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An Existing Conditions and Drought-year Storm-Water Quality Study of Majors Creek: Monterey, CA

Spring 2014

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Executive Summary

The primary objective of this study was to assess the existing conditions of an impaired waterbody in the City of Monterey, California. The goals included in this study were to 1) Determine why Majors Creek was listed on the 303(d) list and outline how to have it removed from this list, 2) Delineate the Majors Creek watershed and use ArcGIS to answer spatial questions about the watershed, 3) Collect water samples to analyze water quality of the Creek during storm-based events and determine pollutant loading, 4) Use the Watershed Treatment Model to analyze potential management and improvement strategies, and 5) Survey stream condition to document the physical condition of the Creek.

Majors Creek is listed on the State's 303(d) List of Impaired Waterbodies for concentrations of zinc, lead, copper, and *Escherichia coli* that exceed water quality standards. Data for which this urban creek was listed were from previous First Flush event sampling. In order to better understand the watershed, water quality, and the creek itself, it is important to have a comprehensive existing conditions evaluation. Knowing the nature of creek flow and land uses with the watershed are central for understanding why this creek is polluted and crucial for choosing appropriate management steps towards to reduce pollutant loads.

We conducted a variety of watershed analyses in order to give the City of Monterey a wide-ranging understanding of Majors Creek. These analyses included: storm water sampling for *E. Coli* and heavy metals, suspended sediment sampling, RTK and topographic surveys, GIS based watershed and land-use analyses, and creek conditions surveys.

This report highlights the major findings from this study and makes recommendations for future studies and action for Majors Creek. The major findings include: concentration levels of 303(d) pollutants above water quality standards, observations that outfall flow from the main sample site is not always from creek flow but sometime from solely street runoff, and that one storm drain on Munras Avenue frequently becomes blocked with debris and diverts additional runoff into the Majors Creek watershed. Future research opportunities for this system could include Total Dissolved verses Total Suspended Solids water sampling or a Hydrologic and Hydraulic Study, and these or other future studies should consider QA/QC procedures, simultaneous water sampling, and a different weather station. Future research may also look into the suspended sediment data from this study, or future studies, to make sure it meets water quality standards. Lastly, some recommendations for Majors Creek and its watershed include: creation of a stakeholder group, additional pet waste education, erosion and sediment control, in-creek structure removal, as well as several treatment options including urban diversion, a treatment wetland, and capture of runoff for irrigation and construction uses. With these findings and recommendations, the City can use this study and its data to move forward in addressing the pollution issues of their urban creek.

Table of Contents

Introduction

1.1 Background

As an effort to better understand the existing conditions of its urban creek systems, the City of Monterey, California contracted a graduate student from the Watershed Hydrology Lab at California State University Monterey Bay to complete a pilot study of Majors Creek. This pilot study is an initial evaluation of Majors Creek's storm-water quality and watershed characteristics that could be used in future management efforts related to Majors Creek. This report presents field data collected during the water year 2013-2014.

Majors Creek was listed on the 303(d) list of impaired water bodies in 2010. This creek's waters were sampled for the annual Snapshot Day event between 2000-2013 by Monterey Regional Storm Water Management Program (MRSWMP) efforts. Also for several years through 2000-2013 the City contracted separately with Maris Sidenstecker to perform additional First Flush and dry weather volunteer monitoring on this creek, over and above the compliance requirements of the MRSWMP. Data from those additional creek sampling efforts identified instances of constituent concentrations above that of water quality requirements for lead, copper, zinc, as well as *Escherichia coli* set forth by California's Water Quality Control Policy, sections 2.1 and 3.1 (Water Quality Control Policy 2004). There are no known prior studies that have looked at Majors Creek runoff during the wet season after a First Flush event. This study fills that data gap by analyzing storm-related water samples collected during the drought winter of water-year 2014.

1.2 Study Area

Majors Creek drains a small north-facing slope on the Monterey Peninsula and flows southwest to northeast through both open channel and manmade systems into the Lagunita Miranda holding pond, and during heavy rain events may overflow into Lake El Estero (Figure 1). The Majors Creek watershed is located mostly within the City of Monterey, but also has some of its headwaters coming from unincorporated Monterey County lands as well as Highway 1 (HWY1) owned by California Transit Authority. The Majors Creek watershed covers 365 acres, with 200 acres within the city boundary. The upper portion of the watershed has an elevation of approximately 800 ft at the south end of the watershed, and the open-channel ends at an elevation of 55 ft. The creek then flows through manmade structures (pipes and box culverts) to the holding pond at its terminus. Runoff delivered to Majors Creek is sourced from both natural slopes and storm-water diversions that transport runoff from neighboring watersheds.

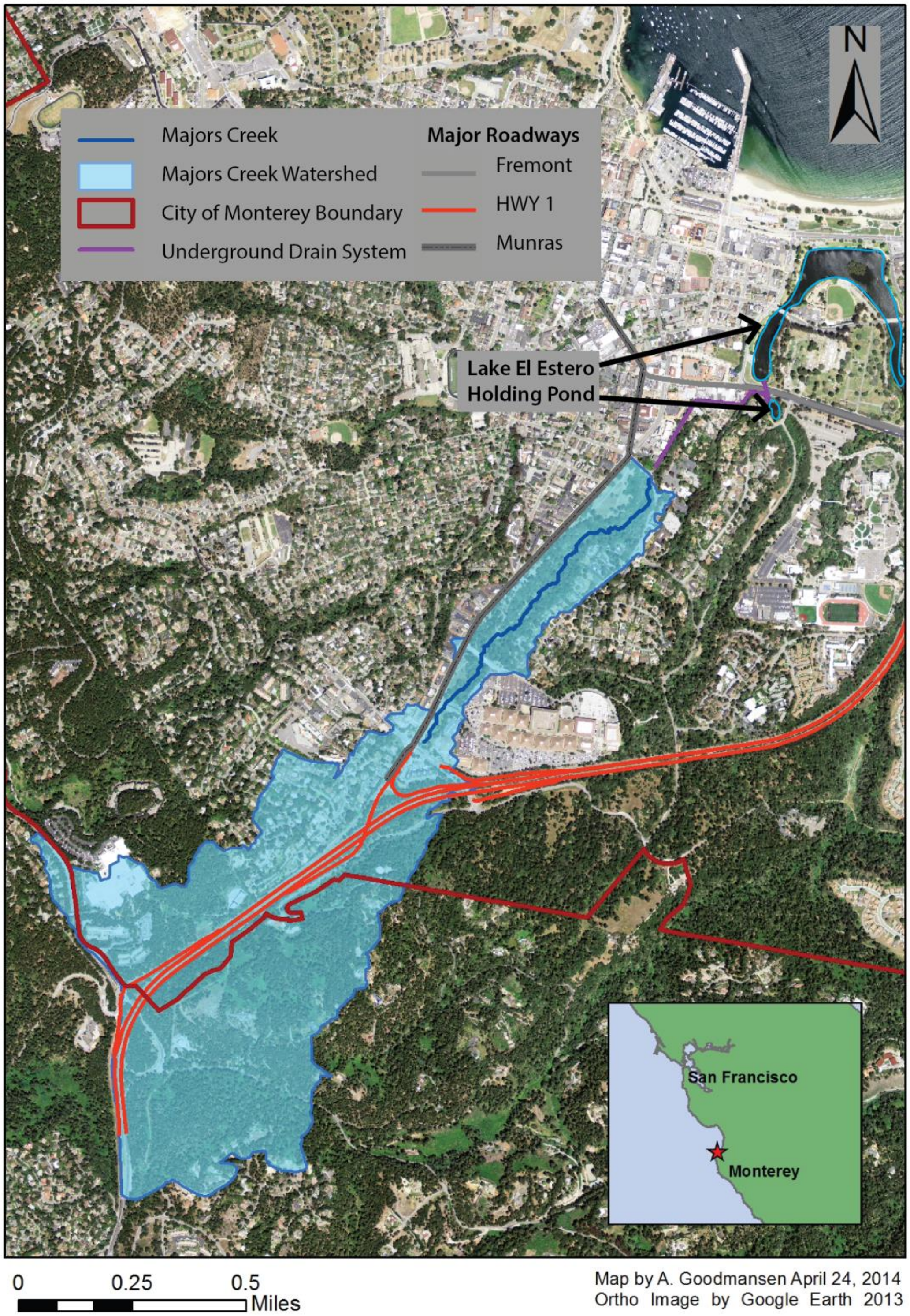


Figure 1. Location map for the Majors Creek Watershed.

1.2.1 Climate

Monterey is situated in a mild Mediterranean climate with cool foggy summers due to its proximity to the Pacific Ocean. This area usually receives around 20 inches of rainfall per year with a wet season lasting from October to April (Table 1). The rainfall in recent years has been lower than this average. The precipitation in 2013 Water Year totaled 11.45 inches, and 11.40 inches fell during Water Year 2012 (Wunderground 2014).

Table 1: Average temperatures and precipitation for Monterey, CA adapted from [WRCC] (2013).

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	59.9	61.3	61.9	63.2	64.3	66.5	67.5	68.8	71.5	70.1	65	60.2	65
Average Min. Temperature (F)	43.4	44.4	45	45.8	47.9	50.2	51.9	52.8	52.8	50.7	46.9	43.6	48
Average Total Precipitation (in.)	4.46	3.32	3.2	1.45	0.5	0.18	0.06	0.08	0.24	0.85	2.07	3.32	19.73
Average Precipiation Days	11	10	10	6	4	3	2	2	2	4	7	10	70

1.2.2 Geologic and Hydrologic Setting

The geological setting has been described by Clark et al. in 1997. The higher elevations of the watershed are underlain by Monterey Formation, shale, and porcelanite from the Miocene. This formation continues until the junction of Munras and HWY1 as well as to the west of Munras where the residential area mainly sits where Monterey Formation semi-siliceous mudstone was found. Artificial fill is located near the on-ramp to HWY1 south and under the Del Monte shopping center. This fill is a mixture of well-compacted sand/silt and poorly compacted sediment. The area of Don Dahvee Park contains semi-consolidated Coastal Terrace deposits overlain by recent overbank deposits. The Creek bed contains small gravel, sand, silt and clay. Locally the creek has exposed porphyritic granodiorite (Clark et al. 1997).

Urban Watershed Setting

The Majors Creek (MC) watershed is located in an urban setting that comprises a variety of land use types including a highway, residential areas, forests and natural park areas. At the top of the MC watershed sits the low-density High Meadows Housing development and thick forests to the southeast, and also the Community Hospital of Monterey Peninsula to the southwest. The watershed then drains the Highway 1 Right-of-Way and urban residential areas. The open-air channel of MC begins as runoff exits a 4 ft metal culvert at the crossroads of Soledad Drive and Munras Avenue. From here the creek flows through Don Dahvee Park for nearly one mile and then exits through another 4 ft metal culvert at the Major Sherman Lane and El Dorado Street intersection in Monterey, where the Creek has been monitored and sampled in past years.

1.2.3 Gas Station Leakage

During the replacement of two 10,000 gallon gasoline storage tanks from the “76” Gas Station on the SE corner of Munras and Soledad in 1995, groundwater and soils samples revealed that gasoline, diesel, and benzene had seeped through the tanks. There have been remediation efforts since 1995 to remove these pollutants from the soil by excavation of the contaminated soils. The most recent excavation was performed in 2013 from August-October, removing soils from the northern portion of the site (AnteaGroup 2013). During the excavation, nearly 2,338 tons of soil was removed. The area was backfilled with 1.5 inch drain rock to a depth of 10 feet and covered with top soil. Nine hundred thirty six pounds of Regenesis brand Oxygen Release Compound Advanced were added to facilitate aerobic biodegradation of any remaining dissolved hydrocarbon plume.

While this soil contamination is important to note as it has likely impacted the groundwater within the Majors Creek watershed, these pollutants were not tested for during the course of this study.

1.3 Previous Studies

First Flush efforts by Maris Sidenstecker and volunteers have been coordinated with and followed the lead of Lisa Emanuelson's contracted work through the MRSWMP Monitoring Program. Past collections of water samples from the MC01 site (previously referred to as 'Jack') were performed by all contractors upon National Oceanic and Atmospheric Administration staff determination that a storm had rained sufficiently to be considered the 'First Flush', which during the 2012-2013 First Flush was when the Monterey Airport rain gauge reported 0.15" of rainfall. Volunteers were then instructed to collect the water samples if the conductivity of the water was at or below 1000 μS, indicating that the runoff was rainwater as opposed to groundwater. Full instructions for the 2013 First Flush can be found in Appendix A. From the conversation with Maris Sidenstrecker, it was determined that the samples were taken directly from the 4 ft pipe culvert below El Dorado Street, which was the MC01 sample site during this study.

Previous data for copper (Cu), lead (Pb), zinc (Zn), and *E. Coil* showed that these pollutants were found to exceed concentration standards a number of times since 2000. Cu has a concentration limit of 30 μg/L and was found in excess on 10 occasions, Pb has a concentration limit of 30 μg/L and was found to exceed this value on 5 occasions, Zn has a limit of 200 μg/L and exceeded this limit on 6 occasions, and *E. Coli* has a limit of 235 MPN/100mL and was found to exceed this limit on 7 occasions during First Flush collection between 2000 and 2011, as can be seen in Table 2. Previous study samples were collected and analyzed for concentration, but no runoff discharge data were included with the sample collections thus no pollutant loading rates were able to be determined.

Table 2: Compilation of the First Flush data for Majors Creek collected for the City (from Sidenstecker to Emanuelson for data upload, 2013). Red bolded values indicate that the pollutant average concentration (two samples 30 minutes apart) exceeded regulatory concentration requirements.

		First Flush Sample by Water Year												
Pollutant	**Not to exceed**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Copper	30 µg/L (ppb)	20	**50**	**110**	**92**	**64**	**41**	**31**	ND	**70**	**36**	**120**	**34**	0
Lead	30 µg/L (ppb)	**35**	ND	12	**36**	6	**43**	11	ND	17	0	**31**	**44**	0
Zinc	200 µg/L (ppb)	50	**450**	**583**	**386**	**299**	**202**	88	ND	197	196	**396**	109	18
E. Coli	235 MPN/100mL	**326**	200	20	ND	17	**260**	**405**	**2100**	**270**	**461**	200	100	**287**

1.4 Goals

Due to the short duration of this study (Spring 2013 to Spring 2014), the goals include one overall objective served by several subtasks.

Overall Goal: Assess the current condition of Majors Creek and its watershed as an existing conditions study that can assist the City of Monterey on their goal of improving the water quality of Majors Creek.

Subtasks for study:

1. Determine why Majors Creek was listed on the 303(d) list and outline how to have it removed from this list
2. Delineate the Majors Creek watershed and use ArcGIS to answer spatial questions about the watershed
3. Collect water samples to analyze water quality of the Creek during storm-based events and determine pollutant loading
4. Use the Watershed Treatment Model to analyze potential management and improvement strategies
5. Survey stream condition to document the physical condition of the Creek

These subtasks were complete for the 2013-2014 water year, and the methods and results for each of these tasks are provided by this report.

2 Methods

2.1 303(d) Review

To determine the conditions under which Majors Creek was listed as a 303(d) impaired water body, a variety of interviews and a literature review were conducted. The primary interview was held with Lisa Emanuelson, the Volunteer Monitoring Coordinator at the Monterey Bay National Marine Sanctuary, who has been in charge of the regional First Flush sampling efforts and provided the framework utilized by Sidenstecker and volunteers to collect water samples for the City at Majors Creek. Emanuelson (2013) provided information on the methodology used to collect First Flush water samples, which was the same methods used for the Majors Creek locations (later known as sample location MC01) as well as the sampling data. Additional interviews were held with Chris Rose (2013), Maris Sidenstecker, and Jennifer Epp (2013). Listing data and requirements were obtained from the State Water Resources Control Board ([SWRCB] 2013).

2.2 Watershed Delineation

When analyzing a water body it is critical to know the extent of the land that it drains. To date, the only known watershed delineation of the Majors Creek watershed had been done using a topographic map. ArcGIS (ESRI 2013) was used in several spatial analyses.

2.2.1 Watershed Boundary

Light Detection and Ranging (LiDAR) elevation data of the Monterey Peninsula area from AMBAG GIS (2010) with 10-meter resolution was used to delineate the Majors Creek watershed. As Majors Creek is not only fed by natural flow direction, GIS layers for storm drains provided by the City of Monterey were incorporated into the analysis (Semple [Date Unknown]). In addition to the storm drains that were intended to divert storm water into the Creek, the potential for drains to get blocked and inadvertently contribute runoff into the watershed was also considered. In such cases, these drains were added to the watershed delineation. Figure 2 shows the ArcGIS flowchart for delineating the Majors Creek watershed.

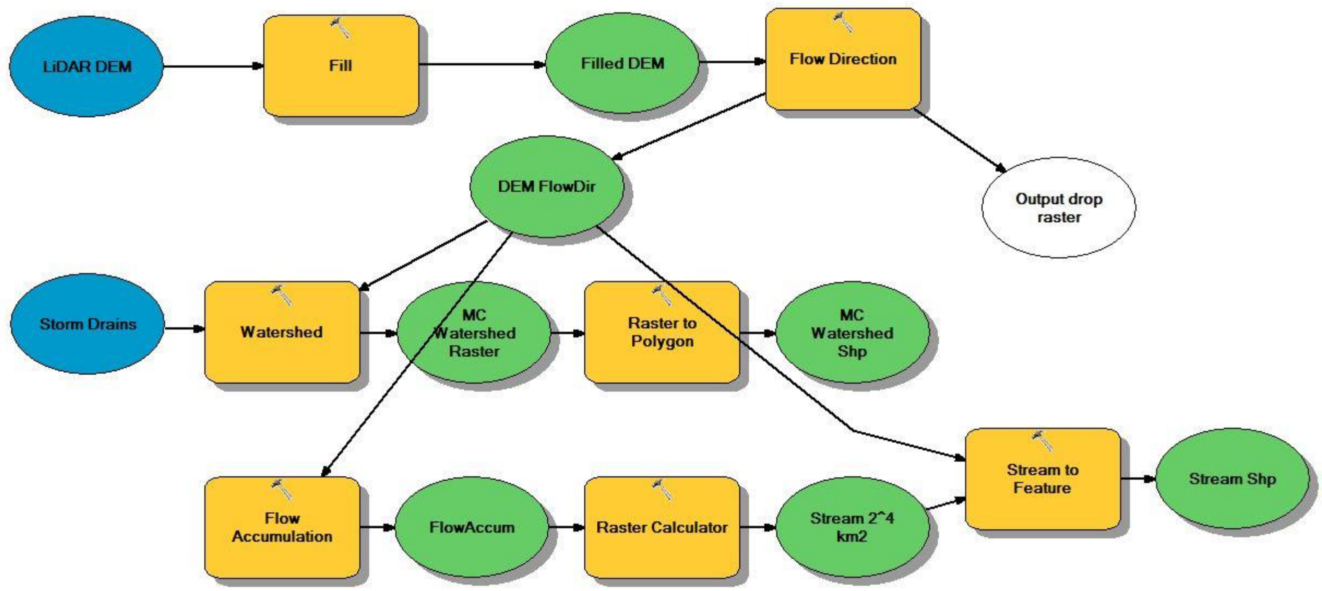


Figure 2. ArcGIS model used to delineate the Majors Creek watershed.

2.2.2 Land Use

The City of Monterey provided General Plan Use GIS layers that were used to determine the land use within this urban watershed (Semple [Date Unknown]). As some of the watershed was outside of city boundaries, it was necessary to digitize land use types using an ortho-imagery background, acquired from Google Earth (2013). ArcMap's Erase and Merge tools were used in this analysis.

2.3 Event-Based Storm Water Sampling

Storm water samples were collected from three locations along the open-channel section of Majors Creek at MC01, MC018, and MC02 (Figure 3). The majority of the sampling occurred at MC01 since that was the lower extent of the listed 303(d) creek, and the point of known impairment. Runoff from MC02 and MC018 were sampled to gain better understanding of water quality in upstream reaches of Majors Creek.

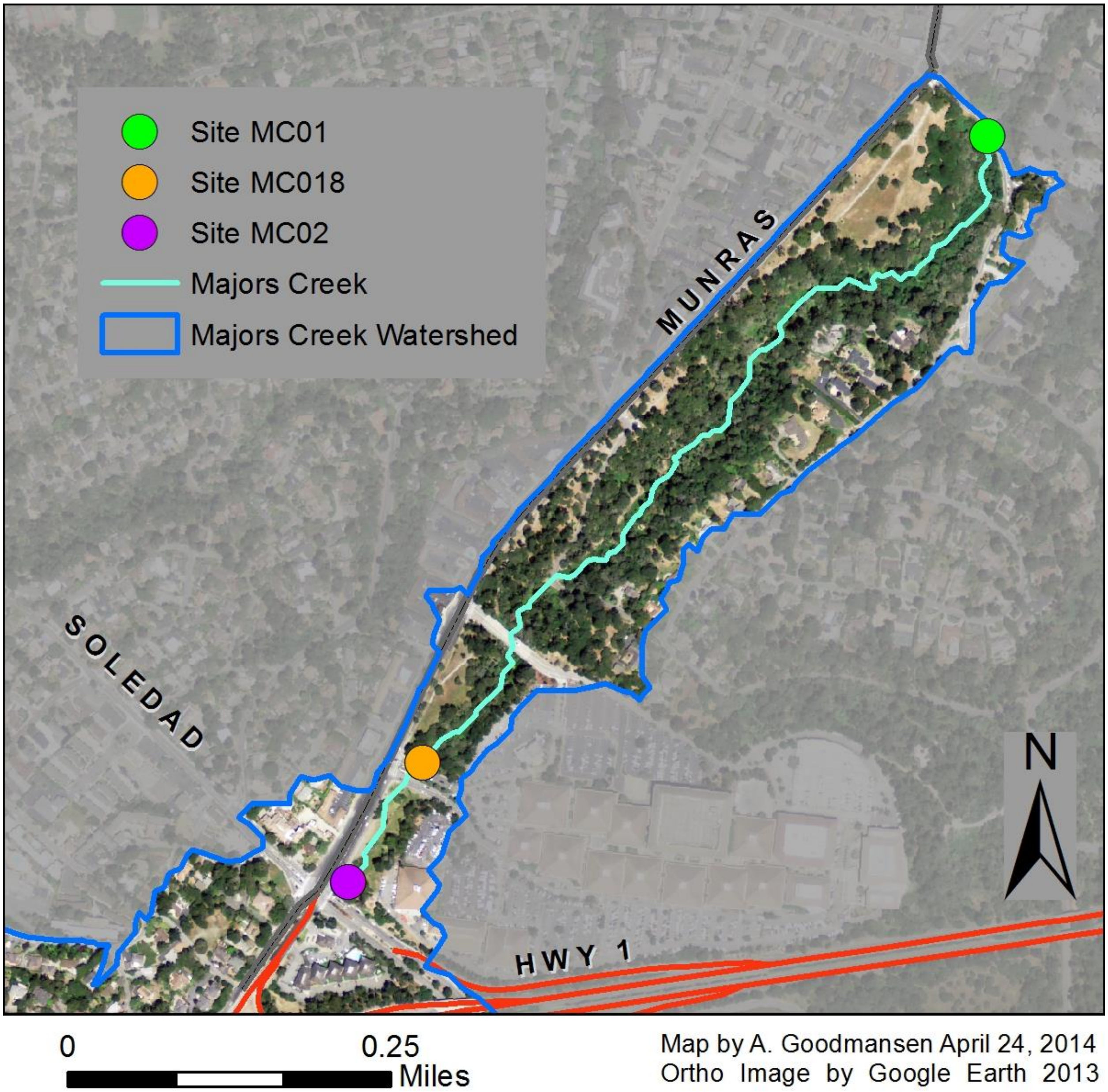


Figure 3. Storm water sampling locations.

Sample sites were all located at hydraulic control points, as suggested by Harmel et al. (2006) since this diminishes the chances of discharge changes due to morphological changes in natural channels. Additionally, the discharges from storm water are measured most accurately when sampled from a man-made flow control structure (USEPA 1992). Each sample location was at a culvert outfall. Pictures of the sample locations are shown in Figure 4 below.

Figure 4: Photographs of the sample location culvert outfalls.

A pressure transducer gauge was considered for installation in the Creek but not installed because of potential equipment loss risk in the urban park, and because of runoff complexity along the study reach. Runoff from Munras Avenue at El Dorado Street, which should typically flow into a different watershed, was found to enter this drainage system when the drain inlet on Munras Avenue was blocked. At these times, the water bypasses the drain inlet and flows to a street inlet at the low point in El Dorado Street that is directly connected to the creek culvert under El Dorado Street, exiting at MC01. These additional flows would have been missed by a standard stream gage installation if located above the MC01 culvert sampling point.

Discrete discharge samples were collected with a 5 gallon plastic bucket using the direct capture method. In high-flow cases only a portion of the flow was captured and the percent of runoff captured was noted. Water discharges were measured to the nearest tenth of a gallon per second using the graduated scale on the side of the bucket. In low-flow situations, discharge was measured in milliliters/second and then converted into gallons/second. Discharge was measured three times throughout sampling then averaged. Multiple discharge samples were collected during a range of runoff stages throughout different precipitation events from February 2014 through March 2014.

In order to collect water samples that would be analytically comparable to those collected by previous effort, we produced storm water sampling instructions (Appendix B) that attempted to duplicate those of the Sanctuary's First Flush methods (Appendix A). This study included one important step in collecting runoff samples that was not incorporated into the Sanctuary's methods. Prior to sample collection, samplers were instructed to inspect the inlet of the MC01 culvert in order to determine if Majors Creek itself was flowing into the culvert (Figure 5). If the Creek was not flowing into the culvert, samples would not be taken. This is an important additional step as it reveals whether water sample collected are from Majors Creek flow, which is the listed impaired water body, or if the water samples are from direct runoff from Munras Avenue and El Dorado Street. In addition to the water quality parameter detailed below, additional water quality parameters were typically measured and included pH, conductivity, water temperature, and nutrient samples.

Figure 5: Inlet to the MC01 Culvert when Majors Creek was flowing on April 6, 2013.

Precipitation data from a rain gauge at Monterey Airport (KMRY) were downloaded from Wunderground (2014). This rain gauge is located approximately 4 miles west of the Majors Creek watershed. Weather data were in hourly observations, with sub-hourly unscheduled observations taken during weather events. Precipitation data were downloaded and compiled to show half-hour weather observations during rain events.

2.3.1 Heavy Metal Sampling

Pollutant sampling, such as that for heavy metals can be achieved by taking discrete samples then described by discrete concentration or by Event Mean Concentrations (EMC) (Driscoll et al. 1990). The equations for determining EMC is:

$$EMC = \frac{Total\ Pollutant\ Loading\ per\ Event}{Total\ runoff\ volume\ per\ event} = \frac{\sum_{i=1}^{n} V_i C_i}{V}$$

where *EMC* = event mean concentration (mg/L), *V* = total storm water runoff volume per event (L), V_i = runoff volume proportional to the discharge rate at time *i* (L), C_i = pollutant concentration at time *i* (mg/L), and *n* = total number of samples per storm (Maniquitz et al. 2010).

Loads for pollutants were calculated by multiplying the EMC by total volume of storm water runoff per storm. While more complicated equations exist for pollutant loading that include land-use, storm length, and period between storms, such as described in Torres (2010), this initial watershed study focused on the EMC to load calculation. Instantaneous loading rates were also determined for constituents.

For this study copper, zinc, and lead Total Suspended Solids samples were collected in sample bottles provided by Monterey Bay Analytical Services (MBAS). Samples were taken after Creek discharge was determined, with further protocol as described in methods in Appendix B. Samples were collected along with discharge in order to determine load of pollutants.

Some duplicate samples were collected then filtered in order to have Total Dissolved Solids (TDS) metals samples, as suggested by Rose (2013). Heavy metals, such as the ones found in Majors Creek, tend to attach to sediment and are thus usually found in higher concentrations when water samples contain suspended sediment (Rose 2013). These samples were collected in plastic sediment bottles provided by CSUMB and then filtered in the CSUMB Hydrology Lab using *Whatman* Glass Microfiber Filters (GF/F 0.7 μm and 934-AH1.5 μm) via vacuum filtration. All samples were delivered to the MBAS laboratory within a timeframe that upheld the QA/QC guidelines (USDA 1996). Data were received from MBAS and imported to Excel spreadsheets and were combined with discharge data (volume/time) in order to calculate pollutant discharge (mass/time) and loads.

2.3.2 *E. Coli* Sampling

Several *E.Coli* samples were collected from the MC01 sample site. Samples were collected in bottles provided by MBAS. After sampling, bottles were placed in an ice-filled chest and were returned to the laboratory within a timeframe that upheld the QA/CA guidelines and were analyzed by MBAS.

2.3.3 Sediment Sampling

Suspended sediment concentrations were measured using direct capture method from MC01, MC02, and MC018 sample locations. Suspended sediment samples were processed in the CSUMB Hydrology Laboratory *Whatman* Glass Microfiber Filters (GF/F 0.7 μm and 934-AH1.5 μm) via vacuum filtration in order to yield a suspended sediment concentration (SSC) (mass/volume). SSC were combined with discharge data (volume/time) in order to calculate suspended sediment discharge (mass/time). Data was input into excel spreadsheets to calculate loads.

2.4 Watershed Treatment Model

Parameters from the Majors Creek watershed were added to the Watershed Treatment Model (WTM) 2013 Off the Shelf Edition (WTM 2013). The WTM comes as an Excel Spreadsheet with specified cells used to input watershed data, and other cells which are un-editable that contain calculations used to analyze pollutant loads and treatment options. Data inputs came from a variety of sources, including ArcMap geospatial analyses, communication with City officials, as well as some internet sources. A full summary of data input and rational can be found in Appendix D. All required input fields had values added to them with the exception of the fields within the 'New Development' Tab, as this study did not assessing future development impacts on this watershed.

The most important aspect of this WTM analysis was to determine the effect that future storm water treatment options would have on storm water runoff in Majors Creek. The future practices that were chosen for inclusion in this model were: erosion and sediment control, impervious cover disconnection program, stream restoration, pet waste education, street sweeping, riparian buffers, and storm water retrofit (dry extended detention pond and wetland). These treatment practices were chosen as potential options that could be useful in this small urban watershed.

2.5 Stream Surveys

Several stream surveys we conducted during the course of this study. Surveys included monitoring of physical characteristics, human use, storm drain and culvert inventories of Majors Creek and within the watershed. Surveys were done by Andrea Goodmansen along with the following people on separate surveys: Dr. Doug Smith, Tricia Wotan, Kevin Anderson, Jeff Krebs, John Silveus, and Jessica Blakely.

2.5.1 Knickpoint Evaluation

Two knickpoints were observed at the beginning of this study in the Whole Foods Reach of Majors Creek. Knickpoints are physical expressions of a creek's attempt to reach an equilibrium when there have been hydrological changes upstream (Riley 1998). Knickpoints are also known to migrate upstream through headward erosion, a process that releases sediment downstream. Due to their tendency to migrate, it is a good practice for them to be stabilized through grade control measures, or monitored especially if their migration could interrupt human infrastructure.

A Real Time Kinematic (RTK) survey of this reach was conducted on December 19th, 2013 by Jessica Blakely, Alex Snyder, and Andrea Goodmansen. One rebar benchmark was placed along the cement path near Munras Ave (E 598315.259, N 4049293.059). A thalweg survey of the channel was conducted by CSUMB's ENVS460 class on February 21, 2014 and then again by John Silveus and Andrea Goodmansen on March 5, 2014. The knickpoint is believed to have migrated in the early morning hours of the rainstorm on February 28, 2014.

The field data were then imported into ArcGIS (2013). The RTK data were used to determine the 'mask' for the area of the creek bed. The two thalweg surveys were converted into Digital

Elevation Models (DEMs) using the IDW gridding tool. These DEMs were used in the Raster Calculator along with the mask to calculate the change in elevation of the creek bed. The Raster Calculator was used again to determine the volume of sediment displaced by the movement of the upstream knickpoint.

2.5.2 Outfall Inventory

Outfalls that contribute drainage to Majors Creek were inventoried, described, and photographed.

3 Results and Discussion

The study results are organized in the following sections: 303(d) Review, Watershed Delineation, Event-based Sampling (pollutant loading), Watershed Treatment Model, and Stream Survey. All conclusions presented here should be considered preliminary due to the short duration of this study. Watershed processes are variable on the decadal and longer timeframe. Averages that are based upon a drought year, in particular, should not be used for generalizations. Long term hydrologic averages are suspect in Central California if they do not include El Niño Events as well.

3.1 303(d) Review

Literature research revealed that there are several steps to creating Total Maximum Daily Loads (TMDL), which is the process required to remove Majors Creek from the 303(d) list of impaired water bodies. The steps to produce a TMDL include (TMDL 2001):

1. <u>Creating Stakeholder Involvement:</u> Stakeholders become involved with the TMDL development process through local groups that work with the Regional Water Quality Control Board staff. Their involvement can include efforts to figure out how to implement new management approaches throughout the community.
2. <u>Water Body Assessment:</u> Determine pollutant sources and loads as well as their overall effect on the water body. At this step, it may be possible to demonstrate, with an adequate amount of data, results and analyses, that the creek could be de-listed. However, assuming this is not possible, the next steps may be necessary.
3. <u>Develop Allocations:</u> Based on Step 2, pollutant load allocations are determined. The developed TMDL may address a single pollutant or many pollutants. The allocations should be designed in a way that the water body will be able to meet water quality standards.
4. <u>Develop an implementation plan:</u> This plan will describe the approach and various activities required to ensure that the prescribed allocations are met.

5. Amend the Basin Plan: Prior to the TMDL becoming enforceable, it must be incorporated into the appropriate Basin Plan by amending the Basin Plans in accordance with state law. If the TMDL is not incorporated into the Basin Plans, there will be no legal standing under state law and thus not enforceable by Regional Boards. The Basin Plans amendments require approved from the appropriate Regional Bard, the State Water Resources Control Board, and the Office of Administrative Law, and the U.S. Environmental Protection Agency Region 9. A public hearing process is used for the Regional Board and State Board steps in the process.

Portions of Step 1 and 2 seem to have been met for the Majors Creek watershed through past volunteer monitoring/sampling efforts and this existing conditions study. The next phase to developing Step 1 further could include educating local jurisdictions, agencies, and residential and commercial landowners within Majors Creek about the drainage issues and attempt to gain interest in the health of this local urban watershed and creek. This effort could involve members of the residential community as well as directors from CHOMP, the Del Monte Center, CalTrans, and other businesses contained within the Majors Creek watershed. This stakeholder group could develop innovative action plans that could be applied throughout the watershed to help reduce pollutant loads as well as increase pollution awareness to their neighbors.

The Step 2 Water body assessment is under study as a part of this effort and further research could take place by the City and stakeholders to more fully assess this drainages conditions. Although this study will provide some background information applicable for Step 2, it is a preliminary examination of existing conditions and thus, some suggestions for future studies are mentioned in the following *Major Findings and Recommendations* sections.

3.2 Watershed Delineation

3.2.1 Delineation

GIS analysis found the watershed for Majors Creek using both natural slope as well as storm drain diverted areas. There was one storm drain, at the southeast corner of Munras and El Dorado that was found to be blocked with debris during multiple storms that led to runoff being diverted into the Majors Creek watershed (Figure 6). This drain and its sub-watershed (approximately 1 acre) were then included in the Majors Creek watershed delineation. From the analysis, we found that Majors Creek watershed has an area of 365 acres. The open-air reach of Majors Creek was determined to be 0.97 miles long, but this could not be ground-verified due to dense vegetation in portions of the Creek. Of the total watershed area, 200 acres were within the City of Monterey boundary, leaving 165 acres in Monterey County land.

Figure 6: Storm drain at SE corner of Munras and El Dorado intersection blocked with debris during Feb 28th rain event. Runoff was rerouted past the drain, down El Dorado Street, and into the storm drain that feeds into the MC01 culvert.

3.2.2 Land use

The analysis of land use types resulted in the can be seen in Figure 7. Five land use types were identified and calculated to have the following areas within the Majors Creek watershed:

- Forest/Open Space: 199.5 acres
- Roads: 64.9 acres
- Low Density Residential: 63.8 acres
- Commercial: 34.7 acres
- Medium Density Residential: 1.5 acres

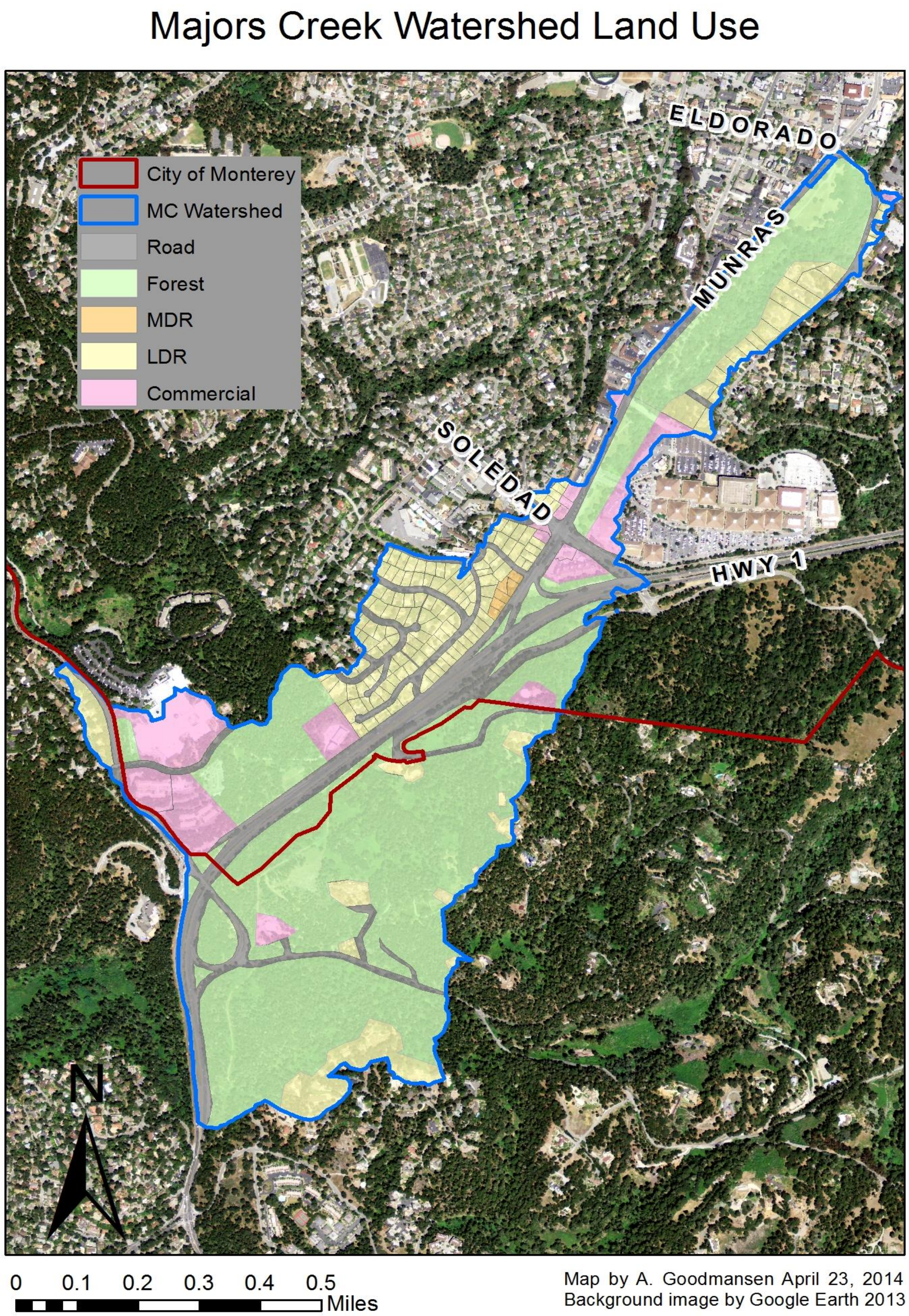


Figure 7: Land use within the Majors Creek watershed. Majors Creek flows from the southwest to the northeast.

The largest land use type found within this watershed was Forested/Open Space. The headwaters of the watershed are found in a forested area with sparse houses. Also, the entire lower reach of the watershed again contains open space (area to the NW of the Munras/Soledad intersection as well as the Frisbee Golf-Course at the NW corner of the watershed) in addition to the forested Don Dahvee Park, which contains the 0.97-mile long creek. It is assumed that these open spaces, especially the Don Dahvee area, would be able to help reduce peak storm water runoff volumes through soil infiltration. Additional information about this area can be found in the *Stream Survey* section.

Roads were found to be the second largest land cover type within the Majors Creek watershed. 27 acres of Roads within the watershed were determined to be Highway 1 or Highway on/off ramps, and 20 of those acres are within the city boundary. Traffic data from the Division of Traffic Operations of the State of California (2012) were collected and can be seen in Table 3 and Table 4. These traffic volumes can be applied to the specified areas of roadway and are useful in understanding traffic conditions within the watershed.

Table 3: Average Daily traffic for Highway 1, estimated in Year 2012.

Road Segment	Postmile	# of Automobiles
Junction RTE. 68, Carmel Pacific Grove	75.135	540,000
Monterey South City Limits	75.733	540,000
Monterey, Munras Ave	75.754	520,000

Table 4: Average Daily traffic for years 2005, 2007 and 2010 for Highway 1 On/Off ramps.

		# of Automobiles		
On/Off Ramp	**Mile Post**	**2005**	**2007**	**2010**
Northbound, Offramp to Route 68W	74.920	6060	5800	5800
Northbound, Onramp From Route 68W	75.010	13900	11900	13100
Southbound, onramp from Route 68W	75.034	6470	6000	6200
Southbound, offramp to Route 68W	75.320	14600	13100	14300
Northbound, Offramp to Route 68W	76.600	9450	8800	9700
Southbound, Onramp from Munras/Soledad	75.640	9620	9100	10400
Soledad Drive Southbound Offramp	75.980	260	300	360
Munras Ave Southbound Offramp	75.990	8990	8800	8700
Soledad Drive Northbound Onramp	76.180	9010	8950	8500

This area of roadway and the amount of traffic going through the Majors Creek watershed is important to consider due to their potential to contribute to the of heavy metal constituents found in Majors Creek. One study of California Highway runoff found that Average Annual Daily traffic was positively correlated to higher constituents including zinc, lead, and copper (Kayhanian et al. 2007). Roadways have the potential to accumulate these pollutants until they are washed away by First Flush and other rain events.

The majority of the residential area, located in the western center of the watershed, was found to be Low Density Residential units. This neighborhood is situated on a steep sloping hill with narrow roadways. Gobel et al. discuss how roof surfaces use different metal materials including zinc and lead, for roof covering, in gutters, and for down spouts (2007). These metals have the potential to be leached due to corrosion processes of low pH rainwater. Thus, heavy metal constituents found in Majors Creek runoff have the potential of being sourced from these residential areas.

3.3 Storm-based Sampling

The precipitation conditions throughout the course of this study were not typical for the region. Governor Brown declared that California was in a state of drought on January 17, 2014. This study took place in the 2014 WY, which had 8.4 inches of precipitation recorded at Monterey Airport from October 2013 through April 2014 (Wunderground 2014).

While there were several rain events between October 2013 and January 2014 (3.2 inches), Majors Creek did not flow into the MC01 culvert until February 6, 2014. The Sanctuary conducted their First Flush sampling across the Monterey Bay region on October 28th and again on November 20th 2013 (Emanuelson and Hoover 2014). On both of these occasions Majors Creek was observed to be flowing upstream at the MC02 culvert, but downstream the creek was dry and not flowing into the MC01 culvert. However, the MC01 sample location did have observed water discharge. This runoff was tracked and determined to be direct runoff from El Dorado Street and Munras Avenue including runoff that was redirected around the Munras/El Dorado storm drain. If this drain had not been blocked, it can be assumed that this runoff would have been diverted into the drain and routed to a neighboring watershed. Had this study's sampling instructions not included checking to determine if the Creek was flowing into the MC01 culvert, these runoff events would have been sampled and analyzed for pollutants, but would not have been representative of the Majors Creek watershed. In addition, prior efforts may not have made the extra effort necessary of checking if the Creek was flowing. To ensure accurate assessment of the Majors Creek watershed pollutants discharge during a first flush event it is crucial to exclude storm water runoff from Munras Avenue by unblocking the storm drain debris as well as determining whether or not the Creek itself is flowing into the MC01 culvert. We recommend that in future, methodology for sampling should be more science based, to help better determine where pollutants are being sourced.

This discrepancy in sampling techniques was realized and water samples from MC01 were collected on February 2, 2014, when discharge from MC01 was determined to be runoff from the El Dorado and Munras roadways with no runoff coming from the Creek. This study's First Flush sample was collected on February 6, 2014, when Majors Creek was observed to be flowing into the MC01 culvert.

Water samples were taken on nine separate days during the course of this study. Graphs of precipitation and runoff discharge can be seen in Appendix C. Figure 8 shows Andrea Goodmansen collecting sample from sample site MC01.

Figure 8: Samples being collected by Andrea Goodmansen from MC01 on February 26, 2014.

Samples were processed for Total Suspended Solids metals analysis (n=30), Total Dissolved Solids metals analysis (n=4), *E. Coli* (n=4), and suspended sediment (n=33). See Table 5 for metals and *E. Coli* data. Zinc was found to exceed concentration limits in 5 samples, with 4 of those 5 samples under conditions were the Creek was flowing (Creek Flow). Lead exceeded concentration limits in 10 samples, all of which occurred during Creek Flow. Copper exceeded concentration limits in 11 samples, where 9 of them occurring during Creek Flow. Finally, *E. Coli* exceeded water quality concentration limits in 2 samples collected during the rain events season.

Table 5: Complete table of Total Suspended Solids concentration results for heavy metals and *E. Coli* results for samples collected between June 2013 to March 2014. Red bolded numbers represent samples that exceeded water quality limits.

			Total Suspended Solids (ug/L)			Bacteria: *E.Coli*	Discharge	Sediment	Conductivity	Temperature	pH	Note
Date	Time	Site	Zinc	Lead	Copper	(per 100mL)	Q (L/s)	Susp Sed (g)	(uS)	(Degrees F)		Storm Series
6/11/13	14:45	MC01	ND	ND	ND	1	0.027	0.0018	-	-	-	(Base Flow)
6/11/13	15:15	MC02	10	ND	ND	66	0.080	0.0003	-	-	-	(Base Flow)
2/2/14	11:58	MC01	**228**	10	**42**	-	0.795	0.0507	290	49.8	6	road runoff
2/2/14	12:36	MC01	195	10	**35**	-	0.336	0.0290	280	49.1	6	road runoff
2/2/14	13:08	MC01	153	6	24	-	0.348	0.1119	300	48.6	6	road runoff
2/2/14	13:50	MC01	165	9	27	-	0.607	0.0366	270	49.3	6	road runoff
2/2/14	14:15	MC01	124	5	20	-	0.275	0.0100	500	49.1	6	road runoff
2/6/14	11:10	MC01	126	**55**	24	1220	17.994	0.0606	520	49.4	6	1st creek flow
2/6/14	11:55	MC01	109	**32**	18	-	7.583	0.0515	620	49.4	6	1st creek flow
2/6/14	12:15	MC01	80	20	15	-	3.681	0.0187	740	49.6	6	1st creek flow
2/6/14	12:45	MC01	78	14	14	-	4.771	0.0192	850	49.8	6	1st creek flow
2/6/14	13:15	MC01	73	10	12	740	6.190	0.0278	960	49.8	6	1st creek flow
2/21/14	13:00	MC02	69	ND	4	-	0.055	-	-	-	-	baseflow
2/26/14	10:00	MC01	**243**	**53**	**130**	-	2.368	0.1939	210	55.1	6	
2/26/14	11:00	MC02	182	12	**56**	-	1.340	0.4212	370	55.2	6.5	
2/26/14	15:45	MC02	**201**	**58**	**53**	-	56.677	0.0976	140	56.5	7	
2/26/14	16:00	MC018	**232**	**174**	**61**	-	56.677	0.0693	140	56.5	7	
2/26/14	16:30	MC01	110	**66**	**31**	-	41.798	0.0107	310	55.5	7	
2/26/14	18:00	MC01	128	**94**	**34**	-	46.722	0.0075	470	55.2	6.5	
2/27/14	10:45	MC01	40	ND	5	-	1.851	0.0024	1740	52.5	7	
2/27/14	11:20	MC02	101	ND	12	-	0.227	0.0433	860	55.6	7	
2/28/14	9:00	MC02	134	**41**	**32**	-	15.258	0.0131	140	53.5	6.5	
2/28/14	9:30	MC01	116	**41**	20	-	36.305	0.0639	560	54.0	7	
2/28/14	14:00	MC02	163	12	18	-	4.104	0.0136	490	55.4	7	
3/3/14	22:45	MC01	19	ND	5	-	0.555	0.0056	1680	52.4	7	
3/29/14	15:30	MC01	97	5	22	-	2.778	0.0260	210	64.1	7	
3/29/14	15:30	MC01b	97	5	19	-	2.778	-	210	64.1	7	duplicate
3/29/14	15:45	MC018	**266**	**85**	**38**	-	3.749	0.1671	150	63.0	7	
3/29/14	16:00	MC02	88	12	**30**	-	9.076	0.0102	150	60.5	7	

3.3.1 Heavy Metal Load Analysis

Zinc: Average EMC for zinc was found to be 0.119 mg/l during storm events where Majors Creek was flowing (from storms on February 6, 2014 and February 26, 2014). The total estimated load of zinc over the 7 storms that produced storm water runoff was calculated to be 387,815 mg (Table 6). The baseline zinc discharge when runoff had a conductivity above 1000 μS was found to be 0.0295 mg/l (n=2). The EMC of zinc runoff from the El Dorado/Munras road runoff was calculated from the February 2, 2014 storm was calculated to be 0.18 mg/l, with a load of 1,466 mg estimated for that event.

Lead: Average EMC for lead was found to be 0.075 mg/l during storm events where Majors Creek was flowing (from storms on February 6, 2014 and February 26, 2014). The total estimated load of lead over the 7 storms that produced storm water runoff was calculated to be 244,742 mg (Table 6). The baseline lead discharge when runoff had a conductivity above 1000 μS was not high enough to be detected (n=2). The EMC of lead runoff from the El Dorado/Munras road runoff was calculated from the February 2, 2014 storm was calculated to be 0.0086 mg/l, with a load of 68 mg estimated for that event.

Copper: Average EMC for copper was found to be 0.032 mg/l during storm events where Majors Creek was flowing (from storms on February 6, 2014 and February 26, 2014). The total estimated load of copper over the 7 storms that produced storm water runoff was calculated to be 102,775 mg (Table 6). The baseline copper discharge when runoff had a conductivity above 1000 μS was found to be 0.005 mg/l (n=2). The EMC of copper runoff from the El Dorado/Munras road runoff was calculated from the February 2, 2014 storm was calculated to be 0.032 mg/l as well, with a load of 255 mg estimated for that event.

Table 6: Event concentration mean (EMC) and estimated Load for zinc, lead, and copper in Majors Creek during 2014 winter storms. Bolded dates indicate storms where samples were taken to calculate EMC, other dates have largely estimated concentrations.

Storm	Total Runoff	EMC (mg/L)			Load (EMC*Runoff) (mg)		
	(l)	Zinc	Lead	Copper	Zinc	Lead	Copper
2/2/14	7973	**0.18393**	**0.00857**	**0.03193**	1466	68	255
2/6/14	550771	**0.11423**	**0.04341**	**0.02103**	62912	23910	11581
2/7/14	32400	0.11922	0.07515	0.03157	3863	2435	1023
2/26/14	560152	**0.12421**	**0.10690**	**0.04211**	69577	59878	23587
2/28/14	993248	0.11922	0.07515	0.03157	118414	74646	31354
3/1/14	705600	0.11922	0.07515	0.03157	84121	53029	22274
3/26/14	66903	0.11922	0.07515	0.03157	7976	5028	2112
3/29/14	343504	0.11922	0.07515	0.03157	40952	25816	10844

Instantaneous loading rates for each constituent were also calculated, and can be seen in seen in the following graphs, Figures 9, 10, and 11 as well as in Table 7. These graphs show how in nearly all instances loading rate for each constituent decrease after the peak water discharge sample during both the February 2nd and 26th storms. In contrast, the zinc loading rate increased between 16:30 and 18:00 during the February 26th storm, where as copper and lead both showed lower loading rates in the 18:00 sample.

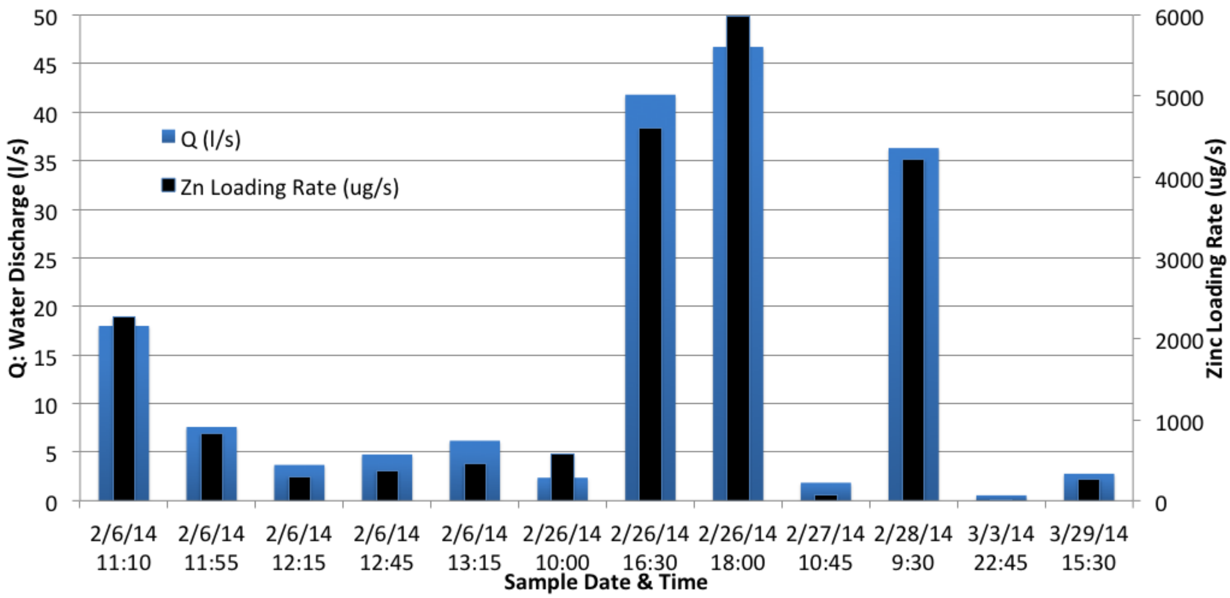


Figure 9: Instantaneous loading rate of zinc in Majors Creek storm water samples from sample site MC01.

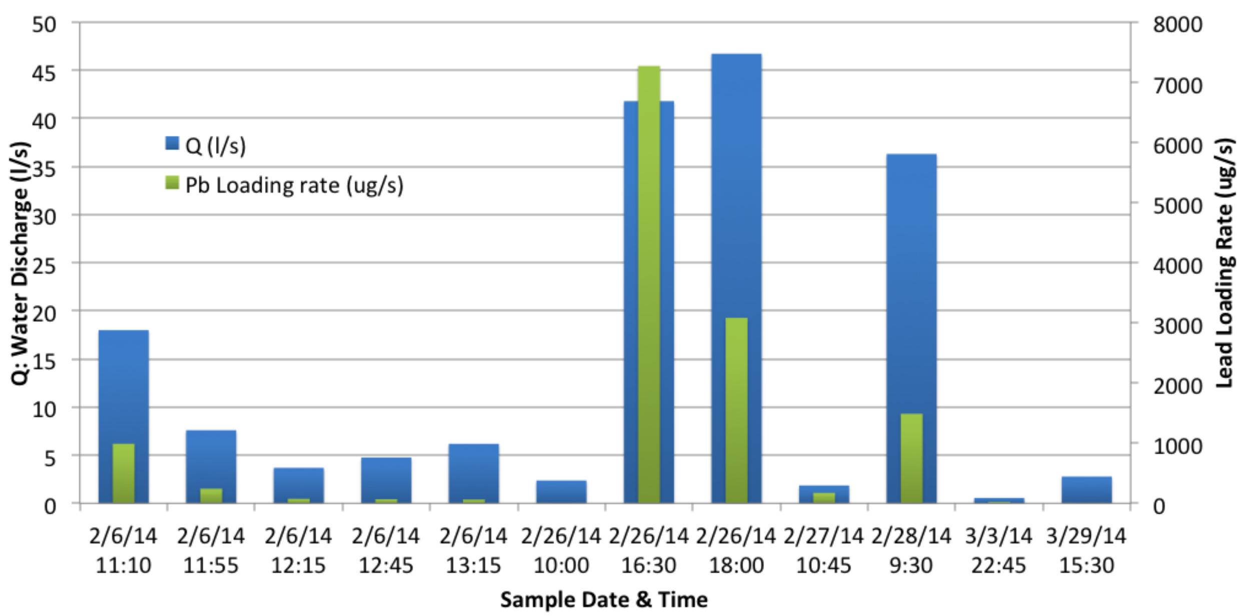


Figure 10: Instantaneous loading rate of lead in Majors Creek storm water samples from sample site MC01.

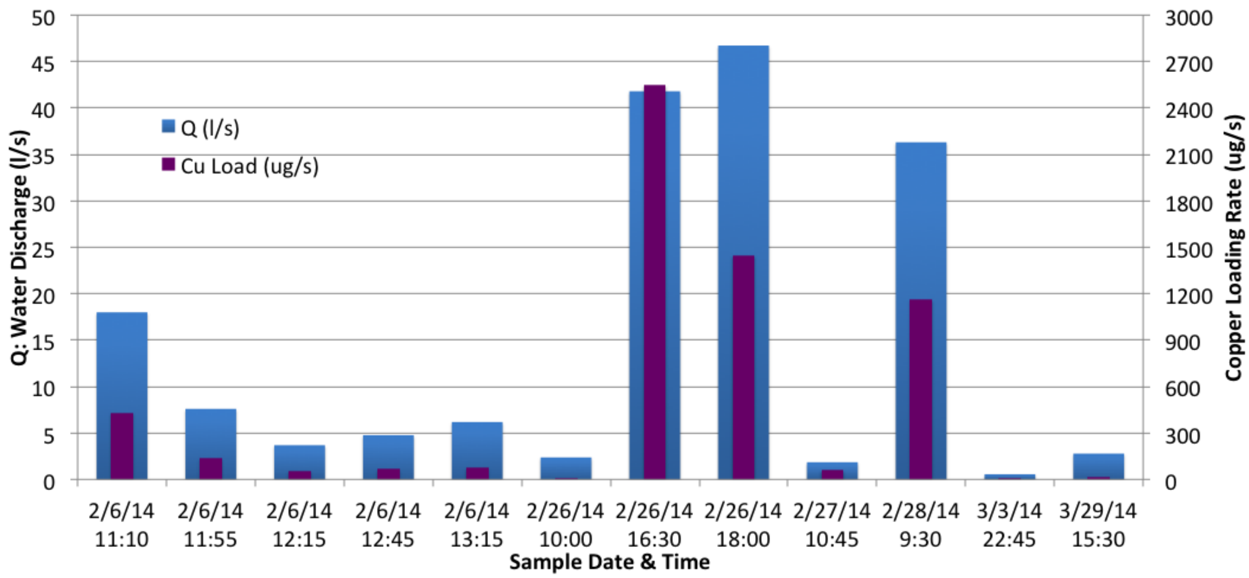


Figure 11: Instantaneous loading rate of copper in Majors Creek storm water samples from sample site MC01.

Table 7: Instantaneous loading rates of zinc, copper, and lead in Majors Creek storm water samples.

	Constituent Loading Rate (ug/s)			Water Discharge (l/s)
Sample Date and Time	Zinc	Copper	Lead	
2/6/14 11:10	2267	432	990	18.0
2/6/14 11:55	828	137	243	7.6
2/6/14 12:15	295	55	74	3.7
2/6/14 12:45	371	67	67	4.8
2/6/14 13:15	451	74	62	6.2
2/26/14 10:00	575	9	0	2.4
2/26/14 16:30	4598	2550	7273	41.8
2/26/14 18:00	5980	1448	3084	46.7
2/27/14 10:45	74	63	174	1.9
2/28/14 9:30	4211	1162	1488	36.3
3/3/14 22:45	11	10	7	0.6
3/29/14 15:30	269	14	0	2.8

TSS vs. TDS: In addition to the Total Suspended Solids samples some water samples were filtered in order to determine Total Dissolved Solids concentrations of zinc, lead, and copper. Concentration values between samples varied (Table 8). Zinc was found to have higher TDS than TSS concentrations in 3 out of 4 samples. Lead was not detected in any of the TDS samples, and copper concentrations were reduced in all of the TDS samples. The zinc concentration values raise a red flag, as it is assumed that TSS samples have higher concentrations than TDS samples in general. Due to this discrepancy further TDS samples were not taken in order to determine source of error. Potential methods that may have cause this QA/QC discrepancy have been identified as the reuse of collection bottle for the TDS samples and/or filtration method.

Table 8: Total Suspended Solids and Total Dissolved Solids heavy metal concentrations in Majors Creek at sample site MC01 during the February 6, 2014 storm event. Red bolded values denote values above water quality limits.

	Total Suspended Solids (ug/L)			Total Dissolved Solids (ug/L)			Discharge	Sediment	Conductivity	Temperature	pH
Time	**Zinc**	**Lead**	**Copper**	**Zinc**	**Lead**	**Copper**	**Q (L/s)**	**Susp Sed (g)**	**(uS)**	**(deg F)**	
11:10	126	**55**	24	125	ND	6	17.994	0.0606	520	49.4	6
11:55	109	**32**	18	151	ND	9	7.583	0.0515	620	49.4	6
12:15	80	20	15	109	ND	11	3.681	0.0187	740	49.6	6
13:15	73	10	12	112	ND	10	6.190	0.0278	960	49.8	6

Successive Sampling: Several samples were collected at MC01 and MC02 at the successively to evaluate longitudinal trends as well as time trends. This practice was used only once because of the potential for the upstream sampler to contaminate water that would reach the downstream sampler. Yet during the last monitored storm, three samples were taken 15 minutes apart and were collected downstream to upstream (MC01 > MC018 > MC02). A `comparison between the instantaneous loads between these sites is presented in Table 9.

Table 9: Pollutant concentrations collected from the three sampling locations (MC01, MC018, and MC02) within 30 minutes during the March 29th, 2014 storm. Pollutant loading rates were determined with storm water runoff rates. Red background represents concentration values that are above water quality objectives.

		Metal Concentration (µg/L)			Runoff	Load Rate (µg/s)		
Time	**Location**	**Zinc**	**Lead**	**Copper**	**Discharge (l/s)**	**Zinc**	**Lead**	**Copper**
15:30	MC01	97	5	22	2.77809	269	110	61
15:45	MC018	**266**	**85**	**38**	9.07610	2414	3230	345
16:00	MC02	88	12	**30**	3.74880	330	45	112

All samples taken from MC018 (located at the culvert outfall under to Del Monte Center Entrance, see Figure 3) were at much higher concentrations and loads (Table 8). The discharge at MC018 was much higher than found at MC01 or MC02. An explanation for the low discharge rate at MC01 could be that the sample was collected before the storm peak reached this outfall or that stream system within Don Dahvee Park was able to retain some runoff. The difference seen between runoff discharge between MC018 and MC02 could also due to the timing that the runoff peak reached these sample sites. Also, MC018 receives additional runoff from storm drains at the western side of Munras near Soledad as well as from the Whole Foods parking lot. Another possible explanation for the large difference in both discharge and pollutant concentrations, between MC02 and MC018 especially, could be due to the sediment concentrations within the samples. As described earlier, heavy metals have the tendency to attach to sediment particles. Sediment samples taken during this series show that MC018 discharge contained more sediment than the other samples by one order of magnitude (MC01= $4.50X10^5$ (g/L); MC018 = $3.79X10^4$ (g/L); MC02=$2.31x10^5$ (g/L)).

It would be beneficial for future studies to collect metals samples from the three sampling locations designated in this report and be able to take samples simultaneously without compromising downstream samples. It would be best for samples to be collected throughout rainfall events at preferably 15 minute intervals but no less than 30 minute intervals. Additionally, TSS and TDS metal samples should be collected to compare pollutant concentrations in the absence of suspended sediment.

E. Coli: The two *E. Coli* samples taken during the February 6th, 2014 storm event showed that this bacterium exceeded water quality limits (1220 and 740 per 100mL). The two samples, taken at the beginning and end of sampling, varied in runoff discharge rate (~18 L/s and 6 L/s). The two *E. Coli* samples taken in June, during baseflow conditions were both found to be below recommended limits, but it is interesting to note that the concentration of *E. Coli* was found to be higher at MC02 than at MC01 during baseflow conditions.

Nutrients: In addition to sampling for the pollutants known to be impairing Majors Creek, additional Nutrient samples were taken. Results from these sample collections can be seen in Table 10. Nitrogen (Nitrate and Nitrite) samples did not exceed the 303(d) water quality objectives (max 10 mg/L), nor did NO3 (max 45 mg/L), or Nitrite (Max 1.0 mg/L). Additionally, phosphorous did not exceed the 1.0 mg/L max limit (U.S. EPA).

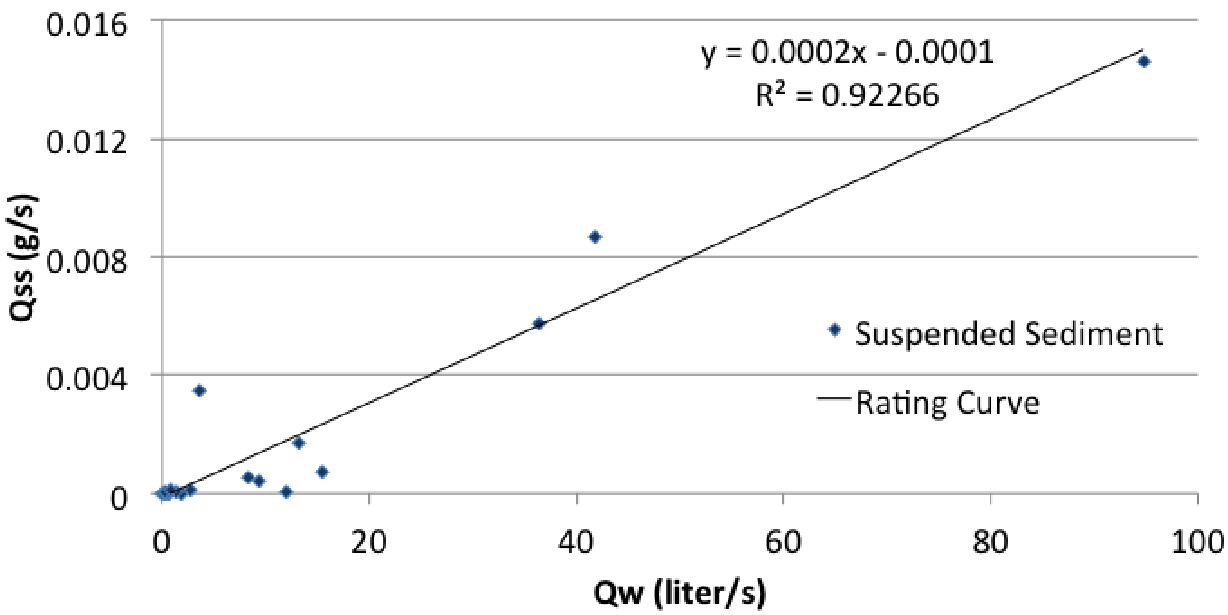
Table 10: Nutrient data collected from Majors Creek.

Date	Time	Site	NO3 (mg/L)	NO3-N (mg/L)	Nitrate and Nitrite N (mg/L)	NO2-N (mg/L)	o-Phosphate-P (mg/L)	Storm Series
2/2/14	11:58	MC01	2	0.5	0.7	0.2	ND	road runoff
2/2/14	12:36	MC01	2	0.5	0.8	0.3	ND	road runoff
2/2/14	13:08	MC01	2	0.6	0.8	0.3	ND	road runoff
2/2/14	13:50	MC01	2	0.4	0.7	0.2	ND	road runoff
2/2/14	14:15	MC01	2	0.5	0.8	0.2	ND	road runoff
2/6/14	11:10	MC01	-	1	-	0.3	0.1	1st creek flow
2/6/14	11:55	MC01	-	1	-	0.3	ND	1st creek flow
2/6/14	12:15	MC01	-	1	-	0.3	ND	1st creek flow
2/6/14	12:45	MC01	-	1	-	0.3	ND	1st creek flow
2/6/14	13:15	MC01	-	1	-	0.2	ND	1st creek flow
2/21/14	13:00	MC02	8	1.8	2	0.1	ND	baseflow

3.3.2 Suspended Sediment Analysis

A total of 33 suspended sediment samples were collected during the course of this study. To create a suspended sediment (SS) rating curve used to interpolate SS discharge rate over a wide range of water discharge, observed SS discharge was correlated with Creek discharge for all MC01 samples (n=19). This relationship was best described by the linear equation $Q_{ss} = 0.0002 * Q_w - 0.0001$, where Qss = suspended sediment discharge (g/s) and Qw = water discharge (L/s) ($R^2 = 0.9227$) as can be seen in Table 11.

Table 11: Graph of the rating curve that best fit the Majors Creek suspended sediment runoff.



The total SS discharged over the course of the seven storms during this study was estimated to be 610 grams. Per storm, the discharge of SS was estimated to be: February 6, 2014 = 90g; February 7, 2014 = 5g; February 26, 2014 = 115g; February 28, 2014 = 191g; March 1, 2014 = 137g; March 26, 2014 = 10g; March 29, 2014 62g. Estimated SS load for February 7 and March 1 storms have less confidence as no water discharge samples were collected on those days and thus discharge values were completely estimated.

It should be noted that this suspended sediment analysis was conducted in a year where the upstream channel of Majors Creek had been mowed (see *Section 3.5.1.1*). Future studies of suspended sediment should take this and any other creek-maintenance into account. If no further mowing of the Creek channel occurs, this data could be considered a baseline for mowed-channel condition.

3.4 Watershed Treatment Model

The Watershed Treatment Model was completed, with exclusion of the 'New Development' tab, and included all of the parameters found in Appendix D. The results from this excel model can be seen in Table 12 where all components with values greater than 0.0 are shown. One issue encountered with this model is that within the results tab, some values for Total Nutrients (lb/yr) came up as Invalid Value, so this column was excluded from the current results but may be reworked in the future.

Table 12: Results from the Watershed Treatment Model, outlining the pollutant loads with existing practices as well as loads from future conditions that include additional implementation and management practices within the Majors Creek watershed. In the table TP= total phosphate and TSS = total suspended solids.

	TP (lb/year)		TSS (lb/year)		Fecal Coliform (billion/year)		Runoff Volume (acre-feet/year)	
Loads to Surface Waters	**Existing**	**Future**	**Existing**	**Future**	**Existing**	**Future**	**Existing**	**Future**
Urban Land	161.5	56.8	14089.2	3866.3	14833.8	5858.1	60.6	30.6
Channel Erosion	-65.0	-64.9	-32467.2	-32467.2	0.0	0.0	0.0	0.0
Forest	40.9	40.9	20442.1	20442.1	2453.1	2453.1	6.7	6.7
Total Surface Water Load	137.5	32.8	2064.2	-8158.8	17286.9	8311.1	67.4	37.4
Total Storm Load	125.2	20.5	20.0	-10203.0	17286.9	8311.1	67.4	37.4
Total Non-Storm Load	12.3	12.3	2044.2	2044.2	0.0	0.0	0.0	0.0

According to the results of this model, if future treatment practices were put into place Total Phosphate (TP) could be reduced by 77%. While any sort of pollutant reduction can be considered a good impact, this pollutant has not yet been found to be an issue within the Majors Creek watershed under current conditions. TSS total loads were a bit confusing as they reported a negative values of suspended solids per year. This is assumed to mean that there should be essentially zero suspended solids discharged per year. Additionally, the model found that Fecal Coliform could be reduced by 52% per year.

As shown by the table in Appendix D: *Future Practices Tab,* the future loads would be accomplished by implementing or improving pet waste education, erosion and sediment control, street sweeping, residential impervious cover disconnection program, and riparian buffers. In addition to these, three Best Management Practices including two dry extended detention ponds and one wetland. These future practices are explained in the *Major Findings and Recommendations* Section at the end of this report.

3.5 Stream Survey

Throughout the course of this study, five stream surveys were conducted in order to evaluate the characteristics of the Majors Creek. Surveys included appraising stream channel features, manmade elements, and areas of fluvial geomorphic interest. Figure 12 displays areas of specific interest found during these surveys.

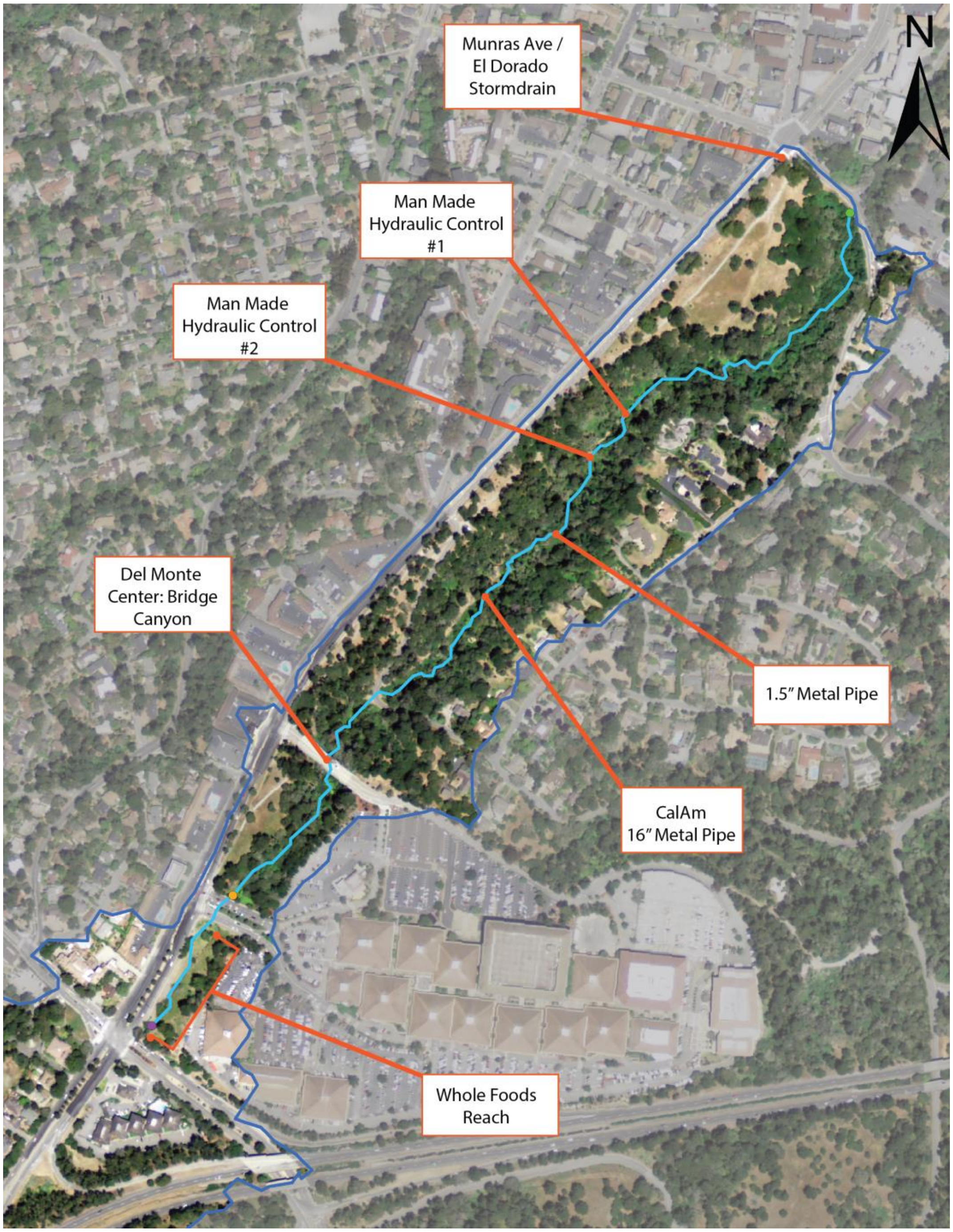


Figure 12. Location of important features along Majors Creek.

3.5.1 Stream Survey Areas of Specific Interest (Upstream to Downstream)

3.5.1.1 Whole Foods Reach

The first survey is of the Whole Foods Reach of Majors Creek, seen in Figure 13. The Whole Foods Reach is a 1.5 acre portion of land NW of the Munras Ave/ Soledad Drive intersection. This is the first open-aired reach of Majors Creek. Geologically, this section seems to be on Old Marine Terraces, with about 5 feet of artificial fill on top of 2 feet of breccia conglomerate rock with bedrock below. The elevation of this reach ranges from 236- to 218- feet above sea level with a 4% slope. The stream in this reach has an incised channel and some undercutting of channel walls was noted.

Figure 13: Whole Foods Reach of Majors Creek.

This Whole Foods Reach was found to be impacted by a few factors. First, the pollution plume from the Gas Station Leakage would have affected this section of the stream as the gas station sits just uphill from this reach. Sampling wells from the plume monitoring can be found on this reach’s flood plain. If the remediation program put in place to remove this plume is followed, no other actions should be required to amend this issue.

Also, this area was observed to be a popular area for transient people to congregate. The only detectable impacts from this was trash in the Creek channel. Items found in the channel include food containers, clothing, glass bottles, and chairs (Figure 14). While the majority of the trash was found in this section of the Creek, trash was found throughout the entire open-air stretch of Majors Creek.

Figure 14: Chairs found inside MC02 Culvert at the top of the Whole Foods Reach of Majors Creek.

One visit to the Whole Foods Reach of Majors Creek revealed that City maintenance had mowed the vegetation in the Creek as well as on the floodplain in October 2013 (Figure 15, left). Before the mowing, reeds grew in the channel, and their root systems could be seen after. Close to five months later, reeds have been observed to begin regrow within the Creek (Figure 15, right).

Figure 15: Downstream view from footbridge of Majors Creek in the Whole Foods Reach post-mowing (left), 5 months later (middle), and 7 months later (right).

This channel and vegetation disruption has likely had an effect of storm water discharge as well as sediment and pollutant loads. A number of studies have found that in-stream vegetation, such as California bulrush, can help stabilize streambed, decrease flow velocity, and store suspended solids (Utomo and Wenefrida 2008; Scholes et al. 1998). Removal of vegetation can then disrupt the stream system and cause instability.

Also within the Whole Food Reach of Majors Creek, surveys revealed two knickpoints. The first knickpoint, located 10 ft downstream of the Oak Tree, did not significantly migrate during the course of this study. Channel surveys of this knickpoint however did show that a large chunk of soil (about 4 ft^3) had been dislodged from the knickpoint. The second knickpoint, see in Figures 16 and 17, was located under the footbridge at the start of this study, and then migrated upstream during the February 28th, 2014 rain event.

Figure 16: Upstream knickpoint in the Whole Foods reach of Majors Creek on February 26, 2014 (left) and on February 28, 2014 (right).

GIS knickpoint analysis revealed that there was sediment deposition (max 0.87 ft) within the channel in areas where plunge pools were noted in thalweg surveys, as well as erosion (max 3.60 ft) in areas where knickpoint migration was noted. Figures 18 shows change in the elevation of the channel bed between February 21, 2014 and March 5, 2014. The volume of sediment removed by the upstream knickpoint was calculated to be 247 ft^3 using a mask that was 3.28 ft wide.

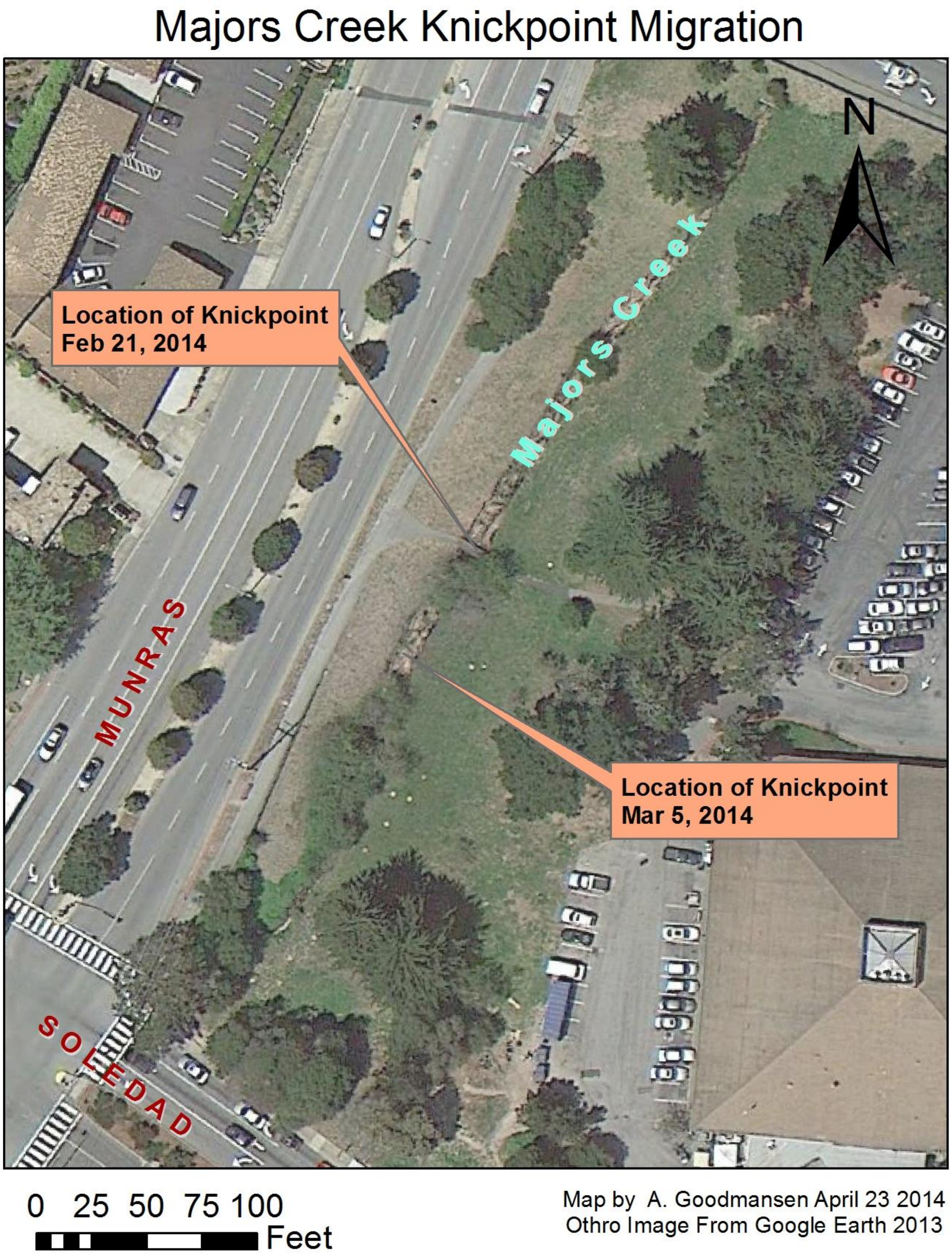


Figure 17: Knickpoint location within the Whole Foods Reach of Majors Creek.

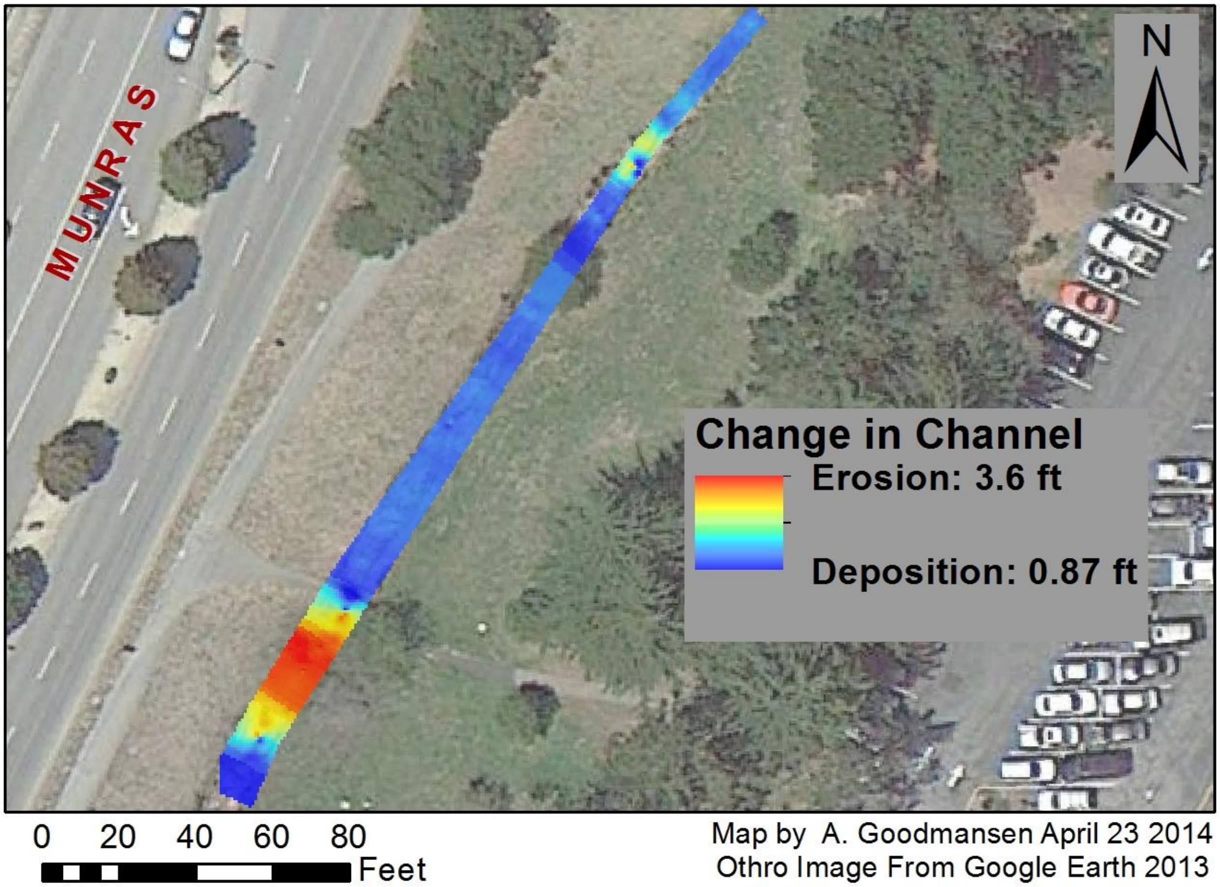


Figure 18: Difference in channel bed elevation after retreat of knickpoint in Whole Foods Reach of Majors Creek.

The movement of this knickpoint is important to note because it is a sign that this system is out of balance. It is recommended that monitoring of both knickpoints continues both before the start of the 2014 wet season as well as throughout the wet season. Coupling knickpoint monitoring with suspended sediment samples and channel vegetation surveys is also recommended.

The Whole Foods Reach of Majors Creek has great potential. While channel vegetation mowing, trash, and knickpoint migration are impairing this reach, its setting is ideal for improvement. The slope and open space available on this lot could be converted into a wetland system. The potential benefits of a treatment wetland are discussed below in the *Majors Findings and Recommendations* section.

3.5.1.2 Del Monte Center Bridge, Canyon

Under the bridge that connects Munras Ave to the Del Monte Shopping Center we found what we call the 'Canyon'. In this reach, the Creek has down-cut through the Monterey Shale conglomerate. The down-cutting has produced tall steep banks (Figure 19). Upstream of the Canyon is a series of natural step-pools where the large change in channel elevation occurs.

Figure 19: 'Canyon' and step-pools found on Major Creek under the Del Monte Center Bridge.

In addition to the Canyon, erosion along the terrace was noted (Figure 20). Runoff from the Bridge that is diverted down to this terrace is assumed to be the source of water causing this erosion. Water runoff from the south drain of the bridge has been diverted (Figure 21) at the outlet to run long the concrete wall to where it meets up with the north drain counterpart. These two discharges then flow together over the land before entering the Creek.

While there does not seem to be any immediate threat from either the Canyon or the overland erosion, we suggest that maintenance is performed on the Bridge drains to ensure that discharge does not continue to erode the overland terrace.

Figure 20: Overland erosion under the Del Monte Center Bridge.

Figure 21: Drain diversion from Del Monte Center Bridge. To the left is the channelized path diverting water to the north, and the image on the right shows the sandbags used at south drain.

3.5.1.3 6" CalAm Pipe

A cut-off 6 inch CalAm metal pipe was located crossing Majors Creek in the Don Dahvee Park Reach (Figure 22). According to Jeff Krebs and Kevin Anderson, this pipe was most likely placed there in the 1920's to supply water to neighborhood to the east of Majors Creek. A little more than one year ago, CalAm cut this pipe due to a problem with the connection, and rerouted water to that neighborhood via another pipe. Currently, about 7 ft of the old pipe remains jetting out over the Creek. The structure that supports the pipe also remains. While this pipe and structure do not appear to be immediate threats to Majors Creek, it is suggested that the pipe is cut closer to where it meets the stream bank and that the support structure is removed from the Creek. Removal of the pipe and support structure would increase the aesthetics of this reach of Majors Creek. Additionally, there is the possibility of the support structure causing debris build up in the Creek, which would change the creek's hydraulics.

Figure 22: CalAm pipe and support structure in Majors Creek.

3.5.1.4 1.5" Metal Pipe

A metal pipe measuring 1.5 inch in diameter was found coming from the west bank into Majors Creek (Figure 23). This small pipe does not have a definite reasoning, but we guess that it may have been used to uptake surface water for ranch use in the past. This pipe was monitored during storm events and no discharge was observed from this pipe. There is no perceive threats from this pipe, but should continue to be investigated.

Figure 23: 1.5" metal pipe coming into Majors Creek.

3.5.1.5 Man Made Control #2

Two man made hydraulic controls were discovered on Majors Creek within the Don Dahvee Park Reach (Figure 24). The City of Monterey had no information on these structures prior to this study. Both structures seem to be from the same era and made of concrete and rock materials. The upstream structure, 'Man Made Control #2', has failed and is no longer a controlling upstream channel elevation. The remaining portion of the structure was measured to be 5x16 feet. The Creek is now forced to flow around the structure on the left bank (when facing downstream, toward the east). The east bank of composed of old terrace deposited with vegetation. While there seems to be no immediate threat, the east bank does show signs of erosion, and due to the steep slope of the bank any erosion would be increasingly incremental. Removing this failed man made control may improve conditions of the creek at this location.

Figure 24: Man made control #2 (failed control) on Majors Creek. Red and blue lines indicate path of creek.

3.5.1.6 Man Made Control #1

A second man made control located on Majors Creek was found to be intact and acting as a hydraulic control (Figure 25). This structure measures to be 4x13 feet and made up of concrete and rock materials. As this structure seems to be in good condition, we recommend that it remains in the Creek.

Figure 25: Man made control #1 on Majors Creek.

3.5.1.7 Munras Ave/ El Dorado St Strom drain

The last important finding from the stream surveys was the discovery of the functionality of the storm drain at the SW corner of the Munras Ave/ El Dorado St intersection (Figure 26). As previously mentioned, this storm drain inlet connects to a drain that delivers runoff one-quarter mile to the west near Pacific St. Instead of directing runoff to this other location (within a different watershed), the drain was noted to be blocked with debris in such a way that it rerouted water around the storm drain, down El Dorado St, into the storm drain at the intersection of El Dorado Stand Major Sherman Lane, which feed directly into the MC01 culvert. This debris blockage and runoff rerouting was noted on several occasions.

Figure 26: Storm drain at the SE corner of Munras Ave and El Dorado St. Drain was observed to become blocked with debris on several occasions and the blockage rerouted water around the drain and into the Majors Creek watershed.

As discussed previously in the *Storm Water Sampling* section, this is an important factor that needs to be evaluated. When this drain is blocked, Majors Creek receives additional runoff from this sub-watershed, thus pollutants are incorporated into Majors Creek water samples, and not the water samples of the creek/stream that this storm drain is intended to flow to. Water quality samples taken on February 2, 2014 were determined to be from that drainage as well as El Dorado St east of Major Sherman Lane and contained concentrations of zinc and copper that were above pollutant limits. In contrast to this, February 6th storm event did not include any runoff from this storm drain as debris was removed by City Maintenance and runoff was observed to be entering the storm drain.

Another important point to be considered from this finding is the contribution of this storm-drain's sub-watershed to previous Majors Creek water quality samples. If samples would have been collected this year when the Sanctuary called for First Flush event samples (October 28 and November 20, 2013), there is a chance that the runoff captured would have been mainly from Munras drainage plus immediate El Dorado Street drainage, as Majors Creek itself was not flowing, but discharge was coming out of MC01.

3.5.2 Tributary and in-line structure inventory of Majors Creek

Two pipes and two in-line culverts were found in the open-air section of Majors Creek. The inventory can be seen in Appendix E.

4 Major Findings and Recommendations

This section highlights the major findings from this existing conditions study of Majors Creek as well as lists some recommendations for both Creek-improvement opportunities as well as future studies.

4.1 Major Findings

- <u>Pollutants:</u> Zinc, copper, lead, and *E. Coli* were all found in higher concentrations than recommended by water quality objectives in several samples during the Water Year 2014 wet season. In addition to samples from the main sample site (MC01), upstream sampling locations (MC018 and MC02) also saw sample concentrations of zinc, copper, and lead at higher than recommended concentrations.

- <u>Creek Flow vs. Street Flow:</u> Perceiving the difference between Creek flow and street flow when collecting samples from Major Creek's primary sample site MC01 is crucial for analyzing water quality data for this stream (refer to *Section 3.3*). In order to determine the constituent content of the Majors Creek water system, samples need to be collected from Creek flow. While previous data cannot be checked, future methodology for sampling should take this into consideration in order to help better determine where pollutants are being sourced from.

- <u>Munras Ave/ El Dorado Street Storm Drain:</u> The potential for this storm drain to be blocked gives way to the inclusion of this sub-watershed into the Majors Creek watershed. Water from this drainage is delivered from the road then directly into the MC01 culvert, making it difficult to sample separately from creek flow. When sampled from the MC01 outfall before Creek flow was present, this sub watershed's water quality did have zinc and copper concentrations above water quality standards in initial storm sample.

4.2 Recommendations

4.2.1 Future Research

- Total Dissolved vs. Total Suspended Solids Sampling: This current study attempted to collect water quality samples for both Total Dissolved and Total Suspended Solids for heavy metal analysis, but the Total Suspended Solids sampling were not completed as planned. As mentioned in *Section 3.3.1*, something occurred during water filtration that caused a higher concentration of constituents to be found is Dissolved samples than Suspended (Total) samples. Future studies should refine filtration methods and continue sampling both Total Dissolved and Total Suspended Solids water quality samples in order to better determine the effect of suspended sediment on heavy metal concentrations.

- Comprehensive Hydrologic and Hydraulic Study: The arrival of Majors Creek runoff flow to MC01 was found to be sudden and unpredictable throughout the course of this study, which indicates that there are hydrologic and hydraulic complexities to this creek system. I suggest a Hydrologic and Hydraulic Study to better understand this stream's natural, minimum in-stream flow regime throughout the hydrologic year. Such a study should include hydrogeologic characterization as this may be an important factor due to the significant groundwater sink or recharge component observed in Don Dahvee Park between MC018 and MC01.

- Quality Assurance/Quality Control Procedures: Future studies on Majors Creek should include defined QA/QC measures into their sampling protocol. While this study included QA/QC protocol including sampling collection, use of gloves, and proper sample delivery to the laboratory, only one sample duplicate was collected and no 'Field Blanks' or 'Replicates' were included in sampling.

- Suspended Sediment: Future analysis should consider the suspended sediment in Majors Creek, either from this study's data or future data, and determine if it follows 303(d) water quality regulations.

- Simultaneous Sampling: Simultaneous sampling from MC01, MC018, and MC02 could prove beneficial in determining the source of pollutants in further studies.

- Weather Station: This study relied on precipitation data obtained at Monterey Airport. While this location is only four miles away from the Majors Creek Watershed, storm pattern on the Monterey Peninsula can be very isolated. We recommend that a weather station closer to this watershed be used in future precipitation analyses.

4.2.2 Recommendations

- Stakeholder Group: We believe it would be beneficial to form a stakeholder group that could include representatives from the City of Monterey, Country of Monterey, Majors Creek watershed neighborhoods, CalTrans, the Del Monte Center, and the Community Hospital. This stakeholder group could collaborate to develop action plans that could be applied throughout the Majors Creek watershed that would help reduce pollutant loads as well as increase pollution awareness to their neighbors.

- Pet Waste Education: While the City currently does have some pet waste educational videos, additional efforts could be made. While this study did not confirm that pet waste was the source of the *E. Coli* found in Majors Creek runoff, future PCR tests could determine the animal source of this bacterium. If canine fecal matter was determined to be a contributing source, brochures about the importance of waste clean up could be sent to homes in the watershed or supplied at local pet shops and vet clinics. While conducting this study, many dog owners were observed walking their pets in the park. The City could consider placing 'Pet Waste Stations' throughout Don Dahvee Park to help encourage dog owners to clean up after their pets.

- Erosion and Sediment Control: The City may want to take some action to help control the erosion of the Majors Creek channel and sediment movement downstream. Further Suspended Sediment studies could be useful in determining whether the mowing and channel de-vegetation in the Whole Foods Reach of Majors Creek (see Section 3.5.1.1) has caused the channel to be more or less stable. An unstable channel would show movement in channel location and potentially a higher suspended sediment load in water samples.

  While so far there has not been any study done to determine the effects of the Whole Foods Reach mowing, it can be assumed that the removal of the reeds from within the channel are likely to have caused increased channel instability. California bulrush has been acknowledged for acting as an erosion control measure, where portions of the plant trap loose sediment as well as dissipate flow energy from runoff (Utomo and Wenefrida 2008). The reestablishment of reeds such as California bulrush in this reach of the Creek may prove beneficial for this system.

- Structure Removal: We recommend that both the Man Made Control #2 (failed control) as well as the 16" CalAm pipe and supporting structure be removed from the Creek. As mentioned above, while the Man Made Control #2 does not seem to pose any immediate threat, the east bank does show signs of erosion and due to the steep slope of the bank any erosion would be increasingly incremental. As for the 16" CalAm pipe, we recommend removal to both improve aesthetics of this reach, which is located adjacent to the Don Dahvee Park trail, and the removal of the support structure there would decrease the chance of debris build up in the creek and hydraulic changes in this reach.

- Streep Sweeping: The City of Monterey currently has a very strong urban street sweeping program, with weekly street sweeping on Munras Ave and bi-monthly sweeping on residential streets. Data about street sweeping along Highway 1 was requested from CalTrans but not received in time for presentation in this report. If sweeping services for this stretch of Highway are minimal, more frequent sweeping schedules may be advised.

- Runoff Treatment Options
  - Urban Diversion: The City should consider the feasibility of Urban Diversion designs for Majors Creek runoff. Urban Diversions typically connect surface runoff to sanitary sewer systems that delivers the runoff to local wastewater treatment facilities where it is processed. Diversion options would need to be examined, including options for the capture and diversion of dry weather flows, first flush flows, and low-flow storm events due to their regular impact on water quality. Sewer capacity would also need to be examined for such a project. According to Wotan (2014), there may be sewer conveyance capacity in a sewer line that runs just upstream of the MC018 sample site at the entrance to the Del Monte shopping center. Sewer line capacity in the downstream reaches of Majors Creek would also need to be examined.

  - Treatment Wetland: The placement of a wetland in the Majors Creek system has the potential of reducing the amount of total suspended solids as well as heavy metal pollution. A study conducted by Walker and Hurl (2001) demonstrated that zinc, copper, and lead were significantly reduced through wetland processes. Their study saw that sedimentation was a major component of heavy metal reduction, but also biological and chemical processes assisted in this pollutant reduction. In addition to heavy metal mitigation, wetland systems can produce storage of storm water, decrease storm event flow velocity, as well as reduce erosion (Scholes et al. 1998). Considering these potential benefits, the City should consider the placement of a constructed wetland in the Majors Creek system as one supporting method of attaining their 303(d) goals.

    Both the Whole Foods Reach as well as the northern section of Don Dahvee Park should be considered as potential locations for such a project. The Whole Foods Reach would be a desirable area as this reach receives the majority of urban runoff in this watershed. But the high lead, zinc, and copper concentration levels observed during the successive sampling at the MC018 sample site, located just downstream of the Whole Foods Reach, would need to be considered for the potential to redirect this drainage to the upstream Whole Foods Reach. Additionally, the data of copper, lead, and zinc coming from the Munras/ El Dorado drainage should be collected in order to determine if that runoff would also need to be treated before being delivered to the MC01 sampling site. If the levels of constituents are high for this small drainage area, the placement of a constructed treatment wetland should be considered for a downstream location within the Don Dahvee Park.

- Capture and Treat Runoff for Irrigation and Construction Uses: Lastly, the City may want to consider the feasibility of capturing flow from the Creek for use by City irrigation trucks, City vactor trucks, or for construction dust suppression. Storm water could be captured above the Soledad outfall (MC02) and diverted into a treatment train system (treatment wetland, UV treatment, holding tank) from where the treated water could then be used for a variety of City water needs.

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6 Appendixes

6.1 Appendix A: Sanctuary First Flush Methods

First Flush 2013 Team Instructions

BEFORE the First Flush:

1. Have all sample bottles pre-labeled with Site ID.
2. On all Field Data Sheets, complete Instrument ID's (under "Field Measurements"), **City**, **Site ID**, **Site name**, and **team members** with phone numbers.
3. Have a medium sized cooler with a **temperature blank** ready to go at weather alert. Make certain to have enough ice at hand to cover your sample bottles well in your cooler.
4. At the site assign tasks: data taker and timer, conductivity reader, sample collector.

DURING the First Flush Event:

1. When you arrive at your site have anyone that will touch the water, sample bottles or equipment, put on gloves.
2. Fill out the top portion of the data sheet in pencil with: the **date**, and **arrival time**.
3. Take all of the equipment out of the little bucket and rinse the little bucket **3** times in the outflow before filling the little bucket for the initial conductivity check and sample collection.
4. Upon filling the little bucket, record the time the little bucket was filled on the **front** of the of data sheet. Time how long it takes to fill the little bucket, and what percentage of the flow you captured.
5. Tip the little bucket to rinse the inside and outside of the red cup three times. Use the red cup to pour a sample from your bucket and IMMEDIATELY take the conductivity reading. If it is below 1000 µS (1 mS) skip to #7.
6. If it is above 1000 µS (1.0 mS), record the results on the front of the data sheet, fill in observations, then wait 3-5 minutes to measure it again. Repeat #3-5 until the meter reads 1000 µS (1.0 mS) or below.
7. If conductivity is below 1000 µS (1.0 mS) flip the data sheet over and record the time the bucket was filled. **Record this time on the sample containers also!**
8. **Double check that the sample containers have: site ID, AND time and date on them as well. They must be labeled before they get wet!**
9. Begin filling sample bottles by using the rinsed red cup and water from the bucket.
   *Never rinse the sample bottles!
   *Fill all bottles provided in the bag to the top.
   *Place all samples in the cooler with the ice & temp blank ASAP.
10. Log your samples in by filling out the bottom portion of the data sheet with site ID, sample time and collector.

Now for Field Measurements:

10. After the sample bottles are filled, you can take measurements in the bucket or use a red cup, whichever is easiest. **Do not take field measurements in the bucket before filling the sample bottles because it may contaminate the water for laboratory samples.**

11. **If it is daylight, begin field measurements with transparency!!!** Swirl the bucket then use the red cup to pour sample water into the transparency tube – the person holding the tube should also swirl the tube. Record results in centimeters. Only measure **transparency** and **pH** during daylight hours.

12. On the back of the data sheet, record pH, water temperature, conductivity and transparency measurements along with the instrument ID for each piece of equipment.

13. During one of the time series, **collect a replicate (repeated) measurement** for temperature, pH, conductivity and transparency. The same person should repeat the measurement using the same water from the bucket as the first time. Record under the "Replicate" heading on the data sheet.

14. After all of the samples have been collected and field measurements taken, **pour out your bucket of water**.

15. Wait 30 minutes from the time your first bucket was filled to begin the second series with a **new** little bucket of water. Triple rinse your little bucket in the outflow and collect a new little bucket of sample water. Use a new data sheet to record the next set of samples and field measurements. Do not worry if the conductivity is above 1000 μS (1.0 mS), just proceed from #8 above.

16. Once you are finished with your second sample collection and field measurements, pour out your bucket of water, look over the site and pick up all of your equipment as well as any trash. Record the time you depart your site on the data sheet!

17. Immediately bring samples to the MBNMS office at 99 Pacific Street, Bldg 455 in Monterey.

Monterey Bay National Marine Sanctuary **First Flush 2013**

Date:			____ **of 2**
City		**Arrival Time**	
Site ID		**Departure Time**	
Site Name			

Team Members

1	4
2	5
3	6

			Answer Y- yes or N-no for the following questions						
Time	**Conductivity (µS)**	**Murkiness clear, cloudy murky**	**Rain**	**Oil Sheen**	**Trash**	**Sewage sighted or smelled**	**Bubbles/ Scum**	**Time to fill the bucket?**	**% of flow?**

NOTE: Begin sampling when the conductivity is below 1000 µS

Sample collection for one time series:

Site ID	Time	Collected by:	Container Type
			clear 120 ml - bacteria
			white plastic 150 ml - metals
			sq. white plastic .5 L - nutrients,TDS,TSS
			Blue lidded vial for urea
			other?

Duplicates(-D) or Blanks(-FB) collected: Yes or No

Field Measurements:

Time Bucket Filled ___:___ am / pm

Parameter	Measurement	Replicate	Instrument ID:	Who did this?
H20 Temp	F or C	F or C		
pH				
Conductivity	µS	µS		
Transparency	cm	cm		

Precipitation	None	Foggy	Misty	Rain	How much time to fill bucket/ cup & % of flow?
Flow/ Discharge	No water present	Trickle (< 1 quart/ sec)	Moderate (<5 gal/sec)	High (>5 gal/ sec)	
Write Y or N	Oil Sheen	Trash	Sewage smelled/sighted?		Bubbles or Scum

Other Observations: types of trash, or any biological observations

Sample Custody:

Relinquished By:	Date /Time	Received By:	Date/Time

6.2 Appendix B: Storm Water Collection Methods and Datasheet

Majors Creek Sampling Instructions

Location: MajorsCreek01 (aka Jack outfall)

1. Have cooler with ice and temperature blank ready
2. Go to MC01 inlet (upstream of El Dorado St) to determine if storm flow is going directly into the culvert or if there is backup with standing water. Continue if there is flow from the creek entering the culvert.
3. Fill out top portion on the data sheet. Take notes, ex: precipitation, litter floating in creek, bubbles
4. Glove up
5. Discharge
    a. Have timer ready, fill 5-gallon bucket to the brim
        i. Note how long it took to fill bucket
        ii. Note percentage of flow the bucket captured
        iii. Repeat 3x
6. Collect grab sample in Metals sample jar #1, label as TSS sample
    a. Put into cooler
7. Collect grab sample in Metals bottle (tall white plastic bottle).
    a. Put into cooler
    b. (At CSUMB lab if need be) Filter sample into Metals sample jar #2, labeled as TDS sample
        i. Without filter on the syringe, fill up syringe using the plunger. Once full crew filter onto the end of the syringe and push down plunger to force the water through the filter and into the sample jar
8. Collect grab sample in suspended sediment bottle
9. Take all remaining samples from 5-gallon bucket
    a. Rinse bucket 3x, then fill ½ full
    b. Using bucket's water, rinse smaller cup 3x inside and out
        i. Fill Bacteria sample jar, place in cooler
    c. Take pH, Conductivity, temperature readings from large bucket
    d. Rinse instruments and buckets with DI water
10. Repeat steps 1-9 (exclude bacteria sampling) 30 minutes after first sample was collected, and repeat to complete all 5 of the collection series
    a. Times may change; we are attempting to collect from the rising limb of the storm, the peak of discharge, and then the falling limb

***Collect Repeat readings of pH, Conductivity, and Temp from one series

*****Collect Duplicate TSS Metals sample from one series**

City of Monterey Storm Water **Majors Creek Study 2013/2014**

Date:

Site ID:

Arrival Time:

Sampling Team:

Notes:

Sample Collection: Series 1

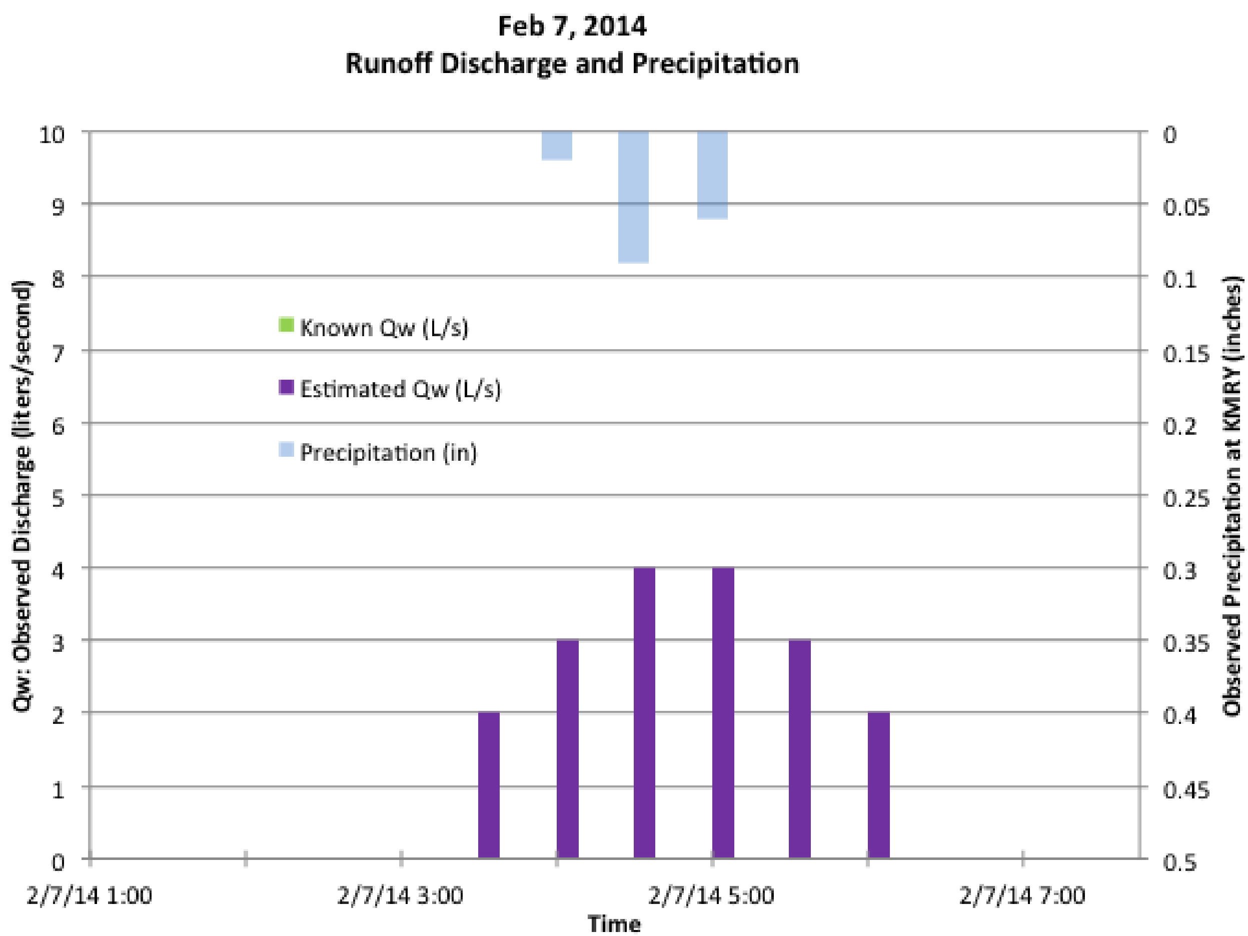
Discharge 1		Units
Volume Captured		
Time to fill bucket		
% of Discharge Captured		
Discharge 2		Units
Volume Captured		
Time to fill bucket		
% of Discharge Captured		
Discharge 3		Units
Volume Captured		
Time to fill bucket		
% of Discharge Captured		

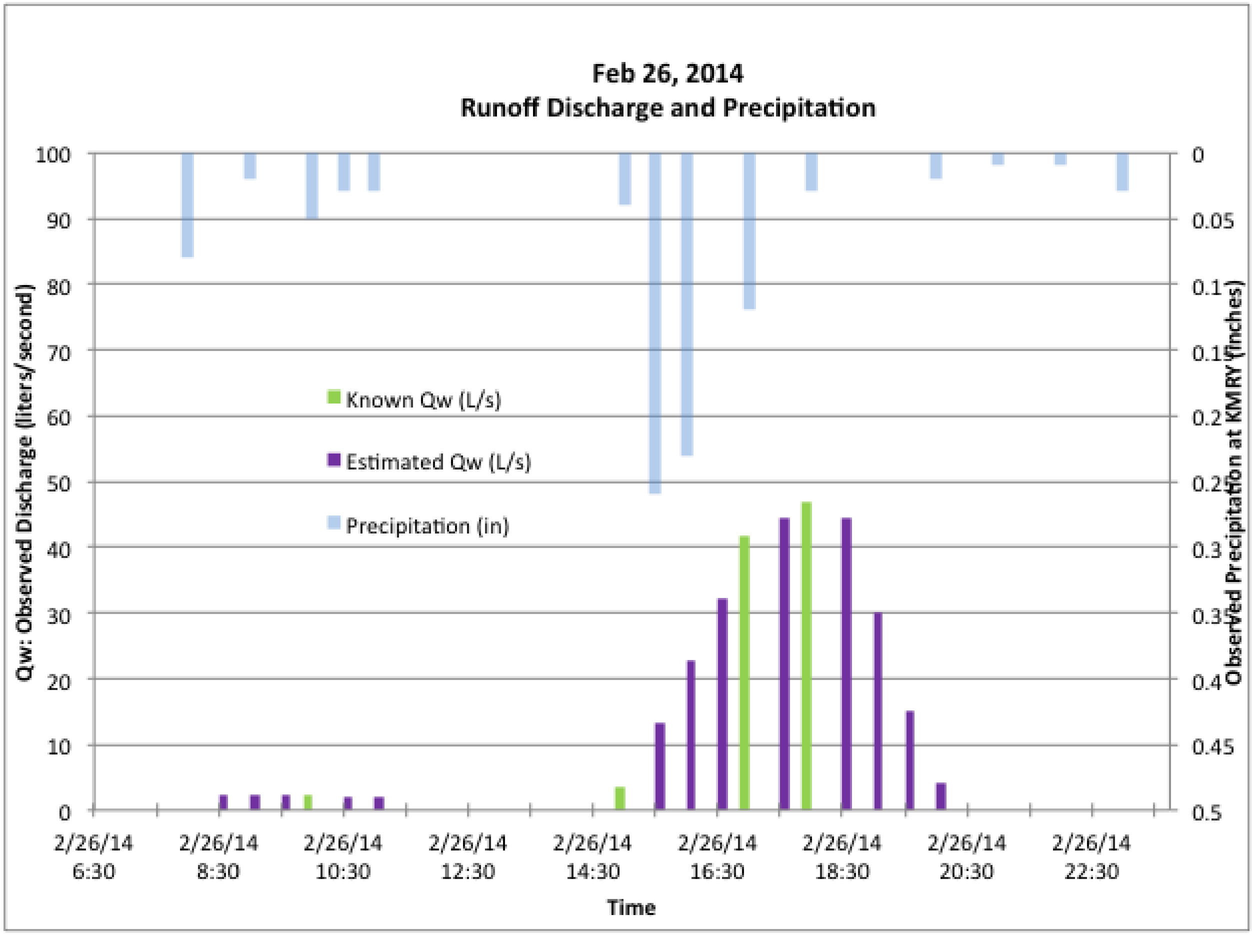
Sample Type	**Container Type**	**Time**	**Bottle ID**
Bacteria	clear 120ml		-
Total Metals	white plastic 150 ml		-
Dissolved Metals	large white plastic		
Suspended Sediment	large white plastic		

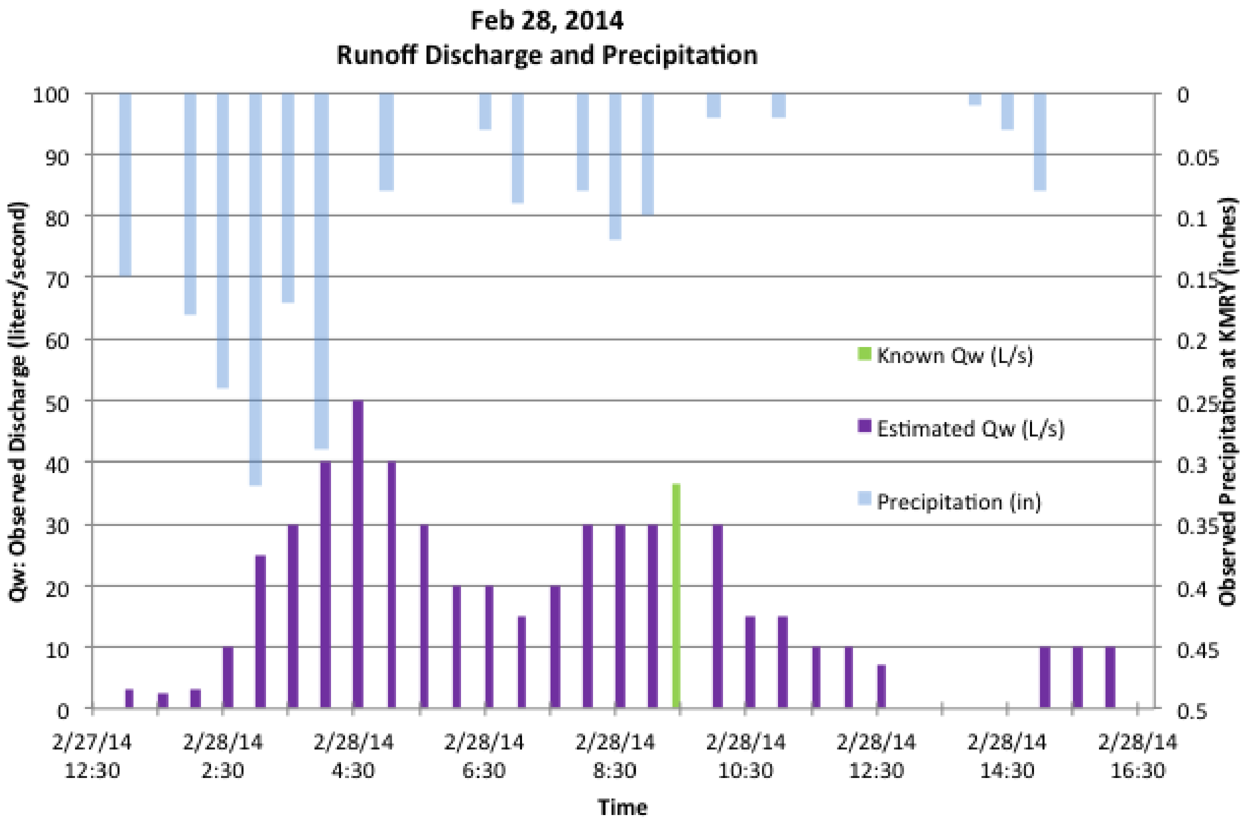
Field Measurements	Time:	Meaurement
Water Temperature (F)		
pH		
Conductivity (µS)		

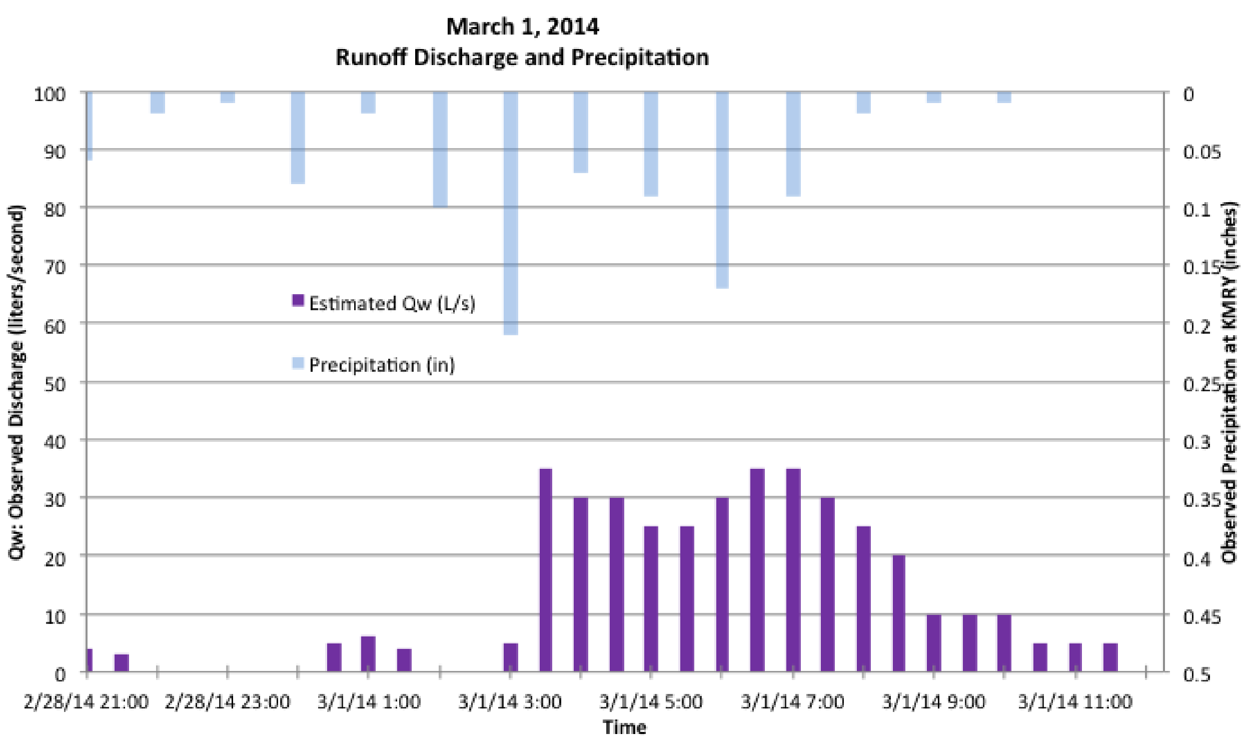
Appendix C: 6.3

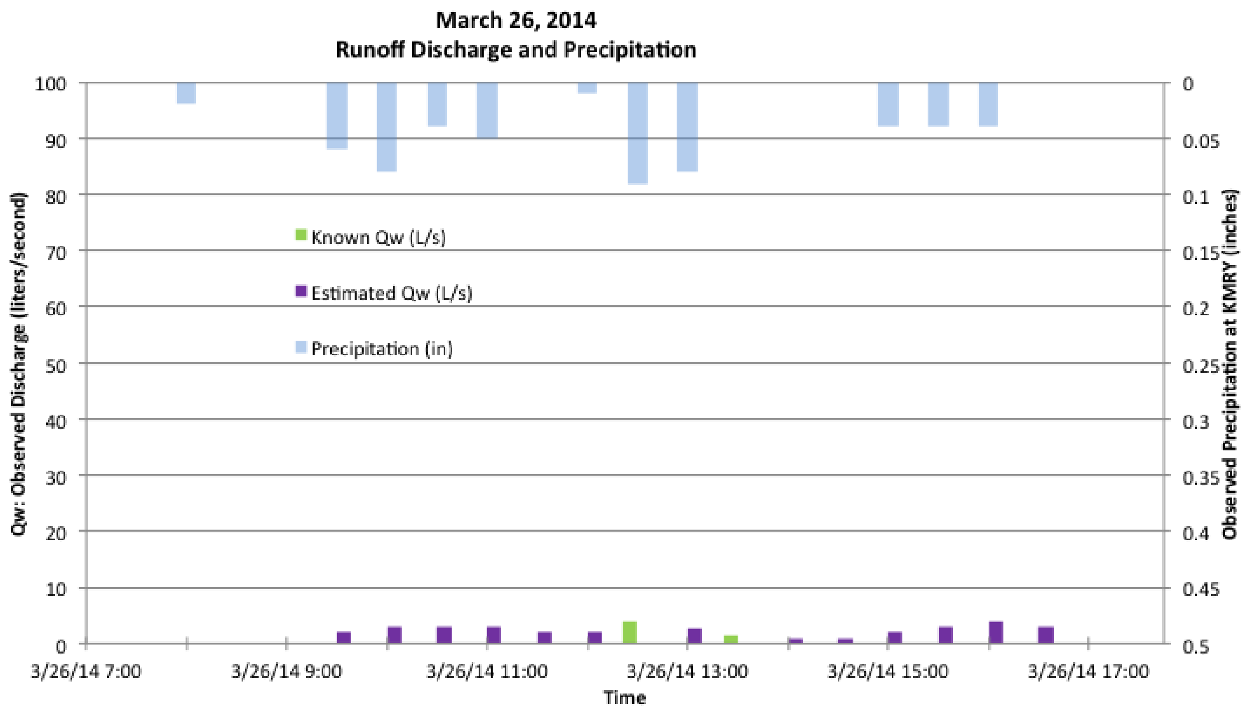
Precipitation and Discharge graphs for the two majors storms between February 2014 and March 2014.

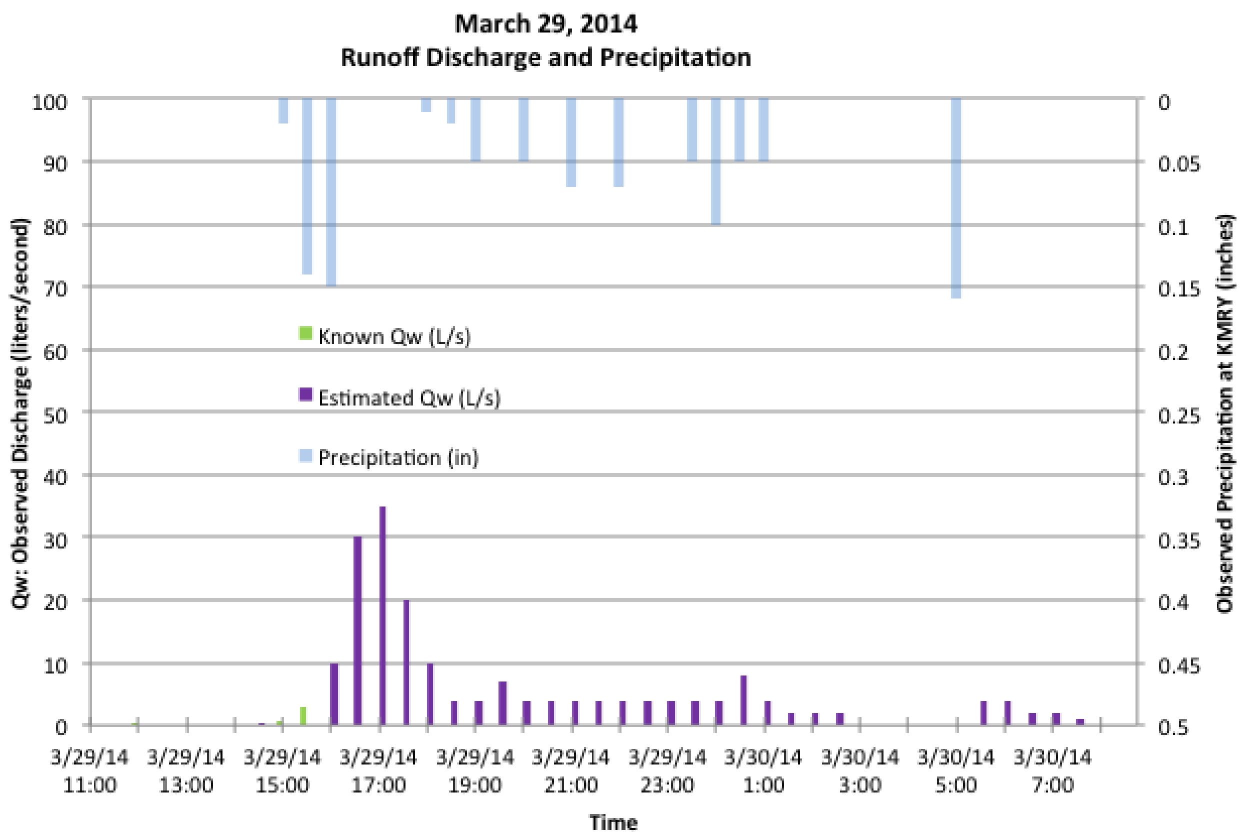



Feb 26, 2014
Runoff Discharge and Precipitation
Known Qw (L/s)
Estimated Qw (L/s)
Precipitation (in)
Qw: Observed Discharge (liters/second)
Observed Precipitation at KMRY (inches)
Time
100
90
80
70
60
50
40
30
20
10
0
0
0.05
0.1
0.2
0.3
0.4
0.45
0.5
2/26/14 6:30
2/26/14 8:30
2/26/14 10:30
2/26/14 12:30
2/26/14 14:30
2/26/14 16:30
2/26/14 18:30
2/26/14 20:30
2/26/14 22:30


Feb 28, 2014
Runoff Discharge and Precipitation
Qw: Observed Discharge (liters/second)
Observed Precipitation at KMRY (inches)
Known Qw (L/s)
Estimated Qw (L/s)
Precipitation (in)
100
90
80
70
60
50
40
30
20
10
0
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
2/27/14 12:30
2/28/14 2:30
2/28/14 4:30
2/28/14 6:30
2/28/14 8:30
2/28/14 10:30
2/28/14 12:30
2/28/14 14:30
2/28/14 16:30
Time


March 1, 2014
Runoff Discharge and Precipitation
Qw: Observed Discharge (liters/second)
Observed Precipitation at KMRY (inches)
Estimated Qw (L/s)
Precipitation (in)
100
90
80
70
60
50
40
30
20
10
0
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
2/28/14 21:00
2/28/14 23:00
3/1/14 1:00
3/1/14 3:00
3/1/14 5:00
3/1/14 7:00
3/1/14 9:00
3/1/14 11:00
Time


March 26, 2014
Runoff Discharge and Precipitation
Qw: Observed Discharge (liters/second)
Observed Precipitation at KMRY (inches)
Known Qw (L/s)
Estimated Qw (L/s)
Precipitation (in)
100
90
80
70
60
50
40
30
20
10
0
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
3/26/14 7:00
3/26/14 9:00
3/26/14 11:00
3/26/14 13:00
3/26/14 15:00
3/26/14 17:00
Time



6.3 Appendix D: Watershed Treatment Model parameters and rational.

The Watershed Treatment Model excel spreadsheet has several tabs that need input data and one tab with results. The data parameters and rational for their use in the Majors Creek Watershed Treatment Model are listed below, with sections separated by spreadsheet tab:

Tab: Sources

Parameter	Value	Data Source	Rational
Watershed Data			
Watershed Area (acres)	364.11	ArcMap analysis	ArcMap watershed delineation
Annual Rainfall (inches)	10.73	Wunderground 2013	Wuderground Data from Monterey Airport, the closest Wundergournd weather station
Stream Length (miles)	1	ArcMap analysis	ArcMap watershed delineation
Primary Sources			
Land Use		Semple, ArcMap Analysis	ArcMap watershed delineation using both Smple Land Use layers as well as free-hand digitizing using a background ortho image
LDR	73.027		
MDR	12.7		
HDR	0		
Multifamily	0		
Commercial 15.53			
Roadway	58.42		
Industrial	0		
Forest	204.42		
Rural	0		
Open Water	0		
Active Construction	0		
Soils Information			
Hydrological Soil Groups		SoilWeb 2014, Purdue Soils Map	The different soil types within the Majors Creek watershed came from SoilWeb, and then sorted into soil groups using Purdue category information. Area for each soil group was estimated for the watershed area
A Soils	10%		
B Soils	30%		
C Soils	0%		
D Soils	60%		
Depth to Groundwater		CASGEM, CA Groundwater	CASGEM was used to determine which groundwater basin was connected to the MC watershed. The Bulletin 118 was used to determine general ground water depth.
<3 Feet	0%		
3-5 Feet	0%		
> 5 Feet	100%		
Secondary Sources			
WWTP Efficiencies			
TN	20%	WTM Documentation	Values were taken from Table 4.4, with values for silt/clay used
TP	100%		
TSS	100%		
Bacteria Log Reduction	100		
General Sewage Use Data			
Dwelling Units	153	ArcMap analysis	ArcMap Delineation Select by Attribute tool selected all of the housing units within the MC watershed boundary
Nutrient Concentration in Stream channel			
Soil P (%)	0.10%	WTM Documentation	From Figure 4.1
Soil TN (%)	0.05%	Data Collection, WTM Documentation	Soil Samples were taken from the stream, but a Nitrate Quick Strip test by MQuant of the soil resulted in a 'No Detection' with a min detection of 10mg/l. Instead, the minimum value from Figure 4.1 was used instead.
Urban Channel Erosion			
Method	2		
Sediment Load from Channel Erosion (tons/year)	0.01		Sediment Analysis, rounded up to account for baseload SS discharge
Sources that were turned off			
On-site Disposal System			None known of in watershed
Marinas			No Marina within watershed
Non-Stormwater Point Sources			None known of in the watershed (communication with Tricia Wotan)
SSO/CSO/Illicit Connections		CIWQS	There have been no SSO or CSO incidences during the study year or previous year (CIWQS 2013). There are no known illicit connections in the watershed
Livestock			No Known livestock areas within the watershed
Road Sanding			Roads in Monterey are not sanded

Tab: Existing Practices

	Parameter	Value	Data Source	Rational
Pet Waste Education				
	Program in Place	Yes	Wotan 2014	
	Awareness of Message	40%		40% was suggested by the WTM Documentation for Video advertising
Erosion and Sediment Control				
	Percent of Building Permits Regulated	100%	Wotan 2014	All Building Permits are believed to be regulated
	Installation/Maintenance Discount	0.3	WTM Documentation	Value of 0.3 recommended when there are few inspectors, and there is no preconstruction meeting
Street Sweeping				
	Technique Discount	1	WTM Documentation	Value of 1 recommended when the streets have parking restrictions regarding street sweeping, and when operators are trained.
Residential	Mechanical	0		Residential street are actually swept twice a month, but this cell only gives the option of once/week or once/month. Main streets were swept once per week.
	Regenerative Air	0		
	Vacuume Assisted (acres)	22.5		
	Sweeping Frequency	Monthly	[MCDS] 2010	
Other Streets	Mechanical	0		Munras was determined to be swept weekly
	Regenerative Air	0		
	Vacuume Assisted (acres)	4.2		
	Sweeping Frequency	Weekly	[MCDS] 2010	
Parking Lots	Mechanical	0		No known information on the sweeping of parking lots within the watershed.
	Regenerative Air	0		
	Vacuume Assisted (acres)	0		
	Sweeping Frequency			
Riparian Buffers				
	Maintenance	0.6		Assumption. 0.6 value is recommended when buffers have ordinances which specify activity, but have enforcement or education.
Buffer 1	Length (Miles)	0.1	ArcMap analysis	Used ArcMap to get measurements of buffer at the NW Corner of Soledad/Munras roads.
	Width (ft)	75	ArcMap analysis	
Buffer 2	Length (Miles)	0.245	ArcMap analysis	Used ArcMap to get measurements of buffer at the NW Corner of the Del Monte Entrance/Munras roads
	Width (ft)	100	ArcMap analysis	
Buffer 3	Length (Miles)	0.608	ArcMap analysis	Used ArcMap to get measurements of buffer in Don Dahvee Park, NW of the Del Monte Center Bridge/ Munras roads.
	Width (ft)	185	ArcMap analysis	
Sources that were turned off				
	Turf practices: Residential		Wotan 2014	No current practices in place
	Turf Practices: Other			Data from Parks department not obtained
	Structural Stormwater Management Practices			No current practices in place
	Catch Basin Cleanouts			No current practices in place
	Marina Pumpouts			No Marina pumpouts within watershed

Tab: Future Practices

Parameter	Value	Data Source	Rational
Pet Waste Education			
Future Program	Yes		
Number of Households	153	ArcMap analysis	Determined by General Plan Use in ArcGIS and Select by attribute tool
Awareness Of Message	61%		61% was suggested by the WTM Documentation for Video advertising, plus billboards, plus brochure/pamphlet.
Erosion and Sediment Control			
Percent of Building Permits Required	100%	Wotan 2014	All Building Permits are believed to be regulated
Installation/ Maintenance Discount	0.9		0.9 value given by WTM Documentation, if the following requirements are followed: inspectors visit weekly, there is contractor education, and preconstruction meetings occur for most sites
Street Sweeping			
Residential			
Mechanical	0		
Regenerative Air	0		
Vacuum Assisted	22.5		
Frequency	Weekly		This was the only parameter changed. This would only need to be applicable directly before and during wet season.
Mechanical	0		
Regenerative Air	0		
Vacuum Assisted	4.2		
Frequency	Weekly		
Impervious Cover Disconnect Program			
Program in Place?	No		None known of in this watershed
Percent of Residential Lands where applicable	100%	ArcMap analysis	Residential attribute table showed all Residential lands to be larger than 1/8th acre.
Percent of Population Reached	45%	WTM Documentation	45% summed from: 7% from workshops, 8% from brochures, 30% from newspaper.
Riparian Buffer			
Buffer 1			
Buffer Length (miles)	0.1		
Buffer Width (ft)	75		
Maintenance	0.9	WTM Documentation	0.9 value comes from increased maintenance including: specific ordinances, with enforcement and education included. Only parameter changed, others were duplicate values as Buffer Baseline
Buffer 2			
Buffer Length (miles)	0.254		
Buffer Width (ft)	100		
Buffer 3			
Buffer Length (miles)	0.608		
Buffer Width (ft)	185		

Tab: Future Practices (cont.)

Parameter	Value	Data Source	Rational
Stormwater Retrofit Options			
Number of Practices	3		
Design Storm (inches)	0.2	Discharge analysis	0.20 inches was chosen because it wasn't until a storm of this size came through that the Creek itself flowed into the MC01 culvert
Discount Factor			
Design	80%	WTM Documentation	0.8 value is given when the Treatment Design meets specific standards, but is not legally binding
Maintenance	90%	WTM Documentation	0.9 value is given when the Treatment method has regular maintenance that is specified and enforced
Practice Type			
1) Dry Extended Detention Pond			
Area Captured	295	ArcMap analysis	This is the area determined by ArcMap that lies within the watershed above MC02
Impervious Percentage	43%	ArcMap analysis	Area of impervious cover determined by ArcMap
Retrofit of Existing?	no		No current Dry extended detention pond practice in watershed
Dominant Soil Type	D	SoilWeb 2014, Purdue Soils Map	See rational from Hydrological Soil Groups from Sources Tab Parameter Table
Depth to GW	>5 Feet	CASGEM, CA Groundwater Bulletin 118	See rational from Depth to Groundwater from Sources Tab Parameter Table
WQv	5000.00		Estimate of appropriate treatment facility size
2) Dry Extended Detention Pond (2)			
Area Captured	340	ArcMap analysis	This is the area determined by ArcMap that lies within the watershed above the lower reach of Don Dahvee Park
Impervious Percentage	43%	ArcMap analysis	Area of impervious cover determined by ArcMap
Retrofit of Existing?	no		No current Dry extended detention pond practice in watershed
Dominant Soil Type	D	SoilWeb 2014, Purdue Soils Map	See rational from Hydrological Soil Groups from Sources Tab Parameter Table
Depth to GW	>5 Feet	CASGEM, CA Groundwater Bulletin 118	See rational from Depth to Groundwater from Sources Tab Parameter Table
WQv	5000.00		Estimate of appropriate treatment facility size
3) Wetland			
Area Captured	295	ArcMap analysis	This is the area determined by ArcMap that lies within the watershed above MC02
Impervious Percentage	43%	ArcMap analysis	Area of impervious cover determined by ArcMap
Retrofit of Existing?	No		No current treatment wetland practice in watershed
Dominant Soil Type	D	SoilWeb 2014, Purdue Soils Map	See rational from Hydrological Soil Groups from Sources Tab Parameter Table
Depth to GW	>5 Feet	CASGEM, CA Groundwater Bulletin 118	See rational from Depth to Groundwater from Sources Tab Parameter Table
WQv	10000.00		Estimate of appropriate treatment facility size
Stream Restoration			
Percent of total stream channel unstable	20%	Survey	Estimated length of stream unstable based on creek surveys
Miles of stream channel stabilized	0.7	Survey	Estimated length of stream stabilized based on creek surveys
Percent of Urban land with flow control for small storms	0%		No known urban land flow controls in watershed
Sources that were turned off			
Residential Lawn Care Education and Turf Practices			Turned off because there does not seem to be a N or P pollution problem in the Stormwater, not the aim of this analysis.
Catchment Basin Cleanouts			Turned off because no catchment basins in watershed
Marina Pumpout			Turned off because there is no potential for marina pumpouts in the watershed
Urban Downsizing			Turned off because not an immediate need for this watershed.

6.4 Appendix E: Tributary Outfalls and In-Line Structure Inventory of Majors Creek

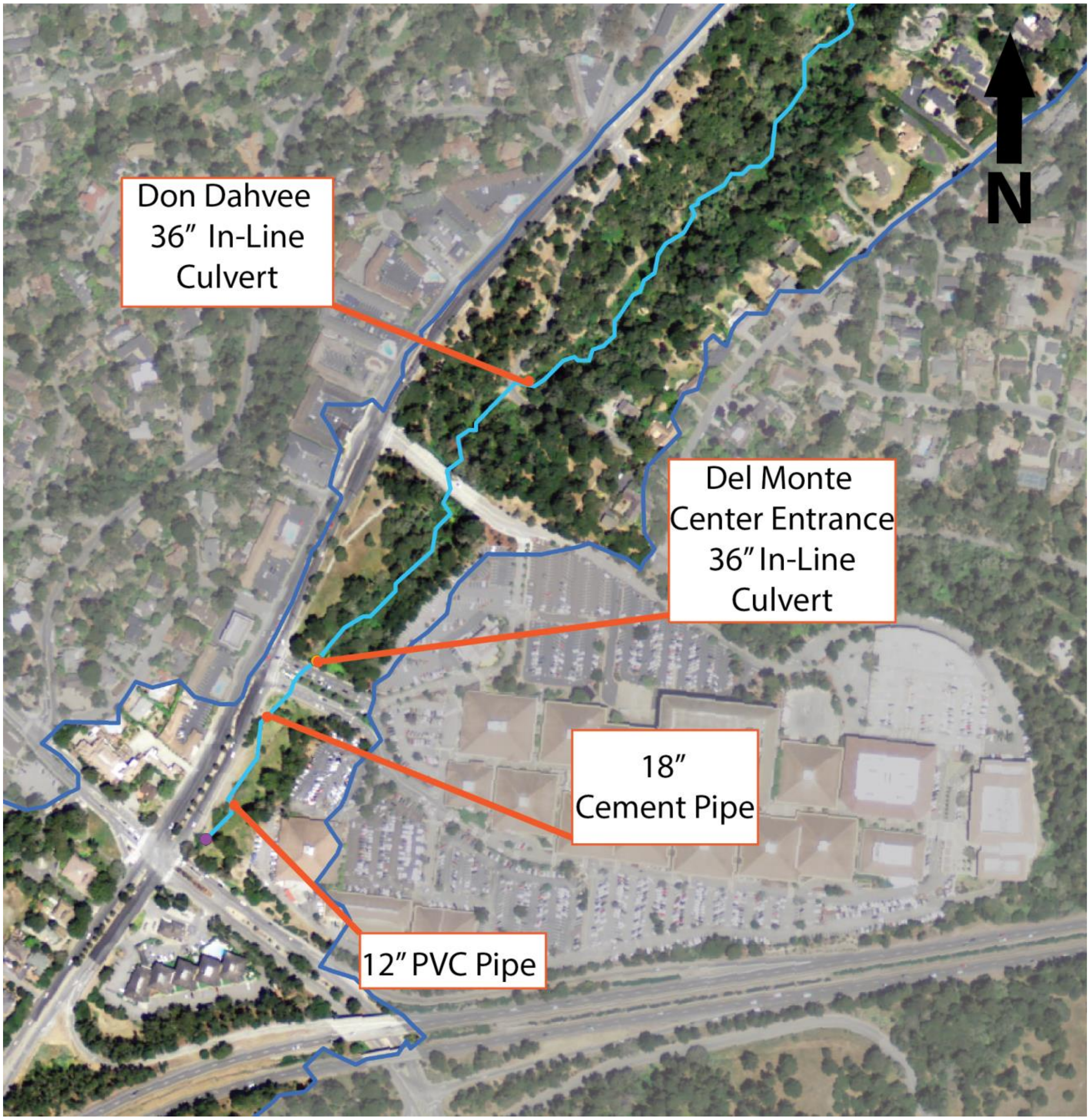


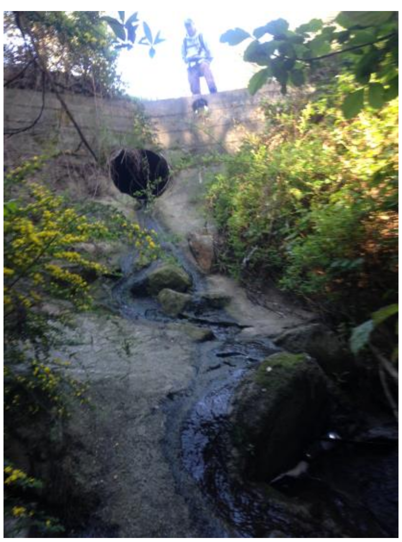
Figure: Locations of tributary outfalls and in-line structures in the open-air section of Majors Creek.

12-inch PVC pipe, near Whole Foods, located on the East Bank of upper Majors Creek

18-inch cement pipe, near Whole Foods, located on West Bank of upper Majors Creek

36-inch culvert under Del Monte Center entrance, located in-stream to convey flow under road.



36-inch CMP culvert under Don Dahvee Lane, located in-stream to convey flow under road.