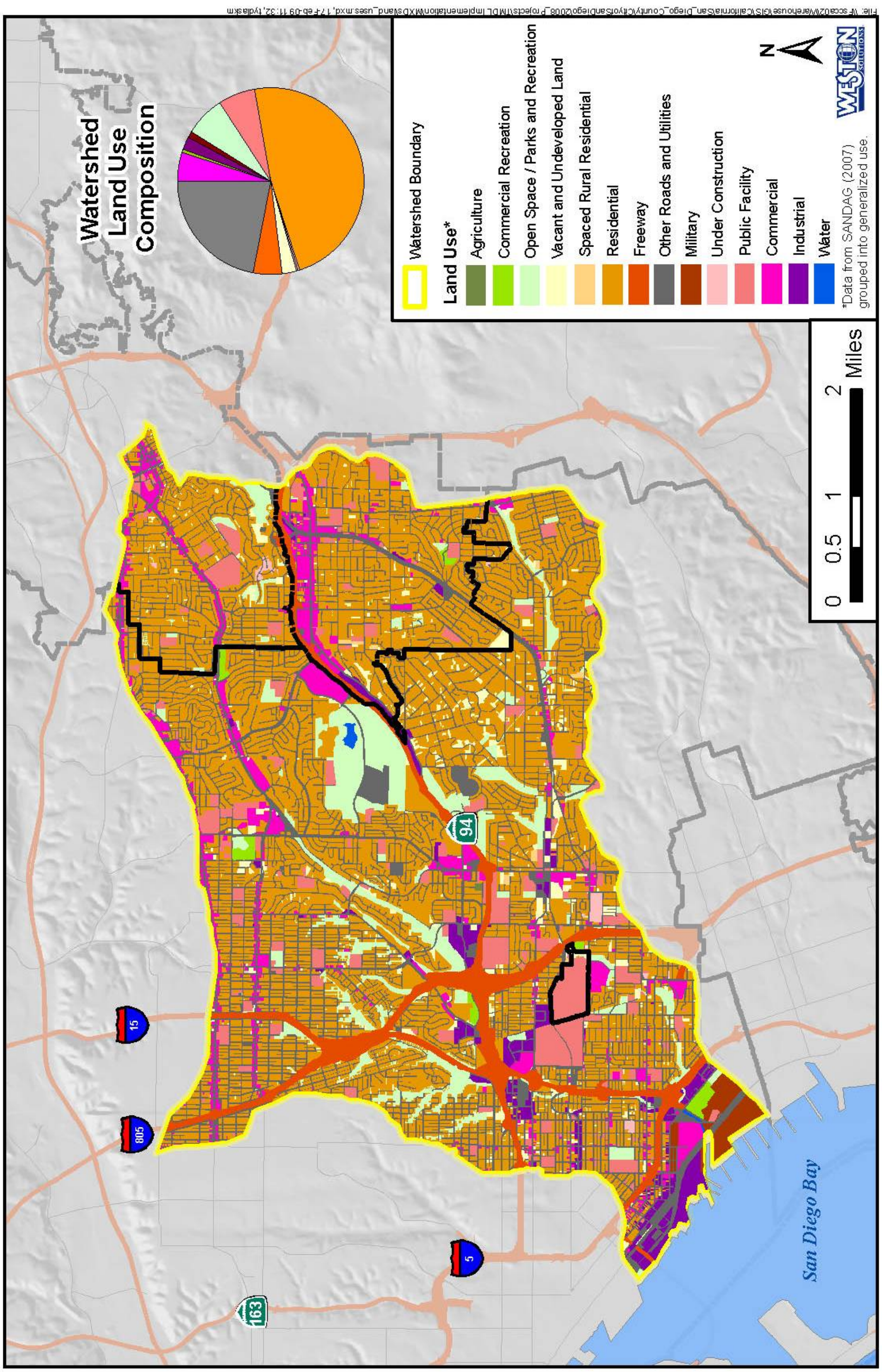


Figure 1-5. Chollas Creek Land Use Map

1.4 Air Quality and Water Quality Concepts and Overview

Aerially deposited contaminants that accumulate and subsequently wash off from dry weather or wet weather flows were identified as sources of contamination related to water quality problems in specific areas of the City of San Diego (e.g., Chollas Creek). An atmospheric deposition study conducted in Santa Monica Bay concluded that the major source of contaminants to the air was re-suspended dust, primarily from roads, and that atmospheric loadings are primarily the result of dry deposition of large diameter particles (>10 µm) on the watershed (Stoltzenbach et al., 2001). However, the Phase I and Phase II aerial deposition studies also demonstrated that additional emissions sources exist within the Chollas Creek Watershed, primarily near the mouth of Chollas Creek. A conceptual diagram of the processes affecting aerial deposition is shown on Figure 1-6.

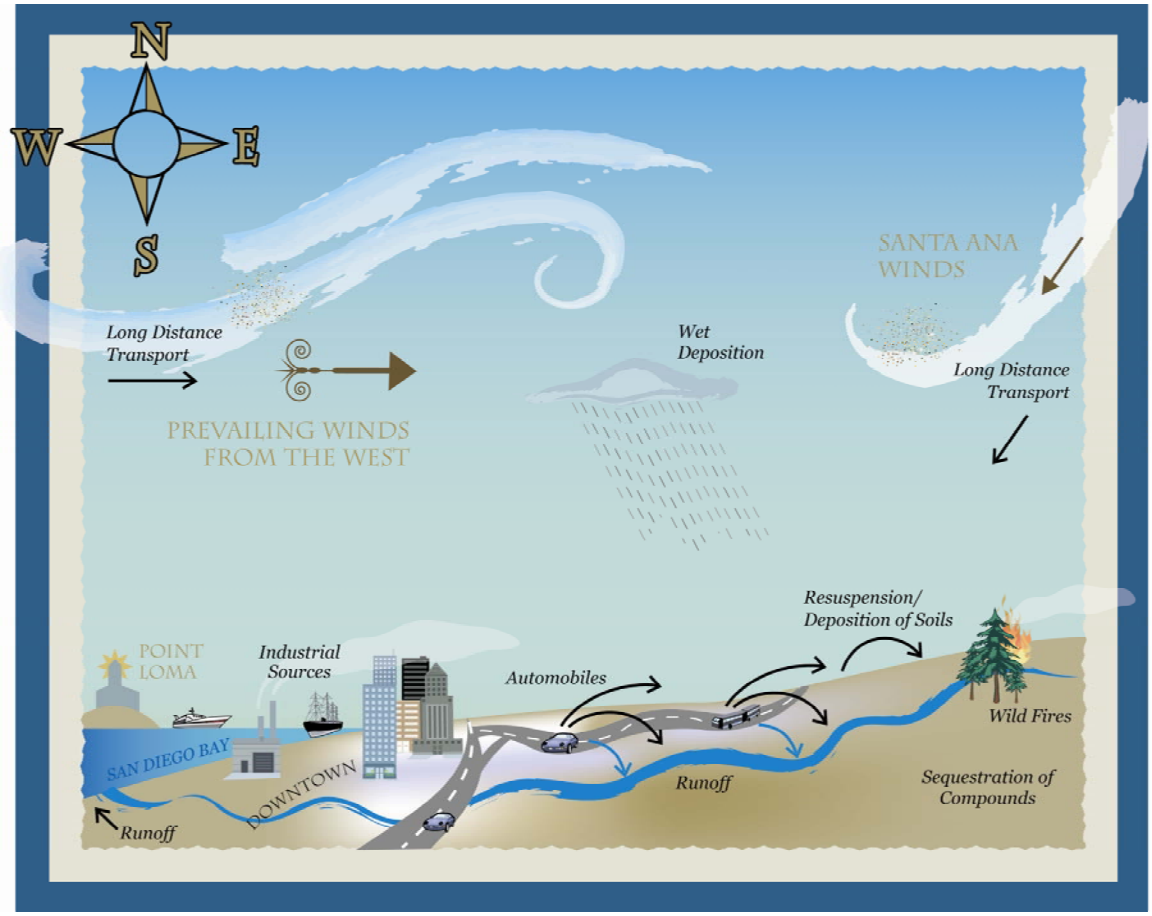


Figure 1-6. Conceptual Diagram of Processes Affecting Aerial Deposition

The terminology used throughout this document bridges two fundamental sciences, the study of air quality and the study of water quality. The terminology is defined as follows:

- **Emission** – The release of gases or particulates into the atmosphere. Emission rates are a measure of the pollutant mass released from a point source over time (e.g., grams of copper per day).
- **Dispersion** – The spreading of gasses or particulates from a small volume of air near the emission source into the surrounding atmosphere.

- **Deposition** – The process of particulates transfer from the atmosphere to the underlying surface.
- **Flux** – For the purposes of this report, flux, or mass flux, is the rate of a specific metal depositing from the atmosphere to a surface. The units are typically presented as micrograms of metal per square meter per day ($\mu g/m^2/day$).
- **Net Flux** – Similar to the example above, the net flux is the rate of the total mass that deposits on a surface and includes both inorganic and organic particulates. The units are typically presented as $\mu g/m^2/day$ or milligrams of metal per square meter per day ($mg/m^2/day$).
- **Buildup** – A term used in water quality studies to explain the process of particulate accumulation, similar to a surface (e.g., roadway, sidewalk, or automobile) that accumulates dust and dirt that may be available to contribute pollutants to storm water runoff.
- **Wash Off** – The process of removing the particulates from the surface. This is primarily associated with rainfall, but may occur with irrigation, car washing, power washing, and other processes.
- **TMDL** – A regulatory water quality term used to define the total amount of a pollutant that can be discharged to a waterbody. The load can be assigned as pounds per year of a given pollutant or also on a concentration basis (mg/L or micrograms per liter (µg/L)).

Particulates are classified as fine, coarse, and large particles. Particles that are less than 10 µm in aerodynamic diameter are called PM_{10} (inhalable particles). Particles less than 2.5 µm in aerodynamic diameter are called $PM_{2.5}$ (respirable particles). Particles will settle out based on several factors related to particle size, density, and wind speed and are summarized as follows:

- Fine particles (< 2.5 µm):
    - Greatest health relevance (increased disease and premature death greatest health relevance).
    - Low deposition rates and mass contribution.
    - Long transport distances.
- Coarse particles (2.5–10 µm):
    - Moderate health relevant (increased disease and premature death).
    - Moderate deposition rates and mass contribution.
    - Shorter transport distances.
- Large particles (> 10 µm):
    - Not health relevant (not inhalable; relatively sparse recent data).
    - High deposition rates and mass contribution.
    - Short transport distances, decreasing with increased particle size.

Particulates are comprised of nitrates, sulfates, organic chemicals, metals, soil, dust, and other material. Some particulates are directly emitted to the air from a variety of sources as follows:

Cars, trucks, buses, and heavy equipment.

Smog – Source: JimmyAkin.org

Industrial sources, construction sites, stone crushing and finishing, sandblasting, welding, and painting.

Concrete Cutting Photo Source: Health and Safety Executive (CIS No. 54)

Sandblasting Photo. Source: WESTON, 2006.

Resuspended dust from paved and unpaved areas.

Leaf Blower – Source: Goldenspirit.com

Wood burning and forest fires.

Smoke Plume from 2003 San Diego Forest Fires – Source: NASA.gov

Particles may also be formed in the air via condensation, nucleation, and coagulation from the vapor phase. However, the majority of these particles are typically smaller than 1 µm. Particles larger than 1 µm are generally derived from mechanically generated processes. As previously stated, particles smaller than 2.5 µm tend to have low deposition rates and lower mass contributions and are dispersed over much larger areas. The SDAPCD reports that San Diego meets the federal $PM_{2.5}$ standard, but has not attained the state $PM_{2.5}$ or the federal and state PM_{10} air quality standard (SDAPCD, 2007). Particulate matter larger than 10 µm is not regulated by the ARB since it is not considered to be an inhalable fraction.

1.5 Pollutants of Concern

The primary pollutants of concern for this study are copper, lead, and zinc. Other elemental data were also collected and are discussed in Section 2. This subsection describes the background information and sources of each pollutant of concern.

1.5.1 Copper

Copper (Cu) has an estimated crustal abundance of approximately 55 mg/kg (Kennedy, 2003). Copper commonly substitutes in minerals (e.g., plagioclase and apatite) and ranges from 10 mg/kg in granite to 100 mg/kg in basalt (Kennedy, 2003). Copper has a specific gravity of 8.96. Copper is an essential element for all higher living organisms. However, dissolved copper is considered to be toxic to aquatic organisms (e.g., algae, salmon, and other marine species) even in minute concentrations. The Chollas Creek metals TMDL WQO for dissolved copper is based on the CTR and varies depending on the hardness concentration from the sample collected. At a hardness concentration of 100 mg $CaCO_3$/L, the dissolved copper CTR acute WQO is 13.4 µg/L. The saltwater numeric criterion for dissolved copper for the Shelter Island Yacht Basin Dissolved Copper TMDL is set at 4.8 µg/L for the acute criteria. In comparison, the Federal Safe Drinking Water Act maximum contaminant level goal for total or dissolved copper is set at 1,300 µg/L.

Copper is a common consumer product used in building construction (e.g., plumbing, architectural copper roofs, mailboxes, and railings), electrical and electronic products (e.g., wiring and cables), metal plating and alloys, antifouling paints, and sandblasting material. Copper is also used as an algaecide and fungicide for swimming pool treatments and as a wood preservative. As of December 2008, the EPA announced it is taking legal action to ban acid copper chromate (ACC) in wood preservatives for residential use. Copper has also been shown to erode from overhead trolley wires from electric trains (Kennedy, 2003).

Copper is also used in brake pads as an additive to prevent brake disk screeching. as previously mentioned, copper in brake pads has been extensively studied in recent years by the BPP. The BPP has a technical library of over 197 studies related to the fate and transport of copper associated with brake wear debris.

Copper slag is used for sandblasting as an economical choice of abrasive grain for shipyards and contractors. Shipyard related industries are concentrated in the areas around San Diego Harbor. Many of the facilities in the vicinity of Chollas Creek have also reported their annual emissions of copper to be in the range of several hundred to several thousand pounds per year. This information is readily available for San Diego Region on the SDAPCD's website. These facilities report the use of copper slag and copper based paints in their processes to the SDAPCD annually.

1.5.2 Zinc

Zinc (Zn) is the 23rd most abundant element in the earth's crust (USGS, 2006). It is the fourth most commonly metal used, behind iron, aluminum, and copper. In the United States, approximately two-thirds of zinc is produced from ores (primary zinc) and the remaining one-third from scrap and residues (secondary zinc). Zinc uses range from metal products to rubber and medicines. Approximately three-fourths of zinc used is consumed as metal, mainly as a coating to protect iron and steel from corrosion (galvanized metal), as alloying metal to make bronze and brass, as zinc-based die casting alloy, and as rolled zinc. The remaining one-fourth is consumed as zinc compounds, mainly by the rubber, chemical, paint, and agricultural industries. Zinc is also a necessary element for proper growth and development of humans, animals, and plants; it is the second most common trace metal, after iron, naturally found in the human body. Though, in its dissolved form, it has been shown to cause toxic responses to aquatic organisms in elevated concentrations (Councell et al., 2004). The EPA has set the maximum water quality goal for zinc at 120 µg/L. The Chollas Creek metals TMDL WQO for zinc is based on the CTR and varies depending on the hardness concentration from the sample collected. At a hardness of 100 mg $CaCO_3$/L, the dissolved zinc CTR acute WQO is 117 µg/L. In comparison, the Federal Safe Drinking Water Act does not regulate the concentration of zinc in drinking water. California sets the secondary (aesthetic) maximum contaminant level, which is non-promulgated, at 5,000 µg/L.

Sources of zinc to air and water include fertilizer, cement production, and transportation activities (e.g., combustion exhaust, galvanized parts, fuel and oil, brake wear, and tire wear). Zinc chromate primer is commonly used in the marine and aircraft industries. Zinc oxide is used in the vulcanization process for tires and rubber (estimated at 1% by weight). In urban environments, several studies reviewed by Councell et al. (2004) reported positive correlations of zinc to traffic volume, primarily as tire wear. Researchers concluded that 60% of the total zinc load in south San Francisco Bay was attributable to tire-wear debris. There is less information related to zinc contamination from fan belt wear from automobiles. It stands to reason that the density of cars, trucks, and other industrial motors (e.g., ventilation fans, air compressors, and other machinery using rubber belts) may also be a significant source of zinc containing particulates. However, further investigation is needed to determine the contribution of fan-belt wear to atmospheric deposition.

Galvanized metal is also used in numerous products that have the potential to release zinc containing particulates to surfaces subject to rainfall and subsequent runoff. These products include galvanized metal roofs, outdoor metals storage, fences, sign posts, guardrails, and drain pipes and are potential zinc sources frequently observed throughout San Diego County. Galvanized roofs have been shown to release elevated concentrations of zinc in storm water runoff captured directly from these sources (Kingett Mitchel & Associates, Ltd, 2001). Other sources of galvanized products include scrap metal recycling and auto-dismantling operations. Several automotive dismantling facilities have been observed in the area of Commercial Street and directly west of the north fork of Chollas Creek.

1.5.3 Lead

Lead (Pb) has the highest atomic number (82) of all stable elements. The main lead mineral is called galena (lead sulfide), which contains approximately 86% lead. It is estimated that 50% of the lead used today comes from recycling. Lead is not an essential element to living organisms and is known historically to be toxic to both humans and aquatic organisms. Lead has been shown to damage the nervous system and cause brain and blood disorders. It is detrimental to the development of young children. While lead awareness has significantly increased and exposure to public health has significantly decreased, lead is still commonly found in the environment. The EPA suggests the primary sources of lead exposure in the urban environment are:

- Deteriorating lead-based paint.
- Lead-contaminated dust.
- Lead-contaminated residential soil.

The EPA's Lead Awareness Program continues to work to protect human health and the environment against the dangers of lead. Information regarding lead can be found on the EPA website (http://www.epa.gov/lead/). The Federal Safe Drinking Water Act sets the drinking water action level for lead at 15 µg/L, and the maximum contaminant level goal is 0 µg/L. The Chollas Creek metals TMDL WQO for dissolved lead is based on the CTR and varies depending on the hardness concentration from the sample collected. At a hardness of 100 mg $CaCO_3$/L, the dissolved lead CTR acute WQO is 64 µg/L, and the chronic WQO is considerably lower at 2.5 µg/L.

Lead has been widely used in the transportation industry, primarily for lead acid batteries, solder, bearings, and wheel-balancing weights. Lead is a soft malleable metal also used for lead shot, fishing weights, sailboat keels for ballast, leaded glass, and television glass. Lead has been used historically in paint and is commonly found in homes built prior to 1978. Many older homes will often have larger concentrations of lead in soil in the areas directly adjacent to the home where paint chips will degrade and eventually slough off. Homeowners and remodelers have often used mechanical sanders to remove this older paint, in some cases, unaware of the hazards involved in releasing this material to the atmosphere as inhalable articulates. Lead was also used in gasoline to prevent engine knock. The use of leaded gasoline peaked during the 1970s but was eventually phased out during the 1980s. Many researchers have shown that lead in soil is primarily a residual effect of the historic use of leaded gasoline and that storm water containing lead is likely a result of the erosion of soils near roadways. The concentration of lead in soil is steadily decreasing over time. Total lead in Chollas Creek has also shown a significant decreasing trend (WESTON, 2006).

2.0 METHODS

This section describes the methods used to collect data throughout the course of this study. The following subsections are discussed:

- Section 2.1 – Permit and Emissions Data Review.
- Section 2.2 – Desktop Geographic Information System Mapping.
- Section 2.3 – Field Reconnaissance and Site Assessment Methods.
- Section 2.4 – Field Sampling.

2.1 Permit and Emissions Data Review

A review of available permit data was conducted to use existing information for guiding the wet weather sampling within the Chollas Creek Watershed and for developing a ranking for GIS-based threat to water quality. This review included using the City of San Diego's Code violations records, industrial and commercial inspection records, dry weather action level exceedance data, and annual emissions data obtained from the San Diego County Air Pollution Control District.

2.1.1 Code Compliance Data

Code compliance enforcement records were obtained from the City of San Diego Jurisdictional Urban Runoff Monitoring Program Report (City of San Diego, 2008). The data were used to determine whether code compliance violations were related to commercial/industrial facilities with potential for metals releases compared to facility construction type. The data were clipped to the Chollas Creek Watershed and included both businesses and residences. The data set included the following data types from July 2007–June 2008:

- Address.
- Substance code.
- Discharge type.
- Who the referral was made by.
- What action was taken (e.g., citation, notice of violation, civil penalty, or other).

2.1.2 Commercial and Industrial Inspection Data

Commercial and industrial inspections records were obtained from the City of San Diego's Storm Water Department via D-Max Engineering, Inc., the company that performs the inspections for the City of San Diego. The data were used to determine if particular facilities that are currently inspected coincide with those identified as facilities of interest during the desktop GIS exercise. The data were also used to determine if a facility had a higher threat to water quality based on the categories of records that were documented. The database is provided in Appendix B.

2.1.3 Dry Weather Monitoring Data

Dry weather monitoring data were obtained from the San Diego County Regional Data Sharing Dry Weather Database. The dry weather metals data for the Chollas Creek Watershed were plotted for those sites with results above the dry weather action level. The metals dry weather action levels are based on the CTR. Sites with results above the action level were plotted and were used to determine if similar patterns were evident in the inspections and code compliance data. One limiting factor of the dry weather monitoring data is that it is primarily collected in the storm drain system and is not associated with one particular site or land use.

2.1.4 San Diego County Air Pollution Control District Annual Emissions Data

The Air Toxics "Hot Spots" Information and Assessment Act (AB 2588, 1987, Connelly) was enacted in September 1987. The act requires stationary sources to report types and quantities of certain substances their facilities routinely release into the air. This information is readily available for San Diego County on the SDAPCD website, and a summary is provided in Appendix C-1 and Appendix C-2. The SDAPCD is the local air regulatory agency and is analogous to the Regional Water Quality Control Board (Regional Board).

During the Phase I Aerial Deposition Study, a cursory review of available emissions data indicated that facility emissions accounted for approximately 50% of the copper emissions, 17% of the zinc emissions, and 5% of lead emissions in a 4-km general area near the mouth of Chollas Creek. These emissions were further investigated by obtaining annual records from the SDAPCD for the period from 1997–2007 that detailed each facility's reported emissions of copper, lead, and zinc. Additionally, the operations or products that caused the emissions were obtained and researched for the product constituents for the period 2000–2007. Metals emissions data reported by facilities in the Chollas Creek Watershed area included NASSCO, BAE Systems San Diego Ship Repair, Continental Maritime, and United States Navy 32nd Naval Station. Sources of copper, lead, and zinc emissions were separately categorized into five major categories, which are shown in Table 2-1. The minor categories were combined together and categorized as "unknown."

Table 2-1. Categories Describing the Major Components of Copper, Lead, and Zinc-Based Emissions Released by Shipyards at the Mouth of Chollas Creek

Use of Material	Description
Abrasives	Removes surface contaminants from coating residues, welding residues, mill scales, oxidation, etc. by forcibly propelling a stream of abrasive material against a surface to clean or prepare it. This ensures optimal resistance of the coating to corrosion.
Brazing	A process similar to soldering that joins metals through the use of heat and a filler metal.
Coatings	Protects and preserves surfaces of ships; specific areas of a vessel require specially formulated coatings.
Diesel	Fuel used in diesel engines.
Unknown	Use of these material names is unknown.
Welding	A process that joins metals or thermoplastics by melting the work pieces and adding a filler metal.

An interview with the SDAPCD staff was conducted to determine whether controls (e.g., tenting, shrouding, or control devices) are accounted for in the emissions inventory. The staff response was that the emissions estimates are based on what leaves the facility, including the controls used. The staff also stated the estimates are only those required to be reported based on the Air Toxics Rule and Criteria Reporting and so do not include all emissions that may be present. In summary, the emissions are based on what the facility's operations are on a regular basis (e.g., welding, brazing, and painting ships).

Emissions inventories are required to be reported to the SDAPCD in accordance with the SDAPCD Regulation II Toxics Rule 19.3 and the Toxics Inventory Program AB2588. Section c(3) and c(4) of Rule 19.3 specify the requirements as follows:

> (3) Any person owning or operating any stationary source of emissions subject to this rule which emits 25 tons per year or greater of volatile organic compounds or oxides of nitrogen shall, in accordance with the 1990 Federal Clean Air Act Amendments, Title I, Section 182 (a)(3)(B), submit Emissions Statement Forms to the District for the 1992 calendar year and for each calendar year thereafter.
>
> (4) Effective January 1, 1994, any person owning or operating any stationary source subject to this rule which emits 5 or more tons per year but less than 25 tons per year of VOC or NOx, and any person who sells or supplies any material the use of which may cause the emission of air pollutants, may be required to submit an Emissions Statement Form and/or Emissions Inventory Report Form, as deemed appropriate by the Air Pollution Control Officer.

Upon compiling the emissions estimates from the SDAPCD, the values were compared as an estimated load in total kilograms per year. These values were compared to the following data sets described in the results section of this report:

- The emission loads were compared to the estimated annual loads deposited on the watershed in kilograms per year via aerial deposition using the median observed values from the Phase II Annual Deposition results for the Chollas Creek Watershed.
- The emission loads were compared to the estimated mean annual load in kilograms per year discharged via storm water events from the Monitoring and Modeling for the Mouths of Chollas, Switzer, and Paleta Creeks (SCCWRP, 2007).
- The emission loads were compared to the estimated annual load removed via street sweeping in kilograms per year as reported from preliminary estimates from the measured street sweeping results based on grams per mile swept per year.

2.2 Desktop Geographic Information System (GIS) Review

A GIS-based investigation of potential metal pollutant sources was conducted in the Chollas Creek Watershed within City of San Diego jurisdiction. Aerial interpretation of site characteristics was performed using Google Earth with a Keyhole Markup Language (KML) overlay of the parcels in particular land uses of interest. Parcel data distributed by San Diego Association of Governments (SANDAG) served as the base layer for recording of site characteristics related to potential metal pollutant sources. The data set was comprised of 52,412 parcels within the City of San Diego limits of the watershed. The 2007 land use data distributed by SANDAG were used to select parcels in commercial, industrial, public facility, military, transportation, multi-family residential (apartment buildings), and land uses noted as vacant or under construction. These land uses were identified as likely candidates to have metal roofs and/or metal storage outside or evidence of emissions, thus the study focused on these classes. Accordingly, 16,412 parcels were categorized by priority sector and were visually inspected in the imagery on a block-by-block basis. Data were recorded by parcel into domain-based attribute fields of a geodatabase in ArcGIS and consisted of the following menu-based information:

- Roof type – metal, flat tar, composite/shingle, wood, or field determination needed.
- Number of metal roofs.
- Condition of roof(s) – new condition (good), shows some wear (fair), rust apparent (poor), or field determination needed.
- Outdoor metal storage type – auto, salvage, recycling, heavy equipment, trash or debris, other, or none.
- Outdoor metal storage amount – approximate percentage of parcel containing outdoor metal storage, recorded as up to 10%, 10–25%, 25–50%, 50–75%, or 75–100%.
- Outdoor metal storage condition – new condition (good), shows some wear (fair), rust apparent (poor), or field determination needed.
- Evidence of emissions – yes, no, or unclear for staining from rooftop exhaust stack.
- Evidence of off-site sediment transport – yes, no, or unclear.

Default values were set to “null," or ”none.” If no likely sources were noted during the image-based assessment, no data were recorded for that parcel. Non-metal roofs were only recorded for parcels in which other site conditions led to an assessment (e.g., outdoor storage or emissions evidence). A total of 465 parcels were noted to contain one or more of the recordable conditions in this GIS-based desktop review.

Data regarding inspections and enforcement activities were then linked to the GIS-based visual assessments by Assessor’s Parcel Number (APN) if available or by geocoding addresses from these permit review records. The geocoding process located the enforcement data addresses along the streets in the right-of-way, which are not included in the parcels. Therefore, the point locations of the enforcement data had to be visually reviewed and spatially adjusted to associate with actual parcel polygons and their APNs. The task identified 212 parcels with inspection data and 111 parcels from the enforcement record. The total number of parcels recorded in the aerial assessment and/or the permit data review was 622.

After the completion of the aerial interpretation and integration of permit review data, field maps were produced by sector that displayed the distribution of the recorded site characteristics. These maps are shown in Appendix D. Using these maps, areas with multiple risk characteristics and clusters of parcels with potential metal sources could be prioritized for field investigation. Tables were also generated that summarized the information for each parcel and assigned a priority rank based on the number of risk variables. The highest rating was given to parcels with three or more recorded variables (e.g., presence of a rusty metal roof, outdoor storage, and presence of inspection data). These maps of priority sectors were reviewed by project management and were then given to Weston Solutions, Inc. (WESTON®) field scientists for visual inspection of specific characteristics of the facilities mapped in various sectors.

Following the field reconnaissance efforts, the field recorded information was compiled and imported into the GIS using the geographic coordinates collected by global positioning system (GPS) at each visited site by the field team. The locations were checked for consistency with the recorded address, spatial adjustments were made if necessary, and APNs were then assigned to these data through a spatial overlay with the parcel data. The field-based information was then linked by APN to the GIS-based records to allow for updating of the GIS values specifically for those records where the need for field verification was noted. There were 149 parcels with field data, 11 of which were not noted in the desktop review. This resulted in 633 total records in the final assessment database. Field-based data were considered to supersede GIS-based assessments. A final priority ranking was assigned to each parcel based on the combination of GIS and field based information regarding that parcel. A higher weighting was assigned to metal roofs in poor condition, and outdoor metal storage was weighted by the percent cover range.

2.3 Field Reconnaissance and Site Assessment Methods

Field reconnaissance was applied as a tool to visually inspect characteristics of specific facilities while using GIS maps developed under the preceding tasks. Potential sites where water quality could be impacted were observed, photographed, and characteristics were noted, and site-specific storm drains were identified for wet weather sampling. Field staff were also instructed to collect samples of dry weather runoff if it was observed during the course of the field effort.

2.3.1 Procedure

WESTON conducted a site reconnaissance (windshield survey) to verify the condition of the facilities identified under Task 3. On arrival at a facility in question, photographs were taken along with a GPS location and field notes verifying whether a facility or an area observed had a low or high potential to impact water quality were documented. In a high potential area, a WESTON field scientist would locate the nearest storm drain where wet weather flow may drain into it and would note it on field maps along with which side of the drain would be most representative of the facility or group of facilities in question.

During field reconnaissance, WESTON field scientists were instructed to investigate any type of illicit discharge observed coming from a facility and sample the flow if observed. If urban runoff from activities was observed, a grab sample was to be collected and analyzed for total and dissolved metals. The flow was to be sampled, documented, and photographed, and the City of San Diego's Storm Water Hotline was to be notified.

During the survey, the conditions of each parcel identified in the GIS exercise were documented. The facility characteristics that were documented included, but were not limited to, the following:

- Evidence of metals emissions due to facility activities (e.g., welding, sandblasting, painting, and stationary source emissions).

- Evidence of galvanized roofs, gutters, and downspouts and if architectural copper is observed.
- Evidence of excessive tire wear due to high traffic or heavy equipment traffic.
- Evidence of facility and/or yard draining directly to the MS4.
- Evidence of weathered chain link fencing.
- Evidence of continuous air conditioning condensate runoff.
- Evidence of excessive runoff staining.
- Location of nearest storm drain curb inlet for representative sample (to be documented on field map).
- Identify facilities or groups of facilities that drain to a particular storm drain.
- Once a site was identified as a representative location and facility characteristics. reviewed, it would be selected as a potential candidate for wet weather sampling.

2.4 Field Sampling

After field reconnaissance was concluded, the data were consolidated using GIS, and specific locations were chosen for sampling. Dry weather sampling, wet weather sampling, and surface dust wipe sampling were conducted as a multi-media monitoring effort to assess areas that may have the potential for metals loading and may potentially affect receiving water quality in the five priority sectors in the Chollas Creek Watershed. The purpose of this sampling was to identify areas or sources with a need for targeted management activities and is consistent with the goals of the Chollas Creek TMDL Implementation Plan. Samples collected during dry weather, wet weather, and rooftop runoff were analyzed for the constituents listed in Table 2-2. Samples were submitted to CRG Marine Laboratories, Inc. (CRG) in Torrance, California. CRG is accredited by the California Department of Health Services Environmental Laboratory Accreditation Program (ELAP) for the analyses of inorganic and organic chemical constituents in wastewater (ELAP 2261). During the field reconnaissance of various priority sectors, no evidence of dry weather flows were observed, and therefore, no dry weather analyses were conducted during this study.

Table 2-2. Dry Weather, Wet Weather, and Rooftop Runoff Analytical Constituents, Methods, and Detection Limits

Analyte	Method	Method Detection Limit	Reporting Limit	Units
Conventional Parameters				
Conductivity	SM 2510	0.001	0.001	mS/cm
pH	SM 4500 H+	0.1	0.1	pH
Total Hardness	SM 2340B	1	5	mg/L
Turbidity	EPA 180.1	1	2	NTU
Total + Dissolved Metals				
Aluminum	EPA 200.8m	5	10	µg/L
Antimony	EPA 200.8m	0.1	0.5	µg/L
Arsenic	EPA 200.8m	0.2	0.5	µg/L
Barium	EPA 200.8m	0.2	0.5	µg/L
Beryllium	EPA 200.8m	0.2	0.5	µg/L
Cadmium	EPA 200.8m	0.2	0.4	µg/L
Chromium	EPA 200.8m	0.1	0.5	µg/L
Cobalt	EPA 200.8m	0.1	0.5	µg/L
Copper	EPA 200.8m	0.4	0.8	µg/L
Iron	EPA 200.8m	5	10	µg/L
Lead	EPA 200.8m	0.05	0.1	µg/L
Manganese	EPA 200.8m	0.2	0.5	µg/L
Molybdenum	EPA 200.8m	0.2	0.5	µg/L
Nickel	EPA 200.8m	0.2	0.5	µg/L
Selenium	EPA 200.8m	0.2	0.5	µg/L
Silver	EPA 200.8m	0.5	1	µg/L
Strontium	EPA 200.8m	0.1	0.5	µg/L
Thallium	EPA 200.8m	0.1	0.5	µg/L
Tin	EPA 200.8m	0.1	0.5	µg/L
Titanium	EPA 200.8m	0.2	0.5	µg/L
Vanadium	EPA 200.8m	0.2	0.5	µg/L
Zinc	EPA 200.8m	0.1	0.5	µg/L

2.4.1 Dry Weather Sampling

WESTON field scientists conducted dry weather investigations during the field reconnaissance in the five priority sector areas. If urban runoff from activities were observed, a grab sample was to be collected and analyzed for total and dissolved metals. Samples were collected by inserting a pre-cleaned high-density polyethylene (HDPE) sample bottle or syringe into the middle of the flowing water. Samples were collected and analyzed if flow was observed and reached a storm drain inlet..

During dry weather investigations, photographs were taken and field observations and measurements were recorded on datasheets. Specifically, field datasheets were used to record site descriptions, characteristics, flow estimations, and visual observations. Any illicit discharges observed or sample results would have been referred to the City of San Diego Storm Water Hotline for further inspection.

2.4.2 Wet Weather Sampling

WESTON conducted wet weather grab sampling during two storm events. Samples were collected from sites identified as high potential metals locations. Samples were also collected from sites with only residential land uses in the vicinity of the high deposition areas and away from the high deposition areas for comparison to the industrial/commercial only facilities. Samples were collected using EPA-compliant Nalgene first flush samplers that were deployed directly in the storm drain inlet to capture runoff representative of a facility or group of facilities draining the area in question (Figure 2-1). The Nalgene Storm Water Sampler collects a full liter of sample within the first 30 minutes of a qualifying rain event. The sampling mechanism has a screen to remove gross solids and closes after sample collection to prevent co-mingling with later run-off or volatile analyte loss. Samples were collected at land uses representative of industrial, commercial, and residential areas in the Chollas Creek Watershed.

Figure 2-1. Nalgene First Flush Sampler Product Diagram

2.4.2.1 Nalgene First Flush Samplers

First flush samplers were installed into selected storm drain inlets 12–24 hours prior to a storm event. After a storm event, samplers were retrieved immediately, properly labeled, documented, and sent to the lab for analyses.

Figure 2-2. Example of Nalgene Sampler Installation

Wet weather samples were collected in 1-L, HDPE, pre-cleaned Nalgene First Flush Sampler bottles. To capture runoff representative of the facility or groups of facilities draining a particular area in question, sampler bottles were installed in storm drain inlets that appeared to be directly downstream from the targeted locations and on the side most representative of the direction of flow. During the installation, it was noted that in some cases, one side of a storm drain captured residential runoff, and the opposite side captured industrial land use runoff. The side draining the area in question was noted, and the drainage area was defined in the field and was then documented in the GIS database.

First flush samplers were either tied on to the storm grate with line or to an anchor mounted to the cement wall of the inlet. When using the anchor method, the anchor site was thoroughly brushed and rinsed down with de-ionized water prior to installing the sampler to ensure that particulates that were generated during the installation were not incorporated into the sample.

Samples were collected during two wet weather events. The first event on March 22, 2009, consisted of ten commercial sites and six residential sites, all located within priority sectors 1 and 2. The second event on April 8, 2009, consisted of 22 commercial sites and seven residential sites located throughout priority sectors 1–5. In total, 45 samples were collected from the Chollas Creek Watershed.

Figure 2-3. Example of Nalgene Sampler Retrieval

2.4.2.2 Rooftop Runoff

Rooftop runoff samples were taken during the April 8, 2009 storm event at six locations in Priority Sector 1 based on evidence of potential sources of high metals / rusty rooftops, which were observed during site reconnaissance. The purpose of the sampling was to characterize rooftop runoff from rusty metal roofs to confirm literature values reported from other studies. The rooftops sampled drained directly to the City sidewalks or right-of-ways. The rooftop samples were also selected based on observed staining of the sidewalks or pavement areas where the drain was located.

Storm water from a number of rooftops created sufficient amounts of flow, which allowed several samples to be collected. Samples were collected by inserting a pre-cleaned 1-L, HDPE sample bottle beneath a draining rain gutter or down spout. While sampling the rain event, photographs and GPS locations were recorded along with sample times.

Figure 2-4. Rooftop Runoff Samples from Locations with Observed Surface Stains

2.4.3 Wipe Sampling

The third step of the monitoring program consisted of using wipe sampling techniques to semi-quantitatively characterize concentrations of metals that build up on watershed surfaces prior to a rain event. The period of buildup totaled 17 days prior to the rainfall event on April 8, 2009. An estimate of the surface area concentrations in micrograms per square meter was obtained using Ghost Wipe samples, which are commonly used in industrial hygiene evaluations. Wipes were collected from smooth, level surfaces at locations throughout each priority sector, usually in conjunction with a predetermined wet weather sample site. A clean 10-cm by 10-cm surface area template was used to obtain a uniform surface area for each sample taken. Pre-cleaned metal forceps were used to extract the Ghost Wipe from the package and also to conduct the wipe of the designated area. Wipe pads were then placed in labeled sample digestion tubes and were sent to the lab for analysis. Samples were analyzed by EnviroMatrix Analytical, Inc. (EMA) in San Diego, California for the total metals listed in Table 2-3. EMA is accredited by the California Department of Health Services for the analyses of inorganic and organic chemical constituents in wastewater and solid matrices (ELAP, 2564).

Table 2-3. Wipe Sample Analytical Constituents, Methods, and Detection Limits

Analyte	Method	Method Detection Limit	Reporting Limit	Units
Silver	EPA 6020	1	1	µg
Aluminum	EPA 6020	2.5	2.5	µg
Arsenic	EPA 6020	3	3	µg
Barium	EPA 6020	1	1	µg
Beryllium	EPA 6020	1	1	µg
Cadmium	EPA 6020	1	1	µg
Cobalt	EPA 6020	1	1	µg
Chromium	EPA 6020	0.5	0.5	µg
Copper	EPA 6020	2	2	µg
Iron	EPA 6020	2.5	2.5	µg
Manganese	EPA 6020	10	10	µg
Molybdenum	EPA 6020	5	5	µg
Nickel	EPA 6020	3	3	µg
Lead	EPA 6020	5	5	µg
Antimony	EPA 6020	1	1	µg
Selenium	EPA 6020	1	1	µg
Thallium	EPA 6020	1	1	µg
Vanadium	EPA 6020	1	1	µg
Zinc	EPA 6020	2.2	2.2	µg

A total of 27 surface wipe samples were collected on the City of San Diego right-of-way directly adjacent to facilities with high potential emission sources to determine elemental source signatures from those sites. Wipe samples were also collected from residential areas to determine analytical signal differences. The samples were obtained from existing surfaces that appeared to be free of rust or cracked painted surfaces (Figure 2-5). The wipes were also conducted by using light wiping as opposed to more intense scrubbing that would alter the structure wiped. The sampling team underwent training to ensure comparability prior to the monitoring event. Although some bias may be introduced by the surface wiped, it is assumed that the material wiped was representative of that which was attributable due to aerial deposition and not due to the surface structure. The overall purpose was to characterize dust samples in-situ and to evaluate if analyte signatures were evident in relation to high deposition rate areas from the Phase II study. The use of the wipe techniques were employed to determine if differences in particulate and metals deposition rates within Chollas Creek Watershed were related to the locations with areas where water quality concentrations were above WQOs.

Figure 2-5. Examples of Ghost Wipe Sampling

2.5 Field Sampling Quality Control

Field sampling quality control included ensuring field personnel were properly trained in sample collection methods, labeling, chain-of-custody procedures, and collecting samples to assess bias and variability.

2.5.1 Chain-of-Custody Procedures

Samples were considered to be in custody if they were (1) in the custodian's possession or view, (2) retained in a secured place (under lock) with restricted access, or (3) placed in a container and secured with an official seal such that the sample could not be reached without breaking the seal. COC records, field logbooks, and field tracking forms were the principal documents used to identify samples and to document possession. COC procedures were used for all samples throughout the collection, transport, and analytical process.

COC procedures were initiated during sample collection. A COC record was provided with each sample or group of samples. Each person who had custody of the samples signed the form and ensured the samples were not left unattended unless properly secured. Documentation of sample handling and custody included the following information:

- Sample identifier.
- Sample collection date and time.
- Any special notations on sample characteristics or analysis.
- Initials of the person collecting the sample.
- Date the sample was sent to the analytical laboratory.
- Shipping company and waybill information.

Completed COC forms were placed in a plastic envelope and were kept inside the container containing the samples. Once delivered to the analytical laboratory, the COC form was signed by the person receiving the samples. The condition of the samples was noted and recorded by the receiver. COC records were included in the final laboratory reports prepared by the analytical laboratories and are considered an integral part of the laboratory report.

2.5.2 Field Blanks

Field blanks were used to evaluate the sample handling process and to ensure that positive bias was not introduced during the sampling events or sample processing. Field blanks were used at a rate of once per monitoring event. Field blanks were collected for the wet weather runoff samples events, using the Nalgene First Flush Sampler as a blank, and for wipe sample monitoring events.

2.5.3 Field Replicate Analysis

Field replicate analyses were performed in duplicate during each sampling event to evaluate the variability within each sample site. The replicates were performed a minimum of once per monitoring event. The replicates are not used to reject data; they are used for evaluation of the site and sample variability only. Sample replicate variability is measured based on the relative percent difference (RPD) between sample duplicates. Variation was grouped as low, medium, or high variability based on the criteria outlined in Table 2-4.

Table 2-4. Variability Criteria for Field Replicate Samples

Variability	RPD
Low	< 15%
Medium	15–30%
High	> 30%

2.5.4 Completeness

Completeness is the measure of the amount of acceptable data obtained from a measurement process compared to the amount of data expected to be obtained under the conditions of the measurement. Sampling events were targeted at 85% completeness for the wet weather sampling events and 90% for the wipe sampling events.

3.0 RESULTS

The results from the facility emissions review, GIS desktop review, and field sampling and analysis are presented in this section. These data were collected, as described in Section 2, Methods, for the purpose of answering the key questions of this study.

3.1 Emissions Summary

The annual emissions reported to the SDAPCD were investigated by obtaining annual records for 1997–2007 that detailed each facility's reported emissions of copper, lead, and zinc. Additionally, information regarding the operations or products that caused the emissions were obtained from SDAPCD and were researched for the product constituents for the period 2000–2007. These data are tabulated in Appendix C-3.

3.1.1 Annual Reported Emissions of Copper, Lead, and Zinc

The reported annual copper, lead, and zinc emissions from NASSCO, BAE Systems San Diego Ship Repair, Continental Maritime, and United States Naval Station San Diego are shown on Figure 3-1 through Figure 3-3. Also shown is the sum of the total emissions for each year. In terms of rank, copper emissions were highest, followed by zinc, and then lead.

Total copper emissions ranged from 254 kg/yr in 1997 to more than 3,180 kg/yr in 2006. Over the ten-year period from 1997–2007, a total of 17,592 kg of copper was reported to SDAPCD and ARB have been emitted from the four facilities reporting metals emissions. The copper emissions from 2007 represent an incomplete reporting year.

Total lead emissions ranged from 2.44 kg/yr in 1998 to 4.04 kg/yr in 2001 and 2003. Over the ten-year period from 1997–2007, a total of 34.88 kg of copper were reported to have been emitted from the four facilities reporting metals emissions. The lead emissions from 2007 represent an incomplete reporting year.

Total zinc emissions ranged from 330 kg/yr in 2004 to 1,341 kg/yr in 2006. Over the ten-year period from 1997–2007, a total of 8,037 kg of copper were reported to have been emitted from the four facilities reporting metals emissions. The zinc emissions from 2007 represent an incomplete reporting year.

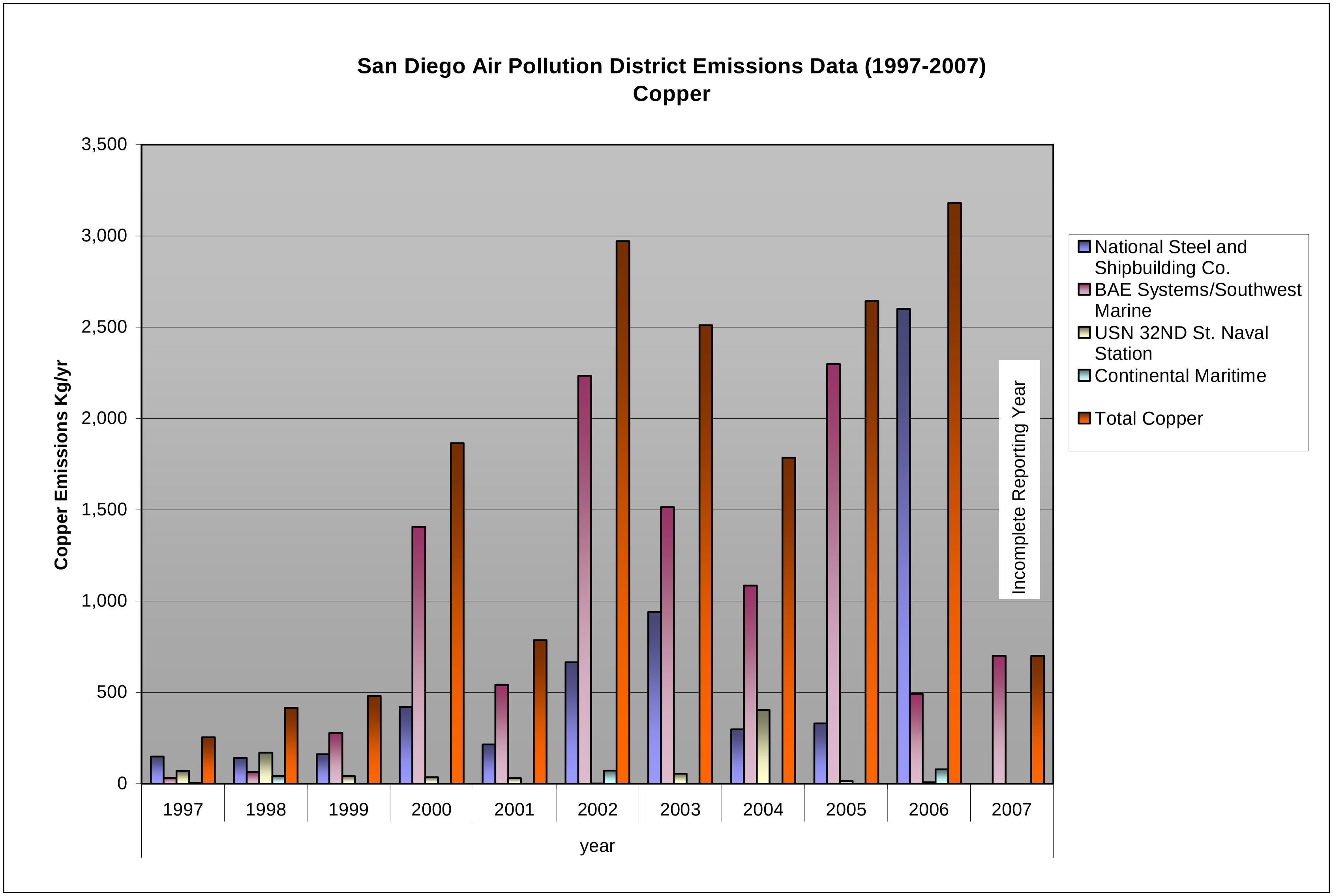


Figure 3-1. Reported Copper Emissions for 1997–2007 from Four Facilities Near the Mouth of Chollas Creek

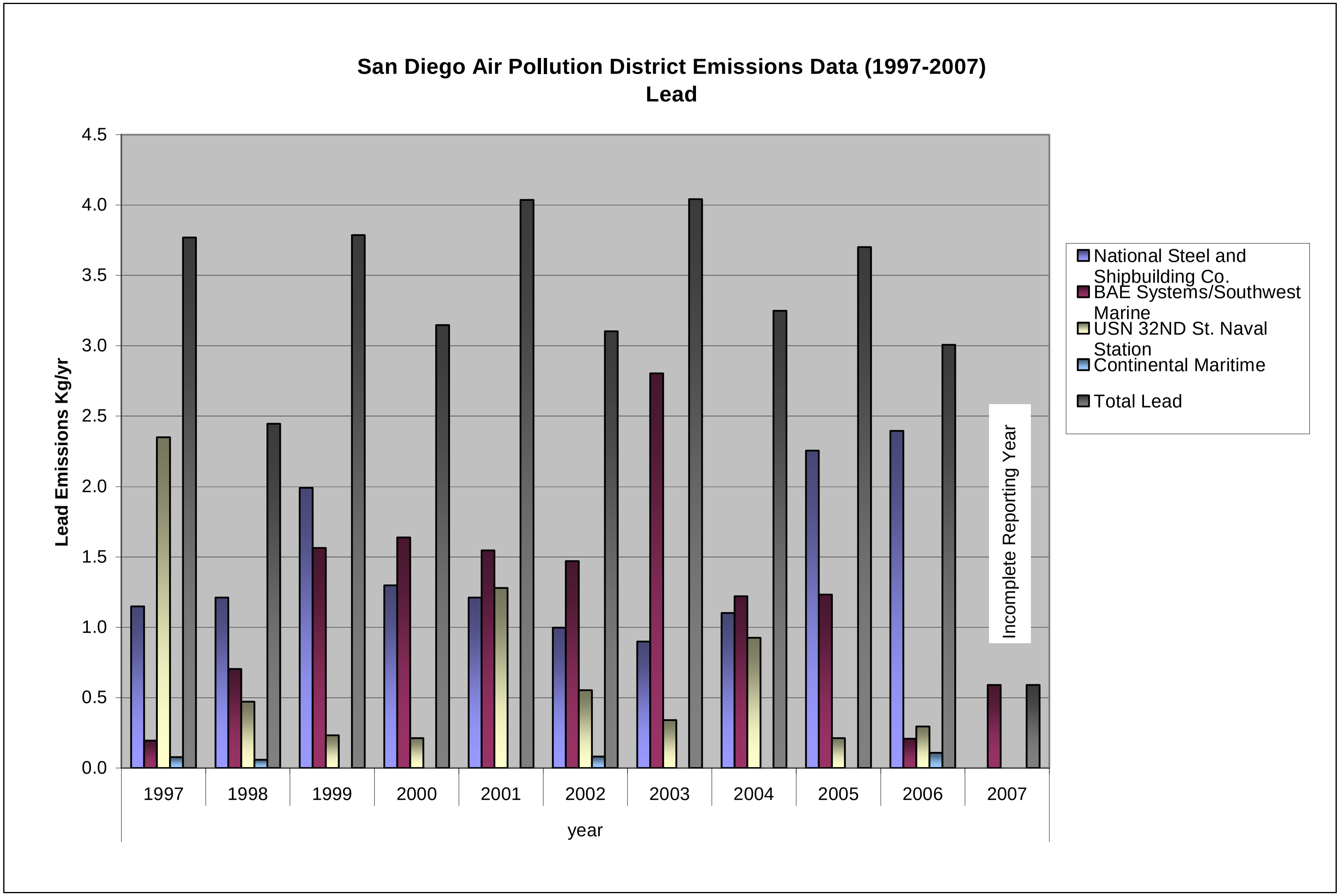


Figure 3-2. Reported Lead Emissions for 1997–2007 from Four Facilities Near the Mouth of Chollas Creek

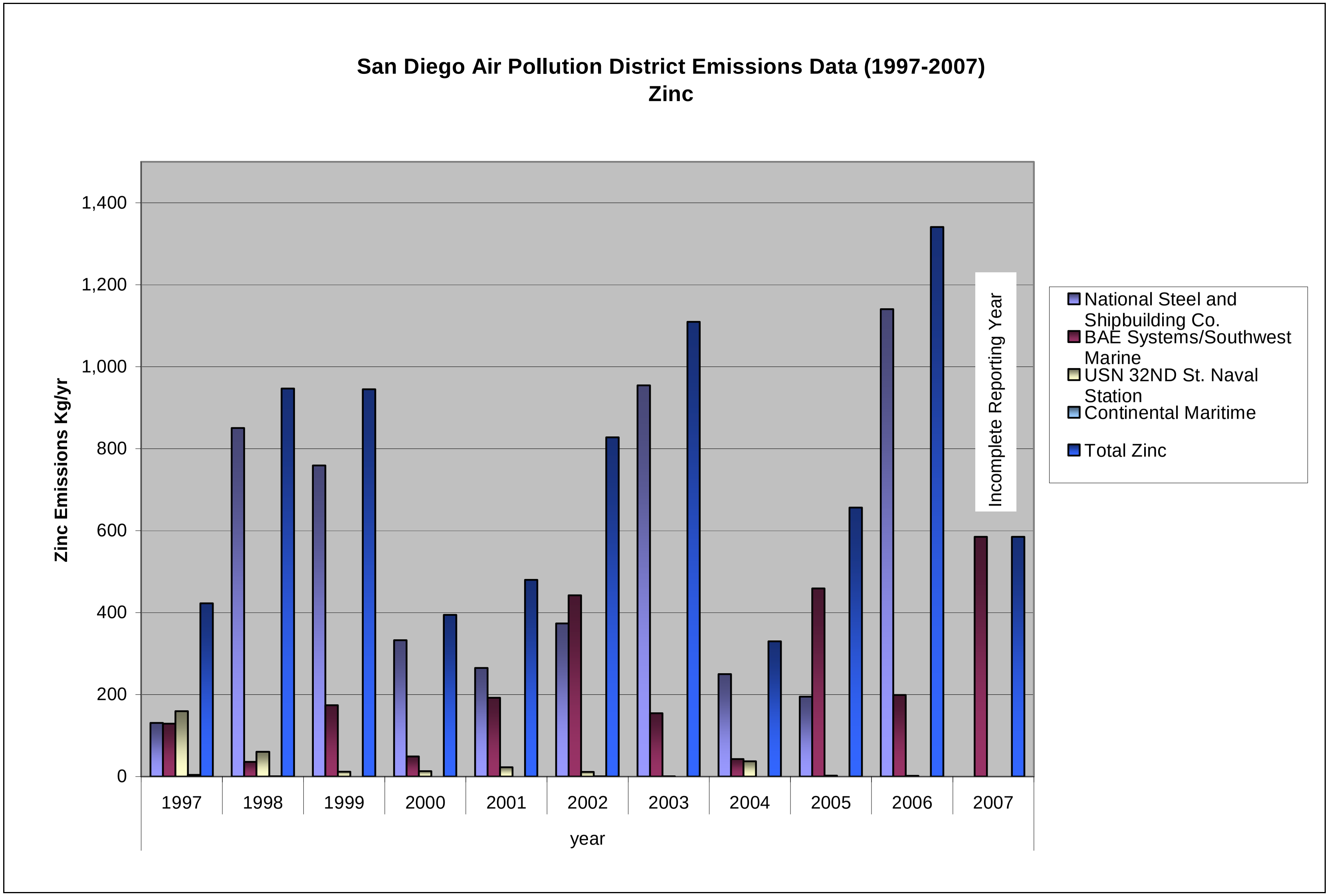


Figure 3-3. Reported Zinc Emissions for 1997–2007 from Four Facilities Near the Mouth of Chollas Creek

3.1.2 Facility Emissions Characteristics

The metals emissions data reported were further investigated to determine the characteristics of the emissions inventories for each facility. The data were queried by the SDAPCD and were provided to WESTON for copper, lead, and zinc. The queried data obtained were for 2000–2007. Sources of copper, lead, and zinc emissions were separately categorized into five major categories, which are shown in Table 3-1. The minor categories were combined together and were categorized as unknown. The sources used to define the product categories are provided in Appendix C-4.

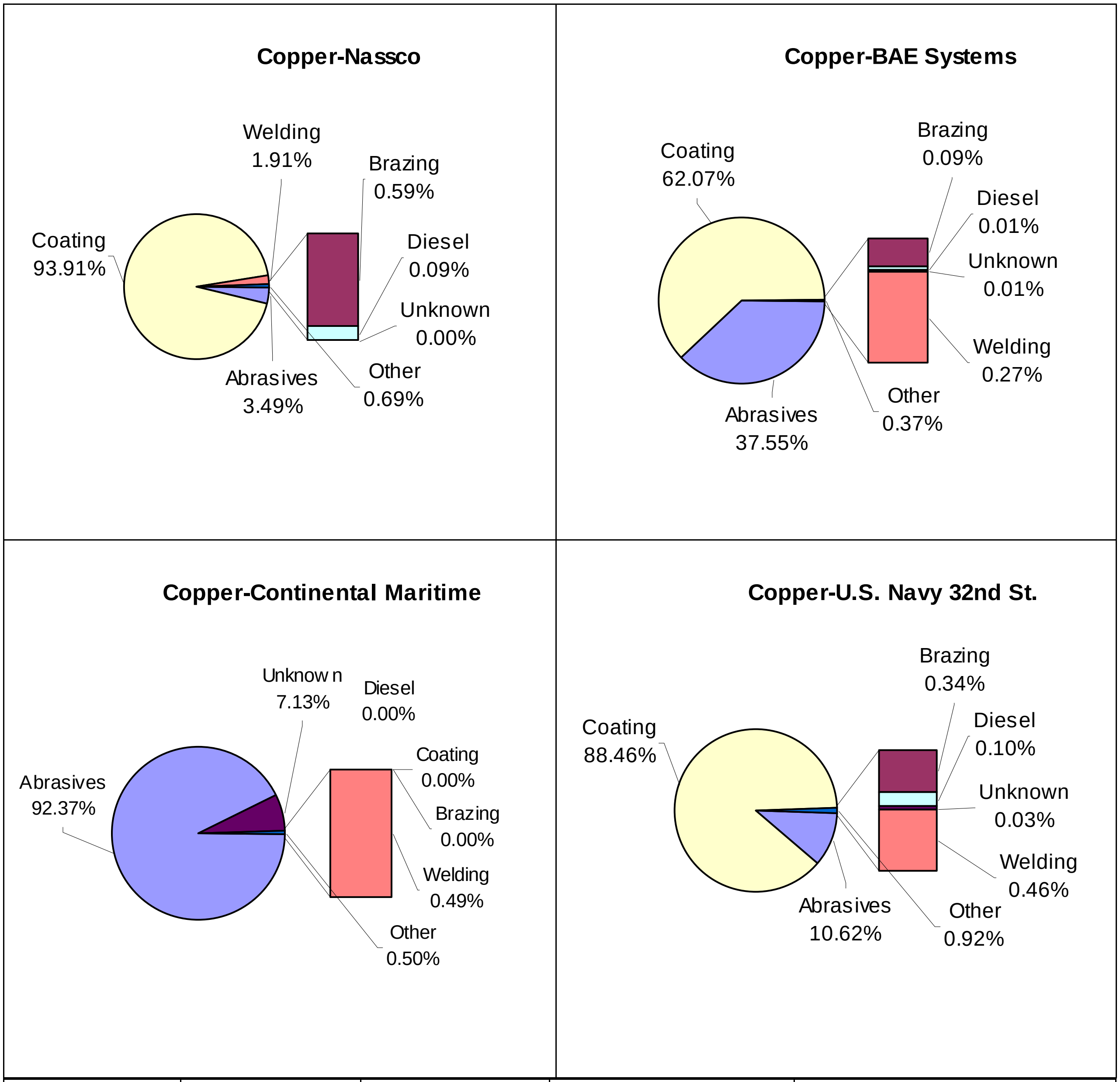
Table 3-1. Categories Describing the Major Components of Copper, Lead, and Zinc-Based Emissions Released by Shipyards at the Mouth of Chollas Creek

Use of Material	Description
Abrasives	Removes surface contaminants from coating residues, welding residues, mill scales, oxidation, etc. by forcibly propelling a stream of abrasive material against a surface to clean or prepare it. This ensures optimal resistance of the coating to corrosion.
Brazing	A process similar to soldering that joins metals through the use of heat and a filler metal.
Coatings	Protects and preserves surfaces of ships; specific areas of a vessel require specially formulated coatings.
Diesel	Fuel used in diesel engines.
Unknown	Use of these material names is unknown.
Welding	A process that joins metals or thermoplastics by melting the work pieces and adding a filler metal.

The reported emissions by product category are shown in Table 3-2 and represent the sum of the emissions by product category from 2000–2007. The coatings category represented the largest source of emissions by product category for copper (10,601 kg) and zinc (5,472 kg). Abrasives represented the second largest emission source for copper (3,322 kg), whereas brazing represented the second largest emission source for zinc (40.4 kg). Lead emissions were highest from abrasives (14.4 kg) and diesel emissions (10.8 kg). The emissions by product used varied by metals and by facility as shown on Figure 3-4 through Figure 3-6.

Table 3-2. Sum of Emissions by Process Category for the Period 2000–2007

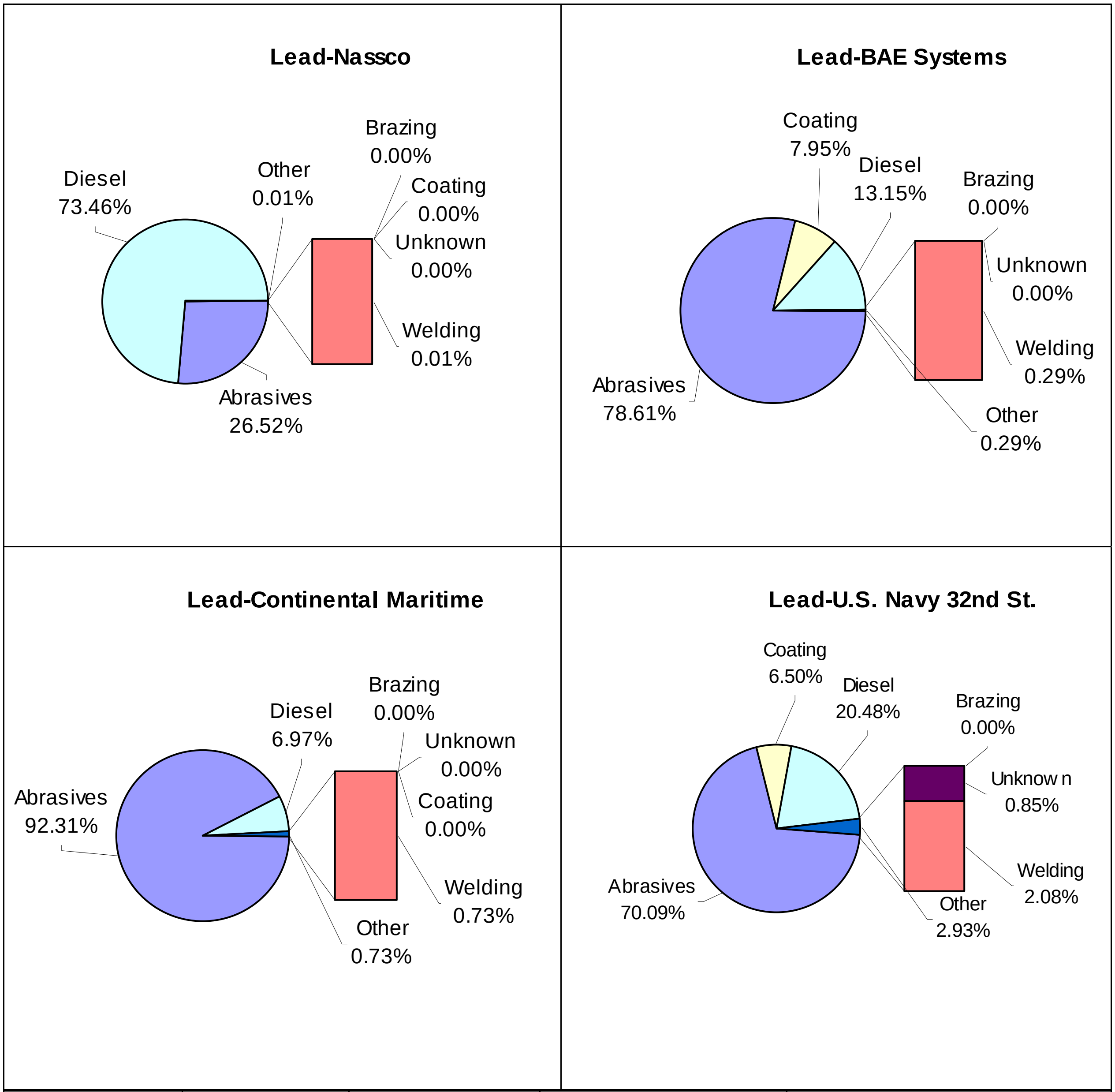
Use of Material	Copper (kg)	Lead (kg)	Zinc (kg)
Abrasives	3,322	14.4	0
Brazing	41.9	0	40.4
Coating	10,601	1.10	5,472
Diesel	6.50	10.8	30.5
Unknown	11.7	0.033	0.509
Welding	132	0.115	0.965
Total	**14,115**	**26.5**	**5,544**



Category	**NASSCO**	**BAE Systems**	**Continental Maritime**	**United States Naval Station 32nd Street**
Abrasives	196	2,928	140	58
Brazing	33	6.75	0	1.84
Coating	5277	4840	0	484
Diesel	5.05	0.90	0.0070	0.54
Unknown	0.16	0.57	11	0.17
Welding	108	20.8	0.75	2.50
Total	**5,620**	**7,796**	**152**	**548**

Colors indicate emissions loads from highest (red) to lowest (green).

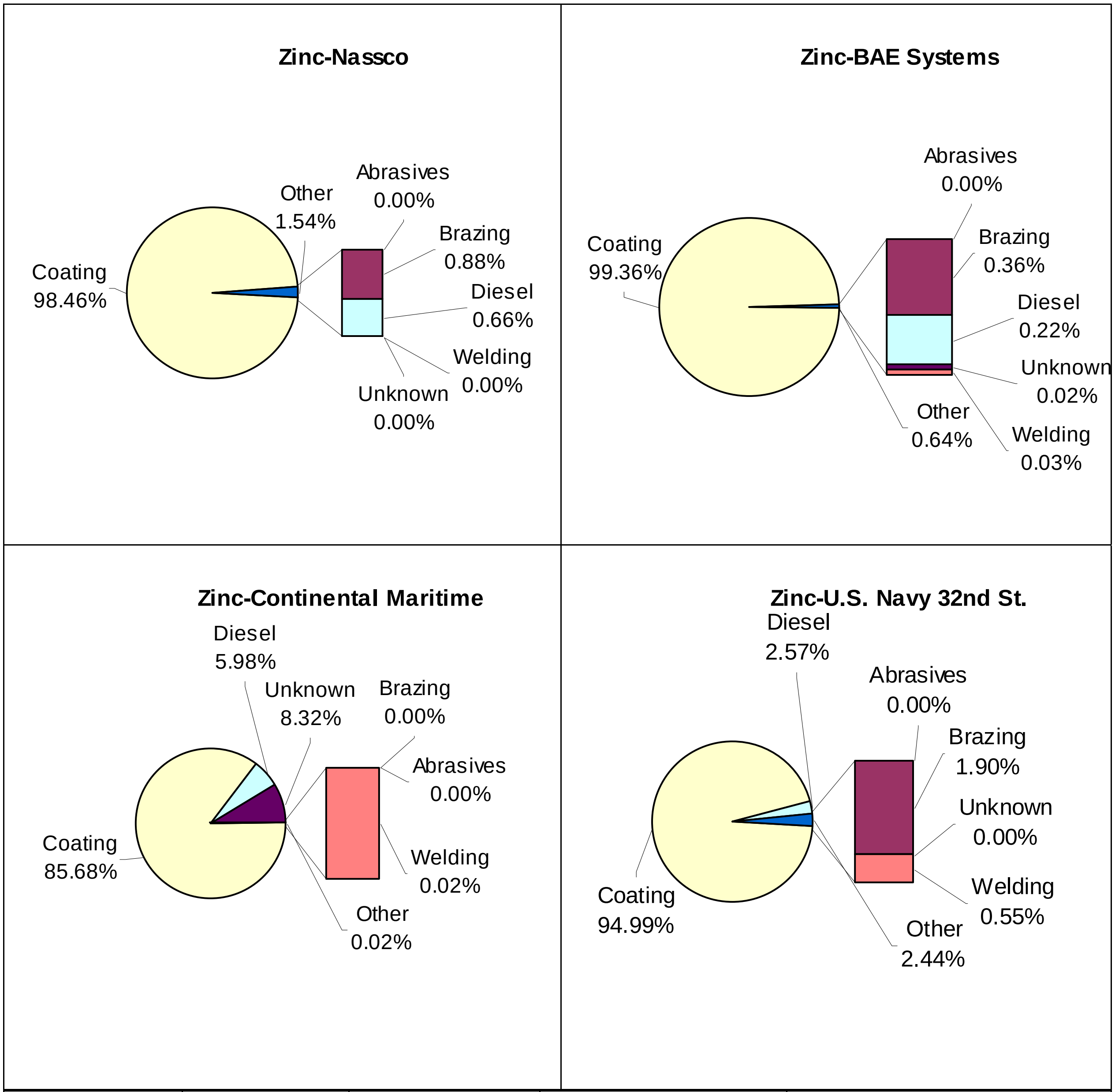
Figure 3-4. Copper Emissions by Product Categories from Facilities in the Chollas Creek Watershed (as reported to SDAPCD, 2000–2007)



Category	**NASSCO**	**BAE Systems**	**Continental Maritime**	**United States Naval Station 32nd Street**
Abrasives	3.11	8.42	0.17	2.71
Brazing	0	0	0	0
Coating	0	0.85	0	0.25
Diesel	8.62	1.41	0.01	0.79
Unknown	0	0	0	0.03
Welding	0.002	0.03	0.001	0.08
Total	11.74	10.72	0.19	3.87

Colors indicate emissions loads from highest (red) to lowest (green).

Figure 3-5. Lead Emissions by Product Categories from Facilities in the Chollas Creek Watershed (as reported to SDAPCD, 2000–2007)



Zinc-Nassco

Zinc-BAE Systems

Zinc-Continental Maritime

Zinc-U.S. Navy 32nd St.

Category	NASSCO	BAE Systems	Continental Maritime	United States Naval Station 32nd Street
Abrasives	0	0	0	0
Brazing	32	6.53	0	1.70
Coating	3,594	1,792	0.51	85.2
Diesel	24	4.04	0.04	2.30
Unknown	0.02	0.44	0.05	0.0004
Welding	0.02	0.45	0.000099	0.49
Total	3,651	1,803	0.60	90

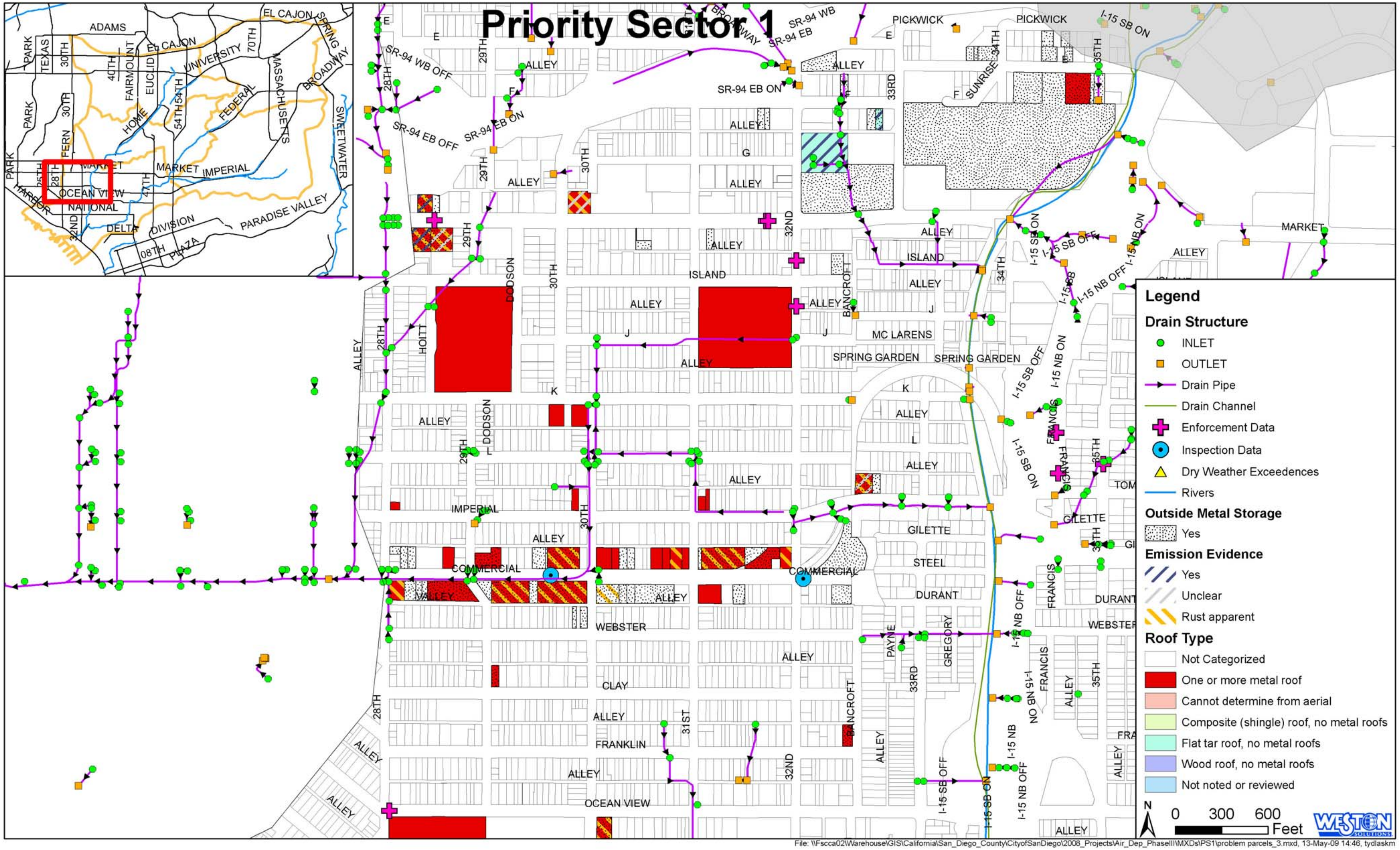
Colors indicate emissions loads from highest (red) to lowest (green).

Figure 3-6. Zinc Emissions by Product Categories from Facilities in the Chollas Creek Watershed (as reported to SDAPCD, 2000–2007)

3.2 Geographic Information System Desktop Review Summary

3.2.1 Desktop-Based Evaluation Results

Figure 3-7 (centered on Commercial Street) provides an example of the initial output of the desktop parcel evaluation. The output maps show the distribution of metal roofs, outside storage, potential emissions evidence, and the inspection and enforcement data that were noted in this area during the aerial imagery review. A series of these maps by priority sector were provided to the field team for use in the field reconnaissance activity. The storm drain data from San Diego Geographic Information Source (SanGIS) were included on the maps to assist in determining drainage areas associated with parcels of interest.



File: \\Fscca02\Warehouse\GIS\California\San_Diego_County\CityofSanDiego\2008_Projects\Air_Dep_PhaseIII\MXDs\PS1\problem parcels_3.mxd, 13-May-09 14:46, tydlaskm

Figure 3-7. Example Map of Initial Results of Geographic Information System-Based Evaluation

The conditions recorded in the GIS desktop review were updated as needed for parcels visited during the field reconnaissance and based on the field observations notes. The results of the parcel-based evaluation are summarized by priority sector in Table 3-3 and on Figure 3-8 for the 633 parcels that had recordable conditions. As expected, Priority Sector 1 contained the greatest number of recordable conditions, including parcels with metal roofs, metal roofs noted to be in poor condition, presence of outdoor storage, evidence of emissions, evidence of off-site sediment transport, and inspection records. One notable difference from this pattern was in the enforcement data that showed more records in Priority Sector 2.

Table 3-3. Summary of Parcel-Based Evaluation Results

Condition	Number of Observations (parcels)					Total
	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	
Metal roof(s)	124	23	6	3	6	162
Poor condition metal roof	26	3	0	0	1	30
Outside storage	178	30	11	15	25	259
Emission evidence	33	18	4	1	0	56
Off-site sediment transport evidence	11	2	1	1	0	15
Inspection data	119	60	13	17	2	211
Enforcement data	32	39	12	14	14	111

Table 3-4 summarizes the outside storage observed by type and relative coverage of the parcel. A low rating indicates that less than 10% of the parcel contained outside storage, medium coverage is 10%–50%, and a rating of high indicates more than 50% of the parcel is covered by outside storage based visual estimation using available aerial imagery.

Automobile storage was the most common type of outside storage noted and more frequently covered a large amount of the parcel. Trash and debris was identified as the second highest identifiable class.

Table 3-4. Summary of Outside Storage Observations by Type and Priority Sector

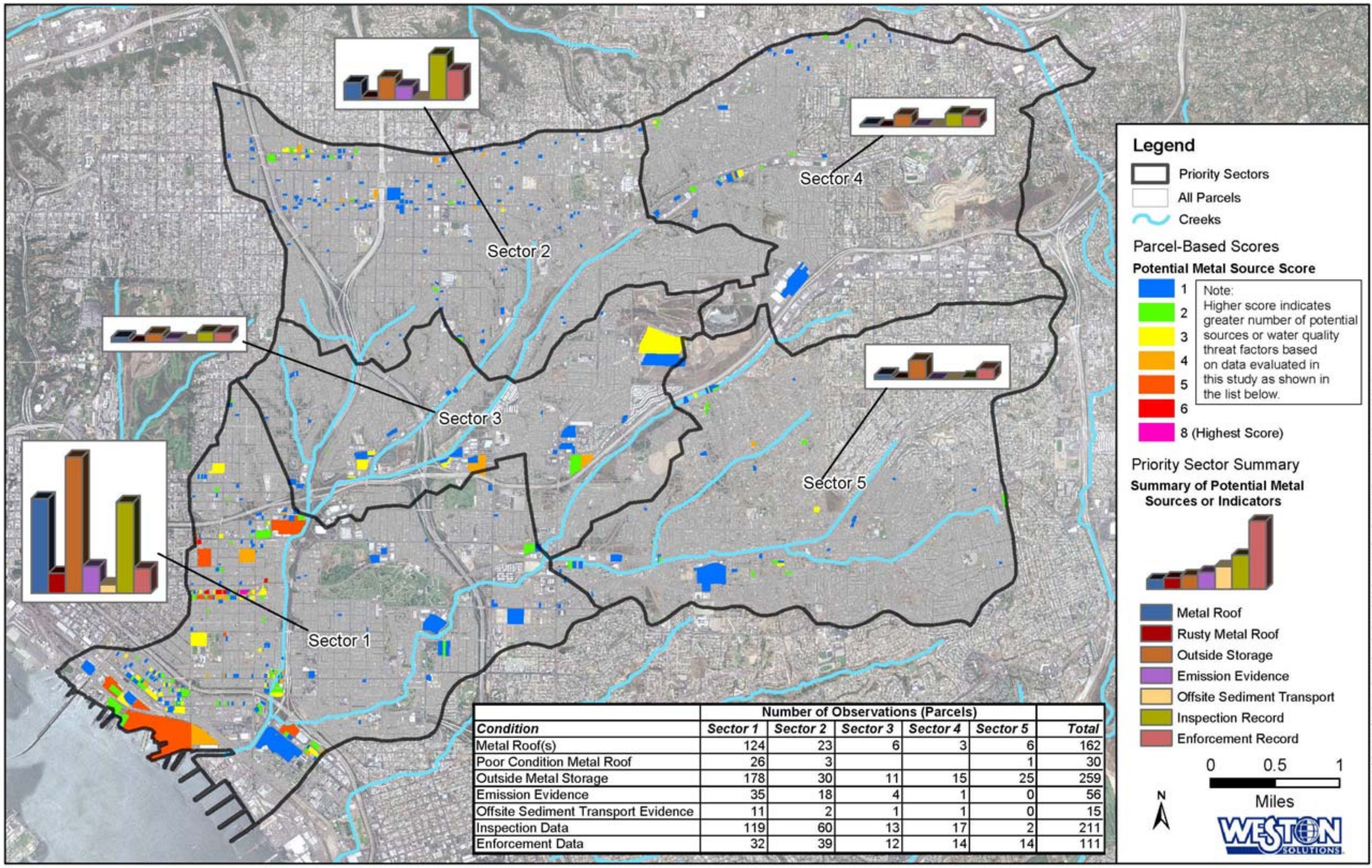
Outside Storage Type	Amount	Number of Observations (parcels)					Total
		Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	
Auto	High	20	7	1	3	1	32
	Medium	24	8	2	5	6	45
	Low	2	2	1	0	4	9
Auto total		47	17	4	8	11	87
Heavy equipment	High	1	0	0	0	0	1
	Medium	1	0	0	0	0	1
Heavy equipment total		2	0	0	0	0	0
Recycling	High	4	0	0	0	0	4
	Medium	10	0	0	0	0	10
	Low	2	0	0	0	0	2
Recycling total		16	0	0	0	0	0
Salvage	High	12	0	0	0	0	12
	Medium	15	0	1	0	1	17
	Low	4	0	0	0	0	4
Salvage total		31		1	0	1	33
Trash and debris	High	2	1	0	0	0	3
	Medium	22	6	0	4	4	36
	Low	17	4	0	0	5	26
Trash and debris total		41	11	0	0	9	65
Other	High	6	0	0	0	1	7
	Medium	25	2	2	0	2	31
	Low	11	0	4	3	1	19
Other total		42	2	6	3	4	57
Total		**178**	**30**	**11**	**15**	**25**	**259**

3.2.2 Prioritization of Parcels in Terms of Potential Metal Sources

Each of the recorded criteria was used in calculating a relative score associated with potential metal sources and/or indicators of risk to water quality by parcel and priority sector. A numeric score was assigned to each parcel based on the count of the criteria that were observed. Each condition that was noted received a 1 to the total score, except for outdoor storage, which was labeled as either 1 for less than half the parcel in outdoor storage or 2 for parcels with more than 50% coverage in outdoor storage. Therefore, the highest possible score achievable (and highest potential risk score) would be determined for parcels with a metal roof (+1 for each metal roof) in poor/rusty condition (+1), presence of more than 50% outdoor metal storage (+2), in poor condition (+1), evidence of emissions on the roof (+1), off-site sediment transport (+1), and recorded inspection (+1) and enforcement data (+1) based on these criteria. A summary of the scores related to potential water quality threat by priority sector is shown in Table 3-5 and on Figure 3-8. The highest score was 8, recorded in Priority Sector 1, and occurred on a parcel with four metal roofs, evidence of emissions, off-site sediment transport, and outside storage. All scores above 4 were in Priority Sector 1. Appendix E contains the complete list of parcels, criteria, and scores. Parcels that have a score of 0 are those for which observations were recorded but the conditions did not result in a risk rating (e.g., roofs in poor condition but not metal).

Table 3-5. Summary of Parcel Scores by Priority Sector

Score	Number of Observations (parcels)					Total
	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	
0	3	18	3	1	2	27
1	196	118	28	31	26	399
2	67	10	2	9	9	97
3	41	6	5	2	4	58
4	19	10	2	1	1	33
5	13	0	0	0	0	13
6	5	0	0	0	0	5
7	0	0	0	0	0	0
8	1	0	0	0	0	1
Total	**345**	**162**	**40**	**44**	**42**	**633**



	Number of Observations (Parcels)					
Condition	***Sector 1***	***Sector 2***	***Sector 3***	***Sector 4***	***Sector 5***	***Total***
Metal Roof(s)	124	23	6	3	6	162
Poor Condition Metal Roof	26	3			1	30
Outside Metal Storage	178	30	11	15	25	259
Emission Evidence	35	18	4	1	0	56
Offsite Sediment Transport Evidence	11	2	1	1	0	15
Inspection Data	119	60	13	17	2	211
Enforcement Data	32	39	12	14	14	111

Figure 3-8. Results of Parcel-Based Evaluation and Priority Sector Comparison

3.3 Field Reconnaissance

The purpose of the field reconnaissance effort was to ground truth the results of the GIS desktop exercise and to identify new or unidentified sites with a high threat to water quality. The field reconnaissance notes were then used to update the GIS database. Activities such as welding, painting, sandblasting, and grinding were noted as potential sources of emission contamination. Reconnaissance also consisted of structural assessments such as roof type, roof condition, and facility staining in parking lots, sidewalks, curbs, and streets. Parcels with outside equipment and materials storage and operations were also investigated for the potential to impact water quality. Storm drains downstream of parcels identified as a potentially high threat to water quality were noted as potential locations for wet weather sampling. Residential sites were also established for comparing residential land use to commercial/industrial land uses.

3.3.1 Priority Sectors Reconnaissance Summary

Field reconnaissance of Priority Sector 1 was more intensive than the remaining four priority sectors due to its high volume of industrial and commercial facilities and aging infrastructure. The lower watershed area near Main Street was a key focus area because it consisted mostly of heavy industrial facilities with high potential for water quality impacts. Commercial Street was another area of high interest in Priority Sector 1 due to its dense makeup of industrial and commercial facilities. A variety of different facilities were observed in this priority sector, including tire shops, auto repair shops, recycling yards, welding, painting, and scaffolding facilities. Many of the parcels in Priority Sector 1 had aging infrastructure in poor to fair condition. Several facilities were observed with rusty metal roofs and rusty outside metal storage (Figure 3-9). Several storage yards were also noted for having rusty metal debris, paint cans, drums, and other materials with potential for contributing metals to receiving waters during storm events (Figure 3-10). Staining was also observed on several parcels' roofs, gutters and drains, and/or pavement. Many of the facilities roof drains also drained directly to city streets or sidewalks with no buffer zone (Figure 3-11).

Figure 3-9. Facilities with Metal Structures in Poor Condition (rust and staining evident)

Figure 3-10. Facilities with Outside Storage Presenting a High Potential for Metals Loading

Figure 3-11. Facilities with Staining on Parcels from Rooftops Draining Directly to City Streets

A total of 19 commercial/industrial storm drain inlets were identified for sampling throughout Priority Sector 1. Several inlets were observed with varying amounts of trash and debris ranging from fairly clean to excessive and in need of cleaning. One inlet located on the southwest corner of 32nd Street and Commercial Street was identified as an ideal location for a field sample location due to its connection to Commercial Street just upstream of the historic mass loading station site (SD8(1)). However, the drain inlet was observed to be completely filled with dirt and sampling could not be performed at this site (Figure 3-12). This storm drain has the potential to contribute particulates and metals directly to the creek during storm events. Additionally, the site is not indicated on the City of San Diego's GIS storm drain layer. The site information was passed on the City of San Diego Stormwater Department, Operations & Maintenance Division to be added to their maintenance list.

Figure 3-12. Storm Drain Inlet with Dirt and Debris (southwest corner of 32nd Street and Commercial Street)

Wet weather samples taken in Priority Sector 1 were collected in areas determined to be representative of specific facility types or groups of facilities identified as potential high threats to water quality. The results from sampling the runoff and rooftops are described in the sample results section.

Priority Sector 2 (El Cajon Blvd. and University Blvd.) consisted of mainly auto repair shops, tire shops, and car sales lots. The area has relatively younger infrastructure in comparison to facilities in Priority Sector 1. The area includes a mix of some commercial and mostly residential parcels in fair to good condition. For the most part, facilities in this priority sector appeared to have better housekeeping practices than the facilities observed in Priority Sector 1. A few locations were noted with staining around the facility and operations yards. The focus areas of this priority sector (El Cajon Blvd. and University Blvd) are dense with commercial activity compared to priority sectors 3, 4, and 5. A total of nine commercial/industrial storm drain inlets were identified for sampling throughout Priority Sector 2.

Priority Sector 3 has a less dense commercial area with more topographical variation than priority sectors 1, 2, and 4. The priority sector is made up of commercial and residential parcels in generally fair to good condition. Facilities in this priority sector tended to have more maintained operation yards and newer metal roofs. There was an inlet noted, at the end of 38th Street that drains directly into the creek, that was filled with dirt, debris, and trash; however, this was not a typical observation for this particular priority sector (Figure 3-13). A total of six storm drain inlets were identified for sampling throughout Priority Sector 3.

Figure 3-13. Storm Drain Inlet with Dirt and Debris Drains Directly into Chollas Creek (38th Street and Ash Street)

Priority Sector 4 has a less dense region of commercial facilities and is primarily comprised of residential land use. The commercial facilities were mostly automotive, tire, exhaust, and repair shops. These parcels were generally in poor to fair condition with some sites observed to have deteriorating automotive parts and rusty metal debris throughout their operations/storage yards with potential for direct runoff during storm events (Figure 3-14). Residential areas in Priority Sector 4 appeared to be in fair to good condition with fairly clean inlets throughout the priority sector. A total of five industrial/commercial storm drain inlets were identified for sampling throughout Priority Sector 4.

Figure 3-14. Rusty Metal Debris in Outside Automotive Repair Facility

Priority Sector 5 has the most topographical variation of all the priority sectors. The area consisted of two main streets (Federal Avenue and Imperial Avenue) with multiple large commercial facilities such as lumber yards, metal scrap yards, and automotive repair shops. The majority of Federal Avenue was densely populated with highly active commercial facilities in good condition. These commercial facilities continued upstream on Federal Avenue but were found to be in the City of Lemon Grove, outside of the City of San Diego limits. These facilities were noted due to their potential for water quality impact, but were not assessed because the facilities were located in an area that was not a part of this study. Imperial Avenue consisted mostly of automotive shops in fair condition. The residential areas of Priority Sector 5 were also in fair condition. However, there was an abundance of homes occupying large plots of land with varying degrees of deteriorating automotive parts, rusty metal debris, cars, boats, and busses. The topography of the residential area was extremely variable, presenting a large potential for runoff and erosion from steep slopes. There were very steep hills throughout this priority sector with limited drainage inlets. A total of three storm drain inlets were identified for sampling throughout Priority Sector 5.

Overall, the GIS desktop output maps were useful in guiding the field reconnaissance effort. Many of the facilities identified as high threats to water quality via the GIS desktop exercise were confirmed during the field reconnaissance. One key issue identified during the field effort was that several storm drain structures identified in the field that were not included in the storm drain layer maps and direction of flow was difficult to verify. Additionally, selecting drains that would be representative of one particular land use or facility type was somewhat challenging. This presents a need for the City of San Diego to update the inventory and cataloging of storm drains in their GIS storm drain layer.

Several sites identified as emission sources in the GIS desktop exercise were noted and field verified as accurate. However, some emission sources were also verified in the field to be fireplace exhausts from multifamily residential housing or other non-emission related ductwork. Several facilities were also observed to have mobile emission sources from the activities conducted on site during operations such as recycling and transfer of products (Figure 3-15).

Note grinding and airborne dust generation.

Figure 3-15. Evidence of Mobile Emissions Source

3.4 Sample Results

Results from the field sampling events are presented below by event and land use. Monitoring occurred during two wet weather events (runoff and rooftop monitoring) and one ambient dust monitoring event (wipe samples). Sample locations are shown on Figure 3-16. Wet weather samples were collected from 14 locations throughout Priority Sector 1 and Priority Sector 2 on March 22, 2009. During the second wet weather event on April 8, 2009, samples were collected from 28 locations throughout all five priority sectors. The rooftop runoff samples from the second event and the wipe samples are presented separately. Wet weather sample results are representative of the first flush of storm water runoff while wipe samples provide an assessment of the material available to be washed off from surfaces prior to the second rain event. Data analysis and additional interpretation are presented in Section 4.0. A Quality Control Summary is presented in Appendix F.

3.4.1 First Flush Runoff Sample Results

3.4.1.1 Sampling Event 1

During the first sampling event, March 22, 2009, seven commercial locations were sampled from Priority Sector 1, and two commercial locations were sampled from Priority Sector 2 (Table 3-6). In addition, two residential locations were sampled from Priority Sector 1, and three residential locations were sampled from Priority Sector 2 (Table 3-7). Dissolved and total cadmium, copper, lead, and zinc metals results for both land uses were higher in Priority Sector 1 when compared with Priority Sector 2, with the exception of total lead results in residential land use Priority Sector 2 at Site-10. The commercial and industrial land uses dissolved copper results ranged from a low of 58.2 µg/L in Priority Sector 2 at Site-10 to a maximum of 806.3 µg/L in Priority Sector 1 at Site 5. Residential dissolved copper results ranged from a low of 28.8 µg/L in Priority Sector 2 at Site-4R to a maximum of 418.5 µg/L in Priority Sector 1 at Site-3R.

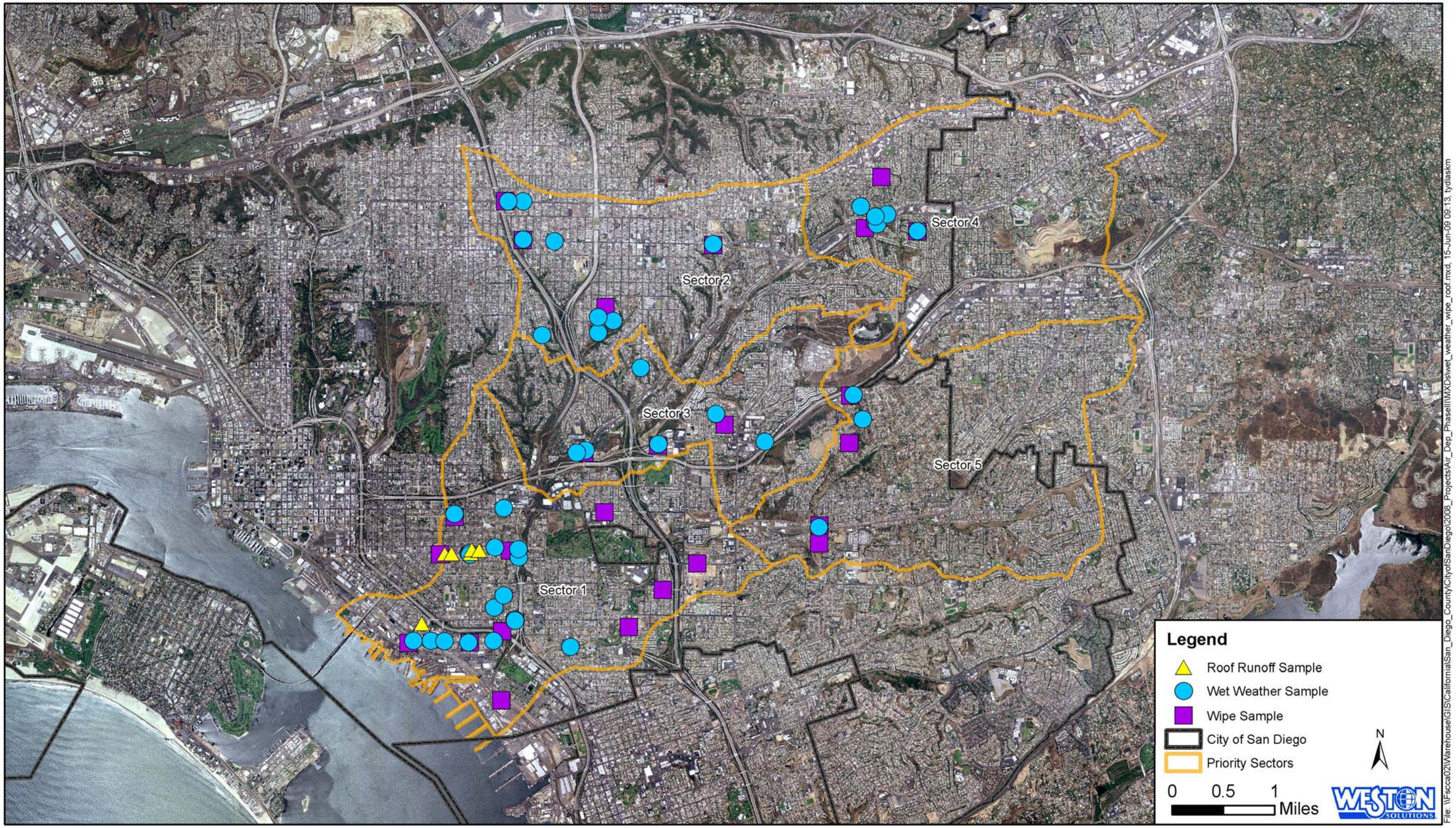


Figure 3-16. Wet Weather Runoff Sample Location Map

Table 3-6. Event 1 Runoff Sample Results – Commercial

Parameter	Units	Sector-1							Sector-2	
		Site-1	Site-2	Site-5	Site-7	Site-8	Site-9	Site-9B	Site-10	Site-11
		3/22/2009	3/22/2009	3/22/2009	3/22/2009	3/22/2009	3/22/2009	3/22/2009	3/22/2009	3/22/2009
General Chemistry										
Conductivity	mS/cm	1.505*	1.72*	1.815*	0.841*	0.643*	0.299*	0.384*	0.209*	0.899*
Total Hardness as $CaCO_3$	mg/L	346.1	351.2	442.7	192.9	162.2	73.2	81.7	39.4	201
pH	pH Units	7.2*	7.3*	6.7*	5.8*	6.6*	7*	6.8*	6.6*	6*
Trace Metals										
Dissolved Cadmium (Cd)	µg/L	0.7	0.7	2.3	2.5	0.7	1.4	1.4	0.4	0.5
Dissolved Copper (Cu)	µg/L	200.0	202.9	806.3	250.8	140.4	136.1	210.8	58.2	110.5
Dissolved Lead (Pb)	µg/L	3.43	2.65	23.67	12.2	5.51	3.72	0.86	2.86	6.4
Dissolved Zinc (Zn)	µg/L	596.7	504.4	1,237.9	2,585.9	1,042.9	2,002.9	13,639.9	492.3	767.3
Total Cadmium (Cd)	µg/L	6.8	2.1	3.3	2.9	2.5	2.7	5.4	0.8	0.7
Total Copper (Cu)	µg/L	2,192.0	720.2	998.7	293.3	304.7	236.8	571.3	125.9	164.8
Total Lead (Pb)	µg/L	443.4	80.77	276.5	35	141.5	76.45	194.4	21.26	13.24
Total Zinc (Zn)	µg/L	5,627.0	1,648.0	1,878.0	2,715.0	2,615.0	2,812.0	20,780.0	682.1	830.1

* Sample received and/or analyzed past the recommended holding time.

Table 3-7. Event 1 Runoff Sample Results – Residential

Parameter	Units	Priority Sector 1		Priority Sector 2		
		Site-1R	Site-3R	Site-4R	Site-5R	Site-6R
		3/22/2009	3/22/2009	3/22/2009	3/22/2009	3/22/2009
General Chemistry						
Conductivity	mS/cm	0.591*	1.095*	^	0.235*	0.196*
Total Hardness as $CaCO_3$	mg/L	161.1	338.6	402.6	56.1	49.5
pH	pH Units	6.1*	6.5*	5.6*	5.7*	6.5*
Trace Metals						
Dissolved Cadmium (Cd)	µg/L	1.3	2.1	0.8	0.5	0.3J
Dissolved Copper (Cu)	µg/L	402.9	418.5	28.8	66.3	36.0
Dissolved Lead (Pb)	µg/L	6.64	10.18	3.96	4.53	3.61
Dissolved Zinc (Zn)	µg/L	3,036.9	1,996.9	1,443.9	1,764.9	236.0
Total Cadmium (Cd)	µg/L	1.6	3.0	1.0	0.7	1.6
Total Copper (Cu)	µg/L	468.5	556.4	173.0	80.7	86.8
Total Lead (Pb)	µg/L	33.84	78.5	23.24	18.49	97.64
Total Zinc (Zn)	µg/L	3,385.0	2,552.0	1,704.0	1,919.0	806.1

* Sample received and/or analyzed past the recommended holding time.

^ Not enough sample volume collected.

J = Reported result is below the reporting limit but above the method detection limit.

3.4.1.2 Sampling Event 2

During the second sampling event (April 8, 2009 through April 13, 2009), commercial locations were sampled, including eight from Priority Sector 1, five from Priority Sector 2, five from Priority Sector 3, three from Priority Sector 4, and two from Priority Sector 5 for a total of 23 samples (Table 3-8). A total of seven residential runoff samples were also collected, including two in Priority Sector 1, one in Priority Sector 2, one in Priority Sector 3, two in Priority Sector 4, and one in Priority Sector 5. Similar to Sampling Event 1, all total and dissolved metals concentrations were higher in Priority Sector 1 than in the other priority sectors, with the exception of total lead results in Priority Sector 4 at Site 4R-2.

Table 3-8. Event 2 Runoff Sample Results – Commercial

Parameter	Units	Sector-1							
		1C-1	1C-2	1C-3	1C-4	1C-7	1C-9A	1C-9B	1C-11
		4/8/2009	4/8/2009	4/13/2009	4/8/2009	4/8/2009	4/8/2009	4/8/2009	4/8/2009
General Chemistry									
Conductivity	mS/cm	0.795	1.411	0.261	0.771	1.058	0.567	0.992	1.097
Total Hardness as $CaCO_3$	mg/L	139.1	234.5	32.5	157.7	201.2	86.8	207.7	179.8
pH	pH Units	6.9	7.5	7*	6.9	6.5	6.5	6.9	5.9
Trace Metals									
Dissolved Cadmium (Cd)	µg/L	1.1	0.6	0.4	0.8	3.3	2.6	4.1	4.2
Dissolved Copper (Cu)	µg/L	339.1	219.9	239.7	377.3	248.2	252.7	654.7	460.2
Dissolved Lead (Pb)	µg/L	7.12	1.94	1.3	13.68	10.06	2.78	5.68	34.43
Dissolved Zinc (Zn)	µg/L	1,581.9	422.8	451.7	571.5	3,159.9	23,139.9	5,339.9	11,109.9
Total Cadmium (Cd)	µg/L	1.6	4.4	0.6	1.2	4.7	3.7	10.4	5.2
Total Copper (Cu)	µg/L	460.8	1,627.7	310.1	447.2	414.3	372.9	1,195.7	557.0
Total Lead (Pb)	µg/L	34.38	245.5	14.83	81.19	122.8	88.3	353.5	123.3
Total Zinc (Zn)	µg/L	2,126.0	2,783.0	586.0	775.0	4,006.0	24,830.0	8,730.0	11,890.0

Parameter	Units	Sector-2			Sector-3				
		2C-1	2C-2	2C-3	3C-1	3C-2	3C-3	3C-4	3C-5
		4/8/2009	4/8/2009	4/8/2009	4/8/2009	4/8/2009	4/8/2009	4/8/2009	4/8/2009
General Chemistry									
Conductivity	mS/cm	0.158	1.565	0.145	0.509	0.416	1.06	0.763	1.481
Total Hardness as $CaCO_3$	mg/L	25.6	264.5	24.4	105	95	199.1	157.4	313.6
pH	pH Units	6.6	6.7	6.7	6.8	6.4	6.8	6.6	7.1
Trace Metals									
Dissolved Cadmium (Cd)	µg/L	0.3	0.7	0.3	0.4	0.7	1.4	1.0	1.3
Dissolved Copper (Cu)	µg/L	64.9	157.8	62.5	68.9	105.6	194.6	157.2	147.5
Dissolved Lead (Pb)	µg/L	2.17	9.8	2	2.49	6.8	2.54	4.95	3.05
Dissolved Zinc (Zn)	µg/L	558.9	936.9	479.8	326.5	1,686.9	1,430.9	1,298.9	694.2
Total Cadmium (Cd)	µg/L	0.5	2.5	0.7	0.5	1.2	3.6	1.8	2.0
Total Copper (Cu)	µg/L	100.3	319.7	116.3	84.1	180.8	418.3	235.9	191.7
Total Lead (Pb)	µg/L	16.81	147.7	24.19	10.81	49.12	82.01	31.66	22.66
Total Zinc (Zn)	µg/L	728.9	2,342.0	740.2	417.1	2,364.0	3,320.0	1,841.0	1,024.0

Parameter	Units	Sector-4			Sector-5	
		4C-1	4C-2	4C-3	5C-1	5C-2
		4/8/2009	4/8/2009	4/8/2009	4/8/2009	4/13/2009
General Chemistry						
Conductivity	mS/cm	1.261	0.537	0.596	0.484	0.93
Total Hardness as $CaCO_3$	mg/L	254.4	102.6	135.2	88	198.6
pH	pH Units	7.5	6.2	5.7	6.6	7.5*
Trace Metals						
Dissolved Cadmium (Cd)	µg/L	2.6	1.2	1.5	1.1	0.2J
Dissolved Copper (Cu)	µg/L	298.1	124.6	161.0	165.7	28.6
Dissolved Lead (Pb)	µg/L	13.59	9.45	5.81	7.27	0.73
Dissolved Zinc (Zn)	µg/L	3,288.9	1,299.9	2,456.9	1,500.9	169.7
Total Cadmium (Cd)	µg/L	8.2	1.6	2.3	1.5	0.4
Total Copper (Cu)	µg/L	753.2	163.1	253.5	205.7	47.3
Total Lead (Pb)	µg/L	349.2	42.66	60.9	49.95	11.48
Total Zinc (Zn)	µg/L	6,135.0	1,472.0	2,968.0	1,740.0	298.4

* Sample received and/or analyzed past the recommended holding time.

J=reported result is below the reporting limit but above the method detection limit.

Table 3-9. Event 2 Runoff Sample Results – Residential

Parameter	Units	Sector-1		Sector-2	Sector-3	Sector-4		Sector-5
		1R-1	1R-2	2R-1	3R-1	4R-1	4R-2	5R-1
		4/8/2009	4/8/2009	4/8/2009	4/8/2009	4/8/2009	4/8/2009	4/8/2009
General Chemistry								
Conductivity	mS/cm	2.24	1.065	1.424	0.446	0.828	0.817	0.454
Total Hardness as $CaCO_3$	mg/L	374.6	274.7	351.3	100.4	183.6	152.6	103.1
pH	pH Units	6.5	5.9	6.4	5.8	7.5	6.3	6.3
Trace Metals								
Dissolved Cadmium (Cd)	µg/L	0.8	1.7	1.2	0.9	<0.2	0.4	1.0
Dissolved Copper (Cu)	µg/L	251.1	242.1	224.1	100.7	19.1	94.6	79.5
Dissolved Lead (Pb)	µg/L	10.6	7.37	8.85	3.47	0.84	3.59	4.48
Dissolved Zinc (Zn)	µg/L	822.7	3,788.9	985.4	1,152.9	427.1	370.3	1,267.9
Total Cadmium (Cd)	µg/L	1.5	1.9	1.8	1.2	0.3	2.1	1.8
Total Copper (Cu)	µg/L	341.0	269.3	275.4	130.3	27.1	195.3	126.3
Total Lead (Pb)	µg/L	61.23	19.68	49.6	20.97	14.44	66.37	41.39
Total Zinc (Zn)	µg/L	1,162.0	4,030.0	1,276.0	1,320.0	558.0	1,281.0	1,708.0

3.4.2 Rooftop Runoff Sample Results

During the second sampling event, samples were collected from the runoff coming directly from rooftops. Six locations were sampled, all of them in Priority Sector 1 (Table 3-10). Dissolved and total zinc were higher in the rooftop runoff samples than in the overland runoff samples presented in Section 1.4.3, and total hardness and copper results were lower in rooftop runoff. However, copper was still above the CTR acute benchmark.

Table 3-10. Rooftop Runoff Sample Results

Parameter	Units	1-RR-Commercial St (E)	1-RR-Commercial St (W)	3-RR-Commercial St (W)	4-RR-Commercial St (W)	5-RR-Shipyard Area	6-RR-Commercial St
		4/8/2009	4/8/2009	4/8/2009	4/8/2009	4/8/2009	4/8/2009
General Chemistry							
Conductivity	mS/cm	0.317	0.343	0.167	0.222	0.361	0.381
Total Hardness as $CaCO_3$	mg/L	33.1	59.9	30.2	41.2	50.1	69.1
pH	pH Units	7.1	5.9	7.3	7.5	7.4	7.4
Trace Metals							
Dissolved Cadmium (Cd)	µg/L	9.9	11.2	0.5	0.8	0.7	1.8
Dissolved Copper (Cu)	µg/L	42.3	162.8	118.2	164.0	115.6	99.3
Dissolved Lead (Pb)	µg/L	1	8.43	1.19	1.62	0.62	1.06
Dissolved Zinc (Zn)	µg/L	28,029.9	36,209.9	670.9	911.8	3,123.9	3,187.9
Total Cadmium (Cd)	µg/L	10.2	11.2	0.6	0.9	0.8	2.1
Total Copper (Cu)	µg/L	47.0	165.3	136.2	192.2	123.6	119.0
Total Lead (Pb)	µg/L	3.73	9.02	8.95	12.65	1.52	13.77
Total Zinc (Zn)	µg/L	29,010.0	37,750.0	767.3	939.6	3,414.0	3,715.0

3.4.3 Wipe Sample Results

In addition to the wet weather runoff sampling, dry weather wipe sampling was also conducted. Results are shown on Figure 3-17 through Figure 3-19. Wipe samples were collected, including 12 in Priority Sector 1, three in Priority Sector 2, three in Priority Sector 3, three in Priority Sector 4, and five in Priority Sector 5 for a total of 26 samples. One of the metals of interest in the study (Cadmium) was not found at detectable levels in the wipe samples. Copper, lead, and zinc were found at variable levels across most priority sectors, with the highest values observed in Priority Sector 1. Priority sectors 2 and 4 (upper watershed areas) were lowest for copper, lead, and zinc. Copper and lead results were highest near the mouth of Chollas Creek.

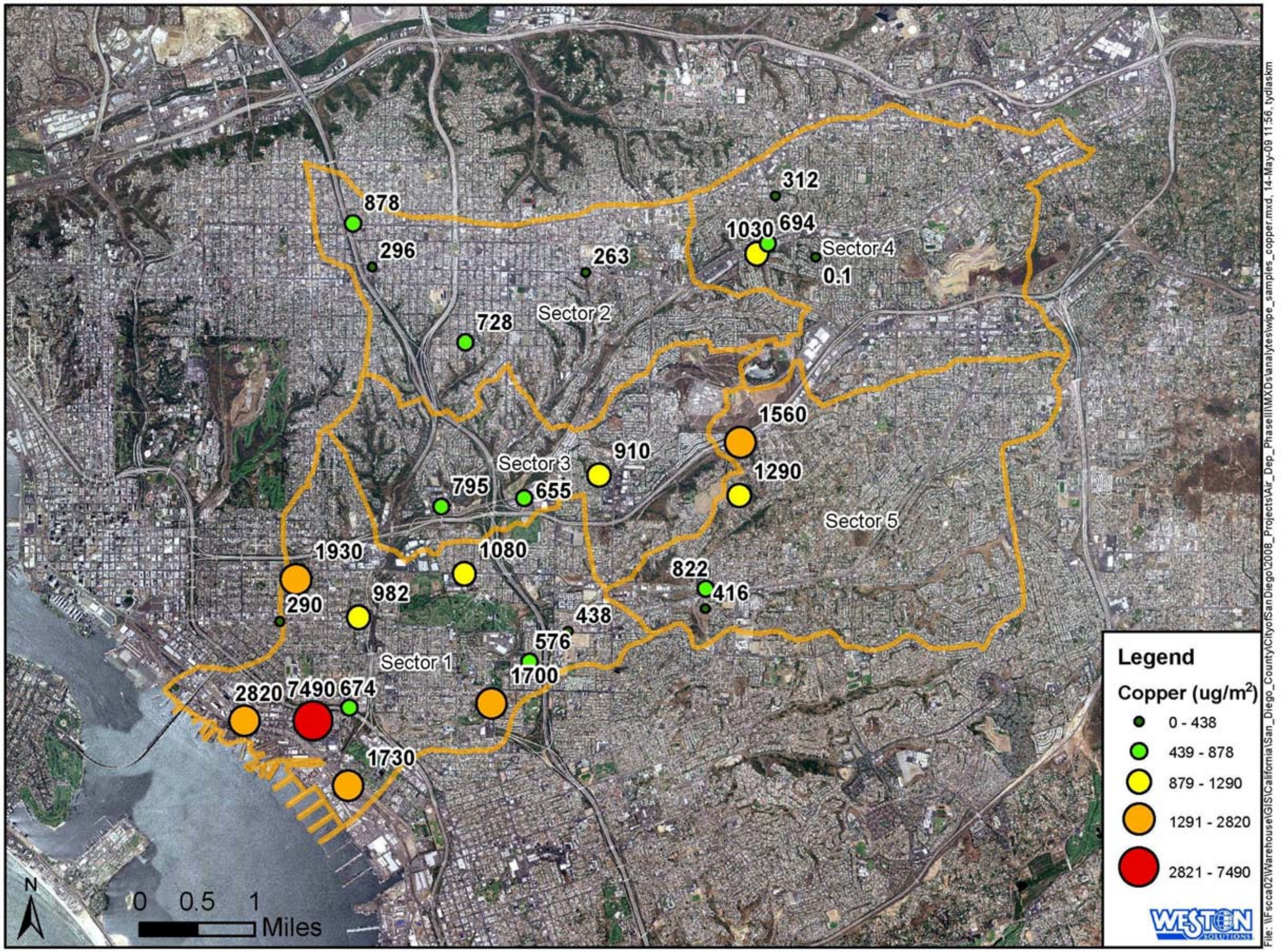


Figure 3-17. Copper Wipe Sample Results

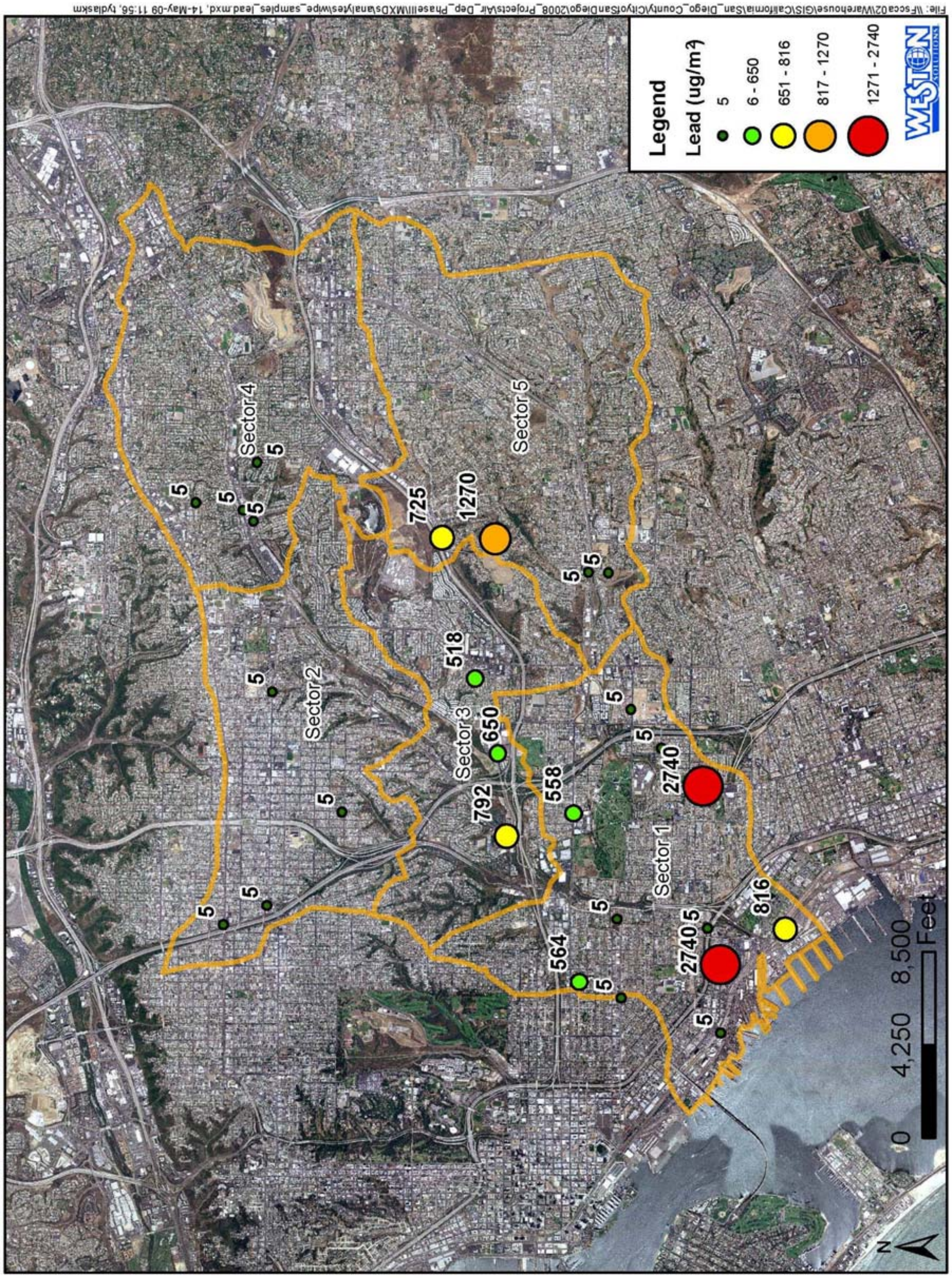


Figure 3-18. Lead Wipe Sample Results

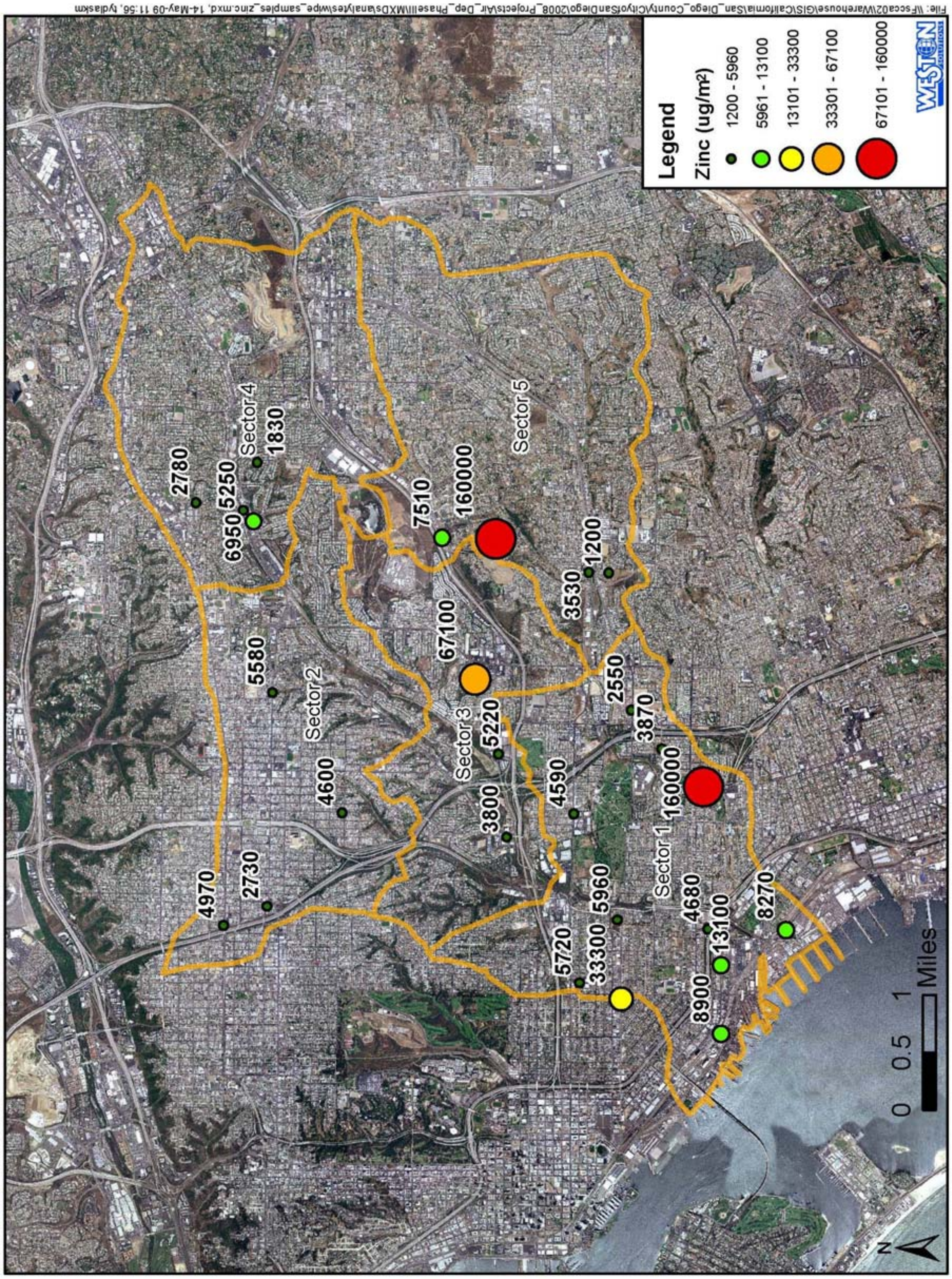


Figure 3-19. Zinc Wipe Sample Results

4.0 DATA INTERPRETATION AND ANALYSIS

The results from the facility emissions review and sample analysis were analyzed to determine the relationship to water quality from potential and likely sources in the Chollas Creek Watershed.

4.1 Facility Emissions Comparison to Modeled Runoff Loads

The results of the stationary facility emissions review were further analyzed to compare the estimated emissions loads in the Chollas Creek Watershed with the load discharged via storm water runoff (Table 4-1). The runoff loads were obtained from the modeling efforts conducted for the development of TMDLs at the mouth of Chollas Creek (SCCWRP, 2007). To further analyze the context of the emissions in light of known sources of copper from brake pad wear and zinc from tire wear, loads from these sources were estimated based on known emissions factors from literature values. The aerial deposition load was also estimated based on the average median results from the 24 measurements per station conducted over the course of a monitoring year under the Phase II Aerial Deposition Study (WESTON, 2009). By analyzing the results in this manner, the estimated loads can be compared to what is emitted into the air within the Chollas Creek Watershed, what settles on the surfaces of Chollas Creek Watershed, and what leaves the Chollas Creek Watershed via storm water runoff. The runoff ultimately discharges to San Diego Bay at the mouth of Chollas Creek.

Comparing the results for each metal, copper load from stationary facilities, and mobile sources, emissions are equivalent and in combination are ten times higher than the observed load deposited and the modeled load discharged. This suggests that a portion of the emissions load is either dispersing in the atmosphere outside of the watershed, is settling in more close proximity to the source than where the deposition monitoring occurs, or is being assimilated via other processes. The mean deposition rate of copper measured at the mouth of Chollas Creek during the Phase I Aerial Deposition Study and by Schiff and Sabin (2006) were higher than all other sites measured along the Southern California Bight. This suggests that sources other than normal transportation sources of copper exist in this watershed. This information also suggests that BMPs targeting copper removal will need to consider stationary and mobile emissions sources in their design and management actions. A conceptual diagram of copper processes for Chollas Creek is shown on Figure 4-1.

In contrast to copper, lead from stationary facilities and mobile sources was considerably lower than the observed load deposited or the modeled load discharged. Since the modeled discharge load is higher than the deposition load, this suggests that sources of lead in storm water runoff are likely a function of existing land-based sources (e.g., historical lead from soil erosion, lead based paint from ageing infrastructure, or industrial and commercial sources). This also suggests that BMPs may be more effective in targeting land-based sources as opposed to emissions sources.

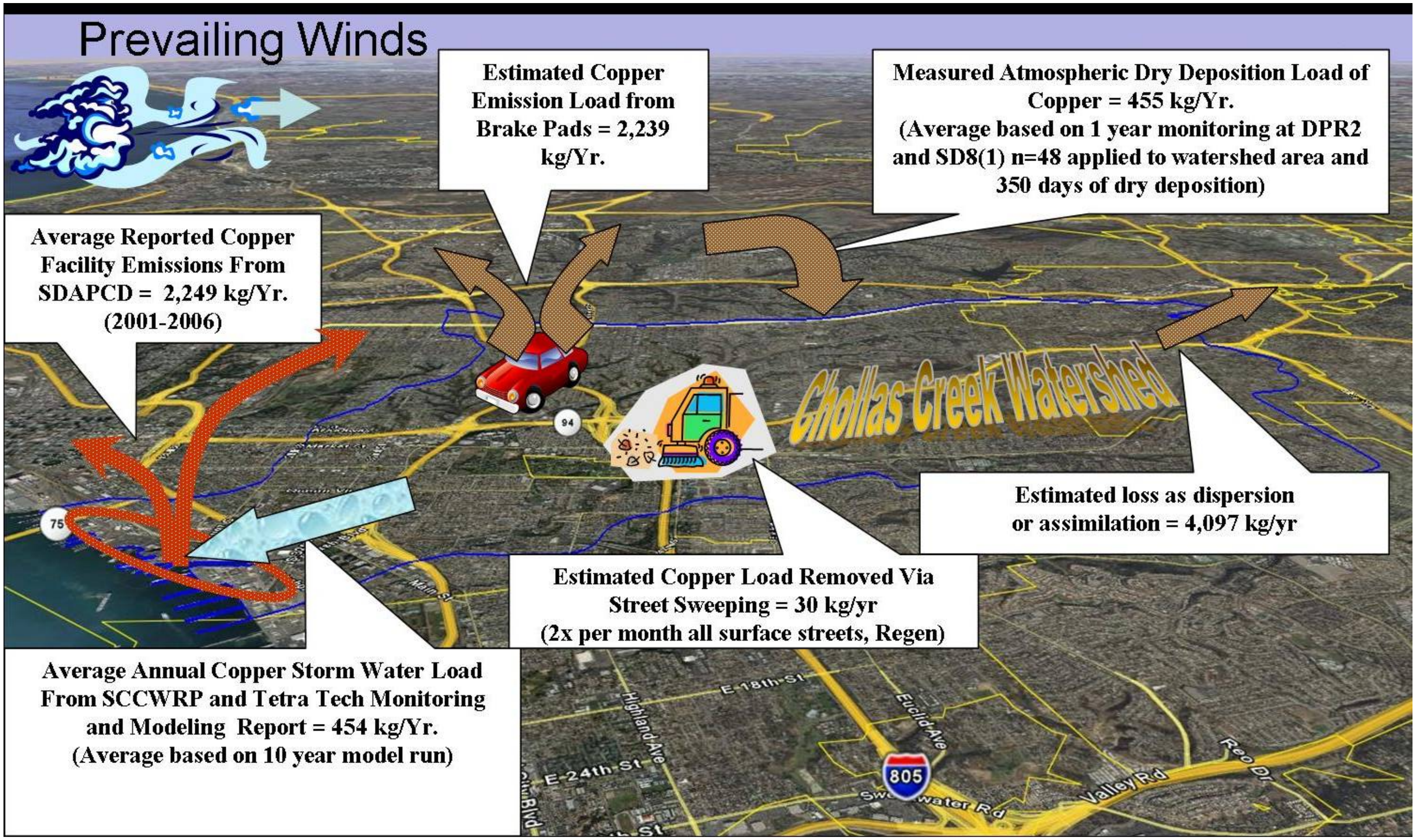
Lastly, the zinc load from emissions sources was highest from mobile sources in comparison to facility emissions or the observed deposition load. The average modeled load of zinc discharged via runoff suggests that zinc sources exist from both stationary emissions, mobile emissions (primarily from tire wear), and land-based sources (e.g., metal rooftops, as was observed during the course of this study). The zinc deposition load was approximately one third of the estimated emissions load of zinc, and the modeled runoff load of zinc was higher than the deposition load, suggesting other land-based sources are contributing to the zinc runoff load. Studies have shown that tire wear particles make up approximately one third of the vehicle-derived particulates in roadway runoff (Councell et al., 2004).

Table 4-1. Comparison of Aerial Emissions, Aerial Deposition, and Storm Water Runoff Loads in the Chollas Creek Watershed

Load Type	Total Copper (kg/yr)	Total Lead (kg/yr)	Total Zinc (kg/yr)	Source
Aerial Emissions (stationary facility emissions)	**2,249**	**3**	**753**	SDAPCD. 2009 *SDAPCD Database*. AB2588 Toxics Inventory Hot Spots Program Emissions. Accessed at: http://www.sdapcd.org/toxics/FacEmiss/facilities.html. Data are the minimum required emissions to be reported and may be higher depending on reporting year.
Aerial Emissions (mobile sources)	**2,239***	**0.117***	**7,722***	Rosselot. 2006. *Copper Emissions from BPP*. Process Profiles. 2006 estimates (0.58 mg_{Cu}/km). Zinc Emissions from Councell, 2004 wear rates (0.05 g_{tread}/km-tire*1g_{Zn}/100g_{tread}). Values multiplied CountNet-2003 ADTV of 6,573,173 cars * 365 days per year for the Chollas Creek Watershed. Lead values from EPA emissions estimates.
Aerial Deposition (Measured deposition load estimate)	**455**	**94**	**2,284**	WESTON, 2009. *Aerial Deposition Phase II Monitoring Report*. Conducted 24 dry deposition measurements over a one-year period (2007–2008). Used average median deposition rate from sites SD8(1) and DPR2 (μg/m2/day) X Area of watershed X 350 dry days (estimate of deposition buildup).
Storm Water Runoff	**454**	**322**	**3,102**	Schiff, K. and S. Carter. 2007. *SCCWP Technical Report 513*. Monitoring and Modeling of Chollas, Paleta, and Switzer creeks. Accessed at: ftp://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/ 13_chollas_monitoring_modeling.pdf). April 14, 2007.

*Note: Values do not account for fugitive dust emissions from paved roads.

The emissions estimates and the modeled runoff are developed from modeling assumptions and possess inherent variability. The values have the potential to be under or overestimated. Stationary emissions are as reported by SDAPCD reporting. Aerial emissions are estimated from emissions factors from cited literature values. Aerial deposition rates are observed values from reported annual monitoring values. Storm water runoff values are model estimated using the Hydrologic Simulation Program Fortran (HSPF) based on calibrated and validated storm water monitoring data.



Estimated Copper Emission Load from Brake Pads = 2,239 kg/Yr.

Measured Atmospheric Dry Deposition Load of Copper = 455 kg/Yr.
(Average based on 1 year monitoring at DPR2 and SD8(1) n=48 applied to watershed area and 350 days of dry deposition)

Average Reported Copper Facility Emissions From SDAPCD = 2,249 kg/Yr.
(2001-2006)

Estimated loss as dispersion or assimilation = 4,097 kg/yr

Estimated Copper Load Removed Via Street Sweeping = 30 kg/yr
(2x per month all surface streets, Regen)

Average Annual Copper Storm Water Load From SCCWRP and Tetra Tech Monitoring and Modeling Report = 454 kg/Yr.
(Average based on 10 year model run)

Figure 4-1. Conceptual Diagram of Copper Sources and Transport Processes in the Chollas Creek Watershed

4.2 First Flush Runoff and Rooftop Runoff Summary

The results of the first flush runoff monitoring were analyzed with respect to the study questions. Rooftop runoff results were also analyzed to compare sources by analyte and to assess whether metal rooftops were a source of zinc or other metals in the watershed. Literature values suggest that metal rooftops (particularly rusty roofs) are a source of high zinc concentrations. Kennedy and Gadd (2001) reported zinc concentrations from galvanized metal rooftops ranging from 1,100 µg/L to 44,000 µg/L, whereas copper and lead were considerably lower with mean values of 19.9 µg/L and 78.9 µg/L, respectively.

A summary of the monitoring results is presented in Section 4.2.1, followed by a breakdown of the results by land use and sector and finally a correlation of land use percentages and specific anthropogenic activities.

4.2.1 Overview of Sampling Results

The results of the wet weather monitoring were compared to the CTR WQO for dissolved metals. Dissolved copper and zinc were above CTR for all samples, whereas dissolved lead results were all below the CTR. The results are presented spatially on Figure 4-2 through Figure 4-4 along with individual results for each sample on the bar charts. The total metal and dissolved metal results are shown on the graphs and in the pie charts together to allow for evaluation of the percent of mass of each sample in the dissolved phase. The size of the pie chart is a representation of how that sample compared with other samples. For example, Site-1 has the biggest pie chart because it was sample with the highest concentration of total copper.

When evaluating concentrations for metals in each sector, the highest concentrations for all analytes of interest (i.e., copper, lead, and zinc) were observed in Priority Sector 1 with the exception of one high result at Site 4C-1 in Priority Sector 4. Results of statistical evaluation (Section 4.2.3) show that Priority Sector 1 concentrations of dissolved and total copper are significantly higher than all other priority sectors. In addition, total zinc concentrations were significantly higher in Priority Sector 1 than in Priority Sector 2.

Evaluation of the differences between land uses (i.e., commercial/industrial, commercial/industrial-metal roof runoff, and residential) shows that overall concentrations are higher in commercial/industrial areas than in residential areas (Section 4.2.2). Residential areas in Priority Sector 1 had higher copper concentrations than in other priority sectors. However, this relationship did not apply to the other analytes, which appear to be approximately equal in residential areas regardless of the priority sector.

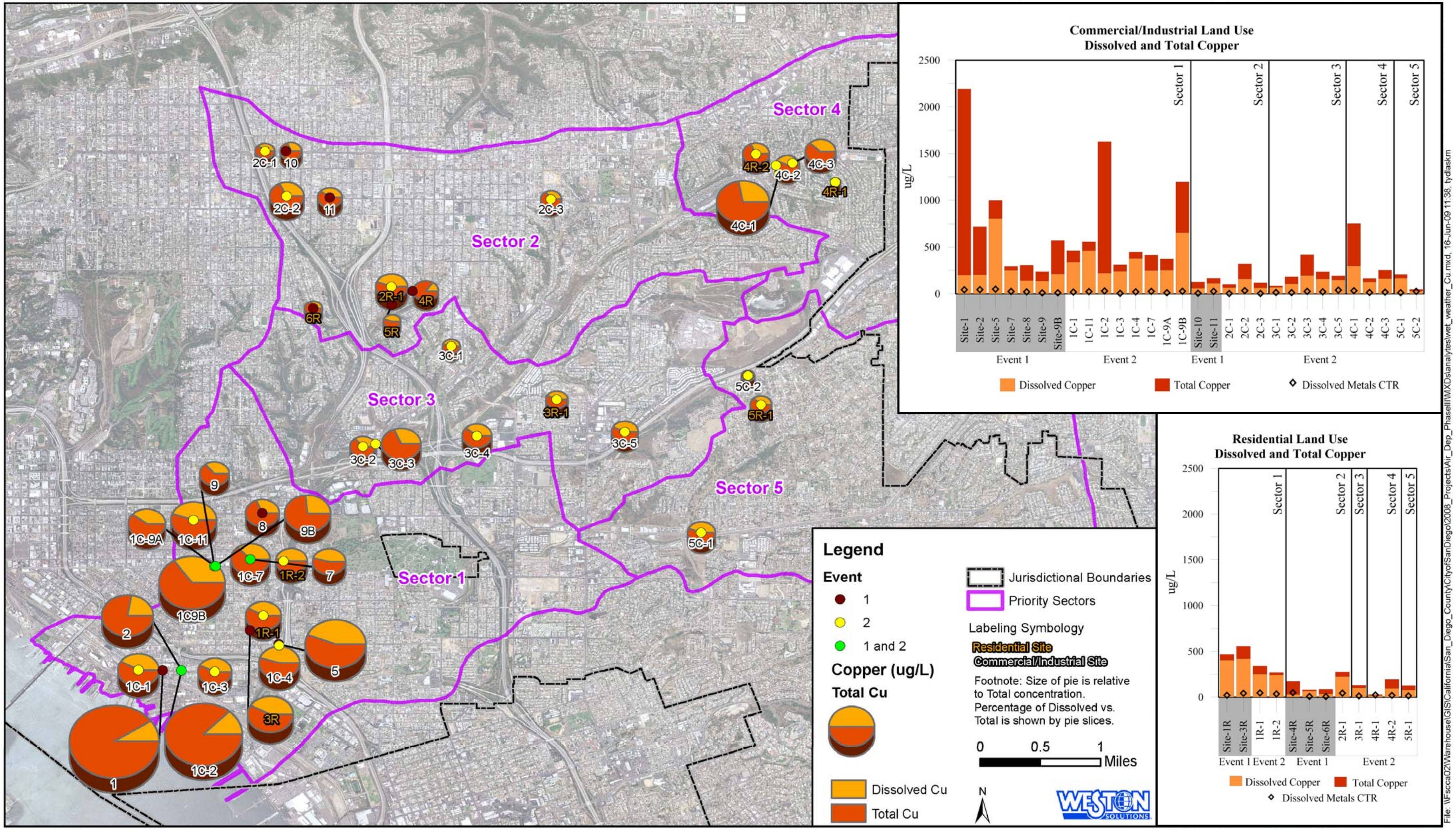


Figure 4-2. Single Sample Total and Dissolved Runoff Concentrations for Copper

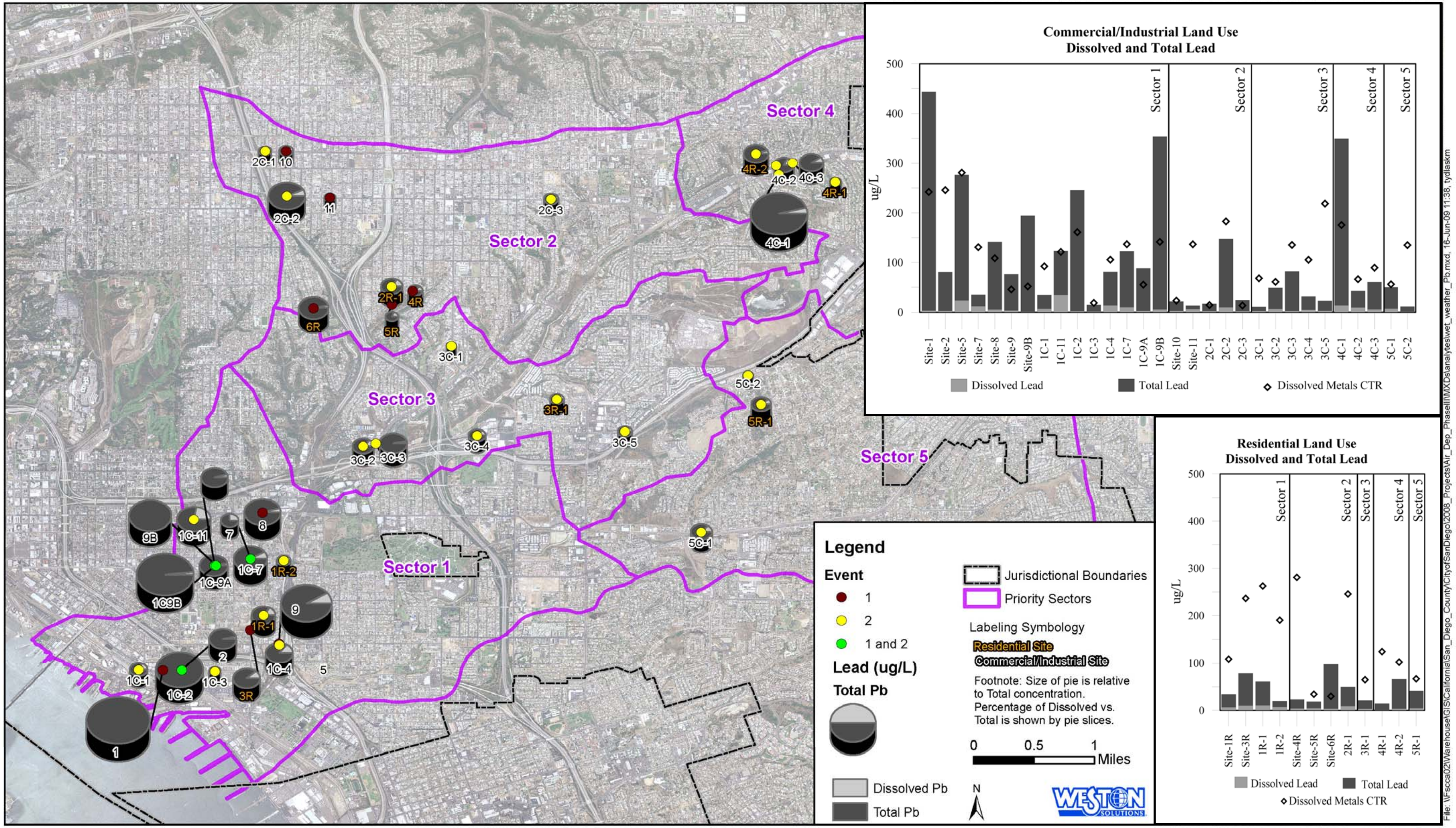


Figure 4-3. Single Sample Total and Dissolved Runoff Concentrations for Lead

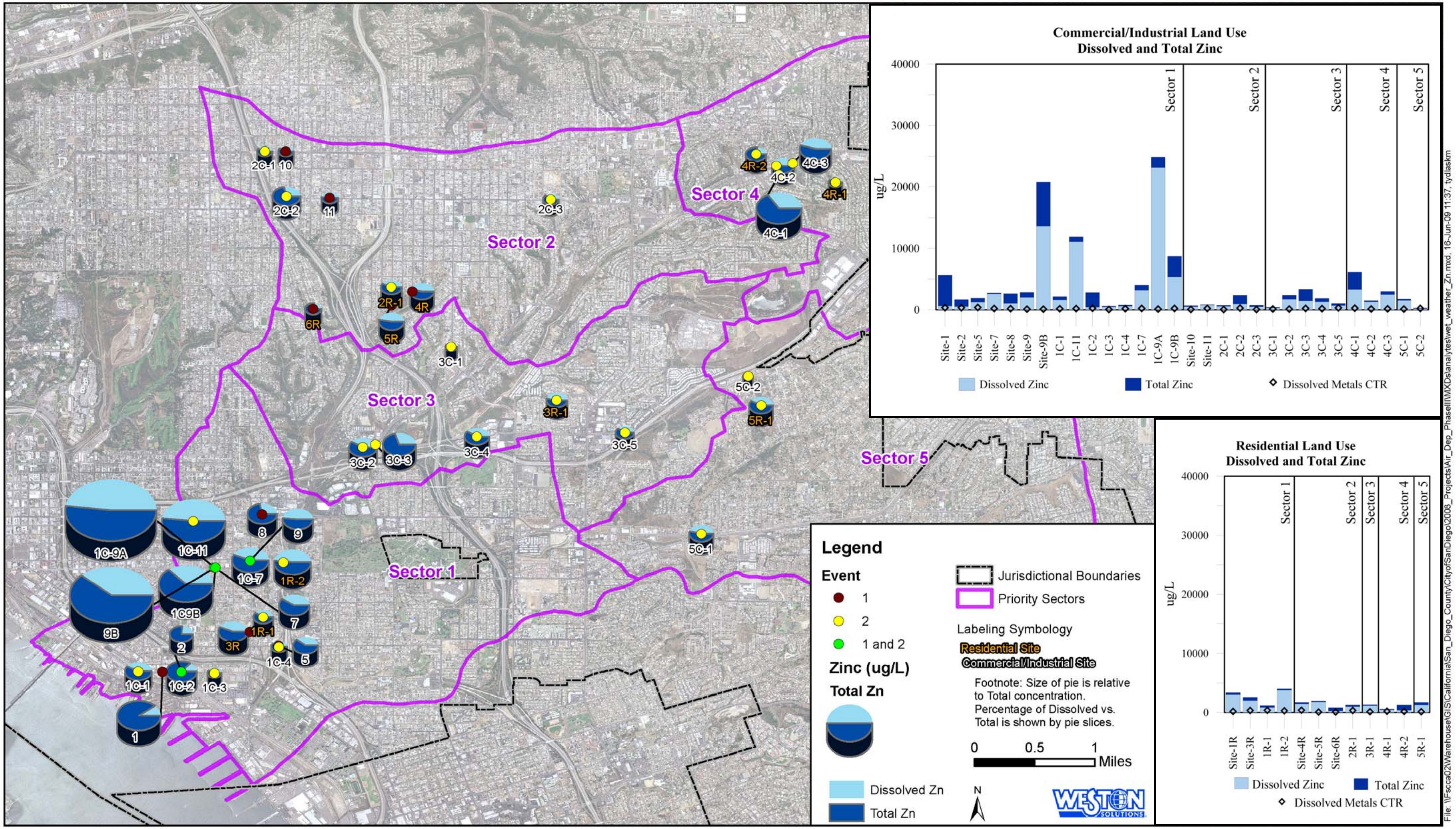


Figure 4-4. Single Sample Total and Dissolved Runoff Concentrations for Zinc

4.2.2 Land Use Comparison

Data were combined for both wet weather sampling events and were summarized to evaluate differences between the commercial/industrial and residential land use categories. The average value for each land use is plotted with overlapping average dissolved concentrations and average total metals concentrations (Figure 4-5). Both the first flush runoff and the metal rooftop runoff samples are included in the plots. Because the total metal concentration is typically higher than the dissolved metals concentration (or equal to it if highly soluble), it is possible to determine what proportion of the total metal concentration the dissolved metals fraction is in. The standard error of the total concentration is also plotted along with the CTR hardness-based values. The comparison with the CTR is purely for the purpose of putting the results in context because these samples are not collected in receiving waters; this comparison is not meant to be used as a regulatory measure.

Total copper average first flush runoff results for the commercial/industrial land use were more than double the metal rooftop runoff average concentration (468.78 µg/L and 210.02 µg/L respectively) and were also higher than the residential first flush runoff results (Figure 4-5). Based on the result of Analysis of Variance testing (ANOVA) with Tukey pair-wise post-analysis, the commercial/industrial first flush concentrations were significantly higher than the commercial/industrial metal roof runoff (Table 4-2). The dissolved copper concentrations did not differ as widely, but were still close to double when comparing the commercial/industrial land use first flush results to the metal roof runoff results (221.49 µg/L and 117.03 µg/L, respectively). Both sets of samples were collected in commercial/industrial areas.

In contrast, the total and dissolved zinc average concentrations show the opposite pattern when compared to copper. Metal rooftop runoff average concentrations are higher for both total and dissolved zinc when compared to commercial/industrial and residential first flush results. The average total zinc concentration for metal rooftop runoff is 12,599.32 µg/L and is 4,023.46 µg/L for commercial/industrial land use. The results of a t-test, including only commercial/industrial metal roof runoff and commercial/industrial first flush samples, show that dissolved zinc concentrations are significantly higher in metal roof runoff than in first flush runoff (Table 4-2) (Figure 4-5).

Table 4-2. Statistical Analysis Results for Land Use Comparison

Parameter	ANOVA Probability	Tukey Pair-Wise Results	Tukey Probability
Dissolved lead	0.014	Commercial-roof runoff – residential-first flush	0.0283
		Commercial-roof runoff – commercial-first flush	0.0141
Total copper	0.014	Commercial-first flush – commercial-roof runoff	0.0363
Total hardness as $CaCO_3$	0.002	Commercial-roof runoff – residential-first flush	0.0017
		Commercial-roof runoff – commercial-first flush	0.004
Total lead	0.000	Commercial-roof runoff – commercial-first flush	<0.0001
		Commercial-roof runoff – residential-first flush	0.003
T-Test			
Dissolved zinc	0.0390	Commercial-roof runoff – commercial-first flush	NA

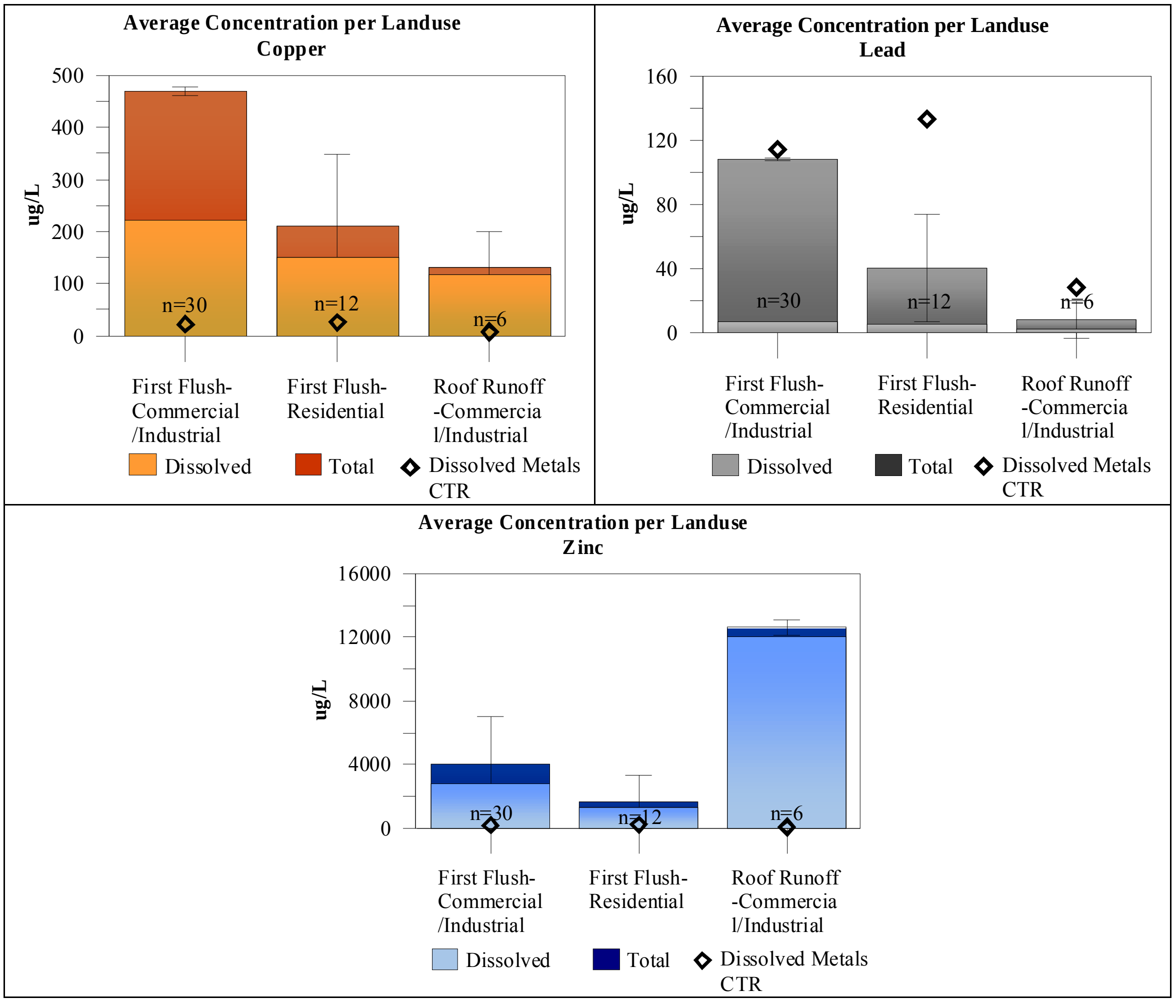


Figure 4-5. Average Concentration of First Flush Runoff and Metal Roof Runoff Concentrations by Land Use for Copper, Lead, and Zinc

The hardness level found in each sample is of particular interest in this study because hardness is linked to the bioavailability of dissolved metals. Metal roof runoff samples had the lowest average hardness concentrations (47.3 mg $CaCO_3$/L), but had the highest variability (Figure 4-6). The low hardness levels parallel the high proportion of dissolved metals in metal roof runoff samples (Figure 4-7). Average residential hardness was the highest, and was statistically higher than metal roof runoff commercial/industrial hardness levels (Table 4-2).

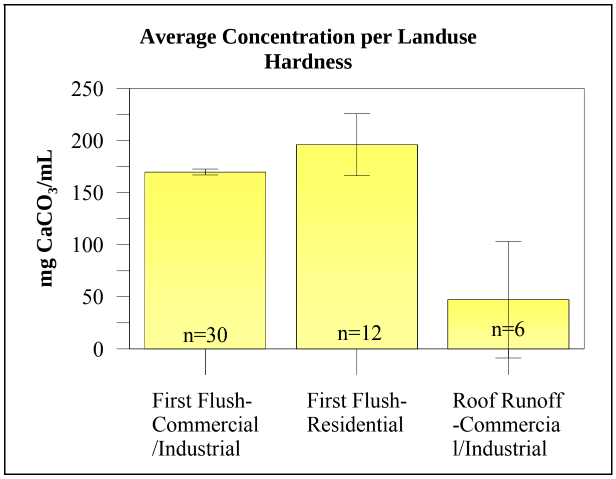


Figure 4-6. Average Concentration of First Flush Runoff and Metal Roof Runoff Hardness Concentrations

4.2.3 Sector Comparison

To further understand the relationships between land use, the sectors were also evaluated. A breakdown of the sampling results by land use and priority sector is included on Figure 4-7 through Figure 4-9. Overall, Priority Sector 1 showed the highest results, regardless of land use, followed by Priority Sector 4 in the commercial/industrial land use. The exception is, again, for zinc. Total and dissolved zinc were higher in metal roof runoff than in first flush runoff at ground level and is likely attributable to galvanized and weather metal roofing containing zinc. However, sites with metal roofs in their drainage area, also exhibited high concentrations of total and dissolved zinc and a relation to the rooftop drainage is evident.

A two-way ANOVA test was performed to evaluate the interaction between land use and priority sector area. The results of the ANOVA test are presented in Table 4-3. The purpose of performing a two-way ANOVA test was to evaluate the significant differences between land uses and priority sectors while accounting for the interaction between land use and priority sectors, because they are not necessarily independent. If an ANOVA test result was found to be significant, a post-ANOVA test evaluation was performed to determine which groups were significantly different (Tukey results in Table 4-3).

In this evaluation, dissolved copper concentrations were found to be significantly higher in commercial/industrial land use compared with residential land use, and in addition Priority Sector 1 dissolved copper concentrations were significantly higher than priority sectors 2, 3, 4, and 5 concentrations (Table 4-3) (Figure 4-7). The same pattern was observed for total copper. Significant differences between priority sectors were also found for total lead and total zinc. No pair-wise (or post-ANOVA analysis) significant results were found for total lead, but Priority Sector 1 was found to have significantly higher levels of total zinc than Priority Sector 2.

Table 4-3. Two-Way ANOVA Test Results

Parameter	Comparison	Probability	Tukey Pair-Wise Results	Tukey Probability
Dissolved copper	Land use	0.022	Commercial – residential	<0.05
Dissolved copper	Sector	0.000	Priority Sector 1 – Priority Sector 3	<0.05
			Priority Sector 1 – Priority Sector 4	0.0052
			Priority Sector 1 – Priority Sector 2	<0.0001
			Priority Sector 1 – Priority Sector 5	0.0138
Total copper	Land use	0.010	Commercial – residential	<0.05
Total copper	Sector	0.000	Priority Sector 1 – Priority Sector 3	<0.05
			Priority Sector 1 – Priority Sector 4	0.0299
			Priority Sector 1 – Priority Sector 2	0.0024
			Priority Sector 1 – Priority Sector 5	0.0279
Total lead	Sector	0.032	None significantly different	–
Total zinc*	Sector	0.026	Priority Sector 1 – Priority Sector 2	<0.05

*Zinc passed heterogeneity testing, but did not pass normality testing, and therefore results should be used with caution

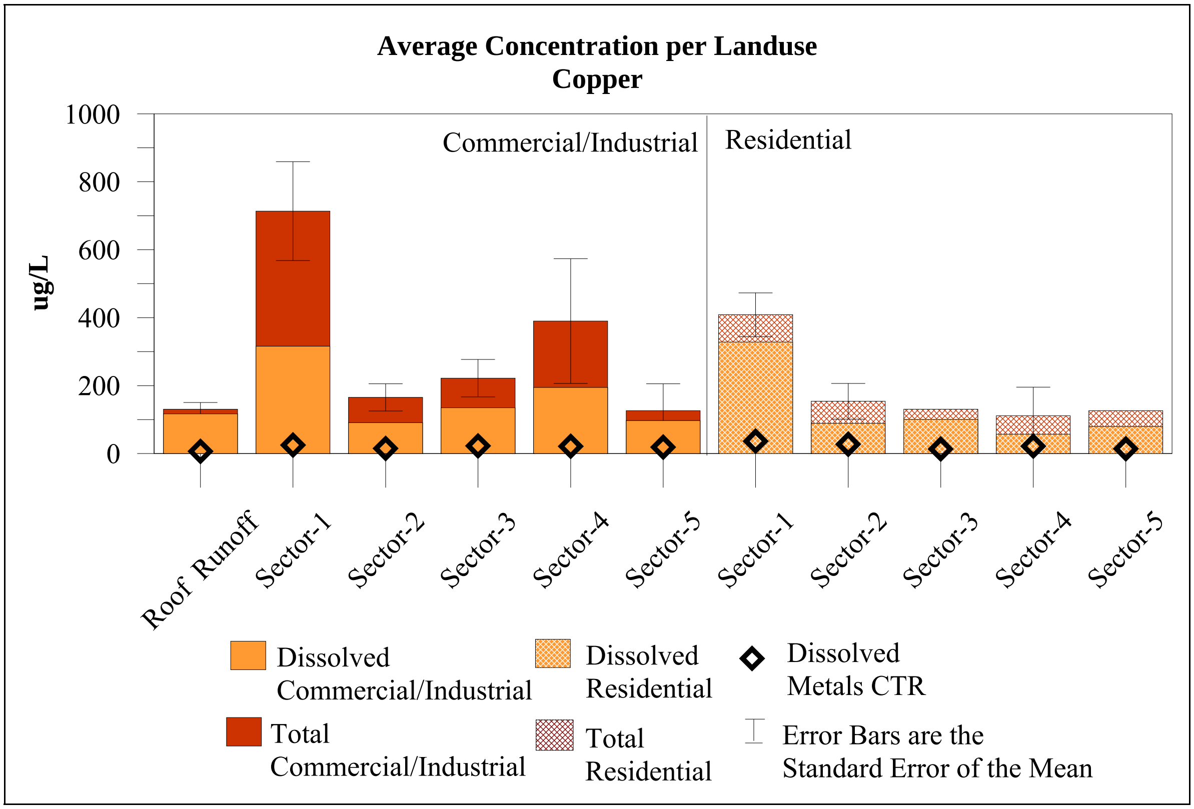


Figure 4-7. Average Total and Dissolved Copper Concentration per Sector and by Land Use

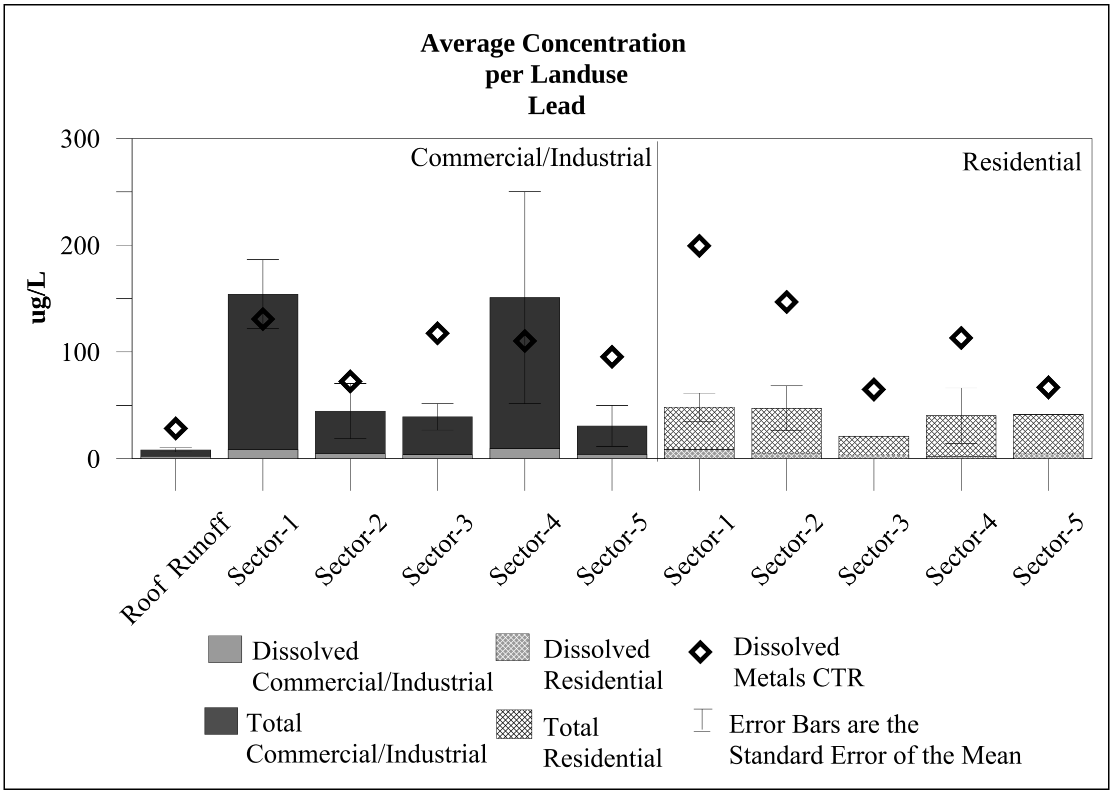


Figure 4-8. Average Total and Dissolved Lead Concentration per Sector and by Land Use

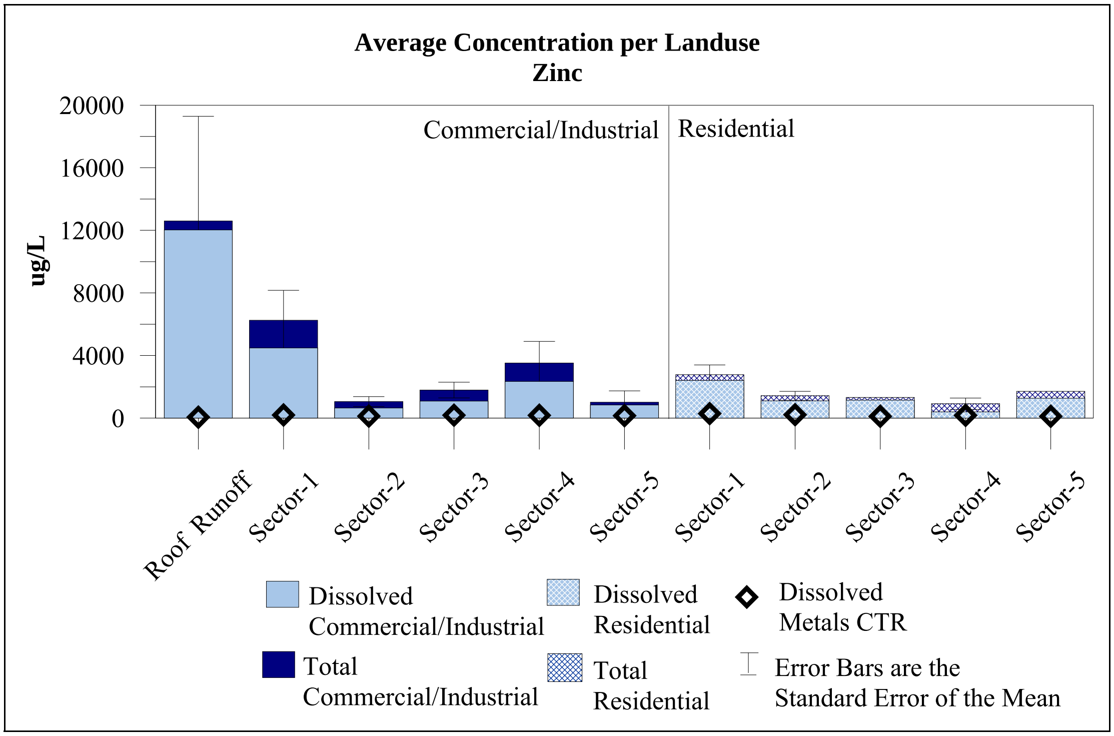


Figure 4-9. Average Total and Dissolved Zinc Concentration per Sector and by Land Use

4.2.4 Land Cover / Impervious Surface Comparison

The land cover composition of each monitored drainage area was characterized to investigate the potential relationship between metal sources in the urban landscape and metal pollutant concentrations measured at the first flush sampling sites. The drainage areas of the sampling sites were delineated using aerial imagery, 2-ft contours from SanGIS, digital elevation model (DEM) data, and storm drain data from SanGIS. The preliminary drainage areas were field verified and were revised as needed based on field determination of local runoff flow patterns. Figure 4-12 provides an example of the drainage areas delineated for three of the monitoring sites.

Using aerial imagery, approximate area and percent cover were calculated in GIS for rooftop, pavement (e.g., road and parking lot), outside storage, and bare soil/vegetation delineated areas within each drainage area. Table 4-4 shows the results of the GIS desktop interpretation of land cover as well as these data represented as impervious (i.e., pavement, rooftop, and outside storage) and pervious surface percentages. Drainage areas ranged in size from 0.96 acre to 14.99 acres and impervious surface from 48–100%.

Figure 4-10. Example Map of Drainage Areas for Three Monitoring Sites

Table 4-4. Percent Cover Analysis of Drainage Areas Associated with First Flush Samples

Monitoring Drainage Area			Percent Cover by Type				
SECTOR	**Sample Identification**	**Acres**	**Road/ Pavement**	**Roof**	**Outside Storage**	**Total Impervious**	**Soil/Vegetation (pervious)**
1	Site-1	5.23	62.8%	23.9%	6.2%	92.8%	7.2%
	1C-1	14.99	61.7%	30.5%	2.7%	95.0%	5.0%
	1C-11	1.36	23.5%	33.8%	14.8%	72.2%	27.8%
	1C-2, Site-2	2.29	56.8%	37.1%	0.0%	93.9%	6.1%
	1C-3	2.93	53.8%	42.1%	0.0%	95.8%	4.2%
	1C-4	2.85	42.0%	30.9%	0.0%	73.0%	27.0%
	1R-1	6.40	27.3%	33.7%	0.0%	61.0%	39.0%
	1R-2	1.60	21.7%	30.1%	0.0%	51.8%	48.2%
	2R	1.43	44.2%	28.9%	0.0%	73.1%	26.9%
	3R	3.48	40.3%	38.2%	0.0%	78.4%	21.6%
	Site-5	6.41	29.3%	51.9%	0.0%	81.3%	18.7%
	Site-7, 1C-7	3.22	36.7%	23.9%	23.7%	84.3%	15.7%
	Site-8	13.24	64.9%	12.2%	0.0%	77.1%	22.9%
	Site-9, 1C-9A	3.31	44.9%	18.6%	24.3%	87.8%	12.2%
	Site-9B, 1C9B	2.68	62.4%	23.6%	5.9%	91.8%	8.2%
2	Site-10	4.98	40.3%	39.4%	0.0%	79.7%	20.3%
	Site-11	3.78	20.2%	66.3%	2.4%	88.9%	11.1%
	2C-1	3.25	51.0%	34.4%	0.0%	85.4%	14.6%
	2C-2	16.73	25.2%	58.9%	0.0%	84.0%	16.0%
	2C-3	4.91	55.2%	29.4%	0.0%	84.6%	15.4%
	2R-1	2.13	21.8%	41.2%	0.0%	63.1%	36.9%
	Site-4R	5.24	16.4%	50.2%	0.0%	66.6%	33.4%
	Site-5R	2.85	19.8%	28.1%	0.0%	47.9%	52.1%
	Site-6R	11.66	26.6%	43.0%	0.0%	69.6%	30.4%
3	3C-1	6.75	28.8%	61.1%	0.0%	89.9%	10.1%
	3C-2	5.69	61.7%	16.5%	0.0%	78.1%	21.9%
	3C-3	3.55	59.6%	29.5%	0.0%	89.2%	10.8%
	3C-4	2.78	54.9%	17.1%	0.0%	72.0%	28.0%
	3C-5	4.32	80.9%	13.5%	0.0%	94.4%	5.6%
	3R-1	4.49	23.3%	31.8%	0.0%	55.1%	44.9%
4	4C-1	3.67	69.1%	18.6%	12.3%	100.0%	0.0%
	4C-2	33.25	21.9%	48.7%	0.0%	70.6%	29.4%
	4C-3	0.96	100.0%	0.0%	0.0%	100.0%	0.0%
	4R-1	2.13	29.9%	31.6%	0.0%	61.4%	38.6%
	4R-2	3.46	23.0%	46.9%	0.0%	69.9%	30.1%
5	5C-1	12.70	27.9%	44.2%	1.0%	73.0%	27.0%
	5C-2	5.85	80.9%	19.1%	0.0%	100.0%	0.0%
	5R-1	1.60	44.6%	4.0%	0.0%	48.6%	51.4%

4.2.5 Correlation Analysis

A Spearman Rank correlation analysis was completed to evaluate the relationship between observed runoff concentrations and runoff area percent land use and anthropogenic activity. The results of the analysis show that high levels of total copper are correlated with high amounts of impervious area, pavement, outdoor storage, outdoor storage amount, number of metal roofs, and overall GIS-calculated score (Table 4-5). All of the metals of interest, except dissolved lead, are correlated with the percentage of outdoor storage in a runoff area. Dissolved lead was not correlated with any category and is likely a function of the low solubility of lead. Total lead was positively correlated to percent storage, emissions evidence, and number of metal roofs. Zinc, which is associated with rusty metal roof runoff, was found to be negatively correlated with the percent of total roof in a runoff area, but was found to be positively correlated with the number of metal roofs. This may be explained by the variability of roof construction in the runoff areas. Some runoff areas composed of large amounts of rooftop area may not have been constructed of metal, or some runoff areas that contain a large percentage of roof area may only count as one metal roof. Please note that correlations are a measure of the association of two variables and cannot be used to claim causal relationships. For example, correlations cannot be used to state that high levels of dissolved copper are caused only by outdoor metal storage unless a study was designed to answer that specific question from a specific and controlled area.

Table 4-5. Spearman Rank Correlation Results of Percent Drainage Cover Analysis and Associated First Flush Samples

Landuse/ Observation	Analyte								
	Total Hardness	Conductivity	pH	Dissolved Copper (Cu)	Dissolved Lead (Pb)	Dissolved Zinc (Zn)	Total Copper (Cu)	Total Lead (Pb)	Total Zinc(Zn)
	Critical Value								
	0.305	0.309	0.305	0.305	0.305	0.305	0.305	0.305	0.305
% Pervious	-0.037	-0.157	-0.604	-0.209	0.302	0.038	-0.368	-0.180	-0.149
% Impervious	0.037	0.157	0.604	0.209	-0.302	-0.038	0.368	0.180	0.149
% Pavement	-0.060	0.025	0.609	0.137	-0.331	0.027	0.319	0.267	0.226
% Total Roof	0.130	0.102	-0.103	-0.079	0.086	-0.413	-0.097	-0.147	-0.438
% Storage	-0.021	0.073	0.082	0.409	0.218	0.574	0.403	0.387	0.591
% Vegetation or Soil	-0.037	-0.157	-0.604	-0.209	0.302	0.038	-0.368	-0.180	-0.149
Emission Evidence	0.050	0.120	0.033	0.258	0.131	0.425	0.254	0.371	0.458
Outside Storage Amount	0.028	0.122	0.377	0.363	0.075	0.265	0.403	0.362	0.351
Number Metal Roofs	0.125	0.210	0.306	0.488	0.151	0.392	0.499	0.462	0.463
SCORE	0.127	0.228	0.332	0.425	0.199	0.344	0.458	0.427	0.422

5.0 CONCLUSIONS AND RECOMMENDATIONS

The sources of metals in the Chollas Creek Watershed originate from a variety of sources, land uses, and activities depending on the metal being investigated. As water quality investigations progress upstream from receiving waters toward the source of a pollutant, the investigations become inherently more complex, with non-point sources being the most difficult to address. A conceptual diagram representing the urban runoff monitoring is presented on Figure 5-1. This figure shows the progression of monitoring from the receiving waters up to identifiable sources, which were exemplified in this monitoring study. Based on concentrations observed from current and historical receiving water monitoring and source identification monitoring studies, it is evident that concentrations of metals increase with each higher progression in the drainage area studied. Additionally, the closer that monitoring occurs to the sources, the more samples are required to statistically identify the differences between land uses, sources, and activities. While non-point sources are more difficult to identify moving towards the surface street areas, the ability to identify point sources from specific activities and facility structures in these areas becomes better defined. In many cases in Priority Sector 1 of the Chollas Creek Watershed, the land uses were mixed with residences, commercial activities, and industrial activities which occur in the same general areas. Additionally, the drainage structures and flow paths are also more difficult to isolate with respect to targeting specific areas. In some cases, one drain may appear to capture a particular land use or facility from GIS review, but may actually drain a different direction based on field reconnaissance. Therefore, the focused sampling activities included additional data gathering to clearly identify the drainage areas and flow directions from identifiable sources.

The sampling strategy and methods used in this study were effective in identifying and verifying potential sources identified via the data compilation and GIS mapping exercise. This process can serve as a basis for a standardized approach for future targeted source identification studies within the City of San Diego and the Region.

5.1 Conclusions

The following conclusions were drawn from this multi-media water quality study to answer the study questions presented at the outset of this Aerial Deposition Source Investigation Program:

1. **Do high deposition rate areas identified in the Phase II Aerial Deposition Study coincide with high runoff concentrations for copper, lead, and zinc?**

Higher deposition rate areas identified in the Phase II Aerial Deposition Study provided useful information for guiding sampling activities. Sample results collected in Priority Sector 1 had significantly higher copper concentrations in both industrial and residential land uses during wet weather runoff compared with other priority sectors. Total zinc was significantly higher in Priority Sector 1 compared with Priority Sector 2, but was not different from priority sectors 3, 4, and 5. Total lead was not significantly different between any priority sectors.

The results of the annual emission loads reported to the SDAPCD combined with the findings of this report suggest that high deposition rate areas coincide with high runoff concentrations in storm water for copper and zinc.

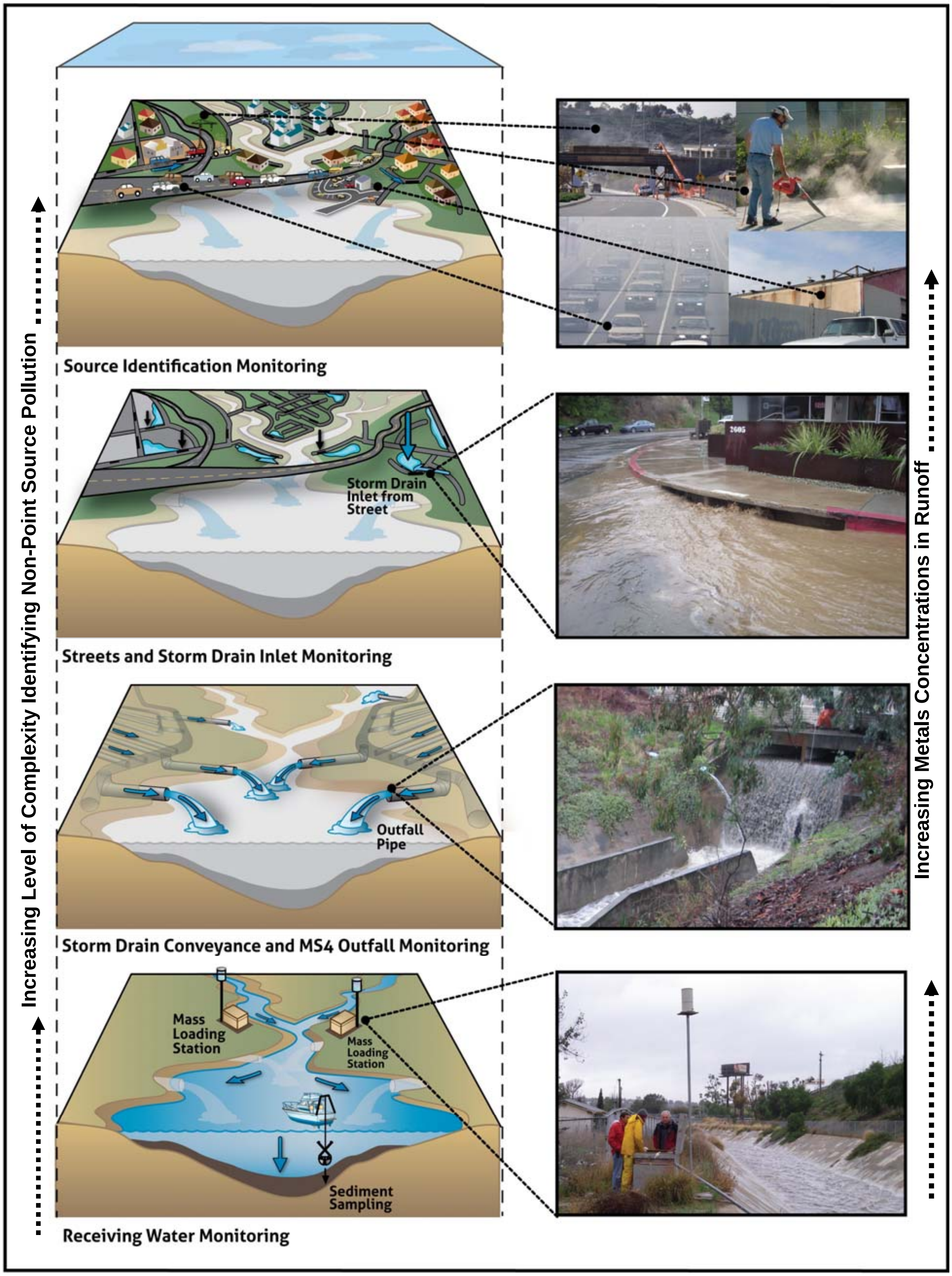


Figure 5-1. Conceptual Diagram of Monitoring Tiers in Relation to Sources

2. How do metals concentrations from residential runoff areas compare to industrial/commercial runoff areas in the same relative aerial deposition area?

Residential drainage areas were sampled in all priority sectors. The drainage areas differed only in their proximity to industrial source areas, but did not capture runoff from any land uses other than residential or surface street areas. Copper was the only metal that was significantly different between land uses by priority sector compared to lead and zinc. Copper was highest in Priority Sector 1 for both commercial/industrial and residential land use drainage areas. Priority Sector 1 residential copper was significantly higher than all other priority sectors residential results. In contrast, zinc and lead were not significantly different. This evidence also suggests that copper from aerial deposition in the heavy industrial areas of Sector 1 may be influenced from stationary facility emissions as opposed to the influence from transportation alone. However, dissolved copper and zinc were still identified as constituents of concern in residential areas when compared to the acute WLAs in the Chollas Creek Dissolved Metals TMDL. Dissolved lead was not detected in levels above the WLA in any of the runoff samples from residential areas.

3. Are some facilities/sites contributing greater runoff concentration of copper, lead, and zinc compared to other facilities/sites?

When the wet weather runoff results of this investigation were evaluated in concert with the emissions data reported to the SDAPCD, it was evident that stationary emission sources near the mouth of Chollas Creek may contribute to the higher copper deposition rates observed in the Phase I Aerial Deposition Study and the Phase II Aerial Deposition Study and subsequently higher copper concentrations observed in Priority Sector 1 storm water runoff.

It is evident that reported emissions of copper, and to a lesser degree zinc, from several facilities near the mouth of Chollas Creek present a continuous source of these metals to the watershed via atmospheric dispersion and deposition. This suggests that sources other than mobile transportation sources of copper exist in this watershed. When compared to transportation sources, the four stationary emission facilities at the mouth of Chollas Creek emit the equivalent amount of copper generated from roughly 6,500,000 vehicle miles travelled per day. This information also suggests that best management practices (BMPs) targeting copper removal will need to consider stationary and mobile emissions sources in their design and management actions. In the event the Brake Pad Partnership legislation (SB346) is passed and copper is banned from the brake pad manufacturing process, stationary emission sources of copper will become a more important area of focus for the Chollas Creek Dissolved Metals TMDL. A conceptual diagram of current copper processes for Chollas Creek is shown on Figure 4-1.

In comparison to modeled annual runoff loads, the annual load of copper returned to the mouth of Chollas Creek in the form of storm water runoff was roughly one-fifth the annual load emitted from four stationary facilities located at the mouth of Chollas Creek (Table 4-1). In contrast, the modeled average annual lead runoff load was roughly ten times higher in storm water runoff than the reported emissions. The modeled average annual zinc load was roughly four times higher than the emissions reported. This suggests that some elements (e.g., copper and zinc) may be influenced from stationary facility emissions, whereas lead likely originates from land-based sources within the watershed (e.g., historical lead from soil erosion, lead based paint from aging infrastructure, or industrial and commercial sources). Since the modeled discharge load is higher than the deposition load, this also suggests that BMPs may be more effective in targeting land-based sources as opposed to emissions sources.

Additionally, copper and zinc loads from mobile emissions play a major role in the annual load contribution to the watershed based on high average daily traffic volumes and the results from emissions factor estimates. The zinc load from emissions sources was highest from mobile sources in comparison to facility emissions or the observed deposition load. The average modeled load of zinc discharged via runoff suggests that zinc sources exist from stationary emissions, mobile emissions (primarily from tire wear), and land-based sources (e.g., metal rooftops, as was observed during the course of this study). The zinc deposition load was approximately one third of the estimated emissions load of zinc, and the modeled runoff load of zinc was higher than the deposition load suggesting other land-based sources are contributing to the zinc runoff load. Studies have shown that tire and belt wear particles make up approximately one third of the vehicle derived particulates in roadway runoff (Councell et al., 2004), which is similar to the concentrations observed in aerial deposition samples within the Chollas Creek Watershed.

Table 5-1. Comparison of Aerial Emissions, Aerial Deposition, and Storm Water Runoff Loads in the Chollas Creek Watershed

Load Type	Total Copper (kg/yr)	Total Lead (kg/yr)	Total Zinc (kg/yr)	Source
Aerial Emissions (stationary facility emissions)	**2,249**	**3**	**753**	SDAPCD. 2009 *SDAPCD Database*. AB2588 Toxics Inventory Hot Spots Program Emissions. Accessed at: http://www.sdapcd.org/toxics/FacEmiss/facilities.html. Data are the minimum required emissions to be reported and may be higher depending on reporting year.
Aerial Emissions (mobile sources)	**2,239***	**0.117***	**7,722***	Rosselot. 2006. *Copper Emissions from BPP*. Process Profiles. 2006 estimates (0.58 mg_{Cu}/km). Zinc Emissions from Councell, 2004 wear rates (0.05 g_{tread}/km-tire*1g_{Zn}/100g_{tread}). Values multiplied CountNet-2003 ADTV of 6,573,173 cars * 365 days per year for the Chollas Creek Watershed. Lead values from EPA emissions estimates.
Aerial Deposition (Measured deposition load estimate)	**455**	**94**	**2,284**	WESTON, 2009. *Aerial Deposition Phase II Monitoring Report*. Conducted 24 dry deposition measurements over a one-year period (2007–2008). Used average median deposition rate from sites SD8(1) and DPR2 (µg/m2/day) X Area of watershed X 350 dry days (estimate of deposition buildup).
Storm Water Runoff	**454**	**322**	**3,102**	Schiff, K. and S. Carter. 2007. *SCCWP Technical Report 513*. Monitoring and Modeling of Chollas, Paleta, and Switzer creeks. Accessed at: ftp://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/ 13_chollas_monitoring_modeling.pdf). April 14, 2007.

*Note: Values do not account for fugitive dust emissions from paved roads.

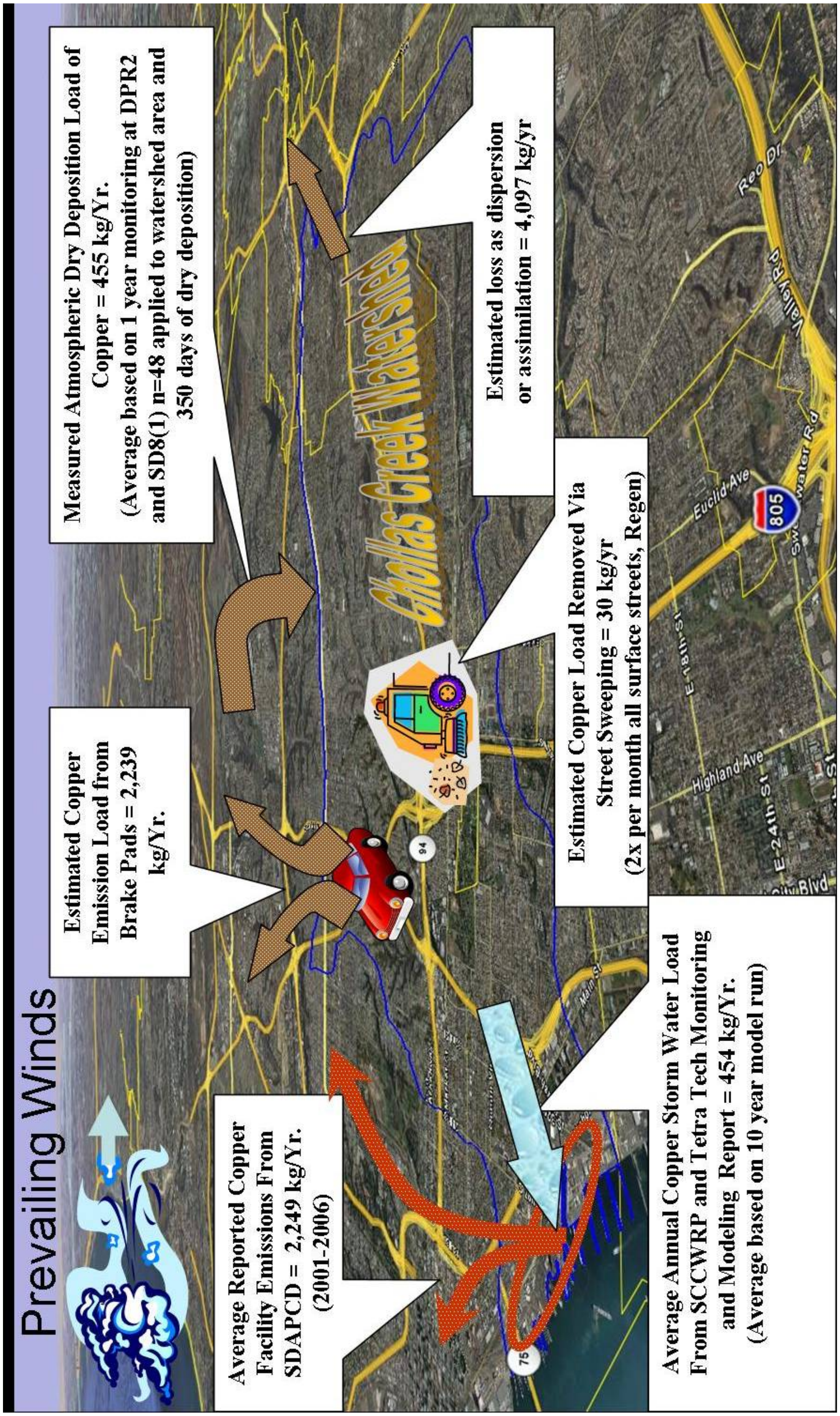


Figure 5-2. Conceptual Diagram of Copper Sources and Transport Processes in the Chollas Creek Watershed

During the course of this study, through visual observations and focused sampling, it is evident that facility structures, various commercial and industrial activities, and outdoor storage also present multiple threats to water quality. High concentrations of copper, lead, and zinc were also identified in areas with observed land-based activities. A Spearman Rank correlation indicated that total copper, lead, and zinc were positively correlated with outdoor metal storage and the number of metal rooftops. Although metal roofs were not identified as a source of copper, the contribution of copper from aerial deposition can explain this correlation. Copper was the only metal correlated with percent impervious area, which suggests aerial deposition as a likely source of copper. This may be associated with the more dispersive nature of finer copper particulates, whereas zinc and lead may be associated with more localized deposition for lead and zinc.

Zinc concentrations from metal rooftops were significantly higher than street level zinc concentrations. Zinc in street level runoff was also highly correlated with the number of metal rooftops (Figure 5-3). Concentrations of zinc in runoff from rusty metal roofs were as high as 500 times the waste load allocation for zinc. Approximately 30 of 162 metal roofs were identified as poor condition in the Chollas Creek watershed commercial and industrial areas, the majority of them occurring in Priority Sector 1. Priority Sector 1 is also one of the oldest and most industrialized areas of the City of San Diego with many World War II era facility structures.

Figure 5-3. Example of Area of Influence on High Zinc Concentrations in Storm Water Runoff from a Commercial/Industrial Drainage Area in Priority Sector 1

Other identifiable sources included uncovered outdoor metal storage and automotive activities. Elevated copper, lead, and zinc results could be explained from a drainage area in Priority Sector 1 with uncovered outdoor metal storage and stained pavement areas from runoff (Figure 5-4).

Figure 5-4. Example of Area of Influence on High Metals Concentrations in Storm Water Runoff from a Commercial/Industrial Drainage Area in Priority Sector 1

Another example of elevated copper, lead, and zinc results from a drainage area in Priority Sector 4 could be explained by the drainage observed from outdoor automotive maintenance activities occurring with no storm water management practices (Figure 5-5).

Figure 5-5. Example of Area of Influence on High Metals Concentrations in Storm Water Runoff from a Commercial/Industrial Drainage Area in Priority Sector 4

5.2 Recommendations

The findings from this report lead to the following recommendations with regard to storm water management and meeting load reductions required by current and future TMDLs in the Chollas Creek Watershed:

- Begin interagency coordination with the staff of the San Diego Air Pollution Control District, Air Resources Control Board, and Regional Water Quality Control Board to address emissions of copper and zinc from stationary facility emissions.
- The City of San Diego will benefit by supporting ongoing legislative efforts with the CASQA Brake Pad Partnership Subcommittee's implementation of Senate Bill 346 (Kehoe). SB346 requires product replacement of copper from the brake pad manufacturing process.
- Consider public-private partnership programs (e.g., maintenance rebates) to renovate rusty galvanized rooftops for metal roofs identified with high zinc loading.
- Consider downspout filters as a potential BMP for metal roofs.
- Implement runoff reduction BMPs in Priority Sector 1 to reduce the effect from impervious areas (e.g., rain barrel retrofit BMPs, porous pavement, or sediment basins).
- Consider additional source investigations for other products (e.g., galvanized pipe drains, fences, and uncovered outdoor metals storage).
- The City of San Diego's storm drain database would benefit from updating and refining the watershed boundary (primarily the border with the Switzer Creek and San Diego River watersheds). Definitions of the boundary do not consider storm drain direction of flow, which may be different from topography. This has implications for BMP project considerations for Chollas Creek.
- Focus on commercial and industrial source control as a priority for metals BMPs.
- It is recommended that tiered BMPs presented in the *Chollas Creek TMDL Implementation Plan* (WESTON, 2009) be implemented with the first tier emphasizing source controls in the high loading areas near the mouth of Chollas Creek and near Commercial Street for BMP focus areas. Pollution reduction measures and source identification studies are also recommended. Source control measures are recommended to be the current focus over storm water treatment BMPs at this phase to reduce loads.

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