Wither Hills Farm Park

Prometheus Wildfire Risk Report Supplement

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1. About Prometheus

Prometheus is a deterministic wildland fire growth simulation model based on the Fire Weather Index (FWI) and Fire Behaviour Prediction (FBP) sub-systems of the New Zealand Forest Fire Danger Rating System (NZFFDRS). The model computes spatially-explicit fire behaviour and spread outputs given heterogeneous fuel, topography and weather conditions. All spatial outputs are compatible with Geographic Information Systems (Tymstra, C.; Bryce, R.W.; Wotton, B.M.; Taylor, S.W.; Armitage, O.B. 2010).

2. Assumptions and Limitations

1. This report supplement should be read in conjunction with the *Wither Hills Farm Park– Wildfire Risk Management Analysis'* report which contains the relevant references.

2. Use of expert opinion assumes the knowledge at the time was the best available.

3. Underlying assumptions within the *Development and Structure of Prometheus: The Canadian Wildland Fire Growth Simulation Model*, the New Zealand Fire Weather Index System adapted from the *Structure of the Canadian Forest Fire Weather Index System,* and the New Zealand Fire Behaviour Prediction System, *A Manual for Predicting Fire Behaviour in New Zealand Fuels*.

4. Remote Automatic Weather Station (RAWS) representative area and the accuracy of weather data. Weather data was analysed from the Woodbourne RAWS long-term fire climate analysis and used as inputs for fire growth modelling. Specifically, weather inputs were selected for days that aligned with scenario requirements.

5. Vegetation species have been categorised into specific New Zealand Fire Behaviour Fuel Models. These fuel models within Prometheus were adjusted to better align with those currently present in the park, as well as those possibly present in approximately 20-year and one hundred-year intervals. The grassland environment used mainly the high producing grassland model as presented in LCDB5. It is noted though that parts of the park would have less fuel volume than this model presents but the approach adds a level of contingency for days with more extreme fire conditions than those used in the scenarios.

6. Revegetation including underplanting occurs to achieve the projected vegetation 20 and 100-year cover concepts. These concepts may not fully eventuate but can be used for master planning.

7. The vegetation concept changes were only made for the Wither Hills Farm Park and not outside its boundary. Vegetation outside the boundary remained as presented in the Landcover Database 5 2018 (LCDB5) downloaded June 2022 for all scenarios.

8. For the 20-year and 100-year concept vegetation covers it is assumed farm stock can be excluded from grazing revegetated areas and that weed control is undertaken.

9. The 100-year vegetation cover assumes a Podocarp Forest strip along parts of the rural urban interface (RUI) buffered with Broadleaf Hardwoods. This was mainly for simulation purposes and may not eventuate.

10. Ignition points for simulation were selected based on fire occurrence history and placed nearby where fire could spread.

11. Fire growth simulations were run for 2-hours with no fire suppression intervention.

12. Simulated fire growth outputs are constrained by the input data including selected vegetation and weather for the simulation period. They are therefore only an indicator of possible fire behaviour under those conditions. Fires may occur under many varying weather and vegetation situations that present different fire behaviour outputs.

13. Fire intensity levels shown on the maps in Section 8 show 10,000 kW/m as the highest level. Fire intensity levels depicted by the highest level are in fact 10,000 kW/m or **greater**, and in some cases reached 60,000 kW/m, for example *Taylor Pass Road - MTB carpark ignition Extreme (current)* scenario and the *Events area beside Rifle Range carpark ignition Extreme (20-year)* scenario. For analysis, 10,000 kW/m is considered explosive, super critical and dangerous to engage in direct suppression, therefore anything above this level is the same.

14. **Fire growth simulations do not account for spot fires starting downwind**. If spot fires occur, fire burnt areas and perimeters will increase. Therefore, the simulations presented in this report do not represent the absolute worst case fire growth scenarios.

15. Roads and track widths were generally estimated and there maybe sections that are wider or narrower.

3. Acronyms

CBH	Crown Base Height
CFL	Crown Fuel Load
DC	Drought Code
DMC	Duff Moisture Code
FFMC	Fine Fuel Moisture Code
LCDB5	Landcover Database 5 2018
MTB	Mountain Bike
RH	Relative Humidity
RUI	Rural Urban Interface
WD	Wind Direction
WHFP	Wither Hills Farm Park
WS	Wind Speed

4. Rational for application

Prometheus fire growth model outputs include fire rate of spread, head and flank fire intensities, fire shape and fuel consumed during combustion. The objective for applying Prometheus was to compare fire behaviour outputs for the current, medium-term, and long-term vegetation (fuel) covers, with the latter two following native regeneration or revegetation as well as on-going farming practice. This information was used to help determine specific vegetation cover and location that could reduce damage potential on both fixed assets, park users and the environment.

Each simulation has a table indicating final fire area and perimeter and how much perimeter at a range of time points is either containable or uncontrollable based on fire intensity, refer Section 8.

5. Scenario based approach

A scenario-based approach was used to determine Prometheus inputs for weather, ignition location and time, with New Zealand fire behaviour fuel models assigned to the current and concept vegetation types. Terrain slope angle and aspect were introduced using digital elevation, and barriers such as roads and tracks added with assigned widths. The barriers were used as firebreaks with breaching switched on in the model, thereby requiring calculation of fire intensity and determination of whether fire will stop or cross a break.

The New Zealand Fire Danger Class Criteria (NZFDCC) were used to determine a likely and a worse-case scenario (not worst case). The NZFDC High was selected for *likely,* and Extreme for *worse case*. The long-term climate analysis indicates annual average number of fire danger days in the New Zealand broad fuel types are as follows. Refer Table 1 for fuel type descriptions and Section 11 for fire danger class criteria definitions.

1. Forest fire danger has an annual average of 42 days in High, 17 days in Very High, and 29 days in Extreme. The rest are Low or Moderate fire danger.

2. Grassland fire danger has an annual average of 86 days in High, 33 days in Very High, and 26 days in Extreme. The remaining days are Low or Moderate fire danger.

3. Standard Scrub fire danger has an annual average of 28 days High, 35 Very High, and 244 days Extreme. The remaining days are Low or Moderate fire danger.

4. Hardwood Scrub fire danger has an annual average of 84 days High, 71 Very High, and 130 days Extreme. The remaining days are Low or Moderate fire danger.

This clearly highlights issues with the standard and hardwood scrub fire danger classes with up to 270 days in an average year where wildfire would be difficult to control in this fuel.

Table 1: Fire Danger Class broad fuel types

Fire Danger Class	Vegetation
Forest	Represents mature forest both conifer and native although may overrate fire danger in native forest
Grass	Represents pasture grassland at an assumed 3.5 ton/hectare dry vegetation
Scrub	Represents highly flammable scrubland vegetation such as gorse and manuka/kanuka
Scrub Hardwoods	Is not standard in the system but represents Broadleaf Hardwoods and uses the Scrub model but with half the rate of spread

Weather inputs were selected from the long-term climate analysis for a day that met the NZFDC scenario requirements (High and Extreme). Windspeeds and temperature were in the mid-twenties for the High scenario and elevated for the extreme scenario. A Fine Fuel Moisture Code equal to or greater than 86 was selected to ensure ease of ignition and fire spread.

Because the objective was comparison of fire spreading through the current and potential vegetation covers, the same input parameters were used for the three vegetation scenarios with only the vegetation changing. Three vegetation cover inputs were created.

1. Current vegetation at the time of preparing this report.

2. A point of growth at 20-years, with the current vegetation being modified in consideration of several land use and land care functions including farming, recreation, environmental restoration, erosion control and wildfire. To inform the vegetation modifications, a range of landforms were identified, and relevant vegetation species assigned to each. Based on landforms, lower flammability species were first considered, followed by medium and higher flammability species.

   In general, the 20-year cover is like the current but with the eucalyptus removed, conifer reduced, and native planting areas extended and consolidated. Farming continues like the current situation.

3. A point of growth at 100-years, where the dry areas are still farmed such as the northeast to west facing mid-slopes, ridgelines, and dry toe-slopes. The rest is native species including Broadleaf Hardwood and Podocarp Forest areas.

6. Process

6.1. Prometheus inputs

Prometheus fire growth modelling was undertaken from four ignition locations, under both High and Extreme fire danger classes, and for three vegetation covers. Ignition locations were selected based on a 10-year historic fire record up to February 2022 and placed nearby actual reported ignitions. Consideration was also given to ease of access for people and vehicles (sources of ignition), high use recreation areas (impact on users should a fire start) and local knowledge, with one ignition placed outside the park boundary.

There are 24 separate scenarios to consider as the vegetation cover is modified. The comparison of these will help understand fire behaviour potential under High and Extreme conditions.

Tables 2 – 8 detail the input data used for the scenarios, with only the vegetation covers changing. The vegetation maps in Section 8 give the detail for current, conceptual 20-year and 100-year covers, with the parameters for each vegetation type given in Table 4.

Table 2: Ignitions

#	File name	Coordinates
1	WHFP_Taylor Pass Road - MTB carpark_ignition	173.933366 / -41.557352
2	WHFP_Events area beside Rifle Range carpark_ignition	173.838662 / -41.546854
3	WHFP_Quail_Stream ignition	173.948387 / -41.551326
4	WHFP_Sutherland Stream walking track - south of Redwood Street carpark_ignition	173.964425 / -41.546187

Table 3: Road and track imports

#	Road/track	Width
1	WHFP _tracks_1m	1 m
2	WHFP _tracks_2m	2 m
3	WHFP _tracks_3m	3 m
4	WHFP_roads_5m	5 m
5	WHFP_roads_8m	8 m

Table 4: Fuels (vegetation)

	Fuel	Parameters
1	Urban Parkland	Use standard in Prometheus with 2 t/ha at 80% cured high and 90% cured extreme
2	Low producing grassland	Use standard in Prometheus with 3 t/ha at 80% cured high and 90% cured extreme
3	High producing grassland	Use standard in Prometheus with 4 t/ha at 80% cured high and 90% cured extreme
4	High-load grassland (incorporates open forest and/or sparse forest cover)	Create new fuel based on high producing grassland and change fuel load to 12 t/ha and 80% cured high and 90% cured extreme
5	Short rotational crop	Use standard in Prometheus
6	Orchard/Vineyard	Use standard in Prometheus
7	Exotic Forest	Use standard in Prometheus and change (CBH) to 5
8	Eucalyptus stringy/ribbon or not	Create new fuel based on 'Exotic Forest' and increase (CFL) (kg/m²) to 2.50, and change CBH to 5
9	Blackwood and Wattle	Use standard Indigenous Forest in Prometheus
10	Tree Lucerne	Use Prometheus Broadleaf hardwoods
11	Indigenous Forest	Use standard in Prometheus
12	Broadleaf Indigenous Hardwoods	Use standard in Prometheus
13	Deciduous hardwoods	Use standard in Prometheus
14	Flax	Use standard in Prometheus
15	Fernland	Use standard in Prometheus
16	Herbaceous Freshwater	Use standard in Prometheus
17	Herbaceous Saline	Use standard in Prometheus
18	Exotic scrub	Use standard in Prometheus
19	Grey Scrub	Use standard in Prometheus
20	Scrub manuka kanuka	Use standard in Prometheus
21	Gorse	Use standard in Prometheus
22	Lakes, ponds, and open water	Use Prometheus non-fuel
23	Non-fuel	Use Prometheus non-fuel
24	Built	Use Prometheus non-fuel (has hard surface and structures)

Table 5: Extreme scenarios

Scenario ignitions	Weather stream name and parameters	Scenario
1) Taylor Pass Road - MTB carpark - extreme 2) Events area beside Rifle Range carpark - extreme 3) Quail Stream - extreme 4) Start of Sutherland Stream walking track - south of Redwood Street carpark - extreme	a) Name - Woodbourne extreme_2 b) Date 2/1/2008 – 4/1/2008 c) FFMC yesterday 90 d) DMC yesterday 35 e) DC yesterday 340 f) Select Diurnal (Lawson)	a) Date 3/1/2008 b) Start time 1430hrs c) End time 1630 hrs d) Propagation tab change display interval to 20 min e) Leave other tab settings as they are f) Breeching on g) All fuel patches h) Physical features – tracks and roads

Table 6: Extreme weather inputs

Date and Time	Temp (deg C)	RH (%)	Precip (mm)	WS (km/h)	WD (deg)
3/01/2008 14:30	31.7	22	0	29.7	270
3/01/2008 14:50	31.7	22	0	29.7	270
3/01/2008 15:10	32	23	0	22.2	300
3/01/2008 15:30	32	23	0	22.2	300
3/01/2008 15:50	32	23	0	22.2	300
3/01/2008 16:10	31	23	0	16.7	260
3/01/2008 16:30	31	23	0	16.7	260

Table 7: High scenarios

Scenario ignitions	Weather stream name and parameters	Scenario
1) Taylor Pass Road - MTB carpark - high 2) Events area beside Rifle Range carpark - high 3) Quail Stream - high 4) Start of Sutherland Stream walking track - south of Redwood Street - high	a) Name - Woodbourne high b) Date 26/03/2008 – 28/03/2008 c) FFMC yesterday 87.8 d) DMC yesterday 60.5 e) DC yesterday 589 f) Select Diurnal (Lawson)	a) Date 27/03/2008 b) Start time 1430hrs c) End time 1630 hrs d) Propagation tab change display interval to 20 min e) Leave other tab settings as they are f) Breeching on g) All fuel patches h) All physical features

Table 8: High weather inputs

Date and Time	Temp (deg C)	RH (%)	Precip (mm)	WS (km/h)	WD (deg)
27/03/2008 14:30	24.2	53	0	27.8	320
27/03/2008 14:50	24.2	53	0	27.8	320
27/03/2008 15:10	24	53	0	25.9	310
27/03/2008 15:30	24	53	0	25.9	310
27/03/2008 15:50	24	53	0	25.9	310
27/03/2008 16:10	23	56	0	25.9	320
27/03/2008 16:30	23	56	0	25.9	320

7. Summary

The vegetation covers may not be fully representative but will give a very good idea of how certain vegetation types, be they high or low flammability species, can influence spreading fires.

To assist in determining a vegetation picture for the 20-year and 100-year time periods, the park was compartmentalised by landform with native species assigned to each based on a species natural habitat and survivability. Lower flammability species were selected where possible however to achieve a more natural vegetation cover and in consideration of survivability often moderate and sometimes high flammability species were assigned. Table 9 indicates species related to landforms.

All scenarios presented are in the absence of spot fire activity with fire runs continuous from the original ignition points for a period of 2 hours. Because there are tree species currently present that are known to produce burning vegetative material that can be lifted by convection or wind, it is highly likely that new fire ignitions will occur downwind of a spreading wildfire. When interpreting the scenario outputs this situation needs to be considered in regards safety of park users and strategic fire suppression options.

Tracks and roads were included as barriers to fire spread with the Prometheus software interpreting the assigned widths and determining if a spreading fire would breech.

7.1. Vegetation transition

The 20 and 100-year concept vegetation covers were derived from discussions with council staff with expertise in farming, erosion control, parks and reserves management, landscapes, and biodiversity. The vegetation scenarios are not defined in Council policy and are only considered likely possibilities.

Present vegetation most likely to produce burning material that can be transported in the air and deposited ahead of a fire thereby starting new fires are eucalyptus species (especially ribbon bark), cabbage tree (fibrous dead leaves) and dead pine (bark). This is not to say other species do not do this.

For the concept 20-year cover eucalyptus species will be removed, and pine areas maintained with a relatively clean understory, pruned to 3 or 4 meters with waste removed, and dead trees removed. Cabbage tree plantings would be in the damper sheltered valley bottoms and generally in a dispersed pattern.

Existing areas of deciduous trees and other lower flammability trees such as Tree Lucerne and Oaks would be managed by lifting limbs off the ground and maintaining a clean understory. In higher use recreation areas trees would be spaced for a park like environment.

Existing native broadleaf hardwood scrub and odd podocarp plantings would continue to mature with new plantings expanding from the edges or infilling where exotics have been removed. Such areas can reduce fire spread and intensity and indicates an opportunity to strategically extend or plant new areas to protect values. Such strategic planting should use predominantly low flammability native species when close to values, followed further out with a transition to mixed low, medium, and higher flammability species. Finally high flammability species such as manuka and kanuka could be planted in small and medium pockets, surrounded by the lower flammability plantings, or buffered by well grazed areas.

Grazed areas that are retired and planted with native species will initially present a mixed vegetation cover of native and ungrazed grass. This cover will burn more as a high fuel load grass before reverting to a more scrub like cover and finally dominant native. Therefore, these areas are likely to burn faster and hotter as they transition into native. If the native is low to moderate flammability, then once dominant, fire behaviour such as rate of spread and intensity will reduce.

Grazing will be maintained much like the status quo apart from where existing native is expanded. Some grazing may be enhanced through fertilizer and grass species selection. Enhancement of this type could occur on upper slopes and ridgelines, especially those with tracks as this would encourage good grazing and in turn reduce grass fuel load. The reduced fuel load will reduce fire intensity allowing track barriers to be more effective in slowing or stopping fire spread. Similarly, such enhancements could achieve the same barrier effect on the lower elevation flats and toe slopes.

Track/road edge grass would be managed to a low height making the barriers more efficient in slowing or stopping fire spread, for example mowing. On the other hand, where tracks pass through scrub the edges should be planted in low flammability native species.

Along the Rural Urban Interface (RUI) there are a range of options to slow or stop fire spread. These may include a bare earth barrier, well grazed or mown grass to property boundaries, or a 5 – 10 metre or greater buffer of low flammability plantings.

For the 100-year vegetation cover farming will remain on the drier flats, toe slopes, northeast through north to west facing mid and upper slopes and ridgelines. South and east facing slopes as well as valley floors will be planted in native, with the lower elevation amenity areas likely to contain exotic tree species both deciduous and evergreen.

The 20-year and 100-year vegetation covers used for modelling fire growth were derived in consideration of the above.

Because the vegetation covers are conceptual, the final location of different species or mixed species can be determined during the master landscape planning process. Exotic

species will continue to be useful vegetation cover, except for the more flammable eucalyptus. The important thing to keep in mind is the strategic placement of lower flammability species or mixed species that can help contain fire in the more flammable vegetation, and therefore help protect visitors, assets, and the environment.

The following table lists the landforms and their associated native species list.

Table 9: Landforms and native species selection

#	Landform	Species	Relative flammability
1	Dry Flats	Grazing – range of grass species	Flammability increases with seasonal die off (grass curing %). The more dead component the faster the fire spread, the hotter the fire
2	Damp Flats	*Coprosma Propinqua*	Very Low
		Lemonwood	Low
		Swamp Flax	Low
		Narrow Leafed Lacebark	Low
		Coprosma Robusta	Low
		Cabbage Tree	Moderate
		Manuka and Kanuka	High
3	Long Valleys	Fivefinger	Very Low
		Kaikomako	Very Low
		Lancewood	Very Low
		Ngaio	Low
		Marbleleaf	Low
		Mahoe	Low
		Matai	Low
		Weeping Broom	Low
		Lemonwood	Low to moderate
		Titoki	Moderate
		Totara	Moderate
		Kahikatea	Moderate
		Black Beech	Moderate

#	Landform	Species	Relative flammability
4	Short Valleys	Lancewood,	Very Low
		Mahoe,	Low
		Ngaio,	Low
		Kohuhu	Moderate
5	Hill Slopes (Fans)	Broadleaf,	Low
		Matai	Low
		Marbleleaf	Low
		Narrow Leafed Lacebark	Low
		Lemonwood	Low
		Swamp Flax	Low
		Totara	Moderate
		Cabbage Tree	Moderate
		Manuka and Kanuka	High
6	Hill Slopes (Toes)	Ngaio	Low
		Broadleaf	Low
		Lemonwood	Low
		Lancewood	Low
		Akiraho	Moderate
		Kohuhu	Moderate
		Black Beech	Moderate
		Kanuka	High
7	Hill Slopes (Mid elevation) North & West facing	*Muehlenbeckia astonii*	Very Low
		Ngaio	Low
		Hebe stenophylla	Low
		Coprosma Propinqua	Low
		Olearia solandri	Moderate
		Tauhinu,	Moderate

#	Landform	Species	Relative flammability
		Akeake	Moderate
		Akiraho	Moderate
		Kanuka	High
8	Hill Slopes (Mid Elevation) East facing	*Muehlenbeckia astonii,*	Very Low
		Ngaio,	Low
		Coprosma propinqua	Low
		kanuka,	High
9	Hill Slopes (Mid Elevation) South facing	Ngaio	Low
		Mahoe	Low
		Lancewood,	Low
		Karamu	Low
		Kohuhu	Moderate
10	High Ridges and Summits	*Coprosma Propinqua*	Low
		Porcupine bush,	Low to Moderate
		Tauhinu	Moderate
		Silver Tussock	High

7.2. Roads and tracks

Under High fire danger conditions, the track system helps contain and, in some cases, stop fire spread. Existing roads and tracks should remain in place, have vegetation managed edges, and where possible mineral earth, metal, or sealed surfaces.

Under Extreme fire danger conditions, the 1m and 2m width tracks have little chance of stopping fire spread although from time to time they did contain parts of flanks and backing fire. The 3m wide tracks and wider roads are more likely to help contain flank and backfire spread.

Simulation outputs can assist in determining sections of tracks and roads that could be enhanced as barriers to help stop fire spread. This could include changing grassed tracks to nonfuel or planting edges with low flammability native species where this is appropriate.

The existing road and track network gives very good access to fire response units and as already noted should continue to be maintained.

7.3. Fire behaviour

Fires burning under the High fire danger simulations for the *Taylor Pass Road - MTB carpark* and *Events area beside Rifle Range carpark* scenarios generated fire intensities on sections of the fire edges that were outside the ability to undertake direct suppression work (direct on flaming edge). For *Quail Stream* and *Start of Sutherland Stream walking track - South of Redwood Street carpark* scenarios, the fire intensities were controllable using direct suppression.

Fires burning under Extreme fire danger for all scenarios generated fire intensities on sections of fire edges that were higher than what is controllable using direct suppression. The percent of fire edge in this state changed over time, reducing after 2 hours once the fires reached ridgelines or were backing or flanking, especially downslope. Of course, the percentage of fire edge at hour two has far more length than the same percentage at hour one.

Fires that preclude direct suppression require an indirect suppression approach such installing firebreaks away from the fire edge or applying long-term fire retardants.

A change in any of the three vegetation fire environment components of fuel, topography and weather will affect fire behaviour. This can go any way and may increase or decrease fire behaviour activity. For example, if a fire encountered volatile Gorse fuel it will increase fire intensity as opposed to Broadleaf Hardwoods where it would decrease fire intensity. On the same note a fire burning upslope will spread faster and with increased fire intensity as opposed to downslope where it would spread slower with less intensity.

Fire spread under the High fire danger scenarios indicated an average over terrain rate of spread range of between 400m/h to 850m/h in current vegetation, reducing to 90m/h to 650m/h in the 100-year concept vegetation.

Under the Extreme fire danger scenarios, fire spread indicated an average over terrain rate of spread range of between 1550m/h to 1850m/h in current vegetation with the *Taylor Pass Road - MTB carpark and Events area beside Rifle Range carpark* scenarios reducing to 550m/h to 600m/h in the 100-year vegetation. For *Quail Stream* and *Start of Sutherland Stream walking track - South of Redwood Street carpark* scenarios the spread rate remains like the current for the 100-year vegetation due to the fires rapidly spreading in grassland up and along the exposed ridgelines.

Under stronger wind speeds or steep slopes fire shapes are narrower and more elliptical, move much faster, and can impact values quickly but on a narrower front.

Under the Extreme scenarios the wind direction changed twice over the 2-hour period giving a direction range of between 260° to 300°. The wind-change at 1600 hours from 300° to 260° caused the fires left flanks to become head fires that then burnt hotter and faster. When a line fire such as a flank becomes a head fire it moves away immediately at its maximum rate of spread for the given environment at the time. There is no window of time where fire builds-up (develops) as there is with a point ignition, and fire growth can be exceptionally rapid with wider fronts and extreme intensities.

8. Scenarios

There are three vegetation cover scenarios presented below based on the current and conceptual 20-year and 100-year vegetation covers.

Each scenario consists of eight fire runs, two from each of four ignition points, with one under High fire danger and the other under Extreme fire danger. As stated in the assumptions and limitations, fire growth is propagated without fire suppression intervention and crucially does not account for spot fires (refer assumptions and limitations). Roads and tracks are used as barriers to fire spread and only stop spread if the inputted barrier widths are sufficient to hold specifically calculated fire intensities. If fire intensity is too high at an intersecting point with a barrier, fire will cross it.

Fire runs spread for 2-hour periods in 20-minute propagations starting at 1430 hours. Two hours growth allows for close analysis of potential impacts a fire may have on the park and surrounds while emergency response is initiated. The initial 20 – 30 minutes is considered the initial attack fire suppression window while fire is accelerating to its potential rate of spread and intensity. The output gives an indication of damage potential based on speed of fire growth and size, the percent of fire perimeter that is controllable by direct suppression methods, or not controllable thereby requiring indirect methods.

Tables 10 and 11 present a summary of the 2-hour fire growth modelling outputs for the 24 scenarios. Table 10 indicates fire area in hectares (ha) and fire perimeter in kilometres (km), with Table 11 indicating the percent of perimeter that is uncontrollable for 3 scenario time points. More specific detail is in subsequent subsections.

Table 10: Scenario 2-hour fire area and perimeter

Scenario	Current	20-year	100-year
Taylor Pass Road - MTB carpark (High)	27ha/3km	27ha/3km	16ha/2km
Taylor Pass Road - MTB carpark (Extreme)	186ha/14km	192/14km	63ha/7km
Events area beside Rifle Range carpark (High)	10ha/3km	9ha/4km	1ha/0.65km
Events area beside Rifle Range carpark (Extreme)	337ha/21km	166km/12km	40ha/7km
Quail Stream (High)	30ha/4km	28ha/4km	17ha/5km
Quail Stream (Extreme)	355ha/19km	316ha/17km	203ha/12km
Start of Sutherland Stream walking track - South of Redwood Street carpark (High)	19ha/4km	6ha/2km	4ha/1km
Start of Sutherland Stream walking track - South of Redwood Street carpark (Extreme)	424ha/14km	274ha/13km	204ha/12km

Table 11: Percent fire perimeter uncontrollable (fire start time 14:30 hours)

Scenario	Time step	Current veg	20-year veg	100-year veg
Taylor Pass Road - MTB carpark (High)	1450 hours	0%	0%	0%
	1530 hours	22%	22%	0%
	1630 hours	17%	17%	8%
Taylor Pass Road - MTB carpark (Extreme)	1450 hours	59%	59%	21%
	1530 hours	26%	22%	5%
	1630 hours	9%	7%	3%
Events area beside Rifle Range carpark (High)	1450 hours	0%	0%	0%
	1530 hours	43%	15%	0%
	1630 hours	16%	13%	0%
Events area beside Rifle Range carpark (Extreme)	1450 hours	14%	7%	0%
	1530 hours	25%	27%	1%
	1630 hours	11%	9%	1%
Quail Stream (High)	1450 hours	0%	0%	0%
	1530 hours	0%	0%	0%
	1630 hours	2%	0%	0%
Quail Stream (Extreme)	1450 hours	17%	20%	20%
	1530 hours	19%	11%	9%
	1630 hours	8%	18%	7%
Start of Sutherland Stream walking track - South of Redwood Street carpark (High)	1450 hours	0%	0%	0%
	1530 hours	0%	0%	0%
	1630 hours	0%	0%	0%
Start of Sutherland Stream walking track - South of Redwood Street carpark (Extreme)	1450 hours	35%	43%	43%
	1530 hours	13%	11%	10%
	1630 hours	19%	16%	10%

Figure 1: Current vegetation cover

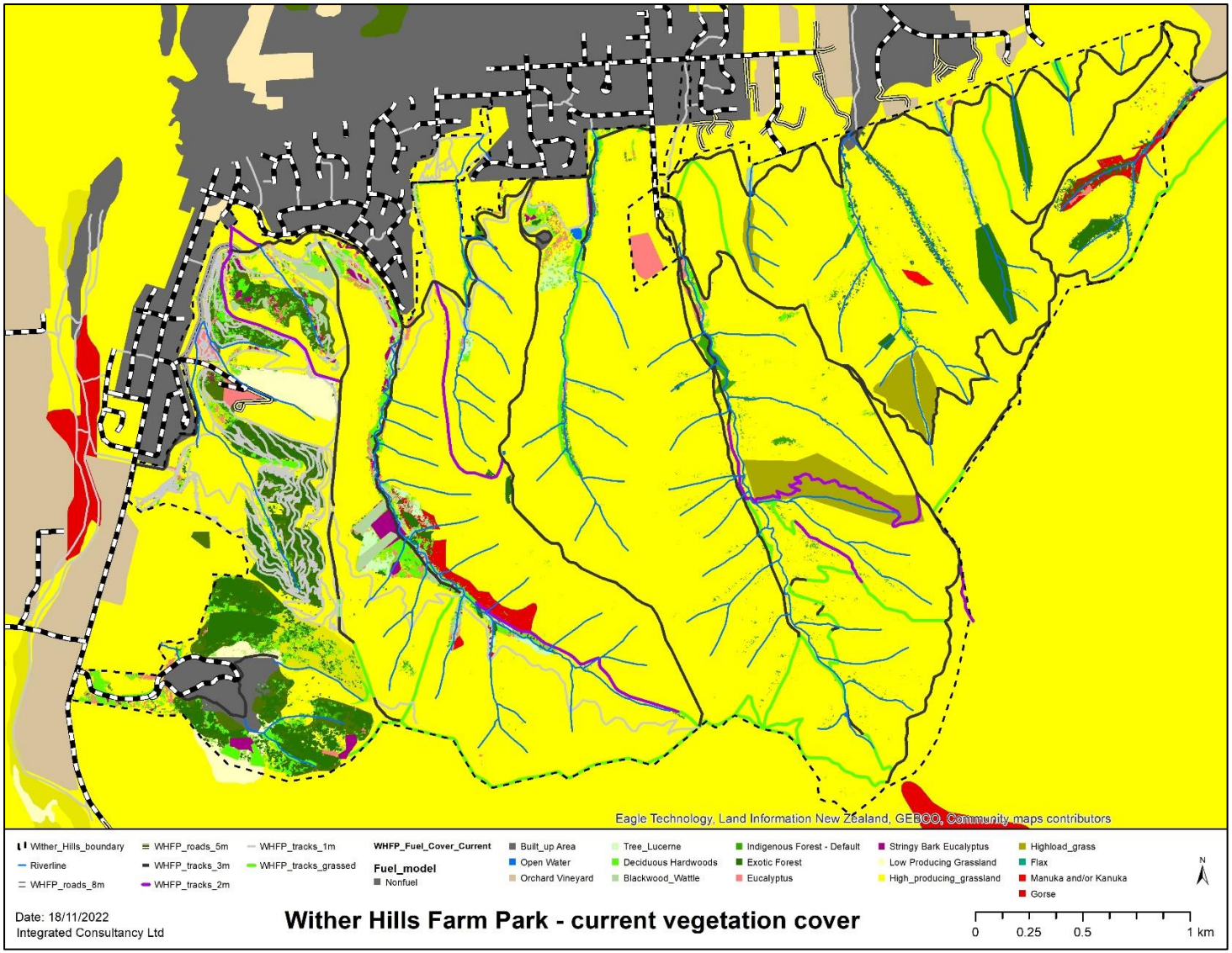
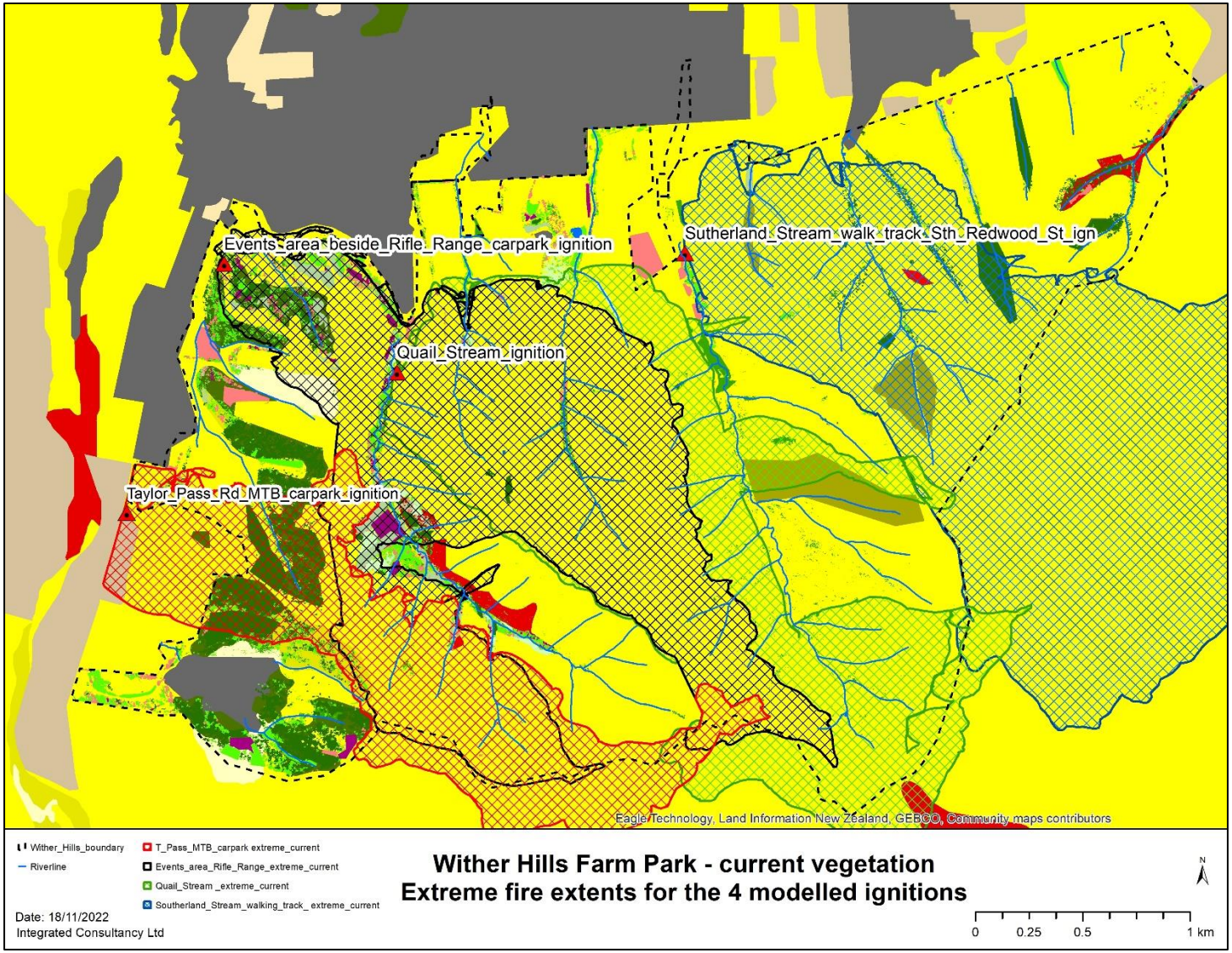


Figure 2: Current vegetation with extreme scenario fire extents



8.1. Current vegetation cover

The current Wither Hills Farm Park (WHFP) vegetation cover (refer Figure 1) has been mapped using site visit observations, ground validation mapping and aerial photography. The vegetation categories referenced on the vegetation map are not species specific, rather they align with a New Zealand fire behaviour fuel model. For example, some areas may present as high-load grass but are in fact a grass and scrub mix or open spaced young pines where grass predominates.

Figure 2 presents the 4 extreme scenario extents overlaying the current vegetation layer.

8.1.1. Interpretation of fire growth modelling (current)

The following detail presents fire growth modelling outputs for fires spreading through the current vegetation cover. The detail includes a current vegetation map, a 2-hour fire growth map for each scenario ignition including fire intensity display and 20-minute fire perimeters, fire growth statistics table and interpretation.

The following tables indicate scenario outputs of fire area and perimeter for three time points following ignition at 1430 hours. Additionally, the tables present the percentage of fire perimeter for each time point that is either controllable by water under pressure, aircraft, or is not controllable.

The scenario outputs are then discussed in regards the likelihood of fire spread being slowed or stopped by existing roads, tracks, non-fuel areas, and lower flammability vegetation.

The simulated fire growth perimeter lines do not account for spot fires.

8.1.2. Taylor Pass Road - MTB carpark ignition High (current)

Referring to Figure 3, at 20 minutes from ignition the fire remains on private land, is burning in grassland and is controllable. It enters the WHFP 20 minutes later and spreads up the face and gullies burning through exotic forest (head fire is not controllable) and out into grass and scattered forest before reaching the main ridge line above Quail Stream. The fire has a narrow front at this point and would be containable here. The mid flanks of the fire maybe problematic to contain although the MTB track system on the left flank may assist containment. Fire intensity peaks mid-slope around 40,000 kW/m.

Table 12: Taylor Pass Road - MTB carpark ignition High- current

Total area burnt	Total perimeter	% Perimeter controllable with water under pressure	% Perimeter controllable with aircraft	% Perimeter not controllable
27ha	3km	• 1450hrs 80% • 1530hrs 76% • 1630hrs 74%	• 1450hrs 20% • 1530hrs 2% • 1630hrs 9%	• 1450hrs NA% • 1530hrs 22% • 1630hrs 17%

8.1.3. Taylor Pass Road - MTB carpark ignition Extreme (current)

Referring to Figure 4, in the two-hour run period the fire experienced two wind direction shifts firstly from 270° to 300° at 1500 hours and then back to 260° an hour later. This affected the fire's spread direction and head fire locations, where parts of the flanks became head fires and other parts quietened down.

Twenty minutes after ignition the fire was burning in the WHFP MTB track system and twenty minutes later was at the ridgeline above Quail Stream where the 3m track did not contain it.

At around this time the fire changes direction and heads more southeast following the ridge and true left slopes of Quail Stream to the main Wither Hills ridgeline. The fire skirts the Landfill and slowly burns down slope toward Taylor Pass and Maxwell Pass Roads. Because of the wind direction the MTB and Quail Stream tracks do successfully contain some perimeter.

With the wind direction change at 1600 the fire produces a finger of fire at the north end that burns down towards Quail Stream, with the main head fire swinging more northeast to follow the Wither Hills main ridgeline to the Reservoir ridge junction.

The head fire intensities reach up to 60,000 kW/m at times where it burns through the MTB park and the heavier fuel areas on the Quail Stream faces. Generally, after 1600 hours most of the perimeter is containable.

Table 13: Taylor Pass Road - MTB carpark ignition extreme - current

Total area burnt	Total perimeter	% Perimeter controllable with water under pressure	% Perimeter controllable with aircraft	% Perimeter not controllable
186ha	14km	• 1450hrs 27% • 1530hrs 61% • 1630hrs 80%	• 1450hrs 14% • 1530hrs 13% • 1630hrs 11%	• 1450hrs 59% • 1530hrs 26% • 1630hrs 9%

Figure 3: Taylor Pass Road - MTB carpark ignition High (current)

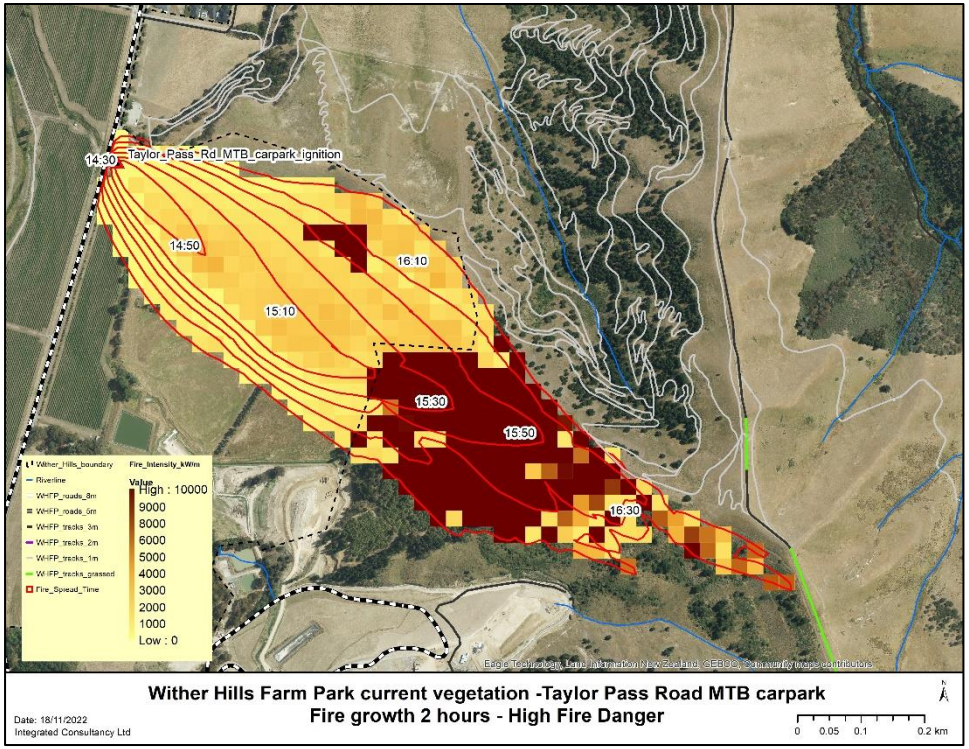
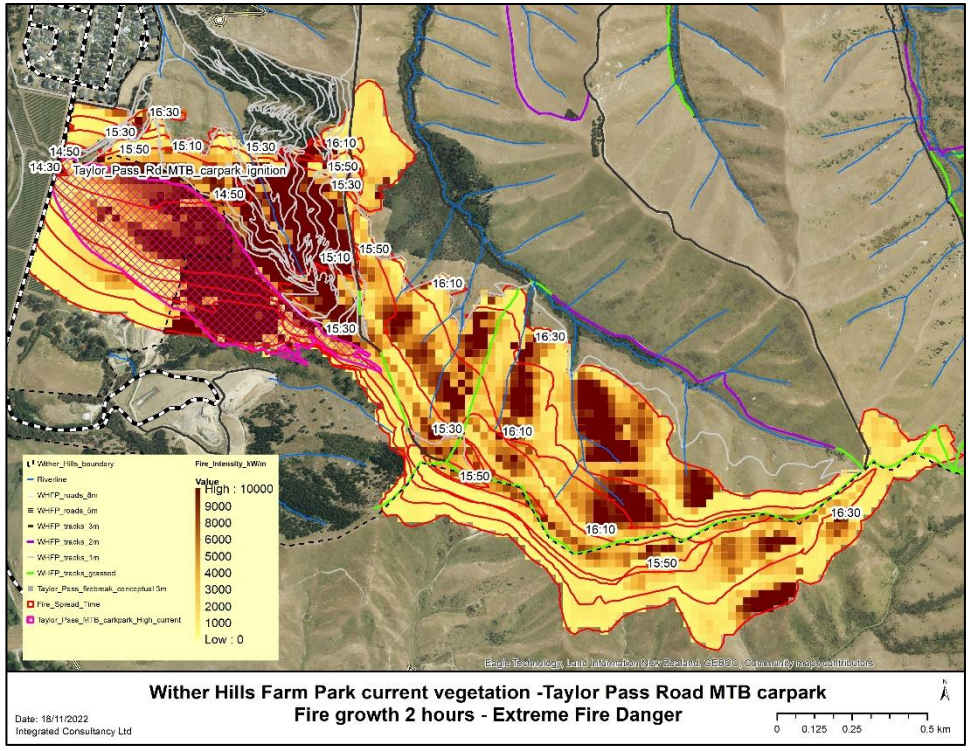


Figure 4: Taylor Pass Road - MTB carpark ignition Extreme (current)



8.1.4. Events area beside Rifle Range carpark ignition High (current)

Referring to Figure 5, the fire is slow to initially spread and would be containable within the initial 40 minutes before establishing in the exotic forest section. After 40 minutes the head fire and upper flanks would be uncontrollable until the fire spreads back to grass.

At 1630 hours the fire reaches the ridgeline above Quail Stream and in one place crosses the 3m track due to the presence of a tree pocket. The lower sections of the right and left flanks as well as the base are contained by the track system.

Table 14: Events area beside Rifle Range carpark ignition High - current

Total area burnt	Total perimeter	% Perimeter controllable with water under pressure	% Perimeter controllable with aircraft	% Perimeter not controllable
10ha	3km	• 1450hrs 100% • 1530hrs 57% • 1630hrs 77%	• 1450hrs NA • 1530hrs 0% • 1630hrs 7%	• 1450hrs NA • 1530hrs 43% • 1630hrs 16%

8.1.5. Events area beside Rifle Range carpark ignition Extreme (current)

Referring to Figure 6, in the two-hour run period the fire experienced two wind direction shifts firstly from 270° to 300° at 1500 hours and then back to 260° an hour later. This affected the fire's spread direction and head fire locations, where parts of the flanks became head fires and other parts quietened down.

The fire initially spreads east around the toe of the hills towards Quail Stream entrance as well as up and across slope near the Gentle Annie Track. The fire reaches Quail Stream entrance around 1500 hours when the wind direction change pushes the fire up both sides of Quail Stream and on to the ridgeline overlooking the southern end of the MTB park as well as crossing ridges into the Harling and Wither Streams by 1550 hours. The fire is now in two main fingers with one heading up Reservoir Ridge to the Wither Hills main ridgeline and the other up Quail Stream.

The wind then changes back and pushes the fire on a very wide front into Sutherland Stream, with the left flank of the Quail Stream finger driven down slope where it crosses the stream in one place around 1630 hours.

In most cases the track system was ineffective at containing the head and flank fires but the 3m Lower Farm Track did contain the backing fire. The Forest Park Drive Road did contain the right flank during initial spread but with the initial backing fire reaching the RUI.

A 1630hrs the down slope burning in Quail and Sutherland Streams would be containable as would the fire on the south side of the main Wither Hills ridgeline.

Table 15: Events area beside Rifle Range carpark ignition extreme - current

Total area burnt	Total perimeter	% Perimeter controllable with water under pressure	% Perimeter controllable with aircraft	% Perimeter not controllable
337ha	21km	• 1450hrs 45% • 1530hrs 58% • 1630hrs 76%	• 1450hrs 41% • 1530hrs 17% • 1630hrs 13%	• 1450hrs 14% • 1530hrs 25% • 1630hrs 11%

Figure 5: Events area beside Rifle Range carpark ignition High (current)

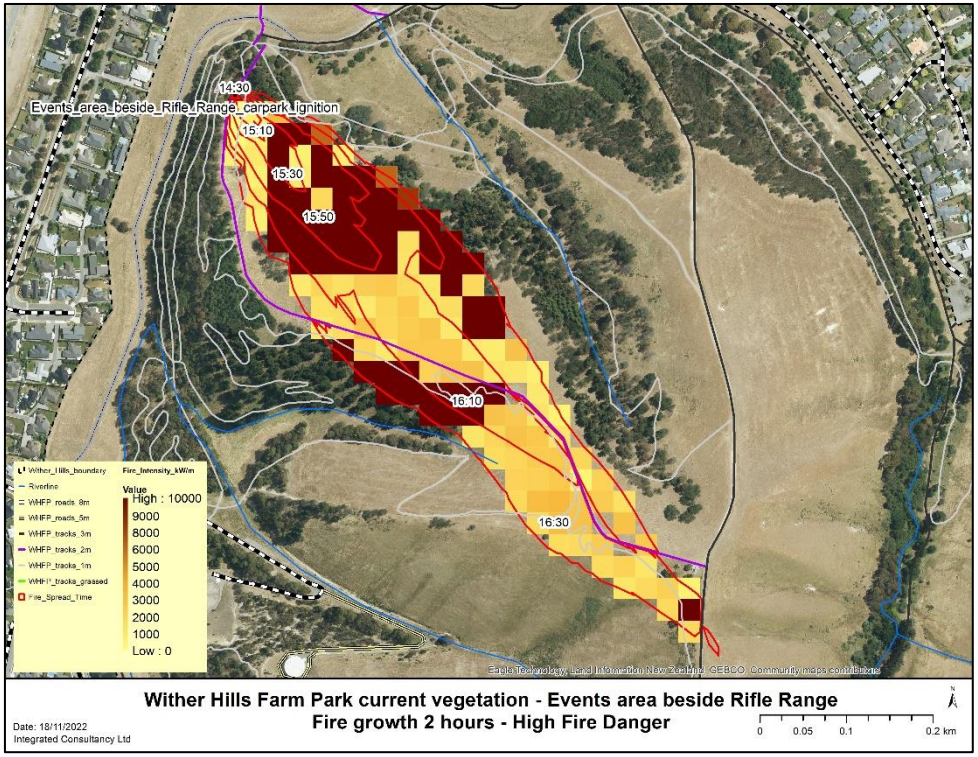
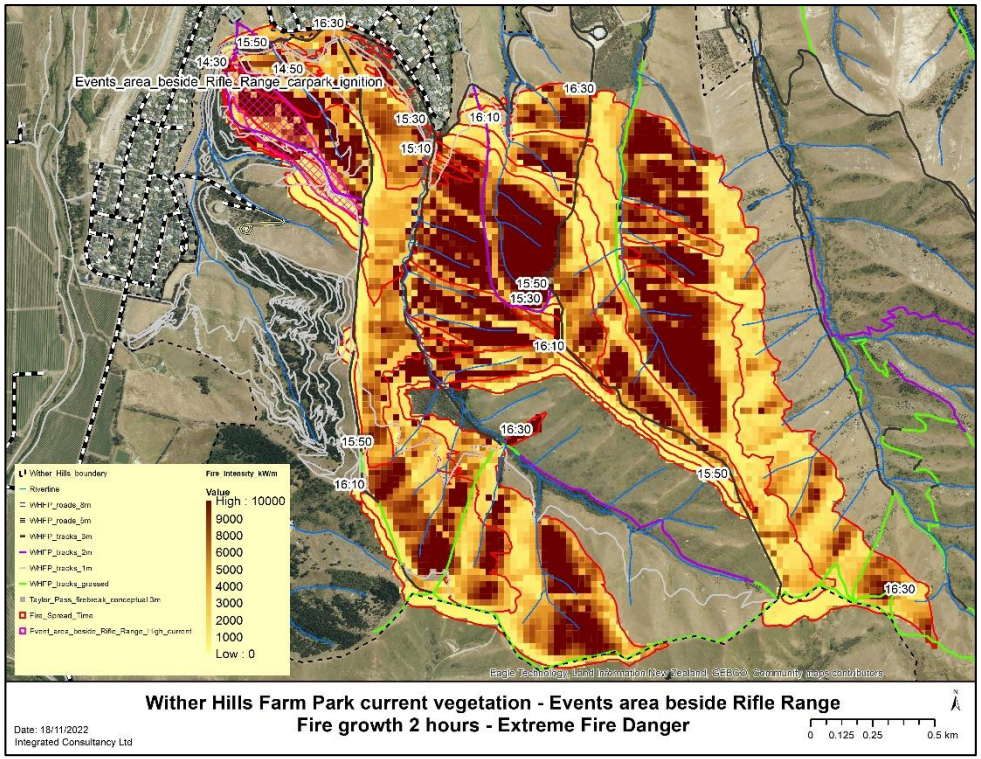


Figure 6: Events area beside Rifle Range carpark ignition Extreme (current)



8.1.6. Quail Stream ignition High (current)

Referring to Figure 7, the fire takes 20 minutes to reach the ridge between Quail and Harling Streams and another half hour to cross the upper Harling Stream to reach Reservoir Ridge. The fire is then pushed along the ridge until the 3m track contains it. The track system during earlier spread was ineffective in containing the fire.

Table 16:Quail Stream ignition High - current

Total area burnt	Total perimeter	% Perimeter controllable with water under pressure	% Perimeter controllable with aircraft	% Perimeter not controllable
30ha	4km	• 1450hrs 76% • 1530hrs 96% • 1630hrs 96%	• 1450hrs 24% • 1530hrs 4% • 1630hrs 2%	• 1450hrs NA • 1530hrs NA • 1630hrs 2%

8.1.7. Quail Stream ignition Extreme (current)

Referring to Figure 8, in the two-hour run period the fire experienced two wind direction shifts firstly from 270° to 300° at 1500 hours and then back to 260° an hour later. This affected the fire's spread direction and head fire locations, where parts of the flanks became head fires and other parts quietened down.

In the first twenty minutes the fire has passed over Harling Stream and Reservoir Ridge and is burning downhill towards Wither Stream. Over the next twenty minutes the fire involves most of the Wither Stream catchment and is on the ridge between Wither and Sutherland Streams. The wind direction then changes and drives the fire southeast along Reservoir Ridge and the slopes leading down to Sutherland Stream, reaching the Wither Hills main ridgeline around 1600 hours. The next wind shift drives the fire east where it crosses Sutherland Stream in two places as well as crossing its upper catchment bowl.

The Sutherland Stream 3m track system is successful in containing sections of the downslope spread, with the Quail Stream Track containing the backing fire. Sections of the Lower Farm Track were successful in containing the left flank.

Table 17: Quail Stream ignition extreme - current

Total area burnt	Total perimeter	% Perimeter controllable with water under pressure	% Perimeter controllable with aircraft	% Perimeter not controllable
355ha	19km	• 1450hrs 45% • 1530hrs 72% • 1630hrs 83%	• 1450hrs 38% • 1530hrs 9% • 1630hrs 9%	• 1450hrs 17% • 1530hrs 19% • 1630hrs 8%

Figure 7: Quail Stream ignition High (current)

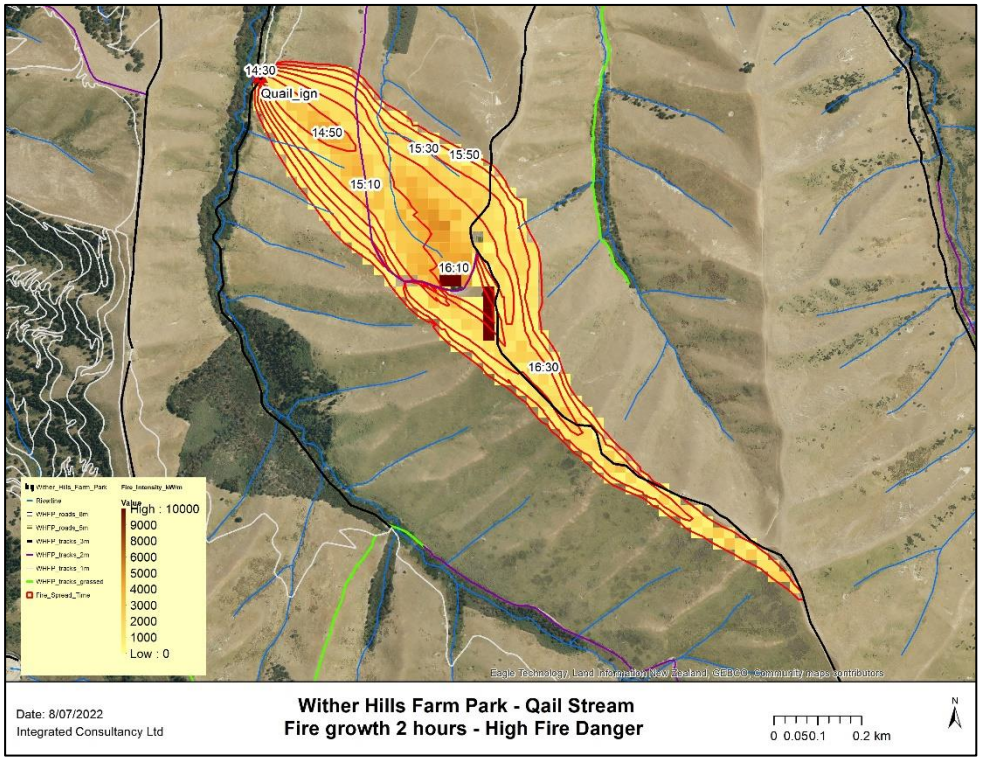
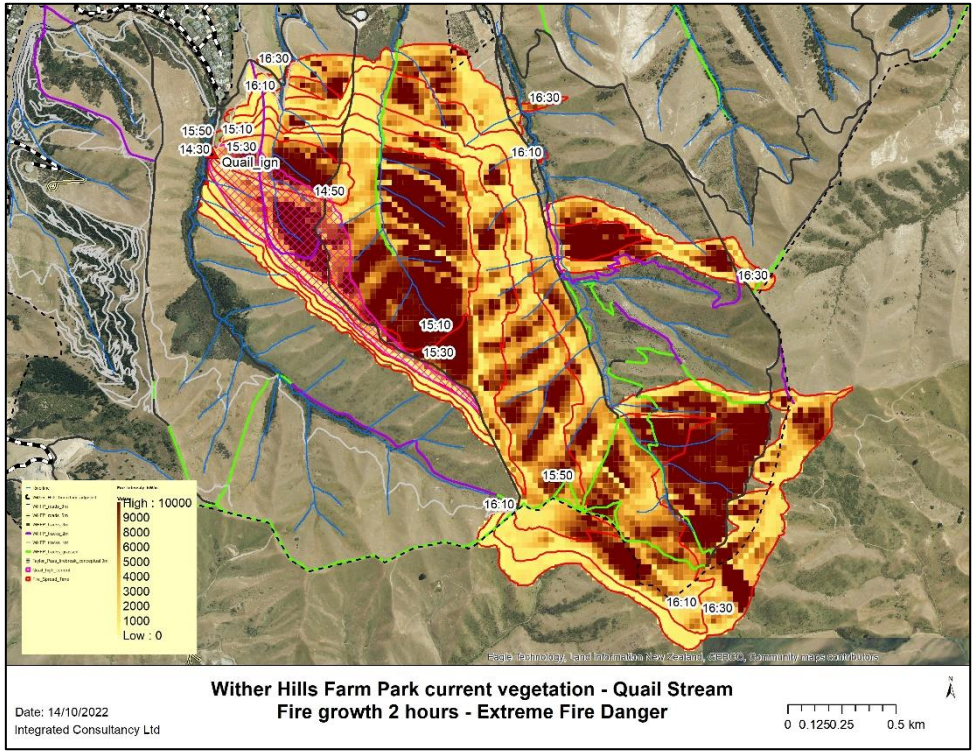


Figure 8: Quail Stream ignition Extreme (current)



8.1.8. Start of Sutherland Stream walking track - South of Redwood Street carpark ignition High (current)

Referring to Figure 9, within twenty minutes the fire crosses the switchback 3m track off the Mt Vernon Track and is spreading across slope towards the ridge between Sutherland Stream and Dungey's Gully. Over the next twenty minutes the fire continues across, and upslope on to the ridge overlooking Mapp Gully West. Once on the ridgeline the fire narrows and runs along both sides of the Mt Vernon Track before being pinched out at the Middle Track junction.

The track system was ineffective at containing the earlier spread but had some effect once the fire was on the ridgeline.

Table 18: Start of Sutherland Stream walking track - South of Redwood Street carpark ignition High - current

Total area burnt	Total perimeter	% Perimeter controllable with water under pressure	% Perimeter controllable with aircraft	% Perimeter not controllable
19ha	4km	• 1450hrs 56% • 1530hrs 94% • 1630hrs 91%	• 1450hrs 44% • 1530hrs 6% • 1630hrs 9%	• 1450hrs NA • 1530hrs NA • 1630hrs NA

8.1.9. Start of Sutherland Stream walking track - South of Redwood Street carpark ignition Extreme (current)

Referring to Figure 10, in the two-hour run period the fire experienced two wind direction shifts firstly from 270° to 300° at 1500 hours and then back to 260° an hour later. This affected the fire's spread direction and head fire locations, where parts of the flanks became head fires and other parts quietened down.

Within twenty minutes the fire has crossed the upper section of Dungey's Gully and is burning downslope towards Mapps Gully West. Over the next twenty minutes the fire burns on a fast-widening front with high intensity, up Mapps Gully West to reach Middle Track. At this point the wind shift pushes the fire over the Cobb Cottage Track and out of the park on an 800-metre-wide front stretching from the Mt Vernon Lookout to the transmission masts. At the same time the fire flanks are widening.

Around 1600 hours the second wind shift pushes the fire east with most of the left flank becoming a head fire. The fire begins moving down the eastern catchments towards Cloudy Bay Drive and State Highway 1. Within the park, the fire spreads east across Mapps Gully East and the head of Simmons Gully. A finger of fire crosses the Mapp Track with potential impact on the RUI.

In some locations the 3m track system is effective in containing flank and backfire. The lower section of track in Sutherland Stream contains the backfire, with the mid and upper sections of the Mt Vernon Track containing the right flank. The Mapp Track is reasonably effective on the left flank except where it is breeched with the 1600-hour wind shift.

By 1630 hours 80% of the fire perimeter is at a controllable fire intensity however around half the burnt area is outside the park boundary.

Table 19: Start of Sutherland Stream walking track - South of Redwood Street carpark ignition extreme - current

Total area burnt	Total perimeter	% Perimeter controllable with water under pressure	% Perimeter controllable with aircraft	% Perimeter not controllable
424ha	14km	• 1450hrs 40% • 1530hrs 72% • 1630hrs 69%	• 1450hrs 25% • 1530hrs 15% • 1630hrs 12%	• 1450hrs 35% • 1530hrs 13% • 1630hrs 19%

Figure 9: Start of Sutherland Stream walking track - South of Redwood Street carpark ignition High (current)

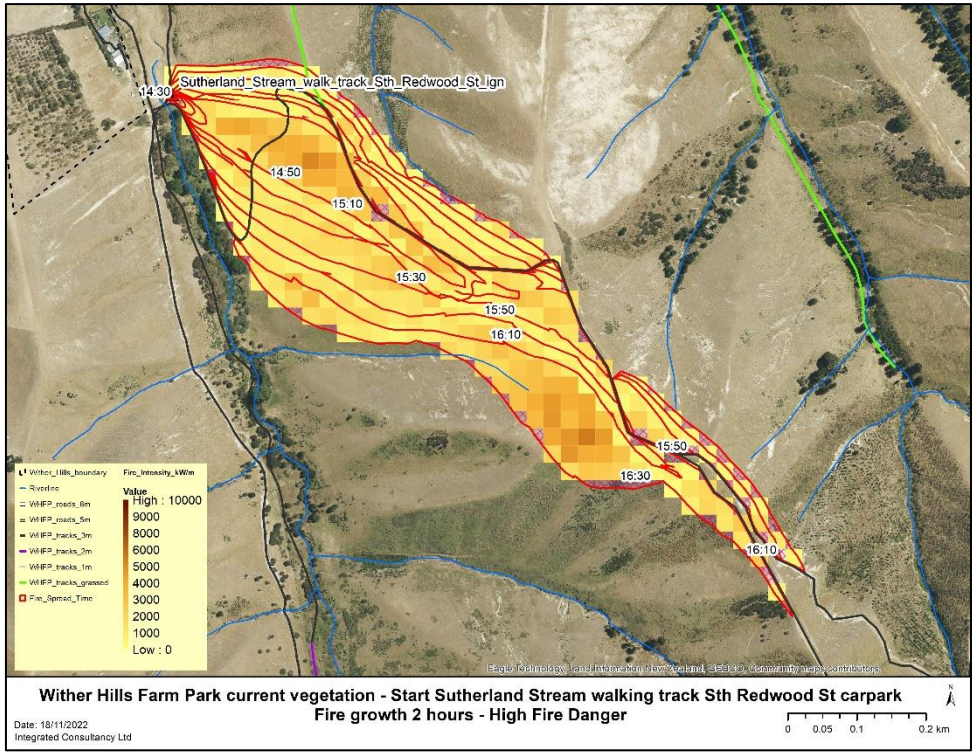


Figure 10: Start of Sutherland Stream walking track - South of Redwood Street carpark ignition Extreme (current)

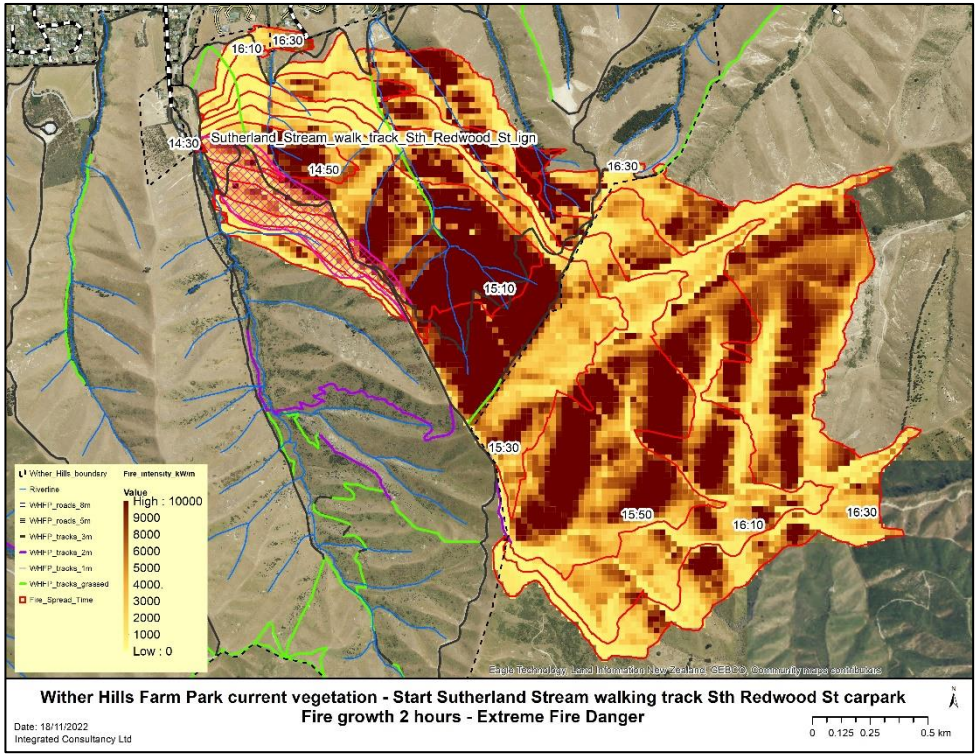


Figure 11: 20-year vegetation cover

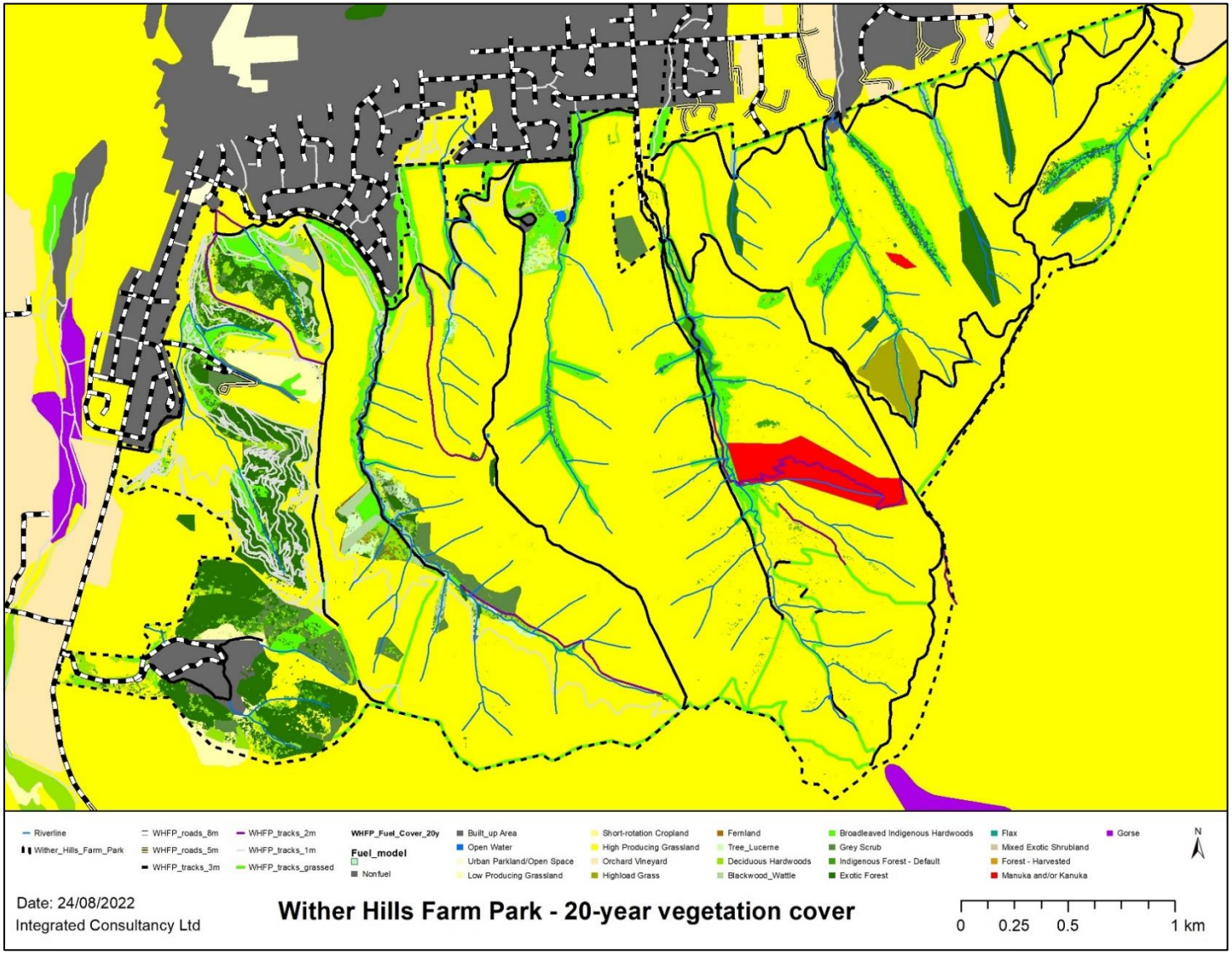
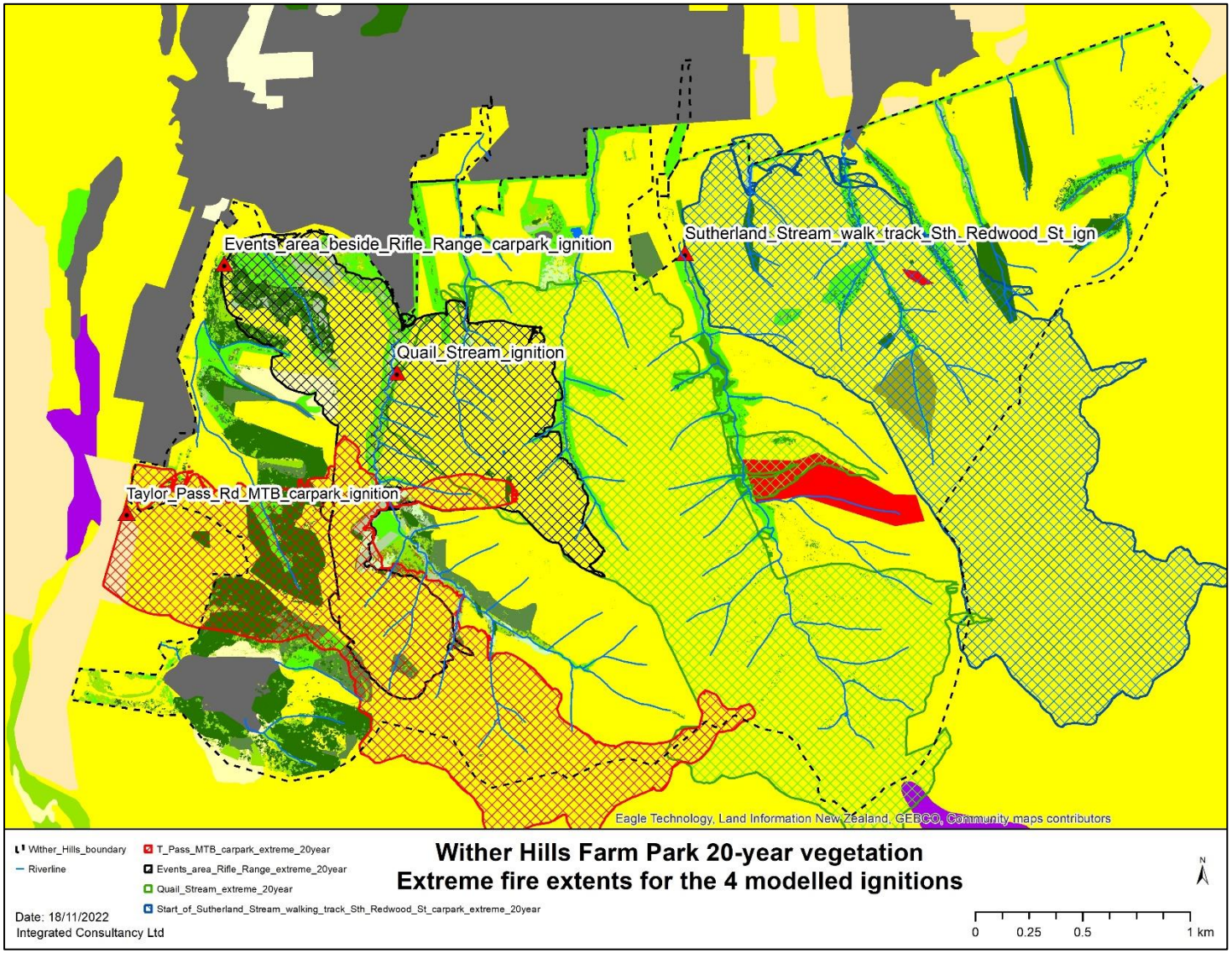


Figure 12: 20-year vegetation with extreme scenario fire extents



8.2. Twenty-year conceptual vegetation cover

The 20-year conceptual vegetation cover (refer Figure 11) uses the current cover as a base and applies changes that could conceptually occur within a 20-year timeframe. The changes consider a revegetating program, forest harvesting and replacement with indigenous species, terrain aspect, landforms as listed in Table 9, and continued farming.

Key revegetation assumptions are that farm stock can be excluded from these areas, underplanting will dominate over the existing sheltering vegetation and weed control will be undertaken.

In formulating the 20-year cover the following changes were applied to the current cover.

1) All Eucalyptus species removed and replaced with either Broadleaf Hardwoods or Grey Scrub depending on aspect and landform.
2) Young Pine compartments matured to 20+years.
3) Other open Exotic Forest underplanted with either Broadleaf Hardwoods or Grey Scrub.
4) Manuka in the Covenant area changed to mature Manuka.
5) Gorse replaced with Broadleaf Hardwood or Grey Scrub.
6) Existing native edges expanded.
7) A strip of Broadleaf Hardwood added to sections of the rural urban interface.

Figure 12 presents the 4 extreme scenario extents overlaying the 20-year vegetation layer.

8.2.1. Interpretation of fire growth modelling (20-year)

The following detail presents fire growth modelling outputs for fires spreading through the 20- year concept vegetation cover. The detail includes a 20-year vegetation map, a 2-hour fire growth map for each scenario ignition including fire intensity display and 20-minute fire perimeters, fire growth statistics table, and interpretation.

All simulation inputs including ignition locations remain the same as for the current vegetation scenarios apart from the 20-year vegetation changes and a 3-metre-wide nonfuel firebreak added east of the Taylor Pass Road rural urban interface.

This allows for an assessment against the current scenario and informs an understanding on likely changes in fire behaviour due to vegetation changes and the firebreak. In turn the findings will inform risk evaluation and future risk treatment options.

The following tables indicate scenario outputs of fire area and perimeter for three time points following ignition at 1430 hours. Additionally, the tables present the percentage of fire perimeter for each time point that is either controllable by water under pressure, aircraft, or is not controllable.

The scenario outputs are then discussed in regards the likelihood of fire spread being slowed or stopped by existing roads, tracks, non-fuel areas, and lower flammability vegetation.

The simulated fire growth perimeter lines do not account for spot fires.

8.2.2. Taylor Pass Road - MTB carpark ignition High (20-year)

Referring to Figure 13, the fire produces very similar fire behaviour to the current vegetation scenario but spreads slower in the final 20-minutes as it encounters a band of Broadleaf Hardwoods. The fire area and perimeter are much the same and the fire does not reach the ridgeline above Quail Stream. Parts of the upper flanks indicate fire intensity levels outside direct suppression capability.

Table 20: Taylor Pass Road - MTB carpark ignition High - 20-year

Total area burnt	Total perimeter	% Perimeter controllable with water under pressure	% Perimeter controllable with aircraft	% Perimeter not controllable
27ha	3km	• 1450hrs 80% • 1530hrs 76% • 1630hrs 76%	• 1450hrs 20% • 1530hrs 2% • 1630hrs 7%	• 1450hrs NA • 1530hrs 22% • 1630hrs 17%

8.2.3. Taylor Pass Road - MTB carpark ignition Extreme (20-year)

Referring to Figure 14, in the two-hour run period the fire experienced two wind direction shifts firstly from 270° to 300° at 1500 hours and then back to 260° an hour later. This affected the fire's spread direction and head fire locations, where parts of the flanks became head fires and other parts quietened down.

The fire exhibits similar fire behaviour to the current scenario but has a larger area burnt with similar perimeter length. Within 40 minutes of ignition the fire is on the ridge overlooking Quail Stream. The wind direction shift at 1500 hours spreads the fire more ESE along the ridge and upper slopes before turning WSW around 1600 hours to push the fire towards Quail Stream.

The larger area burnt is due to the fire crossing Quail Stream in the last 20-minutes and running to Reservoir Ridge above Harling and Wither Streams. The fire crosses the walking track in the upper half of Quail Stream and almost crosses the stream in several places.

The fire burns intensely through the mountain bike park, the mid and upper slopes in Quail Stream, and the spread run to Reservoir Ridge. At 2-hours most of the perimeter is controllable.

Table 21: Taylor Pass Road - MTB carpark ignition extreme - 20-year

Total area burnt	Total perimeter	% Perimeter controllable with water under pressure	% Perimeter controllable with aircraft	% Perimeter not controllable
192ha	14km	• 1450hrs 27% • 1530hrs 64% • 1630hrs 82%	• 1450hrs 14% • 1530hrs 14% • 1630hrs 11%	• 1450hrs 59% • 1530hrs 22% • 1630hrs 7%

Figure 13: Taylor Pass Road - MTB carpark ignition High (20-year)

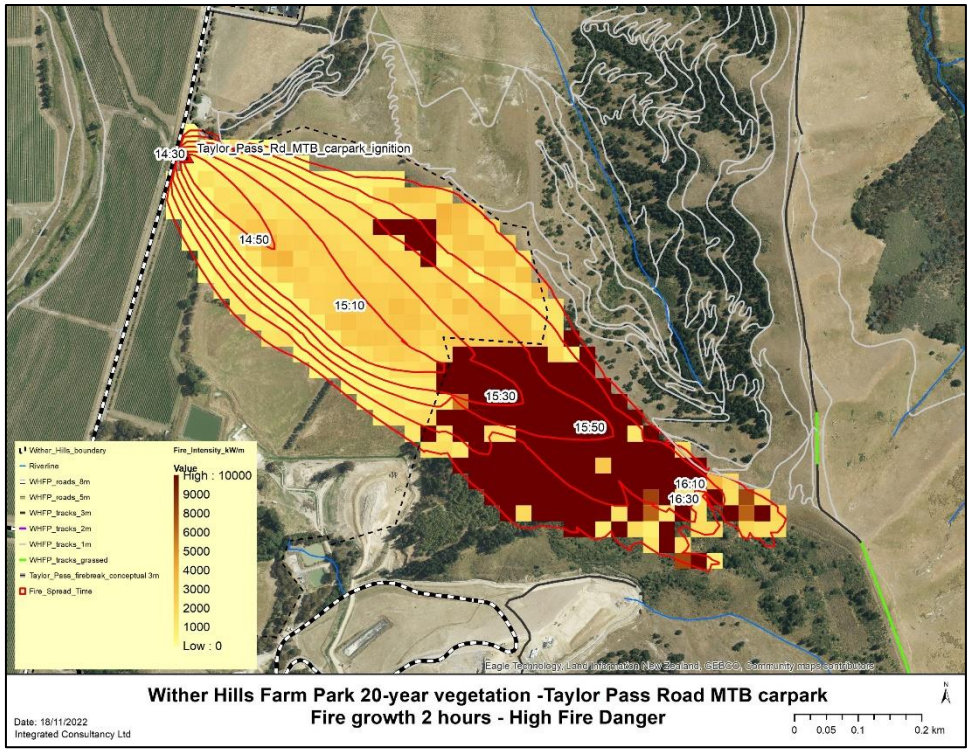
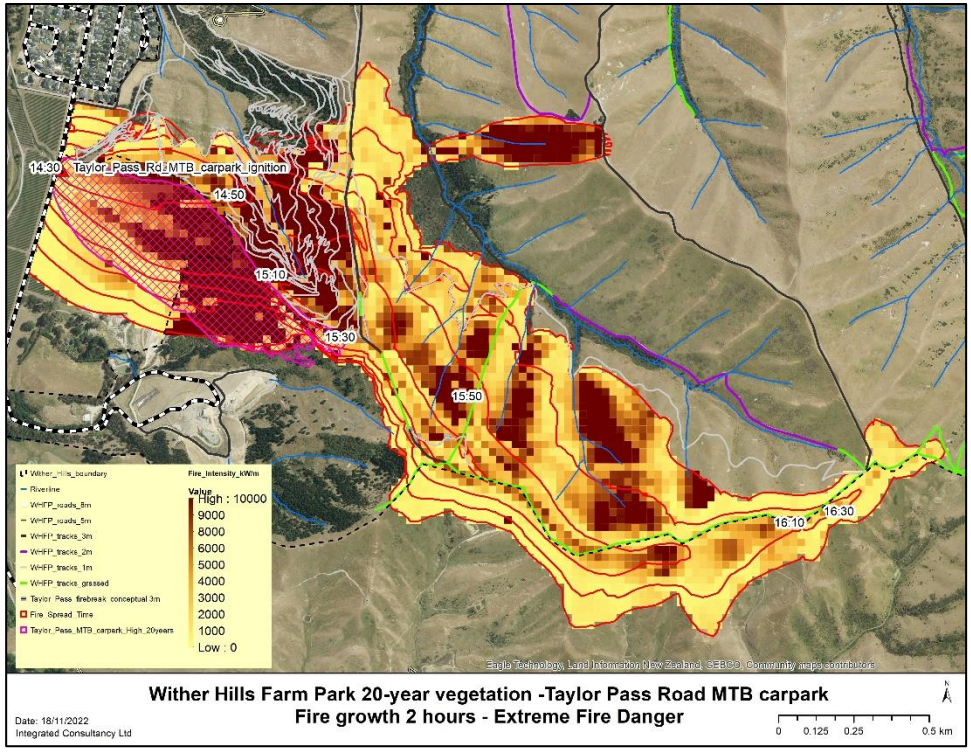


Figure 14: Taylor Pass Road - MTB carpark ignition Extreme (20-year)



8.2.4. Events area beside Rifle Range carpark ignition High (20-year)

Referring to Figure 15, the fire is almost identical to the current scenario with the fire slowly spreading in the first hour before getting a hold in the forest fuels, followed by rapid spread in grassland to reach the ridgeline at 1630 hours. At the 2-hour spread mark, areas of the perimeter burning in heavier forest fuel are outside direct suppression capability.

Table 22: Events area beside Rifle Range carpark ignition High - 20-year

Total area burnt	Total perimeter	% Perimeter controllable with water under pressure	% Perimeter controllable with aircraft	% Perimeter not controllable
9ha	4km	• 1450hrs 100% • 1530hrs 85% • 1630hrs 80%	• 1450hrs NA • 1530hrs NA • 1630hrs 7%	• 1450hrs NA • 1530hrs 15% • 1630hrs 13%

8.2.5. Events area beside Rifle Range carpark ignition Extreme (20-year)

Referring to Figure 16, in the two-hour run period the fire experienced two wind direction shifts firstly from 270° to 300° at 1500 hours and then back to 260° an hour later. This affected the fire's spread direction and head fire locations, where parts of the flanks became head fires and other parts quietened down.

The fire is slower to spread in the first 40 minutes compared with the current scenario due to lower flammability vegetation and is also slowed each time it encounters this vegetation in valley bottoms and lower slopes. The fire only just crosses the Wither Stream at the 2-hour mark.

The fire area and perimeter are almost halved in comparison to the current scenario. The fire perimeter does not reach the main Wither Hills ridgeline in the 2-hour spread time. The 3-meter track system contains sections of the flank fire on the Rotary Lookout Ridge and Reservoir Ridge.

Fire exhibits extreme head fire intensity each time it spreads upslope, reaching 50,000 kW/m. At the 2-hour spread mark most of the perimeter is controllable except in a few places.

Table 23: Events area beside Rifle Range carpark ignition extreme - 20-year

Total area burnt	Total perimeter	% Perimeter controllable with water under pressure	% Perimeter controllable with aircraft	% Perimeter not controllable
166ha	12km	• 1450hrs 43% • 1530hrs 52% • 1630hrs 79%	• 1450hrs 50% • 1530hrs 21% • 1630hrs 12%	• 1450hrs 7% • 1530hrs 27% • 1630hrs 9%

Figure 15: Events area beside Rifle Range carpark ignition High (20-year)

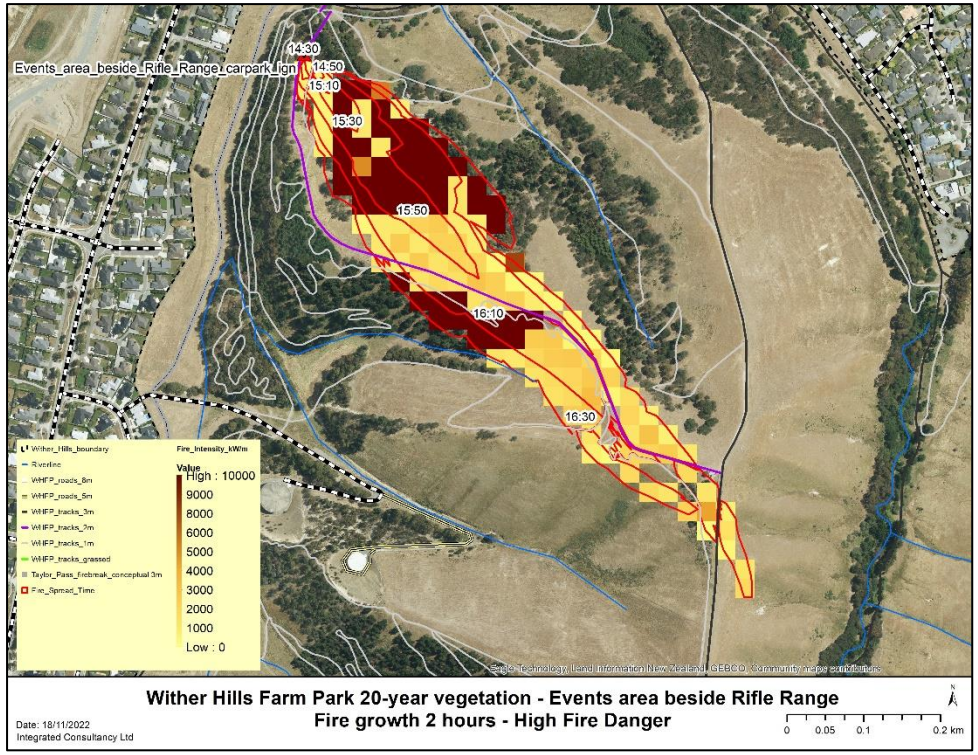
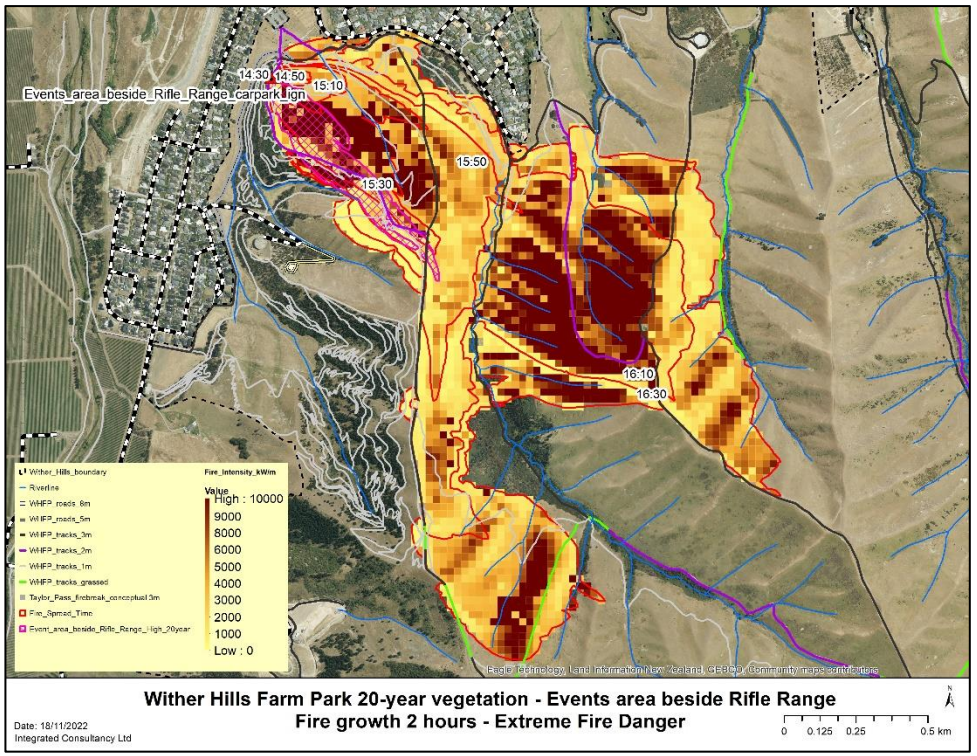


Figure 16: Events area beside Rifle Range carpark ignition Extreme (20-year)



8.2.6. Quail Stream ignition High (20-year)

Referring to Figure 17, the fire is all but the same as the current scenario due to little vegetation change between them. It is slower in the first 20 minutes as it develops in lower flammability vegetation but reaches the same containment location be it a little later.

Table 24:Quail Stream ignition High - 20-year

Total area burnt	Total perimeter	% Perimeter controllable with water under pressure	% Perimeter controllable with aircraft	% Perimeter not controllable
28ha	4km	• 1450hrs 92% • 1530hrs 94% • 1630hrs 98%	• 1450hrs 8% • 1530hrs 6% • 1630hrs 2%	• 1450hrs NA • 1530hrs NA • 1630hrs NA

8.2.7. Quail Stream ignition Extreme (20-year)

Referring to Figure 18, in the two-hour run period the fire experienced two wind direction shifts firstly from 270° to 300° at 1500 hours and then back to 260° an hour later. This affected the fire's spread direction and head fire locations, where parts of the flanks became head fires and other parts quietened down.

Once again, the fire is slower to develop in the valley bottom and is therefore 20 minutes behind the spread of the current scenario. The fire area and perimeter are slightly less than the current mainly due to the slower initial spread and the fact that the 3-meter track along the upper section of Reservoir Ridge contains the flank from spreading back down to Quail Stream.

Additionally, the 3-metre track along the main ridgeline also helps contain the fire due to the wind direction shift at 1600 hours. The wind change causes the fire to slightly flank the track edge as opposed to a direct impact on it.

At the 2-hour spread mark most of the fire is controllable, be it 12 kilometres in length.

Table 25: Quail Stream ignition extreme - 20-year

Total area burnt	Total perimeter	% Perimeter controllable with water under pressure	% Perimeter controllable with aircraft	% Perimeter not controllable
316ha	17km	• 1450hrs 54% • 1530hrs 74% • 1630hrs 73%	• 1450hrs 26% • 1530hrs 15% • 1630hrs 9%	• 1450hrs 20% • 1530hrs 11% • 1630hrs 18%

Figure 17: Quail Stream ignition High (20-year)

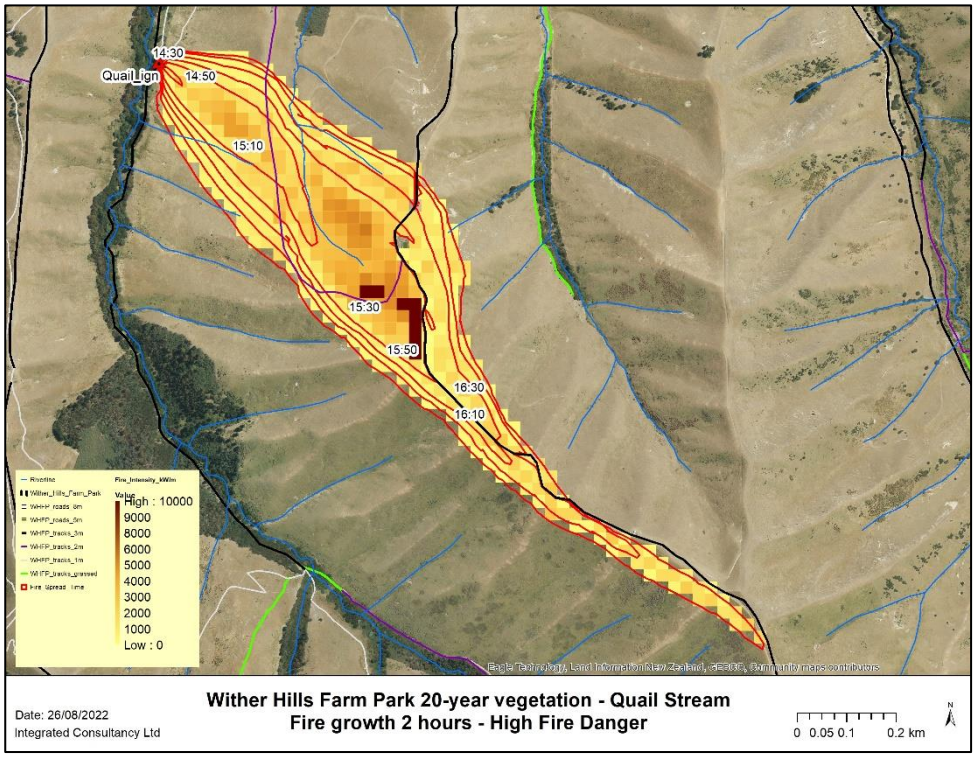
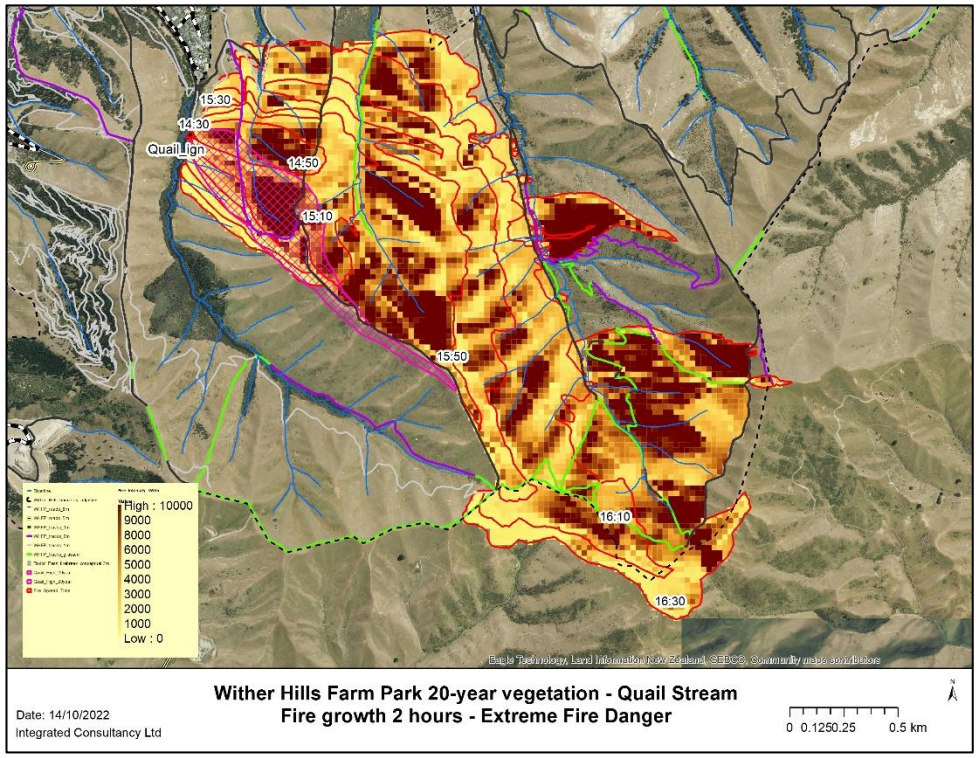


Figure 18: Quail Stream ignition Extreme (20-year)



8.2.8. Start of Sutherland Stream walking track - South of Redwood Street carpark ignition High (20-year)

Referring to Figure 19, the fire is much slower to develop and spread in the lower flammability vegetation in the valley bottom. The fire does not quickly spread until it is in the grassland nearly an hour after ignition. The delayed spread allows containment of the fire by the 3-meter track on the ridgeline keeping the fire on the slopes of Sutherland Stream.

The area and perimeter are reduced by two thirds compared to the current scenario and the fire is always controllable.

Table 26: Start of Sutherland Stream walking track - South of Redwood Street carpark ignition High - 20-year

Total area burnt	Total perimeter	% Perimeter controllable with water under pressure	% Perimeter controllable with aircraft	% Perimeter not controllable
6ha	2km	• 1450hrs 100% • 1530hrs 70% • 1630hrs 97%	• 1450hrs NA • 1530hrs 30% • 1630hrs 3%	• 1450hrs NA • 1530hrs NA • 1630hrs NA

8.2.9. Start of Sutherland Stream walking track - South of Redwood Street carpark ignition Extreme (20-year)

Referring to Figure 20, in the two-hour run period the fire experienced two wind direction shifts firstly from 270° to 300° at 1500 hours and then back to 260° an hour later. This affected the fire's spread direction and head fire locations, where parts of the flanks became head fires and other parts quietened down.

In the first 20 minutes the fire spreads across the upper catchment of Dungey's Gully and into the top of a side creek of Mapps Gully West where lower flammability vegetation begins to slow it down. On the ridgeline the fire spreads in a narrow shape flanking the Mt. Vernon Track before crossing the Wither Hills main ridge and out of the park around 1530 hours. Mapps Gully West and East both slow the fire's eastward spread except in the upper reaches of Mapps Gully West.

The 1600-hour wind direction change spreads the fire on a wide front both in and out of the park and breeches Mapps Track to threaten houses on the rural urban interface.

The fire area is reduced by about a third compared to the current, but the perimeter remains similar. At 1630 hours 10% of the perimeter is uncontrollable.

Table 27: Start of Sutherland Stream walking track - South of Redwood Street carpark ignition extreme - 20-year

Total area burnt	Total perimeter	% Perimeter controllable with water under pressure	% Perimeter controllable with aircraft	% Perimeter not controllable
274ha	13km	• 1450hrs 41% • 1530hrs 74% • 1630hrs 72%	• 1450hrs 16% • 1530hrs 15% • 1630hrs 12%	• 1450hrs 43% • 1530hrs 11% • 1630hrs 16%

Figure 19: Start of Sutherland Stream walking track - South of Redwood Street carpark ignition High (20-year)

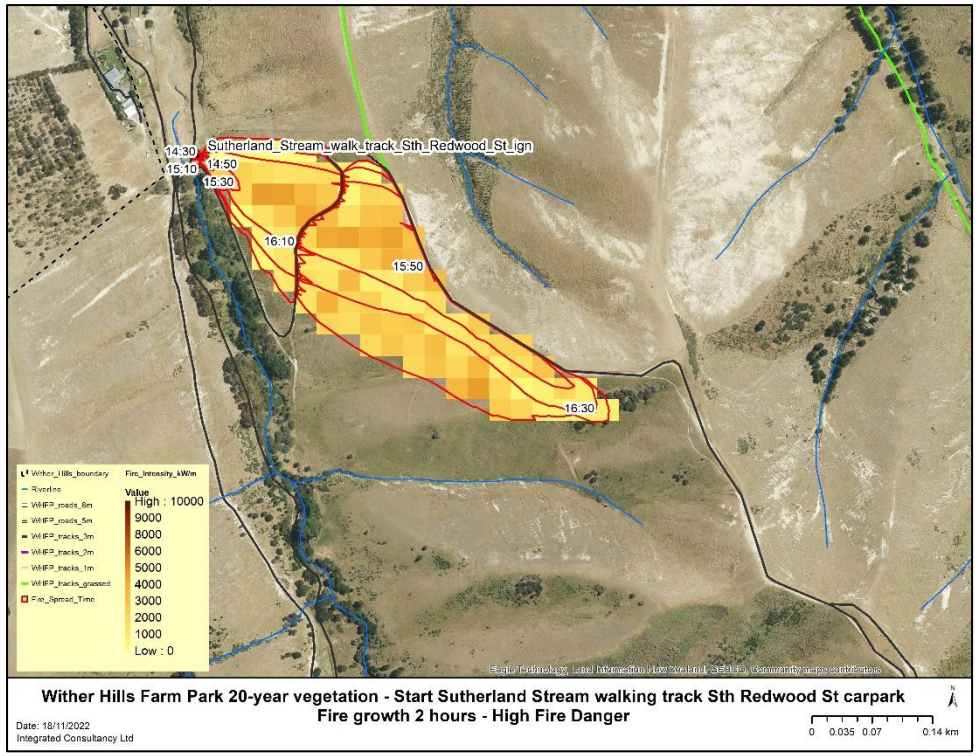


Figure 20: Start of Sutherland Stream walking track - South of Redwood Street carpark ignition Extreme (20-year)

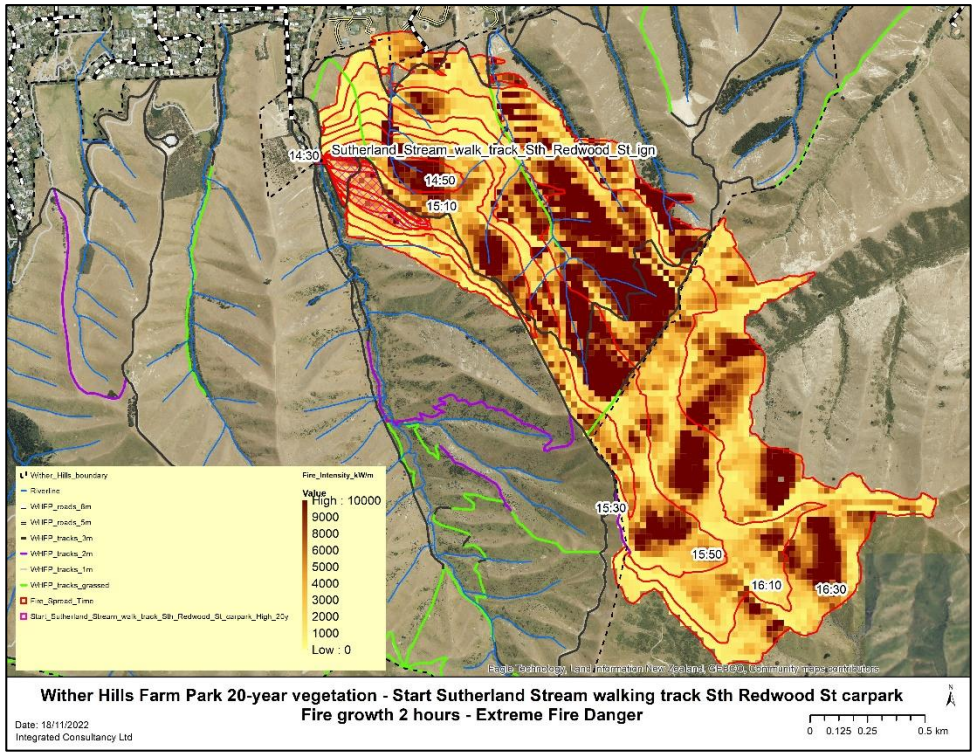


Figure 21: 100-year vegetation cover

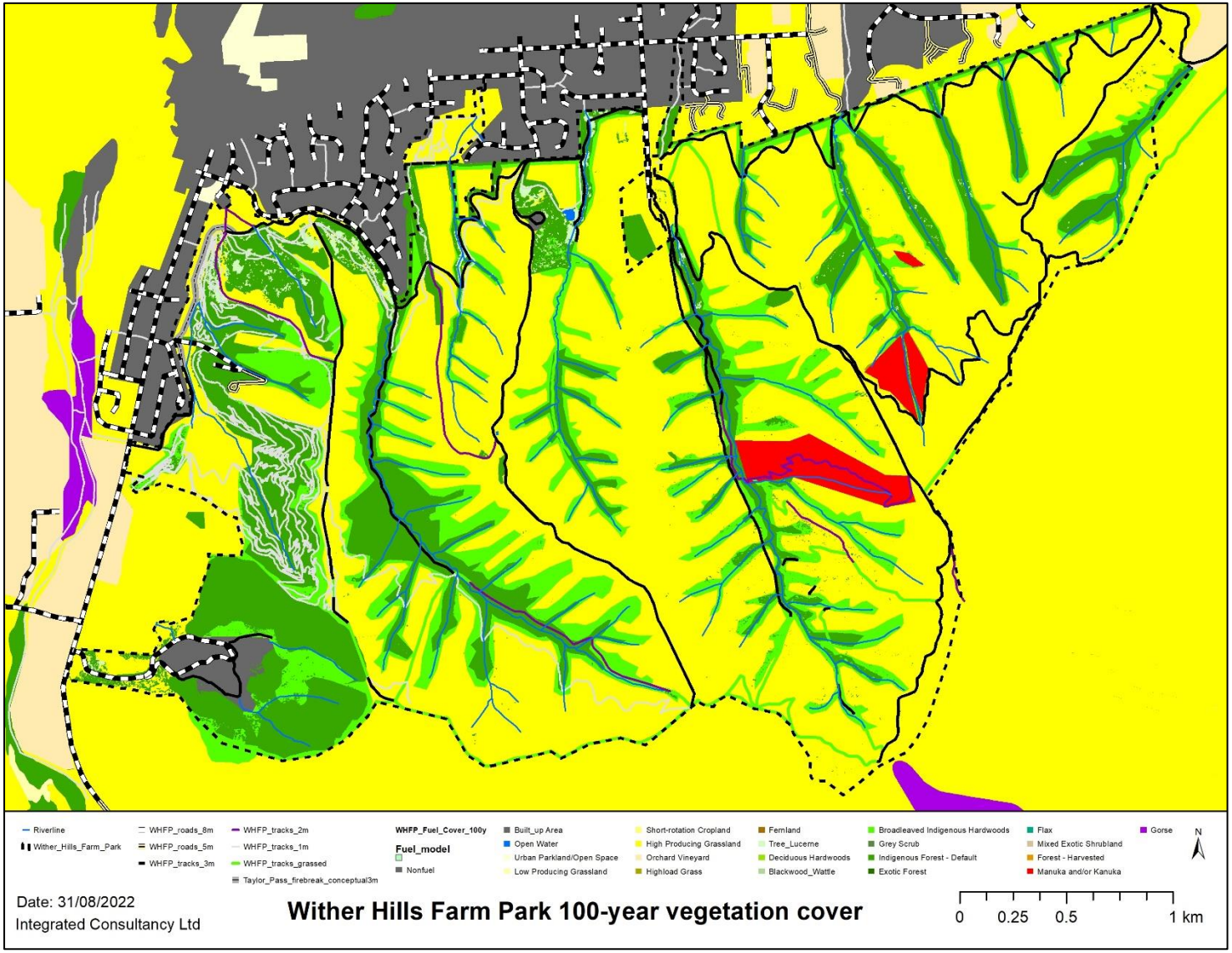
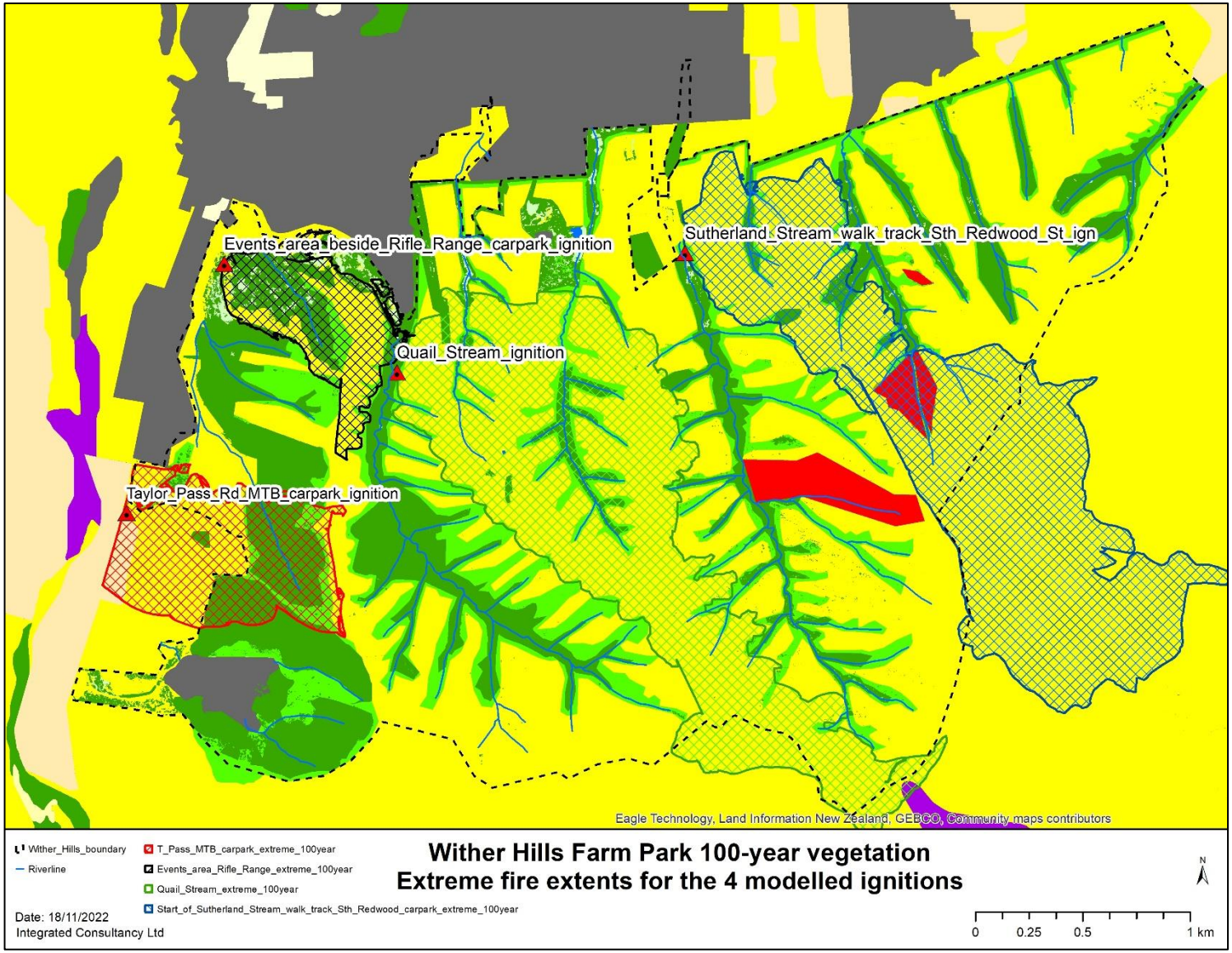


Figure 22: 100-year vegetation with extreme scenario fire extents



8.3. One-hundred-year conceptual vegetation cover

The 100-year conceptual vegetation cover (refer Figure 21) builds off the 20-year conceptual cover and is a long-term projection based on today's thinking. It is intended to provide fire spread data in comparison to the current and 20-year vegetation to help inform priority revegetation areas.

Once again, a key revegetation assumption is that it will be feasible to exclude farm stock grazing from these areas, and that underplanting and weed control will occur. Revegetation would be expected to dominate over sheltering vegetation and mature over the 80-years.

The concept considers a Podocarp and Broadleaf Hardwood Forest cover in the valleys, side streams and damper flats and slopes, with grass cover for farming over the remaining. The slopes of the mountain bike park also change to this vegetation but have pockets of Deciduous Hardwoods interspersed, with the same applying to the amenity and recreational areas along the base of the hills and a little way up the valleys.

The 20-year strip of Broadleaf Hardwood along sections of the rural urban interface transition to Podocarp Forest with an additional Broadleaf Hardwood strip added to further extend the width of native planting. This is an assumed situation for modelling fire spread, and a line of tall Podocarp trees will not necessarily eventuate close to houses.

In formulating the 100-year cover the following key changes were applied.

1) The 20-year Conifer Forest, Tree Lucerne, Blackwood, and Broadleaf Hardwoods replaced with Podocarp Forest with some expansion. This cover is for scenario purposes, and it may eventuate that the cover is a mixed Podocarp/Exotic Forest.

2) Some grassland pockets in and around forest areas have been replaced with Broadleaf Hardwoods.

3) Damper areas and colder aspects transition to Broadleaf Hardwoods, with some of this buffering Podocarp fringes on drier slopes.

4) Deciduous Hardwoods replaced in valleys with Podocarp and Broadleaf Hardwoods, but pockets left in amenity and the lower elevation recreation areas.

5) The Manuka in the Covenant and in Mapps Gully West have been left as Manuka Forest with the old pine area at the head of Mapps Gully West replaced with Manuka Forest. The latter is for scenario purposes to give data on fire behaviour and will not likely eventuate.

6) The 20-year Broadleaf Hardwoods along sections of the rural urban interface transition to Podocarp Forest and Broadleaf Hardwoods extend this buffer.

Figure 22 presents the 4 extreme scenario extents overlaying the 100-year vegetation layer.

8.3.1. Interpretation of fire growth modelling (100-year)

The following detail presents fire growth modelling outputs for fires spreading through the 100- year vegetation cover. The detail includes a 100-year vegetation map, a 2-hour fire growth map for each scenario ignition including fire intensity display and 20-minute fire perimeters, fire growth statistics table, and interpretation.

Apart from the 100-year vegetation changes, all other simulation inputs including ignition locations remain the same as for the current and 20-year vegetation scenarios.

This allows for assessment of scenario outputs for the three vegetation covers and will give an indication of the effects the 100-year vegetation change has on fire behaviour. In turn scenario assessment findings will inform the risk evaluation and future risk treatment options.

The following tables indicate scenario outputs of fire area and perimeter for three time points following ignition at 1430 hours. Additionally, the tables present the percentage of fire perimeter for each time point that is either suppressible by water under pressure, aircraft, or is not suppressible.

The scenario outputs are then discussed in regards the likelihood of fire spread being slowed or stopped by existing roads, tracks, non-fuel areas, and lower flammability vegetation.

The simulated fire growth perimeter lines do not account for spot fires.

8.3.2. Taylor Pass Road - MTB carpark ignition High (100-year)

Referring to Figure 23, for the first 40 minutes the fire spreads like the 20-year but is severely slowed once it enters the park and encounters Podocarp Forest. This reduces the area burnt by a third and is controllable in the first hour.

Table 28: Taylor Pass Road - MTB carpark ignition High - 100-year

Total area burnt	Total perimeter	% Perimeter controllable with water under pressure	% Perimeter controllable with aircraft	% Perimeter not controllable
16ha	2km	• 1450hrs 80% • 1530hrs 92% • 1630hrs 90%	• 1450hrs 20% • 1530hrs 8% • 1630hrs 2%	• 1450hrs NA • 1530hrs NA • 1630hrs 8%

8.3.3. Taylor Pass Road - MTB carpark ignition Extreme (100-year)

Referring to Figure 24, in the two-hour run period the fire experienced two wind direction shifts firstly from 270° to 300° at 1500 hours and then back to 260° an hour later.

The fire enters the park in the first 20 minutes but remains on the west facing mountain bike park slopes. At the 1630 hour spread mark the fire is just cresting the ridgeline and crosses the track at some points.

The southern half of the mountain bike park is impacted by the fire, but the tracks do have some effectiveness in containing the left flank and a section at the left side base of the fire.

The Podocarp Forest and the smaller amount Broadleaf Hardwoods slow the fire once it is in the park. This has the effect of reducing the burnt area by two thirds and halving the perimeter compared to the 20-year scenario. By 1630 hours nearly all the perimeter in controllable.

Table 29: Taylor Pass Road - MTB carpark ignition extreme - 100-year

Total area burnt	Total perimeter	% Perimeter controllable with water under pressure	% Perimeter controllable with aircraft	% Perimeter not controllable
63ha	7km	• 1450hrs 47% • 1530hrs 63% • 1630hrs 71%	• 1450hrs 32% • 1530hrs 32% • 1630hrs 26%	• 1450hrs 21% • 1530hrs 5% • 1630hrs 3%

Figure 23: Taylor Pass Road - MTB carpark ignition High (100-year)

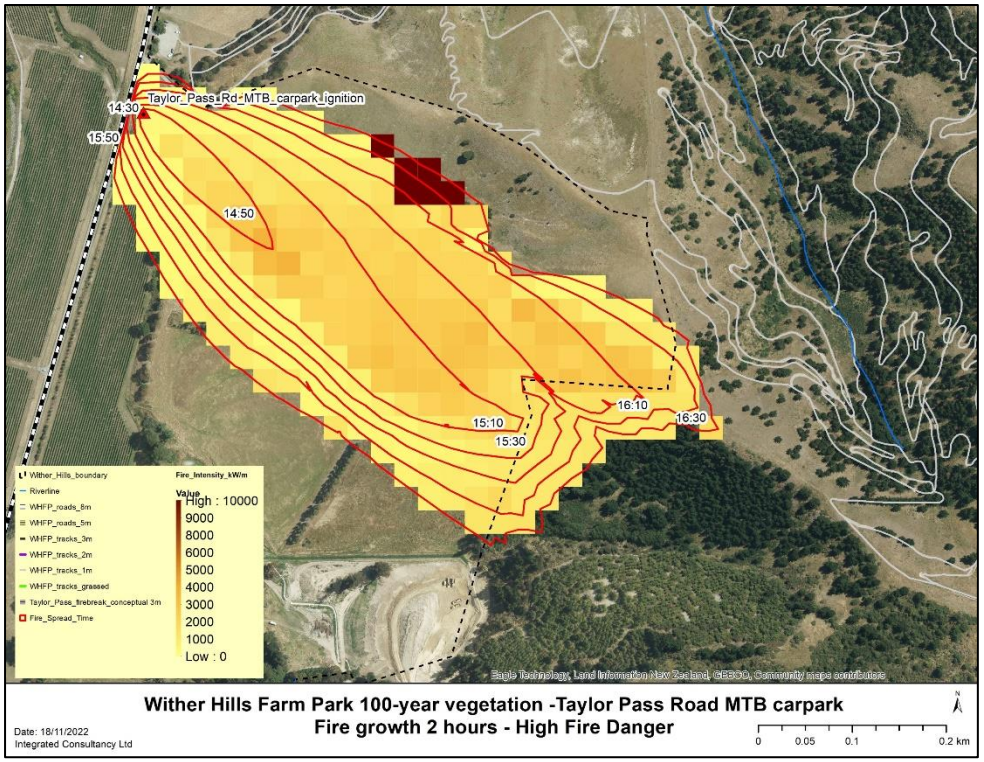
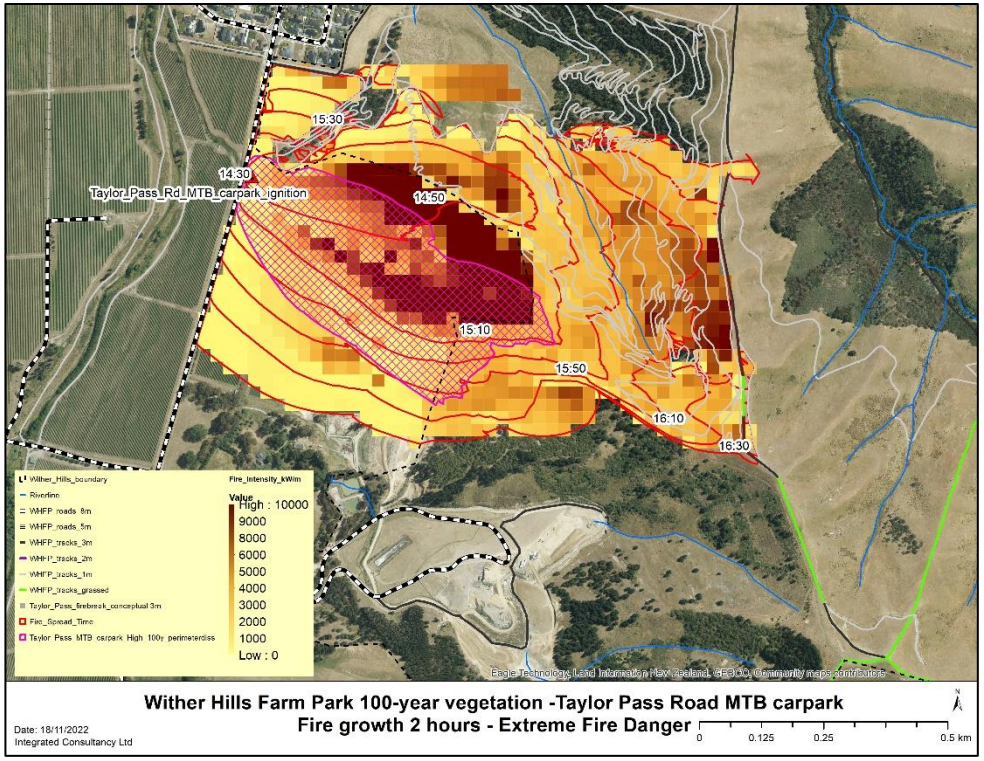


Figure 24: Taylor Pass Road - MTB carpark ignition Extreme (100-year)



8.3.4. Events area beside Rifle Range carpark ignition High (100-year)

Referring to Figure 25, the fire is slow to develop and does not spread out of the mixed Podocarp/Broadleaf vegetation. Burnt area and fire perimeter are small and controllable throughout the 2-hours.

Table 30: Events area beside Rifle Range carpark ignition High - 100-year

Total area burnt	Total perimeter	% Perimeter controllable with water under pressure	% Perimeter controllable with aircraft	% Perimeter not controllable
1ha	0.65km	• 1450hrs 100% • 1530hrs 100% • 1630hrs 100%	• 1450hrs NA • 1530hrs NA • 1630hrs NA	• 1450hrs NA • 1530hrs NA • 1630hrs NA

8.3.5. Events area beside Rifle Range carpark ignition Extreme (100-year)

Referring to Figure 26, in the two-hour run period the fire experienced two wind direction shifts firstly from 270° to 300° at 1500 hours and then back to 260° an hour later. This affected the fire's spread direction and head fire locations, where parts of the flanks became head fires and other parts quietened down.

The fire develops relatively slowly, burning on the lower and mid-slopes for the first hour before quickly spreading to the ridgeline by 1550 hours in grassland vegetation.

With the 1600-hour wind direction change the fire is then pushed towards Quail Stream and Forest Park Drive where it crosses both Quail Stream and the 3-meter track at the base of the hill near Forest Park Drive.

The right flank is contained by the track system and the burnt area is reduced by about three quarters compared to the 20-year scenario.

Table 31: Events area beside Rifle Range carpark ignition extreme - 100-year

Total area burnt	Total perimeter	% Perimeter controllable with water under pressure	% Perimeter controllable with aircraft	% Perimeter not controllable
40ha	7km	• 1450hrs 49% • 1530hrs 64% • 1630hrs 91%	• 1450hrs 51% • 1530hrs 35% • 1630hrs 8%	• 1450hrs NA • 1530hrs 1% • 1630hrs 1%

Figure 25: Events area beside Rifle Range carpark ignition High (100-year)

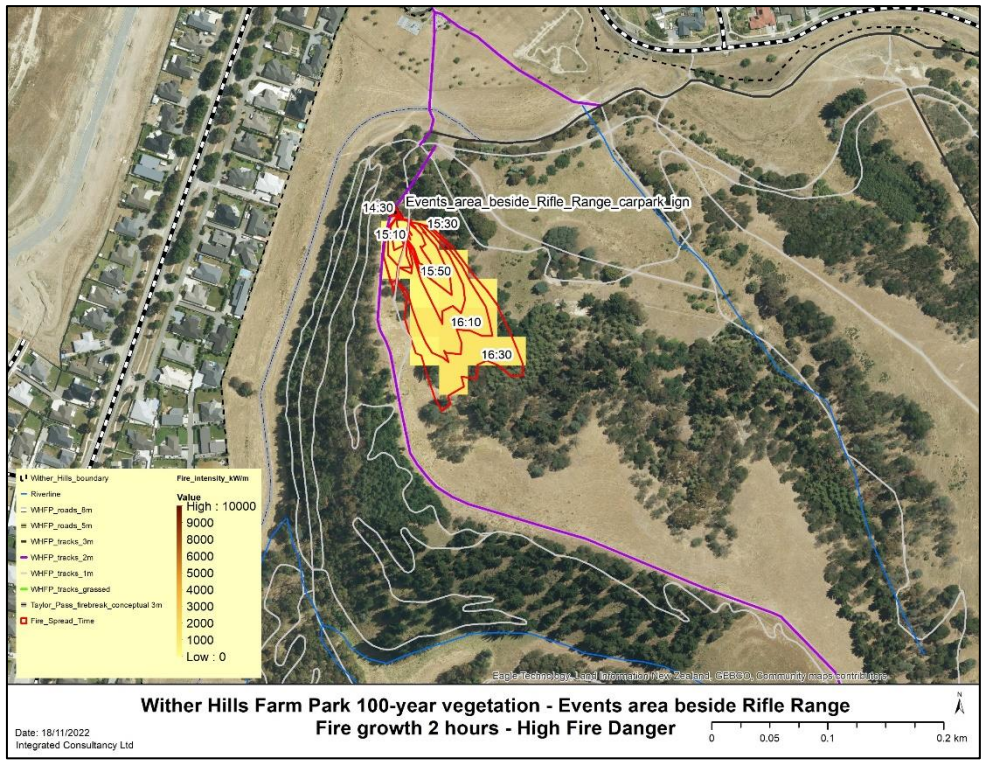
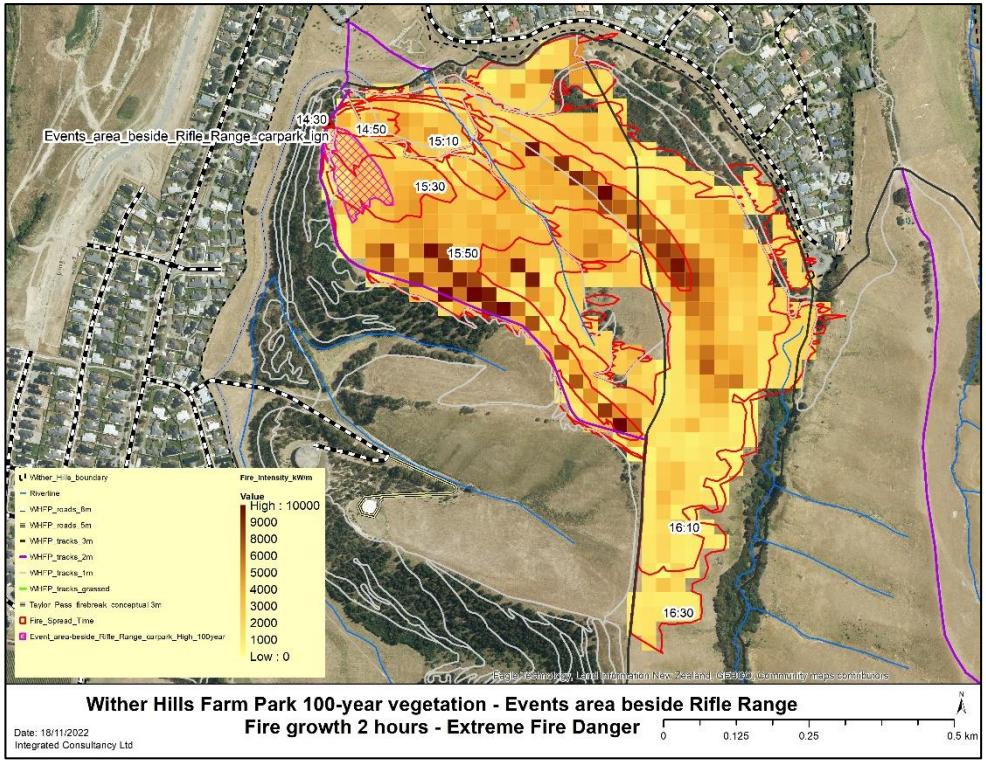


Figure 26: Events area beside Rifle Range carpark ignition Extreme (100-year)



8.3.6. Quail Stream ignition High (100-year)

Referring to Figure 27, the fire is all but the same as the 20-year scenario except the development is a half an hour or so slower. The Reservoir Ridge track acts to help contain the very narrow head fire with the left and right flanks generally lower fire intensity and easily controlled. The fire is controllable throughout the 2-hour spread run.

Table 32: Quail Stream ignition High - 100-year

Total area burnt	Total perimeter	% Perimeter controllable with water under pressure	% Perimeter controllable with aircraft	% Perimeter not controllable
17ha	5km	• 1450hrs 100% • 1530hrs 78% • 1630hrs 97%	• 1450hrs NA • 1530hrs 22% • 1630hrs 3%	• 1450hrs NA • 1530hrs NA • 1630hrs NA

8.3.7. Quail Stream ignition Extreme (100-year)

Referring to Figure 28, in the two-hour run period the fire experienced two wind direction shifts firstly from 270° to 300° at 1500 hours and then back to 260° an hour later. This affected the fire's spread direction and head fire locations, where parts of the flanks became head fires and other parts quietened down.

The fire is slower to develop and spread. In the first hour it has crossed Harling Stream catchment and is burning into Withers Stream. The wind also drives the fire SE along Reservoir Ridge to reach the main Wither Hills ridgeline by 1550. At 1600 the change of wind direction spreads the fire on a wide front on to the mid and upper slopes of Sutherland Stream. The downslope fire spread rates are relatively slow.

At the main Wither Hills ridgeline, the fire begins to follow it NE with some burnt area outside the park. The Mapps Track on the lower slopes above the rural urban interface has some effect in stopping spread, but the fire does cross in one place.

In the 2-hours the fire does not spread to reach Sutherland Stream or the tracks along it. The area burnt and perimeter are reduced by around a third compared to the 20-year scenario. Around 7% of the perimeter is uncontrollable at 1630 hours.

Table 33: Quail Stream ignition extreme - 100-year

Total area burnt	Total perimeter	% Perimeter controllable with water under pressure	% Perimeter controllable with aircraft	% Perimeter not controllable
203ha	12km	• 1450hrs 41% • 1530hrs 78% • 1630hrs 82%	• 1450hrs 39% • 1530hrs 13% • 1630hrs 11%	• 1450hrs 20% • 1530hrs 9% • 1630hrs 7%

Figure 27: Quail Stream ignition High (100-year)

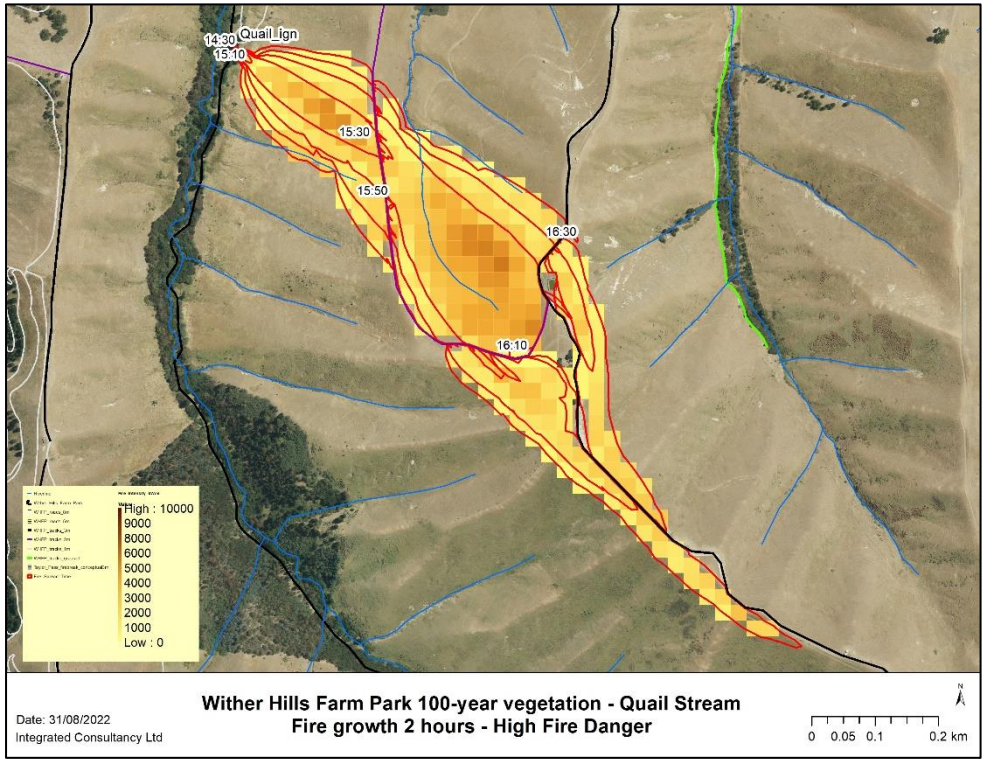
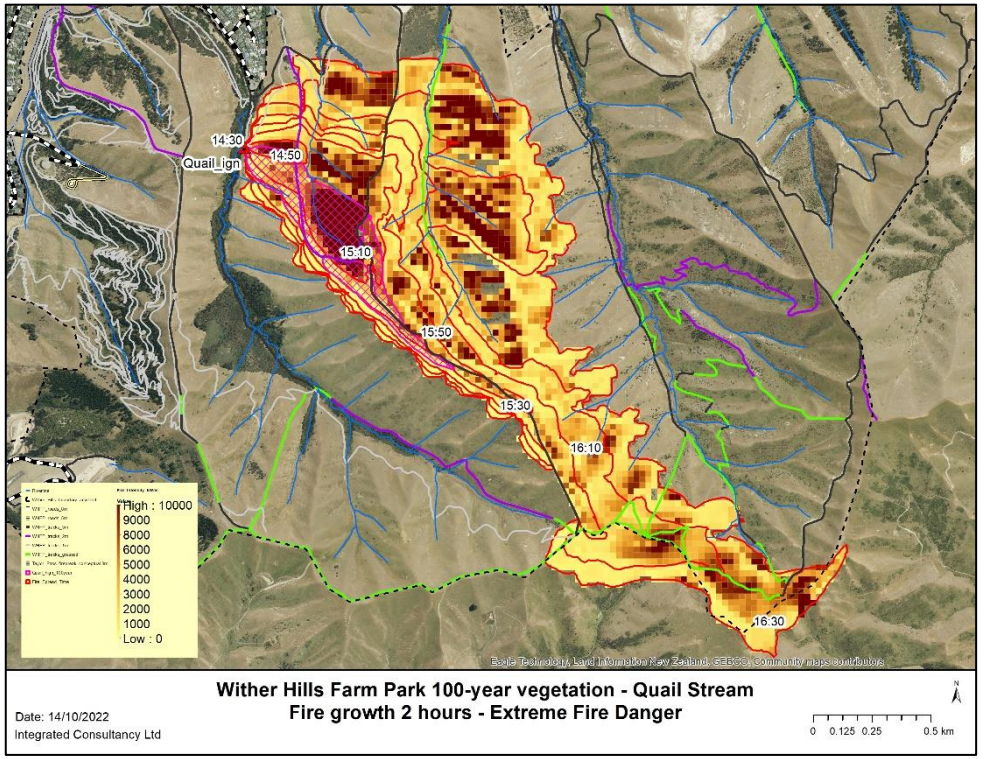


Figure 28: Quail Stream ignition Extreme (100-year)



8.3.8. Start of Sutherland Stream walking track - South of Redwood Street carpark ignition High (100-year)

Referring to Figure 29, the fire is slow to develop, smaller in area to the 20-year but similar shape. The Mt. Vernon track contains the left flank, with the right flank relatively low fire intensity and easily controlled.

The burnt area and perimeter are reduced by about a third compared to the 20-year with the fire controllable throughout the 2-hour scenario.

Table 34: Start of Sutherland Stream walking track - South of Redwood Street carpark ignition High - 100-year

Total area burnt	Total perimeter	% Perimeter controllable with water under pressure	% Perimeter controllable with aircraft	% Perimeter not controllable
4ha	1km	• 1450hrs 100% • 1530hrs 100% • 1630hrs 100%	• 1450hrs NA • 1530hrs NA • 1630hrs NA	• 1450hrs NA • 1530hrs NA • 1630hrs NA

8.3.9. Start of Sutherland Stream walking track - South of Redwood Street carpark ignition Extreme (100-year)

Referring to Figure 30, in the two-hour run period the fire experienced two wind direction shifts firstly from 270° to 300° at 1500 hours and then back to 260° an hour later. This affected the fire's spread direction and head fire locations, where parts of the flanks became head fires and other parts quietened down.

The fire is much the same shape as the 20-year scenario but narrower inside the park. This results in the burn area being 70 hectares less than the 20-year but a similar perimeter length.

The east spreading fire does not cross the lower and mid sections of Mapps Gully West stream but does involve its upper catchment area where the vegetation is Manuka. The fire does not enter Mapps Gully East or Simmons Gully and is generally contained by the Mapps Track on the lower slopes.

Outside the park the burn area is very similar to the 20-year scenario and there is around 10% of the perimeter uncontrollable at 1630 hours.

Table 35: Start of Sutherland Stream walking track - South of Redwood Street carpark ignition extreme - 100-year

Total area burnt	Total perimeter	% Perimeter controllable with water under pressure	% Perimeter controllable with aircraft	% Perimeter not controllable
204ha	12km	• 1450hrs 24% • 1530hrs 77% • 1630hrs 82%	• 1450hrs 33% • 1530hrs 13% • 1630hrs 8%	• 1450hrs 43% • 1530hrs 10% • 1630hrs 10%

Figure 29: Start of Sutherland Stream walking track - South of Redwood Street carpark ignition High (100-year)

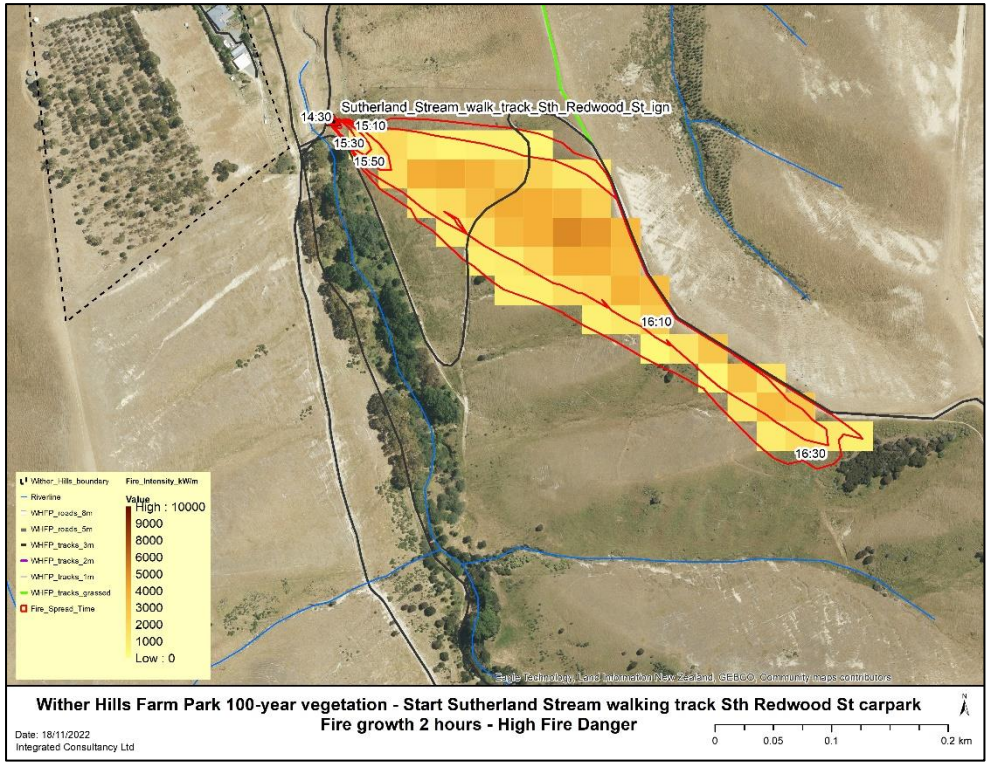
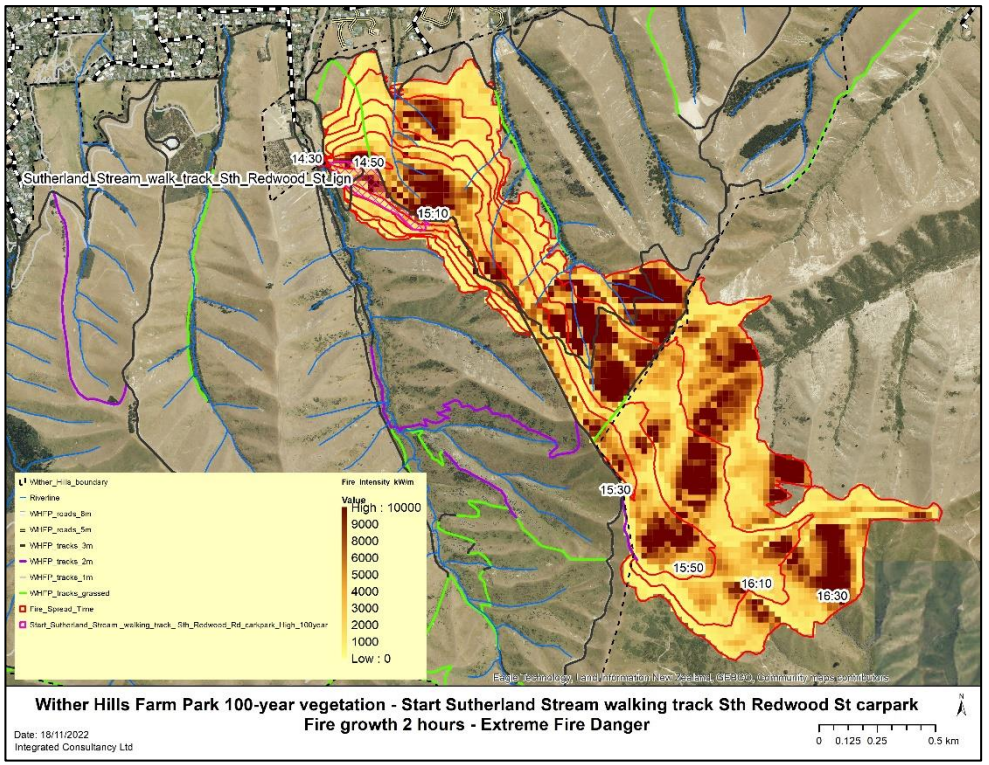


Figure 30: Start of Sutherland Stream walking track - South of Redwood Street carpark ignition Extreme (100-year)



9. Table references

10. Figure references

11. Fire Danger Class Criteria

Table of Suppression Interpretations for the New Zealand Fire Danger Classes (after Alexander, 2008).

Fire Danger Class	Fire Intensity (kW/m)	Description of Probable Fire Potential and Implications for Fire Suppression†	Nominal Max. Flame Height (m)
LOW	< 10	New fire starts are unlikely to sustain themselves due to moist surface fuel conditions. However, ignitions may take place near large and prolonged or intense heat sources (e.g., campfires, windrowed slash piles) but the resulting fires generally do not spread much beyond their point of origin and, if they do, control is easily achieved. Mop-up or complete extinguishment of fires that are already burning may still be required provided there is sufficient dry fuel to support smouldering combustion*. Colour code is GREEN.	no visible flame (< 0.2 m)
MODERATE	10 - 500	From the standpoint of moisture content, fuels are considered to be sufficiently receptive to sustain ignition and combustion from both flaming and most non-flaming (e.g., glowing) firebrands. Creeping or gentle surface fire activity is commonplace. Control of such fires is comparatively easy but can become troublesome as fire damages can still result and fires can become costly to suppress if they aren't attended to immediately. Direct manual attack around the entire fire perimeter by firefighters with only hand tools and back-pack pumps is possible. Colour code is BLUE.	0.2 to 1.3 metres
HIGH	500 - 2000	Running or vigorous surface fires are most likely to occur. Any fire outbreak constitutes a serious problem. Control becomes gradually more difficult if it's not completed during the early stages of fire growth following ignition. Water under pressure (from ground tankers or fire pumps with hose lays) and bulldozers are required for effective action at the fire's head. Colour code is YELLOW.	1.4 to 2.5 metres
VERY HIGH	2000 - 4000	Burning conditions have become critical as the likelihood of intense surface fires is a distinct possibility; torching and intermittent crowning in forests can take place. Direct attack on the head of a fire by ground forces is feasible for only the first few minutes after ignition has occurred. Otherwise, any attempt to attack the fire's head should be limited to helicopters with buckets or fixed-wing aircraft, preferably dropping long-term chemical fire retardants. Until the fire weather severity abates, resulting in a subsidence of the fire run, the uncertainty of successful control exists. Colour code is ORANGE.	2.6 to 3.5 metres
EXTREME	4000 - 10,000	The situation should be considered "explosive" or super critical. The characteristics associated with the violent physical behaviour of conflagrations or firestorms is a certainty (e.g., rapid spread rates, crowning in forests, medium- to long-range mass spotting, firewhirls, towering convection columns, great walls of flame). As a result, fires pose an especially grave threat to persons and their property. Breaching of roads and firebreaks occurs with regularity as fires sweep across the landscape. Direct attack is rarely possible given the fire's probable ferocity except immediately after ignition and should only be attempted with the utmost caution. The only effective and safe control action that can be taken until the fire run expires is at the back and along the flanks. Colour code is RED (or PURPLE for VERY EXTREME).	3.6 to 5.4 metres
VERY EXTREME	> 10,000		> 5.4 m