APPENDIX 4.15

Wildfire

FUEL MANAGEMENT PLAN

NOVEMBER, 2020

SCOTT RANCH

PETALUMA, CA

PREPARED BY WILDLAND RES MGT

149318102.1

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APPENDICES

I – EXECUTIVE SUMMARY

This Fuel Management Plan is for the Scott Ranch project, which includes the Davidon (28-Lot) Residential Project component and the Putnam Park Extension Project component. The plan is intended to meet the requirements established by the City of Petaluma. The purpose of the Fuel Management Plan is to describe actions needed to maintain vegetative fuels in a fire-safe condition and to make vegetation management easier to implement. The plan (1) describes existing conditions that affect fire hazard and risk, (2) delineates fuel management zones, (3) establishes appropriate treatments for each, (4) documents maintenance schedule and frequency, and (5) provides a schedule and criteria for updates to this plan.

The Fuel Management Plan includes a detailed description of existing conditions and proposed fuel modifications that will direct maintenance of landscaping and open space areas. The approximately 58.66-acre project site is located in the southwestern portion of the City of Petaluma and is characterized by rolling hills covered by grasslands, rocky knolls, and trees along the northern property line, with a section of Kelly Creek surrounded by riparian vegetation running through the site. Proposed fuel modifications emphasize actions to decrease fire intensity and thus facilitate fire suppression and minimize property loss and risk to humans. Development and maintenance of a defensible space zone for 100 feet from each structure and 10 feet from each roadside edge, along with management of fuels in the larger open space parcels comprised of lands to be owned by the homeowner association and the Sonoma County Regional Park District, will help improve fire safety and reduce fire risk compared to existing conditions. Open space management will prevent shrubby growth in the grasslands of the open space and minimize ember production in areas with trees. Fire behavior with the proposed project, including management measures, in place is expected to exhibit less than two-feet flame length within 100 feet of any structures. Where fuel management is precluded (i.e. in riparian areas near the existing Red Barn) flame length may exceed two feet.

Appendix A, Technical Report: Fire Behavior and Evacuation Scenarios for Scott Ranch, details the potential for the spread of fire with existing conditions, assuming a west wind and two northeast wind scenarios. Fire behavior characteristics (flame length, rate of fire spread, crown fire potential) with current conditions are mapped.

The same characteristics are then mapped for the Scott Ranch project, which includes the recommendations of the Fuel Management Plan. The comparison of the existing and with-project scenarios shows that the risk of fire spread would be reduced by the project compared to existing conditions, and that this reduction would be particularly pronounced for the northeast (Diablo) wind scenarios.

II – PROJECT DESCRIPTION

PROPOSED PROJECT LOCATION

GENERAL LOCATION OF THE PROJECT

The approximately 58.66-acre project site is located in the southwestern portion of the City of Petaluma in Sonoma County at the northwest and southwest corners of the Windsor Drive and D Street intersection.

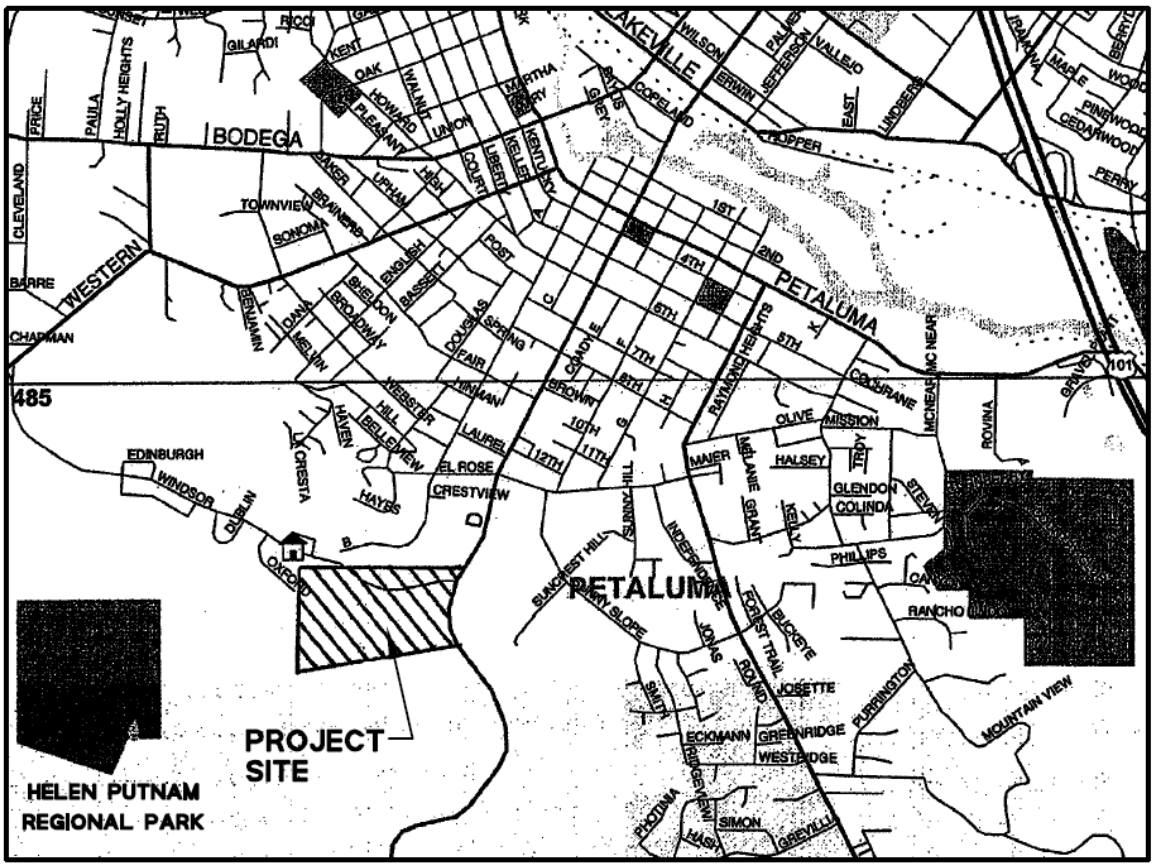

Figure 1. General location of project site.

DESCRIPTION OF ADJACENT PROPERTIES

Single-family subdivisions are located to the north, northwest, and east of the project site. Helen Putnam Regional Park, maintained by Sonoma County Regional Parks, is located immediately contiguous to the western boundary of the project site. The land to the south and southwest of the project site is unincorporated Sonoma County and is used for grazing as well as large lot residential. McNear Elementary School is located approximately 0.5 mile northeast of the project site on Sunnyslope Avenue.

DESCRIPTION OF THE PROJECT

The project site is within the West Hills planning subarea and the majority of the site is designated as Very Low Density Residential (0.6 to 2.5 dwelling units per acre) in the City's General Plan Land Use map. A 300-foot band along the southern boundary of the project site is designated Urban Separator on the General Plan Land Use map. The area surrounding Kelly Creek is designated Open Space. In addition, the General Plan identifies a Proposed City Park on the project site at the southwest corner of the D Street and Windsor Drive intersection that would accommodate an estimated 3 acres for passive recreational facilities.

The proposed project involves development of a 28-home residential component, and extension of Helen Putnam Park to include a barn center, public park, trail network, pasture improvement, stock pond enhancement, and habitat conservation projects.

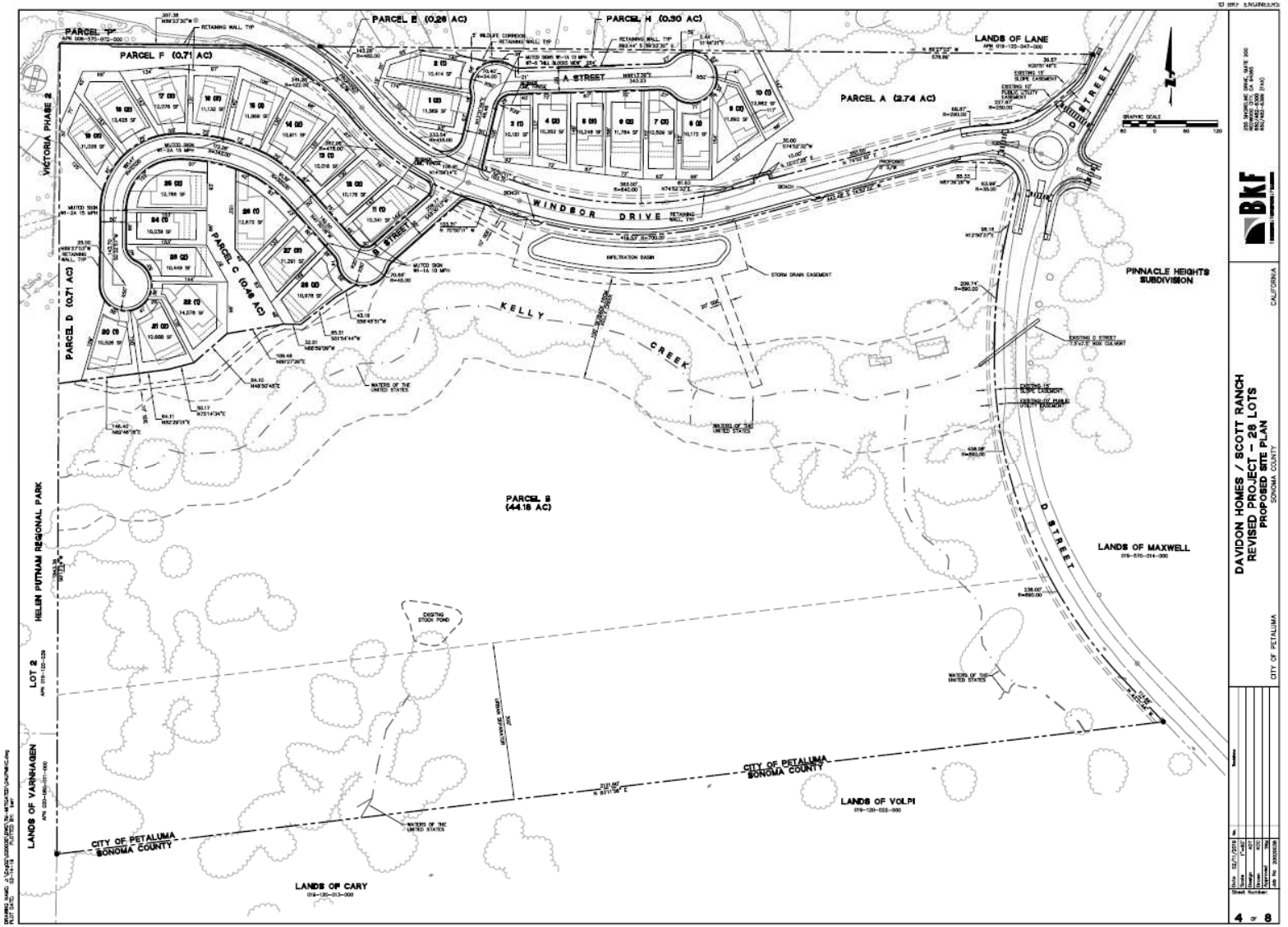

Figure 2. Site map showing proposed residences.

Residential Component proposed by Davidon Homes.

Approximately 25 percent of the project site (15 acres) would be developed with 28-lot single-family residences, streets, and common open space. The residences would be arranged in clusters off each of the two proposed streets. The minimum lot size would be 10,000 square feet (sf) while the average lot size would be 11,245 sf with residences ranging in size between 2,678 sf and 3,523 sf.

Putnam Park Extension Project component

Helen Putnam Park would be extended into the project site and developed to include a barn center, one-mile trail network, a public park with playground and picnic areas. Pasture improvement, stock pond enhancement, and habitat conservation projects would also be initiated.

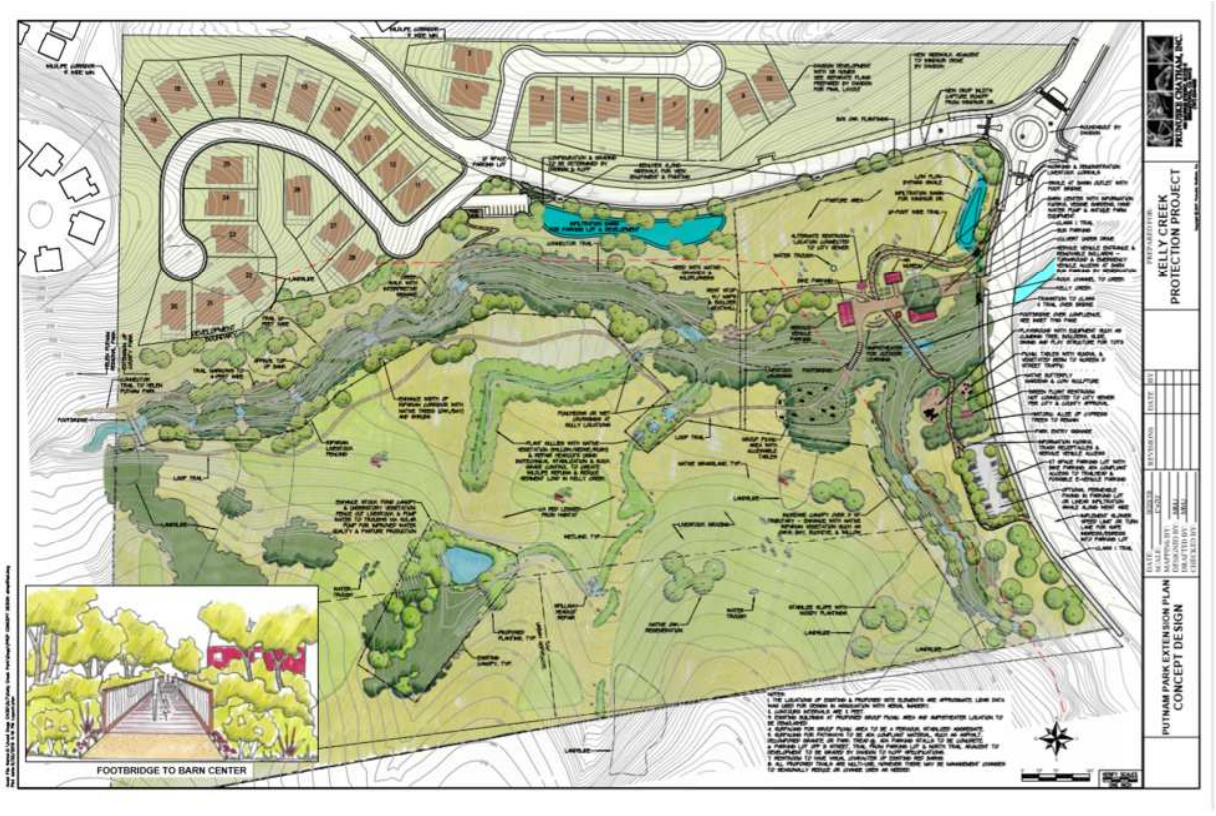

Figure 3. Site map showing details of the proposed Putnam Park Extension Project.

III – FIRE RISK FACTORS

TOPOGRAPHY

Topographic features - such as slope, aspect (orientation with respect to sun and wind), and the overall form of the land - have a profound effect on an area's ecology and the pattern of heat transfer in a wildfire. Topography affects a wildfire's intensity, burning rate (consumption of fuels), direction, and rate of spread. An area's topography also affects local winds, which are either "bent" or intensified by topographic features. Topographic features can also induce diurnal upslope and downslope winds. The speed, regularity, and direction of winds directly influence the direction of wildfire spread and the shape of the flame front.

Topography of Scott Ranch Project Site

The 58.66-acre project site consists of two parcels. Parcel 1 (APN 019-120-041) is a 52.07-acre parcel on the south side of Windsor Drive and west of D Street, and Parcel 2 (APN 019-120-040) is a 6.59-acre parcel on the north side of Windsor Drive.

Parcel 1 is largely undeveloped and is in use for grazing cattle. This parcel is characterized by rolling hills, with a section of Kelly Creek running west to east through the parcel. Elevations range from approximately 100 feet above mean sea level (amsl) at Kelly Creek to 380 feet amsl in the southwestern corner of the parcel. In addition to Kelly Creek, which runs in a deeply incised channel on Parcel 1, there are several drainages on this parcel. An unnamed tributary to Kelly Creek flows along the west side of D Street north into Kelly Creek (referred to as “D Street Tributary”).

Parcel 2 is also undeveloped. The elevation of Parcel 2 rises from 150 feet amsl at Windsor Dr. north to the northern property boundary of Parcel 2 where it reaches 210 feet amsl.

The elevations range widely from Kelly Creek and nearby flatter areas to the steeper areas in the southwestern corner of the project site. Parcel 2 has an average slope of 20.30 percent and Parcel 1 has an average slope of 21.27 percent.

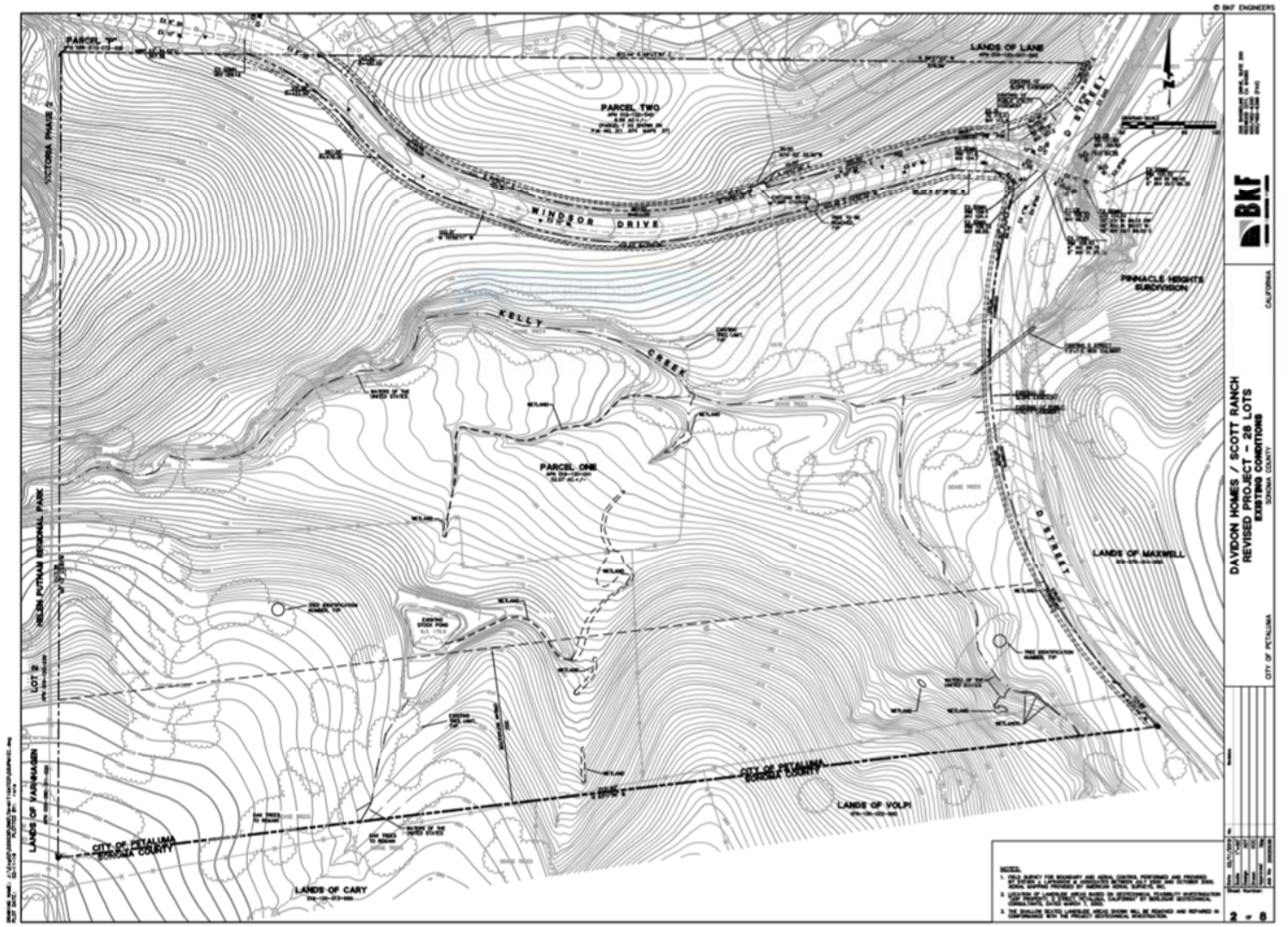

Figure 4. Existing topographic conditions on the Scott Ranch project site.

FUELS

The term "fuel" is used to describe any material that will burn, whether vegetative or structural component. A single fire may consume shrubs, grasses, trees, woodpiles, and structures as fuels. However, a structure built under current codes is ignition-resistant, and a series of structures with defensible space forms a fuelbreak. Because the residences on the project site will be built with ignition-resistant construction, they are considered to not contribute to the spread of a fire. Similarly, young and tended landscaping is also ignition-resistant. This is because the vegetation in residential yards is typically irrigated and relatively free of dead material, and spacing is maintained. Because of these characteristics, the private yards of the project area are not predicted to be part of the spread of a wildfire.

Existing structures that were built before ignition-resistance was required are more prone to burn. However, structure ignitions do not contribute to the wildfire front or wildfire spread because normally there is a delay in ignition compared to wildland fuels such as grass or leaf litter. After a structure is burning fully, it does contribute to ember production and distribution, however wildland fuels produce and spread embers in such quantity that the additional firebrands produced by structures are not significant and do not alter the speed of fire spread. For these reasons, the accepted models for wildfire spread focus on vegetation and not on structures.

It is also noted that with the proposed project, older existing structures, which are in the Putnam Park Extension portion of the project site, would be either removed or rehabilitated to meet applicable fire codes.

Fire Behavior in Different Fuels

Fire managers in virtually all US agencies (as well as in other countries where wildland fire hazards are significant) use fuel model systems for computerized fire behavior prediction systems (FBPS). Information regarding fuel volumes and fire-behavior descriptions is based upon fuel models described in *How to Predict the Spread and Intensity of Forest and Range Fires*, by Richard C. Rothermel (1983), published by the USDA Forest Service Intermountain Forest and Range Experiment Station, General Technical Report INT–143. Fuel models relevant to the Scott Ranch project include grasslands (with tall and short grass having different models), tree model, and wetlands. Each fuel model is given a number designation, which is interpreted by fire managers across the continent to mean the same thing.

Fuel models describe vegetation structure in addition to typical species composition. The most significant factor is the amount and distribution of smaller-diameter fuels, because these materials generally spread wildland fires.

Another important factor is the amount of dead biomass and the ratio of live-to-dead material in brush and tree stands, since dead biomass contributes fine fuel litter as well as carrying flames more readily. Fuel models include these considerations.

This section describes vegetative fuels on the site in a general way. More detailed discussion appears in the Technical Report as Appendix A.

Low Load, Dry Climate Grass (FBPS Fuel Model GR2)
Under existing conditions, 81.7 percent of the project site is covered with grazed and ungrazed "Low Load, Dry Climate Grass" (FBPS Fuel Model G2). See Appendix A, section 1.

Grass fuels do not produce much heat, but they produce a fire that travels quickly. Therefore, containment is the greatest challenge posed by these fuel types. In particular, grass can serve as a wick for more hazardous fuels whose ignition is apt to cause greater damage. Grass thus provides an avenue for fire to travel to densely vegetated areas, allowing it to build up enough of a "head of steam" to burn into landscaping or other types of fuels under conditions that would not otherwise be fire-sustaining.

Grassland fuels (both annual and perennial) are fairly uniform and homogeneous in comparison to other fuel types. Generally, grasslands have a light total fuel load, consisting entirely of fine herbaceous material that cures in the summertime. This material responds markedly to changes in humidity and ignites easily in dry periods.

Dry Climate Grass-Shrub (FBPS Fuel Model GS1 Low Load] and GS2 [Moderate Load])
Some shrubs (mostly coyote brush) are found scattered throughout the project site and beyond. These are classified as a grass-shrub fuel model (GS1 and GS2). Shrubs locally increase fire intensity, but do not affect the rate of fire spread. Shrubs can produce short-range ember cast in both GS1 and GS2 fuel models.

Two grass-shrub fuel types (GS1 and GS2) are located along Kelly Creek and its tributary that runs south to north along the eastern boundary of the lower portion of the property. In addition, there are patches of GS1 and GS2 within the southwestern corner of the property.

In total, these fuel types occupy 7.2 percent of the project site.

Shrubs (FBPS Fuel Model SH5)
One shrub fuel type (SH5) is present on the property. This exists surrounding a structure in the location of the abandoned residences and outbuildings in the southern portion of the property. This is presumably a consequence of overgrown landscaping surrounding the structures. This shrub type is associated with high flame lengths and often generates embers that can cast off quite a distance from the main front of a fire. This fuel type occupies 0.6 percent of the project site.

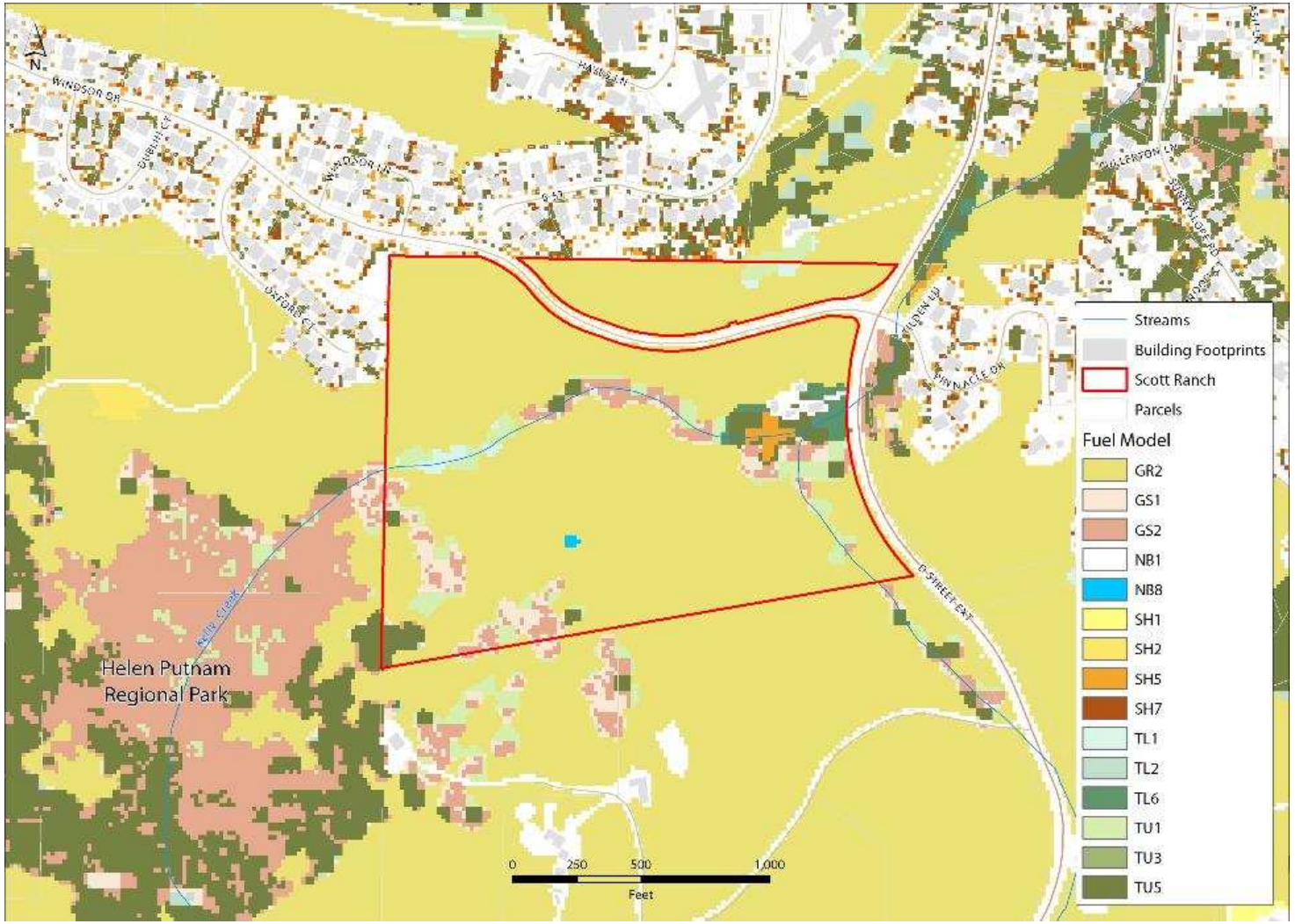

Figure 5. Fuel types of Scott Ranch and vicinity

Trees (FBPS Fuel Model TL1, TL2, TL6, TU1, and TU5)

Because these fuel models were named by the Forest Service, and this organization has most of its land in conifer forests, the fuel models are named "Timber Litter" or "Timber Understory". The fuel models also apply to hardwood forests and woodlands. There are 509 existing trees located on the project site. Of the existing trees, 478 trees are located within the proposed Putnam Park Extension component of the project site.

Some tree species on the project site qualify as City Protected Tree species including native oaks, California buckeye, and California bay; significant groves or stands of trees, trees located in riparian corridors and trees located in the City right-of-way, regardless of species, are also Protected Trees. A stand of oak trees is located in the southwestern corner of the project site, and a group of oak, bay and buckeye trees is found along the northern property line.

Three forest fuel types (TL1, TL2 and TL6) are found within Scott Ranch. These fuel types are found primarily along Kelly Creek and in patches to the north and south. TL1 is predominately located on the banks of Kelly Creek in the western portion of the property (south of Windsor Drive) and in small patches in the northeast of the property north of Windsor Drive and just east of the proposed residential lots. TL2 is located in two small patches at the edge of a large patch of TU5 (described below). And TL6 represents the 1.75-acre non-native Eucalyptus grove surrounding the existing structures on the southern portion of the property. These timber (or forest) types represent treed areas where the fire is carried by the forest litter under the tree canopy. The timber type fuel models describe hardwood forests even though no conifers exist in the project area. TL1 and TL2 are associated with low to moderate fire behavior and represent ideal conditions for fire resiliency. However, TL6, because of its higher fuel load and relatively tall tree height coupled with a low canopy base height, can be associated with a high likelihood for a source of embers. Together these three fuel types represent 2.03 percent of the project site.

Finally, there are two forest/shrub fuel types (TU1 and TU5). These timber types represent treed areas with a shrubby understory where the fire is carried by grass and shrubs under the tree canopy rather than by forest litter. The timber/forest type fuel models describe hardwood forests. TU1 is found in patches along Kelly Creek and its tributary and surrounds the patches of GS1 and GS2 to the south. In addition, it can be found along with TL1 north of Windsor Drive just east of the proposed residential lots. A large patch of TU5 is found at the very southwest corner of the property in addition to surrounding the existing structures and along Kelly Creek. TU5 can be associated with torching trees or crown fires because of its propensity to lead fires into the crown due to the abundant and relatively tall understory fuels. Together TU1 and TU5 represent 7.5 percent of the project site.

Riparian and Wetland Fuel Models

The Kelly Creek riparian area is lined with numerous trees including native oaks and willows.

Typically, riparian fuels do not burn in wildfires because the moisture in the foliage is kept high, due to the availability of water to the plant roots. However, whatever dead material is cast by mature trees can dry out in hot dry weather with the same timing as dead material outside of

the riparian corridor. So, as dead material increases in the riparian corridor, so does the fire hazard. Additionally, periods of drought raise the possibility of ignition and high fire intensities since the plants may be drier.

While fuels in wetlands normally have enough moisture to preclude burning, occasionally conditions such as hot dry winds in the fall can dry the fuels enough to enable combustion and fire spread.

WEATHER

General Weather Information

Weather conditions significantly impact both the potential for fire ignition and the rate, intensity, and direction in which fires burn. The most important weather variables used to predict fire behavior are wind, temperature, and humidity.

Wind direction and velocity profoundly affect fire behavior, but wind is considered the most variable and unpredictable weather element. Wind increases the flammability of fuels both by removing moisture through evaporation and by angling the flames so that they heat the fuels in the fire's path. The direction and velocity of surface winds can also control the direction and rate of the fire's spread. Aloft winds, defined as those that blow at least 20 ft above the ground, can carry embers and firebrands downwind. These burning fuels can ignite spot fires that precede the primary front. Gusty winds cause a fire to burn erratically and make it more difficult to contain.

The winds that create the most severe fire danger, known as the "Santa Ana" or "Diablo" winds, typically blow from the northeast. Because the project is situated east of major expanse of open space the project site (before fuel treatment) is vulnerable to a fire coming from the west with a westerly wind. However, winds from the east are also likely to cause unacceptable damage, particularly to the project site if fuels are not maintained and especially if a fire were to spread by embers generated off-site.

Local Weather Conditions

The project site's location in proximity to the coast influences its weather conditions. It has the warm, dry summers and cool, moist winters characteristic of the fog belt area. The area averages about 30 inches of precipitation a year, primarily in the fall and winter[1]. Most of the measurable rainfall generally occurs during the winter months (mid-October to mid-April). Thus, the fire season (the time of highest fire danger) comprises the dry months of May through October.

The wind normally blows from the west but, as discussed above, the most severe fire conditions occur in association with strong north or northeast winds. Under these conditions (common in the fall), humidities drop to 10% and temperatures soar to over 100 ^{o} F.

[1] http://cesonoma.ucanr.edu/about/weather/?weather=station&station=144

In addition, occasional episodes consisting of several still, stagnant days formed by stationary highs occur during summer months. During these periods—characterized by continuous high temperatures and low relative humidities—fuels dry to a National Fire Danger Rating System rating of over 81 for the Burning Index, indicating extreme resistance to fire-control. This overall weather pattern creates extremely low humidities and enhances the possibilities of ignition and extreme fire behavior.

Remote automated weather stations (RAWS) are used for fire danger ratings, and differ from local weather stations observed by citizens, or by government agencies observed for irrigation and water resource management. The RAWS are purposefully placed in open areas, most representative of the wildlands in question. The data from the nearest RAWS weather station was obtained; it reported ninetieth percentile values for relative humidity as 37%, temperature as 77° F, and wind speed as 11 mph. Seventy percent of the observations recorded winds from the west and southwest; only 13.4% of the observations recorded winds from the north, northeast, or east. The vast majority of hot days coincided with winds from the southwest.

Although average summertime temperatures are usually quite warm (75 to 85 ° F), it is common for the fog to roll in during the early evenings. Thus, proximity to the bay often creates a pattern of hot days and cool nights. Fog also sometimes keeps summertime temperatures cool in the project site.

As noted above, northeasterly winds (typical fire weather conditions) are especially conducive for transport of embers. The most extreme weather values typically are recorded during Diablo wind events in October. The driest recorded relative humidity was 9%; the highest recorded temperature was 103 ° F, and the greatest recorded wind speed was 34 mph. Usually days with recorded relative humidities below 20% are associated with Diablo wind events.

For the periods reviewed in 2019, the months of June, July, August, September, and October experienced the highest temperatures with the lowest relative humidity (from 90 to 104 degrees and 5 to 16 percent). The most consistent southwest winds coincided with the hottest days in August and the strongest northeast winds coincided with the lowest relative humidity (5%).

Although summer time winds were consistent, the strongest (or fastest) wind speeds were recorded during the winter months of January and February. However, due to the lower temperatures and higher relative humidity, these strong winds due to storm systems were not taken into consideration in this analysis.

Highest temperatures are normally recorded between June and August and are associated with weak to strong winds coming from west and southwest. The month of August was chosen for modeling of a fire coming from the southwest because seasonal fuel moistures would be lower than in June or July.

SUMMARY OF FIRE HAZARD AT THE PROJECT SITE WITHOUT MANAGEMENT

Site-Specific Fire Behavior Information

Almost all of the current vegetation at the project site is of low fire hazard. Nevertheless, as described in Appendix A, a fire could spread quickly with wind from the west in the summer. A fire originating in northeast of the project site, driven by northeasterly Diablo winds, would need to advance through embers from off site in order to cross Windsor Dr and other existing roads. Embers from fires in poorly maintained landscaping or shrubs/trees off-site could land anywhere on the project and cause new ignitions. The greatest vulnerability would come from ember cast, and the challenge that a long fire front would pose.

Proposed Project Fuel Changes

For the residential portion of the Scott Ranch project, native trees, shrubs, and groundcover would be planted throughout the development areas. The front yards would be landscaped, complying with water conservation standards from the Petaluma Municipal Code. Additionally, there would be a minimum 5-foot wildlife corridor between the fences of the project's residences and the existing fences of the adjacent Victoria subdivision.

Because landscaping vegetation is situated nearest structures and evacuation routes, this fuel type can either be the most damaging or provide an additional layer of safety/protection.

Domestic landscapes typically fall into a spectrum of fire hazards:

1. Landscapes are moist, and therefore won't burn; or
2. They contain large amounts of fuel, which will burn with great intensity; or
3. They contain fire-resistant plants, and will burn slowly with little resistance to control, or
4. They are maintained to be of low fuel volume, so provide little heat when they do burn.

Problems to avoid in landscaped areas are poor maintenance, breakage in irrigation pipes, and unremoved dead plant material. These problems can result in a large dead-fuel component amounting to a large volume of fuel.

The project offers several areas of improved fuel characteristics that will make the site less prone to ignition and less likely to spread rapidly or burn with intensity. The project

1. Creates areas of low-fuel in the developed portion of the site
2. Creates firebreaks in the form of parking lots, and development of trails
3. Removes flammable abandoned buildings
4. Continues minimizing grass volume through grazing
5. Increases moisture of portions of the grassland through habitat restoration projects that alter the species to more moisture-loving types of herbaceous plants.
6. Includes two infiltration basins that will support plants with higher levels of moisture than currently existing vegetation.

Ignition Potential of Project

There is no accepted methodology for quantifying the risk that development of an undeveloped site might increase the risk of wildfire ignition. Therefore, this analysis is qualitative.

CAL FIRE's annual Wildfire Activity Statistics, 2014-2017 reports indicate the most common causes of wildfires are mechanical use, debris burning, arson, electrical powerlines, campfires, playing with fire, and lightning.

The property is currently fenced, and grazed, but occasionally people enter because there is no formal patrol of the property. Should a fire start, detection and report of the event would be a lucky circumstance because the parcel is currently void of residents to detect and report fires.

Arson, campfire and playing with fire are more likely in vacant lots. In contrast, the risk of fire from mechanical use, vehicles, debris burning, electrical powerlines, and smoking is greater in developed lots. In the case of the project site, debris burning is prohibited and neighbors would be expected to promptly report any such burning. In addition, all electrical powerlines added by the proposed project would be under ground. Therefore, no wildfire ignition risk would be anticipated from these two sources.

As demonstrated by the relative percentage of acreage burned by different causes in these Wildfire Activity Statistics, some causes of fires typically result in longer detection time because they tend to occur in locations which are difficult to access and thus have greater response times associated with them.

Although the risk from ignition sources associated with development (mechanical use, vehicles, and smoking) could increase with the proposed project, the reductions in risk provided by replacement of approximately 15 acres of fuel (grassland) with fire-resistant residences and landscaping; improved access, water supply, and water delivery systems; and restrictions on dangerous fire-related behavior would more than offset whatever increased risk may be associated with development.

Specifically with respect to the Putnam Park Extension, more people would be present in the expanded portion of Putnam Park, which could theoretically result in a greater number of ignitions. However, from a poll of open space managers, indications are that authorizing use, with attendant fuel management, patrol, and enforcement presence, limits wildfires compared to unpatrolled private land.

The managers surveyed reported the following findings, as detailed in Appendix C.

- Stoves have not caused wildfires.
- Illegal campfires are the biggest source of wildfires.
- Fuel management plays a role in the extent of fires that started.
- Trail users have rarely started fires.

Implementation of the Fuel Management Plan described in the next section would provide an extra measure of protection for both the project site and neighboring properties from the existing risk that a wildfire could begin either on-site or off-site.

IV – PROPOSED FUEL MANAGEMENT PROGRAM

SUMMARY OF FUEL MANAGEMENT ZONES

There are six treatment zones in this fuel management plan:

- Residential Defensible Space/Landscaping Zone
- Open Space Defensible Space Zone
- Roadside Vegetation Management Zone
- Fuel-Modification Zone (1)
- Fuel-Modification Zone (2)
- Riparian Zone

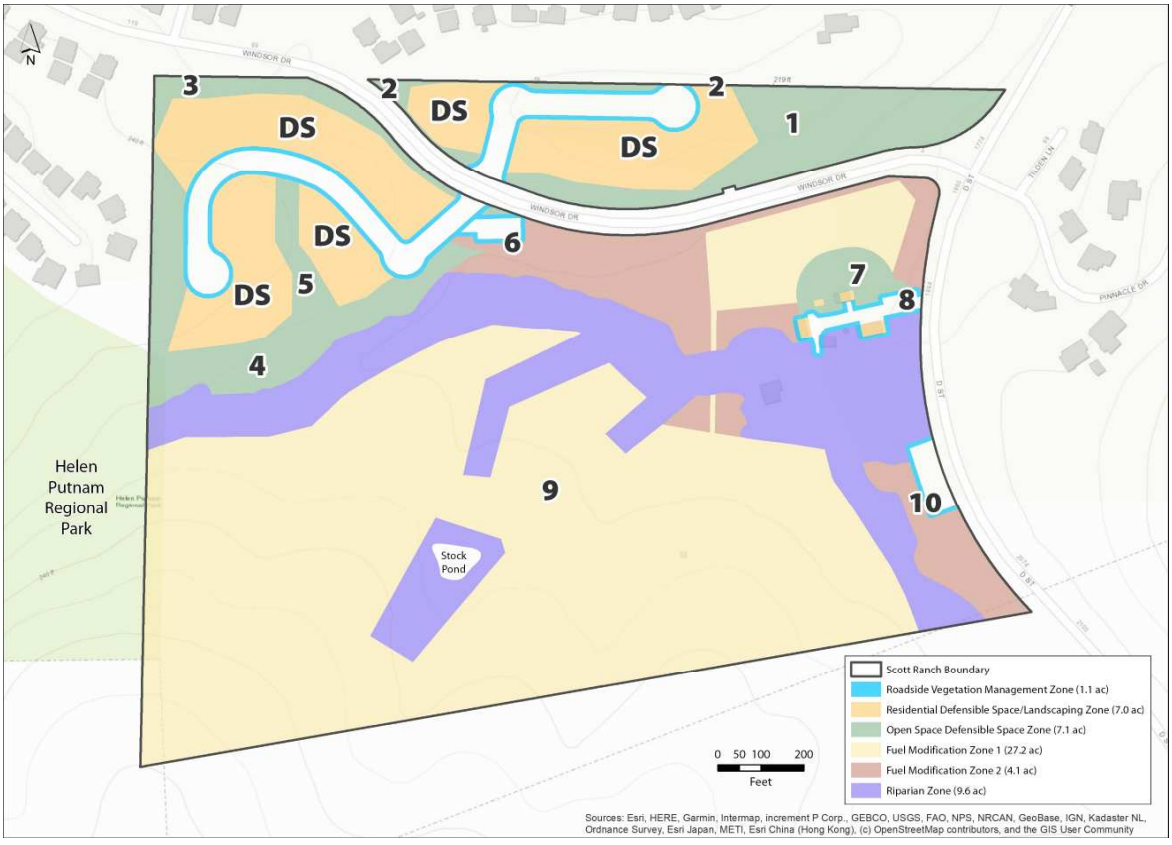

Figure 6. Fuel Management Zones

Both the Residential Defensible Space/Landscaping Zone and the Open Space Defensible Space Zone (including any barbecue areas in the developed portion of the extension of the Helen Putnam Regional Park) are designed to reduce ignitions near structures, support structural survival during a wildfire, and reduce the chance that an ignition will move off site. The

vegetation management actions described in the Standards for Residential Defensible Space/Landscaping Zone and the Standards for Open Space Defensible Space Zone comply with the California State PRC 4291 and the Petaluma Municipal Code. Fuel management zones are shown in different colors in Figure 6; in addition, areas are numbered as a means to describe specific actions and responsibilities for actions within the fuel management zones. The Residential Defensible Space/Landscaping Zone is shown in white on Figure 6, and labeled as DS. The Open Space Defensible Space Zone is shown in green on the same figure, and is comprised of areas 1, 2, 3, 4, 5 and 7.

The Roadside Vegetation Management Zone consists of vegetation along new roads (A and B Streets), driveways, and parking lots, and is designed to assist evacuation and emergency vehicle access and to limit ignitions from vehicles. It is shown in blue on Figure 6 (areas 6, 8, and 10). The standards and actions to comply with both the Defensible Space/Landscaping Zone and the Roadside Vegetation Management Zone are the same, with one exception. In the Roadside Vegetation Management Zone there must also be a 15-foot vertical clearance created by tree-trimming over pavement along the entire length of the roadway, parking lot, or driveway.

The Fuel Modification Zones 1 and 2 encompass the remainder of the open space portion of the project site (shown in yellow and tan, and ensure the fuels do not exacerbate fire hazards to adjacent landowners and structures. Fuel Modification Zone 1 (yellow) is within the fenced cattle grazing area of the proposed Helen Putnam Park Extension and is designed to limit fire intensity and spread by means of the pruning of trees, reduction of understory plants, and use of prescribed herbivory (grazing). Fuel Modification Zone 2 (tan) is also within the proposed Helen Putnam Park Extension, but is outside the regular cattle grazing area; accordingly, options for fuel reduction other than prescribed herbivory are more likely to be used within this zone.

The Riparian Zone is also within the proposed Helen Putnam Park Extension. This Zone covers those areas along Kelly Creek and its tributary, and immediately surrounding the stock pond, and in two gullies that will stabilize and be replanted south of Kelly Creek (shown in purple on Figure 6).

STANDARDS FOR RESIDENTIAL DEFENSIBLE SPACE/LANDSCAPING ZONE

This set of maintenance standards will be used to certify compliance and to direct maintenance activities in the zone within 100 feet of the single-family residences on residential lots.

1. Maintain a 5-foot non-combustible buffer zone around structures. Hardscape surfaces (such as patios, gravel, and bare soil), and landscape materials (such as lawn and succulent herbaceous plants) are examples of non-combustible surfaces. Wood mulch is <u>not</u> considered non-combustible. Make liberal use of hardscaping within 5 feet of structures

2. Remove all dead plants and dry vegetation on all residential parcels. The following actions will provide the same level of fire safety as removing all combustible material, per local and state fire codes.

   a. Cut grass and weeds to less than 4 inches in height when 30% of the grasses have cured. Beginning April 15, inspect the grass on a weekly basis to determine the state of grass curing. Cut the grass within the week when 30% of the grass cover is cured, and no later than June 1. Re-mow if late-season rains promote grass growth after the first cutting. Cutting of native grass and wildflowers may be delayed until after seed set if the Fire Department concurs that these plants do not constitute a means of rapidly transmitting fire to any structure.

   b. Keep the ground, roofs, decking, and balconies free of dead leaves or other plant debris.

   c. Clear leaves, bark, and humus under trees and shrubs (including vines and semi-woody species). At no time should a buildup of leaves and humus exceed 1 inch in depth anywhere in a landscaped area. However, do not expose bare earth in over 50% of the zone

   d. Remove dead material that drapes over ground cover (including leaves, bark, and branches).

   e. Remove all dead branches from within live ground covers, vines, shrubs (including semi-woody species), and immature and landscape trees.

3. Prune trees and large tree-form shrubs (e.g. oaks, toyon) that are being retained to provide clearance of three times the height of the understory plant material, or 8 feet, whichever is higher.

   a. Prune limbs that are smaller than 3 inches in diameter up to 8 feet above the ground; in young trees, prune these branches on the lower one-third of the height of the tree. (Thus, if a tree is 10 feet tall, prune the lower 3–4 feet and keep the understory plant material to less than 1 ft in height. Then as it grows to 24 feet in height, it can achieve the 8-foot distance from the ground, and the understory plant material can reach 2.5 feet in height.)

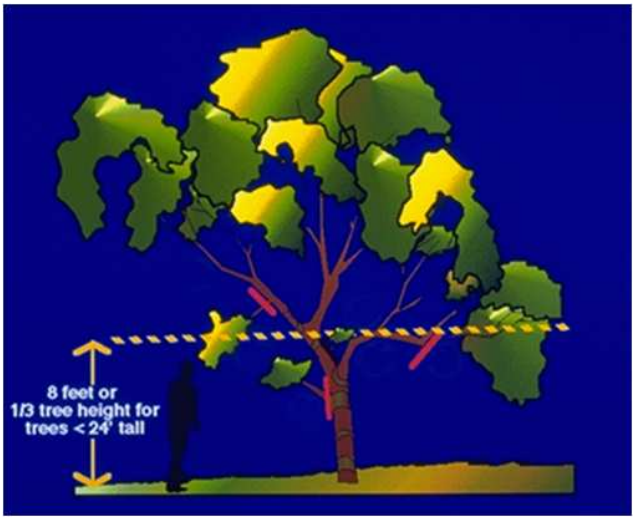

Figure 7. Prune branches to a height of 8 ft above the ground. In young trees, prune branches on the lower one-third of the height of the tree. Do not thin the tree canopy. This promotes growth in the understory, which is more easily ignited.

b. Remove all branches within 10 feet of any chimney, flue, or stovepipe.

c. Maintain 5 feet of vertical clearance between roof surfaces and overhanging portions of trees.

4. Do not locate plants that are replacing ones that die under trees. To avoid creating "ladder fuel situations" (in which a fire can climb from one vegetation layer to the next higher one), do not plant shrubs (including vines, semi-woody species, and all chaparral species) under trees.

5. Woody plants should not be placed under windows, nor within 5 feet horizontally of openings into the structure, such as doors. This will better ensure that these plants remain away from both doors and windows to help reduce the potential for heat or embers to impact these openings in the structures.

6. Make sure that all landscaping is fire-resistant in nature. Prohibit planting of plants that are highly ignitable and burn with intensity. The following website provides a database of fire-resistant and flammable plants: http://www.diablofiresafe.org/tolerance.html

7. Manage individual plants or landscaping shrub masses to maintain adequate horizontal spacing. Design distinct groupings of shrubs (including landscaping or native vines, semi-woody species, and all types of brush) to dampen the spread of fire.

a. Make sure that the plant groupings are small enough to provide adequate horizontal separation between groupings and to allow proper maintenance; groupings should measure no wider than two times the grouping height, or 120 square feet (however, one row of shrubs in a linear band with a maximum width of 7 feet, located at least 10 feet from the structure, need not comply with the 120 square foot area limit.)

b. The space between islands should be greater than three times the height of the shrubs, or 12 feet at a minimum. On emerging trees, clear a spacing of 12 feet from the edge of the canopy.

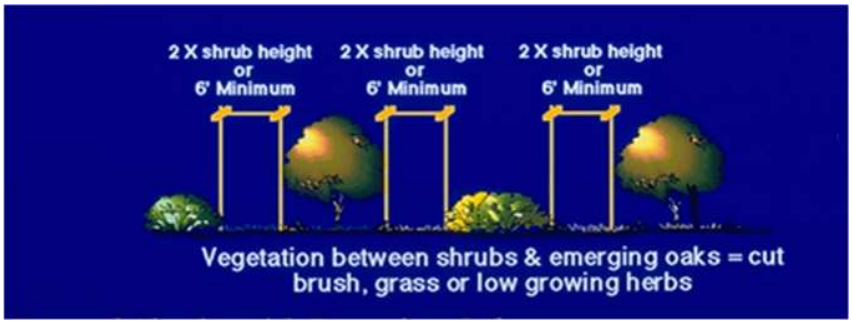

Figure 8. Shrub island spacing. Design groups of plants small enough to provide horizontal separation between groups. This allows proper maintenance and helps slow the spread of fire. Each shrub or group of plants should measure no wider than two times its height, or less than 120 sq. ft. (or 6 ft x 20 ft). The space between groups should be greater than three times the height of the shrubs, or at least a 12 ft. distance

8. Remove and safely dispose of all cut vegetation and hazardous refuse.

9. Allow chipped materials to remain on the site, provided the mulch layer is no greater than 2 inches in depth.

STANDARDS FOR OPEN SPACE DEFENSIBLE SPACE ZONE

This set of maintenance standards will be used to certify compliance and to direct maintenance activities in the zone within 100 feet of the single-family residences on homeowner association-owned open space adjacent to residential lots.

1. Train all personnel conducting fuel management in the Open Space Defensible Space Zone in identification of and avoidance of impacts to California red-legged frog, and in identification of native grasses and wildflowers.

2. Remove all dead plants and dry vegetation. The following actions will provide the same level of fire safety as removing all combustible material, per local and state fire codes.

   a. Flash graze or cut grass and weeds to less than 4 inches in height when 30% of the grasses have cured. Beginning April 15, inspect the grass on a weekly basis to determine the state of grass curing. Cut the grass within the week when 30% of the grass cover is cured, and no later than June 1. Re-mow if late-season rains promote grass growth after the first cutting. Cutting of native grass and wildflowers may be delayed until after seed set if the Fire Department concurs that these plants do not constitute a means of rapidly transmitting fire to any structure. In graded areas seeded with native grasses and wildflowers, do not graze or cut the grasses or wildflowers during the first year after seeding; thereafter, this area will be subject to the same regime as the remainder of the Open Space Defensible Zone.

   b. Clear leaves, bark, and humus under trees and shrubs (including vines and semi-woody species). At no time should a buildup of leaves and humus exceed 1 inch in depth. However, do not expose bare earth in over 50% of the site.

c. Remove dead material that drapes over ground cover (including leaves, bark, and branches).

d. From mature trees, remove all vines, loose papery bark, dead branches, and live branches smaller than 3 inches in diameter to a height of 8 ft above the ground.

e. Remove all dead branches from within live ground covers, vines, shrubs (including semi-woody species), and immature trees.

3. Prune trees and large tree-form shrubs (e.g. oaks, toyon) that are being retained to provide clearance of three times the height of the understory plant material, or 8 feet, whichever is higher.

a. Prune limbs that are smaller than 3 inches in diameter up to 8 feet above the ground; in young trees, prune these branches from the lower one-third of the height of the tree. (Thus, if a tree is 10 feet tall, prune the lower 3–4 feet and keep the understory plant material to less than 1 ft in height. Then as it grows to 24 feet in height, it can achieve the 8-foot distance from the ground, and the understory plant material can reach 2.5 feet in height.)

b. Do not thin the tree canopy, because thinning promotes growth of more flammable vegetation.

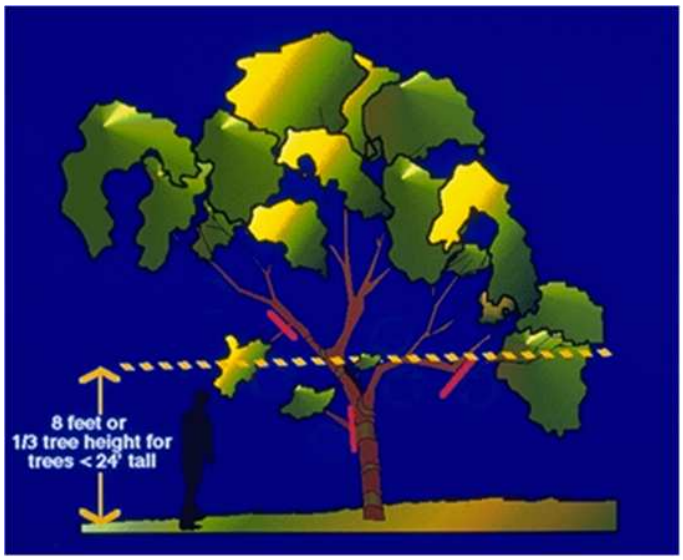

Figure 9. Prune branches to a height of 8 ft above the ground. In young trees, prune branches on the lower one-third of the height of the tree. Do not thin the tree canopy. This promotes growth in the understory, which is more easily ignited.

4. Do not locate plants that are replacing ones that die, or oaks planted as a mitigation measure, under trees. To avoid creating "ladder fuel situations" (in which a fire can climb from one

vegetation layer to the next higher one), do not plant shrubs (including vines, semi-woody species, and all chaparral species) under trees.

5. Make sure that all replacement plants are fire-resistant in nature. Prohibit planting of plants that are highly ignitable and burn with intensity. The following website provides a database of fire-resistant and flammable plants: http://www.diablofiresafe.org/tolerance.html

6. Manage individual plants or shrub masses to maintain adequate horizontal spacing. Design distinct groupings of shrubs (including vines, semi-woody species, all types of brush, and all chaparral species) to dampen the spread of fire.

a. Make sure that the plant groupings are small enough to provide adequate horizontal separation between groupings and to allow proper maintenance; groupings should measure no wider than two times the grouping height, or 120 square feet (however, one row of shrubs in a linear band with a maximum width of 7 feet, located at least 10 feet from the structure, need not comply with the 120 square foot area limit.)

b. The space between islands should be greater than three times the height of the shrubs, or 12 feet at a minimum. On emerging trees, clear a spacing of 12 feet from the edge of the canopy.

7. Remove and safely dispose of all cut vegetation and hazardous refuse.

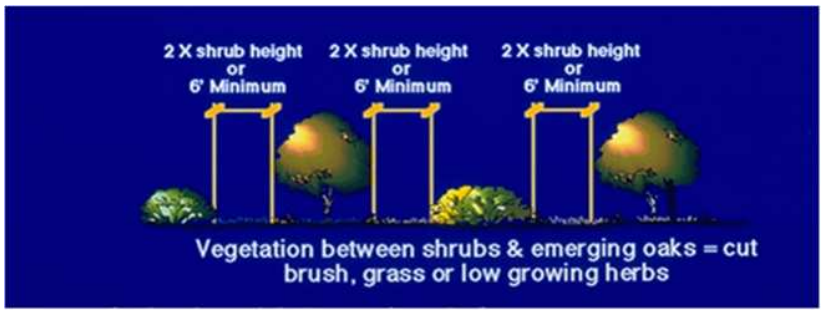

Figure 10. Shrub island spacing. Design groups of plants small enough to provide horizontal separation between groups. This allows proper maintenance and helps slow the spread of fire. Each shrub or group of plants should measure no wider than two times its height, or less than 120 sq. ft. (or 6 ft x 20 ft). The space between groups should be greater than three times the height of the shrubs, or at least a 12 ft. distance

8. Allow chipped materials to remain on the site, provided the mulch layer is no greater than 2 inches in depth.

STANDARDS FOR ROADSIDE VEGETATION CLEARANCE

The standards for the Residential Defensible Space/Landscape Zone will apply to the strip of land within 10 feet of the pavement edge from both sides of the new roadways (A and B Streets), the

Putnam Park Extension project driveway, and parking lots. In the Roadside Vegetation Management Zone there will also need to be an unobstructed vertical clearance of 15 feet over the entire length of the new roadways, driveway, and parking lots. Where a Class 1 trail abuts a road, it is considered to be part of the Roadside Zone; if the trail is 10 feet wide, treatment need only occur on the trail.

STANDARDS FOR FUEL MODIFICATION ZONES

The open space within the project should be managed to preclude the encroachment of shrubs (such as coyote bush, *Baccharis pilularis*) which would increase the fuel load and potential fire hazard. Maintaining the entire site as a grassland can be accomplished by many techniques, including grazing or removal of shrubs with handheld tools. Cattle grazing is currently occurring on much of the site, and should be continued. Fuel Modification Zone 1, which will be regularly grazed, is shown in yellow on Figure 6. Fuel Modification Zone 2, which will not be regularly grazed, is shown in pink.

1. Train all personnel conducting fuel management in the Fuel Modification Zones in identification of and avoidance of impacts to California red-legged frog, and in identification of native grasses and wildflowers.

2. Continue regular grazing in Fuel Modification Zone 1. In Fuel Modification Zone 2, and wherever regular grazing in Fuel Modification Zone 1 does not reduce grasses to 4 inches in height, by June 1, flash graze or cut grass and weeds to less than 4 inches in height, with the following exception:

   a. Approximately 0.85 acre of native grassland will be planted on a north-facing slope within Fuel Modification Zone 1, adjacent to existing native grasslands. This area will be protected from grazing or cutting by temporary fencing for a period of five (5) years.

   b. In addition, in both Fuel Modification Zones, cutting of native grass and wildflowers may be delayed until after seed set if the Fire Department concurs that these plants do not constitute a means of rapidly transmitting fire to any structure.

3. In the areas where trees have been established,
   a. Clear leaves, bark, and humus under trees and shrubs (including vines and semi-woody species). At no time should a buildup of leaves and humus exceed 1 inch in depth anywhere in a landscaped area. However, do not expose bare earth in over 50% of the site.
   b. Remove dead material that drapes over ground cover (including leaves, bark, and branches).
   c. From mature trees, remove all vines, loose papery bark, dead branches, and live branches smaller than 3 inches in diameter to a height of 8 feet above the ground.

d. Remove all dead branches from within live ground covers, vines, shrubs (including semi-woody species), and immature trees.

e. Remove all eucalyptus trees smaller than eight inches in diameter.

f. Prune trees and large tree-form shrubs (e.g. oaks, toyon) that are being retained to provide clearance of three times the height of the understory plant material, or 8 feet, whichever is higher.

g. Prune limbs that are smaller than 3 inches in diameter up to 8 feet above the ground; in young trees, prune these branches from the lower one-third of the height of the tree. (Thus, if a tree is 10 feet tall, prune the lower 3–4 feet and keep the understory plant material to less than 1 ft in height. Then as it grows to 24 feet in height, it can achieve the 8-foot distance from the ground, and the understory plant material can reach 2.5 feet in height.)

h. Do not thin the tree canopy, because these actions promote growth of more flammable vegetation.

i. Chipped materials can remain on the site provided the mulch layer is no greater than 2 inches in depth.

4. Do not locate plants that are replacing ones that die, or oaks planted as a mitigation measure, under trees. To avoid creating "ladder fuel situations" (in which a fire can climb from one vegetation layer to the next higher one), do not plant shrubs (including vines, semi-woody species, and all chaparral species) under trees.

5. Treat the areas within 30 feet of picnic tables and 10 feet of any barbeque spaces per the standards for the Residential Defensible Space/Landscaping Zone. This includes mowing grass and removing lower tree branches.

STANDARDS FOR RIPARIAN ZONE

In the Riparian Zone, special care should be taken not to trample riparian vegetation or alter the creek alignment or the creek or stockpond banks. Hand labor (or flash grazing and/or other fuel management methods if authorized by CDFW) must be used to treat fuels within the Riparian Zone.

Treatments for fire safety in the Riparian Zone are also limited by concerns for wildlife habitat. Fire management treatments that concentrate on dead material can enhance fire safety without compromising wildlife habitat.

The following actions are to be taken in the Riparian Zone:

1. Train all personnel conducting fuel management in the Riparian Zone in identification of and avoidance of impacts to California red-legged frog, and in identification of native grasses and wildflowers.
2. Remove dead vegetation, vines, and dry fuels such as dead lower branches of trees.
3. Remove all invasive alien plants such as French broom, yellow star thistle, and Italian thistle.
4. Living trees and shrubs may not be removed or pruned except as needed for trails, barbecue spaces and pedestrian bridges.
5. Treat the areas within 10 feet of any barbeque spaces per the standards for the Residential Defensible Space/Landscaping Zone. This includes mowing grass and removing lower tree branches.

FIRE-RESISTANT LANDSCAPING

Many communities are promoting the use of fire-safe plants and implementing projects to demonstrate techniques for reducing fire risk to structures. Although there have been relatively few research results on the fire resistance of landscape plants, we can provide several important generalities. First, the spacing and design of the garden is more critical than the species planted. Leaving horizontal spaces between planting masses, specimen trees, and the house helps create a fire-safe landscape. Similarly, leaving vertical spaces between tree branches, shrubs, ground cover, and the structure (particularly windows) is important in designing a fire-safe garden.

Second, good maintenance of landscaped areas requires removing dead material and maintaining the vertical and horizontal spaces that create a fire-safe design. The significance of proper plant and landscape maintenance cannot be overemphasized. Design landscapes to discourage the creation of "fuel ladders"—a continuous fuel path by which a fire can climb from the ground to a shrub, to a tree, and ultimately to the structure. Continuous removal of any potential fuel ladders needs to be part of routine landscape maintenance. *Poorly maintained landscapes can easily become fire hazards, even if many of the plants are favorably recommended for fire performance.*

Third, desirable landscaping plant species have a low fuel volume and high foliar moisture and do not have a tendency to produce and "hold" dead wood. They also have a proper growth form: for example, ground covers or fruit trees (which inherently have adequate vertical spacing or branches).

Some common landscape species are explosive and can exhibit dramatic fire behavior. For example, a juniper that is 6 sq ft in area can produce flames over 15 ft in length. Appendix A of this report contains a list of such prohibited plants.

Factors that must be considered in rating the fire performance of plants include:

- *Total volume*. The greater the volume of plant material (potential fuel) present, the greater the fire hazard.
- *Moisture content*. The moisture content of plants is an important consideration; high levels of plant moisture can both lower fire risk and act as a heat sink if a fire occurs, reducing its intensity and spread.
- *Amount and distribution of dead material*. The amount of dead material in a given plant influences the total amount of water in the overall plant; the dead material is usually much drier than living tissue. Whereas dead material rarely has a moisture content higher than 25%, live foliage moisture content ranges from 60 to 80% for chaparral species in xeric conditions to a high of 200 to 400% for succulent plants or plants under irrigation.
- *Size of leaves, twigs, and branches*. Materials with large surface areas (such as needles, twigs, or large flat leaves) dry more rapidly under fire conditions than materials with lower surface ratios (such as branches and fleshy leaves).
- *Geometry and arrangement of the plant (overall spatial distribution of the biomass).* The shape of a plant and the way in which the biomass is distributed throughout the plant is important because this bulk density affects the air flow and heat transfer through the plant. The arrangement of material within the plant affects its fuel continuity and its tendency to undergo preheating and promote fire spread.

All of the above-mentioned plant characteristics are related to maintenance issues. Plants with a higher moisture content generally have a lower fire risk. For example, the moisture content of a plant is absolutely influenced by regular and proper irrigation, and large amounts of dead material lower the plant's overall moisture content. To increase the plant's overall moisture content, it is important to remove and properly dispose of dead material. In addition, regular fire-prevention maintenance should include thinning or pruning to reduce fuel volume and improve plant geometry.

An appropriately landscaped and maintained defensible space will reduce the fire hazard and the fire risk to structures. A landscape environment that is inconsistently or improperly maintained does not function as defensible space, and it contributes to the fire hazard. Consult a nursery or landscape professional for their recommendations on plant spacing, pruning, aeration, fertilization, irrigation, and other cultivation practices.

PREDICTED FIRE BEHAVIOR WITH FIRE MANAGEMENT MEASURES IN PLACE

SITE-SPECIFIC HAZARD ASSESSMENT

Once the fire-management measures have been implemented on the site, fire behavior in the area within 100 feet of structures should exhibit less than 2-foot flame lengths. Flame lengths of less than 2 feet typically do not threaten structure survival. Also, because available fuels will either be kept mowed or will be compact in nature, any ignited fire(s) should travel only at easily containable speeds.

Flame lengths produced further away than 100 feet from a structure would be slightly greater but crowning and torching of trees is minimized; fires are expected to quickly subside in intensity in the Defensible Space/Landscape Zone. Where fuel management is limited (i.e. in riparian zone) flame length may exceed two feet.

Structures are minimally exposed to ignition from embers because of a band of non-combustible materials immediately next to the structure and landscaping of low fuel volume. Embers that land within 100 feet of structures will not be apt to ignite or carry fire with intensity that can damage a structure.

V. REQUIREMENTS FOR STRUCTURES TO INCREASE IGNITION RESISTANCE

The City of Petaluma has adopted a rigorous set of codes that bolster ignition resistance of structures through the design and material used in construction. The following measures are not required by code, but could be considered best practices within the industry.

VENTS

Structures will include vents such as Vulcan vents https://www.vulcanvents.com), or Branguard vents (https://www.brandguardvents.com/index.php or which use 1/8-inch mesh metal screens and 26 ga G90 galvanized steel to block flying embers from entering structures.

FENCES

Backyard fences will be constructed of either noncombustible material or of timbers with a minimum of one-inch nominal thickness. Side fences may be of one-inch nominal thickness. Typical back yard fencing might include "view fencing", consisting of open wire-mesh with four-inch posts and bottom rails of two-inch minimum thickness. There should be a noncombustible space of a minimum of 5 feet between the structure and any wooden fence members..

ACCESSORY BUILDINGS

GARDEN STRUCTURES

Garden structures, such as gazebos, spas, or other outbuildings – will meet the same minimum standard for materials, timber size, and other requirements as described above for other structures and fences.

BUILT-IN FIREPLACES

Built-in fireplaces will be either no farther than 15 ft from a water source or be equipped with a fire extinguisher. All associated chimneys will be fitted with a spark arrestor.

BARBECUES

Barbecues (built-in or portable) must be surrounded by at least 10 ft radius of noncombustible materials and be located 10 ft away from all overhanging structures or trees. Barbeques must not be left unattended when in use. No structures or trees should overhang the use area within a distance of 10 ft. The barbeque should be located no farther than 15 ft from a water source (including a garden hose). Vegetation will otherwise be consistent with the requirements of the Zone in which the barbecue is located.

VI FUEL MANAGEMENT RESPONSIBILITIES

Fuel management and structure maintenance in the Residential Defensible Space Zone will be the responsibility of the individual landowner, enforced through covenants, codes and restrictions (CC&Rs) and, to the extent mandated by law, the Petaluma Fire Department.

The homeowners association (HOA) will be responsible for fuel management on HOA-owned property (Parcels A, C, D, E, F and H as shown on Figure 2), which comprises all of the Open Space Defensible Space Zone other than the portion of Zone 4 described below.

The land that will be owned by Sonoma County Regional Parks (Parcel B on Figure 2) will be the responsibility of that organization except that the HOA will be responsible for mowing grass in the portion of Area 4, shown on Figure 6, that will ultimately be owned by the Sonoma County Regional Parks. KCPP (a project of Earth Island Institute) will be responsible for continuing existing grazing until the parkland is transferred to Sonoma County Regional Parks.

The HOA will also be responsible for maintaining the Roadside Fuel Management Zone along A and B Streets. Where portions of residential parcels fall within the Roadside Fuel Management Zone, CC&Rs shall require homeowners to maintain the Roadside Fuel Management zone and shall empower the HOA to enforce such maintenance obligations.

SCHEDULE OF INITIAL MAINTENANCE RESPONSIBILITIES AND VEGETATION MANAGEMENT

Upon fire department clearance for issuance of building permits the fuel management standards will apply to the lot encompassed by the building permit. Roadside standards will be enforced at the time the first parcel is sold.

INITIAL TREATMENT (YEAR 1)

- KCPP project will be responsible for continuing existing grazing until the parkland is transferred to Sonoma County Regional Parks.
- Davidon Homes will be responsible for management responsibilities within Area 4.
- Initial vegetation management actions for any lot will be completed before framing of the first parcel begins (if framing takes place between June 1 and Nov. 1). These actions include tree removal, tree pruning, and grass cutting or grazing.
- The Homeowners Association is responsible to ensure fuel management is completed within 100-ft of the building under construction, regardless of land ownership.

MAINTENANCE PHASE

- All required clearing and grass cutting will be completed before June 1 of each year.
- No clippings are permitted to remain in piles or scattered. All brush piles and tree clippings are to be removed within one week of cutting. No brush or clippings are permitted to remain in piles.
- Annual vegetation management measures include:
  - Removal of all combustible vegetation along roadways, driveways, access roads, and trails according to stated standards
  - Maintenance of the emergency-access easement
  - Maintenance of the defensible space around structures according to stated standards for the various fuel management zones.

FREQUENCY OF MAINTENANCE

GRASS

Grass will need to be grazed or mowed annually to a height of four inches or less in all zones other than the Riparian Zone. This will occur when 30% of the grass cover has cured (any time from April 15 - June 1). Should rains occur late in the season and produce more grass growth, the grass may need to be treated again by mowing or grazing.

SHRUBS AND SEEDLINGS

The expected frequency of treatment of shrubs and removal of seedlings below the canopy of landscaping trees is estimated as every three years to five years. Shrubs may need to be pruned of dead wood or shortened, shrub groupings minimized in size, or new shrubs/ tree seedlings removed under tree canopies. Shrub removal or pruning may be done any time of year.

Application of an herbicide to prevent re-sprouting may be more effective in the spring, but will follow the licensed Pest Control Advisor (PCA) recommendation.

TREES

Because trees typically grow from the top and ends of branches, subsequent pruning needs to occur only every five years to ten years, depending on the rate of growth, and significant events which may cause dead wood to develop or breakage to occur. Pruning of landscape trees and tree-like shrubs can be done at any time of the year, depending on recommendations from a professional arborist.

SUMMARY OF FREQUENCY OF FUEL MANAGEMENT

Actions to create defensible space will take place in Parcel A, the residential portion of the project (both Residential Defensible Space/Landscape Zone and Open Space Defensible Space Zone) as soon as construction begins. The successive owners of Parcel B (Davidon Homes, then Earth Island Institute, then Sonoma County Regional Parks) will maintain current grazing practices until Sonoma County Regional Parks opens any portion of Parcel B to the general public, at which point fuel standards set forth in this plan will be achieved and maintained on Parcel B.

Management that will start as an initial treatment in Year 1, then occur every 3 - 5 years

- Remove new understory shrubs and eucalyptus seedlings
- Remove dead wood and branches from mature trees
- Prune trees of lower branches to re-establish vertical clearance

A rotation of pruning may be scheduled so that approximately one-third to one-fifth of the area is treated yearly.

Annual management

- Mow or graze grass near structures, and under trees and shrubs
- Hand crew cut or graze shrubs and weeds in grasslands
- Monitor site for weed and shrub encroachment, maintain horizontal spacings between shrub masses in landscaped areas
- Inspect trees and large shrubs for deadwood, vertical clearances
- Re-establish vertical clearance required for each zone
- Remove weeds, all dead material

PROCESS FOR PLAN UPDATES

While this plan presents recommendations that cover future actions, for the residential portion of the project, the Petaluma Fire Department will have authority to review periodically the condition of vegetative fuel, in order to provide input and direction. Potential issues that should be addressed during this review include:

- Changed fuel hazard conditions including: height of tree branches, size, density or species of vegetation, or fuel load and erosion control or slope stability conditions.
- Lot line adjustments that may change the distances and areas for which the Property Owner is responsible.
- Changes in land use of adjacent properties.

An initial three-year interval of review is recommended, with a five-year interval review thereafter. For example, if the expansion of shrub cover warrants additional action, this process provides for revisions of required maintenance options. Input of the Fire Department would be based on site visits, results and observations from the annual inspections conducted by the Department and experiences from recent wildfires or changes in ordinances or regulations.

If any changes are proposed, the Homeowners Association will submit this plan, along with suggested revisions to the Petaluma Fire Department for their input. The fire district input will be incorporated, and the plan revised. The revised plan would be implemented the following year.

For the Putnam Park Extension portion of the project, Sonoma County Regional Parks will be responsible for Plan updates.

VII RESULTS OF PROJECT IMPLEMENTATION WITH VEGETATION MANAGEMENT

Appendix A provides the results of fire behavior modeling for the project site. The modeling addresses three different fire scenarios: 1) a fire beginning to the southwest of the project site, near the main entrance of Helen Putnam Regional Park, on an August day with a southwesterly wind blowing toward the project site; 2) a fire beginning immediately to the northeast of the project site on an October day with northeasterly Diablo winds blowing toward the project site and with normal moisture in on-site riparian vegetation; and 3) a fire beginning immediately to the northeast of the project site on an October day with northeasterly Diablo winds blowing toward the project site, but with on-site riparian vegetation dried by drought.

For all three scenarios, the proposed project with the Fuel Management Plan shows improved fire conditions compared to the same scenarios under existing conditions. Modeling of fire growth shows a modest improvement for the first scenario (15,683 vs. 16,337 acres burned in 9 hours assuming no fire suppression activity); good improvement for the second scenario (174 vs. 225 acres burned in 9 hours assuming no fire suppression activity); and excellent improvement for the third scenario (193 vs. 4,833 acres burned in 9 hours assuming no fire suppression activity). Given the conversion of grasslands to residences, the improved conditions would also occur if grazing continues within the Putnam Park Extension portion of the project but the other vegetation management measures are not implemented within the park portion until the Putnam Park Extension is open to the public.

IX – APPENDICES

I. APPENDICES

a. Appendix A: Technical Report; Fire Behavior and Evacuation Scenarios for Scott Ranch
b. Appendix B: Fire-Resistant Plants and Prohibited Species
c. Appendix C: The Relationship Between trail use, Campfires and Stoves and Wildfire Risk

APPENDIX A
TECHNICAL REPORT

Fire Behavior and Evacuation Scenarios for Scott Ranch

Report prepared for:
Wildland Res Mgt – Davidon Homes

Report prepared by:
Digital Mapping Solutions
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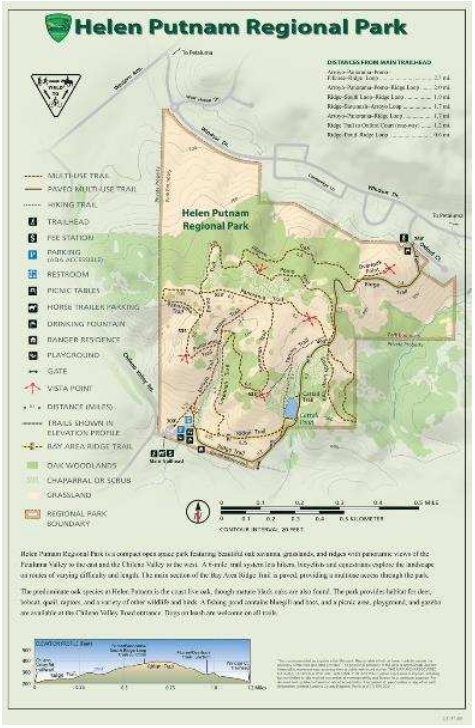
530-386-2368 ~ mandeno@digitalmappingsolutions.com

Abstract

This technical report describes the data used to predict fire behavior on Scott Ranch, a proposed development west of Petaluma in Sonoma County. It also details the methods used to derive impacts to evacuation planning for the area in an event of a fire.

Two main fire behavior scenarios are shown; one with a fire starting just Northeast of the proposed subdivision and another starting within Helen Putnam Regional Park (county owned and maintained), southwest of the proposed development. In addition, each scenario shows results from two different fire behavior prediction systems (FARSITE and FlamMap).

No recommendations for management activity or evacuations are presented in this technical document. Refer to the Vegetation Management Plan for recommended actions regarding fuel treatments.



3.0 Contents

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Purpose

This fire behavior analysis was conducted to determine fire hazard onsite and in the surrounding area under current conditions and then with the proposed project at Scott Ranch in place, with the expectation that it will be used to prepare the vegetation management plan for the project.

Methods

For this project, we used readily available, public data provided to us by Sonoma Veg. This included a newly derived landscape file that has fuel models based on the latest vegetation mapping in Sonoma County. In addition, we compiled weather data from a nearby RAWS station to reflect conditions that may occur in Diablo wind events such as what occurred during the Kincade Fire of 2019 and the Tubbs Fire in 2017. In addition, we modeled a scenario from the southwest, which better represents summertime conditions in this region. For all scenarios, a fairly dry fuel moisture regime was used to model a "worst-case" scenario. While climate change and other factors could create more extreme cases, such conditions cannot be accurately predicted or modelled..

To predict fire behavior, three essential data categories are needed:

1. Fuel model characteristics
2. Weather conditions
3. Fuel moisture conditions

A summary of each used in this modeling effort is presented below.

Data

1 Vegetation/Fuel Model

In 2019, Tukman Geospatial along with Wildland Res Mgt. and Digital Mapping Solutions derived a crosswalk from the 2014 Sonoma County vegetation classification to fuel models described in the technical report: *Standard Fire Behavior Fuel Models: A Comprehensive Set for Use with Rothermel's Surface Fire Spread Model* (Scott & Burgan, 2005).

This effort resulted in a high-resolution (5 meter) county-wide fuel model layer along with all other layers needed to create a landscape file that could be used in fire behavior prediction software such as FlamMap (which currently includes modeling software for one-time fire predictions and fire growth predictions).

The vegetation found on Scott Ranch is primarily grasslands. A riparian area adjacent to Kelly Creek running from west to east bisects the lower portion fo the property and consists primarily of Coast live oak (*Quercus agrifolia*) and Valley oak (*Quercus lobata*). There is a 1.75-acre patch of Eucalyptus near D Street at the eastern portion of the riparian area (shown in bright green in Figure 1).

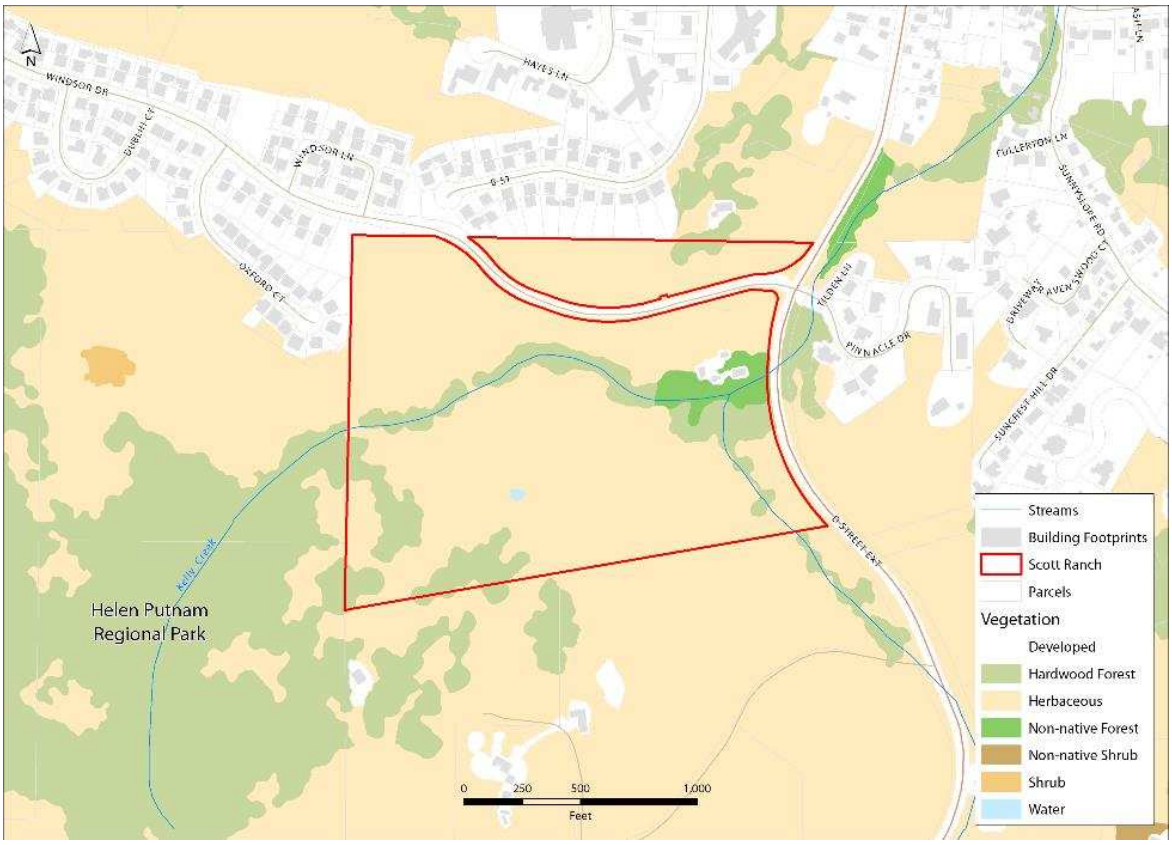


FIGURE 1 - VEGETATION MAP BY MAJOR LIFE FORM (FOREST) (SONOMA VEG MAP, 2015).

Figure 1 shows the broad categories (or lifeforms) for forest vegetation. Vegetation map classification, which identifies dominant tree species, is provided in Figure 2 (next page).

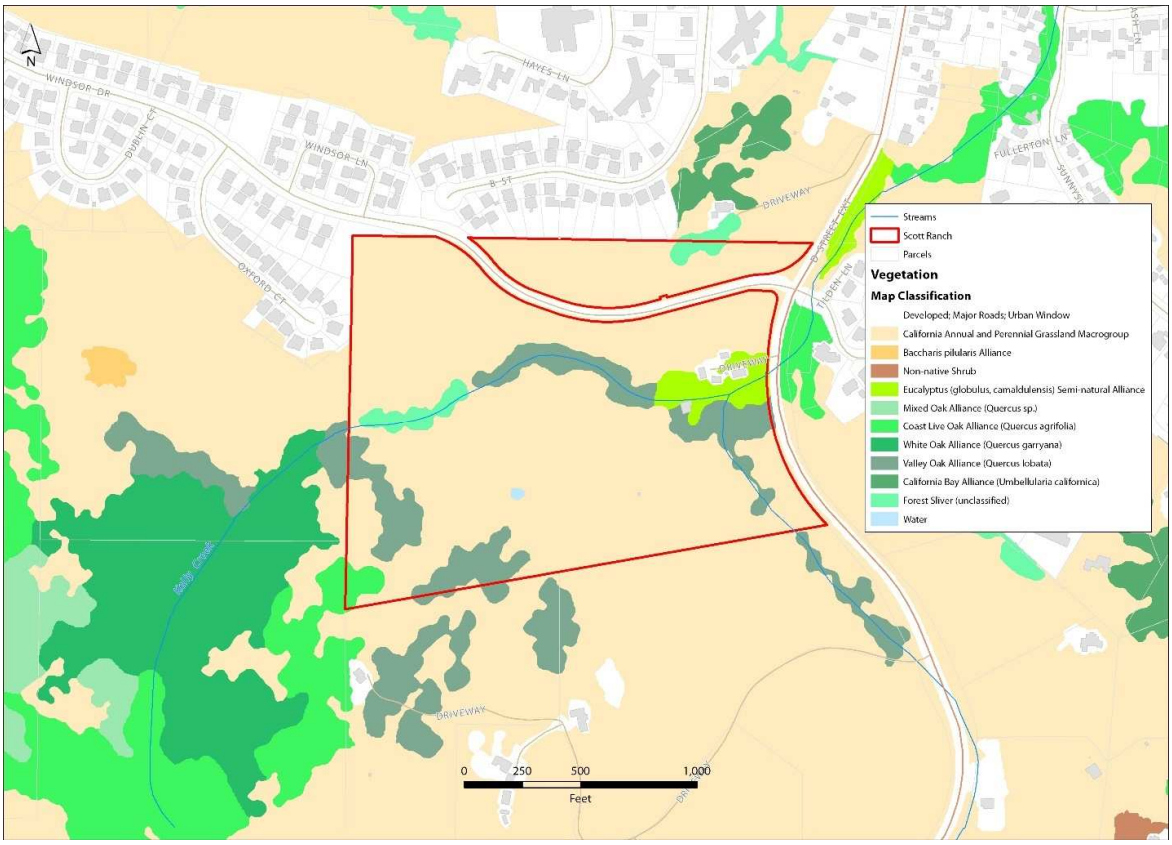


FIGURE 2 - VEGETATION MAP BY MAP CLASSIFICATION (DOMINATE SPECIES) (SONOMA VEG MAP, 2015).

Vegetation Type	Acres	Percent
Hardwood Forest	**8.5**	**14%**
Quercus agrifolia Alliance	0.491	
Quercus lobata Alliance	6.758	
Forest Sliver	1.258	
Herbaceous	**48.1**	**82%**
California Annual and Perennial Grassland Macrogroup	48.1	
Non-native Forest	**1.8**	**3%**
Eucalyptus (globulus, camaldulensis) Semi-natural Alliance	1.8	
Water	**0.1**	**0.1%**
Non-Vegetation	**0.4**	**1%**
Developed	0.407	
Major Roads	0.002	
Urban Window	0.039	
Total Acres	***58.9***	

TABLE 1 – ACRES BY VEGETATION TYPE AND VEGETATION MAP CLASSIFICATION FOR THE SCOTT RANCH PROPERTY.

All vegetation types extend outside the property boundary. To the south and west of the property, the hardwood forests become more extensive and varied within Helen Putnum Regional Park.

These vegetation types determine the fuel models on site. These include a grass fuel type (GR2 - low load, dry climate grass primarily with some small amounts of fine, dead fuel, and shrubs that do not affect fire behavior), which is the predominant fuel. This fuel type occurs throughout the property, particularly within the entirety of the proposed residential areas and throughout the portion of the property south of Windsor Drive.

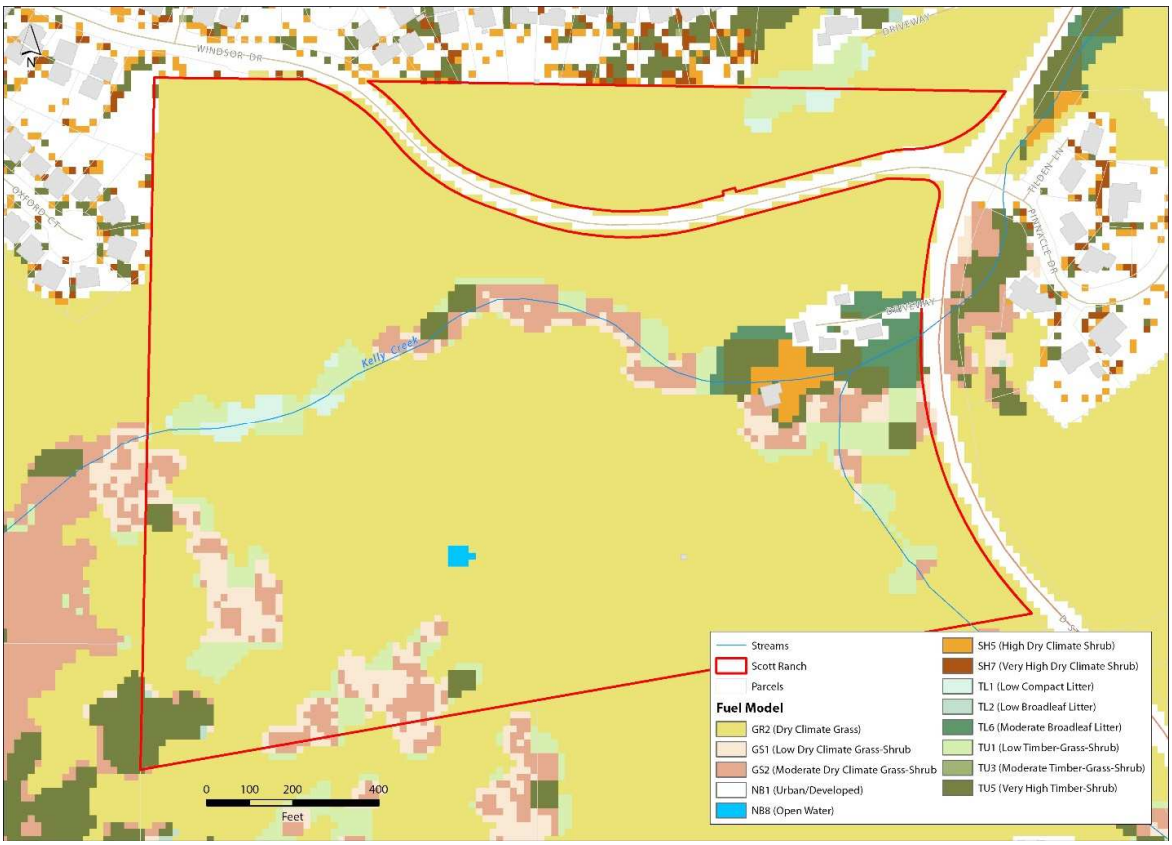


FIGURE 3 - FUEL MODEL/TYPE (TUKMAN, RICE, MANDENO, 2019)

Two grass-shrub fuel types (GS1 and GS2) are located along Kelly Creek and a tributary that runs south to north along the eastern boundary of the lower portion of the property. In addition, there are patches of GS1 and GS2 within the southwestern corner of the property. These fuel types can be associated with taller flame lengths and the potential to cast embers (though not as significant a source of embers as the shrub types described below).

One shrub fuel type (SH5) is present on the property. This exists surrounding one of the existing structures in the southern portion of the property. This is presumably a consequence of overgrown landscaping surrounding the structures. This shrub type is associated with high flame lengths and often generates embers that can cast off quite a distance from the main front of a fire.

Three forest fuel types (TL1, TL2 and TL6) are also found within Scott Ranch. These fuel types are found primarily along Kelly Creek and in patches to the north and south. TL1 is predominately located on the banks of Kelly Creek in the western portion of the property (south of Windsor Drive) and in small patches in the northeast of the property north of Windsor Drive and just east of the proposed residential lots. TL2 is located in two small patches at the edge of a large patch of TU5 (described below). TL6 represents the non-native Eucalyptus grove surrounding the existing structures on the southern portion of the property. These timber (or forest) types represent treed areas where the fire is carried by the forest litter under the tree canopy. The timber type fuel models describe hardwood forests even though no conifers exist in the project area. TL1 and TL2 are associated with low to moderate fire behavior and represent ideal conditions for fire resiliency. However, TL6, because of its higher fuel load and relatively tall tree height coupled with a low canopy base height can be associated with a high likelihood for a source of embers.

Finally, there are two forest/shrub fuel types (TU1 and TU5). These fuel types represent forested areas with a grass or shrub understory. These timber types represent treed areas with a shrubby understory where the fire is carried by grass and shrubs under the tree canopy rather than forest litter. The timber/forest type fuel models describe hardwood forests. TU1 is found in patches along Kelly Creek and its tributary, and also surrounds the patches of GS1 and GS2 to the south. In addition, it can be found along with TL1 north of Windsor Drive just east of the proposed residential lots. A large patch of TU5 is found at the very southwest corner of the property in addition to surrounding the existing structures and along Kelly Creek. This fuel type can be associated with torching trees or crown fires because of its propensity to lead fires into the crown due to the abundant and relatively tall understory fuels.

Table 2 lists all fuel model types found within Scott Ranch along with their associated acreage.

Value	FBFM40	Title	Description	Acres	Percent
91	NB1	Urban/Developed	Urban/Developed	0.5	0.9%
98	NB8	Open Water	Water	0.1	0.1%
102	GR2	Low Load, Dry Climate Grass	Low load, dry climate grass primarily grass with some small amounts of fine, dead fuel, any shrubs do not affect fire behavior	48.0	81.7%
121	GS1	Low Load, Dry Climate Grass-Shrub	Low load, dry climate grass-shrub shrub about 1 foot high, grass load low, spread rate moderate and flame length low	2.0	3.4%
122	GS2	Moderate Load, Dry Climate Grass-Shrub	Moderate load, dry climate grass-shrub, shrubs are 1-3 feet high, grass load moderate, spread rate high, and flame length is moderate	2.3	3.8%
145	SH5	High Load, Dry Climate Shrub	High load, dry climate shrub and shrub-litter, heavy load with depth	0.4	0.6%

Value	FBFM40	Title	Description	Acres	Percent
			greater than 2 feet, spread rate and flame very high		
161	TU1	Low Load Dry Climate Timber-Grass-Shrub	Low load dry climate timber grass shrub, low load of grass and/or shrub with litter, spread rate and flame low	2.8	4.7%
165	TU5	Very High Load, Dry Climate Timber-Shrub	Very high load, dry climate shrub, heavy forest litter with shrub or small tree understory, spread rate and flame moderate	1.6	2.8%
181	TL1	Low Load Compact Conifer Litter	Low load compact forest litter, light to moderate load, 1-2 inches deep, may represent a recent burn, spread rate and flame low	0.5	0.8%
182	TL2	Low Load Broadleaf Litter	Low load broadleaf litter, broadleaf, hardwood litter, spread rate and flame low	0.02	0.03%
186	TL6	Moderate Load Broadleaf Litter	Moderate load broadleaf litter, spread rate and flame moderate	0.7	1.2%

TABLE 2 – FUEL MODEL TYPES AND ACRES WITHIN SCOTT RANCH PROPERTY.

2 Weather

The Remote Automatic Weather Stations (RAWS) system is a network of automated weather stations run by the U.S. Forest Service (USFS) and Bureau of Land Management (BLM) and monitored by the National Interagency Fire Center (NIFC), mainly to observe potential wildfire conditions (Wikipedia, 2017).

RAWS stations are often located in remote areas away from the localized influence of cities and anthropogenic activities. They record weather conditions that better reflect the conditions that wildland vegetation would experience. In addition, many RAWS stations are equipped with fuel moisture sticks to manually or automatically record actual 10-hr fuel moisture. Fuel moisture is critical to predicting fire behavior. Because of this, RAWS data is preferred over any other weather station data.

The nearest RAWS stations to Scott Ranch in Petaluma is the Novato Fire – Robinhood station ID NVHC1. Even though it is closer to the San Francisco Bay, this RAWS station is representative of the vegetation and topography found on Scott Ranch.

The station is operated by the Bureau of Land Management and the Novato Fire District in Marin County. The map below shows the RAWS weather station location in relation to the project site.

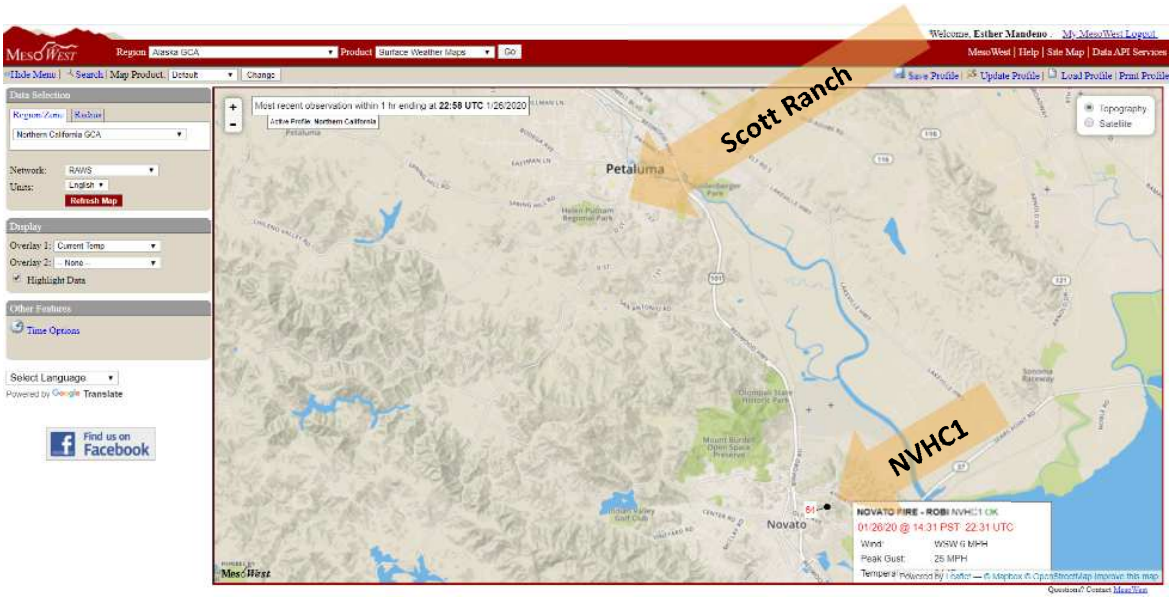


FIGURE 4 - MAP SHOWING NVHC1 IN RELATION TO SCOTT RANCH (SCREEN SHOT CAPTURED ON 01/26/2020 ON THE MESOWEST.UTAH.EDU WEBSITE)

Weather Data Summary for Novato Fire – Robinhood (NVHC1)

Novato Fire – Robinhood (NVHC1) is located at latitude 38.112500, longitude -122.549806 on the top of Cherry Ridge just east of Novato at 482 feet in elevation. This elevation is similar to the elevations found on Scott Ranch (elevation range from 100 to 380 feet). The 2019 total

precipitation reached 37.3 inches. This compares with a range of rainfall from 2017 to 2019 of 25 to 32 inches, as observed at a weather station in Eastern Petaluma[2]. The weather station sits on a flat span along a relatively exposed site near two water tanks. The site surrounding the weather station is best characterized by oak woodlands. Weather observations downloaded include the month of August and the month of October of 2019. Readings are consistently recorded on a half-hour basis.

Because of the egress/ingress pattern on the Scott Ranch site, two weather/ignition scenarios were initially proposed by Carol Rice, the Senior Fire Ecologist on this project. The weather/ignition scenarios requested were:

1. Weather dominated by a southwest wind – the predominant wind direction throughout the year – and
2. Weather dominated by a northeast wind or Diablo Winds – the predominate wind direction during which the area experiences large, devastating fires like the Kincade Fire of 2019.

Based on these criteria, weather derived from actual weather measurements at NVHC1 from August of 2019 were chosen to represent the southwest scenario and observations from October 2019, during the Kincade Fire, were chosen to represent the northeast scenario.

Below is a monthly summary of weather parameters reported on NVHC1. Note the low relative humidity recorded for both August and October in 2019.

	Mean Wind Speed	Mean Wind Direction	Maximum Wind Gust	Average Air Temperature					Average Relative Humidity			Ppt.
Date	mph	Deg	mph	Deg F					%			in
mm/yyyy	Ave.	Vector Ave.	Max.	Ave.	Ave. Daily Max.	Max.	Ave. Daily Min.	Min.	Ave.	Max.	Min.	Total
Jan-19	4.571	144.9	59	51.6	58.26	65	46.81	39	83.4	100	18	6.91
Feb-19	5.827	225.8	56	47.3	54.96	61	41.5	33	82.4	100	23	12.4
Mar-19	4.499	229	47	53.1	63.13	73	45.87	40	77.6	100	26	4.13
Apr-19	3.832	249.4	29	59	72.47	90	49.83	45	73.8	100	23	0.38
May-19	4.074	251.3	36	57.7	71.97	83	49.06	45	77.9	100	25	2.56
Jun-19	3.642	267.7	29	67.4	85.63	104	54.57	49	61.7	100	10	0
Jul-19	3.897	260.5	35	66.7	86.1	102	53.81	50	67.4	100	10	0
Aug-19	3.748	256	31	69.6	88.94	103	57.1	52	67	100	16	0
Sep-19	4.035	250.1	37	69	85.93	101	58.17	49	58.9	100	13	0.02
Oct-19	4.161	260.5	47	64.5	78.97	90	53.84	42	40.6	100	5	0
Nov-19	3.013	236.8	37	55.8	68.43	78	47.47	34	66.2	100	14	1.59

[2] http://cesonoma.ucanr.edu/about/weather/?weather=station&station=144

Dec-19	4.589	131.7	44	50.6	56.29	65	46.26	38	88.3	100	27	9.28

TABLE 3 – MONTHLY SUMMARY OF 2019 WEATHER RECORDED AT NVHC1 (WESTERN REGIONAL CLIMATE CENTER WEBSITE, ACCESSED ON 01/26/2020).

It is important to note that the predominate wind direction in the area is from the southwest. Figure 4 below shows that for the entirety of 2019, winds from the WSW occurred 14% of the time between 4-8 mph. This was the most common wind direction and speed.

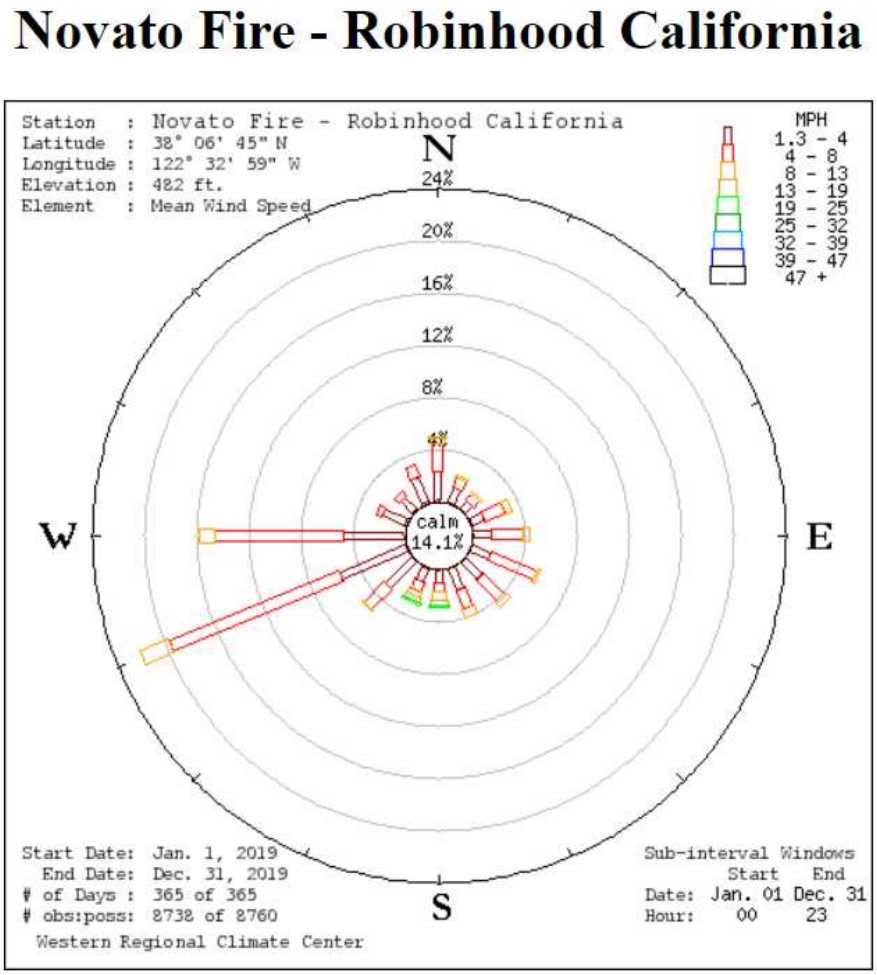


FIGURE 5 - WIND ROSE WIND SPEED AND DIRECTION AVERAGED ACROSS ALL OF 2019 FOR NVHC1 (WESTERN REGIONAL CLIMATE CENTER, 01/26/2020).

For the month of August, 2019, the predominate wind speed and direction were again from the WSW between 4 – 13 mph.

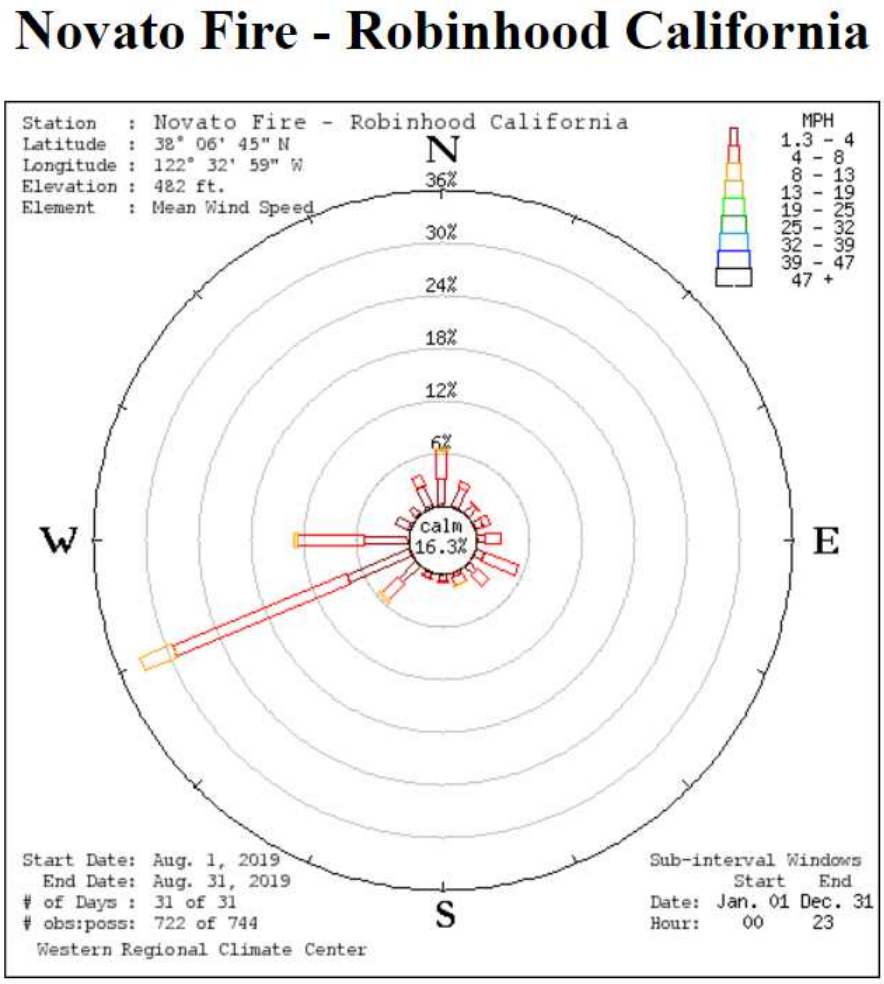


FIGURE 6 - WIND ROSE SHOWING WIND SPEED AND DIRECTION FOR AUGUST, 2019 AT NVHC1 (WESTERN REGIONAL CLIMATE CENTER, 01/26/2020).

For the month of October, 2019, the predominate wind speed and direction were again from the WSW between 4 – 13 mph, however, high wind speeds from the north and northeast (during the Kincade Fire) notably show up on the wind rose (in green on Figure 7).

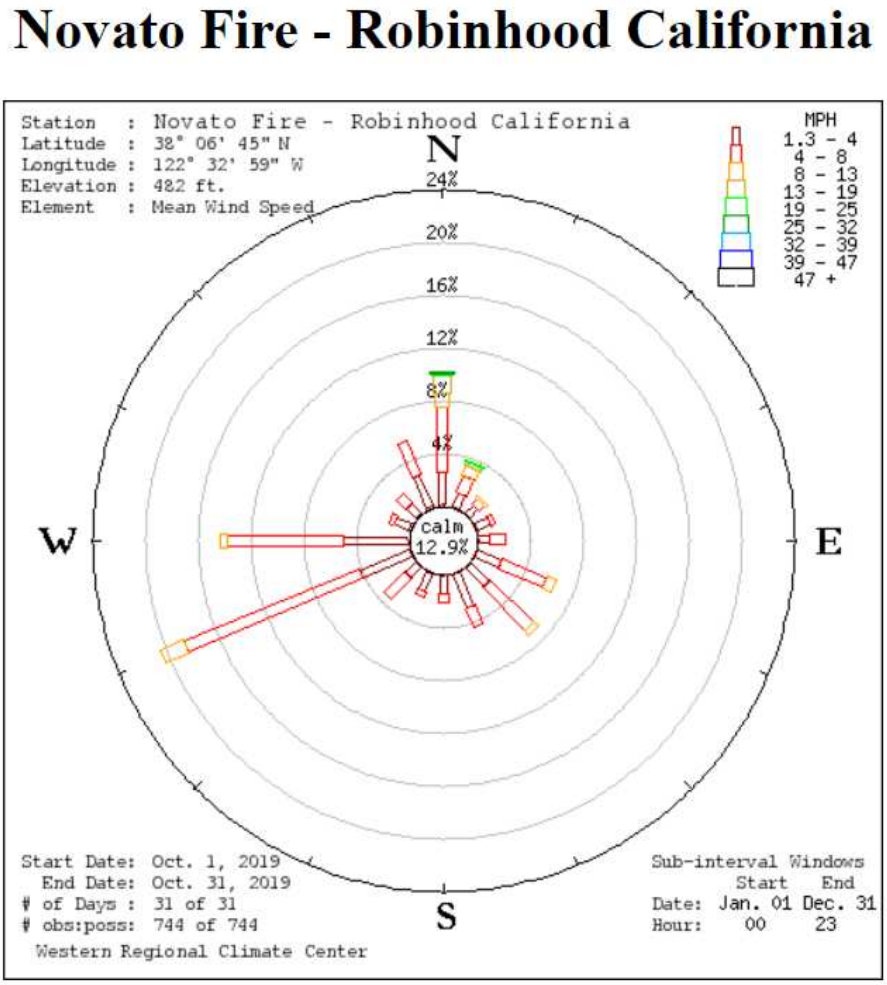


FIGURE 7 – WIND ROSE SHOWING WIND SPEED AND DIRECTION FOR OCTOBER, 2019 AT NVHC1 (WESTERN REGIONAL CLIMATE CENTER, 01/26/2020).

Weather data from these two months were reviewed and analyzed to find a week's worth of weather data in each month (August and October) that best represented the conditions we wanted to model for fire behavior. Table 4 and 5 summarizes the data used for each scenario.

Date	Ave. Mean Wind Speed mph	Ave. Mean Wind Direction Deg	Max. Maximum Wind Gust mph	Ave. Average Temp. Deg F	Max. Average Temp. Deg F	Min. Average Temp. Deg F	Ave. Average RH %	Max. Average RH %	Min. Average RH %	Total Ppt in
8/22/2019	3.67	246	16	76	98	62	65	95	30	0
8/23/2019	2.58	63	20	71.4	91	58	65	92	35	0
8/24/2019	2.75	318	16	69.2	93	56	71	96	31	0
8/25/2019	2.96	323	16	70.8	99	54	66	100	16	0
8/26/2019	3.58	344	16	69.8	96	52	63	100	17	0
8/27/2019	3.08	333	16	68.7	95	54	67	96	17	0
8/28/2019	4.04	259	21	67.3	82	57	75	96	47	0

TABLE 4 – WEEK CHOSEN IN AUGUST, 2019 FOR FIRE BEHAVIOR MODELING ON SCOTT RANCH (WESTERN REGIONAL CLIMATE CENTER WEBSITE, ACCESSED ON 01/26/2020).

Date	Ave. Mean Wind Speed mph	Ave. Mean Wind Direction Deg	Max. Maximum Wind Gust mph	Ave. Average Temp. Deg F	Max. Average Temp. Deg F	Min. Average Temp. Deg F	Ave. Average RH %	Max. Average RH %	Min. Average RH %	Total Ppt in
10/21/2019	3.62	265	13	72.3	90	58	44	70	19	0
10/22/2019	3.04	343	10	73.4	87	61	39	61	25	0
10/23/2019	3.58	328	22	76	87	62	30	58	8	0
10/24/2019	6.25	119	24	78.5	88	71	13	19	9	0
10/25/2019	3	126	17	75.5	87	67	17	25	12	0
10/26/2019	2.83	17	10	67.6	83	56	40	75	15	0
10/27/2019	13.33	6	47	61.6	68	54	20	85	11	0

TABLE 5 – WEEK CHOSEN IN OCTOBER, 2019 FOR FIRE BEHAVIOR MODELING ON SCOTT RANCH (WESTERN REGIONAL CLIMATE CENTER WEBSITE, ACCESSED ON 01/26/2020).

In summary, for the periods reviewed in 2019, the months of June, July, August, September, and October experienced the highest temperatures with the lowest relative humidity (from 90 to 104 degrees and 5 to 16 percent). The most consistent southwest winds coincided with the hottest days in August and the strongest northeast winds coincided with the lowest relative humidity (5%).

Although summer time winds were consistent, the strongest (or fastest) wind speeds were recorded during the winter months of January and February. However, due to the lower temperatures and higher relative humidity, these strong winds due to storm systems were not taken into consideration in this analysis.

Highest temperatures are normally recorded between June and August and are associated with weak to strong winds coming from west and southwest. The month of August was chosen because seasonal fuel moistures would be lower than in June or July. Along with increased temperatures and low humidity, this potentially created a higher fire hazard we were interested in modeling to compare with the northeast conditions summarized below.

Northeasterly winds (typical fire weather conditions) will be especially conducive for transport of embers. The most extreme weather values typically are recorded during Diablo

wind events in October, as was evident in the later part of October, 2019. The driest recorded relative humidity was 5%; the highest recorded temperature was 90° F, and the greatest recorded wind speed was 47 mph. Usually days with recorded relative humidity below 20% are associated with Diablo wind events. Diablo events generally last from 15 to 35 hours. During a Diablo wind event, the wind direction is somewhat sporadic, sometimes even exhibiting a complete reversal for 2-4 hours. The wind speed ramps up slowly - from 1-2 mph up to its maximum speed, and then down again - similar to a bell-shaped curve.

To highlight worst-case conditions, peak (or gust) winds were used throughout all fire prediction scenarios. All data was converted to text file format to be used in the fire behavior prediction software.

3 Fuel Moisture

A standard fuel moisture regime was chosen for both scenarios. This includes using statewide parameters developed by CAL FIRE for fire predictions based on worst-case conditions. However, our fuel moisture file was augmented by the ability to set riparian corridors at a higher fuel moisture regime than the surrounding area. Fuel models flagged as riparian in the newest fuels layer were given higher fuel moistures as indicated in Table 6 below.

Fuel Model	1hr time lag class	10hr time lag class	100 hr time lag class	Live herbaceous fuel moisture	Live woody fuel moisture
All non-riparian models	3	4	5	70	70
Riparian models	6	8	10	100	100

TABLE 6 – FUEL MOISTURES USED FOR FIRE BEHAVIOR PREDICTIONS PER CAROL RICE, SENIOR FIRE ECOLOGIST.

Fire Behavior Modeling

Several fire behavior prediction software applications have been developed by the U.S. Forest Service. These include a wide variety of applications designed to specifically meet fire fighting or fire prevention needs. For this analysis, we used two applications – FARSITE and FlamMap – that have recently merged into one software package (FlamMap version 6.0).

FARSITE predicts fire growth across a landscape. This software package has been combined with FlamMap, a fire behavior simulation package that predicts potential fire behavior characteristics under constant environmental conditions. It allows the analyst to compare fire behavior potential across an entire landscape. FARSITE predictions do **not** include fire suppression action. In this aspect, the results do not portray realistic growth after a few hours from ignition, since suppression actions will slow fire growth and modify its spread pattern. However, FARSITE does show potential fire spread and its associated fire intensity. It also shows us the likely spread direction of a fire. The fire growth analysis that FARSITE allows does not allow for the direct comparison of one fire over another because of the difference with ignition start, terrain, weather, and other parameters. Together, both FlamMap and FARSITE provide information that helps determine fire risk and hazard, in addition helps land managers determine what fuel modifications would best change potential fire behavior.

FARSITE

The inputs into the FARSITE scenarios, both the southwest and northeast (Diablo) scenarios, are summarized in Table 7a 7b, and 7c.

Scenario:	**Southwest Winds (SW Peak Winds)**
Parameter:	***Description/File:***
Landscape File:	ScottRanch_new.lcp – newly derived fuel models and landscape file based on Sonoma County Veg Map clipped to Scott Ranch area
Fuel Moisture File:	standard_conditions_with_riparian.fms
Custom Fuels Used:	SonomaRiparian.FMD (custom fuel model file flagging riparian areas)
Winds:	Wind Direction From Weather Inputs
Fuel Moisture Settings:	Use WTR and WND files
	NVHC1_SW.WTR
	NVHC1_SW-peak.WND
Condition Period:	08/21 1300 to 08/25 1300
Ignition Point:	122° 39' 46.788" W, 38° 12' 46.426" N – just inside Helen Putnam Regional Park main entrance
Model resolution settings:	Perimeter resolution at 30m, distance resolution at 10m, time step at 30 minutes, ember spot probability at 10%, min spot distance at 16m, spotting grid resolution at 8
Foliar Moisture Content:	70%
Crown Fire Calc Method:	Scott/Reinhardt(2001)
Burn Period:	08/23 from 1200 to 1800 (6 hours)

Outputs:	Arrival Time, Flame Length, Rate of Spread, Crown Fire Activity, and Perimeters

TABLE 7A – MODEL PARAMETERS USED FOR SOUTHWEST WINDS SCENARIO IN FARSITE.

Scenario:	**Northeast Winds (NE Peak Winds)**
Parameter:	***Description/File:***
Landscape File:	ScottRanch_new.lcp – newly derived fuel models and landscape file based on Sonoma County Veg Map clipped to Scott Ranch area
Fuel Moisture File:	standard_conditions_with_riparian.fms
Custom Fuels Used:	SonomaRiparian.FMD (custom fuel model file flagging riparian areas)
Winds:	Wind Direction From Weather Inputs
Fuel Moisture Settings:	Use WTR and WND files
	NVHC1_NE.WTR
	NVHC1_NE-peak.WND
Condition Period:	10/22 1300 to 10/26 1300
Ignition Point:	122° 38' 36.383" W, 38° 13' 14.642" N – just west of D Street immediately before Scott Ranch
Model resolution settings:	Perimeter resolution at 30m, distance resolution at 10m, time step at 30 minutes, ember spot probability at 10%, min spot distance at 16m, spotting grid resolution at 8
Foliar Moisture Content:	70%
Crown Fire Calc Method:	Scott/Reinhardt(2001)
Burn Period:	10/23 from 900 to 1800 (9 hours)
Outputs:	Arrival Time, Flame Length, Rate of Spread, Crown Fire Activity, and Perimeters

TABLE 7B – MODEL PARAMETERS USED FOR NORTHEAST WINDS SCENARIO IN FARSITE.

An alternate scenario was run for the Northwest scenario which eliminated the higher fuel moistures for riparian areas. This scenario assumed that all fuel models, regardless of proximity to water, were given the same fuel moisture values.

Scenario:	**Northeast Winds Very Dry (NE Peak Winds DRY)**
Parameter:	***Description/File:***
Landscape File:	ScottRanch_new.lcp – newly derived fuel models and landscape file based on Sonoma County Veg Map clipped to Scott Ranch area
Fuel Moisture File:	**standard_conditions_3-4-5-70-70.fms**
Custom Fuels Used:	SonomaRiparian.FMD (custom fuel model file flagging riparian areas)
Winds:	Wind Direction From Weather Inputs
Fuel Moisture Settings:	Use WTR and WND files
	NVHC1_NE.WTR
	NVHC1_NE-peak.WND
Condition Period:	10/22 1300 to 10/26 1300
Ignition Point:	122° 38' 36.383" W, 38° 13' 14.642" N – just west of D Street immediately before Scott Ranch

Model resolution settings:	Perimeter resolution at 30m, distance resolution at 10m, time step at 30 minutes, ember spot probability at 10%, min spot distance at 16m, spotting grid resolution at 8
Foliar Moisture Content:	70%
Crown Fire Calc Method:	Scott/Reinhardt(2001)
Burn Period:	10/23 from 900 to 1800 (9 hours)
Outputs:	Arrival Time, Flame Length, Rate of Spread, Crown Fire Activity, and Perimeters

TABLE 7C – MODEL PARAMETERS USED FOR A VERY DRY VERSION OF THE NORTHEAST WINDS SCENARIO IN FARSITE.

FlamMap

The inputs into the FlamMap scenarios, both the southwest and northeast (Diablo) scenarios, are summarized in Table 8a and Table 8b.

Scenario:	**Southwest Winds FlamMap**
Parameter:	***Description/File:***
Landscape File:	ScottRanch_new.lcp – newly derived fuel models and landscape file based on Sonoma County Veg Map clipped to Scott Ranch area
Fuel Moisture File:	standard_conditions_with_riparian.fms
Custom Fuels Used:	SonomaRiparian.FMD (custom fuel model file flagging riparian areas)
Winds:	15 mph at 247 degrees azimuth
Fuel Moisture Settings:	Use WTR and WND files
	NVHC1_SW.WTR
	NVHC1_SW-peak.WND
Condition Period:	08/23 1300 to 08/27 1300
Foliar Moisture Content:	70%
Crown Fire Calc Method:	Scott/Reinhardt(2001)
Outputs:	Flame Length, Rate of Spread, and Crown Fire Activity

TABLE 8A – MODEL PARAMETERS USED FOR SOUTHWEST WINDS SCENARIO IN FLAMMAP.

Scenario:	**Northeast Winds FlamMap**
Parameter:	***Description/File:***
Landscape File:	ScottRanch_new.lcp – newly derived fuel models and landscape file based on Sonoma County Veg Map clipped to Scott Ranch area
Fuel Moisture File:	standard_conditions_with_riparian.fms
Custom Fuels Used:	SonomaRiparian.FMD (custom fuel model file flagging riparian areas)
Winds:	15 mph at 45 degrees azimuth
Fuel Moisture Settings:	Use WTR and WND files
	NVHC1_NE.WTR
	NVHC1_NE-peak.WND
Condition Period:	10/22 1300 to 10/26 1300
Foliar Moisture Content:	70%
Crown Fire Calc Method:	Scott/Reinhardt(2001)
Outputs:	Flame Length, Rate of Spread, and Crown Fire Activity

TABLE 8B – MODEL PARAMETERS USED FOR NORTHEAST WINDS SCENARIO IN FLAMMAP.

Results

The results presented below are based on the inputs detailed above and are presented in graphical (map) format and in tabular format. The fire behavior predictions in this section are based on existing conditions. The fire behavior predictions in the **Post Fuel Treatments** section (page 39) are based on likely conditions when the proposed project is in place.

Please note, in all models presented in this document, buildings are **not** considered fuel and fire growth or potential is not predicted where they exist.

Fire Growth (FARSITE)

Southwest Ignition/Wind Scenario

For the inputs detailed in Table 7a above, the following fire growth is predicted for a period of 9 hours, and assumes no fire suppression takes place.

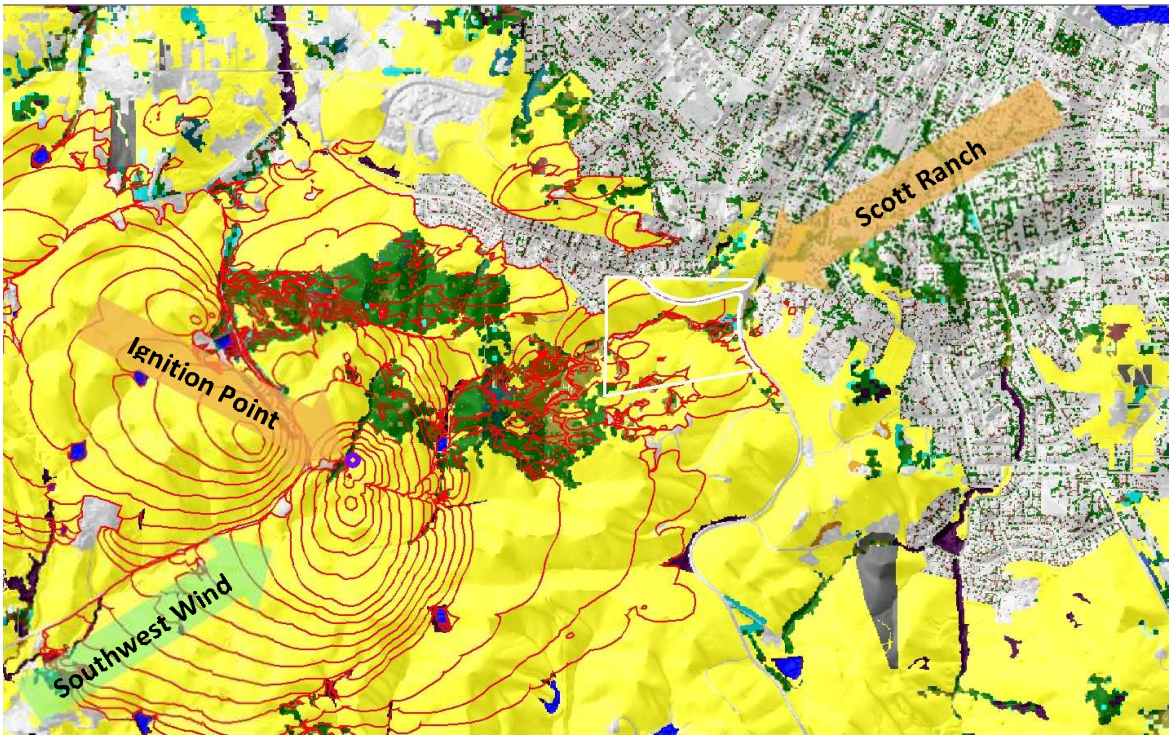


FIGURE 8 - FARSITE FIRE GROWTH PREDICTIONS FOR SOUTHWEST WINDS/IGNITION POINT SCENARIO DESCRIBED IN TABLE 7A.

During the period chosen, the southwest winds were strong, but wind direction was somewhat erratic. A multi-day, consistent southwest wind condition was not found for the month of August. Because of this, the fire has primarily moved northeast (in line with the southwest wind), but it has also moved to the northwest and south, as well as back towards the southwest. However, when afternoon winds became strongest from the southwest, the fire moved steadily northeast and burned through the lower half of the property. During this

9-hour simulation, the fire stopped south of Windsor Drive. Several spot fires started east of D Street and crossed north into an intervening open section of grasslands. The fire grows up to over 16,000 acres in 9 hours, due to the fast fire spread rate in grass, strong winds in the afternoon, and lack of firefighting intervention.

Run: SW Peak Winds Scenario					
Elapsed (DD HH:mm)	Current(MM/DD HH:mm)	Fires	Enclaves	Total Acres	Timestep Acres
00 00:00	Ignition				
00 00:30	8/23/2020 9:30	4	0	0.94	0.94
00 01:00	8/23/2020 10:00	3	1	27.73	26.8
00 01:30	8/23/2020 10:30	2	1	94.18	66.45
00 02:00	8/23/2020 11:00	2	1	182.18	88
00 02:30	8/23/2020 11:30	3	2	307.42	125.25
00 03:00	8/23/2020 12:00	3	2	497.81	190.38
00 03:30	8/23/2020 12:30	4	2	750.75	252.94
00 04:00	8/23/2020 13:00	12	4	1202.85	452.1
00 04:30	8/23/2020 13:30	13	8	1833.4	630.54
00 05:00	8/23/2020 14:00	13	5	2536.59	703.19
00 05:30	8/23/2020 14:30	16	8	3359.79	823.2
00 06:00	8/23/2020 15:00	18	15	4477.62	1117.83
00 06:30	8/23/2020 15:30	17	14	5674.67	1197.05
00 07:00	8/23/2020 16:00	19	15	6974.16	1299.5
00 07:30	8/23/2020 16:30	24	19	8294.97	1320.81
00 08:00	8/23/2020 17:00	65	41	10919.42	2624.45
00 08:30	8/23/2020 17:30	80	52	14084.39	3164.98
00 09:00	8/23/2020 18:00	84	65	16336.5	2252.1

TABLE 9 – FIRE GROWTH REPORT FOR SOUTHWEST WINDS SCENARIO IN FARSITE.

Northeast (or Diablo) Ignition/Wind Scenario

For the inputs detailed in Table 7b above, the following fire growth is predicted for a period of 9 hours, and assumes no fire suppression takes place.

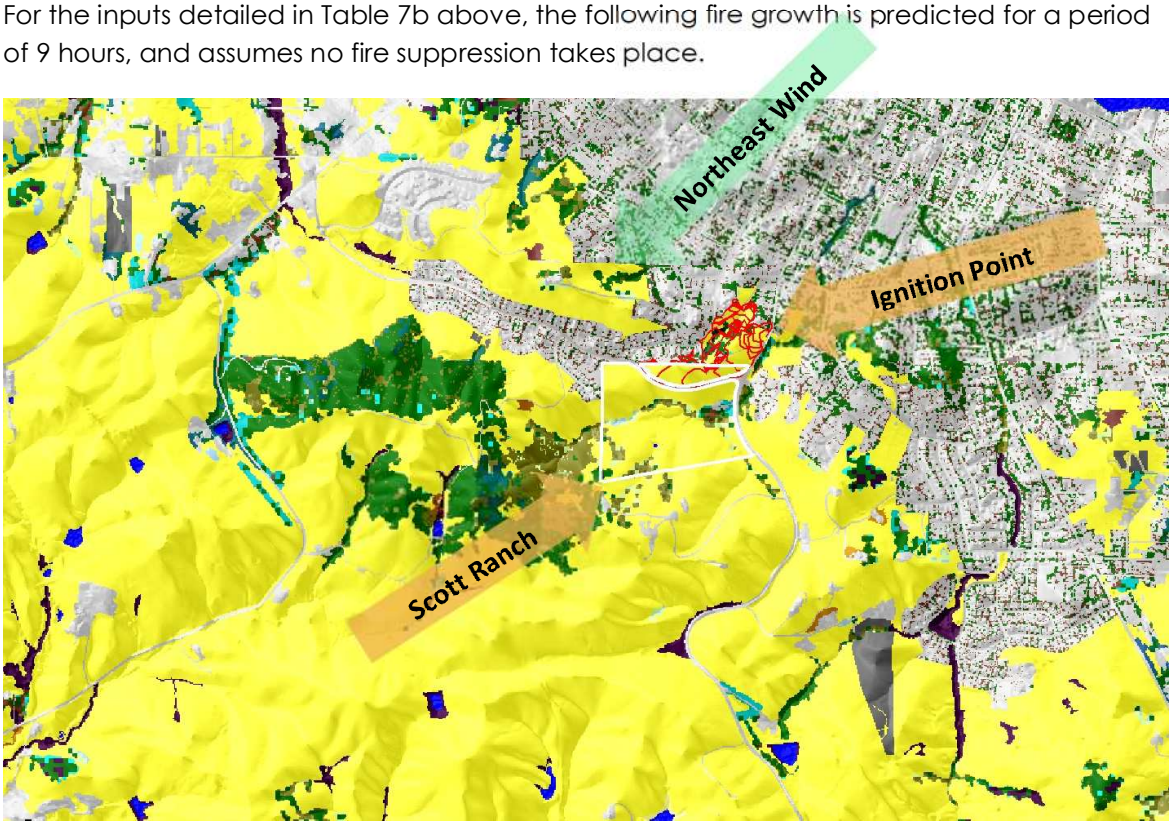


FIGURE 9 – FARSITE FIRE GROWTH PREDICTIONS FOR NORTHEAST WINDS/IGNITION POINT SCENARIO DESCRIBED IN TABLE 7B.

During the period chosen, the while the northwest winds were consistent and strong, Windsor Drive proved an effective barrier for this simulated grass fire starting off the road edge of D Street, due to a lack of fire spread by embers. However, in the 9 hour simulation, the fire did quickly burn into the northern section of the property. The fire only reaches 225 acres in this scenario.

Elapsed (DD HH:mm)	Current(MM/DD HH:mm)	Fires	Enclaves	Total Acres	Timestep Acres
00 00:00	Ignition				
00 00:30	10/23/2020 9:30	1	0	3.03	3.03
00 01:00	10/23/2020 10:00	1	0	11.01	7.98
00 01:30	10/23/2020 10:30	1	0	17.46	6.45
00 02:00	10/23/2020 11:00	1	0	23.88	6.42
00 02:30	10/23/2020 11:30	1	0	30.79	6.91
00 03:00	10/23/2020 12:00	1	0	59.46	28.67
00 03:30	10/23/2020 12:30	1	0	82.62	23.16
00 04:00	10/23/2020 13:00	2	0	121.46	38.84

00 04:30	10/23/2020 13:30	3	1	172.51	51.04
00 05:00	10/23/2020 14:00	7	5	211.4	38.89
00 05:30	10/23/2020 14:30	4	2	219.15	7.75
00 06:00	10/23/2020 15:00	5	3	221.74	2.59
00 06:30	10/23/2020 15:30	6	4	222.81	1.07
00 07:00	10/23/2020 16:00	3	1	223.23	0.42
00 07:30	10/23/2020 16:30	3	1	224.31	1.09
00 08:00	10/23/2020 17:00	3	1	224.38	0.07
00 08:30	10/23/2020 17:30	3	1	224.44	0.06
00 09:00	10/23/2020 18:00	3	1	224.5	0.06

TABLE 10 – FIRE GROWTH REPORT FOR NORTHEAST WINDS SCENARIO IN FARSITE.

Because of the recent devastating fires of 2017 (Tubbs Fire), 2018 (Carr Fire), and 2019 (Kincade), we changed the fuel moisture regime for the northeast scenario to reflect dry conditions throughout the landscape (i.e. not compensating for riparian areas). In this scenario, fire growth was more pronounced due to higher ignitability and greater firebrand creation and distribution.

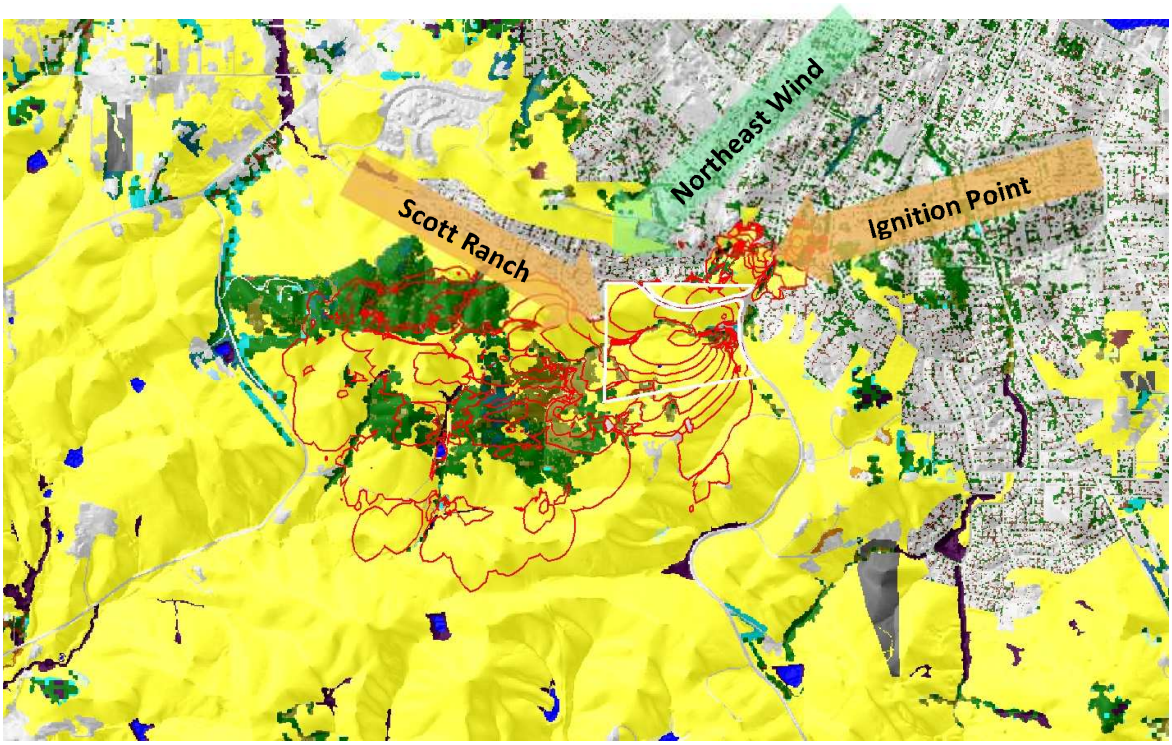


FIGURE 10 – FARSITE FIRE GROWTH PREDICTIONS FOR NORTHWEST WINDS/IGNITION POINT SCENARIO DESCRIBED IN TABLE 7C.

In this scenario, the fire grows up to over 4,800 acres in this drier scenario and quickly burns through the entire Scott Ranch property and into Helen Putnam Regional Park.

Run: NE Peak Winds Scenario DRY

Elapsed (DD HH:mm)	Current(MM/DD HH:mm)	Fires	Enclaves	Total Acres	Timestep Acres
00 00:00	Ignition				
00 00:30	10/23/2020 9:30	1	0	3.03	3.03
00 01:00	10/23/2020 10:00	2	0	15.28	12.25
00 01:30	10/23/2020 10:30	2	0	39.97	24.69
00 02:00	10/23/2020 11:00	2	0	55.98	16.01
00 02:30	10/23/2020 11:30	3	0	76.02	20.04
00 03:00	10/23/2020 12:00	3	0	140.18	64.16
00 03:30	10/23/2020 12:30	3	1	182.66	42.48
00 04:00	10/23/2020 13:00	3	1	235.1	52.44
00 04:30	10/23/2020 13:30	5	2	321.33	86.24
00 05:00	10/23/2020 14:00	10	6	418.89	97.56
00 05:30	10/23/2020 14:30	8	6	597.66	178.77
00 06:00	10/23/2020 15:00	6	4	708	110.34
00 06:30	10/23/2020 15:30	6	4	806.92	98.93
00 07:00	10/23/2020 16:00	9	4	1009.6	202.67
00 07:30	10/23/2020 16:30	14	9	1286.33	276.73
00 08:00	10/23/2020 17:00	37	16	1840.02	553.69
00 08:30	10/23/2020 17:30	88	26	2726.01	885.99
00 09:00	10/23/2020 18:00	65	50	4833.44	2107.43

TABLE 11 – FIRE GROWTH REPORT FOR NORTHEAST WINDS – DRY – SCENARIO IN FARSITE.

Fire Potential (FlamMap)

Southwest Wind Scenario

For the inputs detailed in Table 8a above, the following *fire potential* was predicted for the entire modeled area surrounding Scott Ranch.

Flame Length (SW, pre-development)

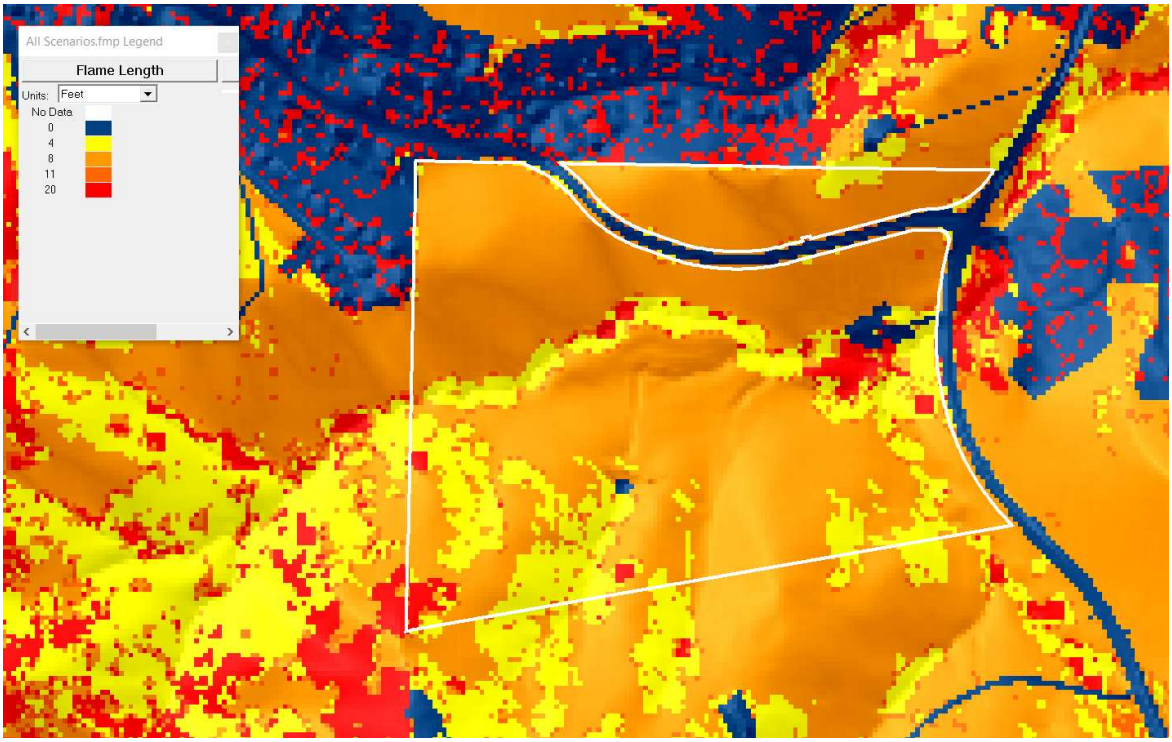


FIGURE 11 – PREDICTED FLAME LENGTHS (IN FEET) FOR THE SOUTHWEST WIND SCENARIO DESCRIBED IN TABLE 8A.

Flame Length Category	Acres	Percent
No predicted fire	0.6	1%
< 4 feet	10.9	19%
4 – 8 feet	44.4	76%
8 – 11 feet	1.2	2%
11-20 feet	0.2	0.4%
> 20 feet	1.5	3%
Total Acres	**58.9**	

TABLE 12 – ACRES PER PREDICTED FLAME LENGTH CATEGORY ON SCOTT RANCH ONLY FOR THE SOUTHWEST WIND SCENARIO DESCRIBED IN TABLE 8A.

No fire is modeled on Windsor Drive, the pond in the southern portion of the property, or the existing building site, where surface vegetation is young, minimal, well tended and irrigated.

Where grass fuels (GR2) exist on the property, relatively high flames lengths (4 to 8 feet in length) are predicted. Lower flames (less than 4 feet) are predicted along Kelly Creek and its subsidiary, and where the patches of shrubs exist in the south. Where pockets of shrub

and timber fuels comingled (near the existing structures and in the southwest corner of the property) flame lengths were predicted to reach over 20 feet.

Rate of Spread (SW, pre-development)

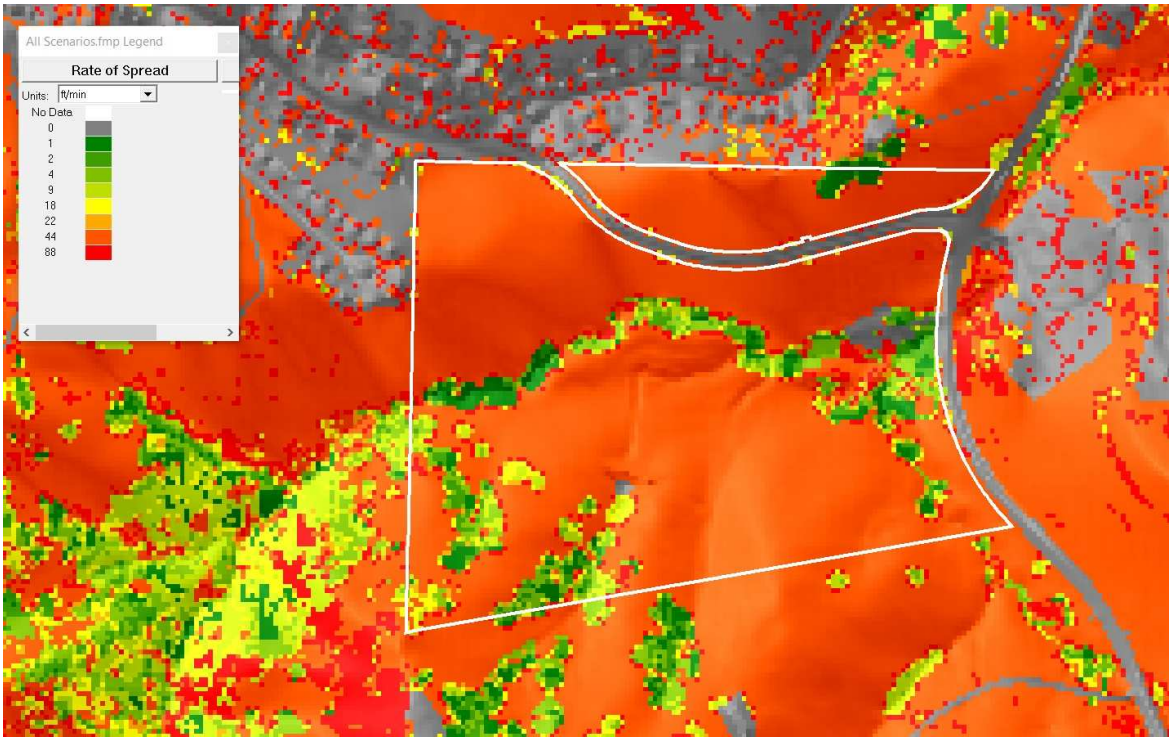


FIGURE 12 - PREDICTED RATE OF SPREAD (FEET/MINUTE) FOR THE SOUTHWEST WIND SCENARIO DESCRIBED IN TABLE 8A.

Rate of Spread Category	Acres	Percent
No predicted fire	0.6	1%
< 1 foot/minute	1.9	3%
1 – 5 ft/min	4.6	8%
5 – 10 ft/min	1.3	2%
10 – 15 ft/min	0.6	1%
15 – 20 ft/min	0.6	1%
20 – 40 ft/min	46.5	79%
> 40 ft/min	2.8	5%
Total Acres	**58.9**	

TABLE 13 – ACRES PER PREDICTED RATE OF SPREAD CATEGORY ON SCOTT RANCH FOR THE SOUTHWEST WIND SCENARIO DESCRIBED IN TABLE 8A.

No fire is predicted on Windsor Drive, the pond in the southern portion of the property, nor is it predicted for the existing building site.

Where grass fuels (GR2) exist on the property, very high rates of spread (over 40 feet/minute are predicted. The spread rates drop dramatically along Kelly Creek to below 20 feet/minute or even as low as 1 or 2 feet/minute where tree canopies exist.

Crown Fire Activity (SW, pre-development)

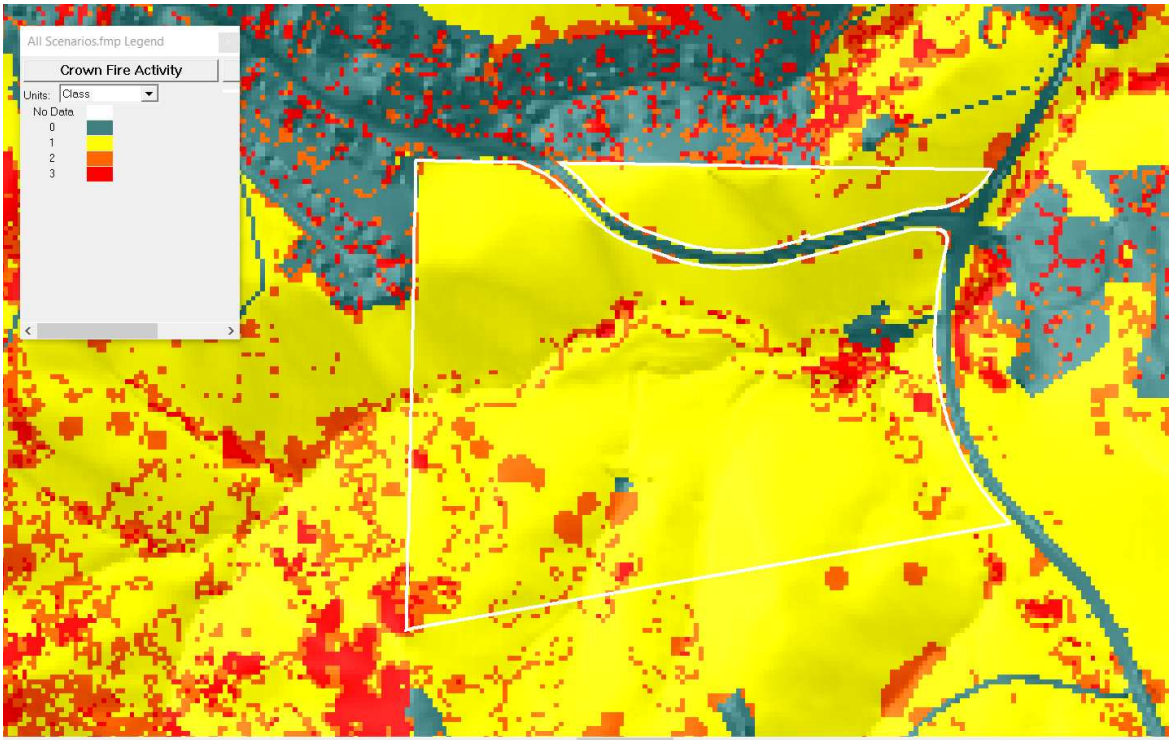


FIGURE 13 - PREDICTED CROWN FIRE ACTIVITY (0 = NO FIRE, 1 = SURFACE FIRE, 2 = TORCHING FIRE, 3 = ACTIVE CROWN FIRE) FOR THE SOUTHWEST WIND SCENARIO DESCRIBED IN TABLE 8A.

Crown Fire Activity Category	Acres	Percent
No predicted fire	0.6	1%
Surface fire (1)	52.5	89%
Torching fire (2)	4.7	8%
Active crown fire (3)	1.1	2%
Total Acres	**58.9**	

TABLE 14 – ACRES PER CROWN FIRE ACTIVITY CATEGORY ON SCOTT RANCH FOR THE SOUTHWEST WIND SCENARIO DESCRIBED IN TABLE 8A.

No fire is predicted on Windsor Drive, the pond in the southern portion of the property, nor is it predicted for the existing building site.

A surface fire is predicted for 89% of the property as would be expected for any grass and shrub fuel types. Where there are tree fuel types, some torching occurs, mainly along the edges of Kelly Creek and the shrub fields where trees also exist. Active crown fire is predicted just south of the current existing structures.

Northeast (or Diablo) Wind Scenario

For the inputs detailed in Table 8b above, the following fire potential was predicted for the entire modeled area surrounding Scott Ranch.

Flame Length (NE, pre-development)

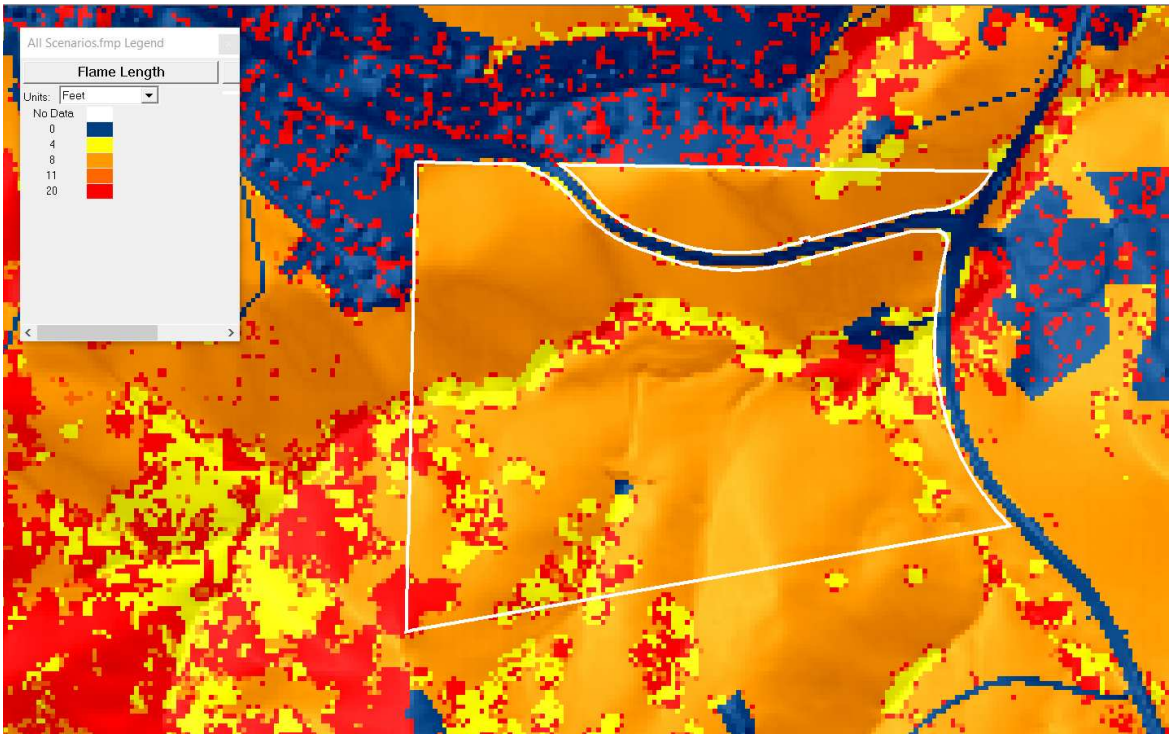


FIGURE 14 – PREDICTED FLAME LENGTHS (IN FEET) FOR THE NORTHEAST WIND SCENARIO DESCRIBED IN TABLE 8B.

Flame Length Category	Acres	Percent
No predicted fire	0.6	1%
< 4 feet	6.2	11%
4 – 8 feet	47.1	80%
8 – 11 feet	0.8	1%
11-20 feet	1.1	2%
> 20 feet	3.0	5%
Total Acres	**58.9**	

TABLE 15 – ACRES PER PREDICTED FLAME LENGTH CATEGORY ON SCOTT RANCH FOR THE NORTHEAST WIND SCENARIO DESCRIBED IN TABLE 8B.

Like in the Southwest FlamMap predictions, no fire is predicted on Windsor Drive, the pond in the southern portion of the property, nor is it predicted for the existing building site.

Where grass fuels (GR2) exist on the property, relatively high flames lengths (4 to 8 feet in length) are predicted. Lower flames (less than 4 feet) are predicted along Kelly Creek and its subsidiary, and where the patches of shrubs exist in the south. Where pockets of shrub and timber fuels comingled (near the existing structures and in the southwest corner of the

property) flame lengths were predicted to reach over 20 feet. Overall, flame lengths are slightly higher than in the Southwest FlamMap scenario.

Rate of Spread (NE, pre-development)

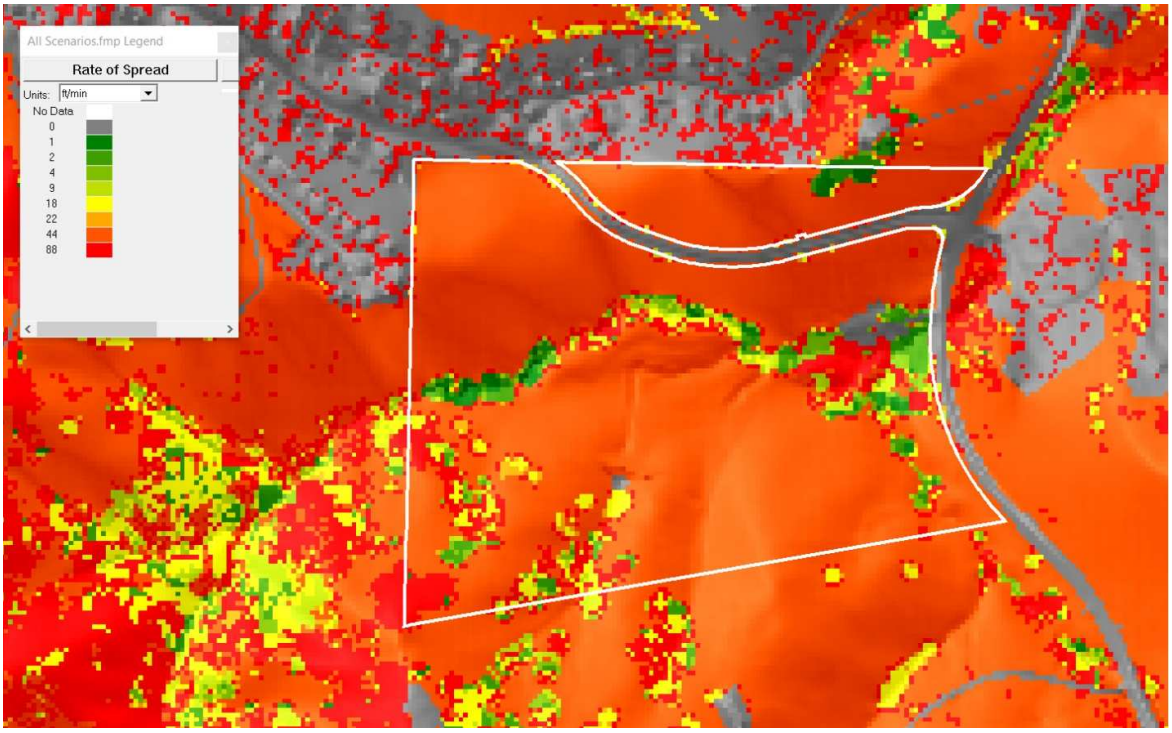


FIGURE 15 - PREDICTED RATE OF SPREAD (FEET/MINUTE) FOR THE NORTHEAST WIND SCENARIO DESCRIBED IN TABLE 8B.

Rate of Spread Category	Acres	Percent
No predicted fire	0.6	1%
< 1 foot/minute	0.7	1%
1 – 5 ft/min	3.2	5%
5 – 10 ft/min	1.4	2%
10 – 15 ft/min	0.7	1%
15 – 20 ft/min	0.5	1%
20 – 40 ft/min	44.1	75%
> 40 ft/min	7.8	13%
Total Acres	**58.9**	

TABLE 16 – ACRES PER PREDICTED RATE OF SPREAD CATEGORY ON SCOTT RANCH FOR THE NORTHEAST WIND SCENARIO DESCRIBED IN TABLE 8B.

Like in the Southwest FlamMap predictions, no fire is predicted on Windsor Drive, the pond in the southern portion of the property, nor is it predicted for the existing building site.

Where grass fuels (GR2) exist on the property, very high rates of spread (over 40 feet/minute are predicted. The spread rates drop dramatically along Kelly Creek to below 20 feet/minute or even as low as 1 or 2 feet/minute where tree canopies exist. Overall, rate of spread is slightly higher than in the Southwest FlamMap prediction results.

Crown Fire Activity (NE, pre-development)

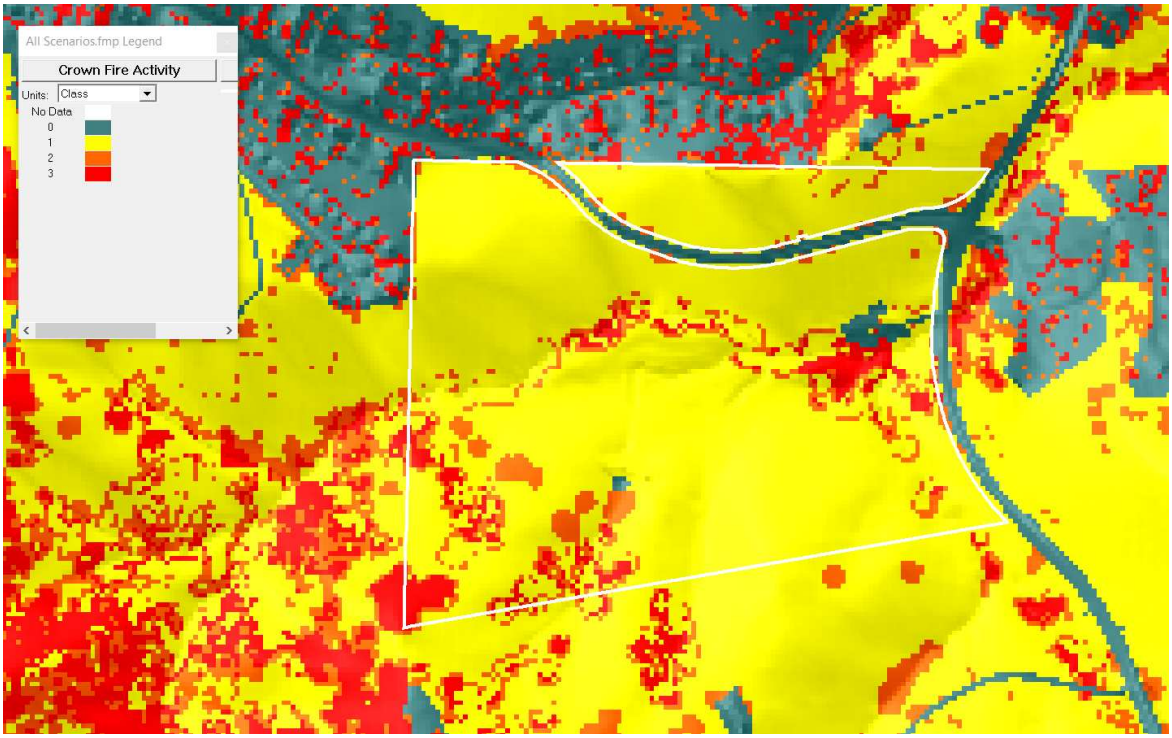


FIGURE 16 - PREDICTED CROWN FIRE ACTIVITY (0 = NO FIRE, 1 = SURFACE FIRE, 2 = TORCHING FIRE, 3 = ACTIVE CROWN FIRE) FOR THE NORTHEAST WIND SCENARIO DESCRIBED IN TABLE 8B.

Crown Fire Activity Category	Acres	Percent
No predicted fire	0.6	1%
Surface fire (1)	50.7	86%
Torching fire (2)	4.7	8%
Active crown fire (3)	2.9	5%
Total Acres	**58.9**	

TABLE 17 – ACRES PER PREDICTED CROWN FIRE ACTIVITY CATEGORY ON SCOTT RANCH FOR THE NORTHEAST WIND SCENARIO DESCRIBED IN TABLE 8B.

Like in the Southwest FlamMap predictions, no fire is predicted along Windsor Drive, the pond in the southern portion of the property, nor is it predicted for the existing building site.

A surface fire is predicted for 89% of the property as would be expected for any grass and shrub fuel types. Where there are tree fuel types, some torching occurs, mainly along the edges of Kelly Creek and the shrub fields where trees also exist. Active crown fire is predicted just south of the current existing structures. Overall, crown fire activity is slightly more active in this scenario than in the Southwest FlamMap results.

A corresponding very dry scenario for the Northeast (Diablo) Wind FlamMap scenario was completed (see input Table 8c). Figures and tables for these results are not included in this document because the drier riparian conditions made no difference in the modeled FlamMap outcomes (though it did make a difference in fire growth).

Post Fuel Treatments

The vegetation management plan for Scott Ranch delineates 10 fuel management zones with recommended fuel management actions. These fuel management actions are designed to change the surface fuel volume and arrangement, and therefore the fuel model should be changed to reflect those management actions.

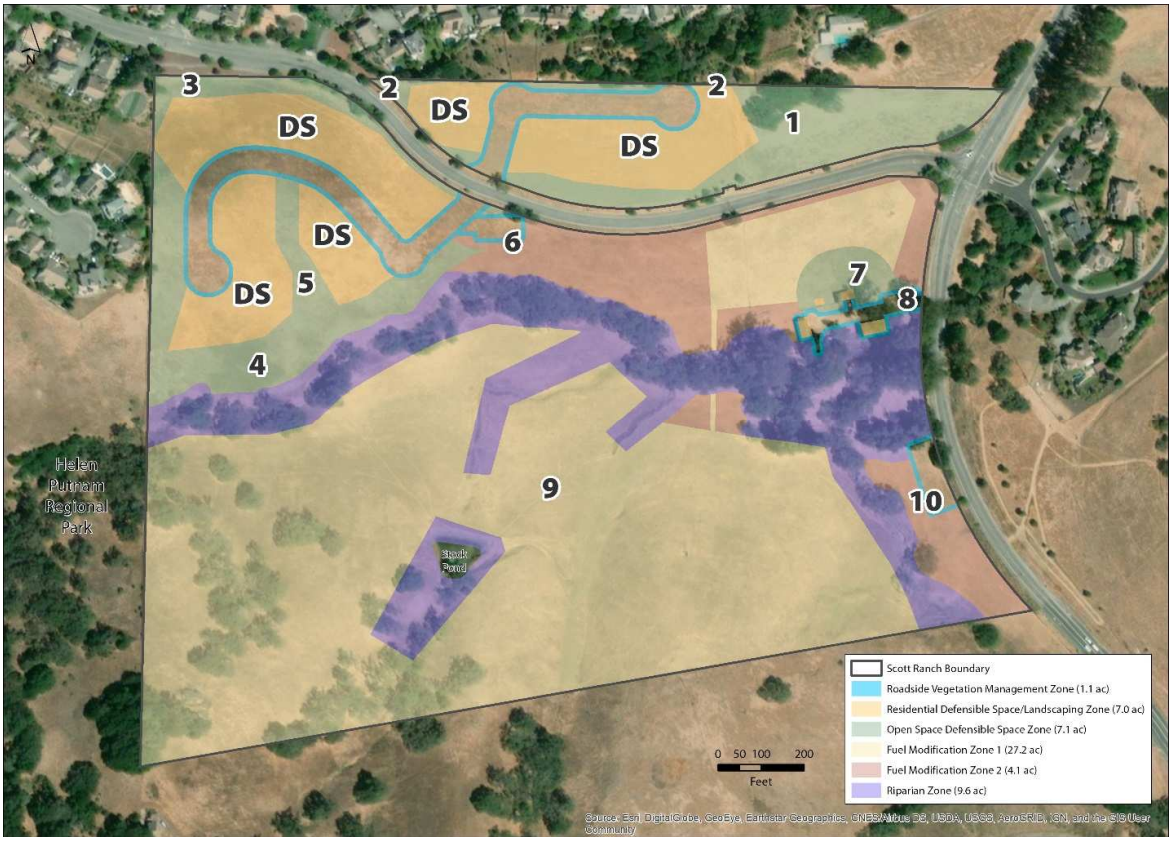


FIGURE 17 – AERIAL IMAGE OF SCOTT RANCH WITH RECOMMENDED FUEL MANAGEMENT ZONES AS PRESENTED IN THE VEGETATION MANAGEMENT PLAN FOR SCOTT RANCH (RICE, 2020).

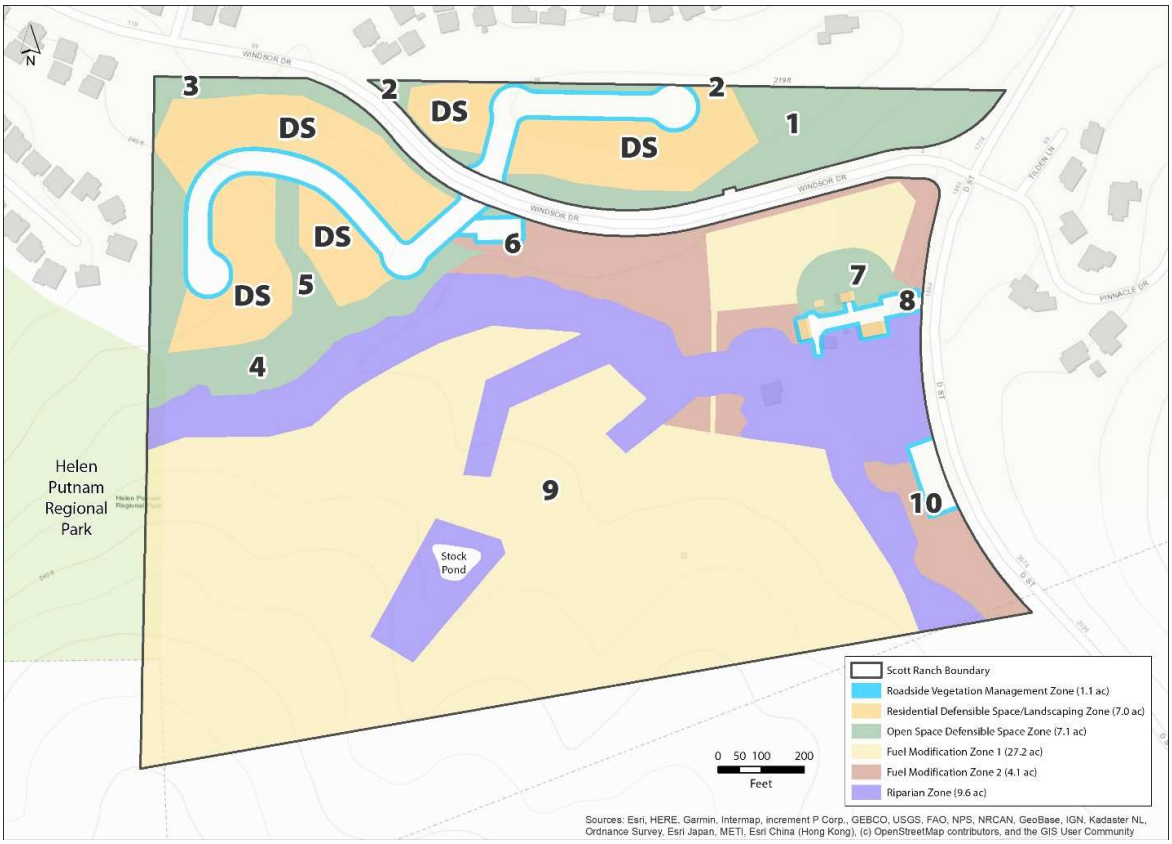


FIGURE 18 – TOPOGRAPHIC BASE MAP OF SCOTT RANCH WITH RECOMMENDED FUEL MANAGEMENT ZONES AS PRESENTED IN THE VEGETATION MANAGEMENT PLAN FOR SCOTT RANCH (RICE, 2020).

Treatment	**Acres**	**Percent**
Roadside Vegetation Management Zone	1.1	2%
Residential Defensible Space/Landscaping Zone	7.0	12%
Open Space Defensible Space Zone	7.1	12%
Fuel Modification Zone 1	27.2	46%
Fuel Modification Zone 2	4.1	7%
Riparian Zone	9.6	16%
Road surface or parking lots	2.6	4%
Existing/proposed common buildings	0.1	1%
Total Acres	**58.8**	

TABLE 18 – ACREAGE FOR EACH FUEL MANAGEMENT ZONE AND OTHER DESIGNATED AREAS FOR SCOTT RANCH/

Based on the recommendations in each zone, in our landscape file used in this analysis, fuel models were changed for Scott Ranch and all fire behavior scenarios were re-analyzed. Other than the changes in fuel models, all other parameters remained the same (see tables above). Note: after this analysis was completed, minor changes were made to the fuel modification zones. The changes are too fine to change the overall results of this analysis, but the figures and tables have been updated to reflect those changes.

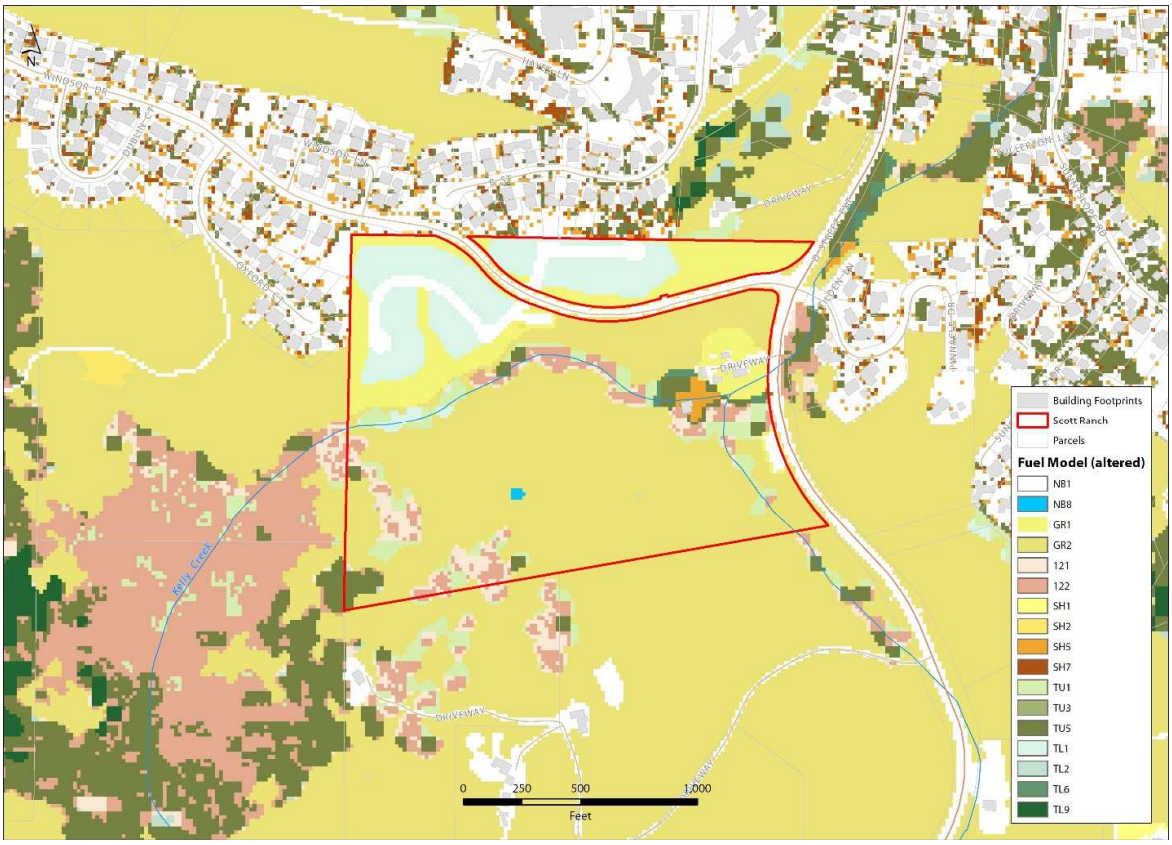


FIGURE 19 - FUEL MODEL/TYPE ALTERED PER VEGETATION MANAGEMENT RECOMMENDATIONS (RICE, 2020)

Value	FBFM40	Acres	Percent
91	NB1	2.72	4.63%
98	NB8	0.1	0.1%
101	GR1	8.05	13.69%
102	GR2	31.05	52.79%
121	GS1	2.0	3.4%
122	GS2	2.3	3.8%
145	SH5	0.4	0.6%
161	TU1	2.56	4.37%
165	TU5	1.39	2.37%
181	TL1	8.11	13.79%
182	TL2	0.02	0.03%
186	TL6	0.21	0.35%

TABLE 19 – FUEL MODEL ACRES WITHIN SCOTT RANCH PROPERTY POST RECOMMENDED MANAGEMENT ACTION.

Fire Growth (FARSITE)

Southwest Ignition/Wind Scenario

For the inputs detailed in Table 7a above, except for the altered fuel model layer, the following fire growth was predicted for a period of 9 hours, and assume no fire suppress takes place.

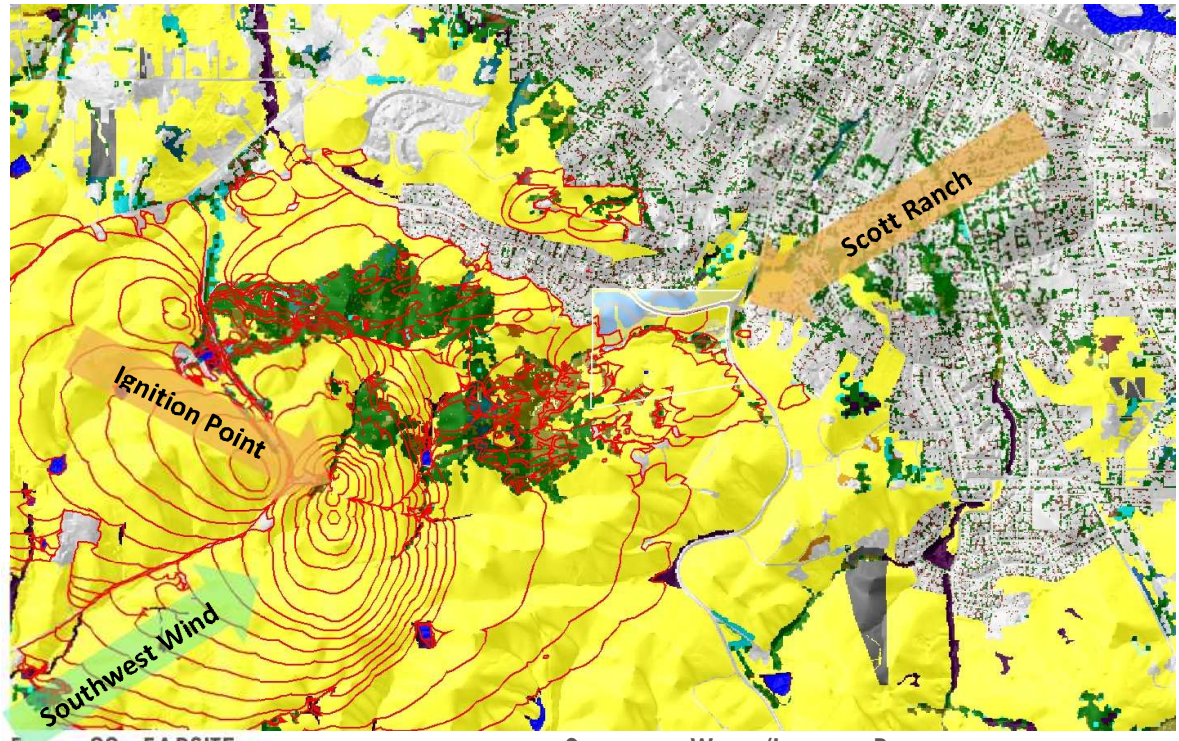


FIGURE 20 - FARSITE FIRE GROWTH PREDICTIONS FOR SOUTHWEST WINDS/IGNITION POINT SCENARIO DESCRIBED IN TABLE 7A WITH THE EXCEPTION OF ALTERED FUELS DUE TO PROPOSED MANAGEMENT ACTIONS.

During the period chosen, the southwest winds were strong, but wind direction was somewhat erratic. A multi-day, consistent southwest wind condition was not found for the month of August. Because of this, the fire has primarily moved northeast (in line with the southwest wind), but it has also moved to the northwest and south, as well as back towards the southwest. However, when afternoon winds became strongest from the southwest, the fire moved steadily northeast and burned through the lower half of the property. During this 9-hour simulation, the fire stopped south of Windsor Drive as in the first scenario depicted in Figure 7. However, the fire also stopped at the edge of the proposed residences due to a change in fuel model from GR2 to TL1 (tree canopy with little to no understory). Several spot fires still started to the north and east of D Street. While there are changes, the changes are subtle and only affected the immediate areas of the proposed lots. This simulated fire grew to less than 16,000 acres in 9 hours.

Run: SW Peak Winds Scenario					
Elapsed (DD HH:mm)	Current(MM/DD HH:mm)	Fires	Enclaves	Total Acres	Timestep Acres
00 00:00	Ignition				
00 00:30	08/23 09:30	3	0	0.93	0.93
00 01:00	08/23 10:00	2	0	30.71	29.78
00 01:30	08/23 10:30	1	0	95.89	65.18
00 02:00	08/23 11:00	1	0	180.45	84.56
00 02:30	08/23 11:30	1	0	302.83	122.37
00 03:00	08/23 12:00	1	0	494.11	191.28
00 03:30	08/23 12:30	2	1	745.68	251.57
00 04:00	08/23 13:00	9	3	1218.76	473.08
00 04:30	08/23 13:30	5	3	1851.99	633.23
00 05:00	08/23 14:00	6	1	2557.26	705.27
00 05:30	08/23 14:30	11	7	3330.23	772.97
00 06:00	08/23 15:00	18	12	4445.21	1114.98
00 06:30	08/23 15:30	14	13	5633.30	1188.09
00 07:00	08/23 16:00	14	13	6997.89	1364.60
00 07:30	08/23 16:30	21	18	8185.04	1187.15
00 08:00	08/23 17:00	69	36	10545.91	2360.86
00 08:30	08/23 17:30	88	57	13454.51	2908.60
00 09:00	08/23 18:00	78	64	15683.09	2228.59

TABLE 20 – FIRE GROWTH REPORT FOR SOUTHWEST WINDS SCENARIO IN FARSITE (POST TREATMENT).

Northeast (or Diablo) Ignition/Wind Scenario

For the inputs detailed in Table 7b above, except for the altered fuel model layer, the following fire growth was predicted for a period of 9 hours, and assume no fire suppress takes place.

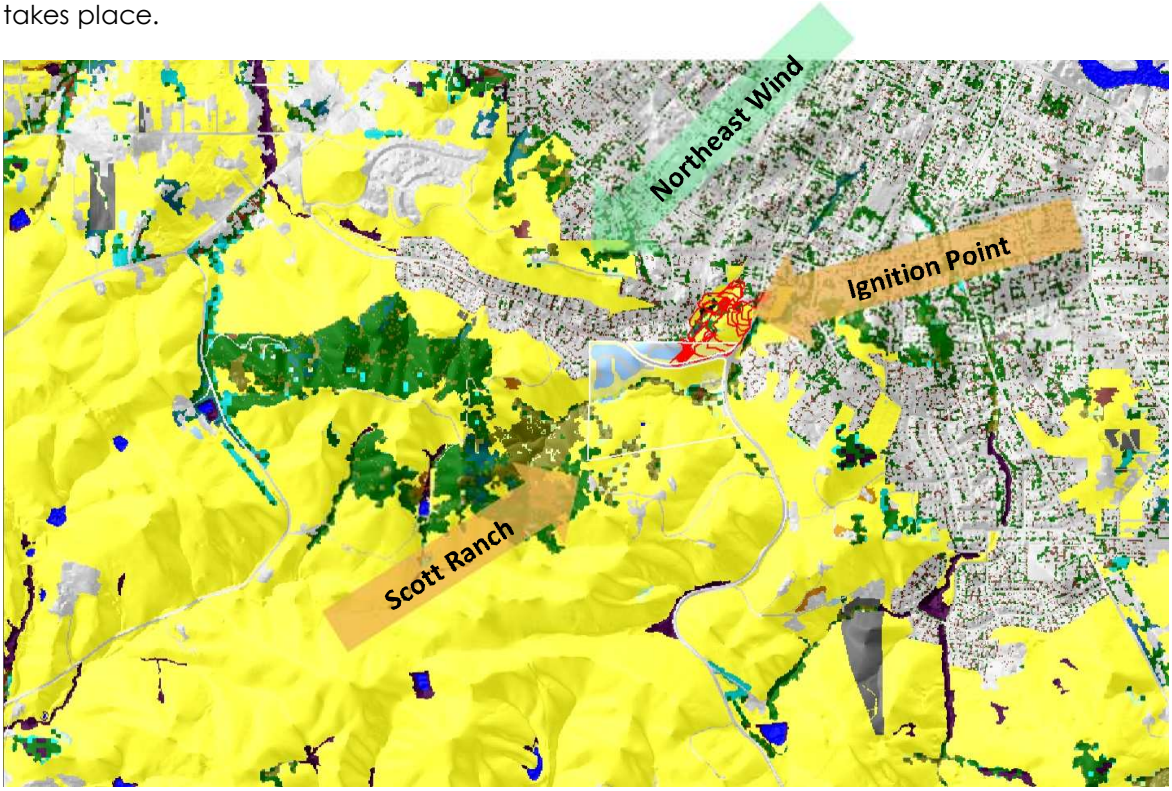


FIGURE 21 – FARSITE FIRE GROWTH PREDICTIONS FOR NORTHEAST WINDS/IGNITION POINT SCENARIO DESCRIBED IN TABLE 7B POST IMPLEMENTATION OF MANAGEMENT ACTIONS.

During the period chosen, while the northwest winds were consistent and strong, Windsor Drive proved an effective barrier for this simulated grass fire starting off the road edge of D Street. However, in this second 9 hour simulation, the fire again burned into Scott Ranch, however, it stops at the proposed residential lots because of the fuel model change from GR2 to TL1. The fire reaches less than 174 acres in this scenario.

Elapsed (DD HH:mm)	Current(MM/DD HH:mm)	Fires	Enclaves	Total Acres	Timestep Acres
00 00:00	Ignition				
00 00:30	10/23 09:30	1	0	3.03	3.03
00 01:00	10/23 10:00	2	0	11.14	8.11
00 01:30	10/23 10:30	2	0	18.38	7.24
00 02:00	10/23 11:00	2	0	25.69	7.31
00 02:30	10/23 11:30	2	0	33.75	8.06
00 03:00	10/23 12:00	2	0	60.63	26.89
00 03:30	10/23 12:30	3	0	78.12	17.48

00 04:00	10/23 13:00	3	1	107.44	29.32
00 04:30	10/23 13:30	5	2	134.80	27.36
00 05:00	10/23 14:00	8	6	159.29	24.50
00 05:30	10/23 14:30	7	5	162.03	2.74
00 06:00	10/23 15:00	7	5	165.92	3.89
00 06:30	10/23 15:30	7	5	167.21	1.29
00 07:00	10/23 16:00	5	3	168.00	0.79
00 07:30	10/23 16:30	5	3	168.75	0.75
00 08:00	10/23 17:00	5	3	169.73	0.98
00 08:30	10/23 17:30	5	3	170.65	0.92
00 09:00	10/23 18:00	5	3	173.51	2.87

TABLE 21 – FIRE GROWTH REPORT FOR NORTHEAST WINDS SCENARIO IN FARSITE POST IMPLEMENTATION OF MANAGEMENT ACTIONS.

The dry Northeast scenario shows the most significant difference between before development and after development action and implementation of the recommendations in the vegetation management plan. This "worst-case" scenario's fire behavior was dampened by the change in fuel model within the proposed residential lots. In this scenario, fire growth was much less at 193 acres (versus over 4,800 acres – Table 11).

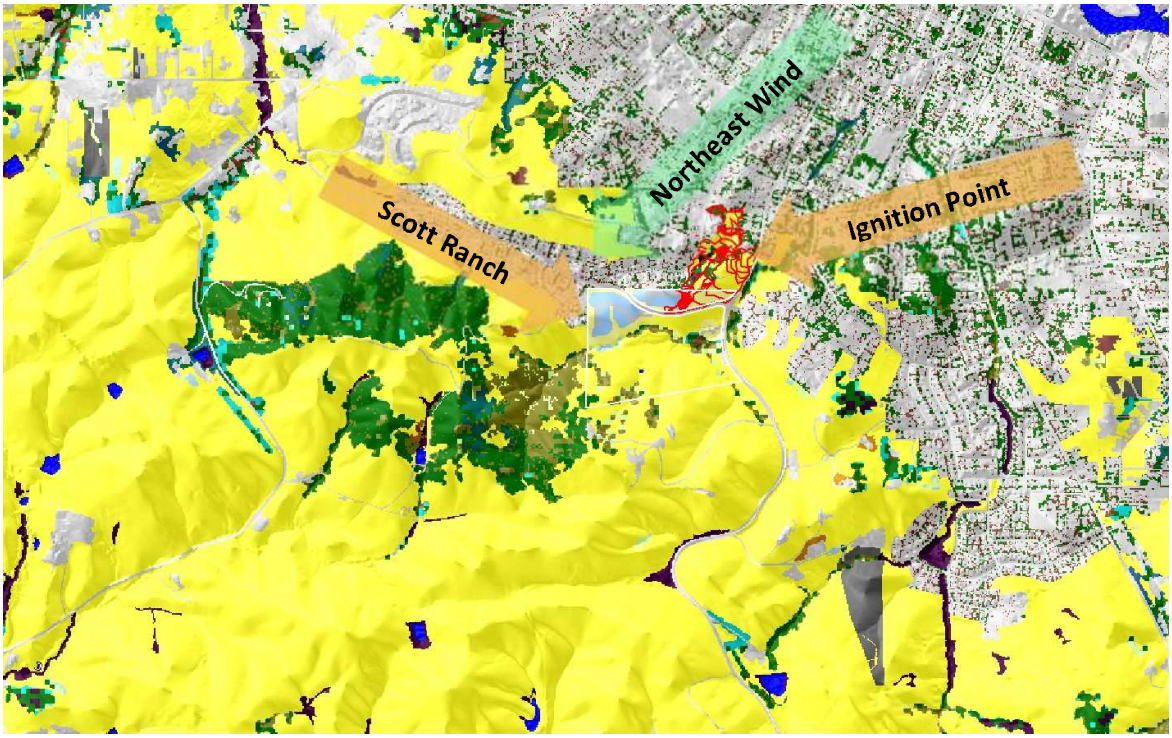


FIGURE 22 – FARSITE FIRE GROWTH PREDICTIONS FOR NORTHWEST WINDS/IGNITION POINT SCENARIO DESCRIBED IN TABLE 7C POST IMPLEMENTATION OF MANAGEMENT ACTIONS.

Run: NE Peak Winds Scenario DRY					
Elapsed (DD HH:mm)	Current(MM/DD HH:mm)	Fires	Enclaves	Total Acres	Timestep Acres
00 00:00	Ignition				
00 00:30	10/23 09:30	1	0	3.03	3.03
00 01:00	10/23 10:00	1	0	11.01	7.98
00 01:30	10/23 10:30	1	0	17.46	6.45
00 02:00	10/23 11:00	1	0	23.88	6.42
00 02:30	10/23 11:30	1	0	30.79	6.91
00 03:00	10/23 12:00	1	0	57.68	26.89
00 03:30	10/23 12:30	1	0	75.08	17.40
00 04:00	10/23 13:00	1	0	104.18	29.10
00 04:30	10/23 13:30	2	1	129.53	25.36
00 05:00	10/23 14:00	5	4	153.91	24.38
00 05:30	10/23 14:30	3	2	158.22	4.31
00 06:00	10/23 15:00	3	2	160.03	1.81
00 06:30	10/23 15:30	3	2	164.19	4.16
00 07:00	10/23 16:00	3	1	174.38	10.20
00 07:30	10/23 16:30	4	2	180.46	6.08
00 08:00	10/23 17:00	5	3	185.26	4.80
00 08:30	10/23 17:30	4	2	190.08	4.82
00 09:00	10/23 18:00	3	1	192.67	2.59

TABLE 22 – FIRE GROWTH REPORT FOR NORTHEAST WINDS – DRY – SCENARIO IN FARSITE POST IMPLEMENTATION OF MANAGEMENT ACTIONS.

Fire Potential (FlamMap)

Southwest Wind Scenario

For the inputs detailed in Table 8a above, with the exception of the altered fuel model layer, the following *fire potential* was predicted for the entire modeled area surrounding Scott Ranch.

Flame Length (SW, post-development)

The difference in flame length is significant where the fuel model was changed from GR2 to GR1 (due to management recommendations) and because of the proposed residential lots (TL1).

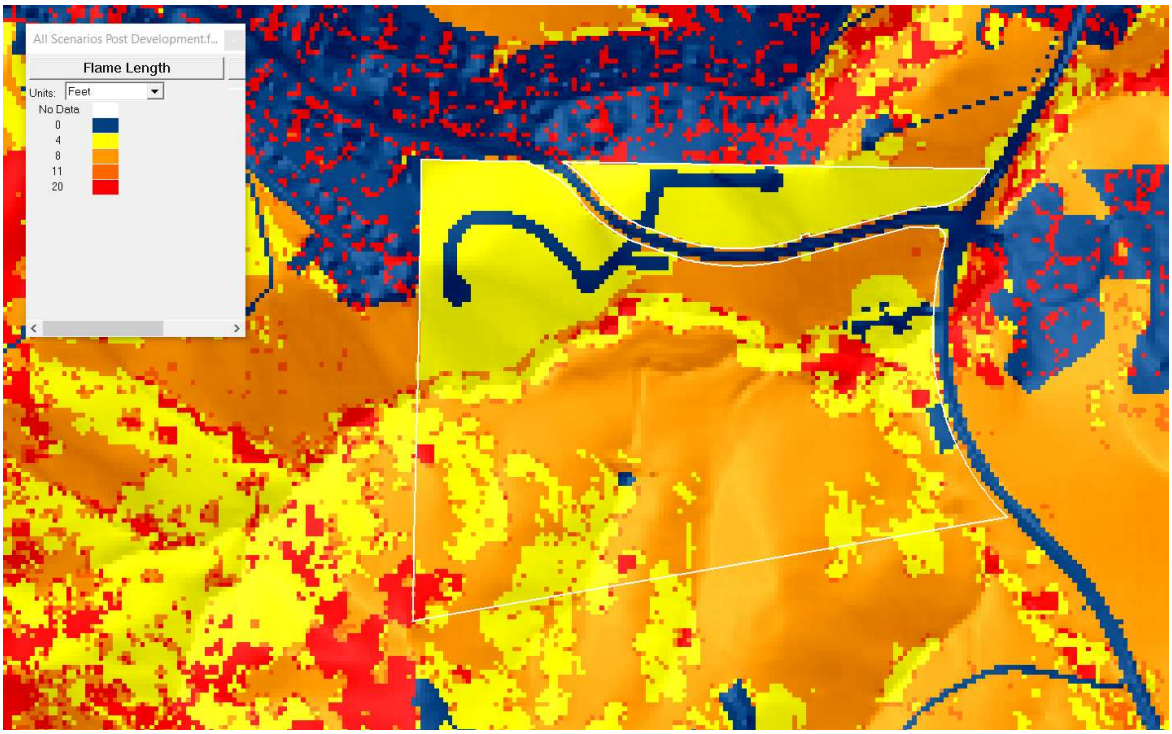


FIGURE 23 – PREDICTED FLAME LENGTHS (IN FEET) FOR THE SOUTHWEST WIND SCENARIO DESCRIBED IN TABLE 8A POST IMPLEMENTATION OF MANAGEMENT ACTIONS.

Flame Length Category	Acres	Percent	Percent Difference*	
No predicted fire	2.78	5%	4%	Slight inc
< 4 feet	25.70	44%	25%	Large inc
4 – 8 feet	27.79	47%	-28%	Large dec
8 – 11 feet	0.93	2%	0	No change
11-20 feet	0.22	0.4%	0	No change
> 20 feet	1.41	2%	-0.2%	Slight dec
Total Acres	**58.9**			

TABLE 23 – ACRES PER PREDICTED FLAME LENGTH CATEGORY ON SCOTT RANCH FOR THE SOUTHWEST WIND SCENARIO DESCRIBED IN TABLE 8A POST IMPLEMENTATION OF MANAGEMENT ACTIONS. *DIFFERENCE IN PERCENTAGE POINTS FROM PRE-DEVELOPMENT SCENARIO.

Like in all the FlamMap predictions, no fire is predicted on Windsor Drive, the pond in the southern portion of the property, nor is it predicted for the existing building site.

Where grass fuels were changed from GR2 to GR1 (Zones 1, 2, 3 4 & 5) and changed to TL1 (primarily the proposed residential lots) flame lengths were reduced to below 4 feet. Flame lengths were also lowered in Zones 6, 7, 8 & 10, whereas flame lengths remained the same in Zone 9 (where grazing prevents shrub growth but does not shorten grass enough to change the representative fuel model).

Rate of Spread (SW, post-development)

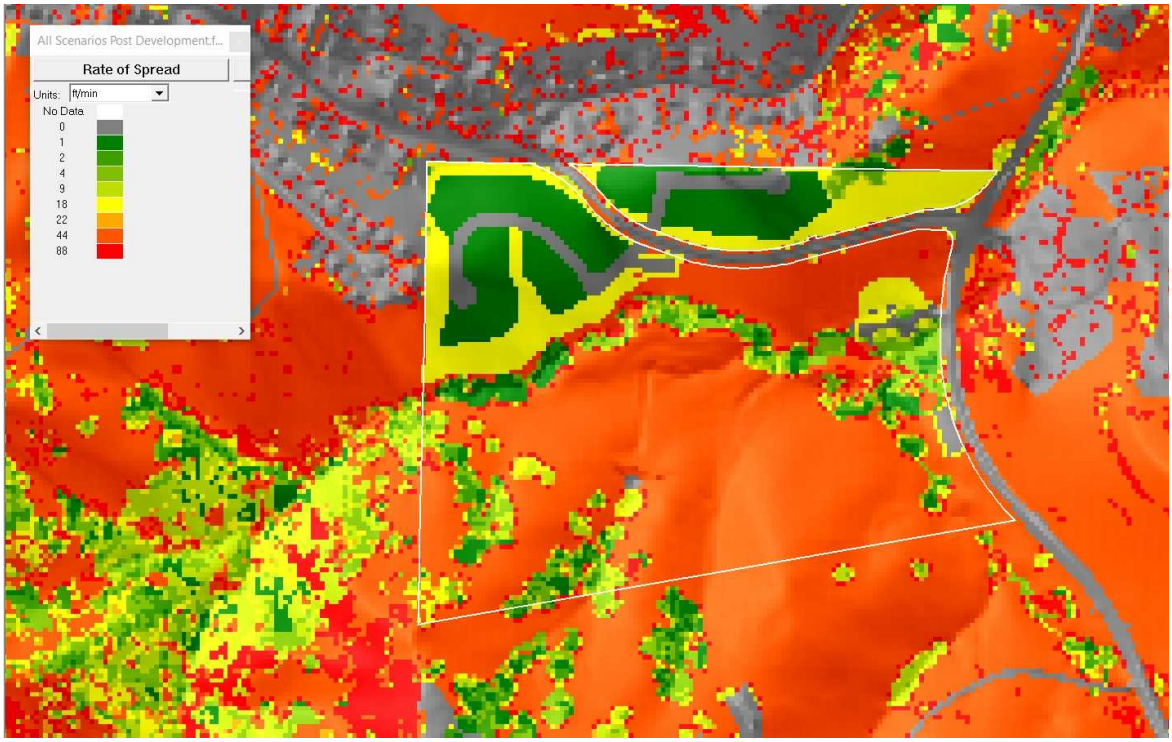


FIGURE 24 - PREDICTED RATE OF SPREAD (FEET/MINUTE) FOR THE SOUTHWEST WIND SCENARIO DESCRIBED IN TABLE 8A POST IMPLEMENTATION OF MANAGEMENT ACTIONS.

Rate of Spread Category	Acres	Percent	Percent Difference*	
No predicted fire	2.8	5%	4%	Slight inc
< 1 foot/minute	9.3	16%	13%	Mod inc
1 – 5 ft/min	4.9	8%	1%	Slight inc
5 – 10 ft/min	1.5	3%	0%	No change
10 – 15 ft/min	7.5	13%	12%	Mod inc
15 – 20 ft/min	0.5	1%	0%	No change
20 – 40 ft/min	29.9	51%	-28%	Large dec
> 40 ft/min	2.4	4%	-1%	Slight dec
Total Acres	**58.9**			

TABLE 24 – ACRES PER PREDICTED RATE OF SPREAD CATEGORY ON SCOTT RANCH FOR THE SOUTHWEST WIND SCENARIO DESCRIBED IN TABLE 8A POST IMPLEMENTATION OF MANAGEMENT ACTIONS. *DIFFERENCE IN PERCENTAGE POINTS FROM PRE-DEVELOPMENT SCENARIO.

Like in all the FlamMap predictions, no fire is predicted on Windsor Drive, the pond in the southern portion of the property, nor is it predicted for the existing building site.

Where the proposed residential lots are located, the fuel model was changed to TL1. This resulted in a much-reduced rate of spread (less than 1 feet/minute) than in the pre-development scenario. Rate of spread is still relatively high in the fuel management zones where grass fuel types predominate, but it is half as much as pre-development (20 feet/minute).

Crown Fire Activity (SW, post-development)

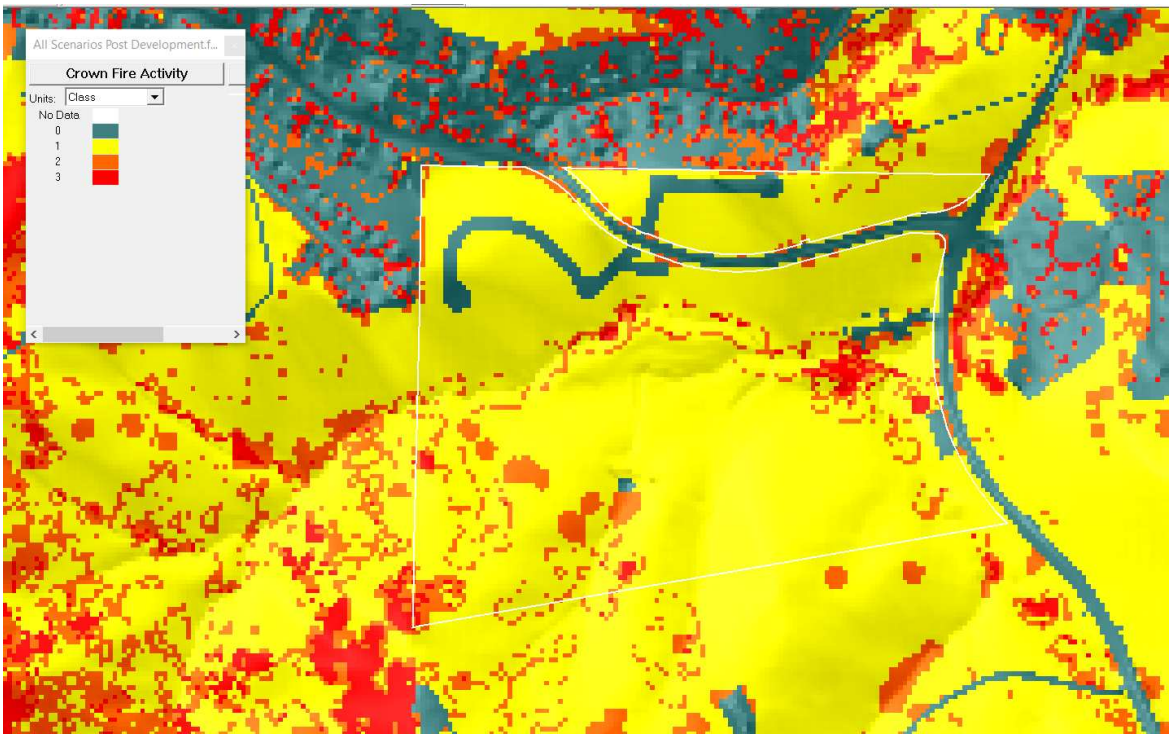


FIGURE 25 - PREDICTED CROWN FIRE ACTIVITY (0 = NO FIRE, 1 = SURFACE FIRE, 2 = TORCHING FIRE, 3 = ACTIVE CROWN FIRE) FOR THE SOUTHWEST WIND SCENARIO DESCRIBED IN TABLE 8A POST IMPLEMENTATION OF MANAGEMENT ACTIONS.

Crown Fire Activity Category	**Acres**	**Percent**	**Percent Difference***	
No predicted fire	2.8	5%	4%	Slight inc
Surface fire (1)	50.3	86%	-4%	Slight dec
Torching fire (2)	4.7	8%	0%	No change
Active crown fire (3)	1.0	2%	0%	No change
Total Acres	**58.9**			

TABLE 25 – ACRES PER CROWN FIRE ACTIVITY CATEGORY ON SCOTT RANCH FOR THE SOUTHWEST WIND SCENARIO DESCRIBED IN TABLE 8A POST IMPLEMENTATION OF MANAGEMENT ACTIONS. *DIFFERENCE IN PERCENTAGE POINTS FROM PRE-DEVELOPMENT SCENARIO.

Like in all FlamMap predictions, no fire is predicted along Windsor Drive, the pond in the southern portion of the property, nor is it predicted for the existing building site.

A surface fire is predicted for 86% of the property as would be expected for any grass and shrub fuel types. Very little change is evident in the predicted results for crown fire between pre and post development because no significant management action is proposed in the treed portion of the property (mainly along the creeks and in the southwest corner of the property).

Northeast (or Diablo) Wind Scenario

For the inputs detailed in Table 8b above, with the exception of the altered fuel model layer, the following fire potential was predicted for the entire modeled area surrounding Scott Ranch.

Flame Length (NE, post-development)

This run also showed the marked decreased in fire behavior post implementation of the fuel management recommendations.

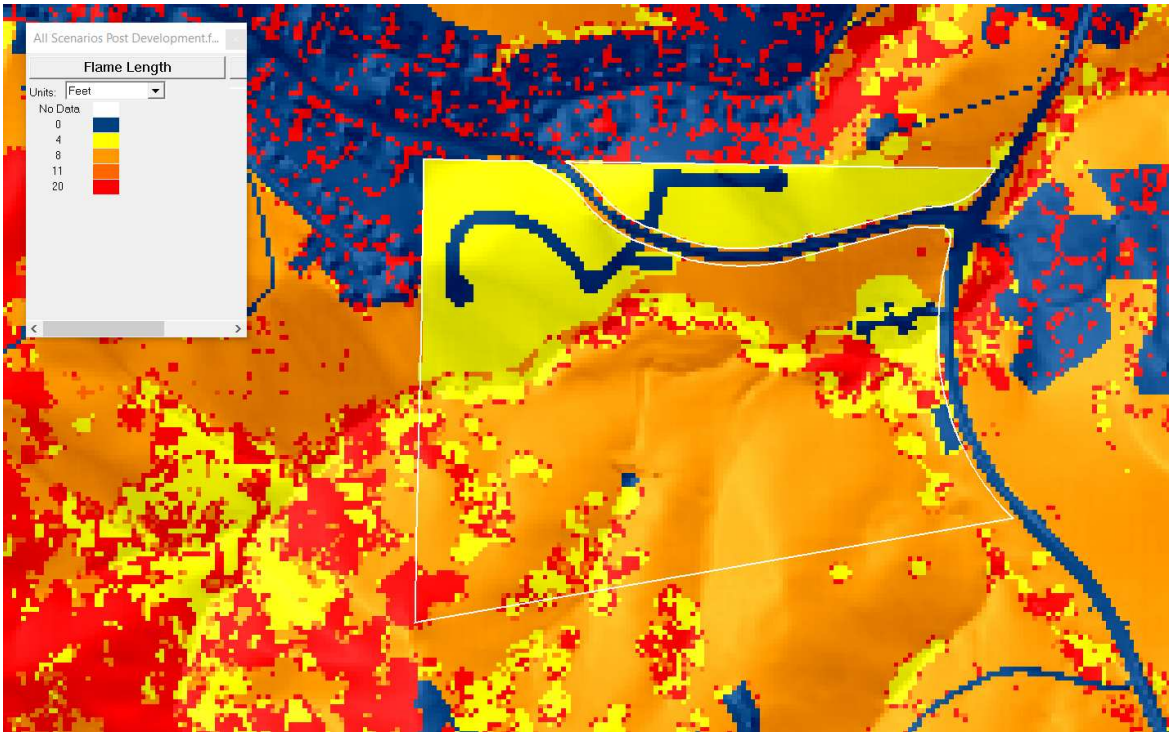


FIGURE 26 – PREDICTED FLAME LENGTHS (IN FEET) FOR THE NORTHEAST WIND SCENARIO DESCRIBED IN TABLE 8B POST IMPLEMENTATION OF MANAGEMENT ACTIONS.

Flame Length Category	Acres	Percent	Percent Difference*	
No predicted fire	2.78	5%	4%	Slight inc
< 4 feet	21.1	36%	25%	Large inc
4 – 8 feet	30.4	52%	-28%	Large dec
8 – 11 feet	0.8	1%	0	No change
11-20 feet	0.8	1%	0	No change
> 20 feet	2.9	5%	0%	No change
Total Acres	**58.9**			

TABLE 26 – ACRES PER PREDICTED FLAME LENGTH CATEGORY ON SCOTT RANCH FOR THE NORTHEAST WIND SCENARIO DESCRIBED IN TABLE 8B POST IMPLEMENTATION OF MANAGEMENT ACTIONS. *DIFFERENCE IN PERCENTAGE POINTS FROM PRE-DEVELOPMENT SCENARIO.

Like in all the FlamMap predictions, no fire is predicted on Windsor Drive, the pond in the southern portion of the property, nor is it predicted for the existing building site.

Similar to the Southwest FlamMap predictions, where grass fuels were changed from GR2 to GR1 (Zones 1, 2, 3 4 & 5) and changed to TL1 (primarily the proposed residential lots) flames lengths were reduced down to below 4 feet. Flame lengths were also lowered in Zones 6, 7, 8 & 10, whereas flame lengths remained the same in Zone 9 (where grazing prevents shrub growth but does not shorten grass enough to change the representative fuel model).

Rate of Spread (NE, post-development)

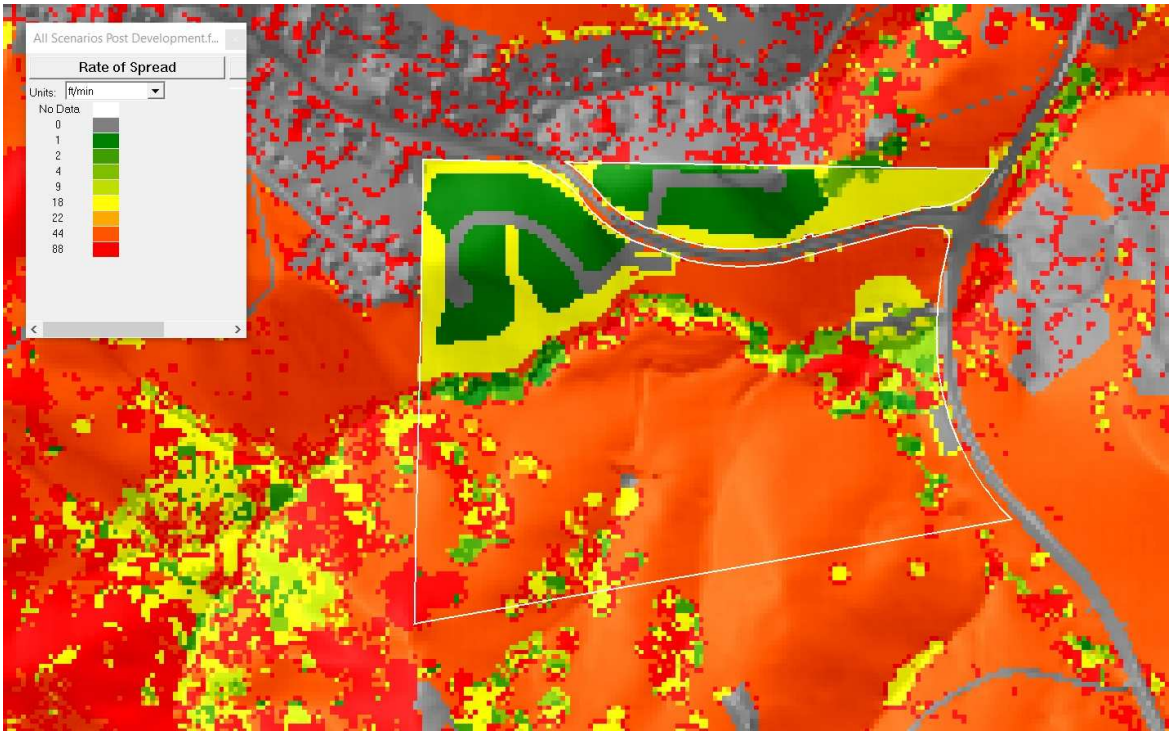


FIGURE 27 - PREDICTED RATE OF SPREAD (FEET/MINUTE) FOR THE NORTHEAST WIND SCENARIO DESCRIBED IN TABLE 8B POST IMPLEMENTATION OF MANAGEMENT ACTIONS.

Rate of Spread Category	Acres	Percent	Percent Difference*	
No predicted fire	2.8	5%	4%	Slight inc
< 1 foot/minute	6.0	10%	9%	Slight inc
1 – 5 ft/min	5.6	9%	4%	Slight inc
5 – 10 ft/min	1.6	3%	0%	No change
10 – 15 ft/min	4.2	7%	6%	Slight inc
15 – 20 ft/min	3.9	7%	6%	Slight inc
20 – 40 ft/min	27.6	47%	-28%	Large dec
> 40 ft/min	7.2	12%	-1%	Slight dec
Total Acres	**58.9**			

TABLE 27 – ACRES PER PREDICTED RATE OF SPREAD CATEGORY ON SCOTT RANCH FOR THE NORTHEAST WIND SCENARIO DESCRIBED IN TABLE 8B POST IMPLEMENTATION OF MANAGEMENT ACTIONS. *DIFFERENCE IN PERCENTAGE POINTS FROM PRE-DEVELOPMENT SCENARIO.

Like in all the FlamMap predictions, no fire is predicted on Windsor Drive, the pond in the southern portion of the property, nor is it predicted for the existing building site.

As with the Southwest FlamMap results, where the proposed residential lots are located, the fuel model was changed to TL1. This resulted in a much reduced rate of spread (less than 1 feet/minute) than in the pre-development scenario. Rate of spread is still relatively high in the fuel management zones where grass fuel types predominate, but it is half as much as pre-development (20 feet/minute).

Crown Fire Activity (NE, post-development)

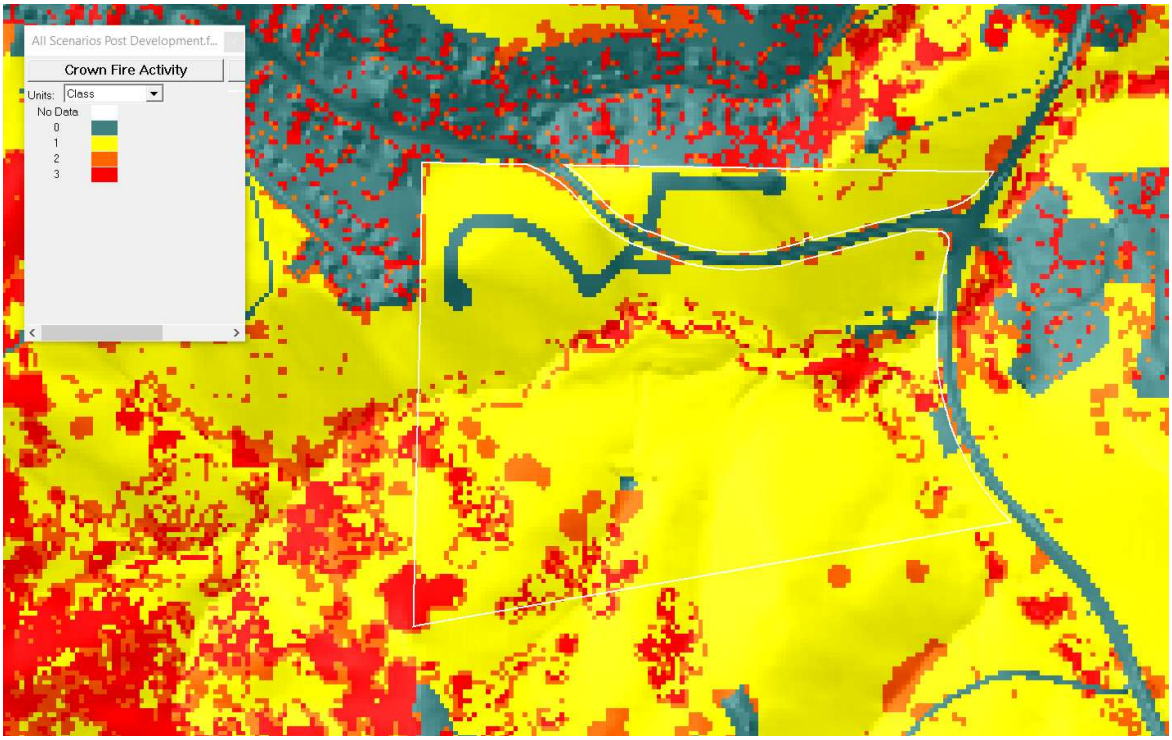


FIGURE 28 - PREDICTED CROWN FIRE ACTIVITY (0 = NO FIRE, 1 = SURFACE FIRE, 2 = TORCHING FIRE, 3 = ACTIVE CROWN FIRE) FOR THE NORTHEAST WIND SCENARIO DESCRIBED IN TABLE 8B POST IMPLEMENTATION OF MANAGEMENT ACTIONS.

Crown Fire Activity Category	Acres	Percent	Percent Difference*	
No predicted fire	2.8	5%	4%	Slight inc
Surface fire (1)	50.3	86%	-4%	Slight dec
Torching fire (2)	4.7	8%	0%	No change
Active crown fire (3)	1.0	2%	0%	No change
Total Acres	**58.9**			

TABLE 28 – ACRES PER PREDICTED CROWN FIRE ACTIVITY CATEGORY ON SCOTT RANCH FOR THE NORTHEAST WIND SCENARIO DESCRIBED IN TABLE 8B POST IMPLEMENTATION OF MANAGEMENT ACTIONS. *DIFFERENCE IN PERCENTAGE POINTS FROM PRE-DEVELOPMENT SCENARIO.

Like in all FlamMap predictions, no fire is predicted on Windsor Drive, the pond in the southern portion of the property, nor is it predicted for the existing building site.

Like the Southwest FlamMap scenario, a surface fire is predicted for 86% of the property as would be expected for any grass and shrub fuel types. Very little change is evident in the predicted results for crown fire between pre and post development because no significant management action is proposed in the treed portion of the property (mainly along the creeks and in the southwest corner of the property).

Traffic Impacts/Accumulations

Once we have an idea of how fire behavior can impact an area, Network Analyst in ArcMap can be used to determine the impacts an evacuation might have on nearby roads. A count of the number of expected vehicles that utilize any given portion of a road can be determined and shown as traffic accumulations. These numbers can help with evacuation planning or highlight areas that may be of concern.

Note, this is different from a normal traffic analysis that assumes that everyone will ***not*** leave a given area at the same time. This analysis assumes a mass exodus and solves for how many vehicles are expected on any given segment of road under those conditions.

Road Network

A road network is prepared to create a Network Dataset in ArcMap. This preparation involved adding road segments that may be missing or, in this case, added due to new development. It also includes making sure a cost (in terms of time it takes to travel any portion of the road network based on speed limits) is associated with every road segment.

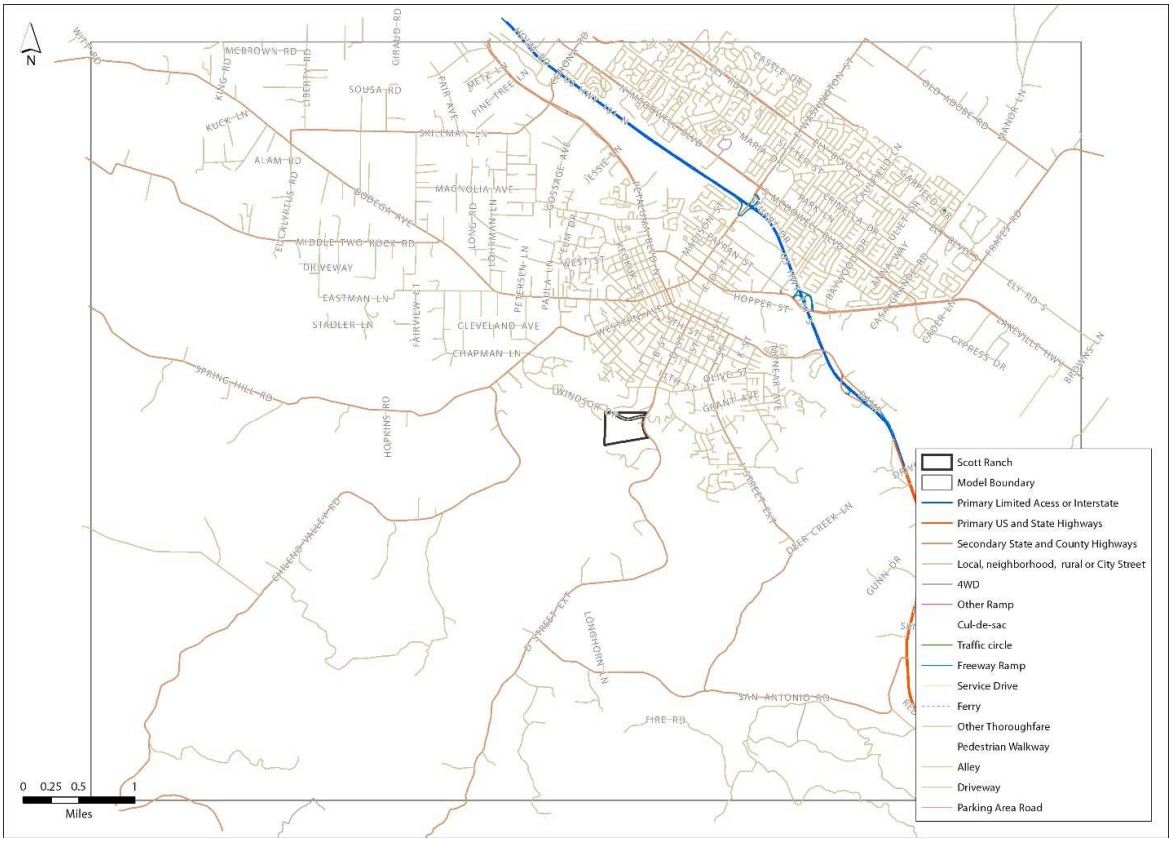


FIGURE 29 - STREETS USED IN EVACUATION ACCUMULATION ANALYSIS (SOURCE: ESRI, 2020).

Egress Points (destinations or facilities)

Egress points (or destinations) were then determined. Three locations were chosen based on traffic studies conducted for the Scott Ranch development and likely locations of congregation. The locations used are listed below:

1. The intersection of Lakeville Highway and East D Street (122° 38' 2.483" W, 38° 14' 12.972" N)
2. On Chileno Valley Road just before San Antonio Creek (122° 42'7.755" W, 38° 12' 3.552" N)
3. At the intersection of San Antonio Road and D Street (extension) (122° 39'4.516" W, 38° 11' 26.13" N)

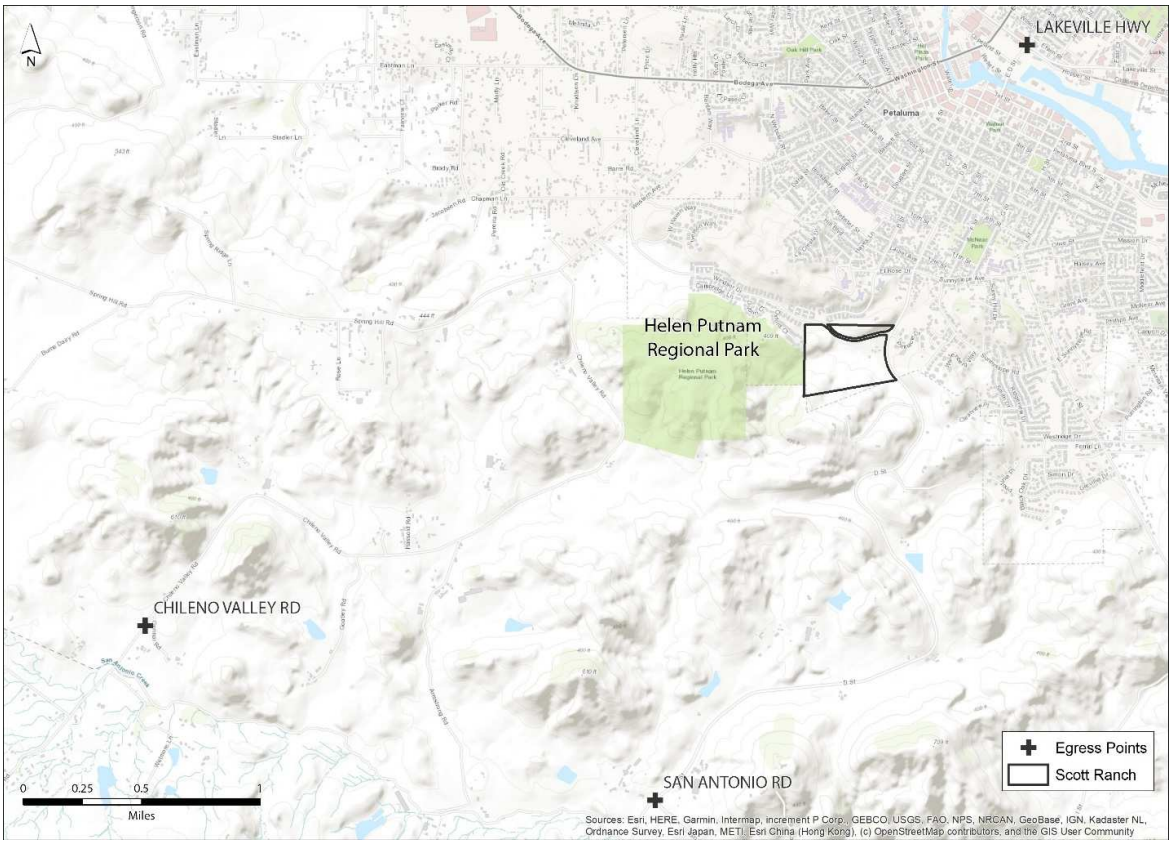


FIGURE 30 - LOCATION OF EGRESS POINTS USED IN EVACUATION ACCUMULATION ANALYSIS.

Structures (incidents)

Building outlines were acquired online from the Sonoma County GIS database portal. The building database did not include identifying features such as single-family residence, outbuilding, etc. Therefore, it was assumed that each structure would have at least one person occupying the site with one vehicle. The centroids for each structure were derived and these points created the basis of the route solver in Network Analyst.

Pre-development, there were 1,103 structures chosen (shown in black in Figure 18) based on the fire behavior predictions for all scenarios presented in this document. Structures that were adjacent to or overrun by any of the fires were included. Post-development, an additional 28 structures/vehicles were added (total of 1,131 structures).

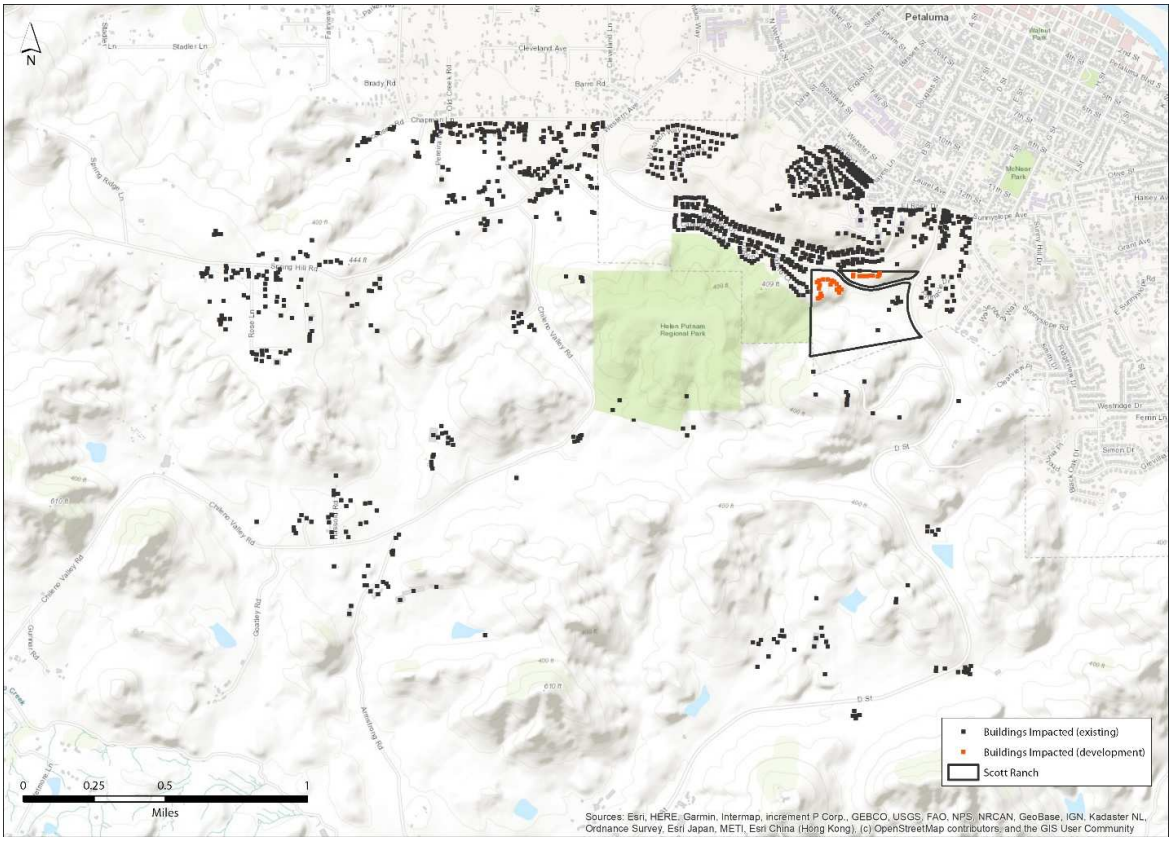


FIGURE 31 - STRUCTURES CHOSEN FOR ANALYSIS.

Routes Solved

Routes from each structure (or incident) were solved for each egress point. The highest-ranking route (less time to travel) were selected from these and joined with the street network to get a count of how many vehicles are expected to travel on any segment of the street network to get to an egress point.

Figures 20 - 23 show these route accumulations along for pre- and post-development along with two of the fire prediction scenarios (Northeast DRY and Southwest scenarios). Buildings are circled. The size of the circle indicates the time at which a house is impacted by the predicted fire. Solved routes are thicker where increasing numbers of vehicles impact the route.

Number of structures impacted by the fire growth at each time step is provided in Tables 18 and 19 (post development only).

Time Step (since fire start)	Total Structures Impacted
30 minutes	5
60 minutes	22
90 minutes	39
120 minutes	41
150 minutes	48
180 minutes	54
Over 180 minutes	1131

TABLE 29 – NUMBER OF STRUCTURES IMPACTED BY NORTHEAST (DRY) SCENARIO WITH DEVELOPMENT.

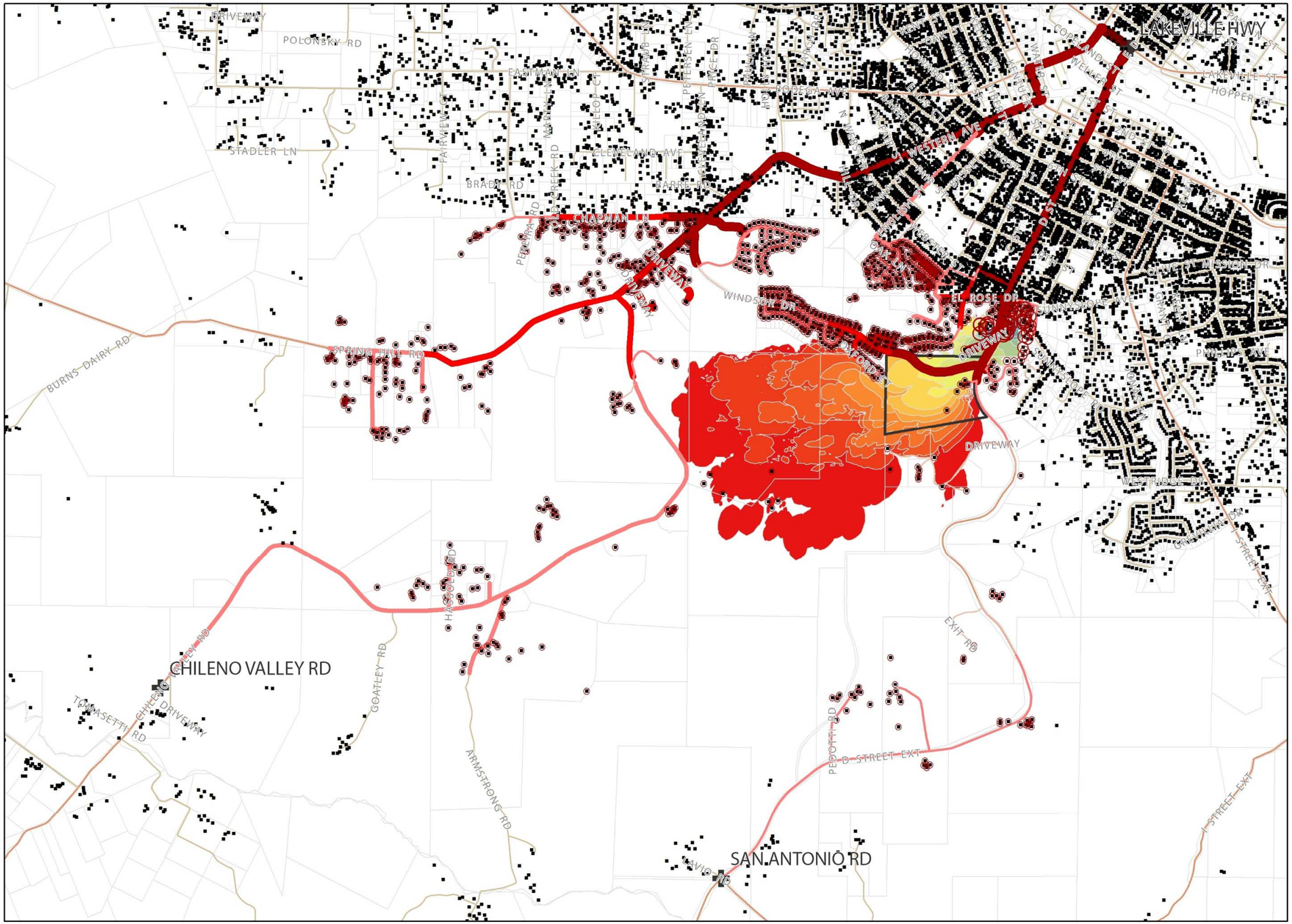
Time Step (since fire start)	Total Structures Impacted
30 minutes	2
60 minutes	3
180 minutes	7
Over 180 minutes	1131

TABLE 30 – NUMBER OF STRUCTURES IMPACTED BY SOUTHWEST SCENARIO WITH DEVELOPMENT.

For all scenarios, pre-development structures impacted numbered 1,103. Post the proposed development, the number of structures impacted would increase by only 28, for a total of 1,131. This structure increase resulted in 28 additional vehicles (given the assumption of one vehicle per structure) along Windsor Drive east of the proposed development and along D Street north of the proposed development. Because the best (quickest) route from the proposed subdivision to the Lakeville Highway egress point (the closest egress point) goes through the intersection of D Street and Windsor Drive, this resulted in an increase at that intersection from 231 to 260 potential vehicles passing through during an evacuation event. This represents a 13% increase.

Route Accumulations
No Development - Northeast (Diablo) Wind Scenario

Scott Ranch Development
City of Petaluma
Sonoma County



Map Features

Legend

Time

- 30 minutes
- 60
- 90
- 120
- 150
- 180
- Over 180 minutes
- All Buildings
- Egress Points

Evacuation Accumulations

- 10 vehicles or less
- 11 - 50
- 51 - 100
- 101 - 150
- 151 - 200
- 201 - 500
- Over 500 vehicles
- Scott Ranch
- Parcels

Fire Perimeters

Hour

- 930
- 1000
- 1030
- 1100
- 1130
- 1200
- 1230
- 1300
- 1330
- 1400
- 1430
- 1500
- 1530
- 1600
- 1630
- 1700
- 1730
- 1800

N

0 1,000 2,000 4,000

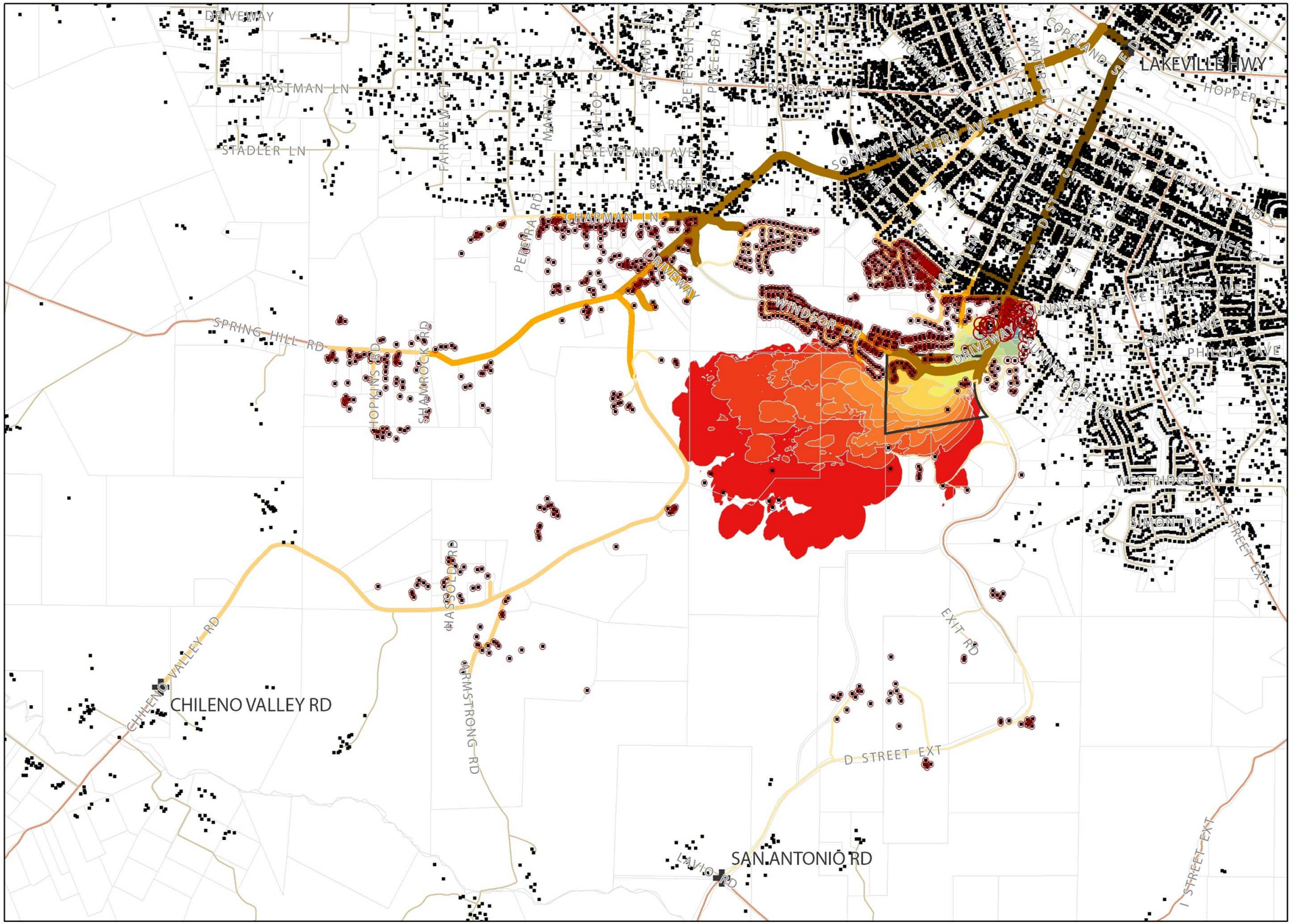
Feet

Wildland Res Mgt
(925) 944-5282
carollrice@aol.com

DIGITAL MAPPING SOLUTIONS
INTEGRATING DATA TO CREATE SPATIAL KNOWLEDGE

Route Accumulations
With Development - Northeast (Diablo) Wind Scenario

Scott Ranch Development
City of Petaluma
Sonoma County



Map Features

Legend

Time

- 30 minutes
- 60
- 90
- 120
- 150
- 180
- Over 180 minutes
- All Buildings
- Egress Points

Evacuation Accumulations

- 1 - 10
- 11 - 50
- 51 - 100
- 101 - 150
- 151 - 200
- 201 - 500
- 501 - 1010
- Scott Ranch
- Parcels

Fire Perimeters

Hour

- 930
- 1000
- 1030
- 1100
- 1130
- 1200
- 1230
- 1300
- 1330
- 1400
- 1430
- 1500
- 1530
- 1600
- 1630
- 1700
- 1730
- 1800

N

0 1,000 2,000 4,000

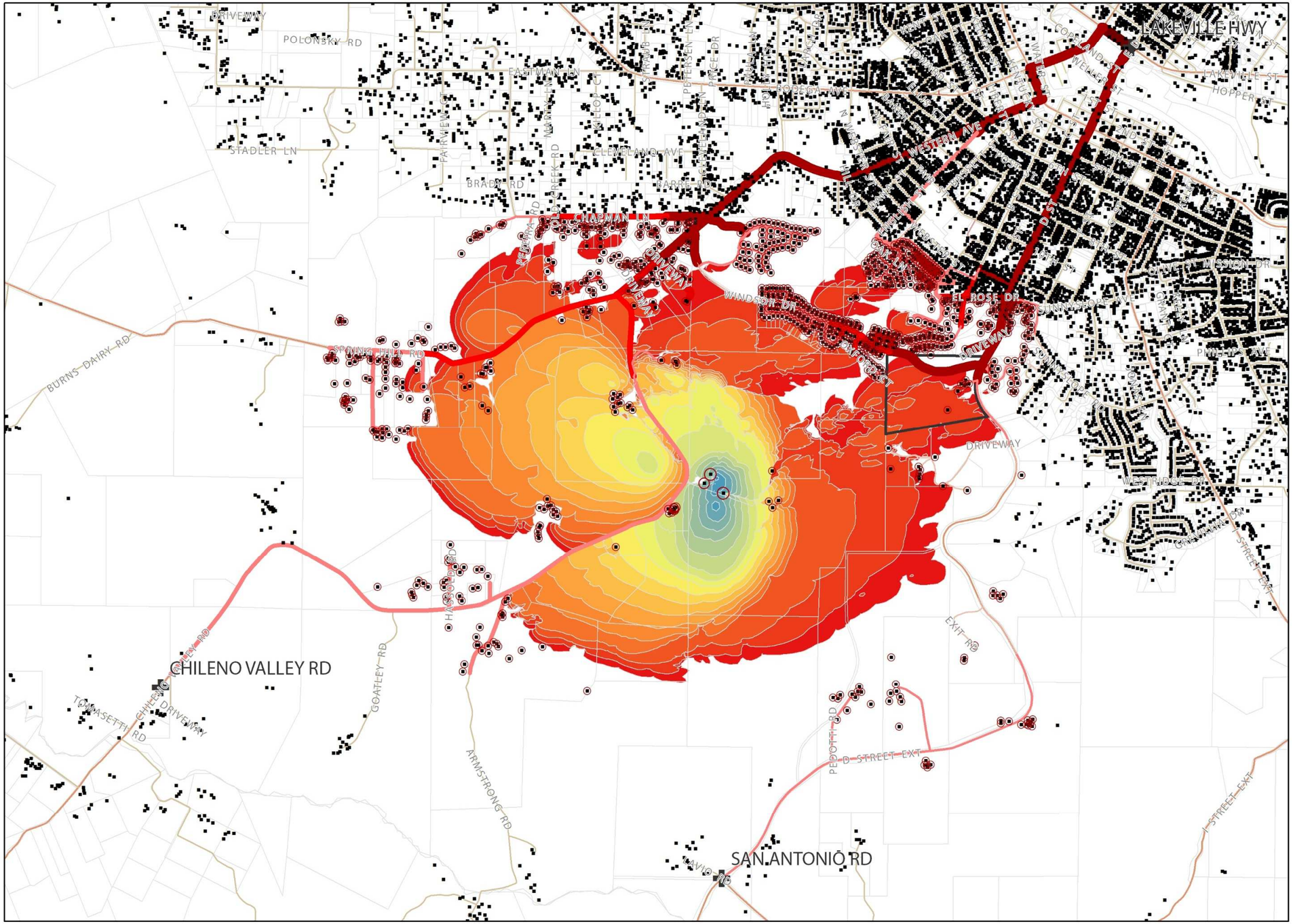
Feet

Wildland Res Mgt
(925) 944-5282
carollrice@aol.com

DIGITAL MAPPING SOLUTIONS
INTEGRATING DATA TO CREATE SPATIAL KNOWLEDGE

Route Accumulations
No Development - Southwest Wind Scenario

Scott Ranch Development
City of Petaluma
Sonoma County



Map Features

Legend

TimeSW

- 30 mintures
- 60
- 180
- Over 180 minutes
- All Buildings
- Egress Points

Evacuation Accumulations

- 10 vehicles or less
- 11 - 50
- 51 - 100
- 101 - 150
- 151 - 200
- 201 - 500
- Over 500 vehicles
- Scott Ranch
- Parcels

Fire Perimeters - Hour

- 930
- 1000
- 1030
- 1100
- 1130
- 1200
- 1230
- 1300
- 1330
- 1400
- 1430
- 1500
- 1530
- 1600
- 1630
- 1700
- 1730
- 1800

N

0 1,000 2,000 4,000

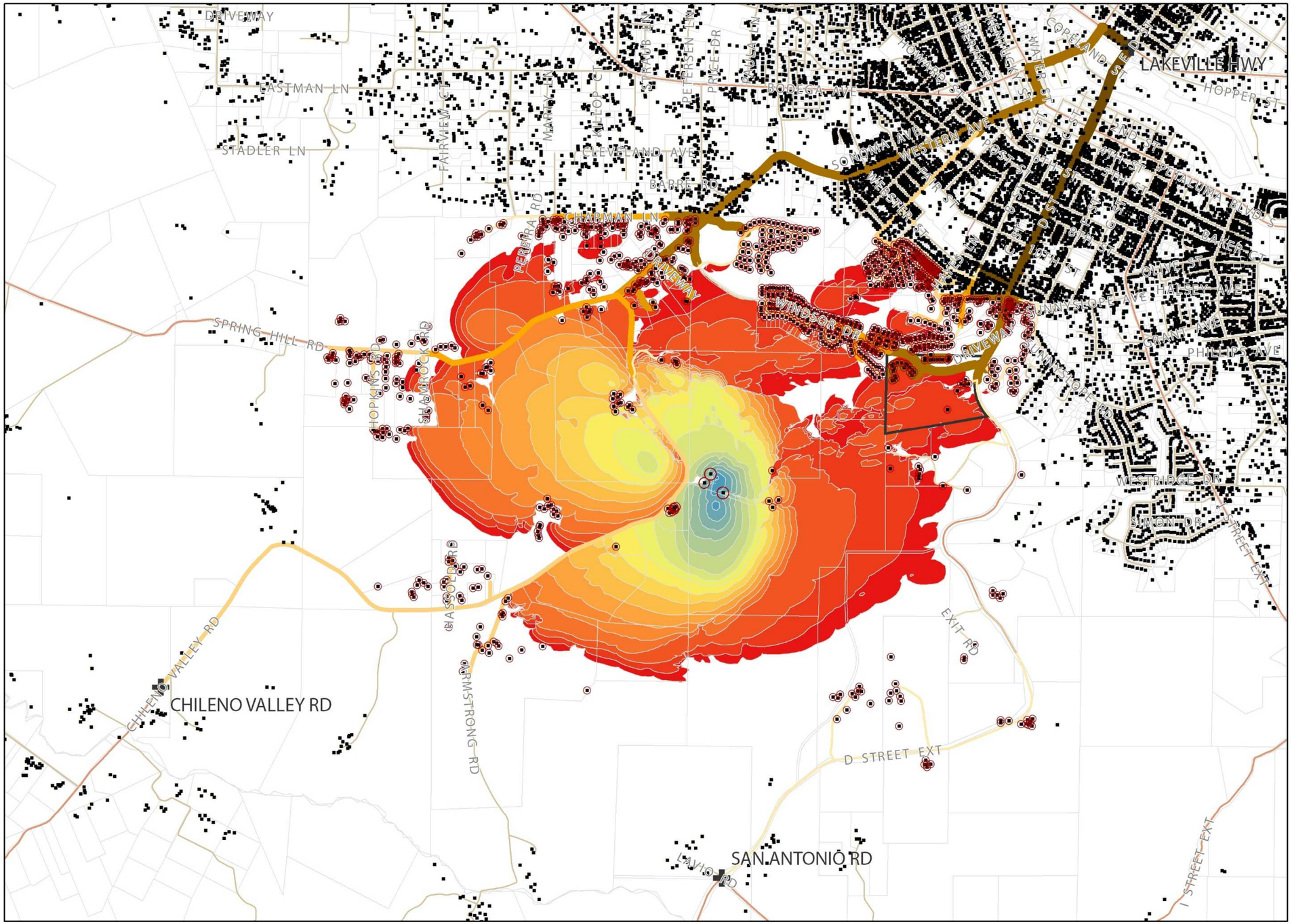
Feet

Wildland Res Mgt
(925) 944-5282
carollrice@aol.com

DIGITAL MAPPING SOLUTIONS
INTEGRATING DATA TO CREATE SPATIAL KNOWLEDGE

Route Accumulations
With Development - Southwest Wind Scenario

Scott Ranch Development
City of Petaluma
Sonoma County



Map Features

Legend

TimeSW

- 30 minutes
- 60
- 180
- Over 180 minutes
- All Buildings
- Egress Points

Evacuation Accumulations

- 1 - 10
- 11 - 50
- 51 - 100
- 101 - 150
- 151 - 200
- 201 - 500
- 501 - 1010
- Scott Ranch
- Parcels

Fire Perimeters

Hour

- 930
- 1000
- 1030
- 1100
- 1130
- 1200
- 1230
- 1300
- 1330
- 1400
- 1430
- 1500
- 1530
- 1600
- 1630
- 1700
- 1730
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DIGITAL MAPPING SOLUTIONS
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APPENDIX B: FIRE-RESISTANT PLANTS AND PROHIBITED SPECIES

THE CHARACTERISTICS OF FIRE-SAFE PLANTS

Many communities are promoting the use of fire-safe plants and implementing projects to demonstrate techniques for reducing the fire risk to structures. It is clear that numerous factors must be considered in rating the fire performance of plants, including:

Total Volume – The greater the volume of plant material the greater the fire hazard. More fuel is provided for the fire.

Moisture Content – The moisture content of plants is an important consideration because high levels of plant moisture can lower fire risk and act as a heat sink, reducing the intensity and spread of fire.

Amount and Distribution of Dead Material – The amount of dead material found in a plant influences the total amount of water in the overall plant because the dead material is usually much drier than living tissue.

Size of Leaves, Twigs, and Branches – Materials with large surface areas (e.g. needles, twigs, or large, flat leaves) dry more rapidly under fire conditions than materials with lower ratios (e.g. branches, fleshy leaves).

Geometry and arrangement (overall spatial distribution of the biomass) of the plant – The shape of a plant and how the biomass is distributed throughout the plant is important because this bulk density affects the air flow and heat transfer through the plant. The arrangement of material within the plant effects the fuel continuity and the tendency for preheating and fire spread.

Plant Maintenance – The significance of proper plant and landscape maintenance cannot be overemphasized. *Poorly maintained landscapes can easily become fire hazards even if many of the plants are favorably recommended for fire performance.*

All of the previously mentioned plant characteristics are related to maintenance issues. Plants with a higher moisture content generally have a lower fire risk. For example, the moisture content of a plant is absolutely influenced by regular and proper irrigation and large amounts of dead material lower the overall moisture content of the plant. Dead material should be removed and properly disposed of to increase the overall moisture content of the plant. Regular maintenance should include the removal of dead material, thinning or pruning to reduce fuel volume and improve geometry to lower the fire risk.

Plant spacing, pruning, aeration, fertilization, irrigation and other cultivation practices should be consistent with a nursery's or landscape professional's recommendations.

The positioning of plants relative to each other and structures is also very important. Landscapes should be designed and maintained to discourage the creation of "fuel ladders" – a continuous fuel path by which a fire can climb from the ground to a shrub, to a tree and ultimately to the structure. Removal of any potential fuel ladders needs to be part of the routine landscape maintenance.

An appropriately landscaped and maintained defensible space will reduce the fire hazard and the fire risk to structures. A landscape environment that is inconsistently or improperly maintained cannot be considered defensible space and contributes to the fire hazard.

For reference on fire-resistant species, see: http://diablofiresafe.org/tolerance.html

SPECIES LIST FOR PROHIBITED LANDSCAPING PLANTS

Due to their combustible nature, these plants shall be prohibited from the lots.

Botanical Name	Common name
Abies spp.	fir
Acacia spp.	acacia
Adenostoma fasciculatum	chamise
Adenostoma sparsifolium	red shanks
Artemsia californica	California sage
Baccharis pilularis consanguinea	coyote brush
Bamboo spp.	bamboo
Cedrus spp.	cedar
Cortaderia selloana	pampas grass
Cupressus spp.	cypress
Dodonaea viscosa	hopseed bush
Erigonom fasiculatum	California buckwheat
Eucalyptus cladocalyx	sugar gum
Eucalyptus globulus	blue gum
Eucalyptus viminalis	Manna gum
Hedera canariensis	Algerian ivy
Juniperus spp.	juniper
Pennisetum setaceum	fountain grass
Picea spp.	spruce
Pinus spp.	pines
Salvia mellifera	black sage
Schinus spp.	California pepper tree

In addition, plants should not be established which could invade nearby regional parks and open spaces. For best practices regarding removal of invasive plant species, see *Vegetation Management Almanac (see http://www.diablofiresafe.org/vegetation_almanac.html)*, which has a list of species that should not be planted because of their invasive nature. The list includes:

Blackwood acacia
coyote bush
Pampas grass
cotoneaster
Italian hawthorn
eucalyptus
broom
mayten
ivy
holly
Monterey pine
pyracantha
blackberry
vinca major

KEY TERMINOLOGY

defensible space – the area within the perimeter of a parcel, neighborhood or community that provides a key point of defense from an approaching wildfire or defense against encroaching wildfires or escaping structure fires

fire intensity – the amount of heat released by a fire in an area in any given time period. Fire intensity is usually related to the flame lengths of a fire.

fuel break – an area in which flammable materials have been cleared away or thinned out to minimize fire spread to structures and/or natural resources

fuel – anything that will burn easily, such as vegetation or small woody material

topography – geographic elements on an area, such as slope steepness, aspect, existence of hills, canyons and rough terrain

wildland – areas which are not developed or farmed

APPENDIX C THE RELATION BETWEEN TRAIL USE, CAMPFIRES AND STOVES AND WILDFIRE RISK

Several land management agencies were contacted with a series of questions aimed at determining the extent to which trail use, campfires and stoves contributed to the risk of wildfire. The questions were:

1. Has your agency experienced any fires started by campers? If so, please provide dates, size and any specifics you may have. Please also note whether the campsites are walk-in or drive-in. I'd be interested in knowing whether the campsites allow campfires or only stoves.
2. Have you observed a difference in ignitions between stove use and campfire use?
3. Has your agency experienced any fires started by trail users? If so, please provide dates, size and any specifics you may have.
4. Has your agency experienced any fires started by vandals in walk-in sites? I would differentiate between fires started at trailheads and those started at locations that had to be walked to. If so, please provide dates, size and any specifics you may have.
5. Overall, has your agency experienced more or less fires where trail use or camping has occurred?

Four agencies responded: East Bay Regional Park District (EBRPD), Marin Municipal Watershed (MMWD), Marin County Open Space District (MCOSD), and the National Park Service (Golden Gate National Recreational Area and Pinnacles National Monument).

The observations each agency for almost every question from were similar.

Prohibition of all fires and restriction of access to hours of daylight did not prevent wildfires associated with trail use. **Indications are that authorizing use, with attendant fuel management, patrol and enforcement presence may limit wildfires**. Pt. Reyes National Seashore has experienced no significant fires where trail use or camping is offered.

Stoves do not cause wildfires. No agency experienced fires started by stoves.

Illegal campfires are the biggest source of wildfires. On MCOSD lands "Most of the fires we experienced have been illegal campfires. Of the 26 wildfires from June, 2006 to January, 2011 listed, 16 were illegal campfires. There were no fires started from authorized campfires. The most damaging, illegal campfire was in 1997 Vision Fire, which was started on Tomales State Park, a walk-in site. This fire destroyed 44 homes in Inverness and burned almost 13,000 acres on Pt Reyes National Seashore, Tomales State Park and private property.

Despite this damaging exception, **most illegal campfires are small in size**. Most of the wildfires caused by illegal campfires on MCOSD lands were confined to a ring or very small area. Others note that even illegal campfires were confined to a ring.

Fuel management plays a role in the extent of fires that started. Lack of abatement around fire rings is believed to contribute to approximately one wildfire/year in the Pinnacles National Monument.

Trail users have started fires, even though it's a relatively rare occurrence. All agencies reported that fires have been started by trail users. Typically the fires are started far from the trailhead, and are associated with "rogue partiers". MMWD experienced a hike-in arsonist who started several wildfires in the 1980's. In 2009 hikers started a campfire in a hollowed-out butt of a standing redwood tree. While it required suppression, the fire only burned a 30' by 30' patch. MMWD similarly reported fires started by trail users were usually smaller than an acre.

Other causes were much more common. Most wildfires in Pt Reyes have been caused by roadside ignitions or arching powerlines. A quote from one agency encapsulates the conclusion: "Fires from campers and trail users are a miniscule part of our fire causes. We get many more from equipment use (mowers hitting rocks, etc.) (27%), vehicles in dry grass (17%) and arsonists." Several other conclusions surfaced.

FEHR PEERS

Memorandum

Date: June 26, 2020

To: Angela Pan, Impact Sciences

From: Matt Goyne and Allison Quach, Fehr & Peers

Subject: Scott Ranch DEIR: Wildfire Evacuation Transportation Assessment

SF14-0761

This memorandum summarizes Fehr & Peers' evaluation of the capacity of local roadways serving the Scott Ranch development site during a wildfire evacuation scenario. This evaluation is based on the evacuation plan developed as a part of the *Scott Ranch Vegetation Management Plan and Wildfire Evacuation Analysis*.[1] We considered evacuation conditions on D Street and Western Avenue for two wind scenarios (Southwest and Northeast), with and without the proposed Scott Ranch development. We find that there is sufficient roadway capacity to accommodate expected evacuation volumes under both evacuation scenarios.

This document is intended to provide an assessment of roadway capacity under the described fire scenarios and should not be considered an evacuation plan.

Methodology

We determined roadway capacities under evacuation conditions for D Street and Western Avenue between Windsor Drive and Petaluma Boulevard. Based on the Highway Capacity Manual[2], the roadway capacity is expected to be 10% below the standard operating capacity for a two-lane roadway due to the number of heavy vehicles typically on these roadways, curves in the roadway, and changes in grade. Based on our conference call with City of Petaluma officials on May 22, 2020, including representatives of the City's Fire Department, we assumed that one lane would operate in the evacuation direction, all non-essential traffic would be diverted away from evacuation routes, and vehicle traffic in the evacuation direction would have priority, whether through traffic control officers or intersection traffic controls operating under emergency conditions. While two lanes would be available under the evacuation conditions described above

[1] *Scott Ranch Vegetation Management Plan and Wildfire Evacuation Analysis*, Wildland Res Mgt, March 2020.
[2] Highway Capacity Manual, 6th Edition, 2016.

assuming one lane of travel for egress is a more conservative assumption that would account for situations in which the second lane needs to be used for emergency access.

We considered evacuation conditions under the two wind scenarios presented in *Scott Ranch Vegetation Management Plan and Wildfire Evacuation Analysis*: a Southwest wind scenario and a Northeast wind scenario. Under both scenarios, we assumed that the majority of residences within the fire zone would evacuate north to Petaluma Boulevard via D Street or Western Avenue. Upon reaching Petaluma Boulevard evacuating residents would have access to multiple arterial roadways with higher capacities than D Street or Western Avenue, such as Petaluma Boulevard North or South, East Washington Street, or Lakeville Highway, whether they could travel to US-101 or to designated emergency centers. The residents south of the fire zone who would have to drive north past the fire to reach Petaluma were assumed to travel south on D Street or Western Avenue, away from the fire zone. These southern residents would generate substantially fewer vehicles than the residents evacuating north into Petaluma; therefore, the remainder of this assessment focuses on the northbound evacuation. **Figure 1** shows the evacuation sheds and travel routes used by evacuating residences.

The preliminary egress point for residences on Western Avenue (Zone A, as shown on Figure 1) would be Western Avenue to Petaluma Boulevard, and residences in the fire zone off of D Street (Zone C) would evacuate to D Street at Petaluma Boulevard before dispersing to their final destinations. Approximately 177 homes north of Windsor Drive (Zone B) are located in an area with multiple egress points; therefore, we assumed that 50 percent would evacuate by D Street and that 50 percent would evacuate via English Street to Western Avenue. Residents within the fire zone on Windsor Street would egress to D Street under the Southwest wind scenario, and at Western Avenue under the Northeast wind scenario. These evacuation routing scenarios were selected to present a conservatively high assessment of vehicle trips on D Street and Western Avenue since Petaluma's grid network would allow evacuating residents to also use other streets such as B Street, Sunnyslope Avenue, 8th Street, or 6th Street to evacuate the fire zone.

We analyzed the two wind scenarios under existing and no project conditions. Development of Scott Ranch would add an additional 28 homes to Windsor Drive, which would evacuate using the same routes as existing homes on Windsor Drive – at D Street under the Southwest wind scenario and at Western Avenue under the Northeast wind scenario.

Vehicle demand in the two wind scenarios was determined by multiplying the number of structures in each evacuation shed by a vehicle trip generation rate based on the Santa Rosa Post-Fire Survey (2018), shown in **Table 1**. Based on this survey, we estimated that approximately 1.75 vehicles per household would be used to evacuate the area. Additionally, we assumed that all households within the evacuation zone would evacuate within the same hour. These assumptions result in a conservatively high estimate of vehicle trips for this evacuation assessment due to the following:

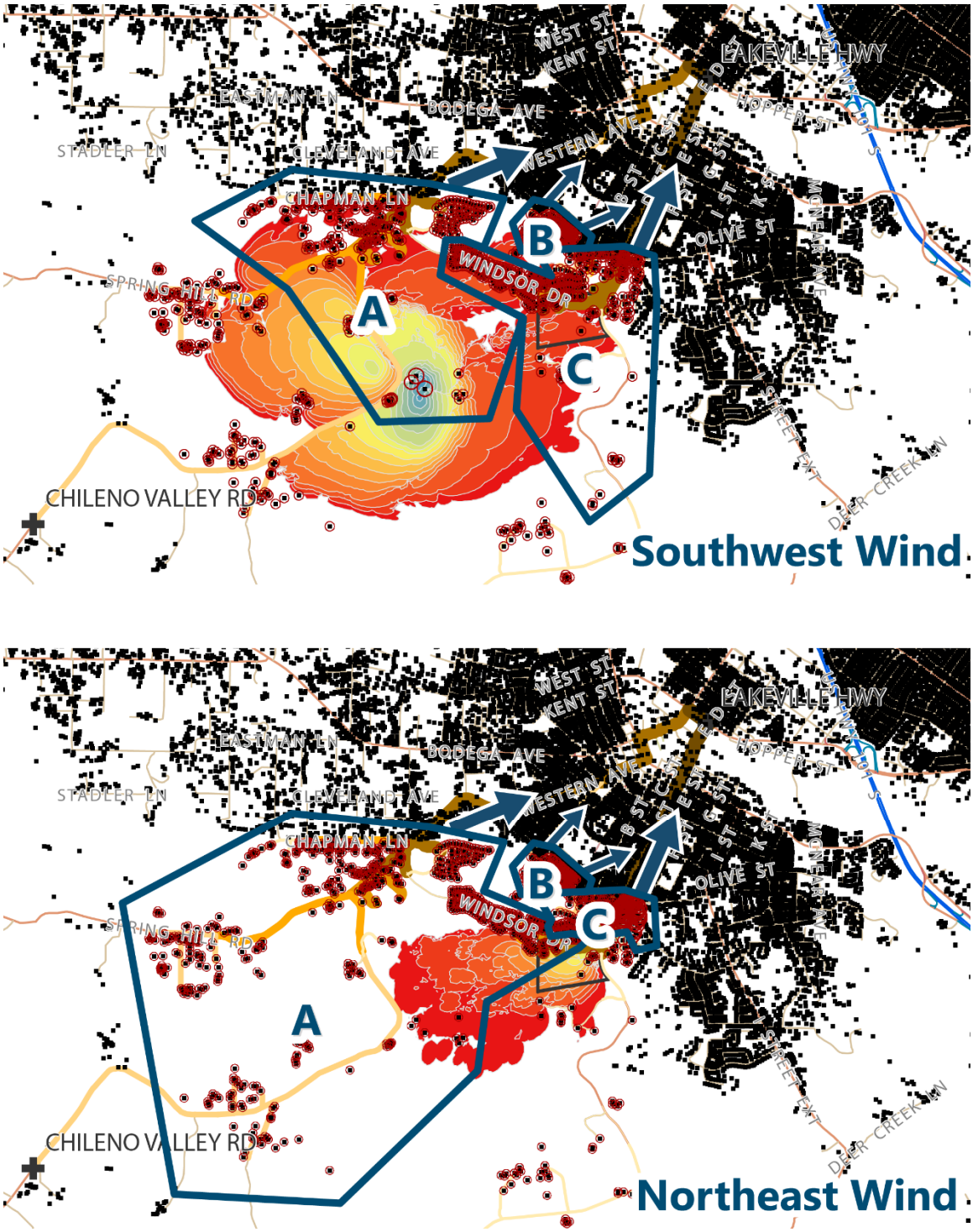
- The *Scott Ranch Vegetation Management Plan and Wildfire Evacuation Analysis* used structures as a proxy for households within the fire evacuation zone, which include non-household or commercial buildings (e.g., sheds, storage units); and,
- The evacuating vehicles would likely be spread out over multiple hours rather than a single hour based on the progression of the fires presented in the *Scott Ranch Vegetation Management Plan and Wildfire Evacuation Analysis*.

Table 1. Vehicle Utilization Rates

Vehicles Used to Evacuate	Percentage of Households
1	46%
2	38%
3	11%
4 or more	5%
1.75	**Weighted Average**

Source: Santa Rosa Post-Fire Survey, 2018. https://www.cmap.illinois.gov/documents/10180/995345/CATMUG-20190403-Lupa-EvacSurvey.pdf/f5550362-e8b3-8d57-2a50-11b4e56162f1, accessed by Fehr & Peers April 2020.

Figure 1. Evacuation Sheds



Results

We compared the estimated vehicle trips generated by evacuating residences to the roadway capacity on D Street and Western Avenue. Under both wind scenarios, all roadway segments would operate at volume to capacity (V/C) ratios of under 1.0, which indicates that the roadways can successfully operate at evacuation capacity. A V/C ratio of greater than 1.0 would result in a vehicle slowdown and longer travel times. The highest V/C ratio expected is 0.86, for Western Avenue between English Street and Petaluma Boulevard, under plus project conditions. Table 1**Table 2** shows roadway evacuation volumes and evacuation capacities.

These results indicate that under the worst-case assumptions described above and the fire scenarios described in the *Scott Ranch Vegetation Management Plan and Wildfire Evacuation Analysis*, D Street and Western Avenue would have sufficient capacity to accommodate evacuating vehicles, and that the active management of vehicle operations at downstream locations by the City of Petaluma Fire Department – whether at Petaluma Boulevard or other intersections, will be important to ensuring that all residents can evacuate in a sufficient amount of time.

Table 2. Roadway Evacuation Volumes and Capacity

Roadway		Roadway Capacity	Existing Conditions		Plus Project	
			Vehicle Trips	V/C[1]	Vehicle Trips	V/C[1]
NE Fire Scenario						
D Street	Windsor Drive to 12th Street	1,620	279	**0.17**	279	**0.17**
	12th Street to Petaluma Blvd N	1,620	434	**0.27**	434	**0.27**
Western Avenue	Windsor Drive to English Street	1,620	1,196	**0.74**	1,245	**0.77**
	English Street to Petaluma Blvd N	1,620	1,351	**0.83**	1,400	**0.86**
SW Fire Scenario						
D Street	Windsor Drive to 12th Street	1,620	713	**0.44**	762	**0.47**
	12th Street to Petaluma Blvd N	1,620	868	**0.54**	917	**0.57**
Western Avenue	Windsor Drive to English Street	1,620	545	**0.34**	545	**0.34**
	English Street to Petaluma Blvd N	1,620	700	**0.43**	700	**0.43**

Source: Fehr & Peers, 2020.
Notes:
1. Volume to capacity ratio. A value less than 1 indicates that the roadway can sufficiently accommodate demand. A value greater than 1 indicates that vehicle demand is higher than roadway capacity, resulting in queuing and delays.

Appendix A: Roadway Capacity Calculations & Assumptions

Scott Homes Wildfire Evacuation Analysis

Prepared by Fehr & Peers, 2020

TRIP GENERATION + ASSIGNMENT

Area	Fire Scenario	Structures[1]		Trips		Route
		No Project	Plus Project	No Project	Plus Project	
A	NE	683	711	1,196	1,245	Western Avenue
B	NE	177	177	310	310	50% Western Avenue, 50% D Street
C	NE	159	159	279	279	D Street
A	SW	311	311	545	545	Western Avenue
B	SW	177	177	310	310	50% Western Avenue, 50% D Street
C	SW	407	435	713	762	D Street

VOLUME/CAPACITY ANALYSIS

Street	from	to	Fire Scenario	Evacuation Lanes	Capacity (1 Lane)	Capacity (Roadway)	Total Reductions	Evacuation Capacity		Trips		V/C	
										No Project	Plus Project	No Project	Plus Project
Western Avenue	Windsor Drive	English Street	NE	1	1,800	1,800	10%	1,620		1,196	1,245	0.74	0.77
Western Avenue	English Street	Petaluma Blvd S	NE	1	1,800	1,800	10%	1,620		1,351	1,400	0.83	0.86
D Street	Windsor Drive	12th Street	NE	1	1,800	1,800	10%	1,620		279	279	0.17	0.17
D Street	12th Street	Petaluma Blvd S	NE	1	1,800	1,800	10%	1,620		434	434	0.27	0.27
Western Avenue	Windsor Drive	English Street	SW	1	1,800	1,800	10%	1,620		545	545	0.34	0.34
Western Avenue	English Street	Petaluma Blvd S	SW	1	1,800	1,800	10%	1,620		700	700	0.43	0.43
D Street	Windsor Drive	12th Street	SW	1	1,800	1,800	10%	1,620		713	762	0.44	0.47
D Street	12th Street	Petaluma Blvd S	SW	1	1,800	1,800	10%	1,620		868	917	0.54	0.57

ASSUMPTIONS

 # Homes[2] 28

Vehicle Utilization[3] 1.75

# of Vehicles	*% Used to Evacuate*
1	*46%*
2	*38%*
3	*11%*
4+	*5%*

Capacity per Lane[4]

Max Theoretical Capacity	1,800
Total Reductions	10%
Operating Capacity	1,620

Notes:

1. Scott Ranch Vegetation Management Plan and Wildfire Evacuation Analysis, Wildland Res Mgt, March 2020

2. Scott Ranch DEIR

3. Santa Rosa Post-Fire Survey, 2018

4. Capacity and reductions based on Highway Capacity Manual (6th Edition) and engineering judgement. Reductions account for the presence of heavy vehicles and roadway characteristics such as curves and grade. Evacuation roadways do not have vegetation overgrowth, which would further reduce roadway capacity in the event of a fire.