



Psa-V Tracing Report:

**Assessing known pathways in the
inter-regional spread of Psa-V:
Tracing incursions in the Franklin
region, South Auckland**

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Contents

Executive Summary

Glossary/Definitions

Trace back investigation time line

Regional Priority Zone

1.0: Trace back Investigation for out of zone incursions

- 1.1 Purpose of the investigation
- 1.2 Key areas explored in an investigation
- 1.3 Limitations to a trace back investigation

2.0: Orchards involved in the trace back investigation

Summary table noting key information on Psa-V positive orchards

3.0: Nature of the infection on the affected orchards

- 3.1 Orchard A, 18 November 2011, Hayward and G3 block
- 3.2 Orchard B, 21 November 2011, G3 block (male and female)
- 3.3 Orchard C, 25 November 2011, G3 block (male and female)
- 3.4 Orchard D, 21 December 2011, G3 block (Bruno suckers)
- 3.5 Orchard E, 17 January 2012, Hayward block
- 3.6 Orchard F, 27 April 2012, G3 block (Female)

4.0: Assessing Pathway 1: Weather related events / Infection periods

- 4.1 Infection periods
- 4.2 Protective spray programme
- 4.3 Plausibility of a weather related incursion

5.0: Assessing Pathway 2: Asymptomatic plant material

- 5.1 Budwood movement
- 5.2 Plausibility of a budwood related incursion

6.0: Assessing Pathway 3: Contractor movement

- 6.1 Direct association, grafting contractors from the Bay of Plenty
- 6.2 Plausibility of a contractor related incursion
- 6.3 Indirect association, harvest bin movements from the Bay of Plenty
- 6.2 Plausibility of a harvest bin movement related incursion

7.0: Conclusion

8.0: Acknowledgements

Disclaimer

The following report has been constructed from information on hand. Therefore, it is subject to change. Should any new information be put forward, which challenges the propositions in this report, the report will be updated and send to the appropriate representatives for review.

Executive summary:

On 18 November 2011, KVH was notified of a positive Psa-V result in the Franklin region, South Auckland. A week later, two more positive results were received on separate orchards. A fourth result was received in late December 2011; a fifth was confirmed in early January 2012 and more recently a sixth result on 27 April 2012. At the first notification of a positive result, KVH senior technical staff visited the affected orchard to confirm symptoms. KVH also initiated a trace back investigation into the Franklin region incursions.

The following summarises the key considerations within this report:

- **Infection on Orchard A**, expressed as Psa-V leaf spot on the Hayward vines—suggest primary infection. Based on what has been observed in the Bay of Plenty region, a likely cause may have been a local inoculum source. Following exposure to a local inoculum source, infection could be induced by a weather event that would provide ideal conditions for an ‘infection period’ allowing for the propagation of Psa-V on the leaf surface. The exact date of the infection is unknown. (This lack of knowledge on infection timing is a strong limitation in understanding all of the Franklin region incursions). As Hayward shows more tolerance to Psa-V and due to the severity of the leaf spot observed in Orchard A, the infection may have been present for some time prior to its discovery.

On 18 April 2012, secondary infection was identified (by Shane Max, ZESPRI) on Orchard A within the new variety block, GOLD3 (G3). Die back was seen on G3 vines and on the male variety, M91. Due to the time period from when symptoms were first observed (November 2011) to a more recent observation of additional symptoms (April 2012), this has prevented KVH from determining whether the latest finds are new symptoms or a progression of a previously existing infection. This new discovery also challenges which block was first infected, Hayward or G3. This is a significant limitation in understanding the pathway for infection on this orchard and in turn the wider region.

On 5 May 2012, orange exudate on Orchard A was reported (on male vines in the G3 block) to KVH.

- **Orchard B and C** were identical in terms of *initial* (November 2011) disease expression. Initial infection seen as shoot wilt (and minor leaf spot) on orchard B and C are considered to be secondary symptoms (predominately seen on M91 males but also seen in some cases on G3). **On 18 April 2012, one male vine expressed dry orange exudate** on Orchard B (observed by Shane Max, ZESPRI).
- **Orchard susceptibility** will determine how vulnerable an orchard is to Psa-V infection following an infection period or under local ‘inoculum pressure’. Orchard A, B, C, D and F had grafted new plant material in August 2011. Grafting creates a long-lasting severe wound, which can provide a direct entry point for Psa-V. In addition, on some of these orchards, no regular protectant spray programme was in place for the new variety blocks. For these reasons, these are considered to have a higher susceptibility for Psa-V infection.

- **Two orchards were the major suppliers of new variety plant material (G3), Orchard I and Orchard A.** Orchard I was the initial supplier of G3 and once supplies were exhausted from this orchard, Orchard A provided G3 (from their 2010 new variety block) to the remaining orchards in the Franklin region who had requested new variety wood. This was part of the local Packhouse's Psa-V management strategy to ensure traceability of plant material should an incursion take place. Orchard A, B, C, D and F are connected through shared plant material (male and or G3). Currently there is no obvious evidence to suggest Psa-V was introduced or spread through plant material (specifically M91 or G3 wood).
- It may be that KVH is observing the result of the challenge faced in collecting or providing graftwood material in known or unknown Psa-V environments. It is thought a vine may have the capacity to contain both Psa-V infected canes and Psa-V uninfected canes. Therefore, it may be expected the Psa-V affected wood could have the capacity to contaminate any vine it is grafted into—while the unaffected wood may not cause infection. It may be that orchard A, B, C, D and F received asymptomatic Psa-V wood. However, in this scenario secondary infection is expected to be observed on the supply orchard and on the orchards that received the 'asymptomatic' material.
- Following the initial detection in November 2011, three additional orchards (**D, E and F**) tested positive for Psa-V. Orchard E has no connections with either A, B, C, D, or F. For this reason it is not considered to be part of the original set of infected orchards. As the symptoms expressed on the 2012 identifications are predominately leaf spot; D, E and F are not considered (at this time) to be related to the original set of infected orchards (A, B and C) but rather, the result of local inoculum spread/pressure.
- **Orchard A, B, C, D and F** are connected through a shared Bay of Plenty grafting contractor. The grafting manager noted the following.
 - No tools were taken up to the Franklin region other than a specialised chisel, which was purchased in the Bay of Plenty on the same day and taken to Franklin;
 - Contractors wore fresh clothes;
 - Two to three days prior to working in Franklin the contractors had been working in Te Puke; and
 - The expected on-orchard hygiene practices involved the cleaning of tools between vines using methylated spirits and chlorine was provided for cleaning vehicle tyres.
- **There is no obvious evidence** to suggest Psa-V was introduced and spread through a shared Bay of Plenty grafting contractor. All orchards (15 in total) with new grafted material using the same contractor had the same exposure time/incubation period for Psa-V infection. However, one would expect the first orchard visited by the grafting contractor would have been at the highest risk to Psa-V contamination. Looking at the records KVH has noted the first orchard visited by the grafting contractor is positive for Psa-V.
- **The most likely scenario** is that Psa-V was introduced onto one of the five orchards through a primary pathway, i.e. plant material or contractor movements, although there is no

obvious evidence to suggest this. However, initial infection on the original orchard(s) (although KVH is unable to determine which orchard(s) were first infected) would have been low and over time this has progressed into secondary infection, which then became a source of inoculum and caused further local spread of the bacteria. This supports and accounts for the leaf spot seen on four of the six orchards. Within this scenario, orchard A, B or C may have been among the first orchards infected and a source of inoculum for wider local spread. It is also indicative that the infection may have originated on or was introduced into one of the new variety G3 blocks on one of these three orchards.

- **At this time**, this investigation has been unsuccessful in identifying the primary pathway for the Franklin incursions. Therefore, the following report is a catchment of information on the affected orchards, factors involved, possible links and reviews on risk factors. Should any new information be presented that aids in the understanding of the Franklin incursions this report will be updated accordingly.
- Following the recent discovery (18 April and 8 May 2012) of secondary infection in the form of orange exudate on two of the incursions identified in late 2011 (Orchard A and B), KVH strongly encourages aggressive orchard management through the method of removal of all infected material (which is being practiced) to ensure Psa-V risk is managed and inoculum pressure is kept to a minimum.
- Infected orchards must be frequently monitored to ensure the disease is being managed optimally. Poor management or neglecting to remove infected material will very likely see an increase in inoculum pressure and further spread of the Psa-V within the Franklin region.

Definition of terms:

Primary symptoms: are symptoms expressed externally, ie leaf spot indicating bacterial presence on the surface of the plant or in the environment.

Secondary symptoms: are symptoms expressed internally, ie shoot wilt, shoot die back, cane die back and/or red exudate indicating the bacteria has invaded into the plant.

Infection periods: are defined as prolonged periods of leaf wetness, which is generally understood to be two to three days. From field observations primary symptoms have typically been expressed to be approximately seven to 14 days outside of a significant weather event, depending on local inoculum pressure.

Tolerance: used to imply a plant is able, at some level, to handle or better manage the presence of Psa-V in its system or on its surface. It does not mean the plant is unable to be affected or infected by Psa-V.

Inoculum: a large amount of bacteria that a plant may be exposed to and may become infected.

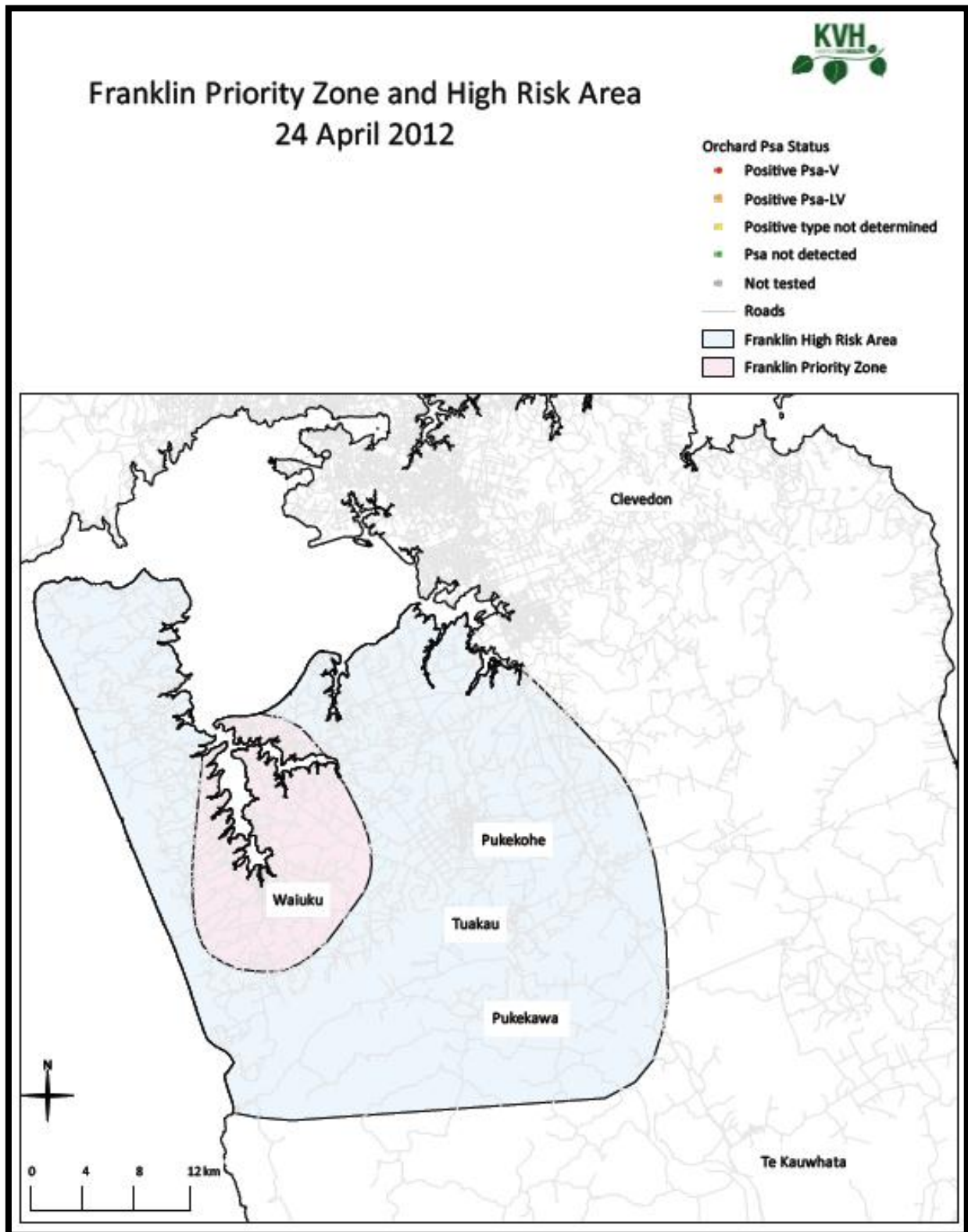
Inoculum pressure: is understood as the local environmental pressure from infected orchards, ie the expected inoculum pressure in Te Puke is said to be high, relative to the number of infected orchards while the inoculum pressure in the Waikato is said to be low/nil as there are no cases of infected orchards.

Graftwood: when establishing a new block small sections of kiwifruit canes are able to be used and grafted onto existing kiwifruit stumps or canes to establish a fruiting canopy or to replace a failed graft.

Trace back investigation time line:

- **18 November 2011**—Positive result received for Franklin region. Trace back process initiated.
- **23 November 2011**—Second positive result received for Franklin.
- **25 November 2011**—Third positive result received for Franklin.
- **22 December 2011**—Draft trace back report complete and submitted for peer review.
- **22 December 2011**—Fourth positive result received for Franklin.
- **18 January 2012**—Fifth positive result for Franklin.
- **20 January 2012**—Trace-back report update actioned.
- **1 February 2012**—Up-dated report submitted for peer review.
- **12–13 March 2012**—Franklin orchards revisited and monitored for Psa-V progression update.
- **27 April 2012**—Sixth positive result for Franklin.
- **May 2012**—trace back report finalised and signed off by KVH.

Franklin region Psa-V map: Identifying established KVH Priority Zone and High Risk Area:



1.0 Trace back investigation for new out of Priority Zone incursion

1.1 Purpose of investigation

KVH's primary objective is to minimise the impact of Psa-V on the New Zealand kiwifruit industry. The purpose of a trace back investigation is to identify and assess known pathways by which Psa-V has and can be transferred—within and across orchards and between regions. In the event of an 'out of Priority Zone' incursion KVH will use biosecurity measures to prevent the further spread of Psa-V. This may involve the sanctioned:

- destruction of plant material that has been recently sourced from a known Psa-V environment and moved into a Psa-V 'free' environment; and
- destruction of 'suspect' plant material moved locally from orchard-to-orchard.

In conjunction with the above KVH's containment strategies in existing/new regions focus on the following.

- Establishing a record of plant movement from any given infected orchard/s.
- Advising managers of orchards deemed to be 'high-risk' (ie any orchard directly associated with a Psa-V infected orchard through close proximity, shared plant material or contractor movements) to frequently monitor their orchards (or blocks) that may be susceptible to contamination.
- Providing regional advice (through grower meetings) about industry best practice in light of a Psa-V environment.
- Informing and implementing biosecurity compliance protocols, eg budwood supply, pollen supply etc relevant to a new Priority Zone.

1.2 Key areas explored in an investigation

KVH will send a trace back questionnaire directly to the affected grower and packhouse Psa-V manager requesting information on the following key areas.

- General orchard set-up—vine variety, rootstock, age of both scion and rootstock, growing system etc.
- The nature of the infection—number of infected vines, symptoms and spread.
- An annual log about plant movement/supply—on and off orchards.
- An annual account of orchard practices and associated contractor movements—with initial focus on high risk activities.

Three primary pathways are explored with regards to the trace back of Psa-V in a new Priority Zone.

1. Weather-related events/infection periods against protective spray programmes in place on affected orchard/s.
2. Movement of plant material and/or orchard materials and equipment.
3. Work history and movement of orchard contractors.

In aid of this investigation the following questions need to be considered.

- **Location**—is the first orchard a true expression of the original point of contamination?
- **Time**—does the level/severity of infection indicate an association with a particular pathway, event or activity?
- **Disease expression**—do the symptoms indicate an association with a particular pathway, event or activity?
- **Plausibility**—is the pathway under investigation knowingly able to spread Psa-V?
- Are the incursions to be treated as individual cases; or is one of the orchards a primary-source orchard with a common link existing between the other incursions, ie linking them together?
- Are there any materials/contractors connected to known Psa-V regions?
- What differences (if any) are there between the Psa-V affected orchards and immediate neighbours?

The answers to these questions will rule some pathways in and others out. Ultimately, it can provide KVH with the necessary information to help to manage the known risks to the wider region.

1.3 Limitations to a trace back investigation

Trace back reports are prepared by KVH to aid in the assistance and understanding of how to effectively manage a new Psa-V Priority Zone. In known Psa-V environments it may be obvious how and when Psa-V has been transferred. However, the same is not necessarily true for new incursions outside of existing Priority Zones.

In many cases:

- there will be a range of possible pathways;
- key background orchard information—plant movement, orchard work history and contractor whereabouts may be incomplete; and
- the undetected presence of the disease in a new region is a possibility.

For this reason this report can only assess the most probable pathways and provide an assessment of the likelihood of each of these as being a primary pathway. Gaps in understanding the lifecycle of Psa-V limit the interpretation of the information gathered. Therefore, KVH may be unable to determine the primary pathway responsible for the introduction of Psa-V into a new region.

2.0 Orchards involved in the trace back investigation

Objective: Identify the primary orchards involved and assess orchard practice and management, and if possible, determine whether these incursions are to be treated as linked or individual cases. In addition, where possible, compare Psa-V positive orchards to neighbouring 'not detected' orchards.

Orchard	Date confirmed	Incursion groupings	Positive test on	Symptoms	Plant material 2011 (see Fig. 5)	Contractors: 2011
Orchard A*	18 Nov 2011	November 2011	HW and M91 in G3 block	Leaf spot, HW Die back, G3 and M91 (18 April 2012) Orange exudate on males in G3 block (8 May 2012)	G3 from I G3 from A (2010)	BOP grafting contractors
Orchard B*	21 Nov 2011		M91 and G3	Minor leaf spot on mature leaves Shoot wilt, M91, Bruce, Bruno suckers and G3 female One case of orange exudate on M91 male vine (18 April 2012)	G3, M91, Bruce from A	BOP grafting contractors
Orchard C*	25 Nov 2011		M91 and G3	Shoot wilt, M91, Bruno suckers and G3 female	G3 from I M91 from A Bruce from Q	BOP grafting contractors
Orchard D	21 Dec 2011	Late Dec 2011/ early 2012	Bruno suckers in G3 block	Leaf spot	G3 from A and I M91 from A Bruce from Q	BOP grafting contractors
Orchard E	17 Jan 2012		HW female	Leaf spot	Nil	Nil
Orchard F	27 Apr 2012		G3	Leaf spot and cane die back	G3 from I M91 from R Bruce from Q	BOP grafting contractors

Table 1: Summary table noting key information on Psa-V positive orchards

Note: *A, B and C were the first three identified orchards prior to December 2011; while D, E and F were post-November 2011 identifications. A, B and C have been the focus of the trace back investigation and any one of these orchards may have been the original/first orchard infected. In addition, one of these orchards may have been a source of inoculum for local spread. This is believed to have been the case in the identification of orchard D, E and F.

3.0 Nature of the infection on the affected orchards

Foreknowledge: The nature of the infection location within orchard, spread throughout block and severity of disease expression can give direction as to where, when and how the initial infection occurred. In field observations has seen weather-related contamination typically result in primary infection as leaf spot. Contamination by plant material and/or contractor work typically results in secondary infection as shoot wilt, cane dieback or orange exudate.

Aim: Visit the affected orchards and gain an understanding of what is being observed with regard to symptom expression. From this, decide on the areas to focus on for the trace-back investigation

Regional-monitoring round: A regional monitoring round was actioned (mid-November 2011) following the initial discovery and confirmation of Psa-V in the Franklin region. From the first round it was noted that a group of orchards had leaf spot. Subsequent enquiries through Packhouse representatives revealed that these symptoms had not been confirmed through Packhouse. Subsequently, the large number of samples sent to labs for testing was in response to the first positive result for the region. None of the tests from the region, other than the known positive orchards, came back with a positive result.

The following field information was collected from or supplied to KVH field staff—on the nature of the infection within the affected orchards in the Franklin region.

- Table 2: Key information on infection expression on Orchard A
- Table 3: Key information on infection expression on Orchard B
- Table 4: Key information on infection expression on Orchard C
- Table 5: Key information on infection expression on Orchard D
- Table 6: Key information on infection expression on Orchard E
- Table 7: Key information on infection expression on Orchard F

Orchard A, confirmed on 18 November 2011 from male leaf samples in a Hayward block


Orchard profile:	KVH field observations:	Course of action:	Growers'/managers' comments:
<p>Positive result 18 November, 2011 for the following:</p> <p>Hayward Block, male (M56) leaf sample</p> <p>G3 Block, male (M91) leaf sample</p>	<p>Infection is seen on the leaves of 31-year old Hayward vines (male) in a narrow band (NE direction) from the roadside across block (Nov 2011).</p> <p>Approximately six bays are affected by leaf spot.</p> <p>Secondary infection as shoot die back was seen in the G3 block in male (M91) and female vines (18 April 2012) confirmed by Shane Max, ZESPRI.</p> <p>A new report of orange exudate on male vines in the G3 block was notified to KVH on the 8 May 2012.</p> <p>Determining which variety was infected first is a key factor in understanding the source of infection and therefore possible pathways of introduction.</p>	<p>Initial affected Hayward vines (approximately three) were removed until more spotting was found. Infected vines have been left for further monitoring.</p> <p>A single, affected male vine has been removed from the G3 block (November 2011)</p> <p>Frequent monitoring of the affected block should continue. If symptoms progress to secondaries, exudate/oozing, symptomatic material should be removed.</p>	<p>A neighbouring orchard packs its fruit in the Bay of Plenty. Bins from the Bay of Plenty would have been sent into the Franklin region for the harvest period earlier this year.</p> 

Table 2: Key information on infection expression on Orchard A

Orchard B, confirmed 21 November 2011 from male (M91) and female leaf samples in a G3 block

Orchard profile	KVH field observations:	Course of action:	Monitoring comments from initial discovery:	Additional comments:
<p>Positive result 21 November 2011 from the following.</p> <p>G3 block, female leaf sample from wilting shoots.</p> <p>G3 block, male (M91) leaf sample from wilting shoots.</p>	<p>There is limited leaf spot in the infected blocks. The only leaf spot noted was on leaves (mature) at the same level as the graft union (five months old). All leaves (young) above the graft region were clean from spotting.</p> <p>The majority of the symptoms seen were shoot dieback/wilt on male vines (M91, Bruce) that had been removed prior to orchard inspection. (No photos were taken of the symptoms prior to removal).</p> <p>Upon inspection, several grafts of the M91 and Bruce variety grafted in August 2011, had recently died back/collapsed down to the graft union. While this dieback is similar to that seen in other grafts infected with Psa-V, individual samples would have to be tested to confirm this is Psa-V related. However, as there is known infection in this block and vines continue to express shoot wilt, it can be assumed with some confidence this is Psa-V related.</p> <p>Continued removal of males (M91, Bruce) is occurring as vines express infection. There was a recent case of orange exudate on an infected male (April 2012).</p>	<p>Symptomatic material has/is being removed to the point where the vines are clean of symptoms.</p> <p>Frequent monitoring of the block should continue. If shoot death continues to develop on new vines this would support the likelihood the symptoms seen are due to Psa-V and not as a result of graft failure.</p> <p>A regular protectant spray programme should be put in place on the orchard.</p>	<p>A small number of vines initially expressed symptoms, which progressed to 20+ vines quickly.</p> <p>The majority of the symptomatic vines are M91 males.</p>	<p>If the dieback/shoot wilt observed in this orchard is Psa-V related, this orchard would be the worst affected/expressing orchard out of the initial three positive incursions in the region (as of December 2011)</p>



Orchard C, confirmed on 25 November 2011 from male (M91) leaf samples in a G3 block


Orchard profile:	KVH field observations:	Course of action:
<p>Positive result 25 November 2011 from the following.</p> <p>G3 block, male (M91) leaf sample from wilting shoot</p>	<p>Identical to orchard B.</p> 	<p>Identical to orchard B.</p>

Table 4: Key information on infection expression on Orchard C

Orchard D, confirmed on 21 December 2011 from Bruno leaf sample in a G3 block


Orchard profile:	Monitoring comments from initial discovery:	Course of action:
<p>Positive result 21 December 2011 from the following.</p> <p>G3 block, Bruno leaf.</p>	<p>Leaf spot is seen on Bruno suckers coming up from a single G3 vine.</p> 	<p>Frequent monitoring of the block should continue.</p> <p>A protectant spray programme should be put in place on the orchard.</p>

Table 5: Key information on infection expression on Orchard D

Orchard E, confirmed on 18 January 2012 from female leaf samples in a Hayward block

Orchard profile:	Monitoring comments from initial discovery:	Course of action:	Comments:
<p>Positive result 18 January 2012 from the following.</p> <p>Hayward block, female leaf sample.</p>	<p>Leaf spot is seen on five vines on the outside row. In some cases the leaf spot is quite severe.</p>	<p>Frequent monitoring of the block should continue.</p>	<p>This orchard is 450m in proximity to orchard C.</p>

Table 6: Key information on infection expression on Orchard E.

Orchard F, confirmed on 27 April 2012 from female leaf samples in a G3 block

Orchard profile:	Monitoring comments from initial discovery:	Course of action:	Comments:
<p>Positive result 27 April 2012 from the following.</p> <p>G3 block, female leaf sample.</p>	<p>Minor leaf spot is seen on one G3 female vine. Die back, in the middle of the vine, was seen on two plants.</p>	<p>Frequent monitoring of the block should continue.</p>	<p>This orchard is 4kms in proximity to orchard D.</p>

Table 7: Key information on infection expression on Orchard F

4.0 Assessing Pathway 1: Weather related events / infection periods

Foreknowledge: Bacteria can be dispersed through a range of means. The most common method of bacterial spread is through wind and rain. Rain drops hitting a leaf causes ‘splashing’ which can redistribute the bacteria locally to neighbouring leaves. ‘Free’ water is required for the proliferation of Psa-V. Infection periods are defined as prolonged periods of leaf wetness; which is generally understood to be two to three days. From field observations, leaf spot has typically been expressed approximately seven to 14 days outside of a significant weather event—depending on local inoculum pressure.

Aim: Identify key infection periods prior to the positive result for each of the orchards, and/or during key orchard activities, eg grafting. Once potential infection periods have been identified assess the protective spray programme in place for each of the orchards to determine an orchard’s expected protection against a potential weather related incursion.

4.1 Infection periods

Weather data was collected and compared from three different sites: BHL Paerata Pukekohe weather station; Belsaas Papakura weather station; and Glenbrook weather station. There was no significant difference in the data sets between weather stations.

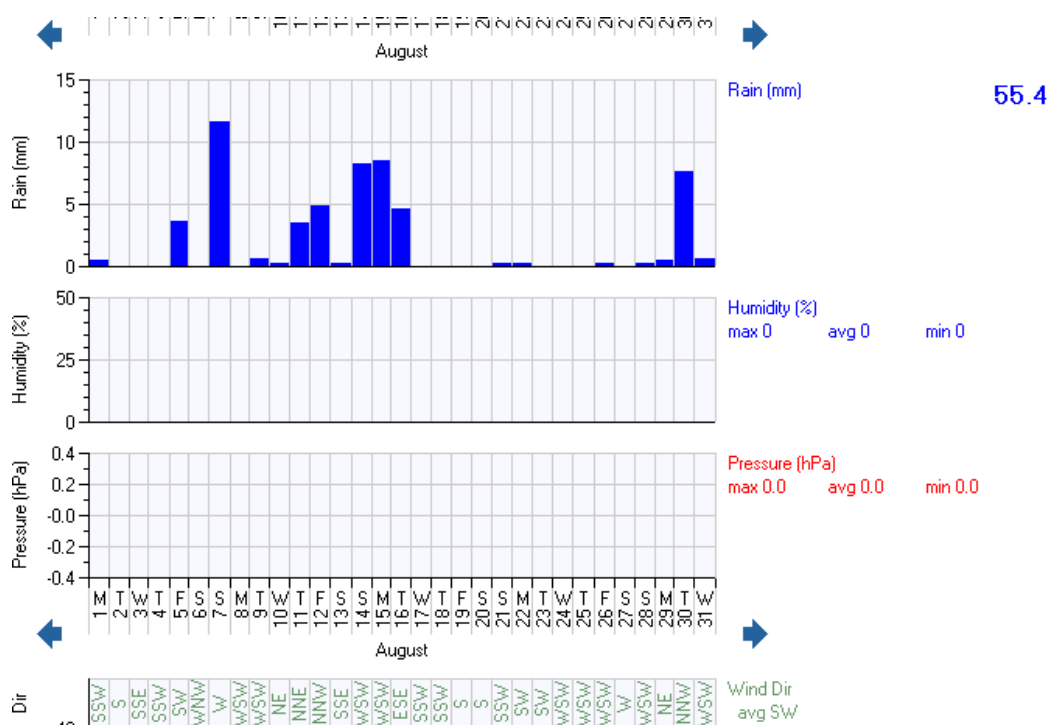


Figure 1: Weather data for the month of August 2011.

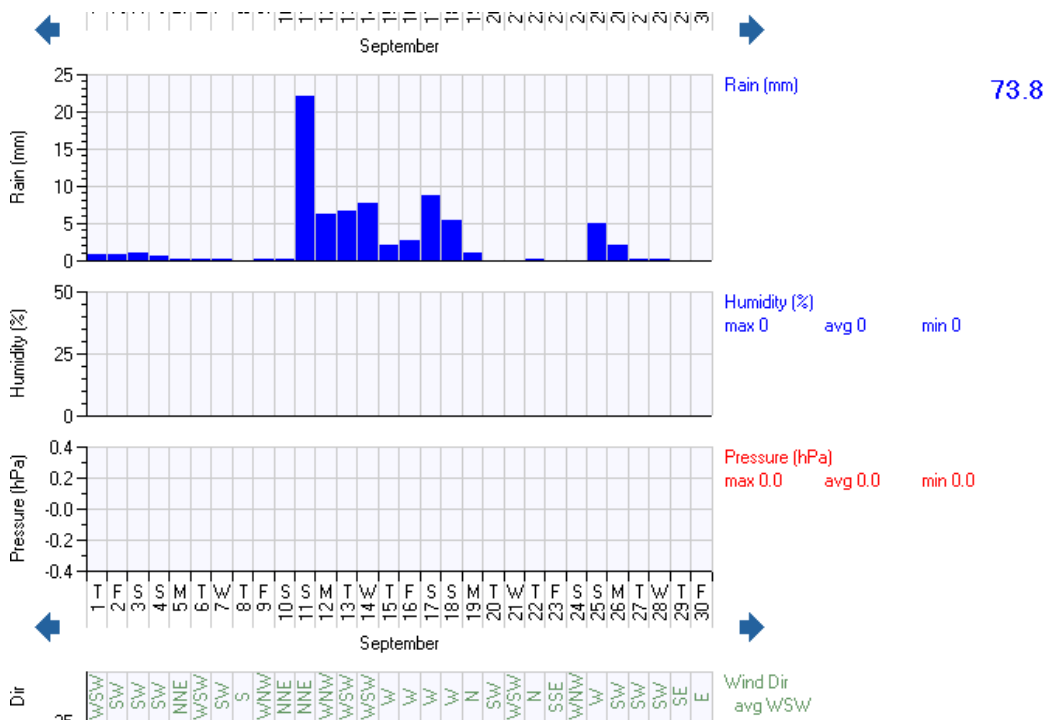


Figure 2: Weather data for the month of September 2011.

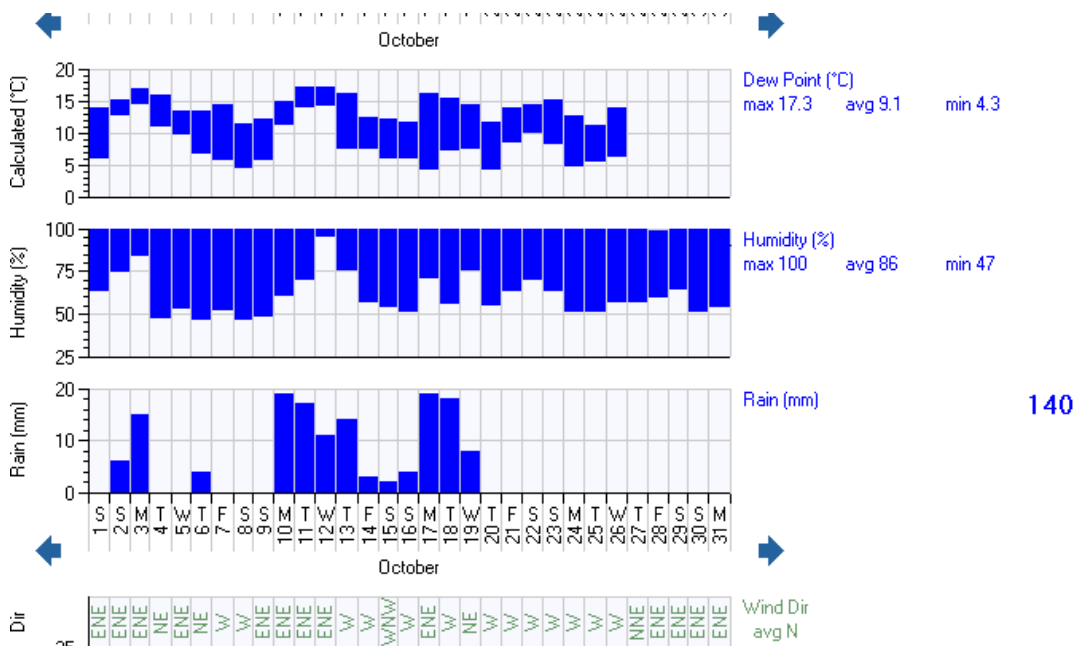


Figure 3: Weather data for the month of October, 2011.

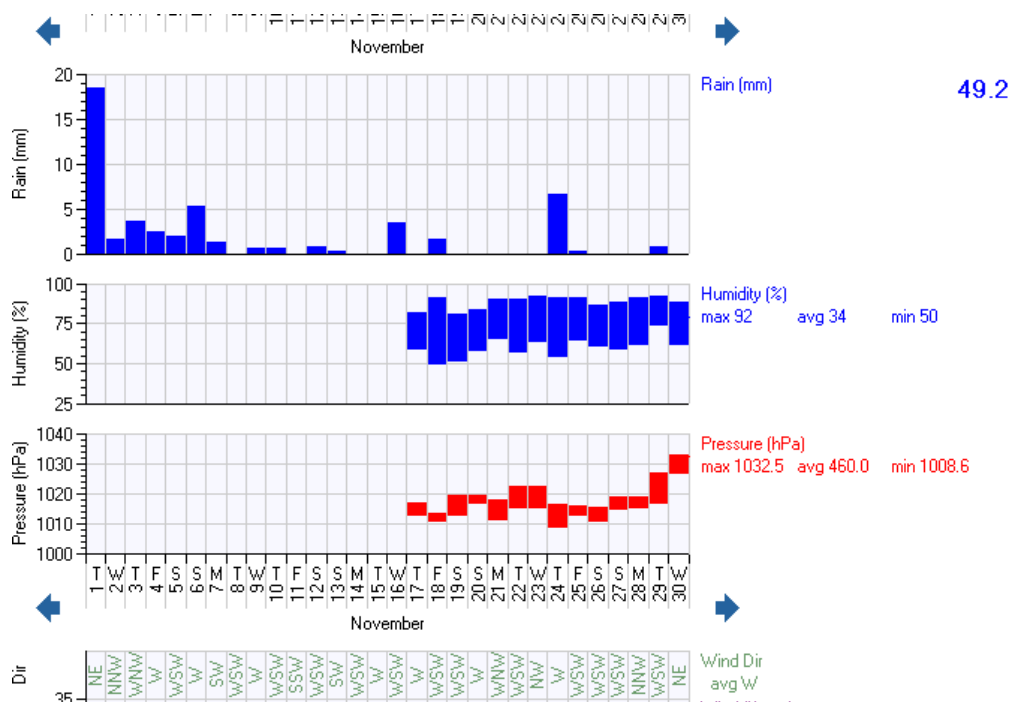


Figure 4: Weather data for the month of November, 2011.

4.2 Protective spray programme

Foreknowledge: The use of protectant sprays has proven to be effective in the field at managing and/or mitigating the risk/onset of Psa-V. Effective protection is determined by good coverage, which in turn is determined by canopy management over and above product choice. Although we cannot assess the efficacy of coverage for these orchards, we can infer a level of protection by noting whether a protectant was used and when it was used in relation to weather events.

Aim: Account for the protective spray programmes in place for each orchard, to infer a level of protection around identified infection periods.

Orchard	Date	Affected variety	Symptoms	Infection period 1	Protectant spray	Infection period 2	Protectant spray	Infection period 3	Protectant spray
Orchard A	18 Nov 2011	HW	Leaf spot	11–19 Sept 2011	29 Sept 2011	10–19 Oct 2011	Nil	1–7 Nov 2011	19 Nov 2011
		M91 and G3	Cane/shoot die back and orange exudate		Nordox 75 WG				Actigard
Orchard B	21 Nov 2011	M91 and G3	Shoot wilt and orange exudate	11–19 Sept 2011	<i>Nil for New Varieties</i>	10–19 Oct 2011	<i>Nil for New Varieties</i>	1–7 Nov 2011	22 Nov 2011 Actigard

Orchard C	25 Nov 2011	M91 and G3	Shoot wilt M91, Bruno suckers and G3	11–19 Sept 2011	<i>Nil for New Varieties</i>	10–19 Oct 2011	<i>Nil for New Varieties</i>	1–7 Nov 2011	22 Nov 2011 Actigard
Orchard D	21 Dec 2011	Bruno suckers in G3 block	Leaf spot	11–19 Sept 2011	<i>Nil for New Varieties</i>	10–19 Oct 2011	<i>Nil for New Varieties</i>	1–7 Nov 2011	Nil
Orchard E	17 Jan 2012	HW female	Leaf spot	11–19 Sept 2011	30 Sept 2011 Nordox 75 WG	10–19 Oct 2011	Nil	1–7 Nov 2011	23 Nov 2011 Actigard
Orchard F	27 Apr 2012	G3	Leaf spot and cane die back	11–19 Sept 2011	<i>No data</i>	10–19 Oct 2011	<i>No data</i>	1–7 Nov 2011	<i>No data</i>

Table 8: Orchards Protective spray timing in relation to potential infection periods.

Note: None of the affected orchards (A, B, C, D, E) had a protectant spray applied following the possible infection period in mid-October. Orchard A may have had some level of protection prior to the mid-October weather event from its September spray application. Of particular note, G3 blocks in orchard B, C and D had not received any protectant sprays since July (not shown here). All other blocks on these orchards had received protectant sprays up to late September/early-October.

4.3 Plausibility of a weather related incursion

Rain events and, therefore, infection periods need to be correlated with the symptoms seen on the orchard. As mentioned earlier, leaf spot is typically caused by prolonged periods of leaf wetness (two to -three days). But this does not assure the source of bacteria was from a rain event. Although Psa-V needs water to propagate, it may be present on leaf surfaces prior to rain events.

If the source of inoculum has not been introduced from a historic weather event (as inoculum would have had to of been transported from a known Psa-V environment i.e. the Bay of Plenty) then there has to be another local incolumn source that has contaminated the affected orchard(s) and a weather event may have simply provided ideal conditions for the bacteria to thrive and cause infection. The infection period in question is mid-October 2011.

Vine age and variety will determine the susceptibility of an orchard to air-born Psa-V infection following a weather event/infection period. Looking at the affected orchards, five of the six orchards have young plant material (G3) where infection has taken hold. Subsequent to vine age, any work that creates major wounds will additionally increase a vines Psa-V risk. New Variety vines (G3) were grafted three months prior to the first positive

Psa-V confirmation in November 2011 – providing a long lasting entry point for Psa-V. For these reasons, along with the absence of a protective spray programme for the new variety blocks; Orchard A, B, C, D and F are considered to be high risk orchards (along with any other orchards in the franklin region with young vines).

5.0 Assessing Pathway 2: Asymptomatic/latently infected plant material

Foreknowledge: Infected (knowingly or unknowingly) plant material that has been moved from an infected orchard onto an uninfected orchard is one of the strongest known pathways for the spread of Psa-V, although the tracking of this is difficult.

Aim: Collect a full record of plant material that has been moved onto and off any of the affected orchards—identifying the source orchard and its current Psa-V status to determine the risks associated with shared plant material.

5.1 Budwood movement

All plant material was sourced locally in August 2011, as coordinated by the local Packhouse. As part of its Psa-V risk management programme, the Packhouse co-ordinated the collection of all plant material from a small group of source orchard (figure 5) to ensure traceability in the event of an incursion. In 2010 new variety budwood was supplied by ZESPRI.

Diagram showing the primary and secondary links from Psa-V positive and Psa-V not detected orchards through shared plant material.

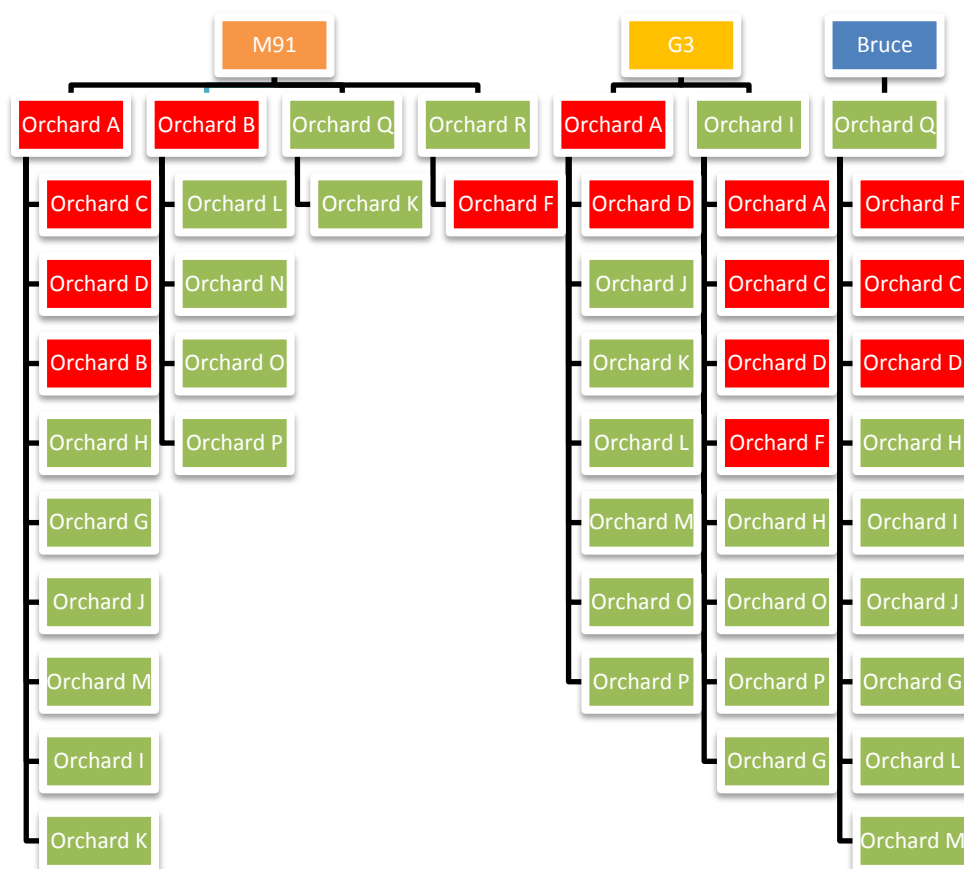


Figure 5 (previous page): Diagram shows orchards connected through the supply of M91, Bruce or G3. Red boxes denote orchards positive for Psa-V while green boxes represent a Psa-V not detected result. Orchard E is absent from this list as it has no connection through shared plant material. Orchard I was the initial supplier of G3 and once supplies were exhausted from this orchard, Orchard A provided G3 (from their 2010 new variety block) to the remaining orchards in the Franklin region that had requested new variety wood.

5.2 Plausibility of a budwood related incursion

At this time, there is no obvious evidence to suggest Psa-V was introduced into the Franklin region and spread through plant material—specifically M91 or G3 wood. Disease symptoms will dictate the likely source of inoculum. For there to be plausibility around the likelihood of a plant related incursion, systemic infection (as shoot or cane die back) would have to be seen on any orchard where ‘asymptomatic’ plant material has been supplied, it is yet to be proven that systemic infection results in leaf spot. In this case, only four orchards are currently exhibiting secondary infection. When looking at the total number of orchards that received common graftwood (figure 5), this may be statistically insignificant. In addition, this would imply Psa-V has been dormant or asymptomatic in the graftwood for quite some time (one to two years).

It may be that KVH is observing the result of the challenges faced in collecting graftwood from known or unknown Psa-V environments. It is thought a vine may have the capacity to contain both Psa-V infected canes and Psa-V uninfected canes. In this way an orchard may be able to provide both clean and ‘asymptomatic’ infected wood. Therefore, it may be expected that Psa-V affected wood could have the capacity to infected any vine it is grafted into—while the uninfected wood could not cause infection. It may be that orchard A, B, C, D and F received asymptomatic Psa-V wood. However, as explained above, in this scenario secondary infection would have to be observed on the supply orchard and on the orchards that received any ‘asymptomatic’ material. Currently, this is not believed to be what KVH is observing in the Franklin region.

6.0 Assessing Pathway 3: Contractor movements

Foreknowledge: Any work on vines that creates wounds provides an entry point for Psa-V—either by means of air-borne incolumn or through direct contact with contaminated tools. Orchard/contractor hygiene practices may reduce this risk. Contractors who have previously worked in the Bay of Plenty, then work in a region free from the detection of Psa-V will be subject to a more vigorous follow-up process in contrast to contractors who have been sourced locally within a Psa-V ‘detection free’ region.

Aim: Identify key contractors and/or materials that have been supplied locally or from the Bay of Plenty. Account for their involvements in the affected orchards, specifically addressing the following.

- Where have they come from and what tools have they brought with them?
- What were their hygiene practices?
- What block did they start in on the orchard?
- Did they ever work in wet conditions?
- If necessary, where did they go following work done in an (now known to be) infected orchard?
- If necessary, what block did they start in following work done in a known Psa-V affected orchard?

6.1 Direct association, grafting contractors from the Bay of Plenty

All grafting of wood supplied by the Packhouse in August 2011 was carried out by a group of contractors based in the Bay of Plenty region. Two parties conducted the grafting practice over a six-day period—visiting and grafting a total of 15 orchards in the Franklin region. On enquiry, the following comments were made around this use of contractors from the Bay of Plenty:

- No tools were taken to the Franklin region except a specialised chisel bought immediately prior to travelling to Auckland.
- All other materials (newly bought) were supplied in Auckland from the Packhouse.
- Contractors bought/wore fresh sets of clothes.
- Contractors had worked in Te Puke two–three days prior to working in Franklin.
- (Expected) Hygiene practices involved the spraying/dipping of tools in methylated spirits and chlorine-based solutions were provided to clean vehicle tyres.

Referring to the identification of orchards as presented in figure 5 (above), the grafting contractors grafted the following orchards in chronological order:

- Orchard B, 4 August 2011
- Orchard F, 4 August 2011

- Orchard A, 5 August 2011
- Orchard G, 5 August 2011
- Orchard H, 5 August 2011
- Orchard I, 5 August 2011
- Orchard C, 6 August 2011
- Orchard J, 6 August 2011
- Orchard K, 8 August 2011
- Orchard D, 8 August 2011
- Orchard L, 9 August 2011
- Orchard N, 9 August 2011
- Orchard O, 10 August 2011
- Orchard P, 10 August 2011

*Red denotes Psa-V positive orchards.

6.2 Plausibility of a contractor related incursion

As Orchard B and C have an identical record for work done on the orchard, and in turn shared local contractors, there is little evidence to suggest Psa-V has been brought onto the orchard by a local contractor who has not also worked in other orchards in the Franklin region. Therefore, specific attention was given to the grafting contractors who are based in the Bay of Plenty.

It has been reasoned with the information on hand (assuming it is accurate) along with the symptoms seen on Orchard A, B, C, D and F that the following set of considerations suggest a medium to low risk is associated with the use of grafting contractors from the Bay of Plenty region.

- All grafting tools used were new and or provided on site.
- Multiple orchards were grafted in a short space of time, giving all orchards the same exposure period for disease expression/development.
- Disease spread throughout Orchards B (the first orchard visited) appears to be random and inconsistent with what would be expected for a typical row-by-row work pattern as practiced by grafting contractors.
- Symptomatic vines were not exclusively seen in the start location of the August 2011 grafting contractors on Orchard B.

As Orchards A, B, C D and F have new plant material and on-orchard practice (in the form of grafting directly wounding the vines) there are a set of internal factors that may have increased their susceptibility to Psa-V infection:

- The true level of hygiene observed between each new graft—were tools cleaned between every vine and was the graft union effectively covered/protected?

- Following grafting, were the graft wounds checked and resealed with wax following significant weather events to ensure a physical barrier existed between the wound and the environment?
- There was no protectant spray programme in place for the new variety blocks.
- These are young plants.

It may be logical that the first orchard visited by the grafting contractors would be at the highest risk to Psa-V contamination. On examining the records KVH has noted the first orchard visited by the grafting contractors is positive for Psa-V.

6.3 Indirect association, harvest bin movements from the Bay of Plenty

KVH was informed about several orchards in the Franklin region from which the fruit is packed in the Bay of Plenty region and consequently bins would have been transported to Franklin for harvest purposes.

A concern was expressed around the possibility of inadvertent plant material being left in harvest bins, which could have blown off a truck and onto one of the infected orchards.

Key representatives from each Packhouse were contacted to collect information around the dates of bin movements and hygiene practices in place. The following table presents this information.

Packhouse	Date bins supplied	Hygiene_protocols
A	29 April and 11 May 2011	Bins were cleaned of any plant material and sanitised via a spray system.
B	21 March 2011	Bins were cleaned of any plant material and sanitised via a spray system.
C	30 September 2011 5 November 2011	Bins were cleaned of any plant material and sanitised via a spray system.

Table 9: Movement record of bins supplied from the Bay of Plenty into the Franklin region.

6.2 Plausibility of a bin movement related incursion

The likelihood of kiwifruit material (leaves) carrying 'live' Psa-V within kiwifruit bins from the Bay of Plenty region and then being transported to the Franklin region, blown off a truck and onto a kiwifruit canopy to cause infection, is an unlikely scenario. And in any case while it may give explanation as to how one of the orchards may have been contaminated it does not account for the other two positive orchards identified a week after the first detection in the Franklin region. It is more probable leaf spot on this orchard has been caused by a local inoculum source from an orchard/block with secondary infection.

7.0 – Conclusion

The most likely scenario for the introduction/detection of Psa-V in the Franklin region is as follows:

- Psa-V has been introduced onto one of the six orchards;
- More precisely as, Orchard D, E and F are not considered to be part of the original set of orchards first contaminated but rather the result of local spread of Psa-V, it is believed that Psa-V was first introduced on Orchard A, B or C;
- Although a primary pathway has not been identified, there is a greater likelihood that Psa-V has been introduced via asymptomatic plant material or contractor movements as-a-posed to weather events. However, there is no obvious evidence to give confidence to the former and long distance spread of Psa-V by wind and rain is not well understood;
- Infection initially would have been low and over time has progressed into secondary infection, which then created inoculum and caused further local spread of the bacteria. This accounts for the leaf spot as seen on four of the six orchards and explains the on-going detection of newly infected orchards.

Based on the above scenario, Orchards A, B or C are expected to have been among the first orchards infected and/or the source of inoculum for further local spread. Alternatively, there may be an undiscovered/unreported orchard within the Franklin region exhibiting severe secondary infection in the form of orange ooze.

Following the recent (April/May 2012) discovery of secondary infection in the form of orange ooze on two of the incursions identified in late 2011, KVH strongly encourages aggressive orchard management through the method of removal of all infected material (which is being practiced) to ensure Psa-V risk is managed and inoculum pressure is kept to a minimum. Infected orchards must be frequently monitored to ensure the disease is being managed optimally. Poor management or neglecting to remove infected material will very likely see an increase in inoculum pressure and further spread of the Psa-V disease within the Franklin region.

At present, this investigation has not been successful in identifying the primary pathway by which Psa-V has been introduced or detected in the Franklin region. Therefore, it is considered a catchment of information on the infected orchards, factors involved, possible links between orchards and assessment on risk factors. Should any new information be presented, that aids the understanding of the Franklin incursions; the report will be reopened and updated accordingly.

8.0 – Acknowledgements

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