Appendix I

Wildfire Assessment

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TECHNICAL MEMORANDUM

Canyon Lane Roadway Improvements Development Project EIR

Wildfire Assessment

This Wildfire Assessment analyzes the impacts of wildfire hazards resulting from implementation of the proposed Canyon Lane Roadway Improvements Development Project (project) and provides general mitigation for those impacts to alleviate wildfire risk to people or structures. CEQA Guidance provides the following thresholds for determining impact significance related to wildfire:

Impacts would be considered significant if the Project would:

a. Substantially impair an adopted emergency response plan or emergency evacuation plan.

b. Due to slope, prevailing winds, and other factors, exacerbate wildfire risks, and thereby expose project occupants to, pollutant concentrations from a wildfire or the uncontrolled spread of a wildfire.

c. Require the installation or maintenance of associated infrastructure (such as roads, fuel breaks, emergency water sources, power lines or other utilities) that may exacerbate fire risk or that may result in temporary or ongoing impacts to the environment.

d. Expose people or structures to significant risks, including downslope or downstream flooding or landslides, as a result of runoff, post-fire slope instability, or drainage changes.

This assessment is divided into seven sections: project description, environmental setting, project exposure to wildland fire, fire behavior computer modeling, discussion, mitigation measures, and references.

PROJECT DESCRIPTION

The Applicant submitted an application for a Grading Permit to the County of San Mateo Planning and Building Department to allow for the construction of the project. The project is located within San Mateo County (County), California, and involves the improvement of Canyon Lane, development of a single-family residence on one parcel, and future development of residences on eleven parcels. The project also involves the construction of new utilities, including a waterline that would loop-in with an existing waterline within the City of Redwood City (City) and an underground electrical distribution line.

ENVIRONMENTAL SETTING

Location

The project is located along Canyon Lane within the Emerald Lake Hills area of San Mateo County, California (see Figures 1 and 2). San Mateo County is situated along the central coast of California and encompasses approximately 554 square miles (including tidal waters) of the San Francisco Peninsula. The County's western border is on the Pacific Ocean and the eastern border is on the San Francisco Bay shoreline. The County is bounded by the City and County of San Francisco to the north and by Santa Cruz and Santa Clara County to the south and southeast, respectively.

The approximately 3.5-acre project site is comprised of 12 parcels and a gated, dead-end gravel roadway (Canyon Lane). One parcel (APN 057-221-060) is located within the City and the 11 remaining parcels (APNs 057-221-070, 057-221-090, 057-221-100, 057-221-110, 057-222-210, 057-222-220 & 230, 057-222-240 & 250, 057-222-260, 057-222-270, 057-222-280, 057-222-290 & 300) are located within unincorporated San Mateo County.

Land Use

The project site is located within the Emerald Lake Park subdivision, which was recorded in the County Office of the County Recorder in 1920. The subdivision includes 59 residential lots bounded by Oak Knoll Drive to the north, Vista Drive to the south, Glenwood Avenue to the east, and Lower Emerald Lake to the west. The project site comprises approximately 3.5 acres of land east of Lower Emerald Lake and west of the George L Garrett Jr Memorial Park (Garrett Park). The site is situated within a hillside canyon, surrounded by single-family residential homes scattered throughout the adjacent hillsides. The project site, minus the gravel roadway, is undeveloped and consists of oak forest, grassland, and intermittent creek that runs parallel to Canyon Lane. The 12 developable parcels are currently zoned RH/DR (Residential Hillside/Design Review) in the County and RH (Residential Hillside) in the City. None of the 12 parcels have been extensively graded or developed and thus maintain the natural slope and vegetation of the hillside canyon.

Topography

The project site is situated within a hillside canyon that aligns east-west with the prevailing winds; the project site is surrounded by single-family residential homes scattered throughout the adjacent hillsides. Slopes vary from 0 to 25 degrees throughout the site.

Flammable Vegetation

Vegetation Communities

The project area is comprised primarily of Coastal Live Oak Forest (2.49 acres), with smaller patches of California Annual Grassland (0.29 acre), Riparian Coast Live Oak Forest (0.69 acre), and previously disturbed land (0.06 acre) and developed land (0.21 acre) (see Figure 3). SWCA biologists carried out a site inspection to verify vegetation density in the project area and to ground truth the spatial fuel model data used in this assessment.

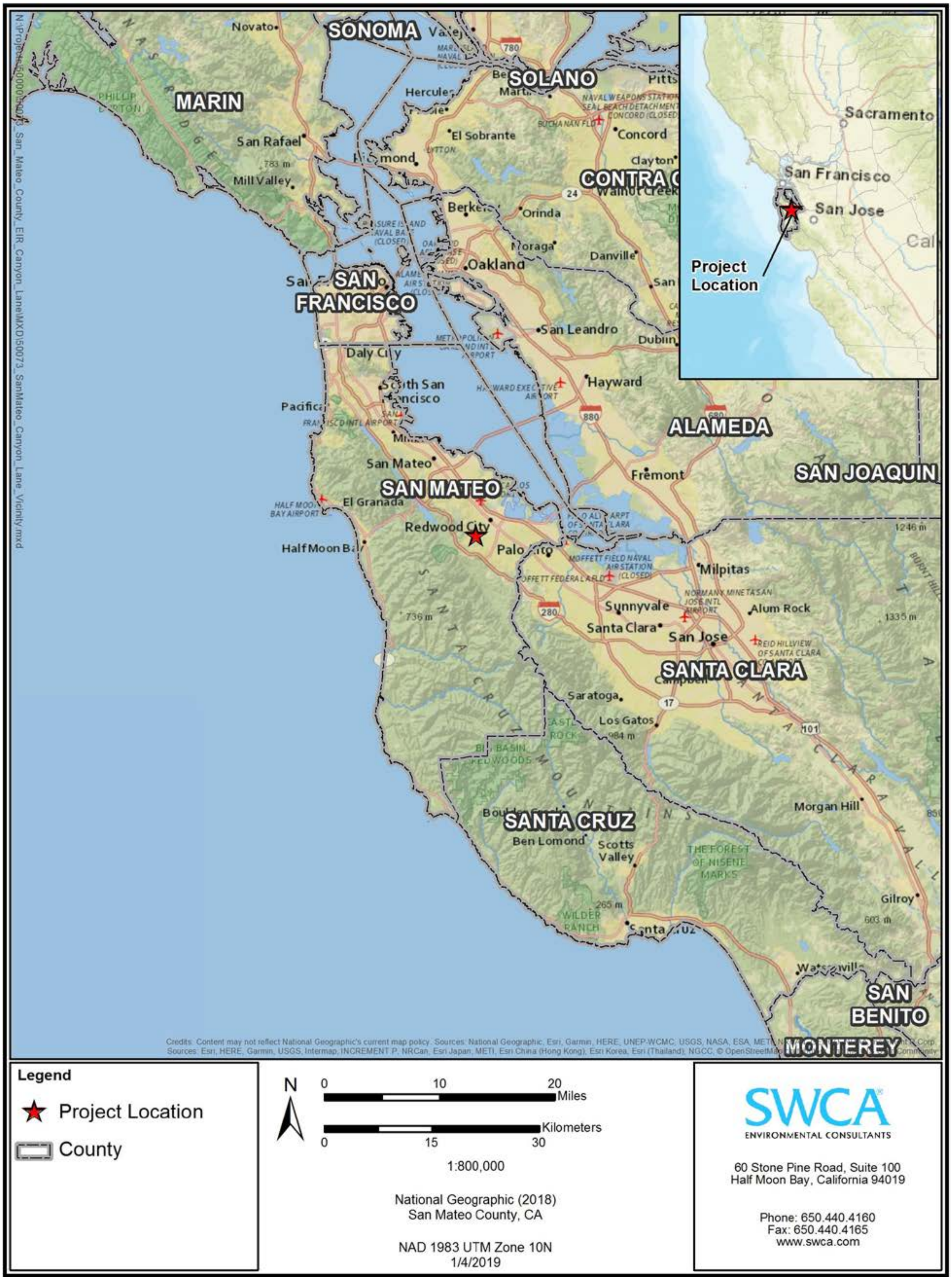

Figure 1 Project Vicinity Map

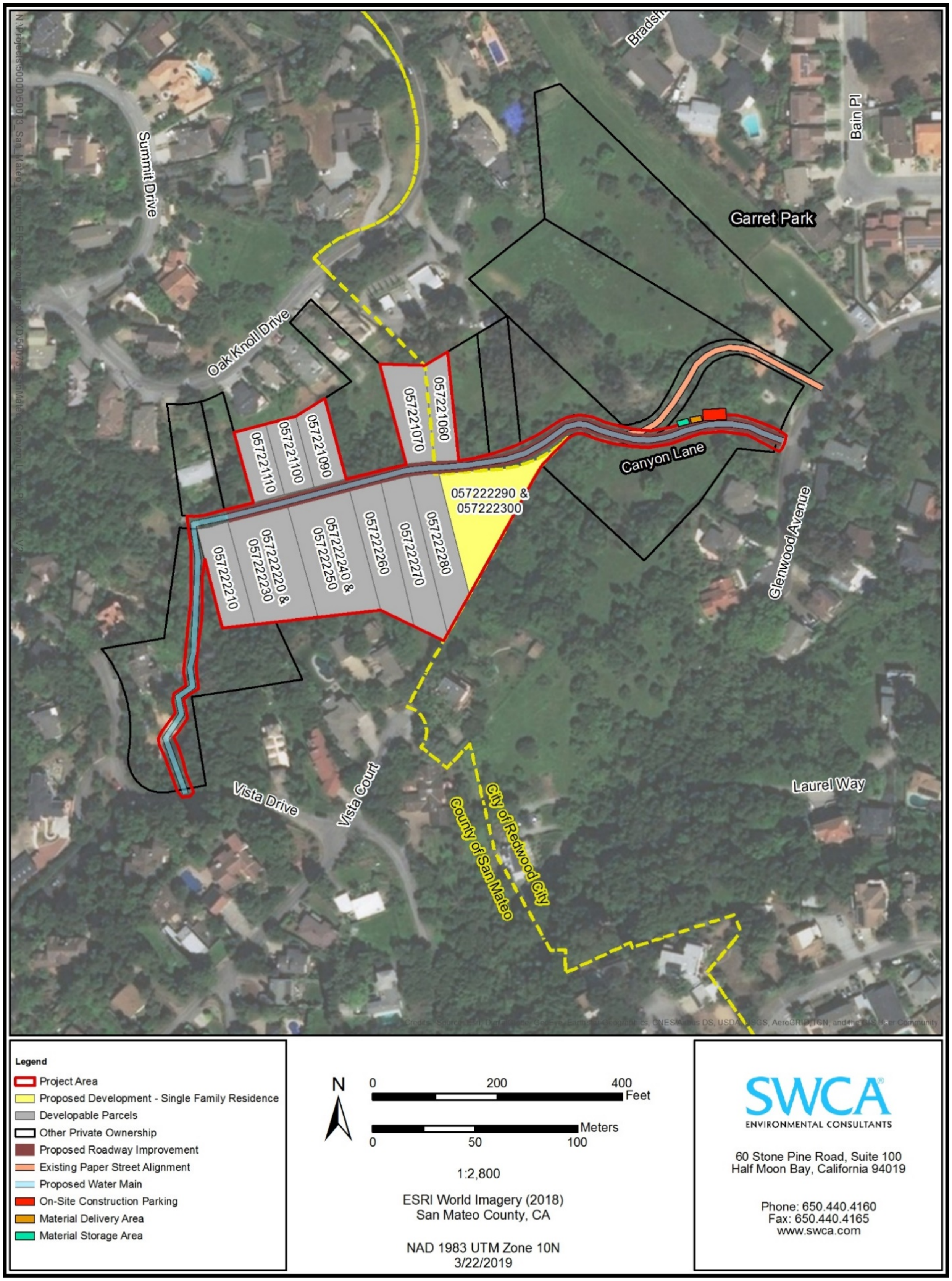

Figure 2 Project Location Map

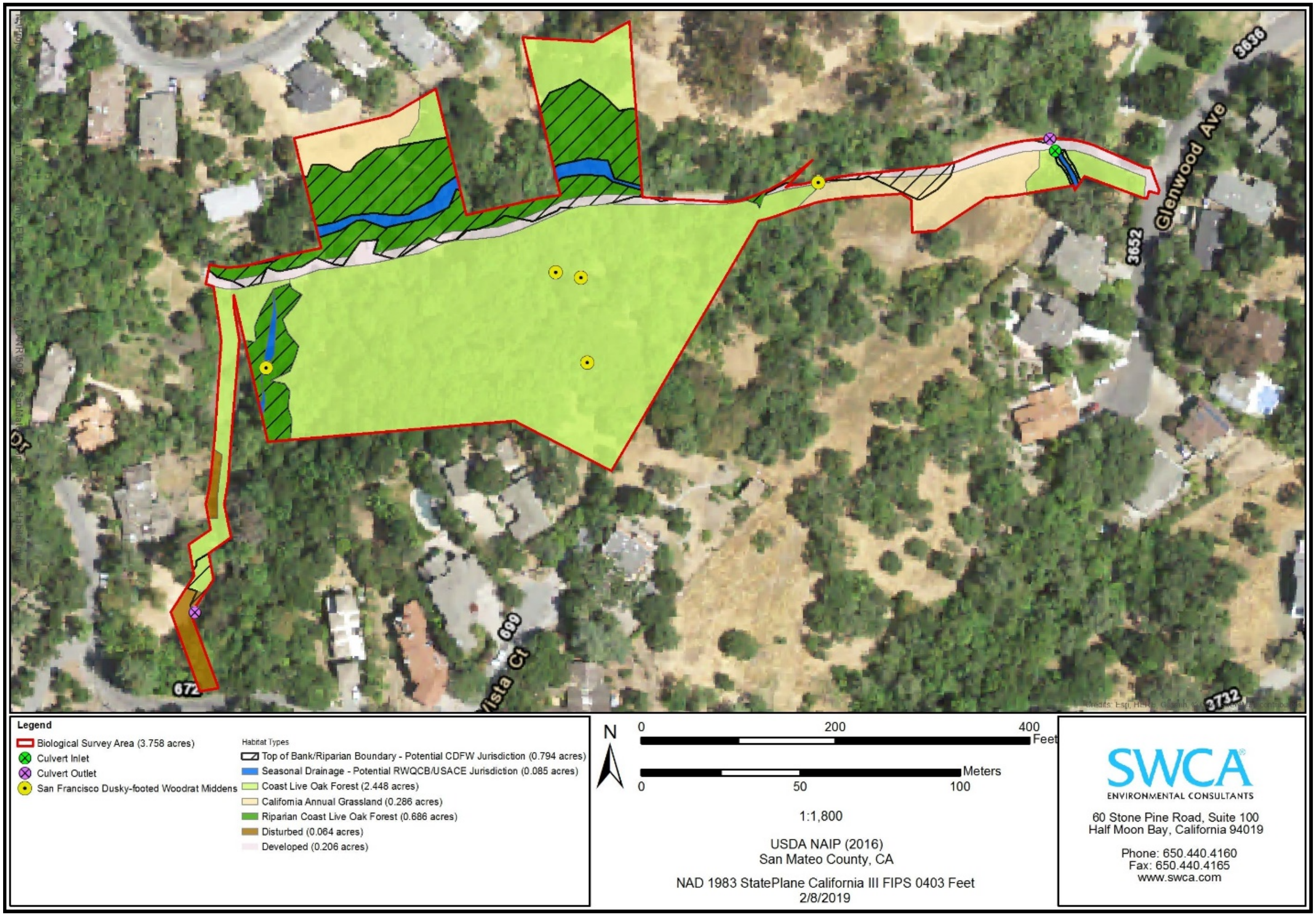

Figure 3. Vegetation Community Types within the Canyon Lane Project Area.

COAST LIVE OAK FOREST

Mature coast live oak and California bay trees are the dominant species in this habitat type. The trees are approximately 4–60 feet tall and form an intermittent to closed canopy on the hillslopes of the project site. Understory shrubs include poison oak (*Taxocodendron diversilobum*), toyon (*Heteromeles arbutifolia*), and coyote bush (*Baccharis pilularis*). Understory herbs that are present include ferns, such as gold back fern (*Pentagramma triangularis*) and California polypody (*Polypodium californicum*); grasses, such as onion grass (Melica sp.); and forbs, such as iris (*Iris sp*.). Leaf litter makes up a large component of the ground cover. A portion of the forest where the waterline would be installed has been cut and understory plants such as coyote bush and poison oak are dominant.

CALIFORNIA ANNUAL GRASSLAND

California annual grassland is restricted to the eastern portion of the project. The grassland community is dominated by non-native species. Common grasses were wild oats (*Avena sp*.), soft chess (*Bromus bordeaceus*), ripgut brome (*Bromus diandrus*), and dogtail grass (*Cynosurus echinatus*). Common forbs include bull thistle (*Cirsium vulgare*), poison hemlock (*Conium maculatum*), bristly ox-tongue (*Helminthotheca echioides*), and artichoke thistle (*Cynara carunculus*). The grassland is short in stature (less than approximately 1 foot tall). A limited number of invasive plants were observed near the existing road in this habitat.

RIPARIAN COAST LIVE OAK FOREST

Riparian coast live oak forest occurs along the banks of the drainage swale and is similar to the non-riparian coast live oak forest type described above. The canopy is intermittent to closed and composed mainly of California bay and coast live oak. Shrub species include Himalayan blackberry (*Rubus amerniacus*) and common snowberry (*Symphoricarpos allus*). The riparian forest supports the invasive weed French broom (*Genista monspessulana*) along small portions of the existing road and riparian banks. Sapling California bay trees also grow in the understory. Herb cover in the riparian forest is very sparse, but native herbs such as California manroot (*Marah fabacean*) are present and the invasive, non-native plant Bermuda grass (*Cynodon dactylon*) is present.

DEVELOPED

Developed area of the project site are composed of the existing Canyon Lane gravel road. The existing road is approximately 12–15 feet wide. The majority of the road is rocky and unvegetated; however, some portions have grassland vegetation growing between two tracks. Tree canopy overhangs much of the road as it passes through the coast live oak and riparian coast live oak forests.

Fuel Types

The vegetation communities described above can be classified into fire behavior fuel models based on the fire behavior that they are expected to exhibit during a wildfire. The fuels in the planning area are classified using Scott and Burgan’s (2005) Standard Fire Behavior Fuel Model classification system. This classification system is based on the Rothermel surface fire spread equations, and each vegetation and litter type is broken down into 40 fuel models.

The general classification of fuels is by fire-carrying fuel type (Scott and Burgan 2005):

(NB) Non-burnable	(TU) Timber-Understory
(GR) Grass	(TL) Timber Litter

(GS) Grass-Shrub (SB) Slash-Blowdown

(SH) Shrub

The project area is classified into several grass, shrub, and timber litter fuel models, as shown in Table 1). Table 2 summarizes the fire behaviors that are typically observed in these fuel models. Figure 4 illustrates the fuel model classification for the project area.

Table 1. Scott and Burgan Fire Behavior Fuel Model composition as classified in the project area

Fuel Model	Percent of project area
NB 1 (Non-burnable)	23
GS 1 (Grass-Shrub)	2
GS 2 (Grass-Shrub)	2
SH 2 (Shrub)	2
TL3 (Timber-Litter)	29
TL6 (Timber-Litter)	42

Table 2. Fuel model descriptions for Scott and Burgan fuel models found in the project area.

Fuel Model	Fire behavior description
NB 1 (Non-burnable)	Urban or suburban development; insufficient wildland fuel to carry wildland fire.
GS 1 (Grass-Shrub)	Shrubs are about 1 foot high, low grass load. Spread rate moderate (5–20 chains[1]/hour); flame length low (1-4 feet); fine fuel load 1.35 (tons/acre).
GS 2 (Grass-Shrub)	Shrubs are 1–3 feet high, moderate grass load. Spread rate high (20–50 chains/hour); flame length moderate (4–8 feet); fine fuel load 2.1 (tons/acre).
SH 2 (Shrub)	Moderate fuel load (higher than SH1), depth about 1 foot, no grass fuels present. Spread rate low (2–5 chains/hour); flame length low (1–4 feet); fine fuel load 5.2 (tons/acre).
TL3 (Timber-Litter)	Moderate load. Spread rate very slow (0–2 chains/hour); flame length low (1–4 foot); fine fuel load 0.5 (ton/acre).
TL6 (Timber-Litter)	Moderate load, less compact. Spread rate moderate (5–20 chains/hour); flame length low (1–4 feet); fine fuel load 2.4 (ton/acre).

Notes: Based on Scott and Burgan's (2005) 40 Fuel Model System. For more information, refer to Scott and Burgan (2005).

[1]One chain is equal to 66 feet.

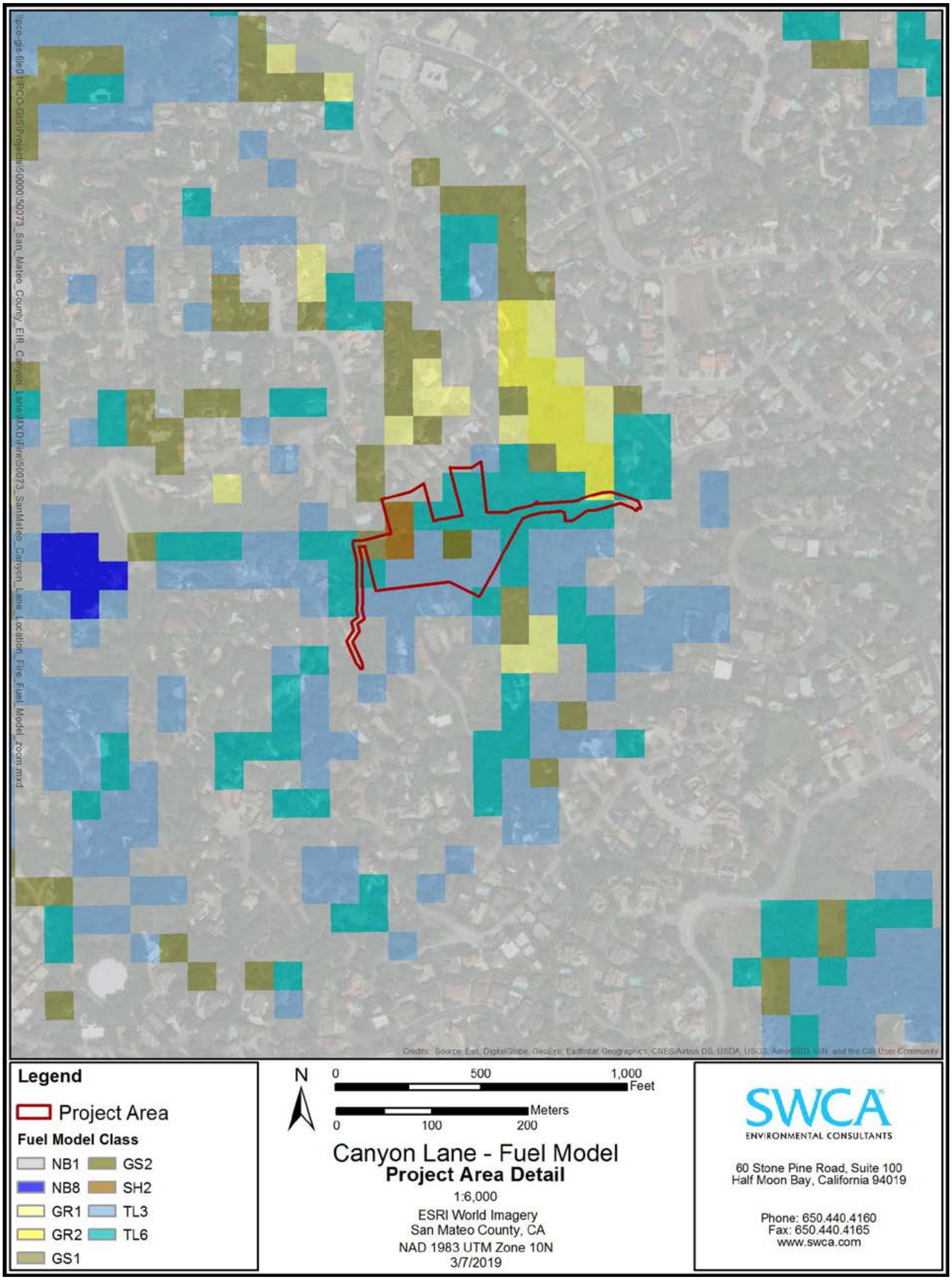

Figure 4. Fuel Model Classification for the project area.

The TL6 model, the dominant fuel model (making up 42 percent of the project area and the immediately adjacent areas), is comprised primarily of the coastal live oak vegetation type. The native hardwood forests support little ground fuel (probably less than 5 tons per acre) (Plumb 1980) and as a result associated fire intensity is minimal. This fuel model characterizes fire behavior in a moderate load broadleaf litter vegetation. The spread rate in these fuels is moderate (5–20 chains/hour) and the flame lengths are typically low to moderate (1–4 feet). These surface fire behavior characteristics are typically suppressed at the head or flanks of the fire by hand crews using hand tools (Andrews et al. 2011) as determined using the surface fire behavior characteristics chart (see Figure 5). Isolated pockets of heavy fuel accumulations can be expected to create erratic but localized fire behavior, which may generate more intense fire behavior (for example 4–8 feet flame lengths). Areas of particular concern are the large patches of coyote brush (*Baccharis pilularis*) intermixed with poison oak (*Toxicodendron diversilobum*) on the western side of the project area (see Figure 6). More intense fire behavior in these fuel types may require crews to use mechanized equipment for suppression.

Spread rates and flame lengths tend to be higher in the grass-shrub fuel models. These fuel models comprise only a small percentage of the project area (4 percent total).

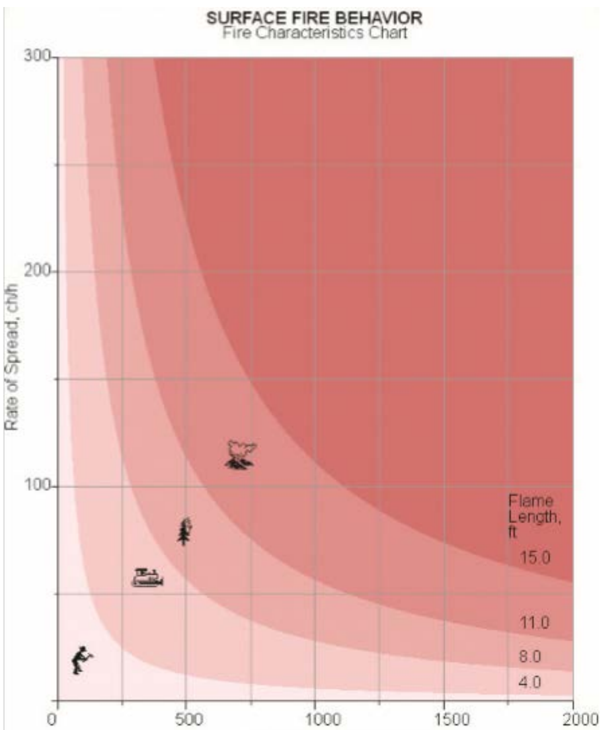

Figure 5. Wildfire “Hauling”/ Fire Characteristics Chart.

Figure 6. Example of coyote brush (*Baccharis pilularis*) intermixed with the poison oak (*Toxicodendron diversilobum*) on the western side of the project area. Note the structures located mid slope.

CANOPY CHARACTERISTICS

The canopy characteristics of the vegetation community influence potential fire behavior in the project area. Canopy characteristics can be described using canopy cover, canopy base height, and canopy bulk density data. The following description of the canopy in the project area is based on the LANDFIRE-modeled fuel data.

Canopy Cover

Canopy cover is commonly expressed as a percentage of total ground area covered by the vertical projection of tree crowns (USFS 2019. The majority of the forested area within the project area is comprised of canopy cover percentages from 30–40 percent and 40–50 percent (Figure 7). The project area has medium canopy cover of overstory trees; in areas with more continuous canopy, fire spread rates are higher due to the direct transmission of flames between individual trees.

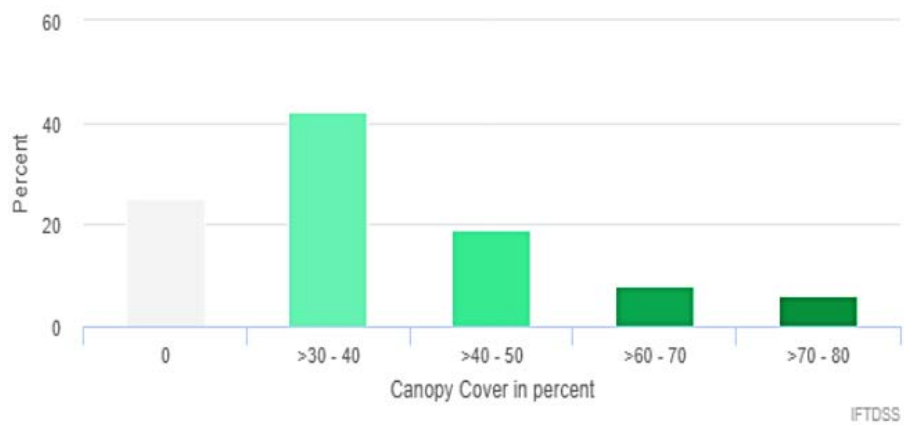

Figure 7. Percent Canopy Cover of modeled fuels within the project area.

Canopy Base Height

Canopy base height is a measure of the distance of canopy fuels to surface fuels (Smith n.d.). The fuels in the project area have relatively high canopy base heights (> 4 feet) (Figure 8), except in areas that have high densities of shrubs and sapling trees (Figure 9). This characteristic is important in determining potential for the transmission of fire from the surface into the canopy.

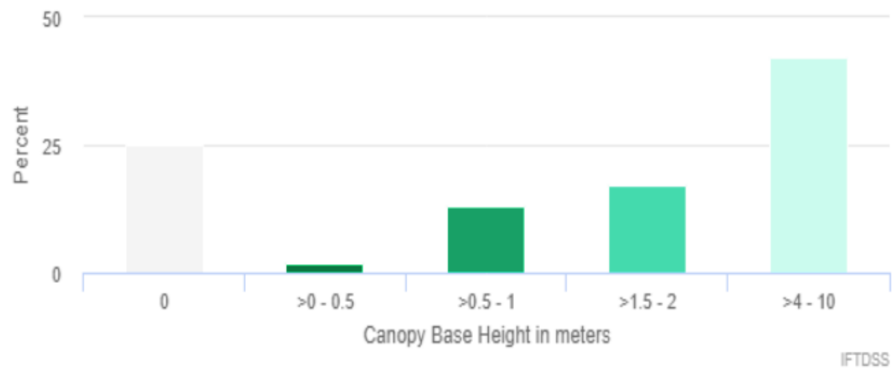

Figure 8. Canopy Base Height of modeled fuels in the project area.

Figure 9. Photograph showing area with dense vertical continuity of existing vegetation.

Canopy Bulk Density

Canopy bulk density is a measure of how closely canopy fuels are packed, which reflects the likelihood that fire can move through the forest canopy. Canopy bulk density in the project area falls primarily in the range of 0.05-.15 kg/m^3.

Aspect

Aspect affects how much solar radiation a site receives as well as the vegetation type on the site and fuel loading. Table 3 outlines the aspect for the project area. Sixty percent of the project area occurs on north- and north-east-facing slopes. North-facing slopes are cooler and more shaded, thus delaying the drying of fuels longer into the fire season and making them less available for combustion. North-facing slopes, however, tend to have heavier fuel loads; consequently, when fuels dry out, they can experience more severe wildfire behavior.

South- and west-facing slopes tend to have less vegetation and lighter fuel loads. South-facing slopes receive much higher solar radiation and are warmer, so fuels dry out sooner and more thoroughly during the fire season.

Table 3. Aspect within the project area

Aspect (degrees)	Percent in project area
338-22 (N)	40
23-67 (NE)	19
68-112 (E)	9
113-157 (SE)	19
158-202 (S)	13

Climate and Fire Weather

Although fires occur year-round, the typical fire season for the region usually starts in June and lasts into October (CAL FIRE 2018b). Weather conditions play a critical role in determining the size and scope of fires that could occur in the area. California regularly experiences extreme fire weather, with periods of strong winds, usually accompanied by high heat and low humidity.

Humidity

In general, relative humidity along the coast and within the project area is moderate to high throughout the year due to frequent ocean winds and fog (Golden Gate Weather Services 2002). The ocean is a source of cool, humid, maritime air; relative humidity decreases at increasing distance from the ocean. Humidity decreases significantly during the passage of dry northeasterly air from the interior of the state during the fall months. Relative humidity is observed as decreasing up to 20 percent during this period.

Wind Patterns

San Mateo County and the project area lie within the zone of the prevailing westerlies, meaning that winds blow out of the west/northwest for much of the year. However, during the fall transition, wind patterns shift from the prevailing west-northwest pattern in the summer to an east-northeast pattern as winds flow out of the Great Basin into the Central Valley, the Southwestern Desert Basin, and the South Coast (NPS 2008). This creates high pressure in Nevada and low pressure along the California coast, causing hot interior air to be drawn westward to the coast. These dry hot winds are known locally as the Diablo winds and are strong and gusty, often exceeding 100 miles per hour. Peak occurrence of these winds is in November, with a secondary peak in March. During this time, extreme fire danger is possible for the San Francisco Bay area because it coincides with low fuel moistures. Red flag warnings during periods of sustained Diablo winds are often posted for the Northern California coast, including the Bay

Area; however, the greatest frequencies of Diablo events are recorded in higher elevation areas in the coastal ranges and not at the elevation of Redwood City (Bowers 2018). In an analysis of Diablo Wind Events, Bowers (2018: 11) writes, "while events at near-coastal stations were infrequent, it is important to consider the impact these northeasterly winds could have on areas more prone to a coastal wind and marine influence."

Drought

This region was impacted by drought from 2012–2016 that has led to severe moisture deficits and significant declines in groundwater. Climate change projections for the region suggest that current and future increases in temperature, regardless of changes in precipitation, raise the probability of enhanced drought magnitude and duration (Ackerley et al. 2018). This condition has significant implications on wildfire frequency and magnitude (Westerling 2018).

Fire History

According to the historic fire records in CAL FIRE's Fire and Resource Assessment Program (FRAP)[1] database, there have only been three large wildfires in the vicinity of the project area since 1962 (Figure 10). This is confirmed in the San Mateo-Santa Cruz Community Wildfire Protection Plan, which states "there is no recent (50 year) major fire history within the planning area," i.e., San Mateo North-Coastal (CAL FIRE, San Mateo-Santa Cruz Unit, 2018), and the County Hazard Vulnerability Assessment, which states that "the county does not have a significant Wildland Urban Interface (WUI) fire history."[2] The reason for the previous lack of fire activity has been attributed to weather impacts, changes in forest management, extended fire regimes, and aggressive fire-fighting, as well as other factors (San Mateo County 2015).

The San Mateo-Santa Cruz CAL FIRE unit responded to 246 ignitions in 2017 in San Mateo and Santa Cruz Counties as a whole; 98 percent of these ignitions were kept to less than 10 acres in size. The top four causes of these 2017 wildfires are listed as undetermined, electrical power, miscellaneous, and debris burning (CAL FIRE 2018b).

Climate Change

There is strong evidence that anthropogenic climate change, especially rising temperatures and periodic droughts, has contributed to increased wildfire extent and severity in the western United States (Westerling et al. 2006, Abatzoglou & Williams 2016, Ackerley et al. 2018). Climate change predictions for the Bay Area suggest that a large proportion of change will occur in the frequency and/or intensity of extreme weather events, such as drought, winds, severe storms, and frosts. The frequency and magnitude of wildfires are expected to increase, resulting in more intense, faster-spreading fires in most locations (Fried et al. 2003, Westerling et al. 2018). Fire return intervals in coastal grass and brush vegetation in the area are expected to be cut in half, and the number of escaped fires is predicted to increase (NPS 2008). These predicted patterns would have significant implications for communities located in Very High Fire Hazard Severity Zones. According to fire history data, there has been a recurring increase in fire activity and acres burned in the Bay Area in recent years (Ackerley et al. 2018), and there are consistent projections of increased fire activity (more frequent or greater area burned) due to a warmer climate (Ackerley et al. 2018). Studies also suggest that increased development may act to reduce fire activity in areas close to high-density human development but would increase it in less populated WUI areas (Westerling 2018).

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[1] CAL FIRE – Fire and Resource Assessment Program (http://frap.cdf.ca.gov/).

[2] https://hsd.smcsheriff.com/sites/default/files/downloadables/2%20-%20Hazard%20Vulnerability%20Assessment.pdf

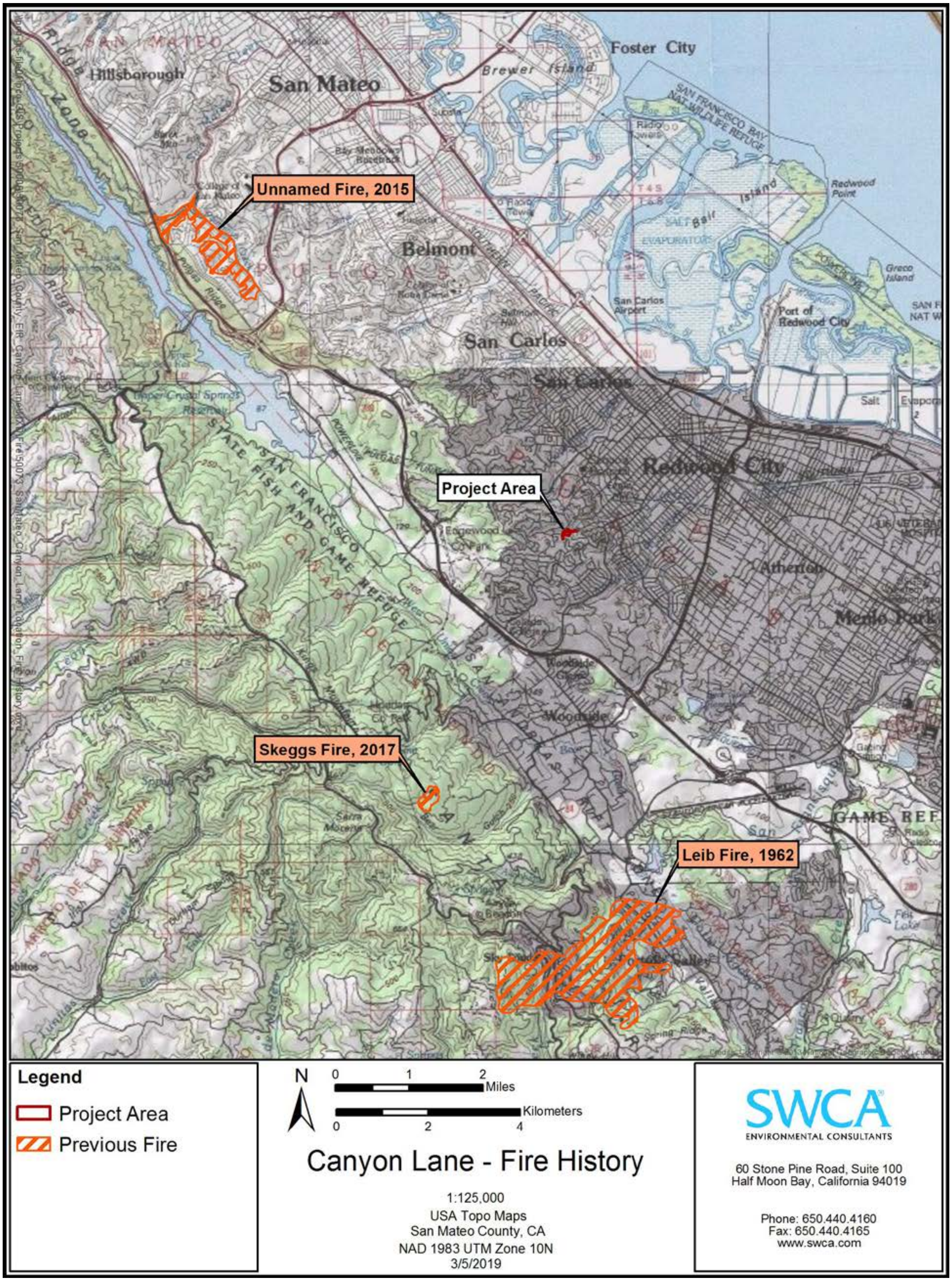

Figure 10. Fire Occurrence Frequency

PROJECT EXPOSURE TO WILDLAND FIRES

Wildfires are an inevitable and ecologically important process within oak-woodland ecosystems. Balancing fire risk with development within the WUI requires careful planning and implementing "Fire Safe" measures. The greatest wildfire risk occurs when homes are located in areas that are vulnerable and especially difficult to protect, and where fire suppression is made even more problematic because access to homes is hampered by narrow roads. Emerald Lake Hills is identified in the San Mateo-Santa Cruz Unit Strategic Fire Plan (CAL FIRE 2018b) as a wildland urban interface Community at Risk.
The Canyon Lane development would promote in-growth within current urban boundaries. The development would be required to adhere to all local and state fire codes in order to minimize wildfire risk. Requirements to mitigate structural ignitability and enhance fire response capability would help alleviate wildfire risk but would not eliminate all risk.

Water Supply for Fire Suppression

The project would involve the installation of an 8-inch water main to provide water and fire protection to the abutting parcels. The water system would equal or exceed the National Fire Protection Association (NFPA) 1142, "Standard on Water Supplies for Suburban and Rural Fire Fighting," 2012 Edition, the California Fire Code, California Code of Regulations title 24, part 9 and Redwood City Ordinance No. 2325, § 2, 1-14-08 Water Main Upgrade.

In accordance with the California Fire Code, the minimum water supply for new dwellings (that do not exceed 3,600 square feet) should be capable of supplying a flow of 100 gallons of water per minute for a duration of 2 hours (10,000 gallons).

Hydrants should be located along the roadway as determined by the Fire Marshal to meet operational needs and at intervals pursuant to the California Fire Code. Fire hydrants should be accessible at all times and should have a perimeter clearance of 3 feet.

Fire Response

The project is predominately located within a State Responsibility Area (SRA) that has a Very High fire hazard severity zone (VHSZ) rating.[3] SRAs are areas in which CAL FIRE has legal and financial responsibility for wildland fire protections and where CAL FIRE administers fire hazard classifications and building standard regulations (California Governor's Office of Emergency Services 2018). The SRA land in the project area is County unincorporated. A portion of the project site (the eastern segment of Canyon Lane and parcel 057-221-060) is located within a Local Responsibility Area (LRA) that has a VHSZ (Figure 11 and 12). The LRA lands within the project area are within Redwood City Fire jurisdiction.

[3] http://frap.fire.ca.gov/webdata/maps/san_mateo/fhszs_map.41.pdf

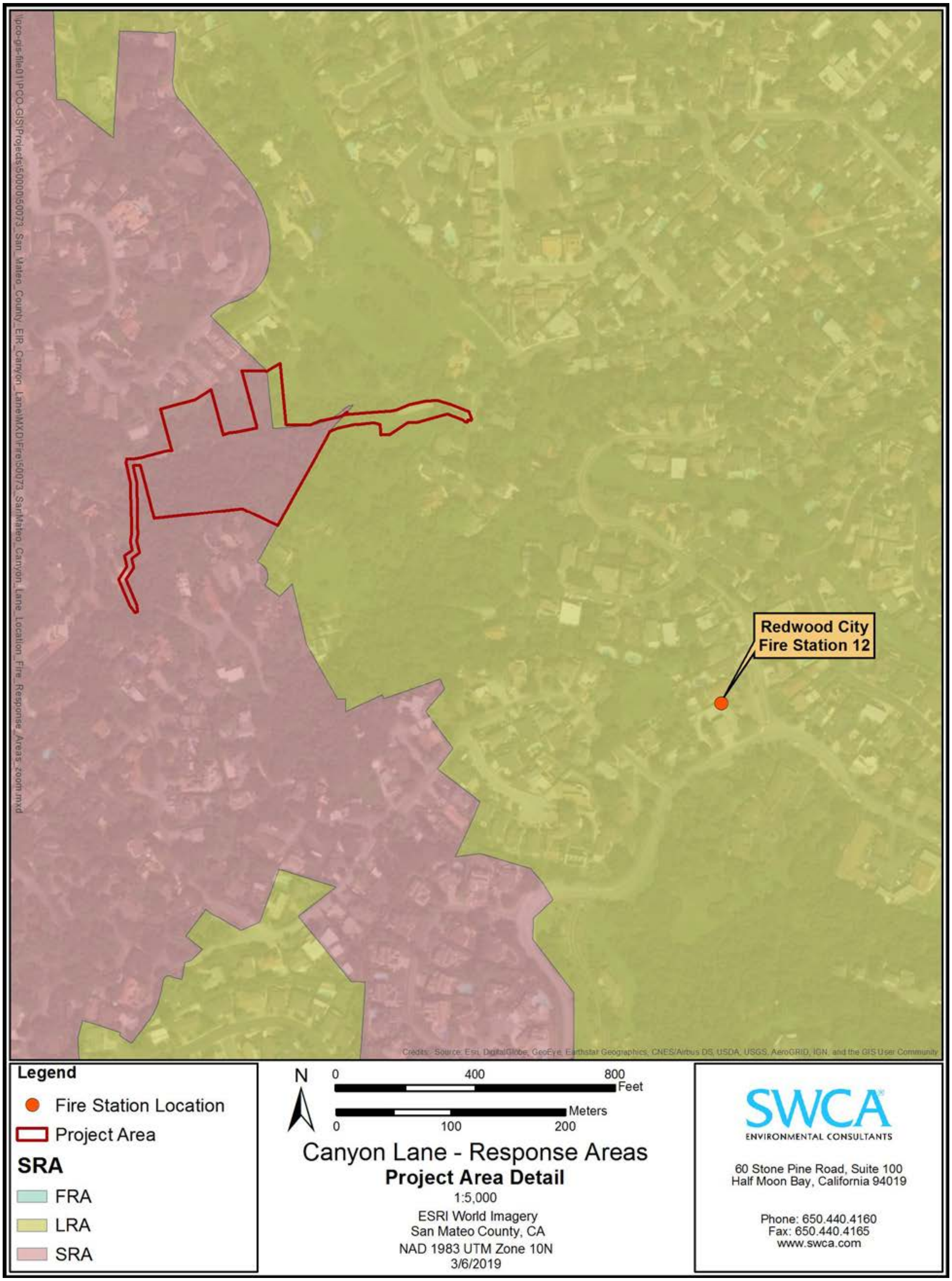

Figure 11. Fire Response Jurisdiction within the project area

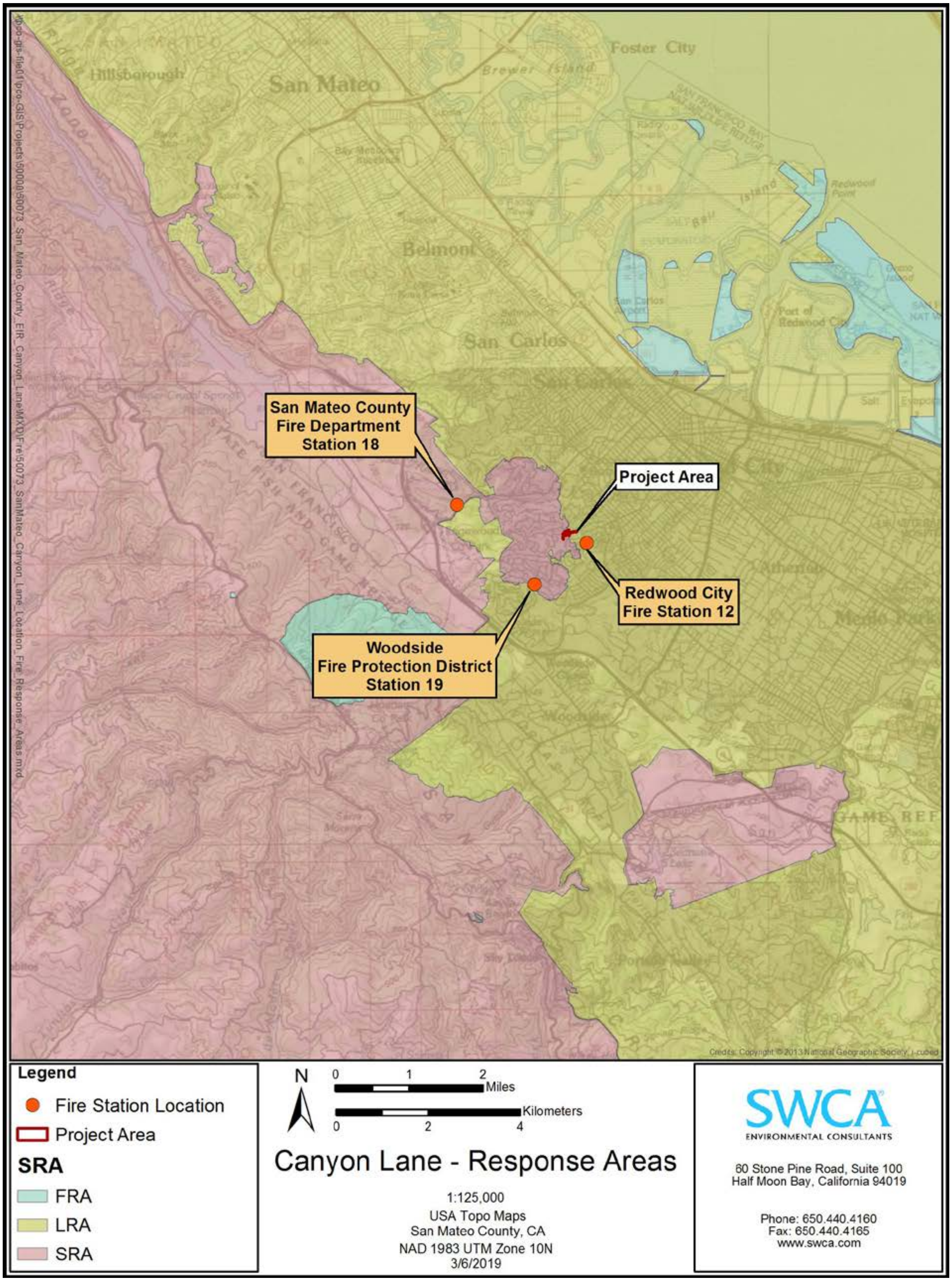

Figure 12. Fire Response across the greater landscape, showing the locations of the three closest fire stations.

Three fire stations are located within 3 miles of the project area (Figure 12):

- **San Mateo County Fire Department – Station 18**: This station is located 2.9 miles from the project area, an 8-minute drive.
- **Woodside Fire Protection District- Station 19:** This station is located 2.3 miles from the project area, an 8-minute drive.
- **Redwood City- Fire Station 12**: This station is located 1.0 miles from the project area, a 4-minute drive.

Within the unincorporated region, fire response would be provided by the San Mateo County Fire Department and the Woodside Fire Protection District. Mutual aid agreements and automatic aid agreements enable non-lead fire agencies to respond to fires outside of their district boundaries. Given the urban developed nature of the adjacent community and the network of access roads, response times would be within the acceptable time frame designated by the County (i.e., within 7 minutes)[4] from any of the three local fire departments.

Fire Access Roads

Canyon Lane is currently an unimproved gravel roadway that is inaccessible to emergency vehicles due to insufficient road width, overhanging vegetation, and insufficient emergency vehicle turnaround space.

The project would involve regrading and paving the unimproved roadway into a 20-foot-wide paved roadway to enable emergency vehicle access and meet CAL FIRE SRA Fire Safe Regulations and the California Fire Code. The roadway would incorporate an emergency vehicle turnaround apparatus and would be designed and maintained in accordance with the American Association of State Highway and Transportation Officials Standard HB-17 and the CAL FIRE SRA Fire Safe Regulations. Further, the roadway would be designated as a fire lane, and no street parking would be permitted. The entire roadway would be marked and posted in accordance with Section 22500.1 of the California Vehicle Code. The road grade should not exceed 16 percent.

Roadside vegetation should be reduced to a level that allows ease of access for emergency response personnel and equipment, reduces the number of roadside fire starts, and ensures the safety of fire suppression personnel using roads as fire control lines. Both local and state fire codes specify clearing of at least 10-feet on each side of a road or driveway and up to 15-feet of vertical clearance above. Fire apparatus access should not be obstructed in any manner, including vehicle parking or vegetation intrusion.

The installation of security gates to residential parcels should be approved by the fire department. Gates should have an approved means of emergency operation.

In the event of a bridge installation, bridges must be constructed and maintained to carry the load of fire apparatus. Load limits should be posted at both entrances to the bridge.

In accordance with the California Code of Regulations, Title 19, Division 1, Section 503.2.3. fire apparatus access roads should be designed and maintained to support the imposed loads of fire apparatus and should be surfaced to provide all-weather driving capabilities.

[4] https://performance.smcgov.org/reports/Fire

Setback from property lines

The minimum building setback from each property line in the project area would be 30 feet. Larger setbacks would be required in areas of increased slope in order to mitigate potential fire behavior.

Building Construction

The project site is located within an SRA that has a VHSZ rating.[5] A portion of the project site (the eastern segment of Canyon Lane and parcel 057-221-060) is located within an LRA that has a VHSZ.

All structures should comply with the ignition-resistive construction requirements of Chapter 7A of the California Wildland-Urban Interface Code[6]. New buildings located within the VHSZ in the SRA and LRA will comply with all sections of the California Code of Regulations Title 24, Part 2, 701A3.2 (New buildings located in any fire hazard severity zone).[7]

The broad objective of the California Code of Regulations pertaining to building standards in WUI areas is to establish minimum standards for materials and material assemblies and provide a reasonable level of exterior wildfire exposure protection for buildings in WUI areas. The use of ignition-resistant materials and design to resist the intrusion of flame or embers projected by a vegetation fire are expected to mitigate structure losses from wildfire.

The San Mateo County Fire Marshal's Office assists the San Mateo County Building Department in reviewing plans for the fire-resistive construction requirements established in the fire and building codes and has developed a joint checkoff sheet for use by the contractors, inspectors, and the plan reviewers (CAL FIRE 2018b). All new construction, remodels, and tenant improvements are reviewed by the San Mateo County Fire Marshal's Office, and field inspections determine project compliance with the state and local amendments to the building and fire codes. Prior to the final sign-off, the roads and driveways, address numbers, smoke detectors, water supply, fire suppression systems, fire alarm systems, automatic fire sprinkler systems, and vegetation clearance around the structure (PRC 4291) are inspected (CAL FIRE 2018b).

Fire Protection Systems:

In SRA areas, automatic sprinkler systems should be installed as per Section 903 of the California Fire Code.[8]

In LRA areas, as per Redwood City Code 903.2.13, approved automatic sprinkler systems should be installed in all new buildings or structures with the exception of one- and two-family residential homes, with a total floor area of 3,000 square feet or more. One- and two-family residential homes should be protected fully by an automatic fire sprinkler system in accordance with NFPA Standard 13D regardless of the square footage; the system should also be installed in accordance with the Redwood City Building Code for such occupancies, including Accessory Dwelling Units.[9]

[5] http://frap.fire.ca.gov/webdata/maps/san_mateo/fhszs_map.41.pdf

[6] http://www.fire.ca.gov/fire_prevention/downloads/ICC_2009_Ch7A_2007_rev_1Jan09_Supplement.pdf

[7] https://firesafesanmateo.org/resources/california-wildland-urban-interface-code-information

[8] https://www.citymb.info/Home/ShowDocument?id=28089

[9] https://library.municode.com/ca/redwood_city/codes/code_of_ordinances?nodeId=CH12FIPR_ARTIIREFICO

Defensible Space

As per California Government Code 51182 and Public Resources Code Sections 4290 and 4291, any person who owns, leases, controls, operates, or maintains a building or structure within the SRA and LRA must maintain a 30-foot firebreak (home defense zone) and will provide a reduced fuel zone for up to 100 feet from a structure.[10,11] Local and state fire departments carry out defensible space inspections (LE-100's) in SRAs and provide educational material to property owners.

Vegetation Management

Defensible space (fuel management zones) will be maintained by the property owners at least annually or more often as needed. Defensible space requires the installation and maintenance of Fire Safe Landscaping, as per the County guidelines.[12] Plants used in the defensible space will be selected from an approved fire-resistant planting materials list maintained by Fire Safe San Mateo County.[13]

FIRE BEHAVIOR COMPUTER MODELING

After field data were collected and available data analyzed, desktop fire behavior modeling was initiated to determine the potential fire behavior within the project area. Modeling was performed with the Interagency Fuel Treatment Decision Support System (IFTDSS 2019). IFTDSS is a state-of-the-art software and data integration framework that organizes fire and fuels software tools into a single online application. The browser-based modeling environment of IFTDSS allows users to simulate fire behavior and fire effects using the scientific algorithms and processes found in common fire behavior modeling applications, including FlamMap, Behave, FOFEM, CONSUME, and Wind Ninja (Drury et al. 2016). By integrating these tools into a server-side processing environment, IFTDSS is designed to improve the efficiency and effectiveness of fuel treatment planning for a variety of end users. This system is used by many land-management agencies across the country.

Fire Behavior Modeling Inputs

Fuels

IFTDSS uses the LANDFIRE vegetation dataset to estimate fuel conditions at a pixel resolution of 30 meters (LANDFIRE 2014). LANDFIRE data in the project area were evaluated for accuracy and suitability for fire modeling. According to LANDFIRE, the dominant fuel type in the project area was classified as TL2 Low Load Broadleaf Litter. This fuel model represents the coastal live oak vegetation assemblage. However, after consulting with local experts and fire behavior specialists and reviewing reconnaissance photos of the project area, the decision was made to modify the model to better capture the vegetation conditions on the ground, particularly the density and continuity of the fuels. The fuel model was modified to TL6, a Timber Litter Fuel model classified as a Moderate Load Broadleaf Litter model. This fuel model compared well with fuel loading information for coastal live oak, and the vertical arrangement of the fuels aligned well with photos of the project area. The intent of the fire behavior modeling was to predict the worst-case fire behavior in the project area, so accurately calibrating the fuel models to conditions on the ground was critical.

[10] https://firesafesanmateo.org/resources/defensible-space

[11] https://www.redwoodcity.org/departments/fire-department/fire-prevention/defensible-space/defensible-space-zones

[12] https://firesafesanmateo.org/resources/defensible-space/fire-safe-landscaping

[13] https://firesafesanmateo.org/resources/defensible-space/fire-resistant-plant-list

Weather/Fuel Moisture

For fire behavior modeling, IFTDSS evaluates wind speed, wind direction, and fuel moisture from the Remote Automated Weather Station (RAW) nearest to the project area. The Pulgas RAWS (37.4750, -122.2981) is within 2 miles of the proposed development. To model the worst-case fire behavior scenario, the Energy Release Component (ERC, related to the available energy at the flaming front of a fire) was first calculated for each day of the station period of record (1999-2016). The period of highest ERC for each year is assumed to be the peak of the fire season; July was determined to be the period with the highest ERC. IFTDSS then determined the 97^{th} percentile wind and initial fuel moisture values within this timeframe. The 97^{th} percentile weather was chosen so that modeling is carried out under extreme conditions. The 97^{th} percentile wind speeds were 20 miles per hour during the timeframe, with a wind direction of 270 degrees. One-, 10- and 100-hour fuel moisture values for dead as well as live herbaceous and woody vegetation were further conditioned by examining probabilistic wildfire risk across a predefined larger landscape, known as a “pyrome.” Pyromes are 128 areas across the continental United States exhibiting similar fire regimes, vegetation, and climate (Archibald et al. 2013). Within each pyrome, all available regional historical weather data were used to better estimate a worst-case fuel moisture profile (Short et al. 2016). For the Canyon Lane project area, IFTDSS used these regional values to adjust fuel moisture estimates taken from the Pulgas RAWS (see Table 4).

Table 4. Fuel Moisture Profile developed for 97^{th} percentile weather conditions in the project area

Fuel Model	1-hr fuel moisture	10-hr fuel moisture	100-hr fuel moisture	Live Herbaceous fuel moisture	Live woody fuel moisture
All	4	5	9	143	164

Other IFTDSS Parameters

Crown fire behavior (the movement of fire through the crowns of trees or shrubs more or less independently of the surface fire) was modeled using the Scott and Reinhardt (2001) method, the method typically used to evaluate worst-case fire conditions. IFTDSS uses WindNinja algorithms to simulate a single-moment wind speed and direction across the model area, considering topography and drag (USFS 2018).

Fire Behavior Modeling Results

IFTDSS uses FlamMap 5.0 to model fire behavior. The primary fire behavior outputs used in this assessment are flame length, fireline intensity, rate of spread, and crown fire potential, described below. Figures 13 to 16 illustrate these four fire behavior parameters across the project area.

- **Flame Length:** The distance from the base to the tip of the flaming front. Flame length is used as an indicator of resistance to suppression and a guideline as to what suppression resources are needed. For example, National Wildfire Coordinating Group (NWCG) guidelines indicate that direct attack by hand crews is most effective for flame lengths under 4 feet, whereas engines and heavy equipment are more effective for direct attack on flame lengths up to 8 feet.
- **Fireline Intensity**: Measured in terms of heat released per unit of time from a 1-foot-wide section of the fuel bed along the flaming front, expressed as British Thermal Units per foot, in seconds (BTU/ft/sec). Like flame length, fireline intensity is used as an indicator of resistance to suppression.

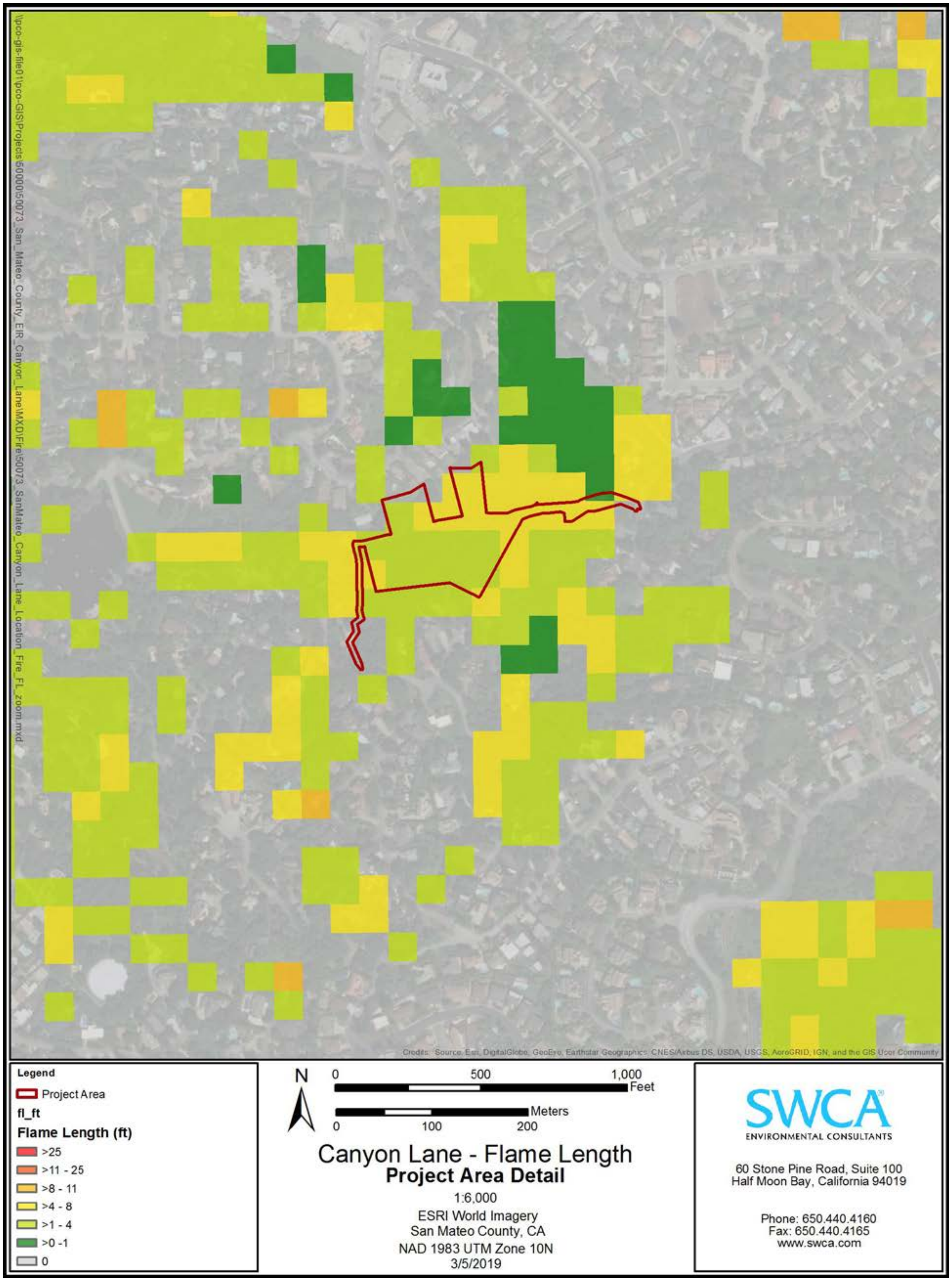

Figure 13. Projected Flame Lengths within the project area.

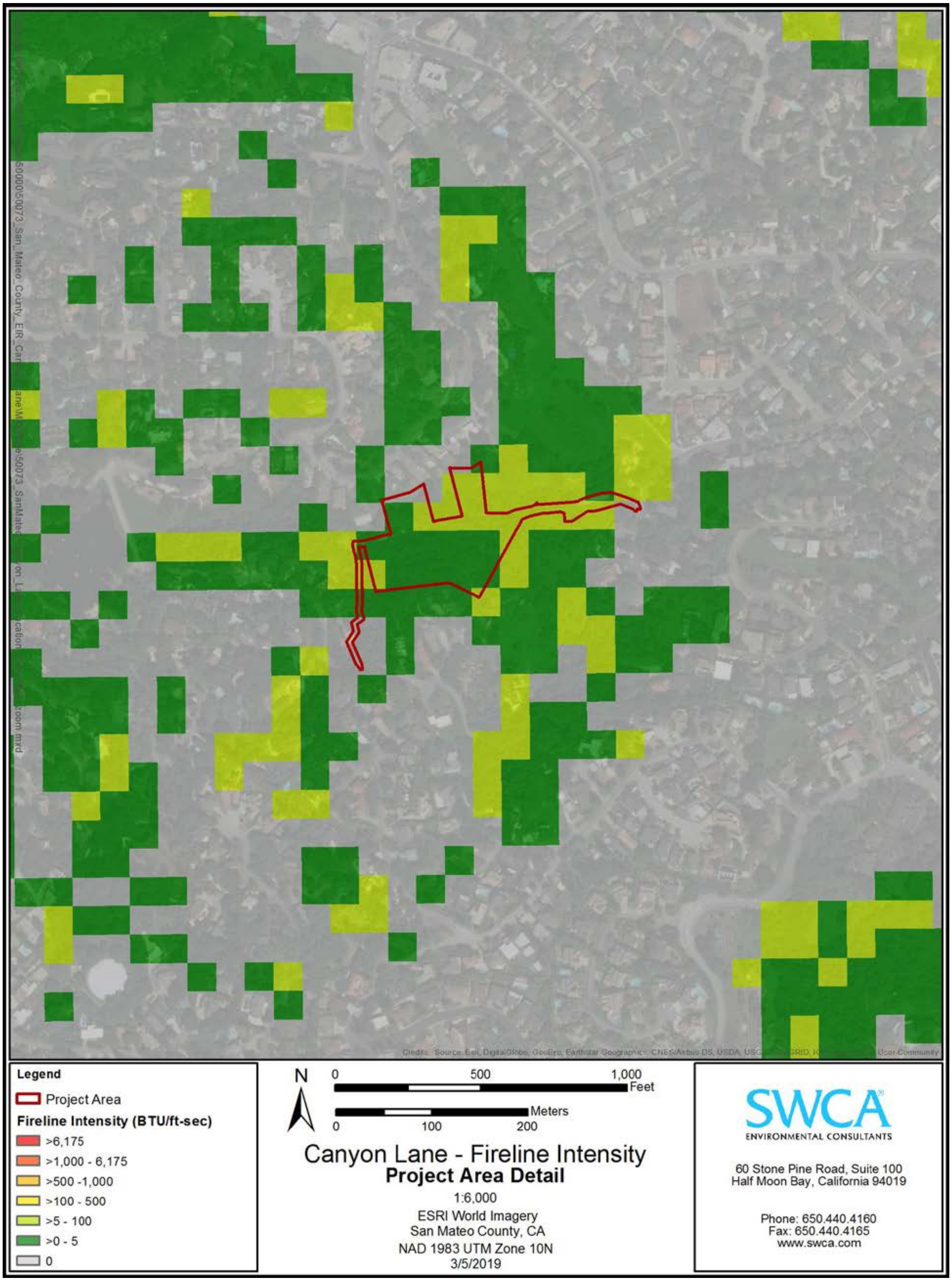

Figure 14. Projected Fireline Intensity within the project area.

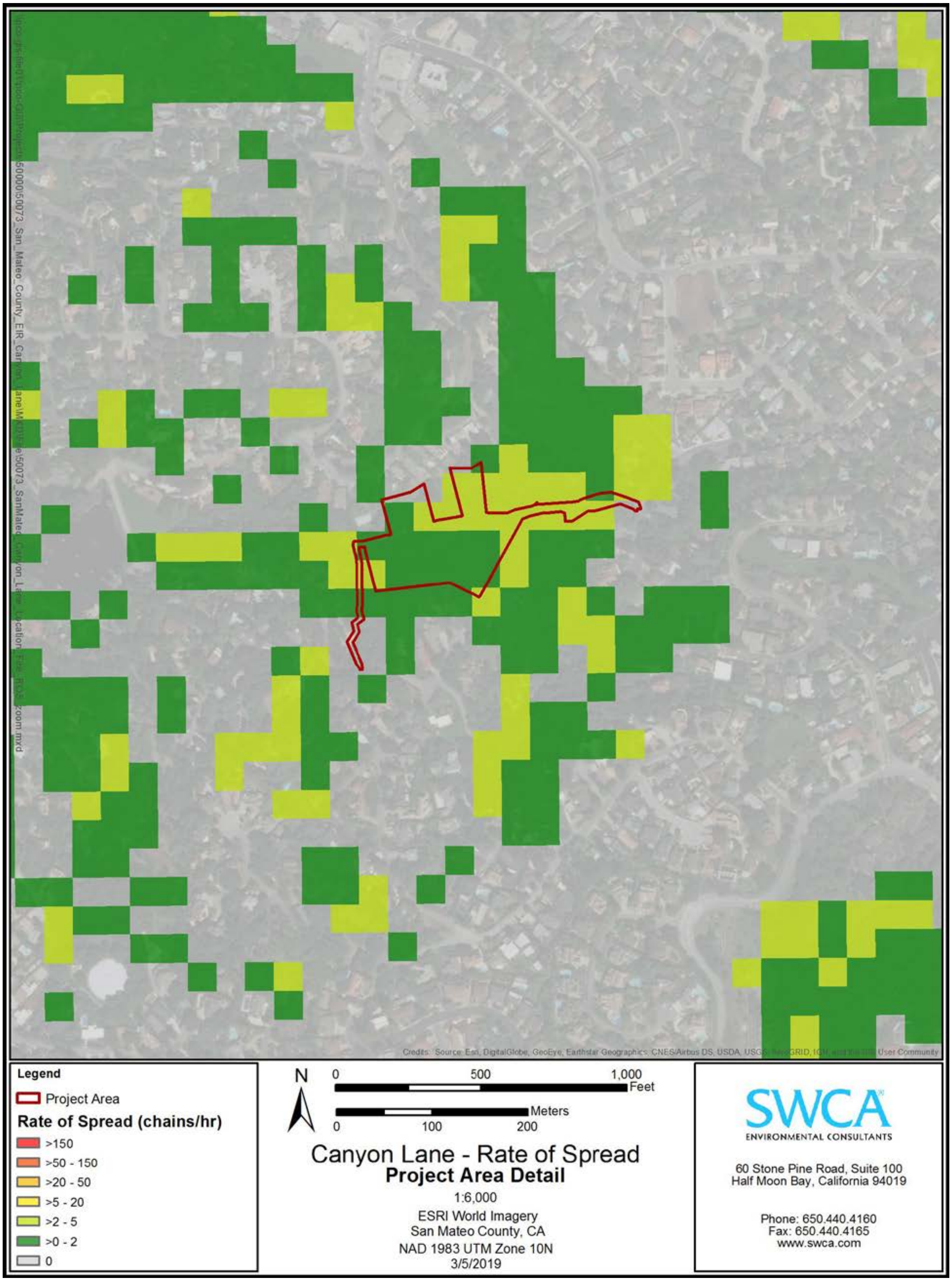

Figure 15. Projected Rate of Spread within the project area.

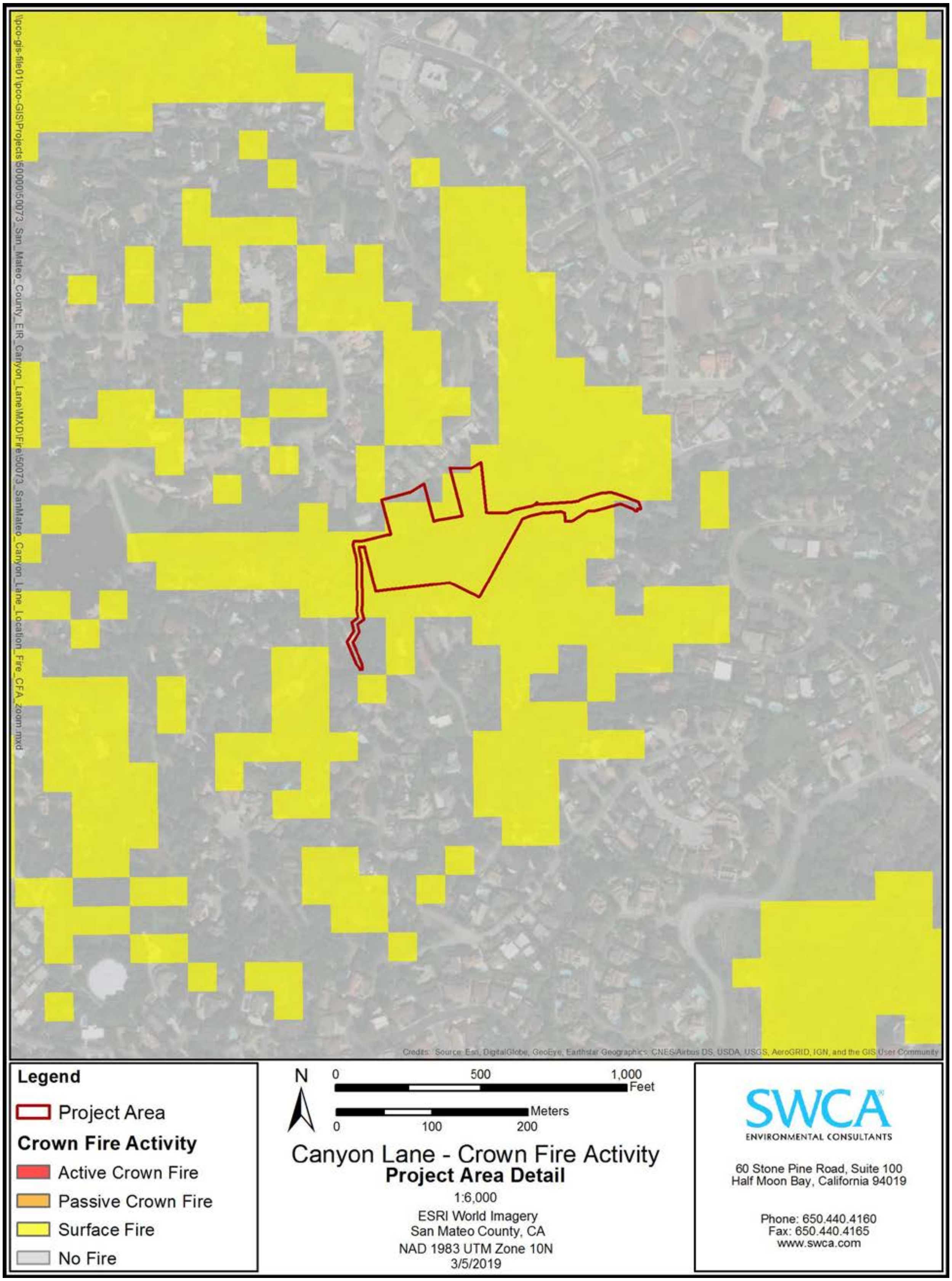

Figure 16. Projected Crown Fire Potential within the project area.

- **Rate of Spread**: The rate at which fire moves through the fuel bed, expressed in chains (66 feet) per hour. Rate of spread is helpful for planning the number and type of fire suppression resources that may be required to contain fire growing at a given rate.
- **Crown Fire Potential**: Describes fire activity in terms of no fire activity, surface fire activity, passive fire activity (torching), and active crown fire (crown to crown). This measure helps to guide treatment methods; for example, where active crown fire could be mitigated by fuel reduction that increases crown spacing.

As presented in Figures 13 to 16, wildfire behavior in the project area under current fuel conditions would be relatively low to moderate, with flame lengths primarily at 1–8 feet, fireline intensity from 0–100 BTU/ft/sec, rates of spread from 0–5 chains/hour, and surface fire only. As indicated by the surface fire behavior hauling chart (Figure 5), fire suppression under these conditions would require engines or heavy equipment. This is especially true where pockets of heavier fuels may be ignited.

Composite Wildfire Risk and Hazard Assessment

In order to model wildfire risk and hazard to the project area, the individual wildfire hazard datasets described above were combined with measures of a burn probability (fire occurrence density taken from historical perimeters and ignitions), to arrive at a composite wildfire hazard score with adjective rating from low to extreme.

All input datasets were in raster format with a cell size of 30 × 30 meters. Before running the model, SWCA equally weighted each of the input datasets (i.e., assign a percentage value reflecting that parameter's importance in the model). The parameters were then placed into a weighted overlay model, which "stacked" the datasets and evaluated an output value for each cell of the overlaid datasets. Cells in the resulting output contained an integer value representing the relative fire hazard severity (Figure 17).

When taken in isolation, the composite wildfire risk and hazard assessment would suggest the wildfire risk and hazard within the project location is low (Figure 17). However, less than 1 mile west of the project area are several vegetated open space areas (including Handley Rock Park, Edgewood Park and Natural Preserve, and, to the north west, Pulgas Ridge Open Space Preserve) that, according to fire behavior modeling, could experience more extreme fire behavior (Figures 18, 19, 20). There is a possibility that a wildfire could spread to the neighboring Emerald Hills subdivision and into the project area as a result of prevailing westerly winds (Figure 21). Interstate 280 transects these open space areas and could be a conduit for potential ignitions from motorists. It is important to consider this landscape-level risk because of the potential for large conflagrations that could spread beyond the project area, especially in the event of extreme weather. It is also important to consider that the fire behavior models classify man-made structures as non-burnable fuels, but in reality these structures may function as a combustible ember bed that could ignite if embers contact a receptive fuel (for example, leaf litter gathered in gutters). The potential structural ignitability is based upon whether the home has been "hardened" to wildfire.

Figure 17. Wildfire Hazard Risk in the project area

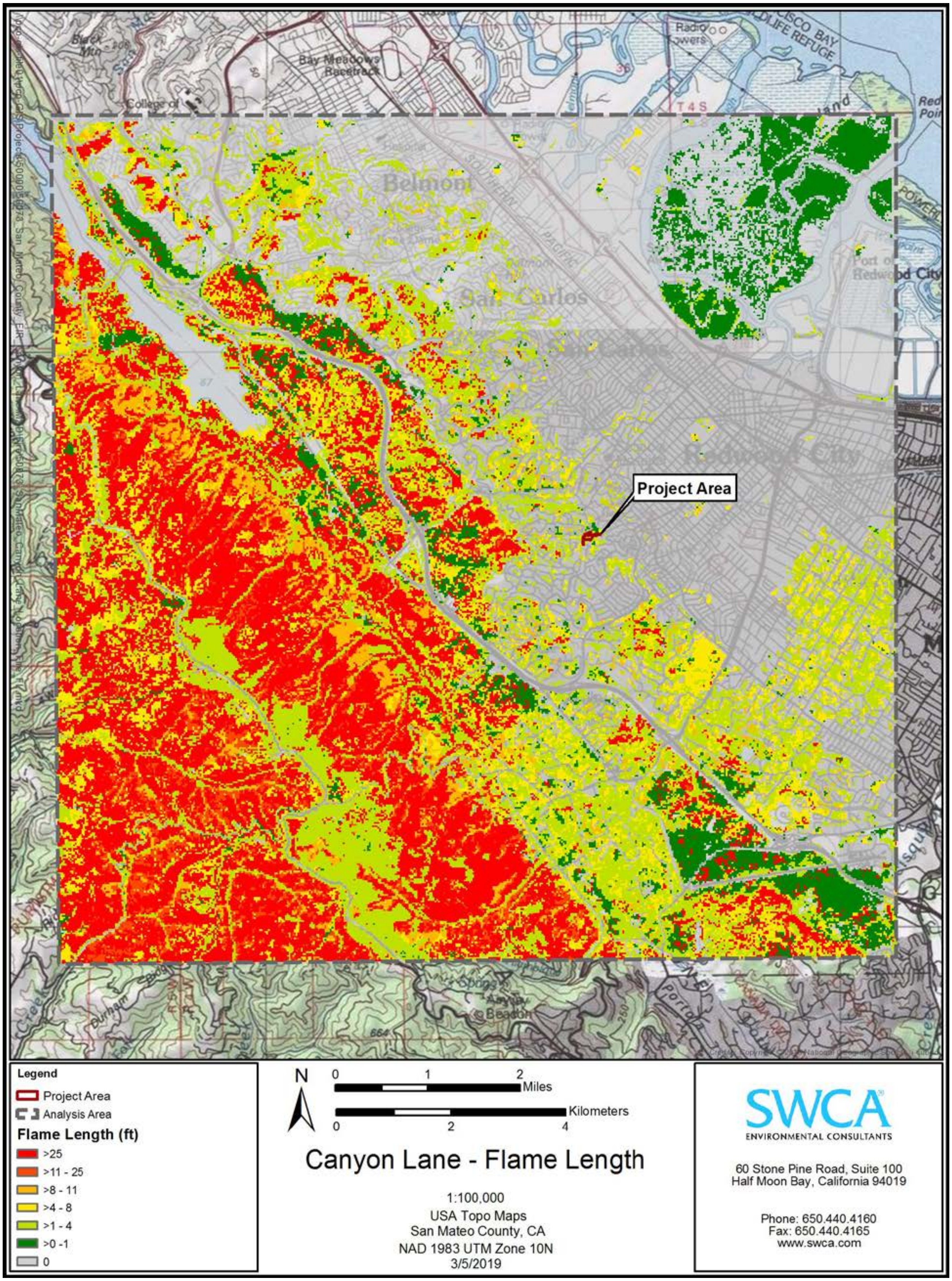

Figure 18. Potential Flame Lengths within the greater landscape

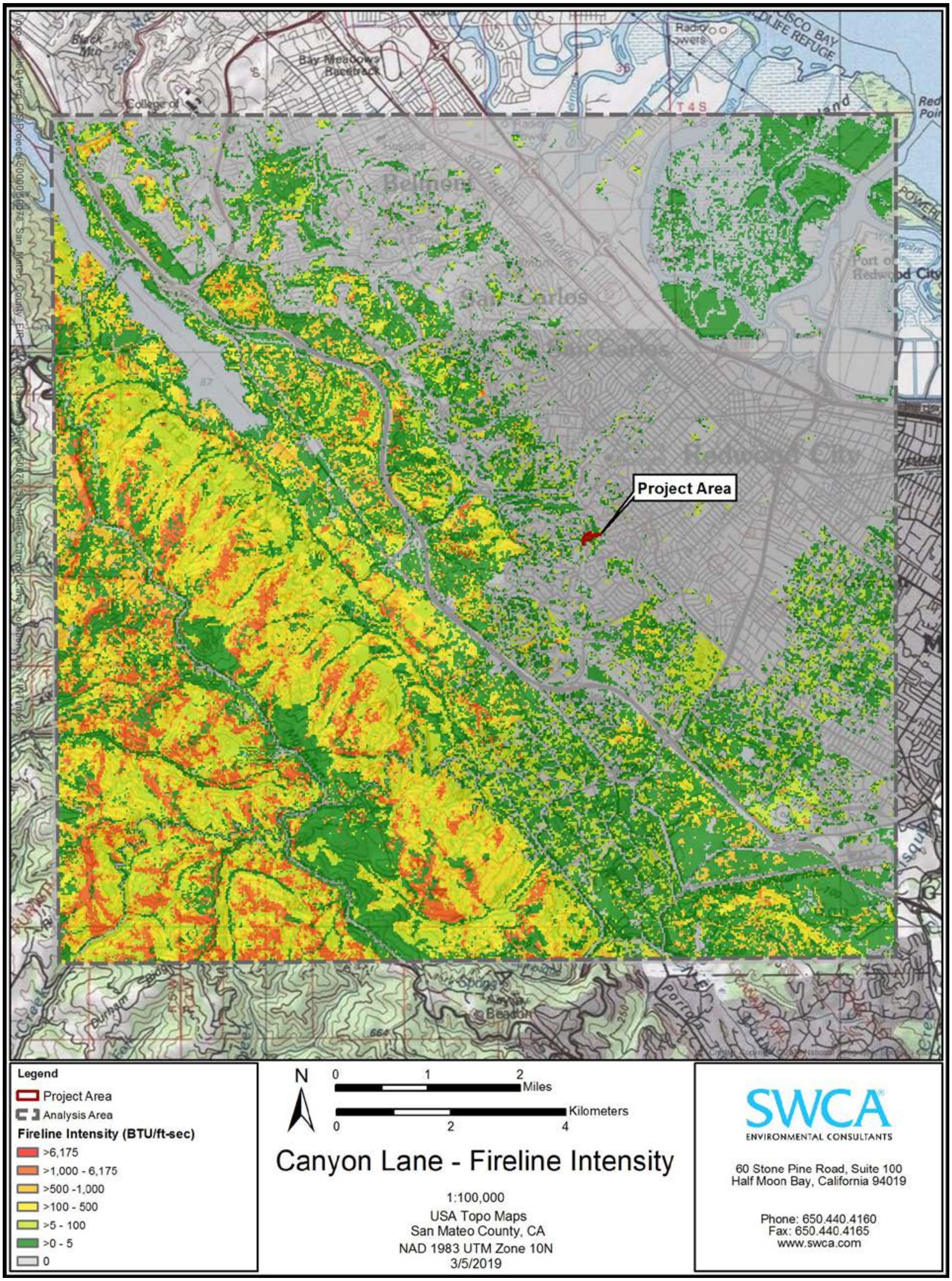

Figure 19. Potential Fireline Intensity within the greater landscape

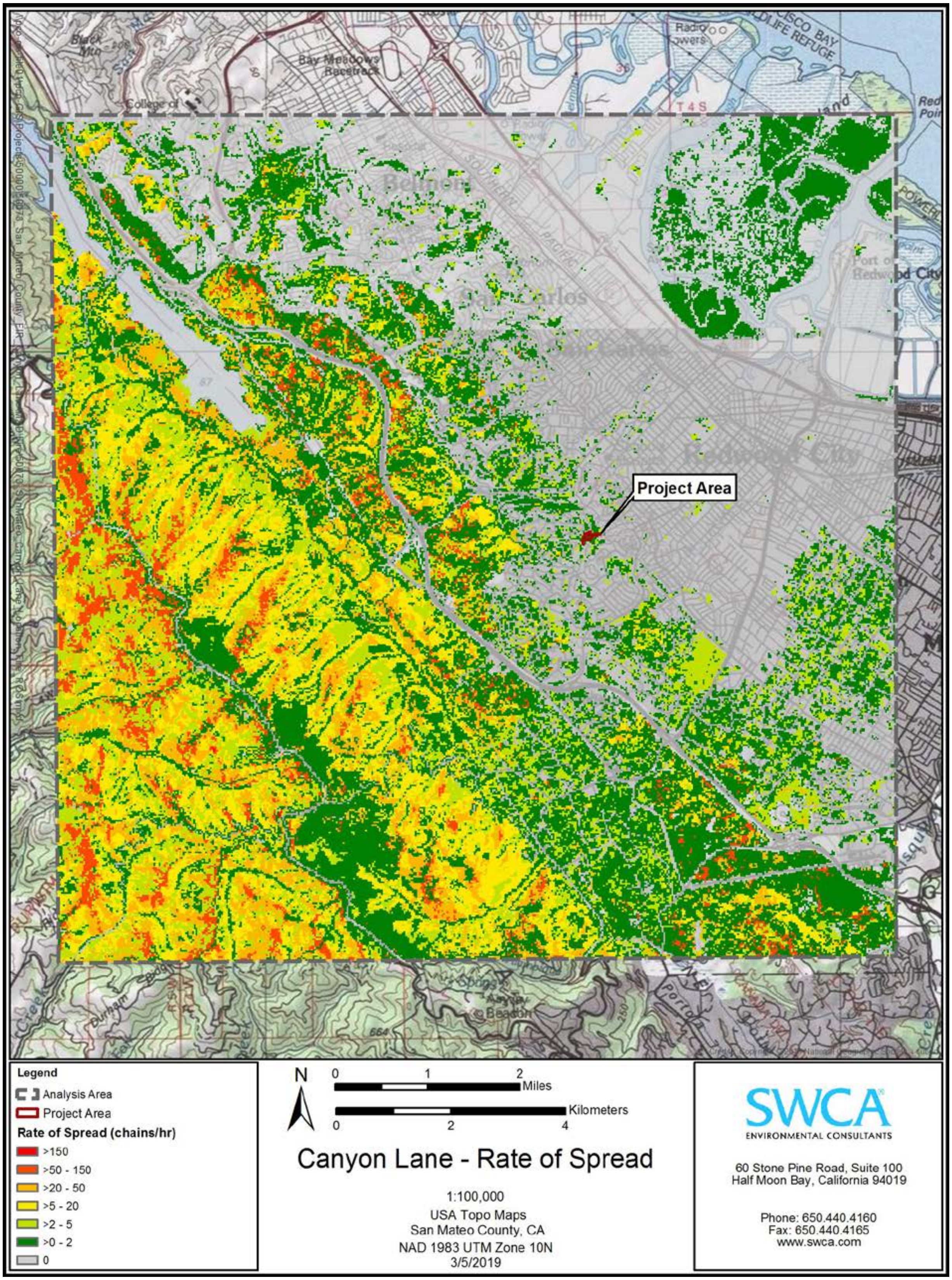

Figure 20. Potential Rate of Spread within the greater landscape

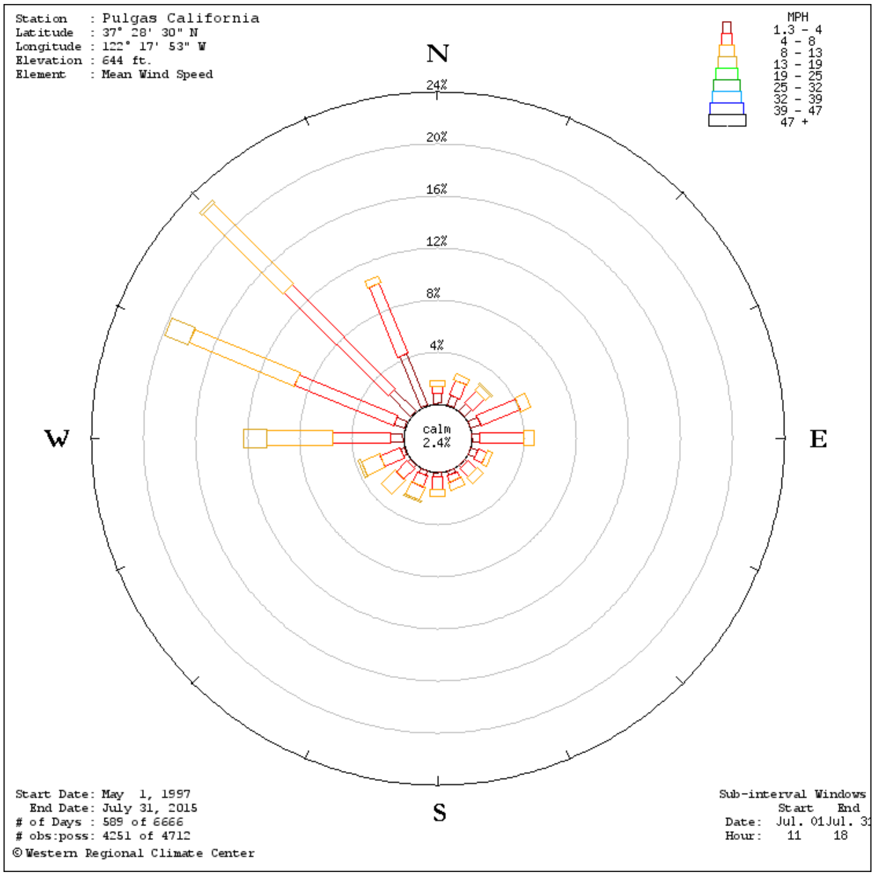

Figure 21. Wind rose from the Pulgas RAW station showing the dominant westerly wind direction during July. Source: Western Regional Climate Center.

DISCUSSION

This Wildfire Assessment analyzes the impacts of wildfire hazards resulting from implementation of the proposed project.

Canyon Lane is currently an unimproved gravel roadway that is inaccessible to emergency vehicles. The road width and overhanging vegetation impede both horizontal and vertical access by emergency vehicles. There is inadequate turnaround space and insufficient road width to safely accommodate large emergency vehicles. In the event of a wildfire, vegetation adjacent to the roadway would pose a hazard to people evacuating the area and to emergency responders and fire-fighters due to an insufficient buffer with the road. The project would involve regrading and paving the unimproved roadway into a 20-foot-wide paved roadway to enable emergency vehicle access. The roadway would incorporate an emergency vehicle turnaround apparatus and would be designed and maintained in accordance with the American Association of State Highway and Transportation Officials Standard HB-17. Further, the roadway would be designated as a fire lane, and no street parking would be permitted. The entire roadway would be marked and posted in accordance with Section 22500.1 of the California Vehicle Code. Because the project would provide emergency vehicle access and assuming that property owners would comply with all applicable design and maintenance provisions, the project would not impair any adopted emergency response or evacuation plan, and no significant impacts would occur.

The Canyon Lane project site is surrounded by residential development on all sides and areas of previous disturbance. Some portions of the project area include steep slopes with structures on the side and top of the slope (Figure 22). The project site is located within an oak woodland vegetation assemblage that is modelled primarily as a timber litter fuel, with small patches of grass and shrubland vegetation. The area has experienced low wildfire occurence over the period of record (1960-2018), and fire behavior modeling predicts the fuels in the area would burn with mostly low to moderate intensity, in terms of flame length, rate of spread, and fireline intensity. During project implementation, fuel loading would be decreased in the area, as native woodland vegetation is removed or thinned in order to accommodate the road realignment and improvements and for the construction of a single-family home on one of the 12 parcels (057-222-290 & 300). The road realignment would support the future development of the 11 remaining currently undeveloped parcels, thereby leading to the removal or reduction of additional native vegetation community assemblages and further disturbing the fuel continuity. Overall the project would lower the potential fire behavior, as it would reduce existing fuel loading.

The area is subject to prevailing westerly winds, which could result in fire spread from adjacent open space located less than 1 mile west of the project site. According to fire modeling, adjacent open space would burn under more intense fire behavior, with more rapid rates of spread, increased fireline intensity, and greater flame lengths (Figures 19 to 20). In the event of an ignition within the open space or from Interstate 280, wildfire exposure would be heightened for the Emerald Hills community. Canyon Lane is in direct alignment with the prominent wind direction; if there were an ignition from the west, it could accelerate towards the project area, moving the fire from east to west, up the canyon. Under extreme conditions, fire could spread through existing residential areas into the project area. Westerly winds, however, are associated with more humid air from the Pacific, and therefore the potential for extreme weather out of the west is unlikely. Furthermore, the large network of roads within the Emerald Hills subdivision would facilitate relatively rapid emergency response, which would ease containment of a fire before it gains in size. Development within the project area would reduce the area of native woodland vegetation, lowering fuel loading and therefore mitigating fire risk overall, regardless of whether an ignition occurs within or adjacent to the project area.

Under extreme conditions, the area may be impacted by dry Diablo winds out of the east and northeast. These strong winds could occur during the late fall when the region experiences low relative humidity (Bowers 2018). However, to the east of the project area is heavy urban development, and therefore the potential for a wildfire ignition to spread from east to west towards the project area is minimal.

Potential ignition sources would be increased during construction activities and as unoccupied residential parcels are developed due to increased human activity. Safety mechanisms would be followed during all construction activities, including the use of spark arrestors and provision of fire- fighting equipment for use by construction crews. The project would comply with all applicable fire codes, which would require the use of fire-resistant construction materials and the development of defensible space, as well as vegetation maintenance and buffers along roadways. These actions would reduce potential structural ignitability and limit fuel continuity and loading, mitigating potential spread of fire from any ignition sources. The project would realign, widen, and improve the current condition of Canyon Lane, as well as develop single-family residences within the unoccupied parcels, which would break the continuity of native woodland vegetation. Developed land would function as a fuel break to slow the spread rate of wildfire and lessen fire intensity in the form of reduced flame lengths and fireline intensity.

In summary, although wildfire occurrence is expected to increase in the greater landscape with increased population growth, projected drought, climate change, and increased fuel accumulation, the development itself is in an area of lower risk, where wildfire occurrence, duration, and size are not expected to be significantly increased with the construction of the project.

MITIGATION MEASURES

The following mitigation measures are compiled from various local sources. Although specific wildfire mitigation measures are not proposed herein, these general mitigation measures are recommended for the protection of communities and infrastructure from wildfire hazard and risk within the project area.

Defensible Space clearing standards

California State Law requires clearance of flammable vegetation for 30 feet around the house. Flammable material includes all dead vegetative matter and live canopy fuels, and fuel reduction measures are recommended to avoid the spread of fire from one tree or shrub to another. In many instances, 30-foot clearance would not be enough to protect a home from wildfire, and some local ordinances require 100 feet of clearance. This is especially true of homes in steep or rolling terrain (characteristic of the project area), where additional clearance would be necessary to combat the influence of slope on fire behavior. As stated in the County Community Wildfire Protection Plan, defensible space is the responsibility of each individual homeowner, and recommendations are to create the maximum possible extent of defensible space around a home (Harper et al. 2019). Maintenance of defensible space is critical and should be accomplished prior to the fire season.

Woodland Health and Resilience

Many homeowners select a woodland setting for their home for aesthetic and wildlife values. One way to mitigate wildfire risk in these vegetation communities is to enhance woodland health and stand resiliency. Trees should be thinned out so that their crowns are separated when they are full grown. Trees should be removed from within 30 feet of a property and spaced out within a 100-foot buffer. Oaks around the home should be regularly pruned of dead wood. In addition, low-hanging branches should be pruned off to avoid being ignited by a ground fire. Trees should be kept in as healthy and vigorous a situation as possible to minimize the fuel loading from dead or dying trees (Harper et al. 2019).

Landscaping

Landscaping plants should be selected from an approved fire-resistant list provided by the San Mateo Fire Safe Council. All landscape trees should be carefully selected and positioned to minimize creation of ladder fuels below natural canopy.

Roadside Fuel Breaks

Roadside fuel breaks are typically between 10 and 40 feet wide and are typically constructed manually by chain-saw crews. Removed vegetation can be processed by chippers, treated by pile burning or lop and scatter, or removed off site. The San Mateo-Santa Cruz County CWPP (2018) provides specifications for roadside fuel breaks. [14]

Shaded Fuel Breaks

Shaded fuel breaks can be placed around structures or around a neighborhood to augment individual defensible space projects. The shaded fuel break should be developed in collaboration with the fire community and responsible fire agency and adapted to local environmental constraints (CAL FIRE 2018a).

[14] http://www.sanmateorcd.org/wp-content/uploads/2018/11/2018_CWPP_update_final-Opt.pdf

Powerlines

Locally, PG&E is the sole owner of the power distribution network. PG&E follows a strict internal program for utility line clearance within the PG&E right of way.

Hardening the Home

FIRE SAFE San Mateo County provides recommended actions that homeowners can take to hardening their home[15] so that it is ember-ignition resistant (resistant to embers carried aloft of a flaming front). Hardening actions include retrofitting a roof using fire-resistant materials such as composition, metal, or tile. In order to prevent embers entering a structure, homeowners are advised to cover all vents with a fine mesh with openings of 1/8 inch. Wood siding should be replaced with ignition-resistant building materials such as stucco or fiber cement. Many of the FIRE SAFE and FIREWISE guidelines are available to homeowners; following these guidelines can help to improve a structures survivability during a wildfire.[16]

Fire response and Evacuation

Pre-incident planning for fire operations can be used to improve fire response, familiarize responders to the area, and pre-identify hazards that may impact fire suppression strategies.[17]

Public Education and Outreach

The local community is heavily engaged in wildfire prevention and fire agencies, including CAL FIRE and the local fire departments, and recognize that fire prevention education is the most effective way to mitigate the number and type of ignitions. Organizations such as the Fire Safe Council and Resource Conservation Districts provide fire prevention support to the public; CAL FIRE also participates in FIRE SAFE programs, providing technical expertise to stakeholders. The San Mateo-Santa Cruz Unit Strategic Fire Plan (2018) and the San Mateo-Santa Cruz Community Wildfire Protection Plan (2018) provide detailed information on community engagement for fire prevention, with recommended actions to mitigate wildfire risk through education and outreach.[17, 18]
CAL FIRE identifies the education of residents as a strategy for fire prevention in the 2018 Unit Plan. The San Mateo-Santa Cruz Unit plans to educate residents using LE-100 inspections (defensible space inspections) and public contacts. The San Mateo County Fire Marshal's Office provides fire prevention services for unincorporated areas.

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[15] https://firesafesanmateo.org/resources/defensible-space/hardening-your-home

[16] https://firesafesanmateo.org/images/documents/home_survival_in_wildfire_prone_areas_8939.pdf

[17] http://cdfdata.fire.ca.gov/pub/fireplan/fpupload/fpppdf1618.pdf

[18] http://www.sanmateorcd.org/wp-content/uploads/2018/11/2018_CWPP_update_final-Opt.pdf

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