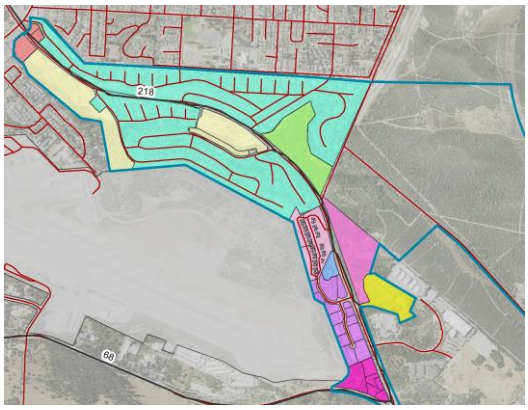

Central Coast Watershed Studies

CCoWS

Stormwater mapping and land use analysis, City of Del Rey Oaks, California

CSUMB Class ENVS660 Fall 2015:

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Prepared for the City of Del Rey Oaks, Monterey Regional Stormwater Management Program, and the Association of Monterey Bay Area Governments

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Executive Summary

This study was conducted as part of a class project by students in the Advanced Watershed Science and Policy (ENVS 660) course at California State University, Monterey Bay.

The central coast of California includes several cities with urbanized watersheds, where runoff can be directed into storm drains. Municipal Separate Storm Sewer Systems (MS4s) convey stormwater runoff separate from sanitary sewer water. Runoff from MS4s can contribute to degradation of receiving waters because water in these systems is discharged to natural waterbodies without being directed to a wastewater treatment plant. The City of Del Rey Oaks, California must manage stormwater discharges within the city limits as a stipulation to their Phase II Small MS4 General Permit under the United States Environmental Protection Agency's (EPA) National Pollutant Discharge Elimination System (NPDES). As a part of the Phase II permit, a Program Effectiveness Assessment and Improvement Plan (PEAIP) must be completed.

In support of the Del Rey Oaks PEAIP, we used a Global Positioning System (GPS) unit to collect locations of unmapped storm drain inlets and outfalls, and verified locations of currently mapped inlets and outfalls. We compiled metadata identifying the type and size of outfalls, and photographed inlets and outfalls. We conducted storm drain watershed (stormshed) delineations to aid in the understanding of stormwater routing within Del Rey Oaks. Land use areas within each stormshed were calculated to identify areas of priority where increased pollution in runoff may occur. We identified potential mitigation areas in the city where runoff and pollution may be diminished. These efforts will support the necessary next steps for Phase II compliance.

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1 Introduction

1.1 Historical and Regulatory Background

The central coast of California contains urbanized watersheds that have large areas of impervious surface cover as a result of paved roads, parking lots, sidewalks, and buildings. Increased areas of impervious cover result in higher amounts of urban runoff. Systems of conveyance such as storm drains are used to mitigate the impact runoff can have on city function. Pollutants from urbanized areas are washed into stormwater runoff (Barbosa et al. 2012). Urban runoff from these areas can degrade aquatic quality of receiving waters (Li et al. 2014).

Cities are required to manage the runoff and accompanying pollutants conveyed within the city limits. The City of Del Rey Oaks, which has a Municipal Separate Storm Sewer System (MS4) operating within it, is responsible for managing the stormwater point source discharge within its city limits.

MS4s are defined by the United States Environmental Protection Agency (EPA) as systems of conveyances which include municipal streets gutters, curbs, and storm drains. MS4s are designed and used for collecting or conveying stormwater. These conveyances are not combined with sewer lines and are separate from Publicly Owned Treatment Works (POTWs).

MS4s are owned and operated by small municipalities such as Del Rey Oaks and are regulated by state law under the authorization of Section 208 of the Clean Water Act (CWA) (EPA 2014a). This portion of the CWA regulates point source pollution such as stormwater runoff (EPA 2015).

Del Rey Oaks' point source stormwater discharge is regulated through the National Pollutant Discharge Elimination System (NPDES) permits. The NPDES permit program is designed to grant permits to entities managing stormwater under the EPA's authorization of the CWA (EPA 2014b).

The EPA allocates responsibility for permitting MS4s through the state water resources control boards. In California, the State Water Resources Control Board (SWRCB) grants permits for managing stormwater under the NPDES section of

the CWA. Stormwater management occurs within this program following guidelines set forth in the Phase II Final Rule (MRSWMP 2011).

Phase II MS4 permits are issued for municipalities managing smaller MS4s. Under Phase II, small cities are defined as cities or towns with fewer than 100,000 residents. Phase II was promulgated on December 8, 1999 by the EPA. Phase II expanded on the 1990 promulgation of Phase I (MRSWMP 2011).

Del Rey Oaks holds a Phase II MS4 permit. The permit was obtained through the formation of the Monterey Regional Storm Water Management Program (MRSWMP) in 2001 (MRWPCA 2012). The MRSWMP includes Del Rey Oaks, Carmel-by-the-Sea, Monterey, Pacific Grove, Sand City, and Seaside, and the County of Monterey. The MRSWMP was formed to work on the permit application for the NPDES Phase II program. The MRSWMP's administrative agent is the Monterey Regional Water Pollution Control Agency (MRWPCA), which assisted in the development of the regional program (MRWPCA 2012).

In accordance with the Phase II Small MS4 General Permit, permittees are required to achieve a variety of milestones. One such milestone is the completion of a Program Effectiveness Assessment and Improvement Plan (PEAIP). The PEAIP was designed to assist in documenting compliance with permit conditions and to allow adaptive management of the stormwater monitoring program (SWRCB 2013). The SWRCB requires that the City of Del Rey Oaks completes its PEAIP by October 15, 2015. The City of Del Rey Oaks must accurately map its storm drain system as a foundation for its PEAIP, and to assist in effectiveness assessment and pollutant load estimations, and in identifying high risk catchments (Roques 2014; Gina Schmidt, pers. comm., AMBAG, October 1, 2015).

Prior to this study, there was no database describing all components of the Del Rey Oaks stormwater system. The most recent mapping of the storm drain system in Del Rey Oaks occurred in 1983 when the City established its General Plan (Gina Schmidt, pers. comm., AMBAG, October 1, 2015). The maps from the General Plan were not digitized. No revisions or additions to the storm drain system more recent than 1983 were included in these maps.

A complete understanding of the drainage patterns and hydraulic conditions in Del Rey Oaks is important to city planning. Knowledge and identification of areas with higher runoff potential can be valuable to area developers and managers (Balance Hydrologics et al 2014). Future building can be informed by the information compiled in this report.

1.2 Project Goals

Our goal was to create a storm drain system database for the City of Del Rey Oaks and examine land uses within each watershed. The City can use the information we compiled to complete the PEAIP. The database includes metadata necessary for the following stakeholders:

- Association of Monterey Bay Area Governments (AMBAG),
- MRWPCA, and
- The City of Del Rey Oaks.

These data can be used for meeting future permitting requirements such as flow and pollutant load modeling as well as future analyses by stakeholders (Roques 2014; Gina Schmidt, pers. comm., AMBAG, October 1, 2015).

A secondary goal was the identification of areas of priority (AOP) and areas of interest (AOI). We defined AOPs as areas of greatest potential risk for stormwater runoff issues. We selected AOPs in areas where impervious cover and specific land uses could lead to increased pollutant load within runoff. We defined AOIs as areas that have the potential to assist with mitigation of stormwater runoff and pollution. These areas were selected as examples of existing management options and opportunities for improvements in stormwater management. AOIs can improve stormwater management and guide future planning.

1.3 Study Area

The study area for this project was the City of Del Rey Oaks, California, located on the Central Coast of California in Monterey County (Fig. 1). Del Rey Oaks is approximately 3 kilometers southeast of Monterey Bay, south of the city of Seaside, and east of the city of Monterey.

Our focus was on the MS4 operating in the City of Del Rey Oaks and the catchment areas that drain into that MS4 (Fig. 2).

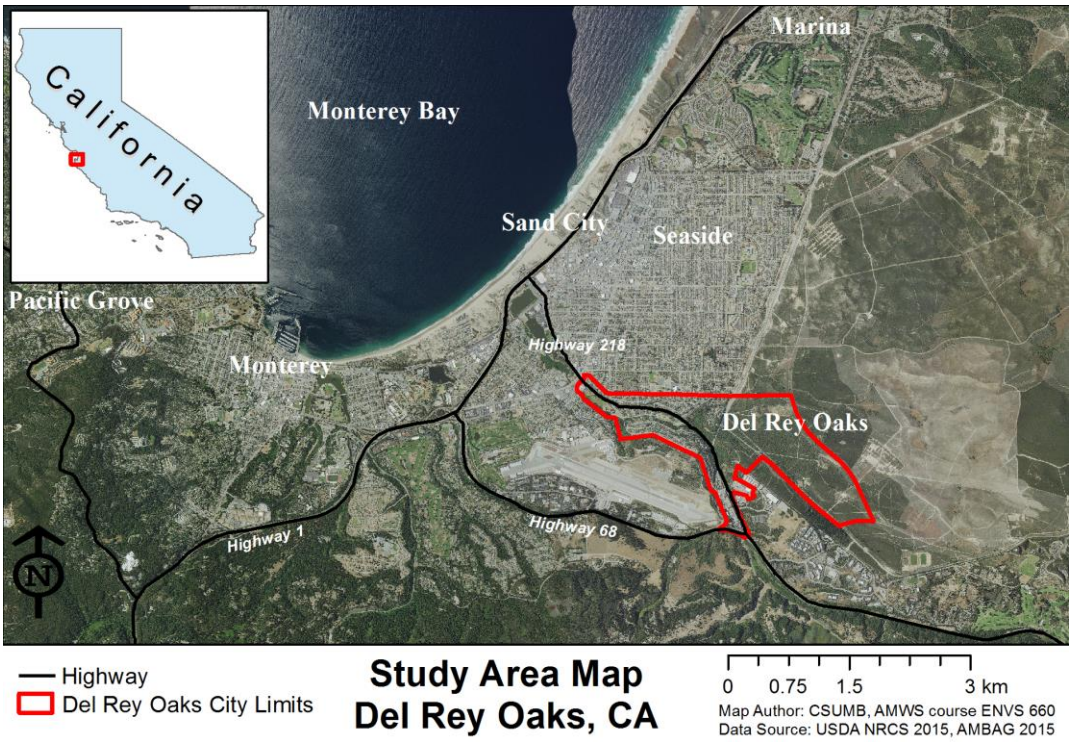


Figure 1. Del Rey Oaks is located in the Monterey Bay Area, California.

1.4 Previous Studies

Previous studies have assessed the drainage conditions as they existed in both the entire watershed and distinct portions of Del Rey Oaks (Fig. 2).

The initial Master Drainage Plan for Canyon del Rey examined hydrologic conditions within the watershed. The plan included analysis of existing hydraulic

conditions, predictions of future conditions, and recommendations for improvements within the area (Monterey County Surveyors and Koretsky King Associates 1977). In 2014, the Drainage Plan was reassessed for changes in hydrologic and hydraulic conditions in the area. The update was recommended to reflect current conditions and changes in development since the original plan. Updates in flood management facilities were examined and included in the most recent Plan (Balance Hydrologics et al 2014).

The hydrologic and erosional condition of Frog Pond Wetland Preserve (FPWP) was studied from December 2012 to June 2014. FPWP is located east of the Del Rey Oaks City Hall and can be seen in Figure 2. The report examined impacts that erosion, Canyon del Rey creek restoration, and future development would have on Frog Pond (Geisler et al. 2014).

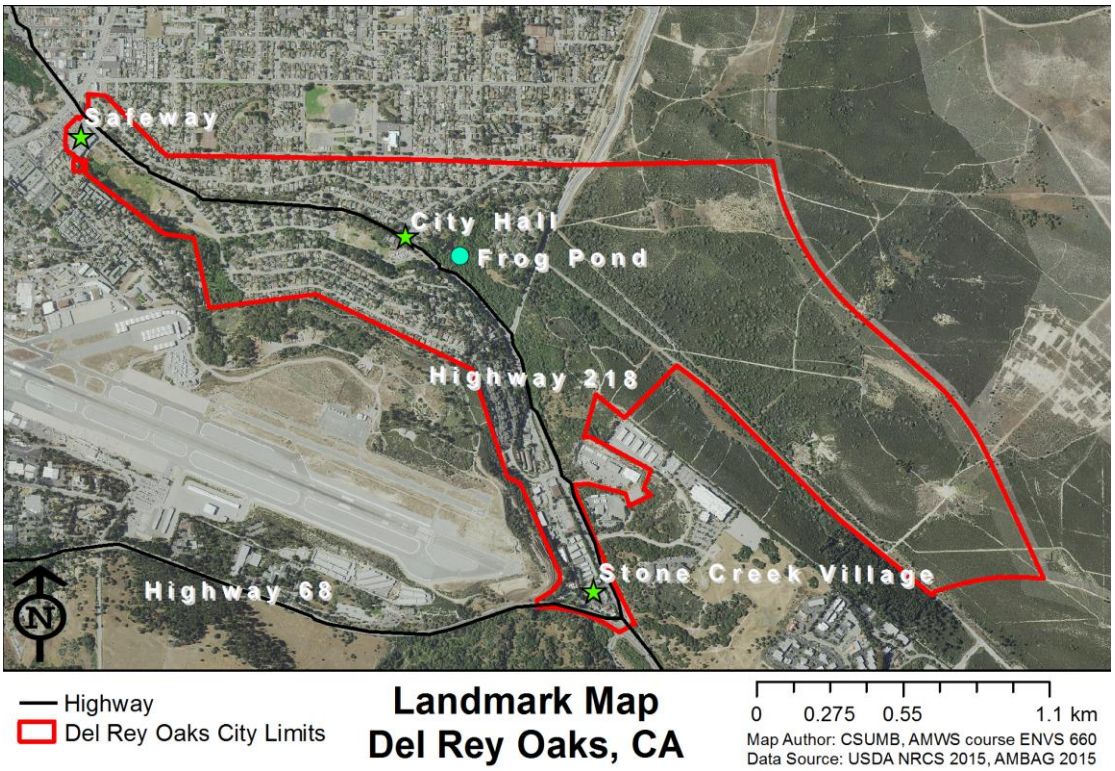


Figure 2. City of Del Rey Oaks, major land marks are shown as green stars. Previous studies have assessed the hydrologic conditions in Del Rey Oaks in its entirety as well as specific locations such as Frog Pond shown in aqua.

2 Methods

2.1 Available Data

Data from the following data sources were used to make several different maps:

- 10 meter resolution Light Detection and Ranging (LIDAR) Digital Elevation Model (DEM) 2010 obtained from AMBAG on September 29, 2015
- Digital Orthoimagery: National Agricultural Imagery Program 2014. Downloaded from United States Department of Agriculture Natural Resources Conservation Service Geospatial Data Gateway on September 29, 2015
- GIS data on streets, inlet and outfall locations, streams and lakes, land use zoning and City boundaries provided by AMBAG, on September 27, 2015
- Scanned Drainage Facilities Map. Neill Engineers Inc. 1983. Scanned on October 5, 2015
- Drawing (DWG) Plansets provided by Balance Hydrologics and Whitson Engineers; downloaded from Monterey Peninsula, Carmel Bay, and South Monterey Bay Integrated Regional Water Management website on October 18, 2015
- Land Use map PDF file provided by AMBAG, on September 27, 2015

2.2 Field-collected Data

We identified and mapped stormwater inlets and outfalls on October 6 and October 8, 2015. In addition to identifying previously unmapped inlets and outfalls, we confirmed the existence of previously mapped storm drain inlets and outfalls. We used a Trimble Juno 3B GPS unit to catalog locations and characteristics of inlets and outfalls (Trimble 2014). Characteristics included drain location, size, and construction materials. We photographed each inlet and outfall for inclusion in metadata. Inlet and outfall point locations were

imported into ESRI ArcMap for spatial analyses (ESRI 2014). We incorporated the metadata from these points into the geodatabase established for this project.

2.3 Preliminary Stormshed Delineation & Construction of Del Rey Oaks Geodatabase

We mapped storm drains and delineated storm drain watersheds (stormsheds) using ArcGIS software. We estimated the location of storm drains from connections between field-validated inlets and outfalls. To incorporate the impact that the storm drains, culverts, and gutters had on runoff direction and accumulation we "burned" them into the DEM. Burning was done by sinking the elevation of the conveyance into the original DEM. The formation of imprinted channels within the DEM allowed for watershed analysis and the creation of flow direction and accumulation rasters. Stormsheds were delineated using flow pathways and storm drain inlets. We calculated the area of each stormshed and its corresponding land use. We followed methods used in similar stormwater studies (CSUMB Class ENVS 660 2011; CSUMB Class ENVS 660 2014).

We compiled a geodatabase containing a mapped system of storm drains, delineated stormsheds, and locations of inlets and outfalls, and all other corresponding data. All inlets and outfalls were cataloged, assigned a numeric identifier, and photographed.

We compiled a geodatabase which represents a preliminary examination of the MS4 system within Del Rey Oaks. We acknowledge that our mapping of the gutters in the city limits is incomplete. Due to the time constraints of our study period, comprehensive mapping was not possible. Our understanding of the hydrologic conditions within Del Rey Oaks is restricted by our limited mapping of the runoff conveyance within the city. Additionally, the scope of our study does not extend past the city limits. The impact of neighboring MS4s from adjacent cities, Seaside and Monterey, on flow paths was not assessed in this study.

3 Results

3.1 Preliminary Watershed Delineation

The maps showing the Del Rey Oaks storm drain system and the stormshed delineations can be seen in Figures 3 and 4. Inlets and outfalls are indicated on these maps, compiled in Tables A1 and A2, and labeled in Figs. A1 – A4 (Appendix A). We delineated 26 stormsheds that drain into the Del Rey Oaks MS4. Land use statistics were calculated for each stormshed within Del Rey Oaks city limits (Tables 1&2; Fig. 5).

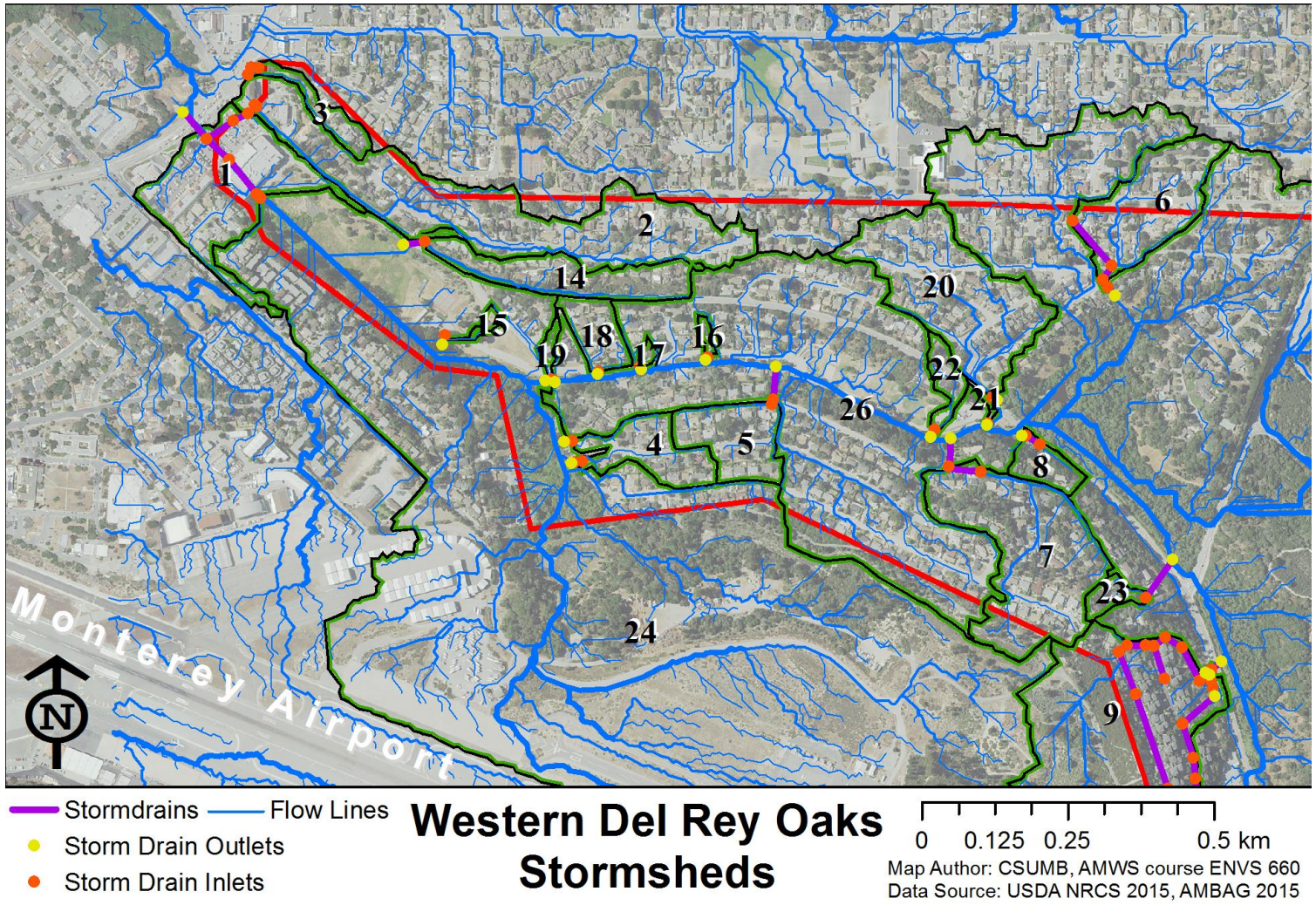


Figure 3. Preliminary storm watershed delineation for the western extent of Del Rey Oaks, California including storm drain inlets and outfalls, estimated storm drain locations, and flow lines.

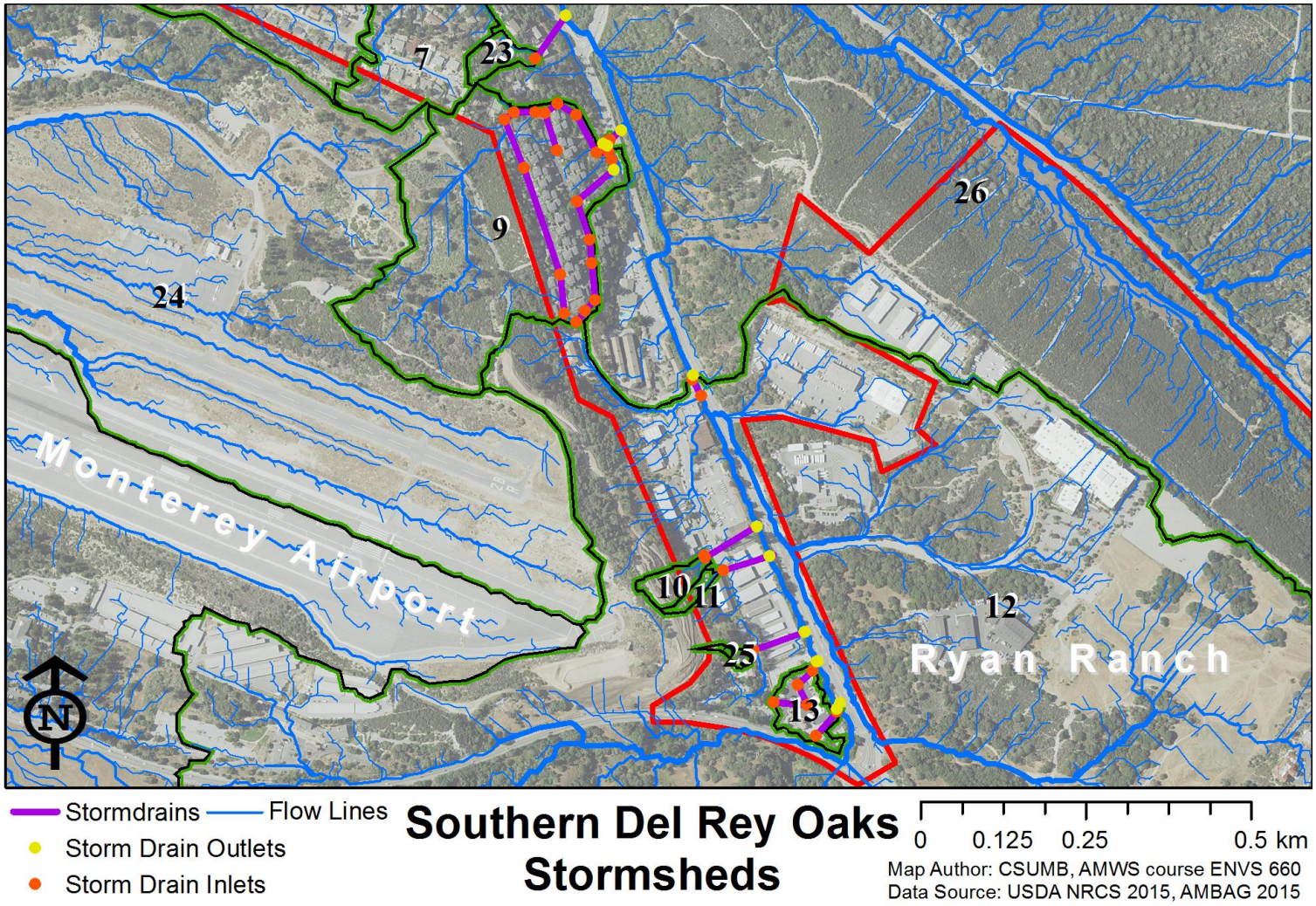


Figure 4. Delineation map of Southern Del Rey Oaks watersheds containing GPS outfalls and inlets, estimated storm drain locations, and flowline variations.

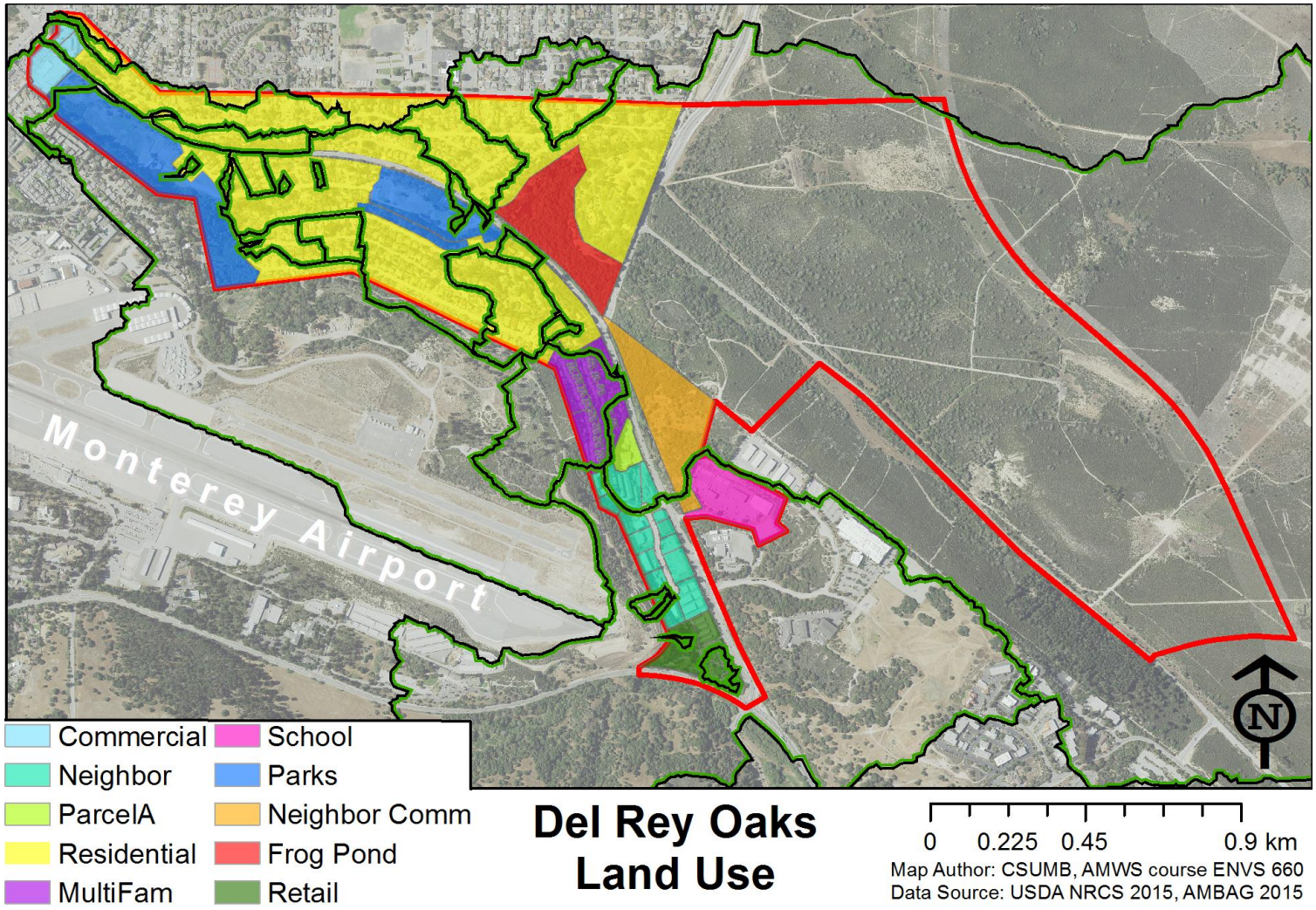


Figure 5. Land use within the Del Rey Oaks city limits.

Table 1. Land use percentages within each stormshed. Values in black are those where some percentage of land use type exists for the specific stormshed, and grey values are those where no land use occurs for the stormshed.

Stormshed ID	Land Use (%)										
	Commercial	Frog Pond	Multi Fam Dwell	Neigh Comm	Neighborhood	Parks	Retail Comm	School	Parcel A	Residential	Other
1	30.5	0.0	0.0	0.0	0.0	9.5	0.0	0.0	0.0	0.0	60.0
2	7.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	83.7	8.8
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	94.1	5.9
4	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0	0.0	98.2	0.0
5	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	99.6	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	44.0	56.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	88.3	11.7
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
9	0.0	0.0	34.4	0.0	0.0	0.0	0.0	0.0	0.0	1.6	64.0
10	0.0	0.0	0.0	0.0	30.9	0.0	0.0	0.0	0.0	0.0	69.1
11	0.0	0.0	0.0	0.0	54.5	0.0	0.0	0.0	0.0	0.0	45.5
12	0.0	0.0	0.1	0.4	4.7	0.0	2.3	3.6	0.0	0.0	89.0
13	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
15	0.0	0.0	0.0	0.0	0.0	17.6	0.0	0.0	0.0	82.4	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	99.6	0.4
21	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	58.8	0.0	0.0	0.0	41.2	0.0
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
24	0.0	0.0	0.0	0.0	0.0	9.9	0.0	0.0	0.0	3.1	87.0
25	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0
26	0.0	1.8	0.3	1.6	0.4	1.3	0.0	0.0	0.2	8.6	85.7

Table 2. Land use acreages within each stormshed, identified by its stormshed ID number (SID). Grey values indicate where there is an absence of a particular land use for the stormshed. Stormsheds with runoff draining into inlets have the corresponding inlet ID number. Stormsheds without inlet to capture flow are classified as diffuse, where runoff drains directly into the Canyon Del Rey Creek. Each stormshed was evaluated for its proximity to a possible mitigation feature which are numbered and explained in detail in section 3.3 Analysis.

	Land Use (acres)													
SID	Commercial	Frog Pond	Multi Fam Dwell	Neigh Comm	Neighborhood	Parks	Retail Comm	School	Parcel A	Residential	Other	Total	Inlet ID	Possible Mitigation Feature
1	3.40	0.00	0.00	0.00	0.00	1.06	0.00	0.00	0.00	0.00	6.71	11.18	64–68	1
2	1.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.08	1.79	20.40	61–63	None
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.89	0.12	2.01	58–60	None
4	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	4.35	0.00	4.43	3–5	None
5	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	4.92	0.00	4.94	9–10	None
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.66	4.66	8.32	18–21	None
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.22	1.75	14.97	11, 14	None
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.77	0.00	1.77	16–17	None
9	0.00	0.00	10.11	0.00	0.00	0.00	0.00	0.00	0.00	0.47	18.81	29.40	23–43	5
10	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.75	1.08	55–56	None
11	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.20	0.43	54	None
12	0.00	0.00	0.18	0.96	12.65	0.00	6.37	9.82	0.00	0.00	241.81	271.80	52–53	None
13	0.00	0.00	0.00	0.00	0.00	0.00	1.97	0.00	0.00	0.00	0.00	1.97	45–50	None
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.63	0.00	5.63	57	None
15	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.28	0.00	0.33	44	None
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.33	8	None
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.24	7	None
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.54	0.00	2.54	6	None
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47	0.00	0.47	1–2	None
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.56	0.06	13.62	23	3
21	0.00	0.00	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.00	0.18	13	3
22	0.00	0.00	0.00	0.00	0.00	0.79	0.00	0.00	0.00	0.55	0.00	1.34	12	3
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.12	0.00	1.12	15	None
24	0.00	0.00	0.00	0.00	0.00	22.53	0.00	0.00	0.00	7.16	198.09	227.79	Diffuse	1,2,3
25	0.00	0.00	0.00	0.00	0.00	0.00	0.26	0.00	0.00	0.00	0.00	0.26	51	None
26	0.00	17.16	2.87	15.25	4.05	12.53	0.00	0.00	1.99	80.55	807.20	941.60	Diffuse	3,4

3.2 Delineation Accuracy

Stormshed delineations for this report include some errors, which cannot be corrected within the scope of this project. An example can be seen in the differences of flow lines in Figures 6a and 6b. An example of successful burning of gutter paths in the DEM is shown on Figure 6a. The flow path of runoff follows the gutters that we burned into the DEM. In contrast, Figure 6b shows an example of an erroneous flow path resulting from an error in delineation. Errors within the burned DEM impacted size, shape, and catchment areas of the stormsheds. Future work can improve accuracy of watershed delineations by verifying gutter locations, adjusting gutter depths and adjacent curb heights, and examining actual flow routing during precipitation events to verify flow line accuracy.

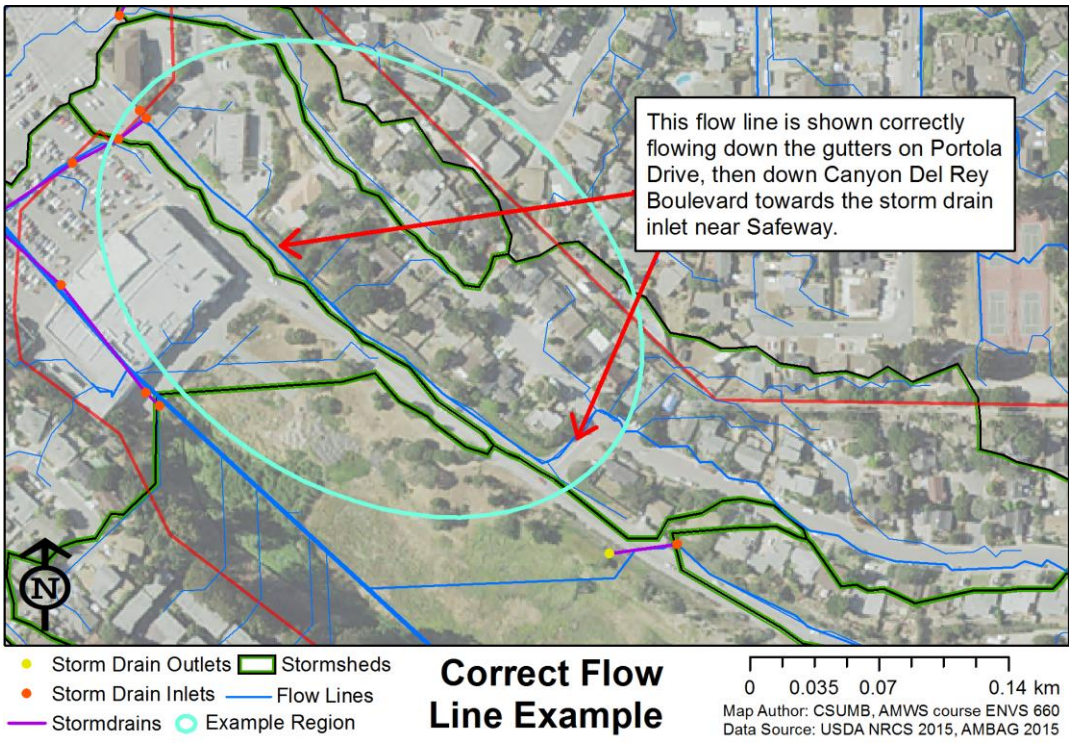


Figure 6a. One example of correct flow line path. The path of the flow line reflects a realistic path directed by gutters that runoff would take in a precipitation event.

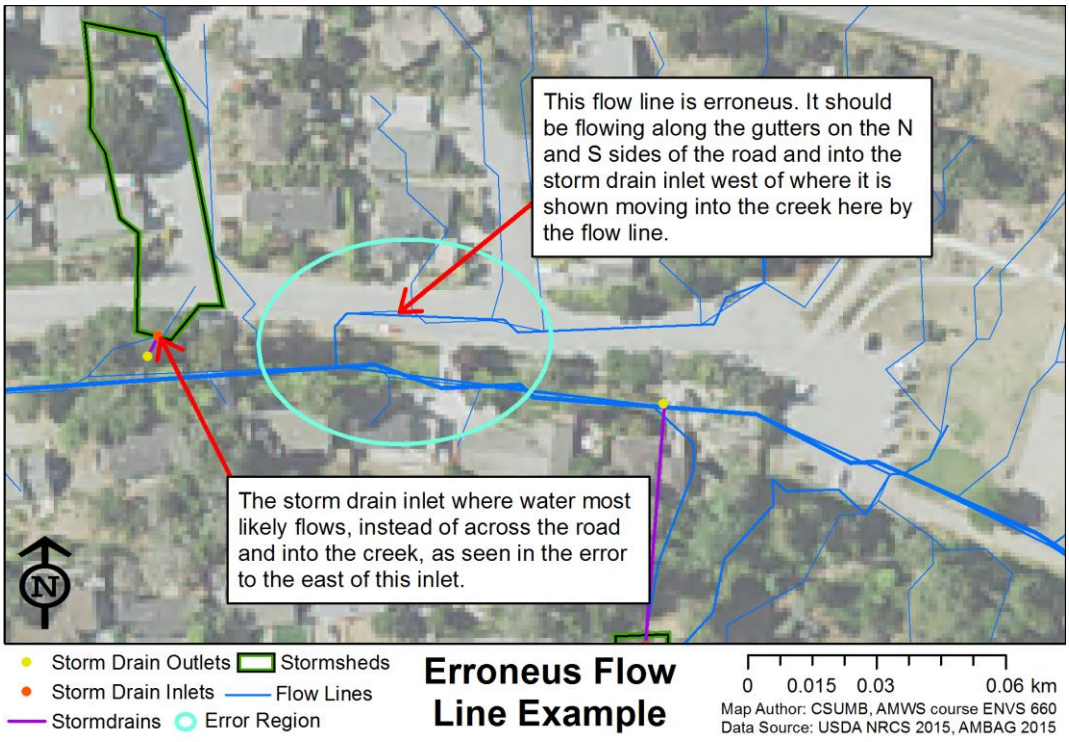


Figure 6b. One example of the delineation errors that occurred as an artifact of the gutters in this area. Gutters were burned in; however, further manipulation of their depths and the adjacent curb heights will need to occur for improved accuracy of the delineation.

3.3 Analysis

We identified 2 areas of priority (AOPs). The first AOP, located at the intersection of Fremont Boulevard and Highway 218, contains 3.4 acres of commercial zoning (Fig. 7). The second AOP, located at the intersection of Highway 218 and Highway 68, contains 2.0 acres of retail zoning (Fig. 8). Both AOPs have large amounts of impervious surfaces and increased traffic associated with businesses in the area. Runoff generated in the heavily trafficked areas can contain high pollutant loads and may contribute to an increased degradation of water quality in Canyon Del Rey Creek. We recognize delineation errors associated with these stormsheds. Errors within the burned DEM resulted in delineation errors and flow line behavior that is not representative of reality. In Figure 7, errors are visible in flow line path and outfall alignment. The straight flow line through the middle of Work Memorial Park should follow the curvature of the creek. All outfalls should be in connection with a flowline; the DEM is incorrectly burned where this does not occur. While these delineation errors are notable, the errors do not affect our designation of these areas as high priority.

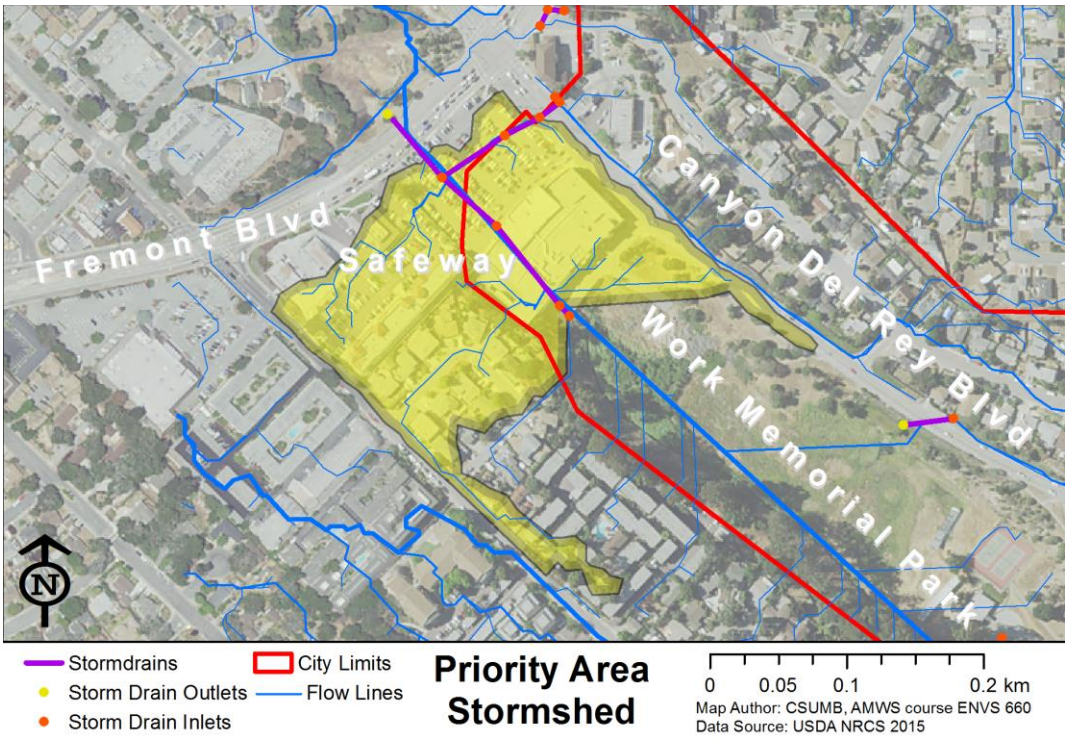


Figure 7. AOP1 located in the commercially zoned area near the Safeway shopping center.

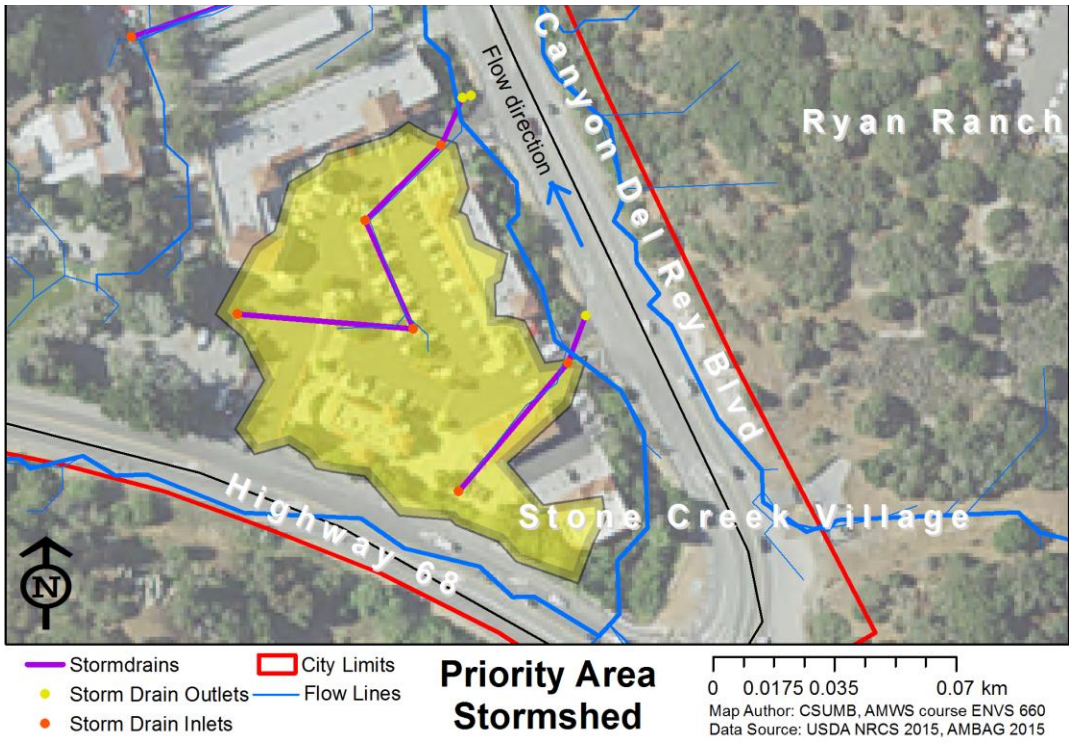


Figure 8. AOP2 located in the commercially and residentially zoned area near the intersection of Highways 218 and 68.

We identified 5 areas of interest (AOIs):

1. Work Memorial Park,
2. A Canyon Del Rey Creek tributary,
3. A floodplain above General Jim Moore Blvd,
4. Frog Pond, and
5. The Oaks Condominiums BMP

for their potential to assist with stormwater runoff and pollution mitigation (Fig. 9). AO1s 1-4 are riparian corridors that may currently be mitigating runoff. AOIs 1&3 have adequate floodplain space which may be reconfigured to increase residence time and mitigate pollutant load of runoff. Future examination of these areas could quantify their runoff and pollutant load reducing potential. AOI 5 is the structure between the Oaks Condominiums and Highway 218. This structure is a detention pond that temporarily stores runoff from the Oaks Condominiums, which could be reducing runoff and pollutant

load. Several stormsheds within Del Rey Oaks may receive benefits from these potential mitigation areas (Table 2). Future studies could evaluate these areas for efficacy as mitigation elements.

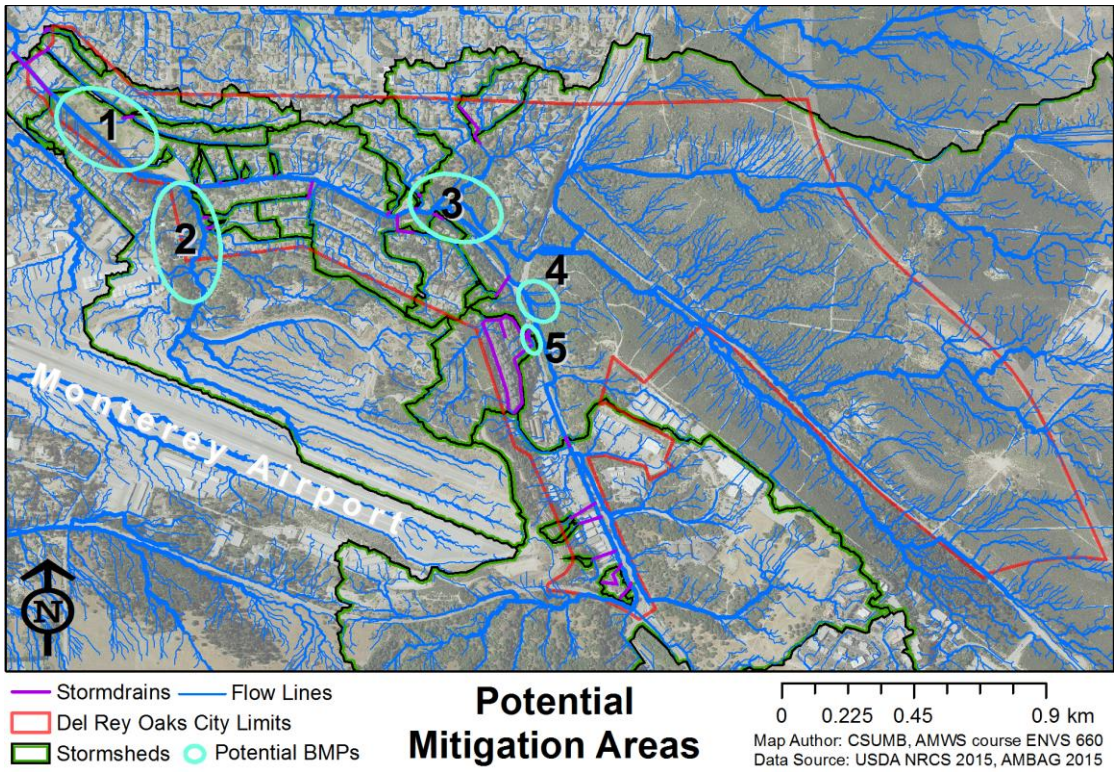


Figure 9. Areas in Del Rey Oaks that could be used for mitigation of stormwater runoff and pollution. See main text for explanation of numbered items.

3.4 Del Rey Oaks Geodatabase

We compiled the metadata collected in the field, from historic mapping, and in the newly constructed maps into a geodatabase. The data contained within the geodatabase included:

- Storm drain inlets within the Del Rey Oaks city limits,
- Storm drain outfalls within the Del Rey Oaks city limits,
- Created feature classes for gutters and burned in water pathways
- Assumed and known storm drain routing between inlets and outfalls,
- ArcMap model used for delineating stormsheds within Del Rey Oaks city limits,
- Delineated stormsheds, and
- Metadata including inlet and outfall pictures as well as outfall construction material and dimension (Appendix).

The geodatabase can be found at:
http://ccows.csumb.edu/pubs/proj_pubs/2015/ENVS_660_DROStormwater/index.htm

4 References

Balance Hydrologics, Inc., Whitson Engineers, California State University, Monterey Bay. 2014. Canyon del Rey master drainage plan. Prepared for: Monterey Peninsula Water Management District, Monterey County Water Resources Agency, and City of Seaside, California. 348 pp. [Internet]. [cited: 2015 Nov 01] Available from: http://www.mpwmd.dst.ca.us/Mbay_IRWM/IRWM_library/CanyonDelRey/CanyonDelRey2014DraftUpdate.pdf

Barbosa AE, Fernandes JN, and David LM. 2012. Key issues for sustainable urban stormwater management. Water Research. 46(20): 6787–6798. [Internet]. [cited: 2015 Oct 22]. Available from: http://www.sciencedirect.com/science/article/pii/S0043135412003569

CSUMB Class ENVS 660: Noble S, Neill C, Missaghian J, Inman J, Malik A, Watson F. 2014. Stormwater characterization for reduction and reuse: Presidio of Monterey, California. The Watershed Institute, California State Monterey Bay, Publication No. WI-2014-11, 80 pp. [Internet]. [cited: 2015 Nov 01]. Available from: http://ccows.csumb.edu/pubs/reports/CSUMB_ENVS660_ClassReport_PresidioStormwater_141109_FW.pdf

CSUMB Class ENVS 660: Pugh K, Arenas R, Cubanski P, Lanctot M, Purdy A, Bassett R, Smith J, Hession S, Stoner K, Ashbach R, Alberola G, Jacuzzi N, Watson F. 2011. Stormwater outfall watershed delineation, land cover characteristics, and recommended priorities for monitoring and mitigation in the City of Pacific Grove, California. The Watershed Institute, California State Monterey Bay, Publication No. WI-2011-02, 74 pp. [Internet]. [cited: 2015 Nov 01] Available from: http://ccows.csumb.edu/pubs/reports/CSUMB_ENVS660_ClassReport_PGStormwater_120306.pdf

[EPA] United States Environmental Protection Agency. 2014a. Municipal Separate Storm Sewer System (MS4) Main Page. [Internet]. [cited: 2015 Oct 03]. Available from: http://water.epa.gov/polwaste/npdes/stormwater/Municipal-Separate-Storm-Sewer-System-MS4-Main-Page.cfm

[EPA] United States Environmental Protection Agency. 2014b. NPDES Home. [Internet]. [cited: 2015 Oct 03]. Available from: http://water.epa.gov/polwaste/npdes

[EPA] United States Environmental Protection Agency. 2015. Stormwater Homepage. [Internet] [cited: 2015 Oct 03]. Available from: http://water.epa.gov/polwaste/npdes/stormwater/index.cfm

[ESRI] Environmental Systems Resource Institute. 2014. ArcMap 10.2.2. ESRI, Redlands, California.

Geisler E, Smith D, Watson F. 2015. Frog Pond Wetland Preserve enhancement and erosion control plan. Central Coast Watershed Studies publication no. WI-2014-04. The Watershed Institute: Science and Environmental Policy, California State University, Monterey Bay. 71 pp. [Internet] [cited: 2015 Nov 01]. Available from: http://ccows.csumb.edu/pubs/reports/CCoWS_MPRPD_FrogPond_EnhancementPlan_150624.pdf

Li Z, Valladares Linares R, Abu-Ghdaib M, Zhan T, Yangali-Quintanilla V, and Amy G. 2014. Osmotically driven membrane process for the management of urban runoff in coastal regions. Water Research. 41(1): 200-209. [Internet] [cited: 2015 Oct 22]. Available from: http://www.sciencedirect.com/science/article/pii/S0043135413007203

Monterey County Surveyors and Koretsky King Associates. 1977. Monterey County. Master Drainage Plan. Canyon Del Rey Watershed. [Internet] [cited: 2015 Nov 01]. Available from: http://www.mpwmd.dst.ca.us/Mbay_IRWM/IRWM_library/Seaside%20Basin/Canyon-Del-Rey-study_1977.pdf

[MRSWMP] 2011. Available from: http://monterey.org/en-us/Departments/Plans-Public-Works/Engineering/Storm-Water-Program/MRSWMP

[MRSWMP] Monterey Regional Stormwater Management Program. 2012. Monterey Regional Stormwater Management Program. [Internet]. [cited: 2015 Oct 03]. Available from: http://www.montereysea.org/about.php

Roques, D. 2014. Effectiveness assessment and monitoring. Letter to Phase II Permittees from the California State Water Resources Control Board Staff.

[SWRCB] State Water Resources Control Board. 2013. Water Quality Order No. 2013-0001-DWQ; National Pollutant Discharge Elimination System General Permit No. CAS000004. [Internet]. [cited: 2015Oct 03]. Available from: http://www.waterboards.ca.gov/board_decisions/adopted_orders/water_quality/2013/wqo2013_0001dwq.pdf

Trimble. 2014. TerraSync version 5. Trimble Navigation Limited, Sunnyvale, California.

5 Appendix A

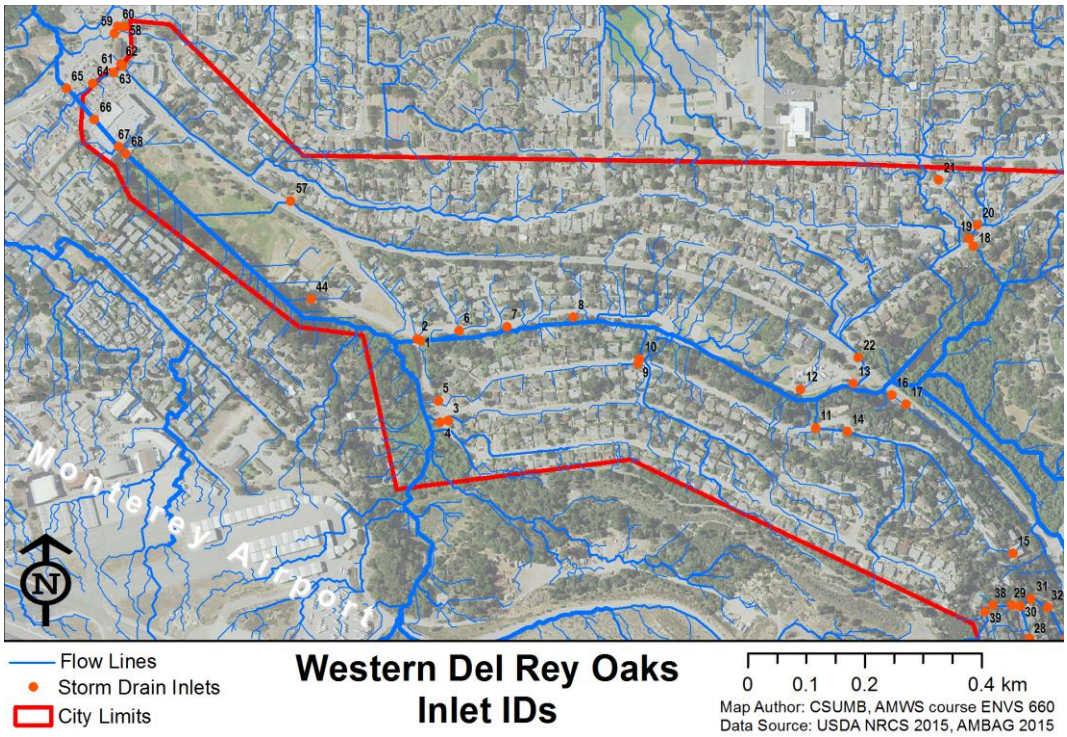


Figure A1. Inlet IDs for the Del Rey Oaks western extent.

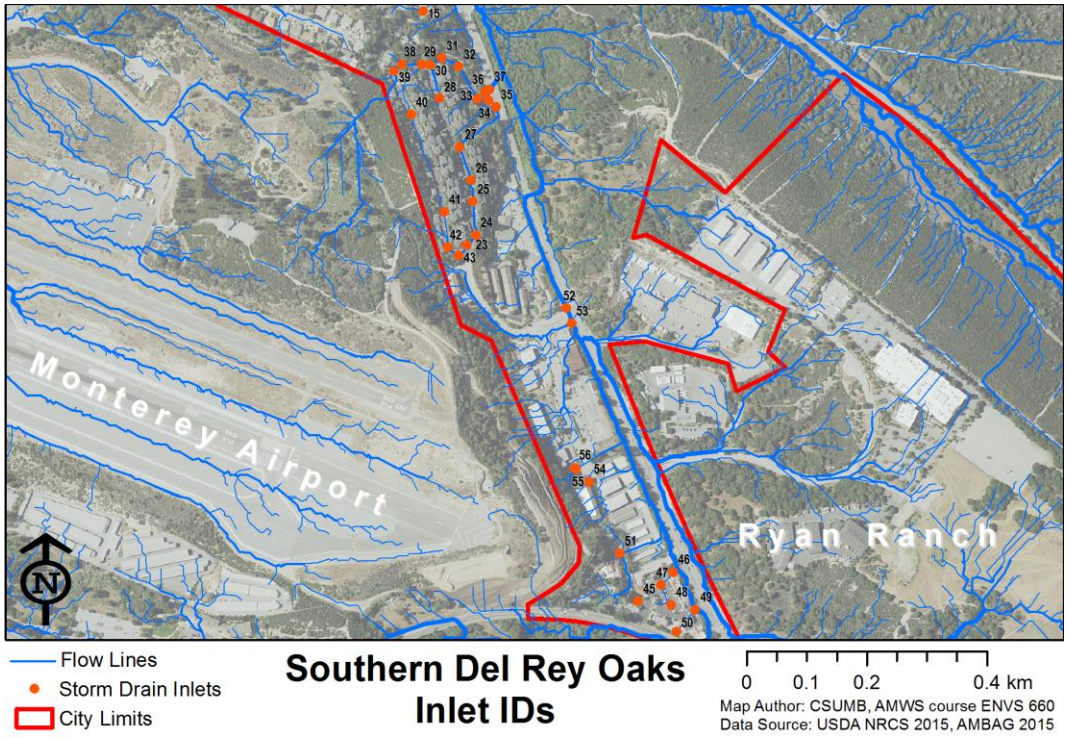


Figure A2. Inlet IDs for the Del Rey Oaks southern extent.

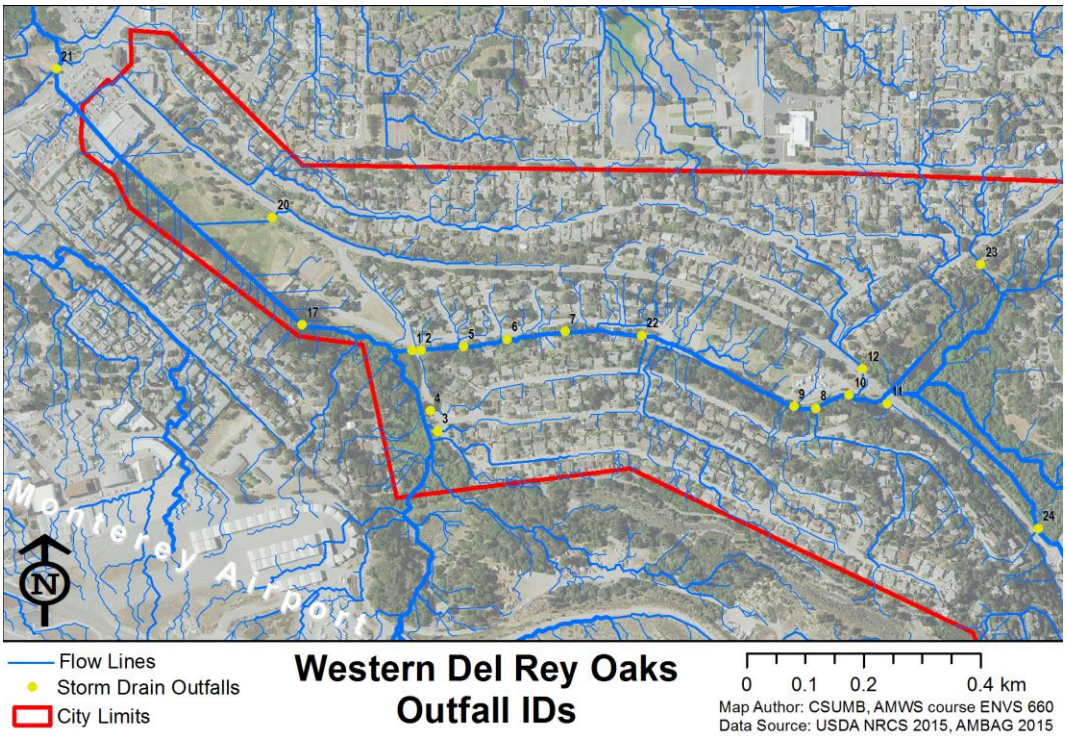


Figure A3. Outfall IDs for the Del Rey Oaks western extent.

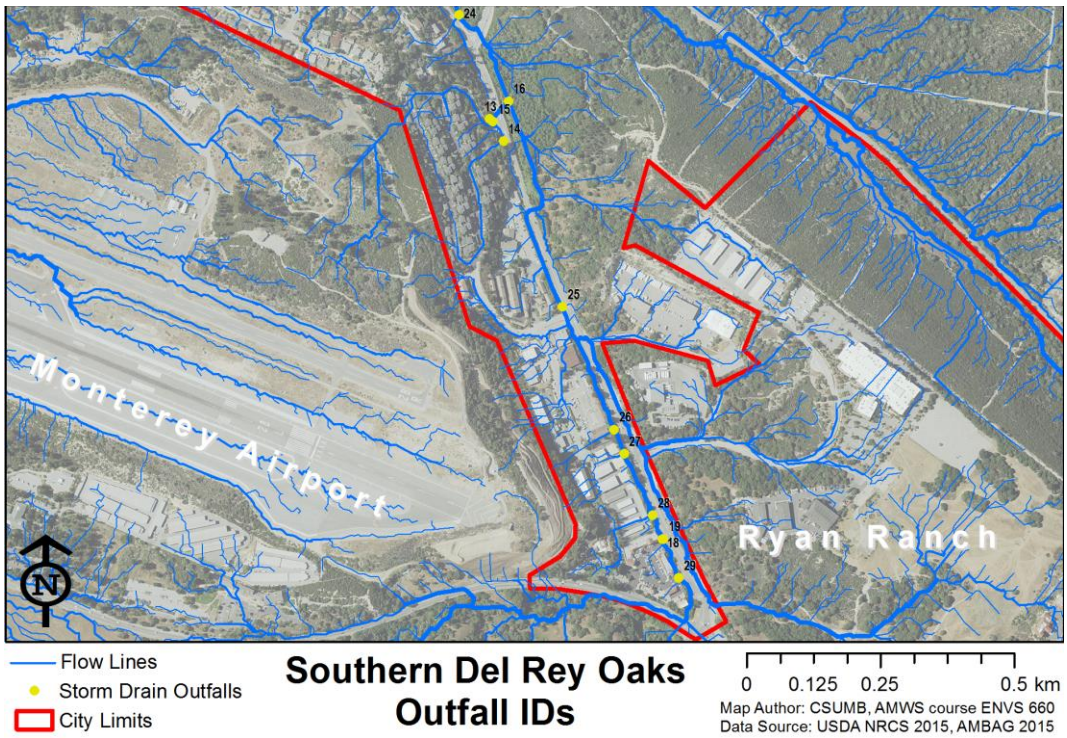


Figure A4. Outfall IDs for the Del Rey Oaks southern extent.

Table A1. Inlets mapped in Del Rey Oaks.

Inlet ID	Picture	Type of Inlet	Latitude	Longitude
1		Curb	36.59429	-121.844658
2		Curb	36.59427	-121.844615
3		Curb	36.59302	-121.844086

4		Curb	36.593	-121.844086
5		Curb	36.59333	-121.844275
6		Curb	36.59439	-121.843762

7		Curb	36.59446	-121.842959
8		Curb	36.59459	-121.841666
9		Curb	36.59387	-121.840443

10		Curb	36.59393	-121.840414
11		Curb	36.59286	-121.837069
12		Curb	36.59343	-121.837335

13		Paved	36.59352	-121.836319
14		Curb	36.59278	-121.836452

15		Curb	36.5908	-121.833332
16		Curb	36.59333	-121.835592

17		Curb	36.59319	-121.835318
18		Curb	36.59561	-121.833988
19		Curb	36.59573	-121.834071

20		Curb	36.59594	-121.833911
21		Curb	36.59664	-121.834642

22		Other	36.59392	-121.836223
23		Curb	36.58735	-121.832538
24		Curb	36.5875	-121.832373

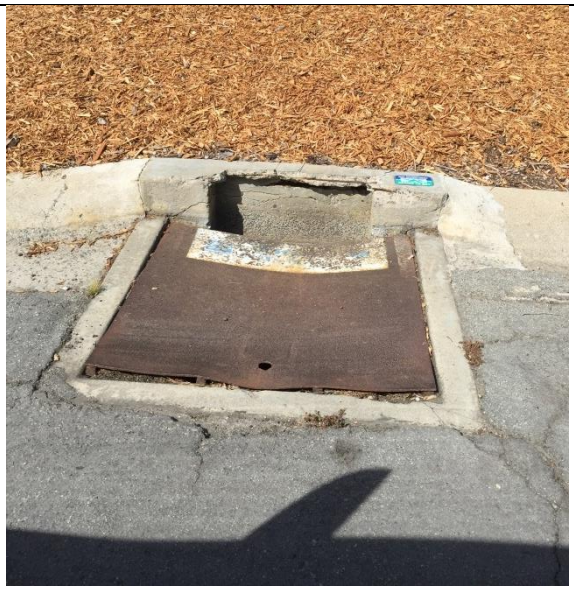
25		Paved	36.588	-121.83242
26		Paved	36.58832	-121.83245

27		Paved	36.58885	-121.832654
28		Paved	36.58955	-121.83299

29		Curb	36.59007	-121.833345
30		Curb	36.59005	-121.833182

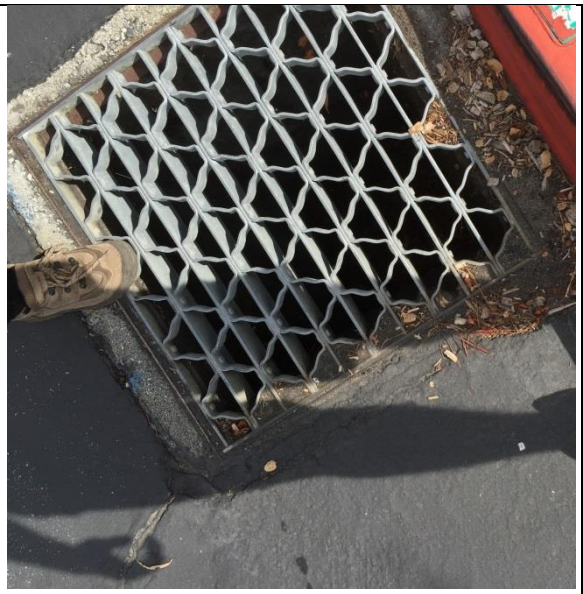
31		Curb	36.59018	-121.83297
32		Curb	36.59003	-121.83265

33		Curb	36.58951	-121.832319
34		Curb	36.58952	-121.832109

35		Other	36.58941	-121.831967
36		Other	36.58965	-121.832163

37		Curb	36.58968	-121.832086
38		Curb	36.59007	-121.833702
39		Paved	36.58997	-121.833861

40		Paved	36.58932	-121.833545
41		Paved	36.58785	-121.832954
42		Paved	36.58732	-121.832897

43		Paved	36.58719	-121.832693
44		Curb	36.59499	-121.846684
45		Paved	36.58197	-121.8294281

46		Paved	36.5824	-121.8287679
47		Paved	36.58221	-121.8290141
48		Paved	36.58192	-121.8288641

49		Paved	36.58183	-121.8283682
50		Curb	36.5815	-121.8287246
51		Paved	36.58269	-121.8297595

52		Curb	36.58639	-121.8307358
53		Paved	36.58617	-121.8305937
54		Paved	36.58378	-121.8302578

55		Curb	36.58396	-121.8305601
56		Curb	36.58398	-121.8305883
57		Paved	36.59644	-121.8470567

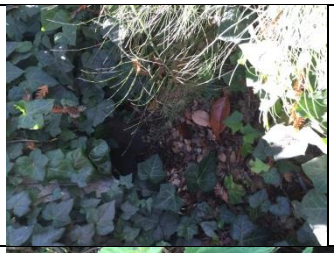
58		Curb	36.59915	-121.8502004
59		Curb	36.59905	-121.8503984
60		Paved	36.59916	-121.8503335

61		Curb	36.59855	-121.8502434
62		Curb	36.59859	-121.8502827
63		Curb	36.59845	-121.8504133

64		Paved	36.59834	-121.8506955
65		Paved	36.59806	-121.8512122
66		Paved	36.59774	-121.8507742

Table A2. Outfalls mapped in Del Rey Oaks.

Outfall ID	Picture	Type Of Outfall	Shape Of Outfall	Diameter (in)	Latitude	Longitude
1		Metal	Circle	12	36.59426	-121.845
2		Other	Circle	12	36.59424	-121.845
3		Other	Circle	12	36.59293	-121.844
4		Other	Circle	12	36.59332	-121.844
5		Metal	Circle	12	36.59428	-121.844

6		Metal	Circle	12	36.59446	-121.843
7		Metal	Circle	12	36.59457	-121.842
8		Concrete	Circle	12	36.59321	-121.837
9		Metal	Circle	12	36.59342	-121.837
10		Metal	Circle	12	36.59342	-121.836

11		Metal	Circle	12	36.59328	-121.836
12		Metal	Circle	12	36.59389	-121.836
13		Concrete	Circle	18	36.58961	-121.832
14		Other	Circle	18	36.58925	-121.832

15		Other	Circle	18	36.58971	-121.832
16		Other	Circle	24	36.58989	-121.832
17		Metal	Circle	12	36.59485	-121.847
18		Other	Circle	12	36.58252	-121.829
19		Concrete	Circle	24	36.58252	-121.829